BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION OF MONTANA-DAKOTA UTILITIES CO. AND OTTER TAIL POWER COMPANY FOR A PERMIT TO CONSTRUCT THE BIG STONE TO SOUTH ELLENDALE 345KV TRANMISSION LINE	GERALD PESALL'S EXHIBIT LIST EL13-028

GERALD PESALL hereby designates the following exhibits and exhibit numbers for the evidentiary hearing to be held June 10-12, 2014 in the above captioned matter, which list may be supplemented at the evidentiary hearing:

EX.	Description	Stipulated	Offered	Admitted	Denied
101	Gerald Pesall Prefiled Direct Testimony	Yes			
102	Gregory Tylka Prefiled Direct Testimony	Yes			
103	Gregory Tylka CV	Yes			
104	Gregory Tylka Prefiled Surrebuttal Testimony	Yes			
105	2014 SCN Distribution Map	Yes			
106	1956 USDA Special Report on SCN	Yes			
107	1998 Soybean Digest Special Report on SCN	Yes			
108	1996 First Report of SCN in South Dakota	Yes			
109	2007 SCN University Fact Sheet	Yes			
110	1955 SCN Plant Disease Reporter	Yes			

Dated this 5th Day of June, 2014

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bob@pesall.com

CERTIFICATE OF SERVICE

The undersigned attorney hereby certifies that at true and correct copy of the **GERALD PESALL'S EXHIBIT LIST** was served upon the following parties of record, electronically or in paper form, this 5th day of June, 2014:

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N. Bob Pesall, Attorney

BEFORE THE PUBLIC UTILITIES COMMISSION
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IN THE MATTER O FTHE APPLICATION OF MONTANA-DAKOTA UTILITIES CO. AND OTTER TAIL POWER COMPANY FOR A PERMIT TO CONSTRUCT THE BIG STONE TO SOUTH ELLENDALE 345KV TRANMISSION LINE	DIRECT TESTIMONY OF GERALD PESALL EL13-028

1. **State your name and address.**

   Gerald W. Pesall, 15062 430th Ave. in Lily, South Dakota, 57274.

2. **Describe your educational and occupational background.**

   I graduated from 12 years of high school in 1955. I worked in construction after school, but have been farming for the last 53 years. I started in 1961 renting 350 acres from family. Today I own and farm about 1,500 acres. My farm includes my house and the house where my family homesteaded back in 1882. The family farm has been in continuous operation since that time. All of this land is in Day County, South Dakota.

3. **Describe the size and general nature of your farming operation.**

   I farm about 1,500 acres right now. I raise soybeans, corn, and wheat. This includes about 400 acres of corn, 400 in wheat, and the rest in soybeans. I also do some custom tillage and harvesting work on the side. I used to raise dairy cattle but discontinued that operation due to flooding in the 1990's.

4. **Are you familiar with other farming operations in your region of South Dakota?**

   Yes.

5. **Are those farms similar to yours?**

   Yes. They mostly raise small grains, corn, soybeans and wheat. They may farm from 600 acres to several thousand.

6. **Would the operators of those farms be likely to experience the same concerns about the proposed B.S.S.E. line that you have?**

   Yes. And at least 12 of my neighbors have told me that they oppose it.

7. **Does the proposed B.S.S.E. line pass over land you farm, and if so where?**

Yes. It would cross over my land at section 17, township 120, rage 56 in Day County, South Dakota. This is about one mile east of my house, and about ¼ from the original family homestead.

8. **Do you oppose the issuance of a permit for the proposed line by the P.U.C.?**

Yes, absolutely.

9. **Why do you oppose the issuance of a permit in this proceeding, and why do you feel the line should not be built?.**

If the line were constructed, it would interfere with my daily farming operations and create more paperwork for me. It would lower my property values. It would create new liability issues for me. It would create health and safety risks. It would also damage cropland and roads. I do not have a pole on my property and I don't want to look at them. All my lines are buried. The land looks almost the same today as it did when my grandfather homesteaded.

10. **What impact would the proposed line have on your day-to-day farming activities?**

It would prevent me, and farmers like me from using irrigation, interfere with electronic farming equipment, and create obstacles in the field which we would have to work around. It would also create extra paperwork for us any time their construction or maintenance crews damage crops, and increase paperwork for crop insurance claims and crop histories.

11. **What impact would the proposed line would have on the value of property you own?**

If the line goes there, I will not be able to acquire the full cash rent if I rent it out. Large farmers will be using electronic gadgets, and the extra obstacles and potential disruption under the lines will require extra effort from him.

If I decided to sell the land, it will not carry the same value. Anything on it impacts the price. I would estimate about $5 per acre less for cash rent. I would estimate about a 3% decrease in the market value of that land.

12. **What impact would the proposed line have on the aesthetics of your region of the state?**

It will distort the overall view of the region.

13. **What are your liability concerns?**

They're putting obstacles out in the field, and I can be responsible if I or a renter or a hired person, collides with any of them. They applicants say they'll have insurance but I have no way of knowing whether they'll maintain that insurance, or if it would be sufficient if a third party gets injured. And, insurance does not prevent harm, it just tries to pay for it after-wards.

If someone gets hurt or killed because this high-voltage line is out in the field, no check from an insurance company is going to bring them back.

14. What are your health concerns?

The builders say there should not be health concerns for people at ground level, but they have to avoid houses and towns. I may have people in tractors or combines that are well above ground level that will get exposed to the fields from this line. My neighbor has a pacemaker. I know people with cochlear implants. If any of these people are in a tractor under that line, they may have problems.

15. What are your safety concerns?

A fallen high voltage line could be deadly. I do not want to see family, friends, or neighbors get injured. Some common farm equipment can get quite tall and come close to those lines. If the equipment connects with one, it could damage the equipment or harm the driver, or start a fire. It creates another hazard for me if I have to be careful not to park equipment under the lines. It could also induce current in fences or other metal items near the lines.

16. What concerns do you have about damage to cropland?

I worry about soil compaction and pests. The builders claim they will fix soil compaction, but I have no way of knowing whether they will follow through. Some soil compaction can take ten years or more to recover. I've seen this happen where roads are constructed in my area, even when the contractors try to fix the soil.

Another concern is the transmission of the soybean cyst nematode, "sudden death syndrome," and chemically resistant weeds. All of these can be transferred from field to field with large equipment. My farm equipment might transfer small amounts in my region, but a construction project this big means equipment moving across fields for miles and miles. Once these pests get started in a field, they remain forever and will permanently harm crop yields.

17. What concerns do you have about road maintenance if the project goes forward?

I was on the township board for over 40 years and I've seen contractors destroy roads, blade them once or twice, and leave. Large equipment used in the wrong season can destroy the roads. Roads around our area were built with elevated graders and using black dirt to construct the roadbed. They cannot withstand a lot of heavy equipment use. The townships and taxpayers will have to pay for the roads if the line is built and the builders do not maintain them.

18. Is it possible for you to calculate the potential dollar value of the damage these would cause to your operation?

I cannot, because the time of year that they do construction or maintenance would be a big factor. If their activities happen during planting or harvest, it could cost me thousands of dollars in lost time and production.

19. Do you believe there would be any benefit to you, or others similarly situated, by the construction of the proposed line?

No.

20. Have you had any problems with the reliability of your electrical services in recent years?

We had an outage last fall when an airplane caught a similar high-voltage line. We were without electricity for a few hours. Otherwise we have had no trouble with our electrical services in recent years. Most of the REA lines in my region are buried and they are burying more every year. I am quite satisfied with the current condition of my electrical services.

21. Do you or anyone you know have any intent to connect directly to this line to buy or sell electricity?

No.

22. Are you aware of anyone in your region who would benefit financially, either through employment or otherwise, from the construction of the proposed line?

All the people I've seen working on this project, asking us to sign easements, are not local people. They are all from out of state. I do not know of anyone from South Dakota who is employed by this project.

23. What kinds of economic activity go on in your region and how will the line impact it?

Just about everyone in my region farms. The farms are getting bigger and more technological. This line would not benefit those operations, but it would interfere with them.

24. Does this conclude your testimony?

Yes.

Dated this 17 day of April, 2014

Gerald W Pesall

Gerald W. Pesall

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF MOODY)

On this 17 day of April, 2014, before me personally appeared Gerald W. Pesall, known to me to be the person who is described in, and who executed the foregoing instrument and acknowledged to me that he or she executed the same.

(seal)

N. BOB PESALL
NOTARY PUBLIC
SOUTH DAKOTA
SEAL

N. Bob Pesall, Notary Public

My Commission Expires: 12-20-18

BEFORE THE PUBLIC UTILITIES COMMISSION
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IN THE MATTER O FTHE APPLICATION OF MONTANA-DAKOTA UTILITIES CO. AND OTTER TAIL POWER COMPANY FOR A PERMIT TO CONSTRUCT THE BIG STONE TO SOUTH ELLENDALE 345KV TRANMISSION LINE	DIRECT TESTIMONY OF GREGORY TYLKA EL13-028

1. **State your name and address.**

Gregory L. Tylka, 922 New Hampshire Circle, Ames, IA 50014

2. **Describe your occupation and educational background.**

I am a professor in the Department of Plant Pathology and Microbiology at Iowa State University. My responsibilities are to conduct research and extension educational programs on the biology and management of plant-parasitic nematodes, with a heavy emphasis on the soybean cyst nematode (SCN), *Heterodera glycines*.

3. **Is a complete copy of your resume or C.V. attached to this testimony?**

Yes.

4. **Are you familiar with the proposed B.S.S.E. transmission line?**

Yes.

5. **Could the construction and maintenance of the proposed line impact the spread of soil-born pests like the Soybean Cyst Nematode or "SCN"?**

Yes, construction and maintenance of the proposed line could accelerate the spread of SCN into previously uninfested townships, farms, and fields.

6. **Please explain what the SCN is.**

Nematodes are microscopic worms, many of which live in terrestrial ecosystems such as row-crop farm fields. A majority of soil-dwelling nematodes are not harmful to plants. They consume bacteria, fungi, and other nematodes and contribute to cycling of nutrients in the soil. But agricultural soils also contain nematodes called plant-parasitic nematodes that feed on plants. Many plant-parasitic nematodes are believed to be native to midwestern soils, feeding off of naturally occurring plants in the landscape. These native, plant-parasitic nematodes must reach high population densities (numbers) in order to be damaging to crops. The soybean cyst nematode, SCN, is very different than native plant-parasitic nematodes that reside in typical midwestern soils. SCN is an introduced pest, which means it does not naturally occur in the United States. Introduced pests like SCN have few or no natural enemies when they are first introduced into a new environment, and the lack of natural enemies allows for very high reproduction in the first few years following introduction into an area. SCN is believed to have been introduced into North America from Asia (Riggs, 2004). The nematode feeds from the soybean root's vascular tissue, stunting the roots and making the roots less able to use atmospheric nitrogen, making it highly damaging to the soybean crop. Also, soybean plants infected with SCN are more vulnerable and suffer greater yield loss from soil-borne soybean diseases caused by fungi that are commonly found in soybean fields in the Midwest (Niblack et al., 2006). The nematode has a relatively short generation time (24 to 40 days), allowing it to complete three to six generations on a single soybean crop, and the nematode females each produce 250 or more eggs, allowing SCN population densities to increase very quickly. Finally, eggs of SCN can survive in a dormant condition in the soil without soybeans or another host crop being grown for a decade or more (Riggs, 2004).

7. **Please describe the research you've done, or of which you are aware, regarding the impact and spread of SCN.**

The soybean cyst nematode, scientific name *Heterodera glycines*, is considered the most damaging pathogen of soybean in the United States and Canada. Annual yield losses in the United States alone are estimated to exceed $1 billion (Wrather et al., 2010). Soybean cyst nematode can reduce soybean yields without causing aboveground symptoms (Wang et al., 2003), which allows the nematode to build up in fields to more damaging levels before farmers notice a problem. In a single growing season, SCN population densities can increase from less than 1,500 eggs per 100 cm^3 of soil (a little less than a half cup) in the spring to more than 19,000 eggs per 100 cm^3 of soil on susceptible soybean varieties and nearly 6,000 eggs per 100 cm^3 of soil on SCN-resistant soybean varieties at the time of harvest (Tylka et al., 2013). The map of the known distribution of SCN in North America was recently updated, and South Dakota was identified as a state that was particularly vulnerable to having SCN spread considerably in the future (Tylka and Marett, 2014).

8. **Please describe the impact SCN can have on crop production.**

It is difficult to scientifically quantify the exact impact of SCN on soybean yields in infested fields because yield loss is dependent on the nematode population density (with greater yield loss occurring at higher SCN numbers), the soybean variety grown (SCN-susceptible varieties suffer greater damage than SCN-resistant varieties), and weather (there is much greater SCN reproduction and greater yield loss in hot dry years than in years of moderate temperatures and adequate to excess moisture). However, one can gain some insight into the yield-reducing effects of SCN by comparing the yields of SCN-resistant and SCN-susceptible soybean varieties in experiments conducted in SCN-infested fields. SCN-resistant soybean varieties allow some nematode reproduction and, consequently the varieties suffer some yield loss. But SCN-resistant soybean varieties suppress reproduction of the nematode compared to susceptible soybeans, which allow unchecked nematode reproduction. My research program at Iowa State University compares the yields of >60 SCN-resistant soybean varieties to yields of several widely grown SCN-susceptible soybean varieties each year at nine locations throughout Iowa (see www.isuscntrials.info). In 2013, the average yield of SCN-resistant soybeans ranged from 3.7 bushels per acre (5.6%) to 18.4 bushels per acre (56%) greater than the susceptible soybean varieties among the nine experiments (Tylka, 2014). Those yield differences equate to $54 to $268 per acre at current soybean prices ($14.60 per bushel). At very high SCN population densities and under very stressful weather conditions (severe drought), yield loss can approach or exceed 50%.

9. **Please describe the ways that SCN can spread from field-to-field.**

The life stage of SCN that best survives dormant in the soil and poses the greatest threat for spread is the cyst, which is the egg-filled body of a dead SCN female. SCN females and cysts are about the size of a period at the end of a printed sentence in a newspaper, and each female and cyst can contain 200 or more eggs. Anything that moves soil particles of this size is capable of moving SCN. Common avenues of spreading the nematode include moving soil on farming equipment, wind-blown soil, and soil moved with surface erosion due to rainfall. Equipment that digs into and disrupts the soil to a depth of a foot or more would likely be more effective at spreading SCN than surface soil adhering to the wheels of vehicles simply because of the volume of soil being moved.

10. **Could both construction equipment and ordinary farm equipment cause SCN to spread?**

Yes. Movement of any equipment (example: tractors, sprayers, combines, cranes, cement trucks) could directly move SCN by transporting clumps of soil containing SCN cysts, which are the size of a period on a printed page and can be full of hundreds of eggs each.

11. **Has SCN been identified in the areas of South Dakota where the proposed B.S.S.E. Line would be constructed?**

Yes. SCN has been found in northeastern South Dakota as well as in southeastern North Dakota (Tylka and Marett, 2014). Also, because fields infested with SCN may not exhibit obvious symptoms of damage for years (Wang et al., 2003), it is likely that more fields and counties are infested with SCN than officially reported.

When SCN becomes first established in a new field, it tends to be aggregated or clustered in discrete areas in the field because the nematode is relatively immobile. The SCN second-stage juveniles that hatch from the egg are the only mobile and infective stage of the nematode, and these juveniles can move no more than an inch or so under their own power. So SCN usually takes years to spread throughout a field. But SCN reproduction rates (increases in numbers over time) on soybeans usually are greatest in the first few years after the nematode is introduced into a field because there are no natural enemies present in the soil (since SCN has never occurred in that field before) and the nematode will have good nutrition because the soybean crop will be relatively healthy.

12. **Can construction equipment used in a project like the proposed B.S.S.E. Line cause SCN to spread farther or more rapidly than ordinary farming practices? If so, how?**

Yes. Soil disturbed by construction equipment would likely result in greater spread of the nematode than soil disturbed by most other common occurrences by making the soil more friable (easily crumbled) and prone to erosion compared to soil that is left undisturbed or disturbed just minimally.

Also, soil moved by construction equipment could be from properties owned by various farmers. And SCN-infested soil from a less-than-diligent farmer's field could be moved into a field farmed by someone who has diligently worked to avoid introduction of SCN into their fields by careful management of the movement of soil.

13. **Could ongoing maintenance of the proposed B.S.S.E. line also impact the spread of SCN in the region? If so, how?**

Ongoing maintenance of the proposed line would not likely have much greater impact on spreading SCN than other activities involving vehicles traveling through the SCN-infested fields, but it depends somewhat on the condition of the soil at the time that vehicles or crews are present in the field. The least chance of movement, in my opinion, would be when the soil is frozen because frozen soil would not adhere well to vehicles or on people's boots. And the greatest chance would be when the soil is moist enough to allow for mud to easily adhere to vehicles and on people's boots.

14. **Are there ways to remove SCN from a field once it has been introduced? If so, please describe these.**

Once SCN is introduced into a field, there is nothing that can be done to eradicate the nematode other than to not grow soybeans for an extended period of time. Many of the eggs that are present within cysts (dead females) of SCN are in a dormant state and capable of surviving in the absence of a host crop for a decade or more. There are anecdotal reports of SCN surviving in soil without a host for thirty years (Riggs, 2004). So a field that is infested with SCN would have to remain fallow or be planted with a nonhost crop from 10 to 30 years or more to eliminate the nematode from the field.

15. **Are there ways to mitigate the damage caused by SCN in a field once it has been introduced? If so, please describe these.**

Soil applied chemicals to kill SCN directly are no longer available for use in fields in the Midwest. Current management options are 1) minimize field-to-field movement of SCN-infested soil, 2) grow SCN-resistant soybean varieties, 3) grow nonhost crops, and 4) use seed-applied nematode protectants when planting soybeans.

The most effective option to maximize soybean production is delaying introduction of the nematode into a field or an area. States like South Dakota and North Dakota are in a unique position to be able to significantly delay the spread of SCN into the soybean-producing areas of their states by managing the movement of SCN-infested soil from field to field and farm to farm.

Growing nonhost crops, such as corn, in an SCN-infested field will reduce SCN numbers, but the reduction can vary from 5 or 10% to about 50% within a single growing season. Unfortunately, the reduction in egg numbers as a consequence of growing a nonhost crop does not occur in multiple years in a row. That is, the greatest reduction of SCN egg numbers occurs in the first year that a nonhost crop is grown, with a slight reduction in numbers occurring the second year, and very little reduction occurring in years thereafter because dormant eggs will primarily remain in the soil after two years of growing a nonhost crop.

SCN-resistant soybean varieties can be effective at producing acceptable soybean yields in SCN-infested fields and slowing the build-up of the nematode, but as described above, even SCN-resistant soybean varieties suffer some yield loss. Also, there will be considerably fewer SCN-resistant soybean varieties adapted for growing in South Dakota than in more southern areas of the Midwest, including Iowa. Another significant shortcoming of SCN-resistant soybean varieties is that almost all (>95%)

contain the same set of resistance genes (Tylka and Mullaney, 2013). This lack of genetic diversity has lead to SCN populations in the Midwest developing an increased ability to reproduce on the SCN-resistant soybean varieties.

There are at least four nematode-protectant seed treatments that are being advertised as providing protection against early season infection by SCN. But the seed treatments infrequently increased yields or reduced SCN population densities in university field experiments conducted throughout the Midwest in 2012 and 2013. So the utility of these nematode-protectant seed treatments has yet to be proven.

16. **Are there ways to prevent SCN from being spread from field-to-field by construction or farm equipment? If so, please describe these.**

Fields could be tested for SCN in advance of moving equipment in by collecting soil samples from the fields and having the samples tested for presence of the nematode. But when we did follow-up testing of soil samples that tested negative for SCN that were submitted to the Iowa State University Plant and Insect Diagnostic Clinic, we discovered a 14% rate of false negative results (Tylka and Flynn, 2000). That is, 14% of the time, we observed SCN females growing on soybean roots after 30 days growing in leftover soil from samples that had tested negative for SCN with our standard extraction procedure. This rate of false negative results would likely occur with any laboratory processing the samples and is the result of soil clods containing SCN cysts remaining clumped during the soil processing procedure and not releasing the SCN cysts to be trapped on the sieves used in the process.

Another possible way to reduce likelihood of spread of SCN on equipment is to clean the equipment before it moves from field to field. Soil adhering to all parts of all machines must be washed off (although disinfecting probably isn't warranted). But this washing effort, no matter how thorough, can be inefficient because all of the soil on a vehicle must be removed and then the run-off water and soil from the rinsing must be directed away from the next area or field that will be worked in.

17. **Is there anything else you feel the Commission should know about SCN as it relates to the construction of the proposed B.S.S.E. transmission line?**

Following are references to scientific articles and extension publications that support specific statements made above:

Niblack, T.L., K.N. Lambert, and G.L. Tylka. 2006. A model plant pathogen from the kingdom Animalia: *Heterodera glycines*, the soybean cyst nematode. Annual Review of Phytopathology 44:283-303.

Riggs, R.D. 2004. History and distribution. Pages 9-39 in: Biology and Management of Soybean Cyst Nematode: Second Edition. Walsworth Publishing Company, Marceline, MO.

Tylka, G.L. and P.H. Flynn. 2000. Effectiveness of soil analysis for presence of the soybean cyst nematode, *Heterodera glycines*. Journal of Nematology 32: 467-468.

Tylka, G.L. and M.P. Mullaney. 2013. Soybean cyst nematode-resistant soybeans for Iowa. Iowa State University Extension Publication PM 1649, 22 pp.

Tylka, G.L., G.D. Gebhart, C.C. Marett, and M.P. Mullaney. 2013. Evaluation of soybean varieties resistant to soybean cyst nematode in Iowa – 2012. Iowa State University Extension, publication IPM-52, 32 pp.

Tylka, G.L. and C.C. Marett. 2014. Distribution of the soybean cyst nematode (*Heterodera glycines*) in the United States and Canada: 1954 to 2014. Plant Health Progress (accepted for publication).

Tylka, G. 2014. Trial results show dual benefits of SCN resistance. Iowa State University Integrated Crop Management News, January 17, 2014 (http://www.extension.iastate.edu/CropNews/2014/00117tylka.htm).

Wang, J., T.L. Niblack, J.N. Tremaine, W.J. Wiebold, G.L. Tylka, C.C. Marett, G.R. Noel, O. Myers, and M.E. Schmidt. 2003. The soybean cyst nematode reduces soybean yield without causing obvious symptoms. Plant Dis. 87:623-628.

