Science Societies

Soybean cyst nematode management in the western Corn Belt

By Susan Winsor

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Soybean roots with soybean cyst nematode females (the white, round objects coming out of the roots). Photo by Angela Tenney, Michigan State University ANR Communications and Marketing.

This is the second article of a four-part series on soybean cyst nematode management. This article focuses on the western Corn Belt (specifically Nebraska and Kansas). Last issue, we discussed the Corn Belt in general; this issue, we'll talk about some of the challenges unique to Nebraska and Kansas. Subsequent articles will address the South and the Mid-Atlantic states.

How can invisible microscopic worms steal large parts of your soybean yield? Soybean cyst nematodes (SCN) can steal up to 40% of soybean yields without even showing an aboveground disease symptom.

"SCN awareness among farmers was my biggest disappointment," says Doug Jardine about his Kansas State University Extension pathologist career. "I could not get growers to give a darn; perhaps out of sight is out of mind. Fewer than 10% of Kansas farmers surveyed had ever sampled for SCN."

This top threat to U.S. soybean production has accompanied the western Corn Belt's increasing number of soybean acres: Nebraska is seventh and Kansas tenth in U.S. soybean production. All states need more vigilance and urgency in controlling SCN if they expect to be profitable soybean producers, says Tamra Jackson-Ziems, University of Nebraska nematologist and Extension plant pathologist. Soybean cyst nematode accounts for a 5 to 10 bu/ac yield reduction or more. Some Nebraska soil samples have registered populations as high as 136,000 eggs per 100 cm^3 (half cup) of

soil.

“SCN has now been confirmed in 59 Nebraska counties covering almost the entire eastern half of Nebraska,” says John Wilson, Nebraska Extension educator emeritus. “These counties produce over 93% of the state’s soybeans.”

Since SCN was first confirmed in Nebraska’s Richardson County in 1986, Jackson-Ziems says most soybean varieties now offer some genetic resistance to SCN with about 96% of this resistance coming from PI 88788.

“Although SCN has been known in [Kansas] for 35 years, there are areas of intensive soybean production with more than 50% prevalence,” says Kansas State nematologist Timothy Todd. “Some of our highest SCN population densities occur in sandy soil, typically in irrigated western Kansas. Since Kansas has a more marginal environment for soybean production than the main Corn Belt, soybeans are frequently irrigated.”

Water (including irrigation) can reduce SCN yield loss greatly, but it will not eliminate yield loss completely, says Iowa State University nematologist and SCN expert Greg Tylka. “And increases in SCN population densities will continue as the nematode reproduces throughout the growing season, even if irrigation mitigates yield loss.”

You might expect the shortest soybean plants to host the most SCN, but actually the healthiest-looking plants sustain more reproducing SCN females, according to Nebraska’s Jackson-Ziems. “Healthier plants mean bigger root systems with more feeding sites available. Unexplained patches of yield loss are the most common SCN symptom. Another SCN indicator is patches of sudden death syndrome (SDS). Both SDS and SCN enter soybean plants through their roots. While each can cause the disease on its own, SCN hastens symptom development and increases their severity, increasing yield losses.”

When visible symptoms of SCN injury do appear, they can easily be confused with other problems including potash deficiency, herbicide injury, seedling blight damage, iron chlorosis, charcoal rot, drought, Phytophthora root rot, and soil compaction," Kansas State's Todd says.

Farmer awareness of SCN is a challenge for CCA Calvin Rupe, Aurora Cooperative Elevator Co. (Nebraska). "My clients are aware that SCN is here, but there's a lot of misconceptions because it's not as easily identifiable as other problems. Last year, SDS ate us alive here with the wet weather. If we don't have aboveground symptoms accompanying a yield drop, I like to pull a soil sample and get a SCN count. There's no cost in Nebraska to submit a sample.

"Last year, for example, a patch of one field with notoriously high pH was off. I dug up some plants and spotted SCN females—they resemble small lemons."

Rupe typically advises two years of a non-host crop (such as corn), a SCN-resistant variety, fall herbicide burndown to eradicate winter annuals (which can host SCN), and seed treatment for SDS/SCN such as Clariva Complete, ILeVO, or Saltro, he says.