Wrather, A., G. Shannon, R. Balardin, L. Carregal, R. Escobar, G.K. Gupta, Z. Ma, W. Morel, D. Ploper, and A. Tenuta. 2010. Effect of diseases on soybean yield in the top eight producing countries in 2006. Online. Plant Health Progress doi:10.1094/PHP-2010-0102-01-RS.

18. **Does this conclude your testimony?**

Yes.

Dated this 23rd day of April, 2014

Gregory L. Tylka

Gregory Tylka

STATE OF Iowa)
:SS
COUNTY OF Story)

On this 23 day of April, 2014, before me personally appeared Gregory Tylka, known to me to be the person who is described in, and who executed the foregoing instrument and acknowledged to me that he or she executed the same.

(seal) NOTARIAL SEAL IOWA RITA M BRUELAND Commission Number 775715 My Commission Expires November 14, 2015 RMB

Rita Brueland, Notary Public
My Commission Expires: Nov. 14, 2015

CERTIFICATE OF SERVICE

The undersigned attorney hereby certifies that at true and correct copy of the foregoing **DIRECT TESTIMONY OF GERALD PESALL** was served upon the following parties of record, electronically or in paper form, this 24th day of April, 2014:

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N. Bob Pesall, Attorney

GREGORY L. TYLKA

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Iowa State University
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EDUCATION

Ph.D. Degree, University of Georgia, Athens, Georgia. 1990, Summa Cum Laude. Major: Plant Pathology. Major professor: Dr. Richard S. Hussey. Dissertation title: The interactions of vesicular-arbuscular mycorrhizal fungi with *Heterodera glycines* and soil actinomycetes on soybean.

M.S. Degree, California University of Pennsylvania, California, Pennsylvania. 1985, Summa Cum Laude. Major: Biology. Major Professor: Dr. Barry B. Hunter. Thesis title: The isolation, quantification, and possible integrated control of *Cylindrocladium* species from Mont Alto and Penn forest tree nursery soils.

B.S. Degree, California University of Pennsylvania, California, Pennsylvania. 1983, Magna Cum Laude. Advisor: Dr. Samuel K. Hood. Major: Biology.

EMPLOYMENT RECORD

July 2000 to present: Professor, Department of Plant Pathology and Microbiology, Iowa State University, Ames, Iowa. Responsibilities include graduate teaching and extension efforts concerning all plant-parasitic nematode species and research on effects of cultural practices and soybean resistance on soybean cyst nematode, *Heterodera glycines*, population densities and soybean yield suppression and the interactions of soybean insect and weed pests with soybean cyst nematode.

July 2003 to September 2010: Coordinator (half time), Corn and Soybean Initiative, College of Agriculture and Life Sciences, Iowa State University, Ames, Iowa. Responsibilities include providing planning, organization, and leadership to coordinate applied research on corn and soybean production in Iowa and the transfer of science-based crop production information to Iowa corn and soybean growers.

July 1995 to 2000: Associate Professor, Department of Plant Pathology, Iowa State University, Ames, Iowa. Responsibilities include extension efforts concerning all plant-parasitic nematode species and research on effects of cultural practices and soybean resistance and tolerance on soybean cyst nematode, *Heterodera glycines*, population densities and soybean yield suppression. Also investigating stimulation and inhibition of hatching of soybean cyst nematode eggs and the interactions of soybean insect and weed pests with soybean cyst nematode.

February 1990 to June 1995: Assistant Professor, Department of Plant Pathology, Iowa State University, Ames, Iowa. Primary responsibilities included research on the effects of cultural practices and soybean resistance and tolerance on soybean cyst nematode, *Heterodera glycines*,

EMPLOYMENT RECORD (continued)

and soybean yield suppression. Also investigated induced hatching of soybean cyst nematode eggs and the influence of soybean insect and weed pests on soybean cyst nematode. Additionally, considerable extension and teaching responsibilities were components of this position.

August 1988 to December 1989: Half-time laboratory technician for Dr. Richard S. Hussey, Department of Plant Pathology, University of Georgia, Athens, Georgia. Participated in a research program utilizing monoclonal antibodies in immunocytochemical studies of the nature and function of disease-inducing secretions of the root-knot nematode, *Meloidogyne incognita*. Investigations were being conducted on the molecular basis of pathogenesis by identifying and characterizing the esophageal gland secretions within juvenile and adult nematodes that modify recipient host root tissue during nematode parasitism.

September 1985 to December 1989: Graduate Research Assistant, Department of Plant Pathology, University of Georgia, Athens, Georgia. Conducted field, greenhouse and laboratory investigations on the influence of vesicular-arbuscular mycorrhizal fungi (*Gigaspora* and *Glomus*) upon development and reproduction of the soybean cyst nematode, *Heterodera glycines*, on soybean. Also investigated effect of soil inhabiting *Streptomyces* species on mycorrhizal fungal spore germination and penetration and colonization of soybean roots.

September 1983 to August 1985: Graduate Research Assistant, Department of Biological and Environmental Sciences, California University of Pennsylvania, California, Pennsylvania. This project, partially funded by the Pennsylvania Bureau of Forestry, involved soil microbiological research into the biology of *Cylindrocladium* species and their infection of conifer seedling roots in Pennsylvania's State Forest Tree Nurseries. Served as teaching assistant for undergraduate Principles of Biology and Scientific Photography courses and instructor of Microscopy and Photography courses for the Summer Academy for Gifted Students (1984 and 1985).

PROFESSIONAL AND HONORARY ASSOCIATIONS

American Phytopathological Society
American Soybean Association
Beta Beta Beta
Iowa Corn Growers Association
Iowa Soybean Association
Sigma Xi
Society of Nematologists

AWARDS

Regents Faculty Excellence Award, Board of Regents, State of Iowa (2010)

Educational Materials Award of Excellence for Computer Software Programs, American Society of Agronomy, for computer training module for certified crop advisors on biology and management of corn nematodes (2009)

AWARDS (continued)

Educational Materials Award of Excellence for Printed Materials, American Society of Agronomy, for special issue of the Integrated Crop Management Newsletter (2007)

Educational Materials Award of Excellence for Computer Software Programs, American Society of Agronomy, for computer training module for certified crop advisors on biology and management of the soybean cyst nematode (2006)

Dean's Citation for Extraordinary Contributions to the College of Agriculture (2005)

Outstanding Individual Achievement Award, Iowa State University Extension (2002)

Meritorious Service Extension Education Award, United Soybean Board (2000)

Excellence in Extension Award, American Phytopathological Society (1999)

Meritorious Service Award, Iowa State University Extension (1999)

Novartis Crop Protection Award, Society of Nematologists (1999)

Meritorious Service Production Research Award, United Soybean Board (1998)

Outstanding Alumnus Award, Beta Beta Beta, California University of Pennsylvania (1992)

GRANTS (last 5 years, 2009-present)

Toward increased efficacy of soybean cyst nematode management tools. **G.L. Tylka** and S. Pandey. Funded by the Center for Arthropod Management Technologies for $120,00 total over two years (2014-2015).

Development of multiple pest resistant soybeans for breeding and research purposes using field and molecular tools. A.K. Singh, M. O'Neal. **G. Tylka**, G. MacIntosh, and A. Singh. Funded by the Iowa Soybean Association for $310,348 over three years (2013-2016).

Enhancing soybean yield through strategic use of soybean seed treatments for seedling disease and insect pest management. A. Robertson, G. Munkvold, **G. Tylka**, and E. Hodgson. Funded by the Iowa Soybean Association for $409,456 over three years (2013-2016).

Exploring soybean aphid and soybean cyst nematode interactions for improved integrated management in Iowa. M.E. O'Neal, **G.L. Tylka**, G. MacIntosh, E.W. Hodgson, and M. McCarville. Funded by the Iowa Soybean Association for $339,417 over three years (2013-2016).

Developing an integrated management and communication plan for sudden death syndrome. D. Mueller, L. Leandro, C. Bradley, M. Chilvers, **G. Tylka**, K. Wise, S. Cianzio, J. Faghihi, A. Tenuta, V. Ferris, D. Malvick, A. Fakhoury, and G. Hartman. Funded by the North Central Soybean Research Program for $500,000 over three years (2013 – 2015).

GRANTS (continued)

Modifying *Bradyrhizobium japonicum* to enhance nodulated soybean disease resistance. R. Peters, L. Leandro, A. Robertson, and **G. Tylka**. Funded by the Iowa Soybean Association for $246,266 over two years (2013-2015).

Continuation of assessment of nematode control and yield of SCN-resistant soybean varieties in response to different soybean cyst nematode populations (HG Types). **G. Tylka**. Funded by the Iowa Soybean Association for $444,129 over three years (2012–2015).

Determining soybean pest and pesticide interactions as a means to optimize soybean yield, E. Hodgson, A. Gassmann, and **G. Tylka**. Funded by the Iowa Soybean Association for $201,206 over three years (2012–2015).

Characterization of the mechanisms involved in the SDS-SCN interaction to develop soybean lines with resistance to SDS and to SCN, L. Leandro, **G. Tylka**, S. Cianzio, and O. Radwan, S.R. Cianzio. Funded by the Iowa Soybean Association for $127,251 over two years (2012–2014).

Exploring soybean aphid and soybean cyst nematode interactions for improved integrated management in Iowa. M.E. O'Neal, **G.L. Tylka**, G. MacIntosh, E.W. Hodgson, and M. McCarville. Funded by the Iowa Soybean Association for $339,417 over three years (2011-2014).

Assessing nematode control and yield of SCN-resistant soybean varieties in response to different soybean cyst nematode populations (HG types), **G. Tylka**. Funded by the Iowa Soybean Association for $613,720 for three years (2010-2012).

Determining the impact of multiple pests on soybean yield and grain composition, G. MacIntosh, M. O'Neal, **G. Tylka**, P. Pedersen, and F. Avendano. Funded by the Iowa Soybean Association for $300,326 for three years (2007-2010).

Increasing Iowa soybean profitability by renewing interest in managing the soybean cyst nematode, **G.L. Tylka**. Funded by the Iowa Soybean Association for $517,199 for four years (2006-2010).

Improving soybean profitability in Iowa by reducing the hidden effects of brown stem rot and its interaction with the soybean cyst nematode, G. Tabor and **G.L. Tylka**. Funded by the Iowa Soybean Association for $216,760 over three years (2006 to 2009).

INDUSTRY RESEARCH CONTRACTS

AMVAC
BASF Plant Sciences
Bayer Crop Sciences
Bushvale Seeds
CENEX/Land O'Lakes
Chemtura
DeKalb Genetics Corporation
DM Crop Research, Inc.

INDUSTRY RESEARCH CONTRACTS (continued)

Divergence Company
DuPont Crop Protection
Evolutionary Genomics Inc.
JGL, Inc.
LiphaTech, Inc.
MBS Genetics
Monsanto
Novartis Crop Protection, Inc.
Pioneer Hi-Bred International, Inc.
Stine Seed Company
Stoller Enterprises Inc
Syngenta Crop Protection
TJ Technologies, Inc.
Valent

AGENCIES AND ORGANIZATIONS ADVISED

BASF
Bayer CropScience
DNA Plant Technologies
Garst Seeds
Illinois Department of Agriculture
Iowa Department of Agriculture
Iowa Soybean Association
LiphaTech, Inc.
Monsanto
North Central Soybean Research Program
Novartis Crop Protection, Inc.
Pioneer Hi-Bred International, Inc.
Syngenta
United Soybean Board

PUBLICATIONS

I. Refereed research articles:

Tylka, G.L. and C.C. Marett. Distribution of the soybean cyst nematode (*Heterodera glycines*) in the United States and Canada: 1954 to 2014. Plant Health Progress (accepted).

McCarville, M.T., D.H. Soh, **G.L. Tylka**, and M.E. O'Neal. 2014. Aboveground feeding by soybean aphid, *Aphis glycines*, affects soybean cyst nematode, *Heterodera glycines*, reproduction belowground. PLoS ONE 9(1): e86415. doi:10.1371/journal.pone.0086415.

McCarville, M.T., C. Kanobe, M. O'Neal, G. MacIntosh and **G.L. Tylka**. 2012. Measuring the yield and fatty-acid response of soybean cultivars with seed oil low in linolenic acid to multiple biotic stresses. Crop Protection 42:210-216.

McCarville, M.T., M. O'Neal, **G.L. Tylka**, C. Kanobe and G. MacIntosh. 2012. A nematode, fungus, and aphid interact via a shared host plant: implications for soybean management. Entomologia Experimentalis et Applicata 143:55-66, doi: 10.1111/j.1570-7458.2012.01227.x.

Tylka, G.L., A.J. Sisson, L.C. Jesse, J. Kennicker and C.C. Marett. 2011. Testing for plant-parasitic nematodes that feed on corn in Iowa 2000-2010. Online. Plant Health Progress doi:10.1094/PHP-2011-1205-01-RS.

PUBLICATIONS (continued)

Tylka, G.L., T.C. Todd, T.L. Niblack, A.E. MacGuidwin, and T. Jackson. 2011. Sampling for plant-parasitic nematodes in corn strip trials comparing nematode management products. Plant Health Progress doi:10.1094/PHP-2011-0901-01-DG.

Rotundo, J.L., **G.L. Tylka**, and P. Pedersen. 2010. Source of resistance affects soybean yield, yield components, and biomass accumulation in *Heterodera glycines*-infested fields. Crop Science 50:2565–2574.

Pedersen, P., **G.L. Tylka**, A.P. Mallarino, A.E. MacGuidwin, N.C. Koval, and C.R. Grau. 2010. Correlation between soil pH, *Heterodera glycines* population densities, and soybean yield. Crop Science 50:1458–1464, doi: 10.2135/cropsci2009.08.0432.

Niblack, T.L., **G.L. Tylka**, P. Arelli, J. Bond, B. Diers, P. Donald, J. Faghihi, V.R. Ferris, K. Gallo, R.D. Heinz, H. Lopez-Nicora, R. Von Qualen, T. Welacky, and J. Wilcox. 2009. A standard greenhouse method for assessing soybean cyst nematode resistance in soybean: SCE08 (Standardized Cyst Evaluation 2008). Online. Plant Health Progress doi:10.1094/PHP-2009-0513-01-RV.

Rogovsa, N., F.W. Blackmer, and **G.L. Tylka**. 2009. Soybean yield and soybean cyst nematode densities related to soil pH, soil carbonate concentrations, and alkalinity stress index. Agronomy Journal 101:1019-1026 (also online, doi:10.2134/agronj2008.0086x).

Studham, M., G.C. MacIntosh, F. Avendaño, D. Soh, and **G.L. Tylka**. 2009. The soybean resistance gene *Rag1* does not protect against soybean cyst and root-knot nematodes. Online. Plant Health Progress doi:10.1094/PHP-2009-0401-01-BR.

Charlson, D.V., K.R. Harkins, and **G.L. Tylka**. 2008. Relationship between juvenile hatching and acridine orange fluorescence of *Heterodera glycines* eggs. Nematology 10:603-610.

Zasada, I.A., F. Avendano, Y. Li, T. Logan, H. Melakeberhan, S. Koenning, and **G.L. Tylka**. 2008. Potential of an alkaline-stabilized biosolid to manage nematodes: case studies on soybean cyst and root-knot nematodes. Plant Disease 92:4-13.

Gavassoni, W.L., **G.L. Tylka**, and G.P. Munkvold. 2007. Relationships among tillage practices, dissemination, and spatial patterns of *Heterodera glycines* and soybean yield. Plant Disease 91:973-978.

Tabor, G.M., **G.L. Tylka**, and C.R. Bronson. 2007. Genotypes A and B of *Cadophora gregata* differ in ability to colonize susceptible soybean. Plant Disease 91:574-580.

Tabor, G.M., **G.L. Tylka**, and C.R. Bronson. 2006. Soybean stem colonization by genotypes A and B of *Cadophora gregata* increases with increasing population densities of *Heterodera glycines*. Plant Disease 90:1297-1301.

PUBLICATIONS (continued)

Donald, P.A., P.E. Pierson, S.K. St. Martin, P.R. Sellers, G.R. Noel, A.E. MacGuidwin, J. Faghihi, V.R. Ferris, C.R. Grau, D.J. Jardine, H. Melakeberhan, T.L. Niblack, W.C. Stienstra, **G.L. Tylka**, T.A. Wheeler, and D.S. Wysong. 2006. Assessing *Heterodera glycines*-resistant and susceptible cultivar yield response. Journal of Nematology 38:76-82.

Tabor, G.M., S.R. Cianzio, **G.L. Tylka**, R. Roorda, and C.R. Bronson. 2006. A new greenhouse method to assay soybean resistance to brown stem rot. Plant Disease: 90:1186-1194.

Leon, R., M.D.K. Owen, D. Soh, and **G.L. Tylka**. 2005. Absence of interactive responses of early soybean growth to soybean cyst nematode, post-emergence herbicides, and soil pH and texture. Weed Technology 19:847-854.

Charlson, D.V. and **G.L. Tylka**. 2003. *Heterodera glycines* cyst components and surface disinfestation affect *H. glycines* hatching. Journal of Nematology 35:458-464.

Tabor, G.M., **G.L. Tylka**, S.C. Cianzio, and C.R. Bronson. 2003. Resistance to *Phialophora gregata* is expressed in the stems of resistant soybeans. Plant Disease 87:970-976.

Tabor, G.M., **G.L. Tylka**, J.E. Behm, and C.R. Bronson. 2003. *Heterodera glycines* infection increases incidence and severity of brown stem rot of soybeans. Plant Disease 87:655-661.

Wang, J., T.L. Niblack, J.N. Tremaine, W.J. Wiebold, **G.L. Tylka,** C.C. Marett, G.R. Noel, O. Myers, and M.E. Schmidt. 2003. The soybean cyst nematode reduces soybean yield without causing obvious symptoms. Plant Disease 87:623-628.

Fallick, J.B., W.D. Batchelor, **G.L. Tylka**, T.L. Niblack, and J.O. Paz. 2002. Coupling soybean cyst nematode damage to CROPGRO-Soybean. Transactions of the American Society of Agricultural Engineers 45:433-441.

Niblack, T.L., P.R. Arelli, G.R. Noel, C.H. Opperman, J.H. Orf, D.P. Schmitt, J.G. Shannon and **G.L. Tylka**. 2002. A new classification scheme for genetically diverse populations of *Heterodera glycines*. Journal of Nematology 34:279-288.

Nutter, F.W., **G.L. Tylka**, J. Guan, A.J.D. Moreira, C.C. Marett, T.R. Rosburg, J.P. Basart, and C.S. Chong. 2002. Use of remote sensing to detect soybean cyst nematode-induced plant stress. Journal of Nematology 34:222-231.

Perry, R.N., J. Beane, C.C. Marett, and **G.L. Tylka**. 2002. Comparison of the rate of embryonic development of *Globodera rostochiensis* and *G. pallida* using flow cytometric analysis. Nematology 4:553-555.

Gavassoni, W.L., **G.L. Tylka**, and G.P. Munkvold. 2001. Relationship between tillage and spatial patterns of *Heterodera glycines*. Phytopathology 91:534-545.

PUBLICATIONS (continued)

Paz, J.O., W.D. Batchelor, **G.L. Tylka**, and R.G. Hartzler. 2001. A modeling approach to quantify the effects of spatial soybean yield limiting factors. Transactions of the American Society of Agricultural Engineers 44:1329-1334.

Paz, J.O., W.D. Batchelor, and **G.L. Tylka**. 2001. Method to use crop growth models to estimate potential return for variable-rate management in soybeans. Transactions of the American Society of Agricultural Engineers 44:1335-1341.

Buckelew, L.D., L.P. Pedigo, H.M. Mero, M.D.K. Owen, and **G.L. Tylka**. 2000. Effects of weed management systems on canopy insects in herbicide-resistant soybeans. Journal of Economic Entomology 93:1437-1443.

Wang, J., P.A. Donald, T.L. Niblack, G.W. Bird, J. Faghihi, J.M. Ferris, D.J. Jardine, C. Grau, P.E. Lipps, A.E. MacGuidwin, H. Melakeberhan, G.R. Noel, P. Pierson, R.M. Reidel, P.R. Sellers, W.C. Stienstra, T.C. Todd, **G.L. Tylka**, and D.S. Wysong. 2000. Soybean cyst nematode reproduction in the north central United States. Plant Disease 84:77-82.

Workneh, F., X.B. Yang, and **G.L. Tylka**. 1999. Soybean brown stem rot, *Phytophthora sojae*, and *Heterodera glycines* affected by soil texture and tillage relations. Phytopathology 89:844-850.

Workneh, F., **G.L. Tylka**, X.B. Yang, J. Faghihi, and J.M. Ferris. 1999. Regional assessment of soybean brown stem rot, *Phytophthora sojae*, and *Heterodera glycines* using area-frame sampling: prevalence and effects of tillage. Phytopathology 89:204-211.

Workneh, F., X.B. Yang, and **G.L. Tylka**. 1998. Effect of tillage practices on vertical distribution of *Phytophthora sojae*. Plant Disease 82:1258-1263.

Levene, B.C., M.D.K. Owen, and **G.L. Tylka**. 1998. Influence of herbicide application to soybean on soybean cyst nematode egg hatching. Journal of Nematology 30:347-352.

Levene, B.C., M.D.K. Owen, and **G.L. Tylka**. 1998. Response of soybean cyst nematodes and soybeans (*Glycine max*) to herbicides. Weed Science 46:264-270.

Thompson, J.M., and **G.L. Tylka**. 1997. Differences in hatching of *Heterodera glycines* egg-mass and encysted eggs in vitro. Journal of Nematology 29:315-321.

Kraus, G.A., S. Vander Louw, **G.L. Tylka**, and D.H. Soh. 1996. The synthesis and testing of compounds that inhibit soybean cyst nematode egg hatch. Journal of Agricultural and Food Chemistry 44:1548-1550.

Shapiro, D.I., **G.L. Tylka**, and L.C. Lewis. 1996. Effects of fertilizers on virulence of *Steinernema carpocapsae*. Applied Soil Ecology 3:27-34.

PUBLICATIONS (continued)

Behm, J.E., **G.L. Tylka**, T.L. Niblack, W.J. Wiebold, and P.A. Donald. 1995. Effects of zinc fertilization of corn on hatching of *Heterodera glycines* in soil. Journal of Nematology 27:164-171.

Shapiro, D.I., **G.L. Tylka**, E.C. Berry, and L.C. Lewis. 1995. Effects of earthworms on the dispersal of *Steinernema* spp. Journal of Nematology 27:21-28.

Browde, J.A., L.P. Pedigo, M.D.K. Owen, **G.L. Tylka**, and B.C. Levene. 1994. Growth of soybean stressed by nematodes, herbicides, and simulated insect defoliation. Agronomy Journal 86:968-974.

Browde, J.A., L.P. Pedigo, M.D.K. Owen, and **G.L. Tylka**. 1994. Soybean yield and pest management as influenced by nematodes, herbicides, and defoliating insects. Agronomy Journal 86:601-608.

Browde, J.A., **G.L. Tylka**, L.P. Pedigo, and M.D.K. Owen. 1994. A method for infesting small field plots with *Heterodera glycines*. Agronomy Journal 86:585-587.

Browde, J.A., **G.L. Tylka**, L.P. Pedigo, and M.D.K. Owen. 1994. Responses of *Heterodera glycines* populations to a postemergence herbicide mix and simulated insect defoliation. Journal of Nematology 26:498-504.

Kraus, G.A., B. Johnston, A. Kongsjahju, and **G.L. Tylka**. 1994. The synthesis and evaluation of compounds that affect soybean cyst nematode egg hatch. Journal of Agricultural and Food Chemistry 42:1839-1840.

Wong, A.T.S. and **G.L. Tylka**. 1994. Eight nonhost weed species of *Heterodera glycines* in Iowa. Plant Disease 78:365-367.

Tylka, G.L., T.L. Niblack, T.C. Walk, K.R. Harkins, L. Barnett, and N.K. Baker. 1993. Flow cytometric analysis and sorting of *Heterodera glycines* eggs. Journal of Nematology 25:596-602.

Wong, A.T., **G.L. Tylka**, and R.G. Hartzler. 1993. Effects of eight herbicides on in vitro hatching of *Heterodera glycines*. Journal of Nematology 25:578-584.

Tylka, G.L., R.S. Hussey, and R.W. Roncadori. 1991. Axenic germination of vesicular-arbuscular mycorrhizal fungi: effects of selected *Streptomyces* species. Phytopathology 81:754-759.

Tylka, G.L., R.S. Hussey, and R.W. Roncadori. 1991. Interactions of vesicular-arbuscular mycorrhizal fungi, phosphorus, and *Heterodera glycines* on soybean. Journal of Nematology 23:122-133.

PUBLICATIONS (continued)

II. Non-refereed, online research articles:

Tylka, G.L., G.D. Gebhart, and C.C. Marett. 2006. Iowa 2005 soybean cyst nematode-resistant soybean variety trial results. Crop Management (http://www.plantmanagementnetwork.org/pub/cm/trials/2005/soy/Tylka.xls).

Tylka, G.L., G.D. Gebhart, and C.C. Marett. 2006. Iowa 2004 soybean cyst nematode-resistant soybean variety trial results. Crop Management (http://www.plantmanagementnetwork.org/pub/cm/trials/2004/soy/Tylka.xls).

Tylka, G.L., G.D. Gebhart, and C.C. Marett. 2006. Iowa 2003 soybean cyst nematode-resistant soybean variety trial results. Crop Management (http://www.plantmanagementnetwork.org/pub/cm/trials/2003/soy/Tylka.xls).

Tylka, G.L, G.D. Gebhart, and C.C. Marett. 2003. Iowa 2002 soybean cyst nematode-resistant soybean variety trial results. Crop Management (http://www.plantmanagementnetwork.org/pub/cm/trials/2002/soy/Tylka.xls).

Tylka, G.L, G.D. Gebhart, and C.C. Marett. 2003. Iowa 2001 soybean cyst nematode-resistant soybean variety trial results. Crop Management (http://www.plantmanagementnetwork.org/pub/cm/trials/2001/soy/Tylka.xls).

III. Miscellaneous refereed online journal articles:

Robertson, A. and **G.L. Tylka**. 2007. Building the "Rust Fast Track System" for identifying Asian soybean rust in Iowa. Journal of Extension 45(3) Article 3IAW7. www.joe.org/joe/2007june/iw7.shtml.

Tylka, G.L. and C.A. Jasalavich. 2001. Free-living and plant-parasitic nematodes (roundworms). The Plant Health Instructor. DOI: 10.1094/PHI-K-2001-0409-01.

Davis, E.L. and **G.L. Tylka**. 2000. Soybean cyst nematode disease. The Plant Health Instructor. DOI: 10.1094/PHI-I-2000-0725-01.

IV. Book chapters:

Niblack, T.L., K.N. Lambert, and **G.L. Tylka**. 2006. A model plant pathogen from the kingdom Animalia: *Heterodera glycines*, the soybean cyst nematode. Annual Review of Phytopathology 44:283-303.

Kraus, G.A., **G.L. Tylka**, S. Van der Louw, and P.K. Choudhury. 2004. Chapter 11, Management of the soybean cyst nematode by using a biorational strategy, pp. 161-172 in Agricultural Applications in Green Chemistry, W.M. Nelson, ed., American Chemical Society, Washington, DC.

PUBLICATIONS (continued)

Tylka, G.L. 2004. Management of nematode diseases: options in Encyclopedia of Plant and Crop Science. R.M. Goodman, ed., Marcel Dekker, Inc., New York.

Niblack, T.L., **G.L. Tylka**, and R.D. Riggs. 2004. Chapter 16, Nematode pathogens of soybean, pp. 821-851 in Soybean Monograph, 3rd Edition. H.R. Boerma & J.E. Specht, eds., American Society of Agronomy, Inc., Crop Science Society of America, Inc., Soil Science Society of America, Inc., Madison, WI.

Jones, P.W., **G.L. Tylka**, and R.N. Perry. 1998. Chapter 8, Hatching, pp. 181-212 in Physiology and Biochemistry of Free-living and Plant-parasitic Nematodes. R.N. Perry and D.J. Wright, eds., CAB International, Oxon, United Kingdom.

V. Research abstracts (from last 5 years, 2009-present):

Olson, L.K., **G.L. Tylka**, J. Jordhal, S. Meyer, J. Goltz, J. Kringler, T. Helms, and S. Markell. 2013. Increasing awareness of soybean cyst nematode in North Dakota. Phytopathology 103(S4):107-108.

Tatalovic, N., **G.L. Tylka**, and L.F. Leandro. 2013. Effect of watering regime and *Fusarium virguliforme* (Fv) infection on location of soybean cyst nematode (SCN) syncytia in soybean roots. Phytopathology 103(S4):143.

Tylka, G.L., M.T. McCarville, C.C. Marett, G.D. Gebhart, D.H. Soh, M.P. Mullaney, and M.E. O'Neal. 2013. Direct comparison of soybean cyst nematode reproduction on resistant soybean varieties in greenhouse and field experiments. Journal of Nematology 45(4): 279–330.

Diaz-Arias, M., **G.L. Tylka**, L. Leandro, and G.P. Munkvold. 2011. Interactions between Fusarium root rot pathogens and *Heterodera glycines*, on soybean roots. Phytopathology 101:S42.

Niblack, T.L., J. Bond, and **G.L. Tylka**. 2011. The nightmare of plant diseases associated with soybean cyst nematodes. Phytopathology 101:S209.

Tatalovic, N., **G.L. Tylka**, and L.F. Leandro. 2011. Microscopic observation of the interaction between the soybean sudden death syndrome pathogen, *Fusarium virguliforme*, and the soybean cyst nematode, *Heterodera glycines*, in soybean roots. Phytopathology 101:S175.

Wiggs, S.N. and **G.L. Tylka**. 2011. The nature of the relationship between soybean cyst nematode population densities and soil pH. Phytopathology 101:S191.

Arias, M.M.D., **G. Tylka**, L. Leandro, and G. Munkvold. 2010. Effects of soybean cyst nematode infestation and resistance on Fusarium root rot on soybeans. Phytopathology 100:S30.

Tylka, G.L. 2010. Maximizing effectiveness of extension education efforts. Journal of Nematology 42:274-275.

PUBLICATIONS (continued)

VI. Extension publications:

Tylka, G.L., G.D. Gebhart, C.C. Marett, M.P. Mullaney, and S.N. Wiggs. 2013. Evaluation of soybean varieties resistant to soybean cyst nematode in Iowa – 2012. Iowa State University Extension, publication IPM-52. (updated annually)

Tylka, G.L. 2012. Soybean cyst nematode field guide, 2nd Edition. Iowa State University Extension Publication CSI 0012, 62 pp.

Tylka, G.L. and M.P. Mullaney. 2012. Soybean cyst nematode-resistant soybeans for Iowa. Iowa State University Extension Publication PM 1649, 27 pp. (updated annually)

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VII. Electronic extension education materials:

Tylka, G.L. and A. Ciha. 2009. Corn nematodes. Iowa State University Crop Adviser Institute training module (online and on CD).

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NOTEWORTHY INVITED PRESENTATIONS (last 5 years, 2009-present)

January 2014	Syngenta National Clariva Launch Conference, January 7, 2014, Orlando, Florida, "Status of resistant soybean varieties for management of SCN"
August 2013	Innovations in Seed Treatments for Crop Protection and Health symposium, American Phytopathological Society annual meeting, August 14, 2013, Austin, Texas, "Nematode-protectant seed treatments: New options for nematode management in row crops"
March 2013	Soybean Cyst Nematode and Nematodes on Corn Workshop, Fargo, North Dakota, March 6-7, 2013
February 2013	Syngenta Soybean Crop Team Nematode Conference, February 5, 2013, Campinas, Brazil, "Managing SCN with resistant soybean varieties"
February 2013	World Soybean Research Conference, February 20, 2013, Durban, South Africa, "SCN resistance: how it all comes together in the Midwestern United States"
March 2012	"Nematode Seed Treatment Protectants: Do Growers Need That Type of Insurance?", 7th International Integrated Pest Management Symposium, Memphis, Tennessee, March 28, 2012
March 2012	"SCN-resistant Soybeans, HG types, Yield, and SCN Reproduction – How It All Comes Together in the Field in Iowa", Annual meeting of the Southern Soybean Disease Workers, Pensacola, Florida, March 7, 2012
February 2012	"Soybean Cyst Nematode Update for the Region", Advanced Crop Advisers Workshop, Fargo, North Dakota, February 10, 2012
February 2012	"Nematodes of Soybean and Corn: Recognizing the Risk and Tapping into the Right Management Tools", Advanced Crop Advisers Workshop, Fargo, North Dakota, February 9, 2012
December 2011	"Nematodes That Feed on Corn: Prospects for 2012", South Dakota Agronomy Conference, Sioux Falls, South Dakota, December 15, 2011
November 2011	"Nematodes That Feed on Corn: What to Make of it All", University of Missouri Crop Management Conference, Columbia, Missouri, November 30, 2011
November 2011	"The ISU Corn and Soybean Initiative: Redefining Crops Extension Through Formal Partnerships with Private Industry Service Providers", Ohio State University, Columbus, Ohio, November 1, 2011

NOTEWORTHY INVITED PRESENTATIONS (last 5 years, 2009-present) (continued)

November 2011	"Soybean Cyst Nematode, Host Resistance, and HG Types: What Does it All Mean for Growers?", Ohio State University, Columbus, Ohio, November 1, 2011
March 2011	Soybean Cyst Nematode and Nematodes on Corn Workshop, Fargo, North Dakota, March 9-10, 2011
February 2011	"Biology and Management of Plant-parasitic Nematodes on Crop Plants", Great Plains Consultants Meeting, Bayer CropScience, Denver, CO, February 22, 2011
December 2010	"Biology and Management of Nematodes that Feed on Corn" and "Soybean Cyst Nematode; Biology, Scouting, and Management for South Dakota", 2010 South Dakota Agronomy Conference, Sioux Falls, SD, December 14, 2010
July 2010	"Maximizing Effectiveness of Extension Education Efforts", Symposium on Educational Strategies and Methodologies in Nematology, Society of Nematologists 2010 Annual Meeting, Boise, ID, July 13, 2010
February 2009	"Managing Soybean Cyst Nematode Using Precision Farming Technologies", National Alliance of Independent Crop Consultants, Bloomington, MN, February 12, 2009

PATENTS AWARDED

Coats, J. R., A.L. Eggler, C.J. Peterson, R. Tsao, and **G.L. Tylka**. 2003. Compounds related to natural sources and their use as biopesticides. U.S. Patent Number 6,545,043.

Coats, J. R., C.J. Peterson, R. Tsao, A.L. Eggler, and **G.L. Tylka**. 2001. Biopesticides related to natural sources. U.S. Patent Number 6,207,705.

Kraus, G.A., **G.L. Tylka**, and S. Van der Louw. 1997. Ketodiacid compounds that inhibit nematode egg hatching. U.S. Patent Number 5,648,318.

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER O FTHE APPLICATION OF MONTANA-DAKOTA UTILITIES CO. AND OTTER TAIL POWER COMPANY FOR A PERMIT TO CONSTRUCT THE BIG STONE TO SOUTH ELLENDALE 345KV TRANMISSION LINE	SURREBUTTAL TESTIMONY OF GREGORY TYLKA EL13-028

1. **State your name and address.**

   Gregory L. Tylka, 922 New Hampshire Circle, Ames, IA 50014

2. **Did you previously provide direct testimony regarding the B.S.S.E. Project?**

   Yes.

3. **Have you reviewed the Henry Ford Rebuttal Testimony?**

   Yes.

4. **Can you describe when and how SCN was originally discovered to be a threat to soybean production?**

   In the United States, first-time discoveries of new crop pathogens are usually announced by publishing a short article in a refereed scientific journal. Winstead and colleagues from North Carolina announced the first discovery of the soybean cyst nematode (SCN) in North America in 1954 in an article in the journal Plant Disease Reporter in 1955 (full citation at the end of this document; copy of publication attached). The circumstances of the discovery were that Winstead and colleagues examined soybean roots from a field of stunted, yellowed soybeans and collected soil samples from the field. They observed the telltale swollen females of SCN on the soybean roots and recovered other life states of the nematode from the soil samples.

5. **Can you describe when and how SCN became a known risk in Eastern South Dakota?**

   Smolik and colleagues announced the initial discovery of SCN in 1995 in the state of South Dakota in a short article in the refereed scientific journal Plant Disease in 1996 (full citation at the end of this document; copy of publication attached). A total of 225 fields in 12 counties were surveyed and sampled for the presence of SCN that year (1995). And various life stages of SCN were recovered from soil samples collected from 11 soybean fields in Union County, in the southeastern corner of South Dakota.

6. **Is the attached map reflective of the current presence of SCN in Eastern South Dakota?**

Yes. The current known distribution of SCN in counties in the United States and the provinces in Canada is illustrated in the attached map, which was updated in early 2014.

7. **How was this map prepared, and how long has it been available?**

To my knowledge, a map of the counties and provinces in which SCN was known to occur has been updated and disseminated to plant pathologists and nematologists working with soybeans in the United States and Canada 11 times: in 1957, 1962, 1973, 1980, 1990, 2001, 2002, 2005, 2007, 2008, and 2014. There is no regular interval of time between updates of the map. I accepted responsibility for maintaining and updating the map in 2008.

To update the map, I phone and email personnel at universities and state departments of agriculture in all of the soybean-producing states in the United States and the soybean-producing provinces in Canada and ask them to provide me with a list of counties in which SCN has been discovered in their state to date. Then, once the updated, overall map is created, I send one person in each state or province a draft of the updated map and ask for final verification that the map for their state is accurate.

Once an update map is finalized, I send a copy to every person who provided information for the update of the map. I also send a copy to all other university personnel in the United States and Canada who I am aware of having responsibilities associated with soybean production. Finally, I send a copy of the updated map to anyone in the soybean industry and in the print and radio media with whom I have communicated concerning SCN in the past.

Dr. Emmanuel Byamukama was the person with whom I communicated at South Dakota State University when I updated the map for 2014; he is an assistant professor and extension specialist at the university with responsibilities for soybean diseases. I communicated with Dr. James Smolik at South Dakota State University when I updated the map in 2008; he was a professor and plant nematologist in the same department in which Dr. Byamukama currently works. Dr. Smolik would have been the person who provided information about SCN in South Dakota for maps updated prior to 2014.

8. **Are there other agricultural resources which have published information about the risks posed by SCN?**

Yes. There are numerous articles published each year by agricultural print media about the threat of SCN to soybean production in the Midwest. Also, university faculty and extension personnel in the region conduct several radio interviews each year on the same topic.

I, personally, have given several interviews to media (print, radio, and television) that serve soybean farmers in North Dakota and South Dakota (for example, an interview with Randy Koenen, Red River Farm Network, May 15, 2014). Also, I have given several presentations about the biology and management of SCN in South Dakota (as recently as in Brookings on February 5, 2014).

Another primary means of educating farmers about the risks of SCN is creation and distribution of printed extension bulletins by the land-grant universities in each state in the Midwest. Attached is a copy of South Dakota Extension Fact Sheet 902-A, "Soybean Cyst Nematode," which indicates that it was "Revised February 2007." This publication has a section titled "Sanitation" on page 3 of 4 that states "Anything that moves soil can move SCN. Avoid spreading SCN from infested to uninfested fields. If possible, uninfested fields should be planted first and equipment should be power-washed after working infested fields. Soil peds in seed stocks may contain SCN; therefore, plant only properly cleaned seed. Tillage practices that reduce wind and water erosion also can slow the spread of SCN."

The most notable (in my opinion) specific example of published information explaining the risks of SCN to farmers in South Dakota and other Midwestern states is a special insert in the national Soybean Digest magazine that was published in August-September 1998. A copy of that special insert is attached. The special insert, which was titled "Let's Declare War on Cyst Nematodes!" and was direct mailed to 240,000 farmers in the Midwest, was produced and printed by a 12-state educational effort team the "SCN Coalition". The "SCN Coalition" was called a "coalition" because it involved not only university personnel, but the staff of each state's soybean checkoff organization (including the South Dakota Soybean Association) as well as many private-industry seed companies who served farmers in the Midwest. The goal of the project, which operated from 1997 through 2000, was to inform farmers about the serious risk of SCN and to advise them on how to slow the spread and manage the build up of SCN once it arrived in a field. Page 6 of the publication contained a map of the known distribution of SCN in the Midwest at the time (with nine SCN-infested counties shown in South Dakota) and page 8 of the special insert contained an article titled "Stop Nomadic Nematodes"

9. **Are you aware of any other construction projects which have contributed to the spread of SCN? If so, please describe them.**

No, I am not aware of other construction projects that have contributed to the spread of SCN. But I am not aware of any scientific study ever being conducted to assess the risk for spreading SCN on construction equipment. Such studies have been done to confirm the risk of disseminating SCN by farm equipment. For example, a USDA report titled "Soybean Cyst Nematode" published in August 1956 stated, "Samples were taken of the soil and dust clinging to two combines that were used to harvest infested fields. Per pound of soil taken from these machines, an average of 4,156 cysts were recovered, of which 16.5 percent contained eggs with viable larvae."

10. **Does this conclude your testimony?**

Yes, except that immediately below are specific citations for the publications referenced above:

Anonymous. 1956. Soybean Cyst Nematode. United States Department of Agriculture Agricultural Research Service Report 22-29, 12 pages.

Anonymous. 1998. Let's Declare War on Cyst Nematodes! Soybean Digest, special insert. 24 pages.

Smolik, J.D., J.L. Jones, D.L. Gallenberg, and J.P. Gille. 1996. First report of *Heterodera* *glycines* on soybean in South Dakota. Plant Disease 80:224.

Smolik, J.D. and M.A. Draper. 2007 (revised). Soybean Cyst Nematode. South Dakota State University Fact Sheet 902-A. 4 pages.

Winstead, N.N., C.B. Skotland, and J.N. Sasser. 1955. Soybean cyst nematode in North Carolina. Plant Disease Reporter 39:9-11.

Dated this 21st day of May, 2014

Gregory L. Tylka

Gregory Tylka

STATE OF Iowa)
:SS
COUNTY OF Story)

On this 21 day of May, 2014, before me personally appeared Gregory Tylka, known to me to be the person who is described in, and who executed the foregoing instrument and acknowledged to me that he or she executed the same.

(seal)

NOTARIAL SEAL IOWA
RITA M BRUELAND
Commission Number 775715
My Commission Expires
November 14, 2015
RMB

Rita Brueland
Rita M Brueland, Notary Public
My Commission Expires: Nov. 14, 2015

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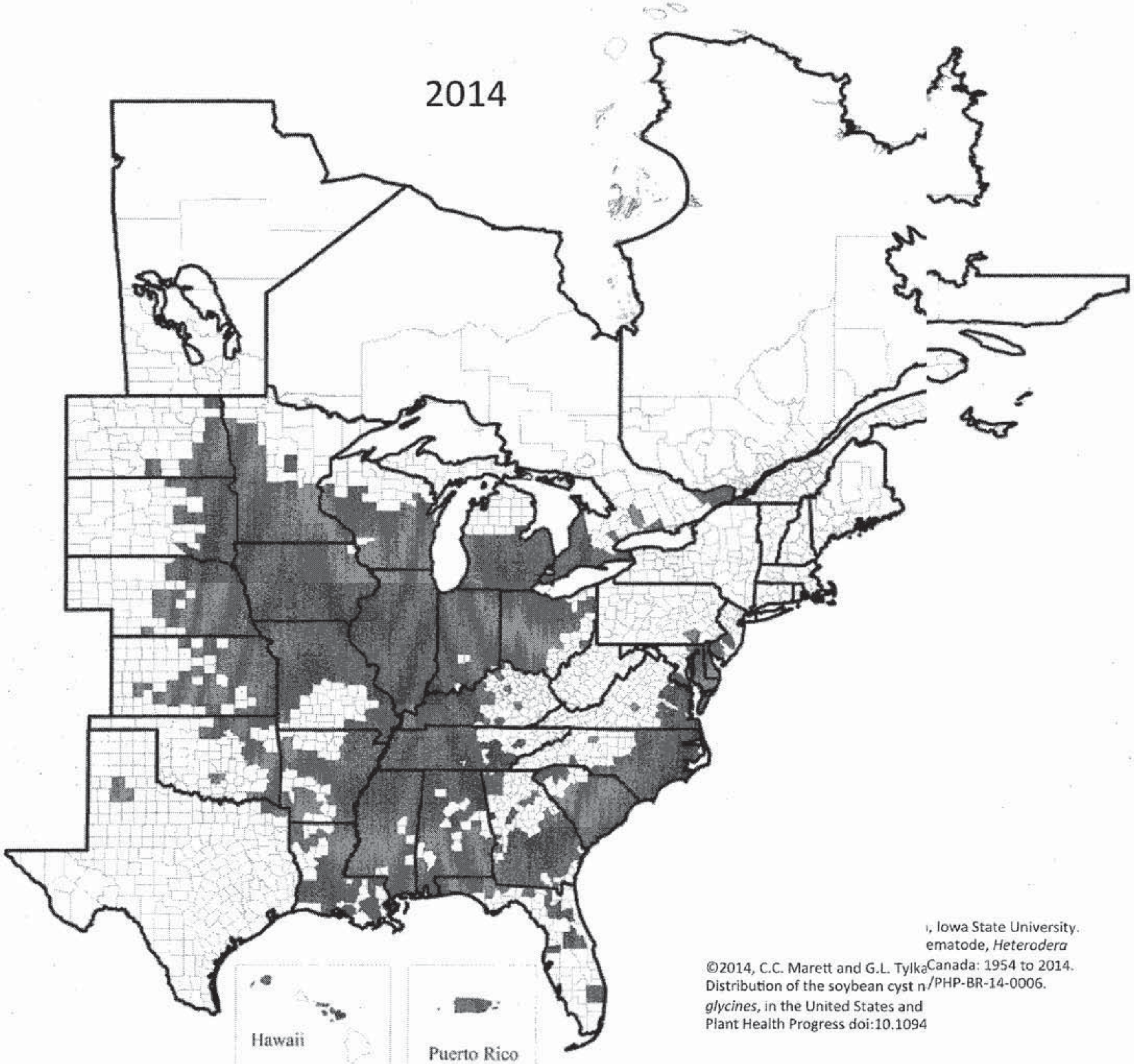

ı, Iowa State University.
ematode, *Heterodera*
©2014, C.C. Marett and G.L. TylkaCanada: 1954 to 2014.
Distribution of the soybean cyst n/PHP-BR-14-0006.
glycines, in the United States and
Plant Health Progress doi:10.1094

ARS SPECIAL REPORT

Soybean Cyst Nematode

ARS 22-29

August 1956

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

SUMMARY

The soybean cyst nematode, which, depending on the degree of infestation, can cause damage to soybean fields ranging from no measurable amount to complete destruction of the crop, has been found on an area of about 1,400 acres in southeastern North Carolina.

Surveys undertaken since its discovery in August 1954 and warnings sent to soybean-producing States have failed to reveal its presence in any other area.

Research programs, begun in 1955, are continuing. These efforts are directed toward finding vulnerable points in its life history, seeking out soil fumigants, crop rotations, and resistant strains of soybeans that will assist in control or eradication of the pest. It also affects annual lespedeza, common vetch, and snap beans.

Information in this report was furnished by the North Carolina Agricultural Experiment Station, the Field Crops Research Branch, the Horticultural Corps Research Branch, and the Plant Pest Control Branch, Agricultural Research Service

SOYBEAN CYST NEMATODE

THE SOYBEAN CYST NEMATODE, which is capable of causing total destruction of a crop of soybeans and which was previously known only in the Orient, has now been found on about 1,400 acres in southeastern North Carolina. It was first observed in the United States in August 1954.

Described by a Japanese scientist in 1952 as a new species, the soybean cyst nematode has as additional hosts in Japan the adzuki bean (a food bean in the Orient but grown only for experimental purposes in the United States), the Spanish runner bean (also seldom grown in this country), and the snap bean (which is the same species as the kidney bean, Phaseolus vulgaris). Preliminary host-range studies in North Carolina in 1955 indicate that it also parasitizes annual lespedeza and common vetch.

Soon after discovery of the pest, North Carolina authorities asked the Federal Government to assist in making a survey to determine the extent of the infestation. Early in 1955 the State entomologist issued a notice of the presence of the pest in North Carolina to all State plant regulatory officials. A soybean cyst nematode control program was organized in March 1955; cooperating agencies include the North Carolina State Department of Agriculture, the North Carolina State College of Agriculture, and appropriate branches of the Agricultural Research Service, U. S. Department of Agriculture. Preliminary research on the nematode under North Carolina conditions was started by the State Experiment Station and the Field Crops Research Branch in the spring of 1955. The Plant Pest Control Branch, Agricultural Research Service, in July issued an alert to the States in which soybeans are produced commercially, urging them to be on the lookout for unexplained losses.

Surveys of the infested area have established the presence of the pest in fields totaling 1,400 acres on 74 premises. Except for a fairly restricted area in New Hanover and Pender counties, north of Wilmington, the nematode has not been found elsewhere in North Carolina or in the neighboring States of South Carolina and Virginia.

In March 1956 North Carolina imposed a quarantine on the movement of soil, plant parts, machines, and other materials that might spread the infestation.

DISCOVERY AND SURVEY

IN AUGUST 1954, a farmer in the Castle Hayne area, New Hanover County, asked a plant pathologist of the North Carolina Agricultural Experiment Station what could be causing the yellowing and stunting of his soybeans. Samples of plants and soil were sent to an Experiment Station nematologist at Raleigh, who tentatively diagnosed the cause as the soybean cyst nematode. This organism is very difficult to distinguish from the clover cyst nematode. Several thousand cysts (egg-filled bodies of females) and numerous male nematodes were found per pint of soil examined. Samples were sent to a nematologist of the U. S. Department of Agriculture, at Beltsville, Md., who confirmed the diagnosis.

Although proof is lacking, it has been suggested that the nematode slipped into the country shortly before the start of World War II in a shipment of Easter lilies from Japan. The soybean was first mentioned in American literature in 1804; the Nation is fortunate that this soybean pest waited nearly 150 years to follow it. The nematode does not attack bulb plants, but cysts may have adhered to bulbs while in transit. In the intervening years the nematode slowly spread through the soil, moved mostly by cultivating and harvesting equipment, in an area where soybeans are used as a cover crop for bulbs or in rotation with bulb or vegetable crops.

First published announcement of the presence of the pest in the Western Hemisphere appeared in the Plant Disease Reporter, January 15, 1955.

Immediate steps were taken: Japanese scientific papers (with summaries in English) were studied to learn how the pest behaved before it left home. Research projects were set up to study its life history and habits in the new location. Surveys were initiated to find how far the nematode had spread--always a prerequisite to regulatory and control operations.

Infestation was, and is, heavy in the Castle Hayne area. In most of the fields it was relatively easy to find live cysts attached to the roots of soybean plants or live males in the soil. During 1955 the pest was found on 770 acres in 50 properties. In some fields only dead cysts were found, which are so similar to those of the clover cyst nematode that no trustworthy way had yet been found to distinguish between them. Dead cysts were found on 157 acres in 20 properties.

Means of spread were important to the survey. Samples were taken of the soil and dust clinging to two combines that were used to harvest infested fields. Per pound of soil taken from these machines, an average of 4,156 cysts were recovered, of which 16.5 percent contained eggs with viable larvae. Inspectors then began to check custom combining machinery that was used outside the immediate area of Castle Hayne. This led to 91 infested acres in 3 properties north of the county line in Pender County (which in 1954 harvested 3,450 acres of soybeans). Other means of spread include wind (by which the pest was moved 200 yards in one instance tested), water, animals, farm workers and machinery, local traffic, or any means capable of spreading small amounts of infested soils.

Considering the number of cysts found in soil on combines, inspectors made a closer study of combining practices: The beans are threshed and put in burlap bags on the combine, and are tied shut and pushed off the combine onto the ground for later transport by truck. A load of bagged-up beans was taken from Castle Hayne to Goldsboro, about 80 miles north, on a truck. Inspectors swept the body of the truck after it was unloaded at an oil mill. Among half a gallon of soybeans and 3 or 4 ounces of soil they found one living cyst. A cyst contains 50 to 600 eggs, averaging about 200.

Up to February 17, 1956, some 8,500 soil samples had been taken on 6,182 acres in 12 North Carolina counties. In 1954 these 12 counties (including New Hanover and Pender) harvested 77,360 acres of soybeans. The range was from 160 acres in Henderson County to 34,200 in Beaufort County, both of which grow some soybeans in rotation with bulbs. Outside of the two infested counties, New Hanover and Pender, the nematode was not found elsewhere in North Carolina.

Special effort went into a survey of 7 southeastern Virginia counties where bulbs and soybeans are grown in the same fields. Eighty-four soil samples were collected on 21 properties having an area of 232 acres. The samples were processed at the Virginia Agricultural Experiment Station. No soybean cyst nematodes were found.

Four counties of northeastern South Carolina were surveyed and a determined search was made for bulb-soybean plantations. No such associations were found, and survey and observation of many soybean fields revealed no symptoms of infestation by this nematode.

Inasmuch as nearly 20 million acres of soybeans are grown in the United States, the Plant Pest Control Branch sent a letter to the following States to alert them to the problem: Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wisconsin. Table 1 shows soybean acreages in the States of principal production. The value of the 1954 U. S. soybean crop for all purposes was estimated at about $1 billion.

This alert has been in the hands of interested officials of the soybean-growing States since July 1, 1955. None has so far reported the presence of the pest or symptoms that could not otherwise be explained.

THE NEMATODE

THE SOYBEAN CYST NEMATODE (Heterodera glycines Ichinohe) is one of numerous kinds of tiny, almost transparent eelworms that infest the soil, plants, and animals the world over. The root meaning of the word nematode is "threadlike." The name is very descriptive of these little animals before the cyst-forming stage as revealed by a low-power microscope. The male of the species is about one-twentieth of an inch long--the width of a period in ordinary print--and about 1 one-thousandth of an inch in thickness. The female, when distended into an egg-bearing cyst, is slightly shorter but much thicker so that it can easily be seen by the unaided eye.

For many years it was considered impossible that these tiny worms could damage plants by feeding on them, even when they appeared in myriads in the soil. But such judgment reckoned without the peculiar adaptation of this and thousands of other types of nematodes. The worm has six lips and inside its mouth is a short sharp stylet or spear measuring about 1 one-thousandth of an inch. The stylet is hollow, like a hypodermic needle, and it is incredibly sharp and durable. Piercing a hole in a soybean rootlet with this amazing mouth-dagger, the nematode wriggles inside the root. Moving along until it reaches a set of vascular bundles, the nutrient pipelines of the plant, it fixes itself there and begins to tap this abundant food supply. After that, life is easy. All the nematode has to do is to suck in the juices through its hypodermic tongue and devote itself to growth and reproduction.

But life becomes difficult for the plant. In order to feed, the nematode injects chemicals that predigest the plant food for its own use, but these substances interfere with the plant's metabolism and cause it to become dwarfed and yellow. Millions of nematodes working on thousands of plants in a field cause a disease of soybeans first called "yellow dwarf" disease in Japan, Korea, and Manchuria, where the soybean cyst nematode has its only known habitat outside of North Carolina. The nematode-caused

Table 1.--Soybean acreages in States of principal production[1]

State	Grown for all purposes		Grown for beans	
	Average 1944-53	1955	Average 1944-53	1955
	1,000 acres			
Illinois	3,804	4,642	3,611	4,530
Minnesota	925	2,371	870	2,335
Iowa	1,735	2,248	1,685	2,223
Indiana	1,704	2,202	1,557	2,114
Missouri	1,154	1,987	1,070	1,930
Ohio	1,077	1,264	1,015	1,245
Arkansas	515	1,030	431	933
Mississippi	385	752	222	544
North Carolina	390	423	255	285
Kansas	361	348	322	300
Tennessee	245	287	130	185
South Dakota	48	272	46	263
Nebraska	46	252	44	245
Virginia	182	237	122	172
Kentucky	194	206	103	130
South Carolina	78	183	52	150
Michigan	112	170	96	165
Alabama	179	157	59	106
Louisiana	107	152	31	56
Maryland	87	141	58	116
Wisconsin	73	91	37	71
Georgia	72	89	20	35
Delaware	66	80	53	71
North Dakota	19	80	17	79
Oklahoma	50	48	29	30
Pennsylvania	58	46	24	21
New Jersey	36	41	17	23
Florida	[2] 12	40	[2] 9	34
New York	9	8	6	6
West Virginia	18	7	....	....
Texas	7	6	....	....
UNITED STATES	13,740	19,860	11,987	18,397

[1] Data reported in Crop Production, 1955, an annual summary issued by the Agricultural Marketing Service.
[2] Short-time average.

disease has been known since 1915, when Japanese scientists attributed it to a strain of the sugar-beet nematode, which it greatly resembles. During the 1940's it was considered rather to be a variant of the pea cyst nematode, which it also resembles. Finally, in 1952, it was identified as a separate species.

The soybean cyst nematode goes through four stages as a worm. It molts once while still in the egg and emerges as a second-stage larva. This is the so-called infectious stage, when the nematodes, still young and slender, penetrate into plants. They molt twice more within the host and become adults. In the first two stages they are sexless; after the third molt sexual differentiation begins, and after the fourth molt males and females are easily distinguished. The female remains within the plant, feeding and enlarging until her swollen body causes the rootlet to crack open and her body protrudes, remaining attached by the neck. This may be an adaptation for mating with the males, which emerge from the plant in the adult stage and are free-living in the soil, and for the later release of young larvae. After mating, some eggs are deposited in a gelatinous mass outside the body of the female, but some 50 to 200 eggs are retained within the distended lemon-shaped body. The female body is at first white, changing to yellow, and, after death, it turns to an olive brown. This is the tough-skinned cyst characteristic of the cyst nematodes. The cyst, which is highly resistant to decay, protects the eggs until they are ready to hatch. This resistance to decay and other adverse conditions is of great significance in the survival and dissemination of cyst nematodes.

Second-stage larvae develop within the eggs in the cyst. They may hatch immediately, though many may remain unhatched for an indeterminate period. Research has yet to demonstrate how long they remain quiescent and what finally causes them to hatch. Once hatched, they are apparently able to "scent" and move toward the roots of host plants on which they must feed to produce the next generation.

In the latitude and climate of Japan, this nematode can produce three generations in a growing season. Greenhouse tests made at the North Carolina Agricultural Experiment Station indicate that three to four generations could develop during the growing season there, which starts in mid-May and ends in late September.

Host plants were studied in Japan. Pot tests were run on 32 different plants, including legumes, grains, and vegetables. Full-sized egg-bearing cysts developed on the soybean and the adzuki bean. On the snap bean the young females in the roots did not grow to normal size, the cysts were small, and the number of eggs was reduced. The nematodes attacked the Spanish runner bean but development was not complete.

Forty different plant varieties were studied in greenhouse host tests conducted at the North Carolina Station in 1955. Here again the soybean was the favored host. But two new hosts were added, annual lespedeza and common vetch, in both of which the pest reproduced as readily as in soybeans.

Legumes found not susceptible, in North Carolina greenhouse tests, include cowpea, velvet bean, lupine, perennial lespedeza, crotalaria, garden pea, red and ladino clover, alfalfa, and peanut.

Damage done by the soybean cyst nematode to a field of soybeans has been stated in different ways by scientists of the Eastern and Western

Hemispheres. In North Carolina, where the uneven yellow patches have appeared in the fields for anyone to see, the damage has varied from slight in the early stages of infestation to such destruction that no effort was made to harvest the crop.

In Japan nematode-infested plants were weighed, measured, and their pods were counted in comparison with uninfested plants. Height of infested plants ranged from 9 to 16 inches, compared with 24 inches for healthy plants. Nematode-ridden plants ranged in weight from one-tenth to seven-tenths of an ounce, whereas healthy plants weighed 3 ounces. The number of pods per infested plant ranged from an average of 2.4 in a badly infested area to 10.7 in a less heavily infested area; healthy plants had 38 pods.

STEPS BEING TAKEN

Research

SCIENTISTS of the North Carolina Agricultural Experiment Station, working in 1955 with the North Carolina State Department of Agriculture and the Agricultural Research Service of the U. S. Department of Agriculture, in one year of preliminary research assembled an impressive group of findings.

Identification of the soybean cyst nematode as distinguished from the clover cyst nematode, which is widely distributed in several soybean-producing States, has been worked out in a series of meticulous morphological studies by a worker at the experiment station. Until this method was evolved it was necessary to identify the soybean cyst nematode by the time-consuming method of planting cysts or larvae with red or white clover and soybeans to see which they would attack. The problem was further complicated by the fact that the two nematodes have other hosts in common--the snap bean, annual lespedeza, and common vetch.

No readily discernible difference was found in the size, shape, or pattern of markings of eggs or cysts. But, once the second-stage larva leaves the egg and is examined microscopically, many differences are evident. Measuring 150 larvae of each species, it was found that several anatomical measurements are distinctly different. The measurements are consistent, and the averages of the two sets of measurements never overlap. Once recognized, these differences can be detected rapidly by an experienced worker, greatly shortening the time required to identify a soybean nematode. Another difference becomes evident in the adult stage--males of the soybean nematode are very common, whereas males of the clover nematode are seldom found.

Resistance studies were carried out in preliminary greenhouse tests by exposing 309 soybean varieties to natural infestations of the soybean cyst nematode. Approximately one-half of the varieties proved susceptible in these tests, including some that had shown resistance in Japan. Those that showed no infestation will be tested again. Because the growing season of 1955 was generally unfavorable, scientists working on this project felt that some varieties may have escaped infestation because of weather conditions.

Soil fumigation was tried in field tests with two types of commercial nematocides--one a mixture of dichloropropane and dichloropropene (DD mixture) and the other containing 85 percent ethylene dibromide (EDB). Both were applied at the recommended rate for other nematodes, double that, and quadruple that. The DD mixture was used at the recommended rate of 20 gallons per acre and at 40 and 80 gallons per acre. EDB was applied at the recommended rate of 4.5 gallons per acre and at 9 and 18 gallons per acre.

At recommended and double rates of application, with both nematocides, there was increased plant growth and yield over unfumigated plots. At quadruple rates there was stunting and evidence of toxic effects on the plants. Living cysts were found in all of the plots after fumigation, indicating failure of these materials at the rates applied or methods used to eradicate the soybean cyst nematode. But, these tests must be regarded as preliminary and will be repeated.

Eradication treatments were tested on daffodil bulbs and gladiolus corms, a great many of which are grown in and shipped from the infested area. While daffodils and gladiolus are not susceptible to the nematode, bulbs or corms of these plants might easily become contaminated with cysts and serve as carriers in introduction of the pest. The tests began with accepted bulb-dipping treatments that are in current use for fungus rots, including hot water with 1 part of 40-percent formalin to 200 parts of water, and 85-percent sodium trichlorophenate. The same treatment as that given the bulbs was applied to screened soil containing nematode cysts, enclosed in cloth bags. After treatment the cysts were placed in pots containing nematode-free soil, and soybeans were planted. In 6 or 8 weeks the soil and roots of the soybeans were examined for the presence of new cysts, and the efficacy of the treatment was determined.

Using hot water, it was found that when bulbs are steeped or soaked in water at 120° F. for 30 to 60 minutes it kills all soybean cyst nematodes. A similar result was obtained when bulbs were soaked 15 to 30 minutes in water at 130° F.

Using 40-percent formalin in a 0.5-percent solution by volume at 111° F., all nematodes were killed after soaking 3 or 4 hours. This solution was not fatal to the pests when they were immersed for an equal length of time at a temperature of 77° to 86° F.

Using 85-percent sodium trichlorophenate, which is widely employed to treat bulbs and corms for fusarium rot, at the rate of 2 pounds to 100 gallons of water at prevailing temperatures, all soybean nematodes were killed after soaking for 1 hour. When soaked for 15 minutes, the same result was obtained in solutions of 3 and 6 pounds to 100 gallons of water. Scientists say that the sodium trichlorophenate treatment can be applied very cheaply. For materials alone, 2 tons of bulbs can be dipped for less than $1. This, of course, does not represent the total cost, which includes investment in dipping equipment and the charge for labor.

As a control, bulbs and small bags of nematode cysts collected for the purpose were run through water at the prevailing temperature, and through water containing a detergent. Neither had any effect on the viability of the organisms. Two other chemicals, 97.5-percent phenylmercury acetate and 5-percent ethylmercury phosphate, failed to kill the soybean cyst nematode.

Air-drying experiments were tried on nematode-infested soil in order to measure the mortality of nematodes in the normal practice of air-drying bulbs. In one experiment, two soil samples weighing 3.2 grams (0.1 oz.) were taken from soil that had been removed from an infested field. Hatched larvae were counted in one sample, which had not been air-dried, and 52,314 larvae were found. The other sample was dried at room temperature for 42 days and hatched larvae were counted. Forty-two were found. Thus, assuming that both samples of equal weight had originally contained an equal number of nematodes, air-drying had reduced the number 1,245-fold.

In another experiment, soil samples of similar size were taken from pots in which diseased soybeans had been grown in the greenhouse. From the sample not air-dried, 44,158 larvae were counted. The other sample was air-dried for 72 days and hatched larvae were counted. They numbered 70--a 630-fold reduction.

Quarantine

Following a hearing of interested parties at Raleigh, March 29, 1956, the North Carolina State Board of Agricluture the same day issued a quarantine covering infested areas and premises. Regulated articles may be moved out of quarantined areas only when accompanied by a permit, which is issued when the following conditions, quoted from the quarantine regulations, are met:

(1) Living soybean cyst nematode in any stage of development may not be moved or transported except for scientific purposes as authorized by the State entomologist, unless a certificate or permit has been issued therefor.

(2) Soil as such or soil attached to plants or articles may not be moved from the quarantined area to any point outside thereof unless such soil, under the supervision of the inspector, has been sterilized, fumigated or otherwise treated so as to kill all nematodes.

(3) True bulbs, corms and rhizomes may not be moved out of the quarantined area until at least a 60-day drying period, after digging, has elapsed and they have been thoroughly cleaned of soil.

(4) Root crops and tubers may not be moved out of the quarantined area unless all soil has been removed by washing.

(5) Farm tools, implements, and other construction and maintenance equipment may not be moved out of the quarantined area, unless all soil has been removed by washing.

(6) Crates, boxes, burlap bags, or other farm product containers used for harvesting in infested fields may not be used for marketing.

(7) Except as noted above, portions of plants without roots attached (such as cut flowers) may be moved from the quarantined area without certification.

(8) Compliance with subsections (2), (3), (4), and (5) of this section shall not be necessary when such treatment or washing is found by an inspector to be unnecessary because the particular portion of the quarantined area involved is found by the inspector not to be infested or not to be so located or used as to be exposed to infestation.

THE OUTLOOK

Economic Importance of Host Plants

THE SOYBEAN CYST NEMATODE has a limited number of hosts. However, these hosts occupy extensive acreages in many States.

Soybeans.--This is the principal host, and soybeans are a big crop in the United States--grown for all purposes on nearly 20 million acres in 31 States (table 1). They have a farm value of about $1 billion.

Lespedeza.--According to the North Carolina host-range studies, the soybean cyst nematode attacks annual lespedeza quite as willingly as soybeans, and goes through the full cycle of penetration and reproduction in this host. Lespedeza is grown in 18 States for hay and seed, in addition to its role as pasture, green-manure, and cover crops. In 1954 a total of 3,702,000 acres of lespedeza was harvested for hay, of which about 10 percent is estimated to be of the perennial variety, and 580,500 acres of annual lespedeza for seed, making a total of 4,282,500 acres grown for these two purposes in Alabama, Arkansas, Delaware, Georgia, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Virginia, and West Virginia. Largest producers of lespedeza hay are Tennessee, Kentucky, and North Carolina; States producing most lespedeza seed are Missouri, North Carolina, and Kentucky. Farm value of the seed for the country as a whole was placed in 1954 at $15.8 million.

Common Vetch.--As tested in North Carolina, this plant is attacked as readily by the soybean cyst nematode as are soybeans and lespedeza. In areas where it is used as a winter cover crop, common vetch is of considerable importance to farmers. Because it grows as a weed in some places, along roadsides and fencerows, it might serve as an alternate host when other plants suitable to sustain the nematode are not available.

Snap Beans.--As shown by host tests in Japan and North Carolina, the soybean cyst nematode does not develop as well on this plant as on more favored hosts, growing fewer and smaller cysts. No information has been developed on the damage this nematode does to snap beans. Snap beans, which had a value of $85.7 million in 1954, are grown commercially on 309,400 acres in 32 States: Alabama, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Virgina, Washington, and Wisconsin. Farm value of the crop harvested for the fresh market in 1954 was $43.2 million and the farm value of snap beans used for processing was $42.5 million. States of heaviest production, in the order given, were Florida, New York, Wisconsin, Maryland, South Carolina, and North Carolina.

Research

Rotation.--The North Carolina Agricultural Experiment Station has leased a tract of nematode-infested land for 5 years, beginning in 1956, to carry out a series of crop rotations. Soybeans and other host plants will be left out of rotations for 1 to 5 years to determine whether and in what period of time the nematode can be starved out by this means.

Soil fumigation trials will be continued.

Resistance studies will be continued, with some 150 varieties of soybeans that did not become infested during the 1955 trials. Early research in this direction will be aimed at complete resistance to the nematode. Tolerance will be sought later, if resistance cannot be found.

In general, an attitude of optimism prevails, among State and Federal workers associated with this problem, that research will point the way to control of the pest.

Agriculture - Washington

S P E C I A L · R E P O R T

Supplement to Soybean Digest

SOYBEAN DIGEST®

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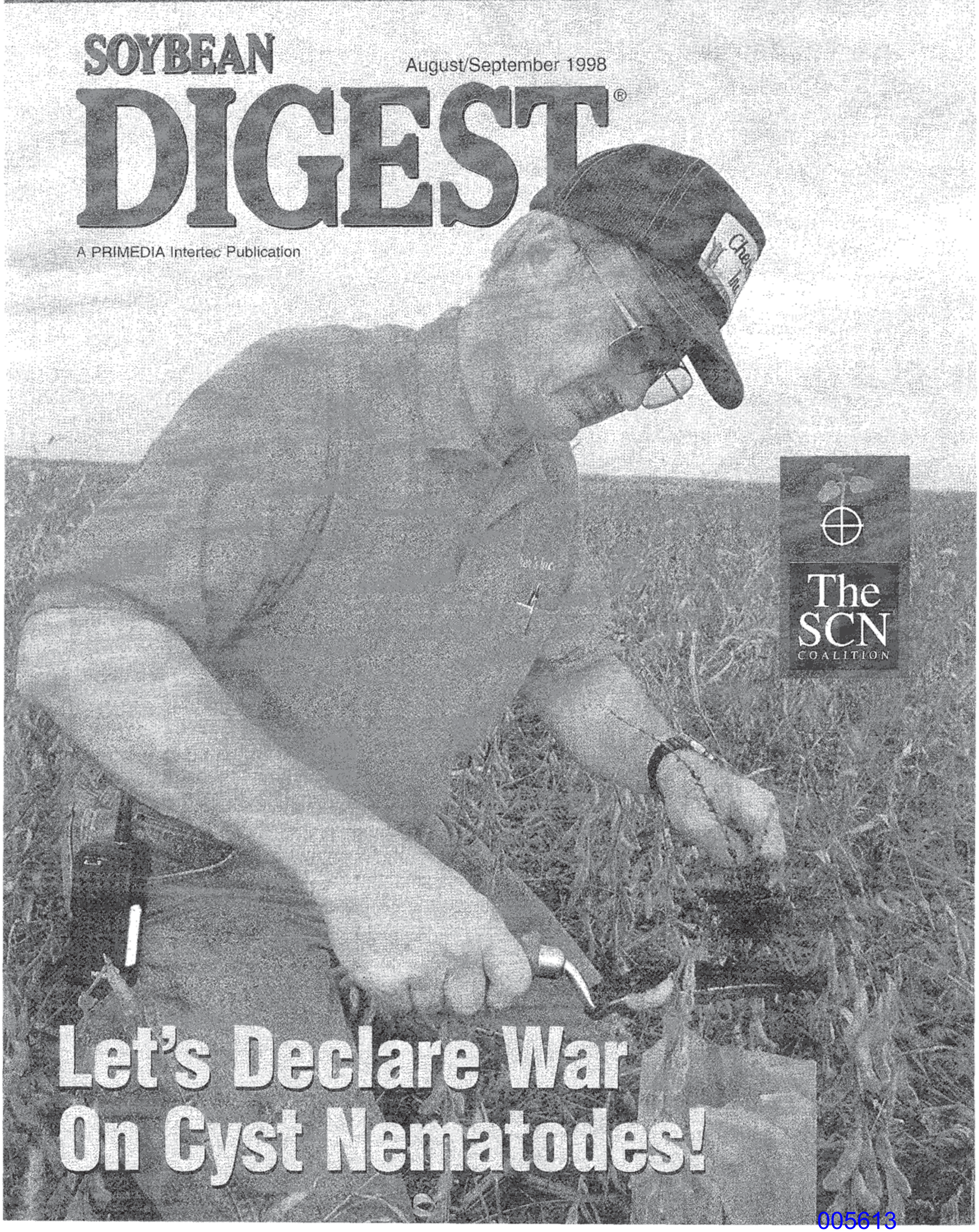


Let's Declare War On Cyst Nematodes!

005613

Let's Get Tough On SCN Now

It's almost tragic what farmers are letting soybean cyst nematodes do to them. And the pity is, most farmers don't even realize it.

This Special Report is your blueprint toward whipping this profit robber, if you have it, or keeping fields clean or near so if you don't.

We salute companies whose advertising helped bring this important information to you.
– **The Editors**

Catch more on SCN on our Web site at www.homefarm.com Find even more on the SCN Coalition site: www.ex net.iastate.edu/Pages/plant path/tylka/scncoalition.html

Also: AgDay TV will soon devote part of a 30-minute segment on soybeans to SCN. The broadcast is on Friday, Aug. 14, and re-broadcast on various satellite hookups that weekend. Don't miss it.

CONTENTS

On The Cover: Ron Heck, Perry, IA, grower, shown here taking soil samples for SCN testing, found to his surprise nematodes were causing big losses.

COVER PHOTO: Bob Elbert

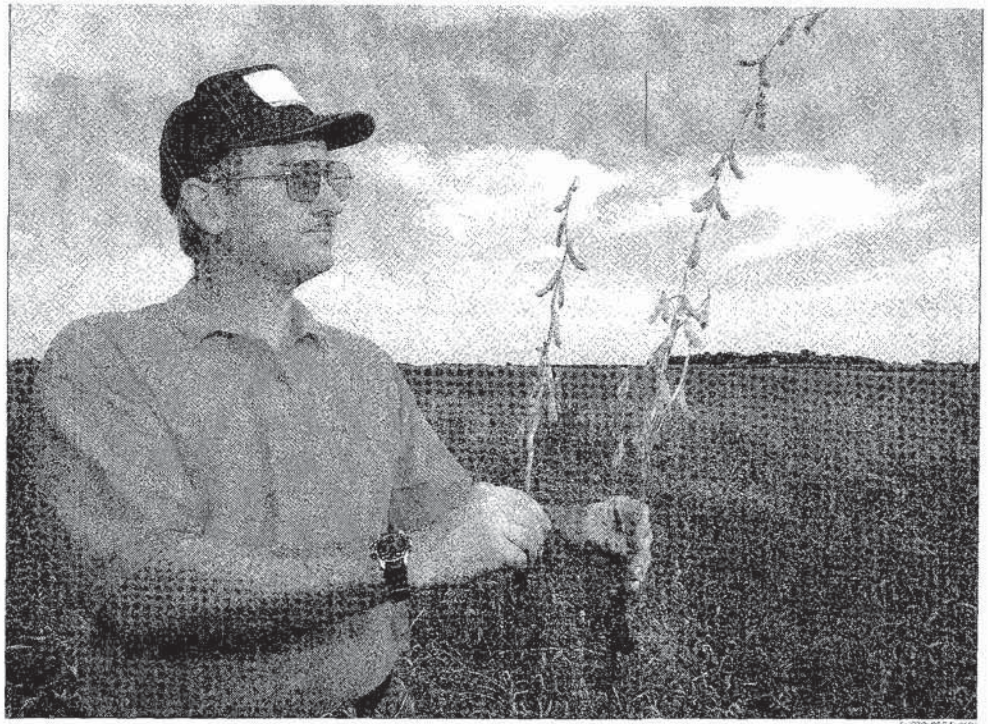


PHOTO: BOB ELBERT

Ron Heck, Perry, IA, shows the difference between a non-damaged SCN-resistant variety and a damaged susceptible variety.

Declare War On SCN

10-state challenge: "Take the test. Beat the pest."

by Syl Marking

Soybean cyst nematodes slap soybean growers collectively with more than a $1 billion loss each year.

Regrettably, most farmers shrug off those national-loss figures with the feeling, "That's the other guy's problem."

Listen up! Let's put it in terms then of one farmer – a top grower and one-time president of his state's soybean grower association. Ron Heck, an Iowa State University graduate from Perry, IA, found that SCN had sneaked up on him like a fox looking for dinner. He sought help from his alma mater, then told growers at the Midwest Soybean Conference last August:

"Each year I failed to do something about SCN, I lost about $20,000."

In 1997 research on his farm, Heck found out exactly how important it was to take some corrective action. Early that spring, after studying 1996 research results, he fired an important management shot by switching varieties and leaving check strips with his old, non-resistant varieties. Let him tell it in his own words.

"I picked up 13 bu per acre when I planted a resistant variety on that infested land. And at $7 per bu (the price available at that time), that's $91 per acre. Besides, I spent less on weed control because of the quicker canopy with the resistant beans.

"And all I did was change my seed order!"

A dramatic example? Yes. But let's be conservative, say Heck and Greg Tylka, Iowa State University nematologist, who is doing SCN research at Heck's farm.

Let's say the loss was 7½ bu per acre. And let's use $5.50 per bushel, which most any grower-marketer ought to be able to beat for his '98 crop. That's $41.25 per acre. If you raise, say, 300 acres of soybeans, that's $12,375. Over two years, that's just a tad under $25,000 – the price of a new, pretty decent pickup truck.

Heck's situation isn't all that unusual, say scientists, and there are plenty of cases that involve worse losses.

There's good news, and there's hope for soybean growers, however. Scientists like Tylka, grower associations and various industries that serve farmers have come to an overdue decision: Enough is enough! They have teamed up to form a 10-state SCN Coalition. Its challenge to soybean growers: "Take the test. Beat the pest."

Its mission: get all soybean growers to take soil samples and have them analyzed for SCN. Then, if they find they have the pests, to take the proper corrective action.

Admittedly, SCN hasn't yet infested every soybean grower's fields. But compared to even 10 years ago, if you're still free of this single-biggest, profit-stealing pest for U.S. soybean growers, it is getting much closer to nailing you.

The thing most growers don't realize – which is probably why they haven't tested for the pest – is that you can have SCN several years before they build high enough numbers to cause noticeable SCN symptoms. The real bad news is this: In most cases, plant damage and yield loss occur years before symptoms are visible.

Consider this: The first reports of SCN in the U.S. came from North Carolina in 1954 – 44 years ago. The destructive buggers now have been identified in virtually all 30 states where soybeans are grown.

For example, 82% of Illinois soybean fields are infested, 74% of Iowa fields, 71% of Missouri fields and 53% of Minnesota fields – and counting in every case.

Sadly, say SCN fighters, two-thirds of soybean growers have done nothing to beat these pests.

Here's what's scary about the nematode spread: Your fields could get infected – even if you do everything known to science to prevent and/or control cyst nematodes.

Migratory geese or ducks could stop to eat in a wet, infested field miles from your farm or even your county and then stop to feed in one of your fields and seed SCN with their muddy feet. Or nematodes can spread via seed harvested from infested fields then planted in your clean fields.

Even if farmers declare all-out war on these destructive pests, they cannot banish them completely. They can't be totally eliminated, caution scientists. But they can be managed well enough to become only small-time thieves, they assure. That's the good news.

In the articles that follow in this Special Report, you will find the details needed to hog-tie these thieves that steal significant profits from so many U.S. soybean growers. ○

An Open Letter From The Editor

This is "war." And as editor of this magazine, I am declaring it.

It's war on soybean cyst nematodes – microscopic roundworms that could be stealing you blind.

Worse yet, you may not even know it. SCN can be as sneaky as a stealth bomber in military combat. It can be down and dirty.

That's partly why it's gouging so many U.S. soybean growers by an estimated total of $1 billion-plus per year!

People, listen up. You cannot control weather. You cannot control crop prices.

But, by thunder, you can do something about the $5,000 to $20,000 loss many of you are needlessly suffering from SCN.

Admittedly, not every soybean grower has cyst nematodes. Count your blessings if you've tested for them and found you don't.

Study the management pointers in these Special Report articles, so you can do everything possible to avoid getting them – and if you do get them, keep them confined to small areas.

So, my challenge to you is to read – no, study – every article in this report. Then take action now!

Take the test. Beat the pest. Good Luck!

Syl Marking
Editor

A Letter From SCN Regional Coordinator

After weeds, soybean cyst nematodes are the most important soybean pests in the Midwest. Every year, SCN robs yields and profits from soybean producers. In 1997, SCN "stole" 209 million bushels of beans from producers' bins and bottom lines.

Last year, the North Central Soybean Research Program, which uses checkoff dollars to fund research in a 10-state region, decided to do something radically different to get the word out to producers about SCN. Thus, the SCN Coalition was born.

As the SCN regional education coordinator, I am pleased to be working with university, industry and state soybean checkoff board partners in spreading the word about SCN. This coalition is truly a unique venture, combining the efforts of university scientists and state checkoff board staffs in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota and Wisconsin. Also part of the effort are these industry partners: Asgrow, American Soybean Association, Cargill, Cenex/Land O'Lakes, Dekalb, Growmark/Countrymark, Mycogen, Novartis, Pioneer, *Soybean Digest* and United Soybean Board.

This Special Report is an example of our coalition working together. I want to thank Syl Marking and the staff at *Soybean Digest* for their efforts in raising awareness about SCN through past feature stories and this SCN Special Report.

Paulette Pierson
SCN Regional Education Coordinator

005615

New Coalition Launches All-Out Assault On SCN

Its mission: to control No.1 profit stealer

Take the test. Beat the pest.

The SCN COALITION

by Syl Marking

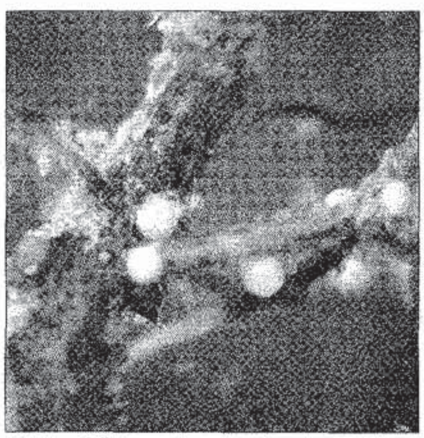
A ground-breaking partnership of state soybean checkoff boards and land grant universities from 10 North Central states has formed the Soybean Cyst Nematode (SCN) Coalition.

The coalition's goal: to get soybean growers to test for SCN, and if they find they have it, take the necessary steps to manage the problem – which ranks No. 1 as a profit stealer.

The coalition's slogan, which you will hear and see a lot in the next year is, "Take the test. Beat the pest."

The massive coalition effort is being largely underwritten by the North Central Soybean Research Program. That's an alliance created by 10 state soybean checkoff boards.

Cooperating states include: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota and Wisconsin.



White SCN cysts clinging to roots can each contain hundreds of eggs.

In addition to grower checkoff funds, the coalition is getting financial backing from several seed companies and ag cooperatives.

Industry partners, besides the American Soybean Association and the United Soybean Board, include Asgrow Seed Co., Cargill Hybrid Seeds, Cenex/Land O'Lakes, Dekalb Genetics, Growmark/Countrymark, Mycogen Seeds, Novartis Seeds and Pioneer Hi-Bred International.

Besides extension and research scientists at each of the North Central land grant universities, representatives from seed companies, farm cooperatives, crop consulting firms and ag media will be involved in executing the regional umbrella program.

SCN has spread so that it has now been identified in virtually every state where soybeans are grown. It has also been written about and talked about in educational efforts.

So why is such a special, all-out effort needed now?

The answer is simple, says Bryan Hieser, an Illinois soybean grower and chairman of the North Central Soybean Research Program: It's volume.

"We feel the urgency of our message wasn't reaching the grower," he declares. "By enlisting partners from state soybean boards and private industry, we could reach more growers and have greater impact with our key messages of testing soils for SCN and using the management tools available to prevent further damage, if you have the problem."

There's another reason – and it's a very key one, notes Greg Tylka, Iowa State University nematologist and coalition leader for the scientists cooperating in this regional effort.

"This whole idea of having significant yield loss without seeing any above-ground symptoms," he emphasizes, "is a concept that obviously hasn't been getting through to growers and needs to be pushed."

Now it will be. So, the next move is up to soybean growers.○

The SCN Land Rush

Pest invades most growing areas

by Stacey Hager

Like the pioneers of the Oklahoma land rush, soybean cyst nematodes are moving west and staking claim to new land.

Paulette Pierson, regional education coordinator for the SCN Coalition, believes it's actually an old claim just up for renewal.

First identified in North Carolina in 1954, SCN spread west and north, eventually reaching the heart of the nation's Soybean Belt. Recent diagnoses in parts of the Midwest are thought by many to be a continuation of the pest's migration.

But Pierson figures most of the movement took place years ago.

"The spread or introduction of SCN occurred some time in the past," she states. "I believe it's just now being identified."

Very high SCN populations are being found in areas where the pest previously had never been identified. The high numbers indicate SCN has been there for years, she says.

For example, counts of over a quarter million eggs in 200 cc of soil were found last year in a previously "SCN-free" county in Ohio.

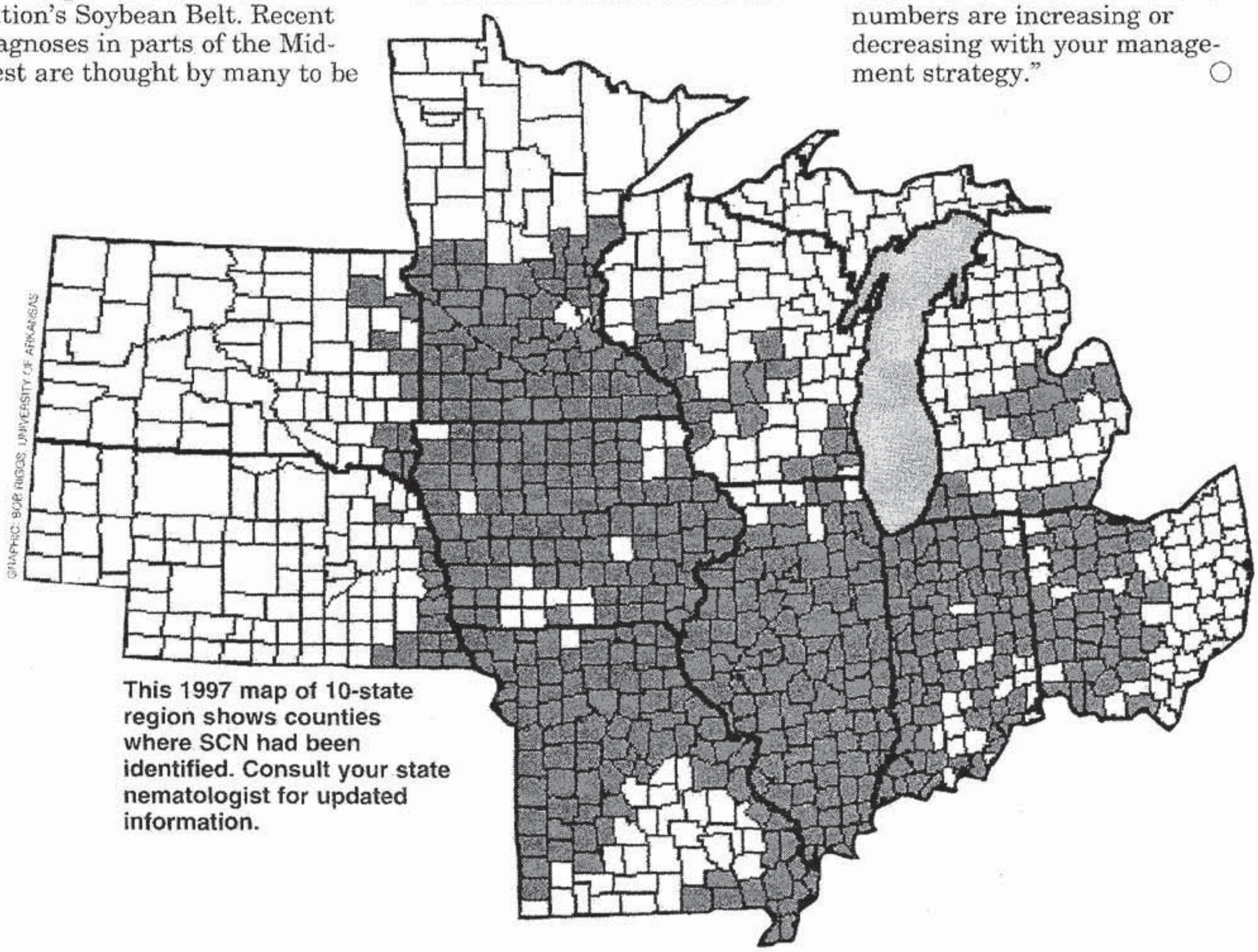
"Those are extremely high counts if you consider 250 eggs in the same volume of soil can cause damage to SCN-susceptible soybeans," says Pierson.

She says SCN is probably present in more counties than the map below indicates.

In fact, it likely infests most soybean-growing counties.

"Growers really haven't been sampling. Where it hasn't been identified, it probably hasn't been looked for." The fact that SCN probably infests most fields emphasizes the need for growers to identify the problem and adopt a control program. That program should include periodic soil testing to monitor nematode populations.

"SCN can be managed," she says. "But you can't say I'm going to put a Band-Aid on it and just plant resistant varieties. You need to know if SCN numbers are increasing or decreasing with your management strategy." ○



This 1997 map of 10-state region shows counties where SCN had been identified. Consult your state nematologist for updated information.

Can the war with SCN be won?

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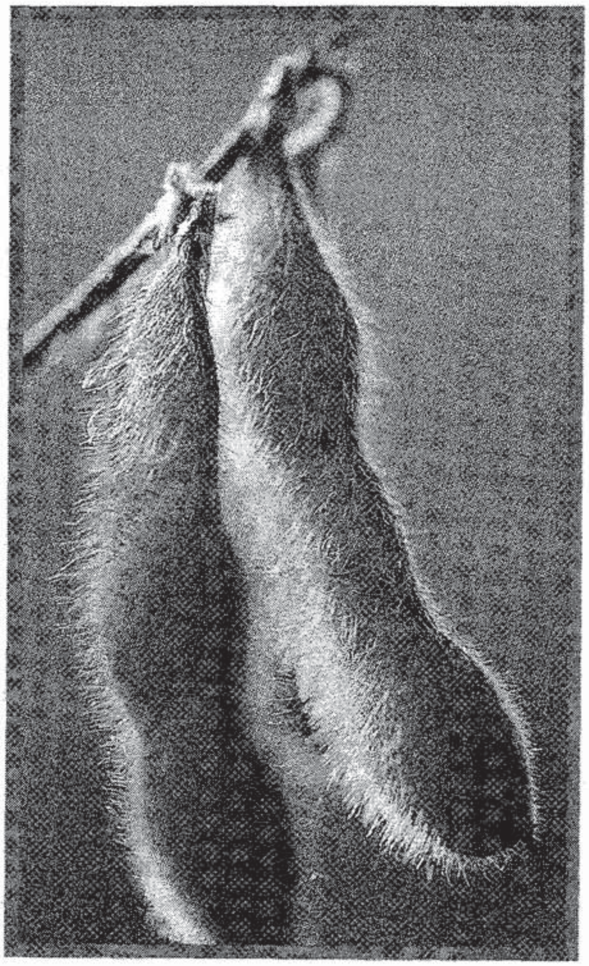

DEKALB and the Soybean Cyst Nematode Coalition have teamed up to help farmers win the war against Soybean Cyst Nematode. SCN causes hidden yield loss. **A soil test is the only way to know if a field is infested.**

Several soybean varieties from DEKALB provide the SCN resistance that can help you bring the invasion under control. We have a lineup of 21 varieties in a wide range of maturities with SCN resistance, including four varieties that are Roundup Ready® soybeans with SCN Resistance. Lead The Charge! Contact your DEKALB dealer today!

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Take the test. Beat the pest.
The SCN Coalition

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005618

Stop Nomadic Nematodes

Here's how you can prevent them from spreading

by Fae Holin

Power-washing tillage equipment will help stop the spread of SCN from field to field.

PHOTO: FAE HOLIN

They'll hitch a ride on anything that moves, be it dust, Canada geese or water.

But the main way soybean cyst nematodes spread? Maybe the answer's in your mirror.

"The biggest way is through impatient farmers who are out working fields that are too wet," says Pat Donald, a University of Missouri extension nematologist.

"They get mud on everything and just carry dirt from field to field."

To keep SCN from spreading, work fields not known to have nematodes first, then move your rig into infested fields.

Or power-wash equipment between fields. Just don't move soil back and forth between fields, she reiterates.

"I never knew I had a problem, so I didn't clean my equipment off," admits Dave Broghamer, Decorah, IA. He's in his first year of fighting SCN on 60 acres.

"I just assumed this year that I had already spread it to all the other fields, so all the soybeans I planted are nematode-resistant," says Broghamer.

"Some think soybean cyst came into this country with soil that was brought in as inoculant," Donald says.

Others surmise that SCN has been around all along and that it was surviving on weeds, says Jamal Faghihi, a Purdue University research nematologist. "When soybean cultivation became widespread, it started showing up in different places," Faghihi adds.

Once it was found in North Carolina, it was discovered throughout the Southeast and later into the Midwest, reports John Ferris, a Purdue University nematologist.

"We first found it in 1970 in southern Indiana. Eight years later we found it in the northern border of the state. Then we found it all over."

However it got here, SCN is here to stay. Canada geese and other waterfowl are active carriers of the costly pest. So is water, says Donald.

"We know that water moves it; I documented in the flood of '93 that it was being brought into different areas along the Missouri River."

Blowing soil also carries SCN, says Walker Kirby, University of Illinois plant pathologist. He, too, suggests scrubbing and spraying tillage tools, tires and fender wells, for example. Custom harvesters should especially be asked to wash equipment because "you have no idea where they are coming from."

"If you take time to do this, it will reduce the spread," Kirby says.

Publication Lists Resistant Varieties

For a listing of SCN-resistant soybean varieties, check out Marion Shier's *Soybean Varieties With Soybean Cyst Nematode Resistance*, an 18-page publication.

Shier, a Crop Systems Unit educator with the University Of Illinois Cooperative Extension Service, listed varieties alphabetically by company code in Maturity Groups I through VIII. The information is useful from Louisiana to Minnesota, according to Shier.

Check out the listing on the Internet at: www.ag.uiuc.edu/~wardt/cover.htm, or get a copy the old-fashioned way: send for it.

Send a $2 check to: Livingston County Extension Office, 1412 S. Locust St., Pontiac, IL 61764. Make checks payable to the Livingston County Extension Office.

SCN Symptoms: What You Can't See Hurts

Sneaky pests leave few early signs

by Fae Holin

Dave Broghamer had never been satisfied with yields from one of his farms. It's 60 acres of "pretty good ground" he rotates between corn and soybeans.

But last year the Decorah, IA, grower had enough.

"It was easy to see I had a problem; plants were not developing properly," Broghamer says. "They were smaller than normal."

Although parts of fields produced healthy plants, plants a few rows away were struggling. So he called in his local co-op agronomist, who suggested soil tests.

Soybean cyst nematodes strike again.

Broghamer is just one of many farmers who early on failed to recognize the above-ground symptoms of SCN. That's because there aren't any – until the nematodes are fully entrenched in a field and affecting yield.

"Unfortunately, the message got out fairly early that growers could see above-ground symptoms of soybean cyst nematodes," says Universit y of Missouri extension ne matologist Pat Donald.

"And that, if they ha d chlorotic leaves or dying plan ts, then they had SCN, and th at's not necessarily true."

What is true is that the main early SCN symptom is a "half-empty weigh wagon vs. an over-flowing one," says Joh n Ferris, a Purdue University ne natologist.

Walker Kirby, a Uni versity of Illinois plant patholog ist, says the soils in his area ar e rich enough to support vig orous plant growth, even in the pr esence of nematodes.

"But the plants tend to set fewer flowers and hav e fewer pods, so they generall y don't yield as well. To grow ers driving by the field, they look absolutely perfect."

And there's the rub, Donald says.

"Our biggest problem is getting people to get out of the pick-ups and sample fields," she states. "I recommend, if you have a field going into soybeans, that you sample. Peri od.

"We have people wh o say they've been growing soybeans forever and don't have a problem because they don't see any symptoms. When I fin ally get them to do egg counts, the egg counts come back at a level of 40,000 eggs per cup of soil."

That's enough to cause damage, even on resistant varieties, says Donald.

"The big symptom you don't visually notice is the cyst nematode feeding on the roots," says Kelly Holthaus, Broghamer's agronomist and branch manager of the Winneshiek Co-op, Burr Oak.

"The cysts basically eat off the root system and starve the plant," Holthaus explains. "After they start eating, the roots can't take up the nutrients. Then the visual effects start showing up."

By then it's too late to do something that year for that crop, Donald says.

Growers who've noticed uneven patches in their fields should dig up roots and check their condition. Broghamer's roots "didn't finger out like they should have."

Other than little white cysts clinging to roots, you might find adult females actually feeding on them.

Most experts recommend sampling right ahead of or during harvest. But the best time to dig up and view roots is late June or early July, depending on the soil temperature and when the crop was planted, Donald says.

Symptoms growers do see – when SCN populations are quite high and yields may be reduced by 10 bu/acre or more – include stunted, yellowing plants.

Yellowing is more visible in drought years and in sandy soils, Ferris says.

Plants are also smaller and less vigorous. Dead or uneven patches appear in fields.

"One of the things that I do, when the timing is right, is go out and look at the field with a producer and say, 'Look, this field is very uneven; there are a lot of different heights in the field,' " says Donald.

SCN also prevents good canopy closure, which increases weed pressure, she warns.

"There should be a light bulb going off when they see weeds where they haven't seen weeds before."

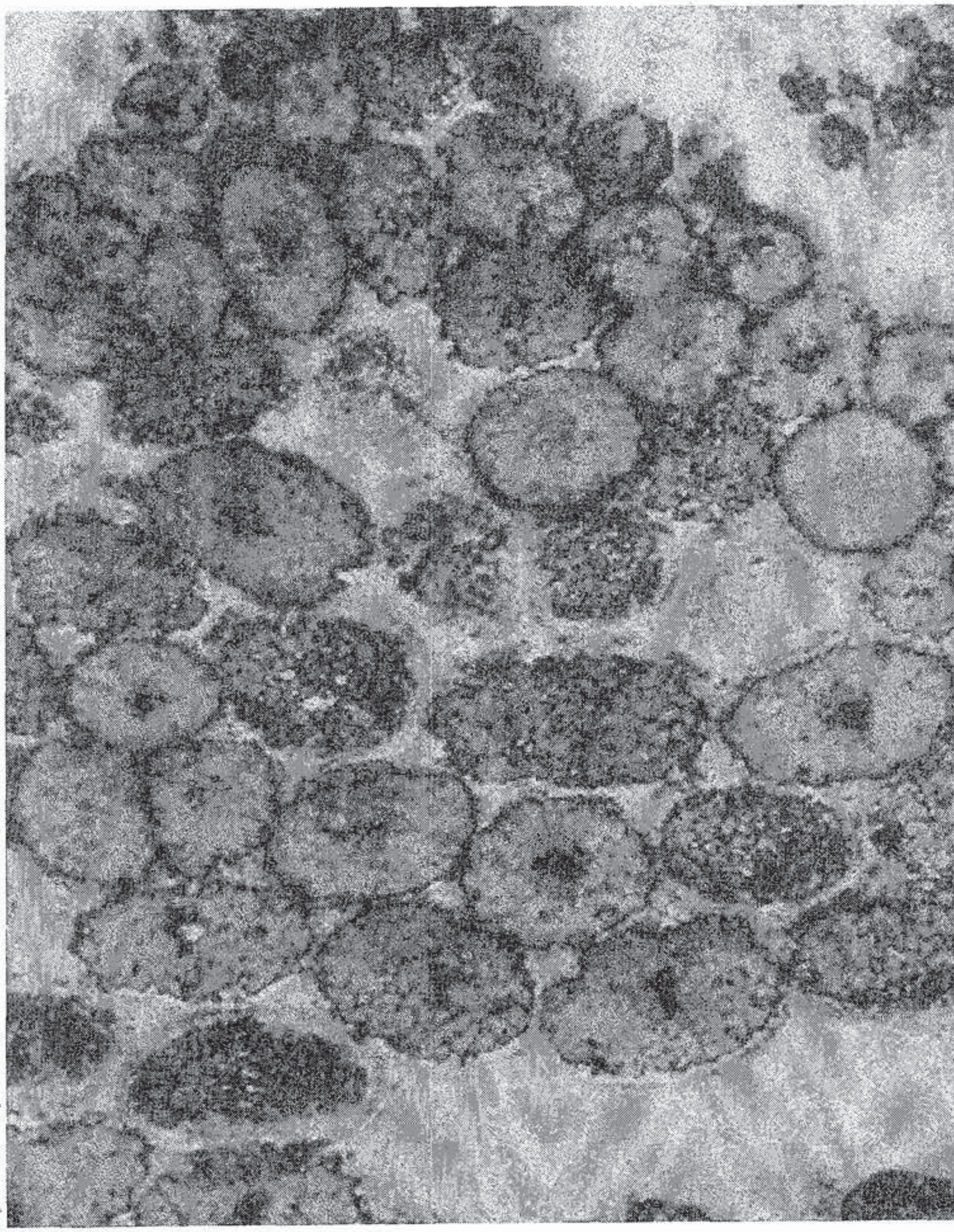
And that leads to something else Donald would love to see growers do: track their field histories.

"You need to get a field history so that you know that the management techniques you're using are actually working. If you're doing something that's making the problem worse, and if you don't test repeatedly, then you don't know whether you're helping.

"You may delude yourself into thinking that you're really taking care of something when you are not." ○

Dave Broghamer (left) and agronomist Kelly Holthaus discuss SCN-resistant varieties.

005621



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SCN Signals Can Trick You

by Fae Holin

Most growers seem to want to find anything but soybean cyst nematode in problem fields.

Maybe that's why it's usually the last thing they look for.

"Farmers will look at pesticides, fertility, soil compaction," says Walker Kirby, University of Illinois plant pathologist. "Soil sampling (for SCN) is usually one of the last things they do."

Maybe that's because SCN is a sneaky little devil, sometimes posing as compaction, herbicide carryover, a nutrient deficiency or any fungal disease imaginable.

"What growers are first seeing is a yellowing of the plants," says John Ferris, a Purdue University nematologist.

That can mean that SCN has a firm hold on those plants – or that the crop has a nutrient deficiency.

SCN is commonly confused with iron chlorosis. But iron chlorosis symptoms usually appear in June; SCN yellowing occurs in July or August.

Some growers hope to cure the yellowing with a shot of manganese, Ferris says. If the crop isn't manganese deficient, however, the beans may look better, but not yield better.

Dry, sandy fields in southern Illinois are often accused of having potash deficiencies rather than SCN. Symptoms of both include a burning or dying of leaf margins, Kirby says.

SCN can be confused with most any fungal-type root disease, Ferris adds.

Some growers may have pockets of phytophthora root rot, rhizoctonia or fusarium root rot, especially if they have heavy soil that stayed wet and cool all spring, warns Pat Donald.

Donald, a University of Missouri extension nematologist, recommends that growers be "good scouts and problem solvers and look at a wide range of things. The best thing a producer can do is dig up a plant and the soil around it and take it to a diagnostic lab to see if there are any diseases."

"Or if they have a thin stand, they can take seed in for a germination test. If they think they have herbicide carryover, they need to go back and look at their records and see what they put on the fields.

"And they can always do a soil test and see if soybean cyst nematodes are present."

Actually, Donald recommends soil testing every soybean field for SCN, whether it appears to have a problem or not. ○

Classic SCN symptoms were confirmed in the above field, but these symptoms are often confused with those for iron chlorosis.

SCN Fooled These Growers

"We got knocked over the head with it last year."

Gary Klaassen is referring to the SCN problem that clobbered his 60-70 clients in 1997.

"We could find the symptoms about everywhere," says Klaassen, a Pioneer sales rep in northwestern Iowa.

He knew there was SCN in his territory, but thought it was limited to a small area. Spotty plant yellowing in other areas was blamed on iron chlorosis, and growers planted chlorosis-tolerant varieties to combat it.

But the spots kept getting bigger, and last year the problem worsened when late-summer weather turned dry.

"The drouth enhanced our cyst nematode problem," he says.

After attending a scouting school at Iowa State University, Klaassen dug up plants and examined the roots with a magnifying glass.

"We found out what the real problem was," he states.

Clients who planted SCN-resistant soybean varieties last year got about 10 bu/acre higher yields than those who didn't. ○


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Take the test. Beat the pest.
The SCN

005624

Soil Testing Diffuses Soybean Time Bomb

Here's how to collect samples

by Stacey Hager

SCN is like a time bomb in the soil waiting to explode.

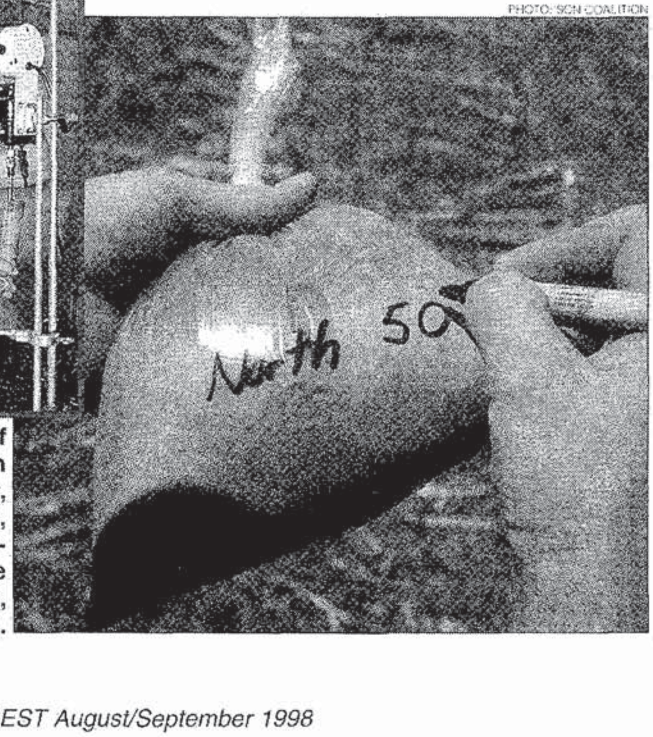
That's how Ann MacGuidwin describes this yield-robbing, microscopic pest.

MacGuidwin, a University of Wisconsin nematologist, says it's important that every grower diffuse the bomb by having soil tested for SCN and then using recommended practices to control the pests.

MacGuidwin recommends that growers test regularly for SCN.

PHOTO: SYL MARKING

PHOTO: SCN COALITION



University of Wisconsin nematologist, Ann MacGuidwin, tests a soil sample, like the one collected at right, for SCN.

Negative test results can ease growers' minds, but are not a guarantee there won't be future problems.

She advises sampling in the fall before every other soybean crop, although samples can be accurately analyzed at any time during the year.

Guidelines for collecting soil samples:

1) Limit the number of acres represented in a single sample. Usually 10-20 acres is ideal. If the field is bigger than that, break it into 10- to 20-acre units.

2) Collect 10-20 soil cores from each field or unit using a probe, hand trowel or shovel. The intensity of sampling depends on the information at hand. If there are problem spots that show up year after year, then sampling efforts can be limited to that area. When there are no obvious symptoms, use the 10-20 cores approach.

In any case, its never a good idea to take fewer than five soil cores because the sample will not be very representative of the field. The more spots you sample, the better.

- Take samples from a depth of 6-8" in the plant root zone.
- Combine the soil in a bucket and mix well. A composite sample mixed well will represent the area better.
- Place 1 pint of soil in a plastic bag or paper soil-test bag.
- Keep samples out of the sun and ship them ASAP to a university or private soil lab. See page 23 for a soil lab listing in your state. Cost ranges from $5 to $24, but some state checkoff boards cover processing costs.

3) Include the following when submitting your samples:

- Name, address and telephone number of farmer or sample collector.
- County and nearest town where samples were collected.
- Estimated acreage of areas sampled.
- Cropping history of areas sampled.
- Current crops of areas sampled.

Each test will give an estimate of SCN population density based on the volume of soil. The standard volume used is 100 cubic centimeters (cc) of soil.

Most labs report the number of SCN eggs, but some give the number of cysts. Cyst and egg counts are not directly comparable. A low cyst count does not equal a low egg count, since each cyst can contain hundreds of eggs. ○

005625

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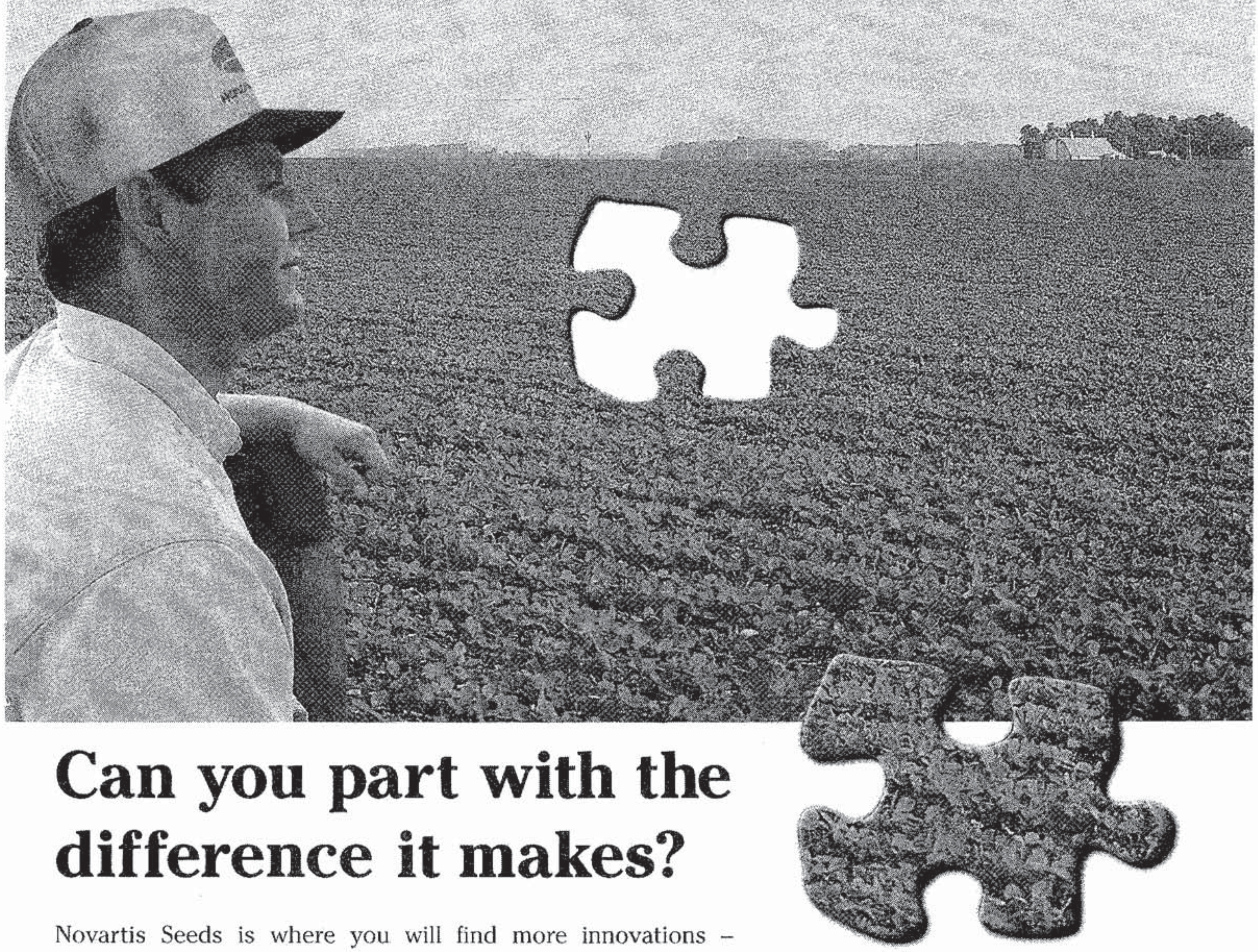

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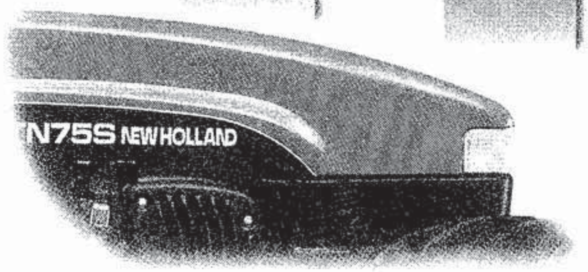

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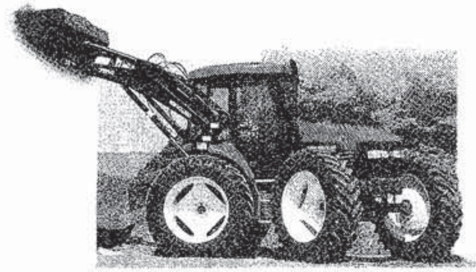

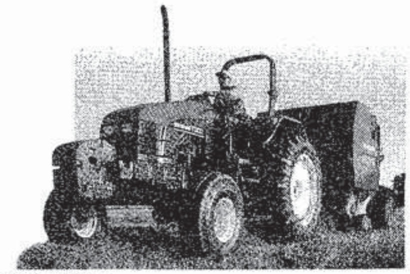

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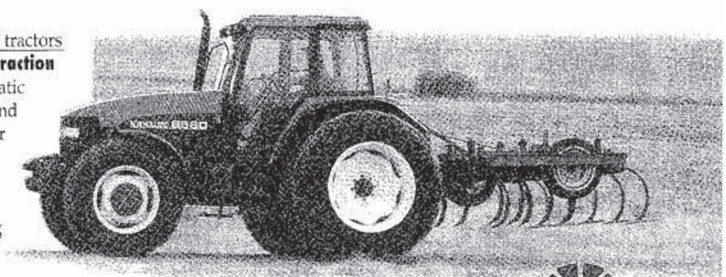

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005627

Outmaneuver SCN

Use crop rotation, resistant varieties – and patience

by Fae Holin

To win the fight against soybean cyst nematodes, rotate crops, plant resistant varieties, and don't be sloppy about weed control, since some weeds are hosts.

But don't expect miracles, says Pat Donald, a University of Missouri extension nematologist.

"It's a long-term proposition. The way you manage nematodes is you starve them out gradually," Donald says.

Just remember that once they infest a field, cyst nematodes can't be totally eliminated.

The year after you discover SCN, plant a non-host crop such as corn, suggests Walker Kirby, a University of Illinois plant pathologist. "The following year, plant a soybean cyst-resistant variety. The third year, plant corn and retest."

If SCN numbers are below threshold, consider planting a susceptible soybean the fourth year. Then go with a corn-to-resistant soybean rotation the two following years, says Kirby.

"The idea behind using a susceptible is that we know there are different races or distinct genetic populations in Illinois and other states. We also know that if you go three to four years with the same resistant soybean in the field, you can shift the race from one that cannot feed on that bean to one that can."

Following resistant beans with resistant beans – rather than a non-host crop – can cause an even quicker race shift, notes Kirby.

Knowing what SCN race you have isn't important in picking a resistant variety because you may have several races within a field, Donald says.

Certain labs will test for race designation, but it takes a month to get results.

"We discourage it," states John Ferris, a Purdue University nematologist. "It's laborious and costly. Once the grower does know the race, the question is, 'so what?'

"We have four races here in Indiana, only one of which has seed labeled for resistance to it. Even if you have a race and plant a variety that says it is resistant to it, there's no guarantee that it will be resistant in that field."

Donald agrees.

"We know there is a lot of genetic diversity in the cyst nematode population. It isn't entirely a moot point whether you have a race 3 or race 5 variety. But, in general, it's better to have some resistance than no resistance."

So how does a grower pick a nematode-resistant variety?

Donald advises Missouri growers to look at variety trial results, especially if some of those sites are infested with SCN.

"Try to match geographically," she says. "Also keep in mind what the egg level is at that site compared to what's in your fields."

Other ways to combat SCN: keep plants as healthy and fields as clean as possible, Donald says. That means using good overall management and cleaning equipment between fields.

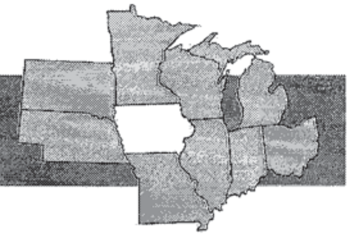
An option that's really not an option to hold back SCN is using nematicides, says Kirby.

"Number one, a lot of pesticides are water-soluble. If you get a heavy rain after application, it actually washes below the root zone," he says.

"Number two, some of these nematicides cause a rebound effect. They cannot kill 100% of the population. The individuals it leaves behind are now able to feed on a root system that is in top condition. More nematodes will reproduce and more will survive."

PHOTO: BOB ELBERT

Growers should plant resistant varieties if SCN numbers are above threshold levels.



Iowan Takes Extra Steps To Battle SCN

Doug Blomgren says there are two types of farmers in his area: those who have soybean cyst nematodes and those who will. And if you're wondering how he knows, the Boone, IA, farmer has battled the pests himself for nearly a decade.

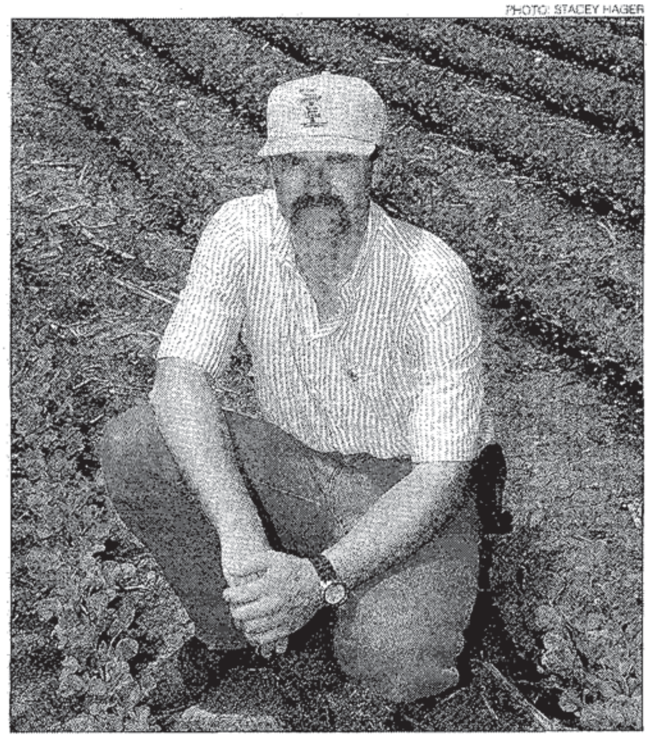
"We started noticing clusters or circles of yellowing plants in a field near our home," he says of his 1988 introduction to SCN. "It looked like chlorosis but different. Not much was known about SCN at the time."

But with help from Iowa State University and hard work, Blomgren, with his brother Dick and uncle Don, started managing SCN for the long haul. After learning they had egg counts of over 14,000 per half cup of soil, the Blomgrens altered their cultural practices and eventually whittled that number to a more manageable 1,200 to 1,300 count.

"Initially, we began working fields from clean areas in toward the bad spots and after working the bad spots, we'd clean and wash the equipment in the field," Blomgren recounts. "We did this for several years and held the problem in check in those hot spots."

In addition, the Blomgrens scout their fields four to six weeks after planting, and dig plants to see if adult females are present on roots. They also rotate to non-host crops, plant SCN-resistant varieties and continue their in-field equipment sanitation regimen.

PHOTO: STACEY HAGER



Doug Blomgren has battled SCN for almost a decade.

As illustrated by the Blomgrens, managing SCN isn't something you do in one year. A planned, well-thought-out strategy covering several years is needed when battling this yield-robbing pest.

The first step is simple: sampling your soils for SCN.

"There's no question that SCN management begins with submitting a soil sample for analysis," says Greg Tylka, an Iowa State University nematologist. "It's the best way to verify the presence and population densities of SCN. Also, despite the fact that visual effects of SCN sometimes include yellowing and stunted plants, the only consistent symptom of SCN is yield loss, and that can't be determined by looking at your crop."

Tylka emphasizes that yield losses typically can range from 10 to 50% – and even higher in extreme cases. But, with proper management and using SCN-resistant varieties, SCN's impact can be dramatically reduced. However, it does require that producers become familiar with SCN identification, soil testing and management options. That's where the SCN Coalition comes in.

The SCN Coalition originated from funding provided by the North Central Soybean Research Program (NCSRP), a 10-state

(Continued on page 23)

Cyst Nematode Management Recommendations For Iowa

Preplant soil sampling: Sample fields to determine SCN population densities, preferably before buying soybeans for the next season but certainly before planting soybeans.

Although SCN population density is only one component in yield loss, it is indicative of the potential for yield loss and is information vital for sound SCN management decisions.

Resistant varieties: SCN-resistant soybean varieties are an important tool in SCN management. Planting resistant varieties will reduce yield loss due to SCN and prevent increases in SCN population densities.

Although some of the first resistant varieties lagged behind susceptible varieties in yield, even these early resistant varieties outyielded susceptible varieties in SCN-infested fields. Newer SCN-resistant varieties do not suffer the same yield penalty of their predecessors on non-infested fields.

Resistant varieties should be planted when SCN eggs are detected, since yields of susceptible soybeans likely will be reduced and SCN population densities will increase greatly. Resistant varieties are not immune and should not be planted when SCN egg counts exceed 5,000 eggs per 100 cc of soil. Their yield can be reduced by root damage or lack of nitrogen-fixing nodules due to high SCN population densities.

Fields with high SCN population densities always should be rotated to non-host crops to reduce SCN numbers before planting even resistant soybeans. Crop rotation will maximize yield and prevent SCN race shifting and the loss of the usefulness of certain resistant varieties.

PHOTO: BOB ELBERT

Rotation with non-host crops: Non-host crops grown in rotation with SCN-resistant varieties are the cornerstones for SCN management. Growing non-host crops will reduce SCN population densities. High SCN population densities (>5,000 per 100 cc of soil) are best managed by rotating to a non-host crop such as corn, a small grain or alfalfa until population densities are lowered.

Once population densities have been reduced below 5,000 eggs per 100 cc of soil, a six-year rotation scheme incorporating non-hosts, SCN-resistant and susceptible soybean varieties can prevent SCN population density buildup and race shifting and reduce soybean yield loss.

Suggested crop rotation

Year 0 – identification of SCN.
Year 1 – non-host crop.
Year 2 – PI 88788 SCN-resistant soybean variety.
Year 3 – non-host crop.
Year 4 – Peking SCN-resistant soybean variety.
Year 5 – non-host crop.
Year 6 – SCN-susceptible soybean variety.

Cultural practices: Providing a plant the best possible growing conditions will reduce stress and yield loss due to SCN. Maintain optimum soil fertility to optimize plant growth and development. Weed control not only reduces plant stress, but some weeds act as alternate hosts of SCN. Disease control and insect control maintain plant health and minimize SCN damage.

Sanitation: Avoid spreading SCN from infested to uninfested fields. If possible, plant non-infested fields first and power-wash equipment after working infested fields.

Nematicides: Nematicides may reduce yield loss of SCN-susceptible varieties planted in infested fields, but will increase the cost of production. Although a nematicide application may give early season protection against yield loss, it will not reduce nematode population densities in the long term. Final SCN population densities often are as high as if a nematicide had not been used.

Results obtained from nematicides may vary by soil type, weather and many other factors. Consequently, growers are advised to try nematicides in strips first to determine the potential for economic benefit before implementing field-wide applications.

For information, contact:
Greg Tylka
Dept. of Plant Pathology
Iowa State University
351 Bessey Hall
Ames, IA 50011
Phone: 515-294-3021
Email: gltylka@iastate.edu

Please send soil samples to:
Plant Disease Clinic
323 Bessey Hall
Dept. of Plant Pathology
Iowa State University
Ames, IA 50011

IOWA STATE UNIVERSITY
University Extension

Extra Steps

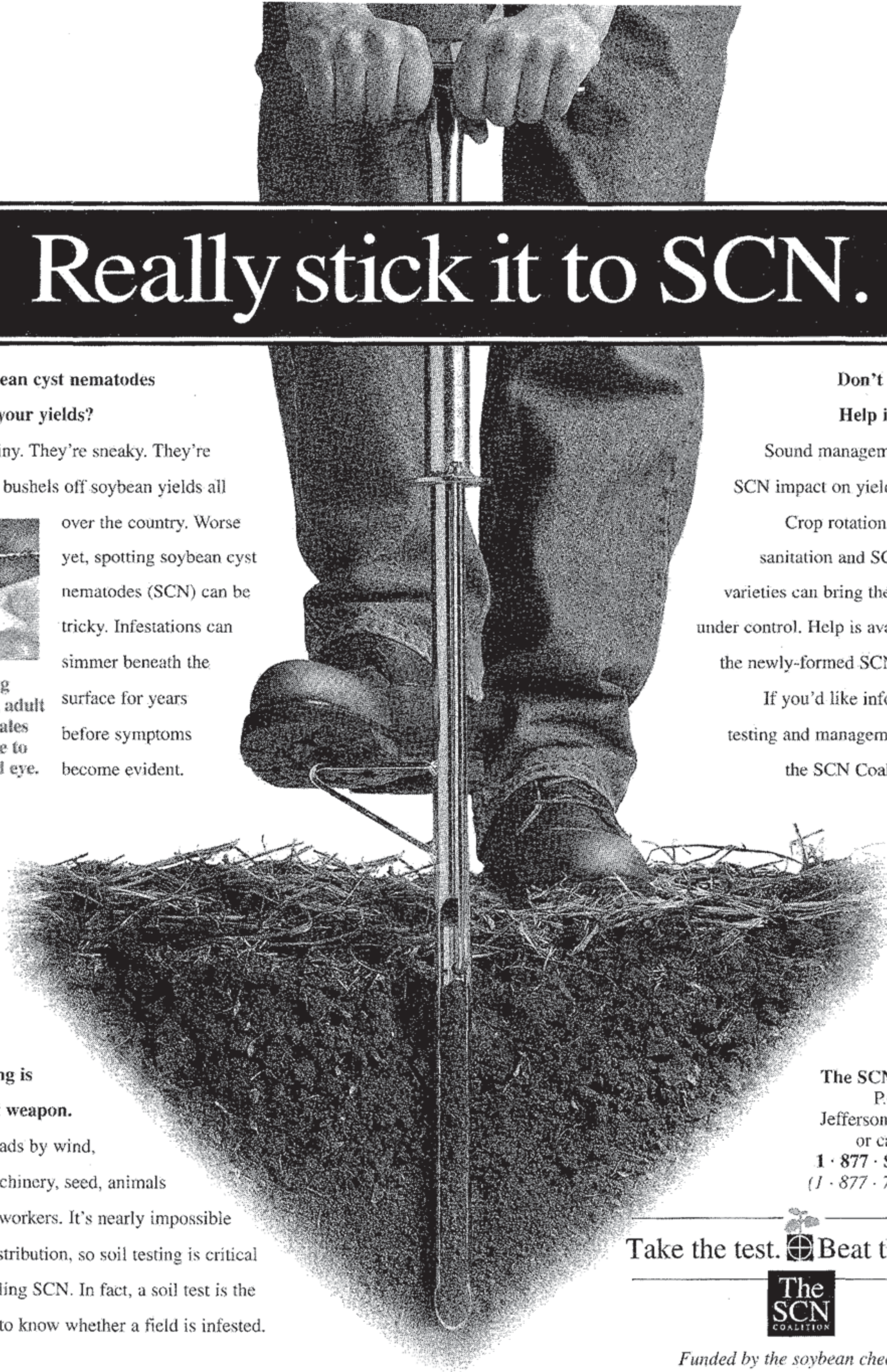
(Continued from page 21)

alliance of state soybean checkoff boards which fund soybean research projects. The 10-member farmer board designated SCN a priority and approved the creation of an education and awareness program.

"The rapid spread of SCN into the North Central grain-producing region requires producers to scout, sample and manage their soils for SCN," says Paulette Pierson, SCN regional education coordinator for the SCN Coalition. "SCN is responsible for millions in lost soybean yields and profits in Iowa. If we're successful in educating producers about the value of SCN management, our effort's impact on a producer's bottom line could be significant."

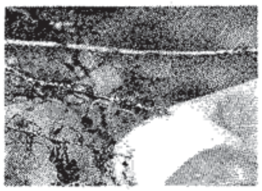
And if you don't believe managing SCN can have a big impact on a grower's bottom line, just ask Doug Blomgren.

Really stick it to SCN.



Are soybean cyst nematodes robbing your yields?

They're tiny. They're sneaky. They're knocking bushels off soybean yields all over the country. Worse yet, spotting soybean cyst nematodes (SCN) can be tricky. Infestations can simmer beneath the surface for years before symptoms become evident.



When dug carefully, adult SCN females are visible to the naked eye.

Don't go it alone. Help is available.

Sound management reduces SCN impact on yield and profit. Crop rotation, equipment sanitation and SCN-resistant varieties can bring the infestation under control. Help is available from the newly-formed SCN Coalition. If you'd like information on testing and management, contact the SCN Coalition today.

Soil testing is your best weapon.

SCN spreads by wind, water, machinery, seed, animals and farm workers. It's nearly impossible to stop distribution, so soil testing is critical to controlling SCN. In fact, a soil test is the *only* way to know whether a field is infested.

The SCN Coalition
P.O. Box 381
Jefferson, WI 53549
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(1 · 877 · 726 · 8378).

Take the test. Beat the pest.

The SCN Coalition

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Disease Note.

First Report of Heterodera glycines on Soybean in South Dakota. J. D. Smolik, Plant Science Department, South Dakota State University, Brookings, 57007. J. L. Jones, and D. L. Gallenberg, Plant Science Department, South Dakota State University, Brookings, 57007; and J. P. Gille, Union County Extension Office, Elk Point, 57025. Plant Dis. 80:224. Accepted for publication 21 December 1995. DOI: 10.1094/PD-80-0224F.

Soybean fields in 12 eastern South Dakota counties were surveyed for the soybean cyst nematode (Heterodera glycines Ichinohe) during the 1995 growing season. The 255 fields included in the survey had a 10- to 15-year history of soybean production (primarily in rotation with corn), and were selected with the aid of local extension service agents. In the initial phase of the survey, H. glycines was detected in a single field of the 23 sampled in Union County, which is located in the extreme southeastern corner of South Dakota. Twenty-two additional fields within 2 to 3 km of the original field were assayed for H. glycines. The nematode was confirmed in 10 (45%) fields. Nematode identification was based on cyst morphology (2), presence of males, and reproduction on soybean in greenhouse studies. Reproduction of the original H. glycines isolate on the race differentials (1) was consistent with the definition of race 3.

References: (I) A M. Golden el al. Plant Dis. Rep. 54:544, 1970. (2) R. H. Mulvey and A. M. Golden. J. Nematol. 15:1, 1983.

PLANT DISEASE MANAGEMENT IN SOUTH DAKOTA

Soybean Cyst Nematode

South Dakota Extension Fact Sheet 902-A
Revised February 2007

by
James D. Smolik
Research Nematologist

Martin A. Draper
Extension Plant Pathologist

SDSU Plant Science Department

History and Importance of SCN

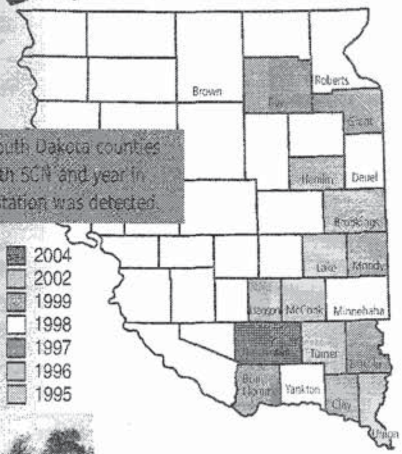

Figure 1. South Dakota counties infested with SCN and year in which infestation was detected.

The soybean cyst nematode (SCN), *Heterodera glycines* is a serious threat to South Dakota soybean production. It was reported from Japan more than 75 years ago and was first found in the United States in North Carolina in 1954. Currently in North America, SCN occurs in 28 states and one Canadian province. **SCN is the most damaging pest of soybeans in the U.S. Losses from SCN in the U.S. have been estimated at $1 billion annually.** In South Dakota, SCN was first detected in Union County in 1995 and is currently found in 19 counties (Fig 1). While it has not yet been found in all soybean-producing counties, soybean cyst nematodes are hardy and are likely to survive anywhere soybeans are produced in South Dakota.

Figure 2. Unless managed, SCN has the potential to devastate soybean fields. In most instances, SCN damage is not nearly as severe as in this field.

Figure 3. Lower populations of SCN may not cause dramatic above-ground symptoms, but yields are still reduced. The susceptible variety in this photo yielded 28% less than the resistant variety. This photo is more typical of SCN damage.

Figure 4. Uneven growth (roller-coaster effect) and yellowed patches due to SCN.

Injury Symptoms

Very low populations of this nematode do not cause obvious symptoms. In a corn-soybean rotation, it may take 8–12 years for SCN population densities to increase to damaging levels. Continuous cropping of soybeans or rotating soybeans with another susceptible crop such as dry beans will dramatically shorten this time interval. Detection of SCN may be difficult because it can reduce yields by as much as 30% with no obvious symptoms. One indication that SCN may be present is declining soybean yields in portions or all of a field. Symptoms of SCN often include stunting (Fig 2, 3 and 4). The stunting may be fairly general across the field, but it is more often expressed as a roller-coaster effect (Fig 4). Additionally, fields infested with SCN often have areas where the plants are slow to close the rows. Infected plants may become yellow in July or August, and they may have reduced vigor or mature earlier than those in surrounding areas of the field.

Biology of SCN

Nematodes are unsegmented roundworms. Most plant parasitic types are very small and feed on or in roots by means of a stylet (Fig 6 inset), a hollow, needle-like structure used to pierce plant cells and withdraw nutrients. The adult females of SCN are about 1/32 of an inch long and are visible to the unaided eye (Fig 11). Various stages in the life cycle of SCN are shown in Figures 6–10. Under favorable conditions, the life cycle can be completed in 4–5 weeks.

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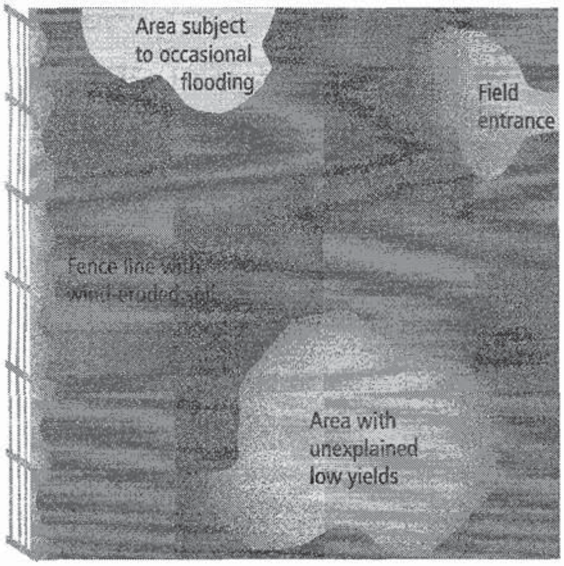


Figure 5. The first step in SCN management is to recognize the problem. Collect soil samples prior to planting or after harvest and submit for analysis. Include soil samples from high-risk areas where nematodes may have been introduced:
- Field entrances
- Fence lines
- Areas subject to occasional flooding
- Areas with unexplained low yields.

STAGES IN SCN LIFE CYCLE

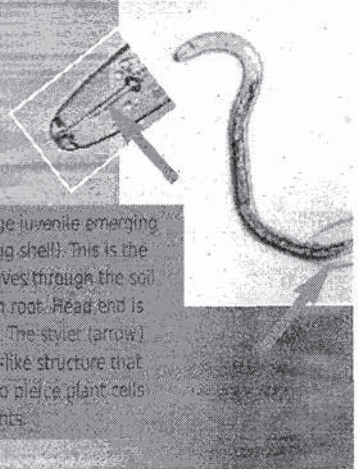


Figure 6. Second stage juvenile emerging from an egg (note egg shell). This is the infective stage. It moves through the soil and enters a soybean root. Head end is enlarged in the inset. The styler (arrow) is the hollow, needle-like structure that the nematode uses to pierce plant cells and withdraw nutrients.

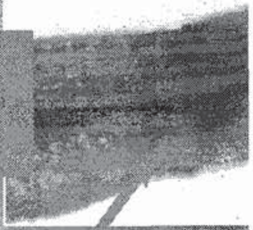


Figure 7. As the nematode feeds within the soybean root, it gradually enlarges.

Figure 8. Freshly emerged female cyst nematode. Note gelatinous matrix at rear of nematode.

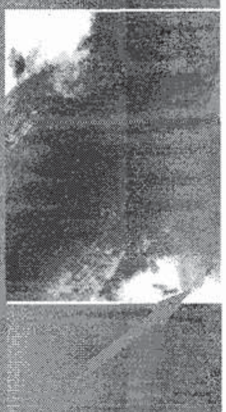


Figure 9. Cyst nematode attached to root opposite a large scar where another cyst nematode emerged. Some of the eggs are laid in the gelatinous matrix (arrow). As the nematode matures, her body covering becomes tougher and thicker and forms a protective cyst for the eggs inside.

Figure 10. Ruptured cyst. The cyst is a dead female nematode that may contain several hundred eggs. Eggs within cysts may remain viable for as long as 10 years.

Management of Soybean Cyst Nematodes (SCN)

The overall objective of SCN management is to reduce the nematode population below the level that may result in significant yield losses. Once SCN has become established, there is no practical way to eliminate it from a field. SCN can, however, be effectively managed through combined use of the three Rs:
- Recognition of the problem.
- Rotation with a non-host crop.
- Resistant soybean varieties.

SOIL SAMPLING

The first and most important step in management of SCN is recognition of the problem. Soil sampling will determine the presence of the nematode and its population levels. Soil samples can be collected any time, but fall sampling is generally preferred because it provides adequate time to employ SCN management techniques.

The Soybean Cyst Nematode (SCN) Soil Sampling Information Sheet, available at county extension offices or online at: agbiopubs.sdstate.edu/articles/PSstl-scn.pdf, provides a convenient method for supplying the necessary information (field location, cropping history, grower's address, etc.) when submitting a sample. The reverse side of the sheet contains instructions for collecting the soil sample. Samples for SCN analysis should be collected to a depth of 6 inches and do not need to be air dried before mailing to the **Nematode Testing Services, PSB 117, Box 2108, SDSU, Brookings, SD 57007.** Areas of a field where SCN may have been introduced should be included in soil sampling (Fig 5). The presence of SCN can also be confirmed by carefully digging plants in late July or August and examining roots for white females (Fig 11).

CROP ROTATION

Crop rotation using non-host crops to reduce SCN populations is an essential component of SCN management. High SCN population densities (above 1000 eggs per 100 cm^3 soil—less than a half cup) are best managed by rotating to a non-host crop such as corn, small grains, sunflowers, flax, canola, or alfalfa followed by a SCN-resistant soybean variety. If adapted, SCN-resistant varieties are not available, longer rotations with non-host crops will be required between soybean crops. Dry beans are an excellent host for SCN and should not be rotated with soybeans.

RESISTANT VARIETIES

SCN-resistant soybean varieties, in combination with crop rotation, are a very important management tool (Fig 12). Planting SCN-resistant soybean varieties will reduce yield loss due to SCN and also will reduce SCN population densities. In field plot tests conducted over an eleven-year period, yields of SCN-resistant lines have been 23–63% higher than susceptible (Fig 13). It is best to plant a SCN-resistant variety in fields where SCN has been detected even when population densities are low (less than 150 eggs per 100 cm^3 soil). If a susceptible variety is planted the SCN population will rapidly increase to very damaging levels. Fields with extremely high SCN populations (greater than 5000 eggs per 100 cm^3 soil) should be rotated to non-host crops to reduce SCN numbers before planting resistant soybean varieties.

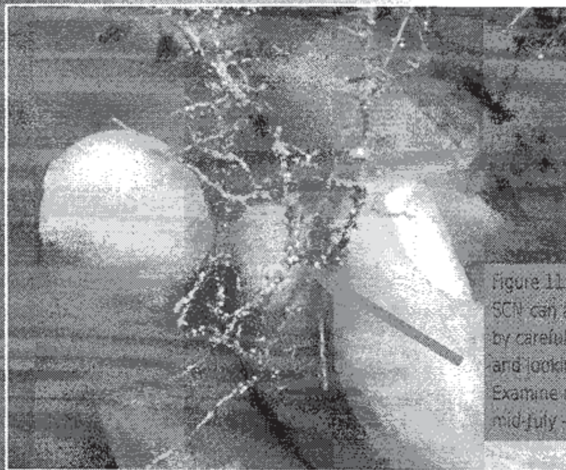


Figure 11. The presence of SCN can also be determined by carefully digging roots and looking for white females. Examine roots for SCN from mid-July – August.

Figure 12. Resistant varieties are one component of effective SCN management. Yield of the resistant variety in this photo was three times that of the susceptible variety.

Photos: J.D. Smolik

PLANT HEALTH

Providing optimal growing conditions for the crop will reduce stress and yield loss due to SCN. Careful seedbed preparation and adequate soil fertility will improve plant growth and development. Management of weeds, diseases, and insects reduces plant stress and minimizes SCN damage.

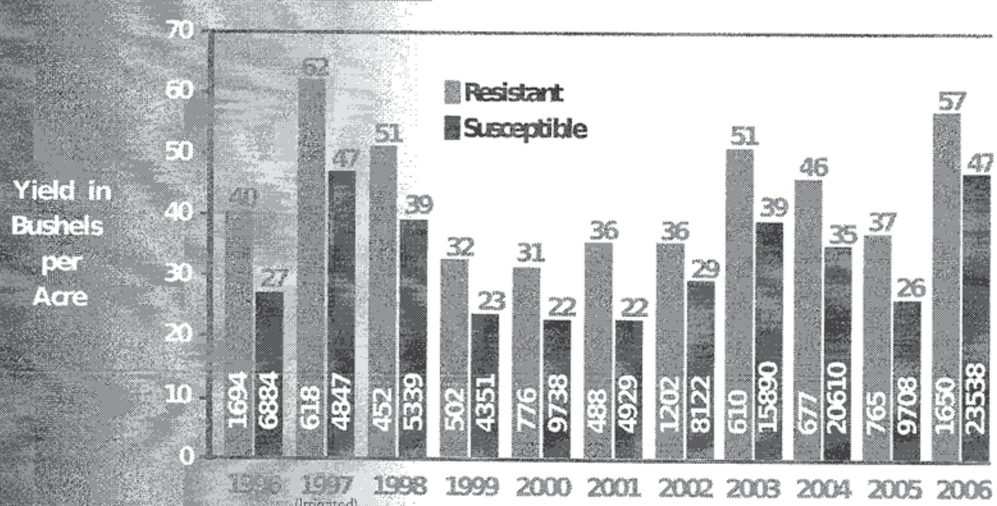
SANITATION

Anything that moves soil can move SCN. Avoid spreading SCN from infested to uninfested fields. If possible, uninfested fields should be planted first and equipment should be power-washed after working infested fields. Soil peds in seed stocks may contain SCN; therefore, plant only properly cleaned seed. Tillage practices that reduce wind and water erosion also can slow the spread of SCN.

NEMATICIDES

Nematicides have not been tested for control of SCN in South Dakota. Data from other states indicates nematicides can suppress early-season SCN populations and increase yields. However, nematicides may not provide season-long SCN control, and final nematode populations may be as high or higher in nematicide-treated areas as in non-treated. Also, nematicides increase production costs and are extremely toxic. Longer-lasting and more economical control can be achieved with rotation and resistant varieties.

Figure 13. Average yield of resistant and susceptible soybean varieties in test plots in Clay, Roberts, Turner, and Union counties, South Dakota, 1996–2006.



* Numbers inside columns are population densities of SCN eggs plus second-stage juveniles per $100cm^3$ soil at harvest.

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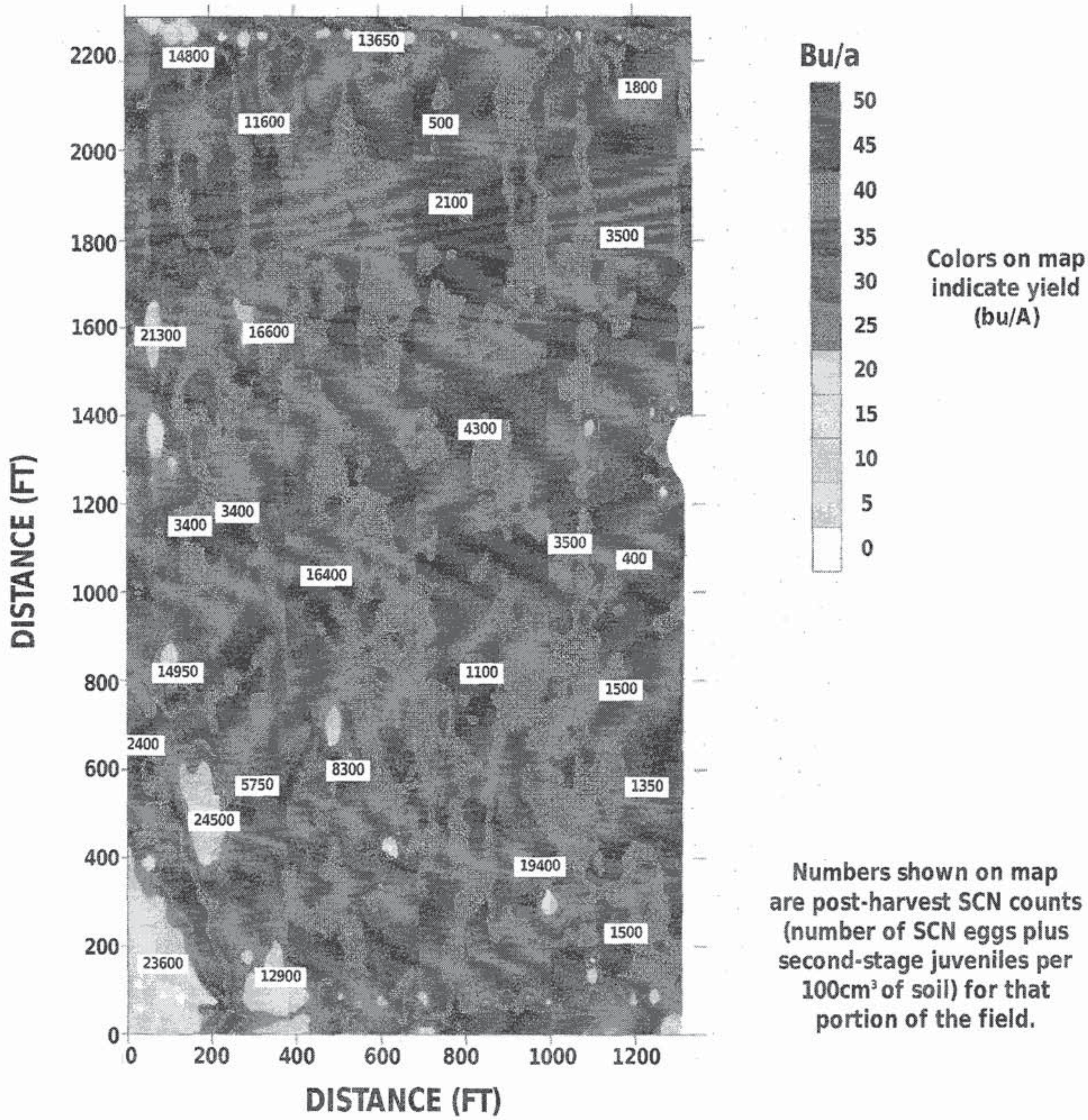
Figure 14. Map of soybean yields and SCN populations, irrigated field, Turner Co.



A yield map was prepared for an irrigated field in Turner County. The field had been planted to corn for the three years prior to planting a SCN-susceptible soybean variety. About mid-August, symptoms typical of SCN damage (stunted, yellow plants) began to appear in the field, especially in the southwest portion.

A yield map of the field (Fig 14) revealed several "pockets" of low- to very low-yielding areas. Soil samples were collected from these pockets and from higher-yielding areas and SCN population densities were measured. In general, there was a good correlation between low-yielding areas and high SCN populations (Fig 14).

The patchy distribution of SCN is typical of well-established SCN infestations encountered in SDSU research surveys and indicates the importance of obtaining representative soil samples. Although SCN damage was obvious in this field for much of the growing season, yield maps such as this may be useful in detecting earlier stages of a SCN infestation.

Also, it should be noted that even though a nonhost crop was planted the previous three years, SCN survived at very damaging levels in much of the field. This is an example of the management difficulties this nematode can present, and indicates the importance of testing soil for SCN.

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SOYBEAN CYST NEMATODE IN NORTH CAROLINA

N. N. Winstead, C. B. Skotland and J. N. Sasser[1]

A cyst-forming nematode of the genus Heterodera has been found parasitizing soybean (Glycine max (L.) Merrill) in Southeastern North Carolina. Examination of soybean roots from small areas where the plants were severely stunted and chlorotic (Fig. 2), revealed the presence of numerous lemon-shaped female nematodes attached to the roots (Fig. 1). Soil samples from infested areas were found to contain several thousand cysts per pint of soil. Males were also very numerous.

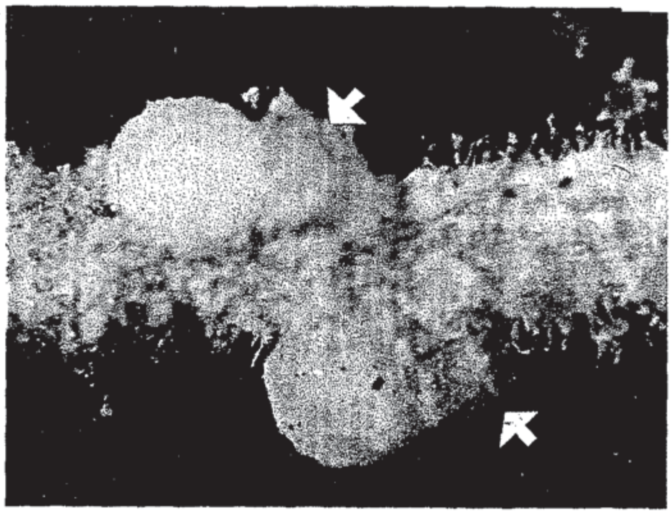

FIGURE 1. Soybean root showing attached female nematodes. Note egg masses (arrows) attached to the females. Approx. 37.5 x. (Photograph by Dr. C. J. Nusbaum).

This nematode has been tentatively identified as the soybean cyst nematode, Heterodera glycines Ichinohe, 1952[2, 3]. Two other Heterodera species are known to attack legumes -- the pea cyst nematode, H. göttingiana Liebscher, 1892, and the clover cyst nematode, H. schachtii trifolii Goffart, 1932. Mature cysts of the soybean cyst nematode can be distinguished from those of the pea cyst nematode by the presence of dark bodies (brown knobs) at the posterior end. These are absent in the pea cyst nematode. The clover cyst nematode apparently does not attack soybeans[4].

Investigations on the morphology and biology of the nematode, including field and laboratory experiments, are in progress. A survey is also being conducted to determine if the nema-

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[1] Assistant Professor of Plant Pathology, Vegetable Research Laboratory, Castle Hayne, North Carolina, Plant Pathologist, Field Crops Research Branch, Agricultural Research Service, and Assistant Professor of Plant Pathology (Nematode Diseases), North Carolina State College, Raleigh, North Carolina, respectively.

[2] Ichinohe, Minoru. 1952. On the soybean nematode Heterodera glycines n. sp. from Japan. Magazine of Applied Zoology 17: 1-4.

[3] Specimens were sent to Mr. A. L. Taylor, Section of Nematology, Plant Industry Station, Beltsville, Maryland, for identification.

[4] Gerdemann, J. W. and M. B. Linford. 1953. A cyst-forming nematode attacking clovers in Illinois. Phytopath. 43: 603-608.

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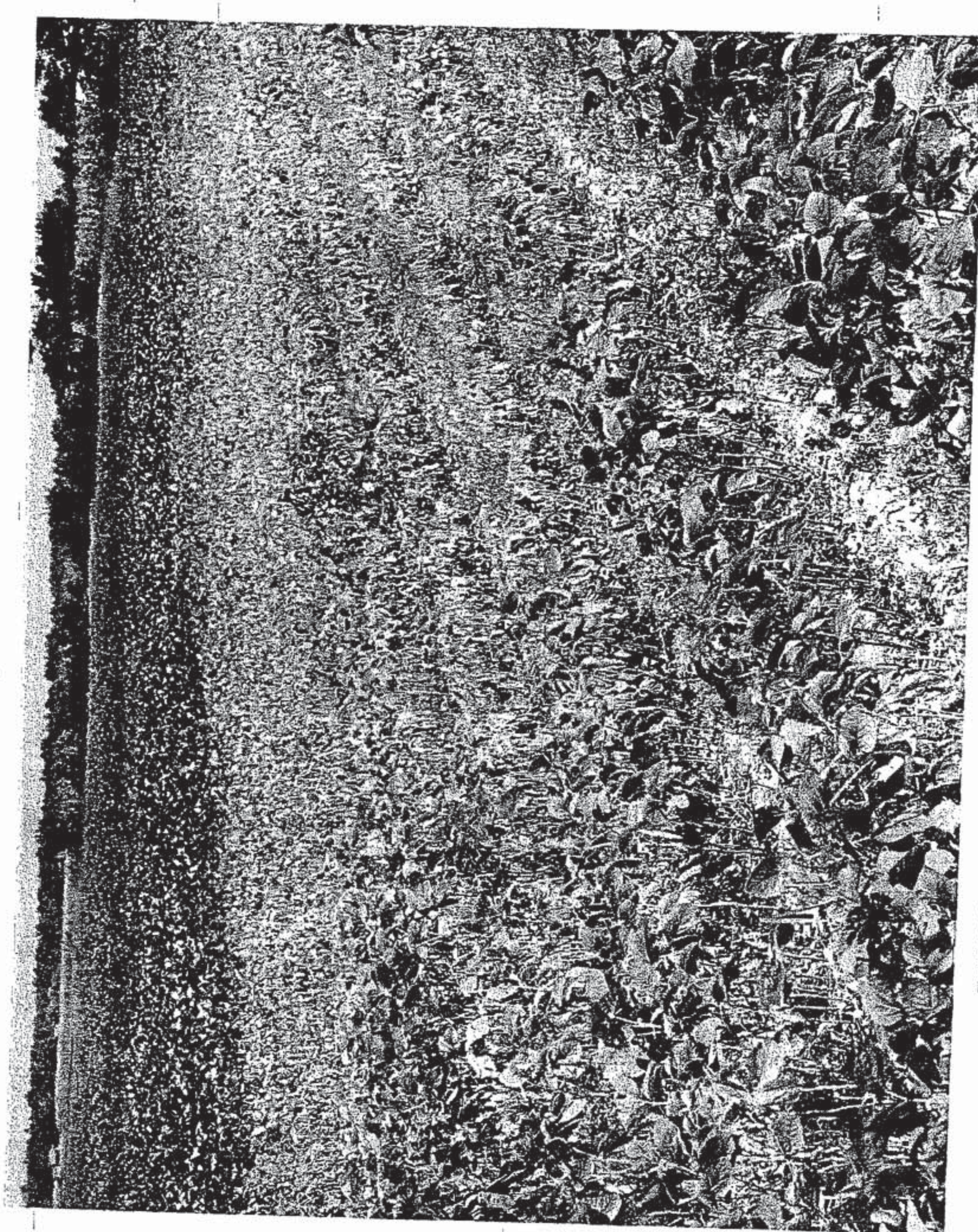

FIGURE 2. Soybean field infested with the soybean cyst nematode, *Heterodera glycines*. (Photographed by Mr. Ralph Mills).

tode is widespread in North Carolina. The known distribution of this species is Japan (Hokkaido, Honshu), and China (Manchuria)[2]. It has not been previously reported as occurring in the United States.

VEGETABLE RESEARCH LABORATORY, CASTLE HAYNE, NORTH CAROLINA, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, AND NORTH CAROLINA STATE COLLEGE, RALEIGH, NORTH CAROLINA

FIGURE 2. Soybean field infested with the soybean cyst nematode, *Heterodera glycines*. (Photographed by Mr. Ralph Mills).