"Where both SDS and SCN occur, SDS symptoms develop earlier in the season and to greater severity levels throughout the season when SCN is present compared to if SCN were not present," says Iowa State's Tylka. "SCN worsens SDS damage and yield loss by causing SDS symptoms to occur earlier in the season and to develop to more severe levels throughout the season."

Soil pH also plays a role with SCN vulnerability. University research found that SCN populations of soil pH 7.1-8 averaged 3.8-fold higher than those at soil pH 5.8–6.4. See **https://bit.ly/SCN_pH** for study details. "Increasing soil pH has a profound effect on the degree of yield loss from SCN," the study's researchers concluded.

Control Measures

Kansas State's Jardine and Todd emphasize the importance of monitoring in controlling SCN. Jardine advises producers to "assume every field is SCN-infested until you have evidence that it is not" while Todd points out that it "requires a long-term focus."

Know Your SCN Number

"Control starts with sampling, and not just once," Todd says. "Monitoring can tell you if nematode populations are increasing even though 'resistant' varieties are being grown."

Test before every third soybean crop, Tylka recommends, after harvest. Sample at the same time of year, following the same crop, and send samples to the same lab for consistent comparisons.

"If your SCN egg count increases, it could indicate your SCN population can reproduce on the most common source of resistance, PI 88788, found in over 95% of resistant soybean varieties," says Nebraska's Wilson. "In that case, select SCN-resistant soybean varieties with sources of resistance other than PI 88788. Look for varieties that list 'Peking' (PI 548402) as the resistance source. It is found in less than 5% of SCN-resistant varieties commercially available."

Nebraska's Jackson-Ziems recommends focusing especially on field zones that did not yield what you had expected.

Threshold levels where measurable yield loss occurs vary with environment but are lowest under conditions with coarse-textured soils, long growing seasons, and warm temperatures, Todd says.



"Control starts with sampling, and not just once," says Kansas State's Timothy Todd. "Monitoring can tell you if nematode populations are increasing even though 'resistant' varieties are being grown." Source: Shutterstock/Nolanberg11.

"In Kansas, economic damage in coarse-textured soils can occur with as few as 300 eggs per 100 cm^3 of soil at planting or 1,000 eggs per 100 cm^3 of soil in fine-textured soils," he says. "When SCN egg counts exceed 5,000 eggs per 100 cm^3 in coarse-textured soils or 10,000 eggs per 100 cm^3 in fine-textured soils, consider non-host crops instead of even SCN-resistant soybean varieties."

A zero SCN count doesn't necessarily mean there is no SCN in the field, Jardine adds. "They are not uniformly distributed across a field; they exist in clumps."





A light-to-moderate SCN infestation (left) can cause slight difference in height on otherwise healthy-appearing plants. Yellow, stunted soybean plants (right) are damaged by a severe SCN infestation. These areas are often circular or oval. Source: University of

*Nebraska–Lincoln Extension, NebGuide G1383 (**https://bit.ly/2YE3GwL**).*

“A new SCN generation is born every 24 days during summer,” Tylka says. “What might have started out as one in a million SCN worms being resistant (meaning being able to reproduce on PI 88788 resistance) now becomes one in four or one in three as PI 88788 resistance is grown continually over decades. Even if you have an extremely low SCN population, like 200 eggs per half cup of soil, and 98% don’t survive to adulthood, you still can end up with 10,000 eggs per half cup of soil in a single growing season.”

The bottom line is “soybean varieties with PI 88788 SCN resistance no longer control SCN well in many fields … and farmers are losing yield as a result of increased SCN reproduction on resistant soybean varieties,” Tylka says.






Crop rotations to non-host crops like corn, wheat, sorghum, and alfalfa could help control soybean cyst nematode (SCN) numbers.

Choosing the Right Variety Pays

Choosing an effective resistant variety can make a huge difference in your yields and your SCN numbers, according to annual Iowa State University SCN-resistant variety trials. In 2019, there were 69 SCN-resistant soybean varieties and three susceptible varieties representing 18 different brands studied and compared in three SCN-resistant variety trial experiments across northern, central, and southern Iowa.

In an experiment in southeastern Iowa where SCN reproduction was high, on average, varieties with PI 88788 resistance yielded 51 bu/ac, whereas varieties with Peking SCN resistance yielded 72 bu/ac (see graph). Also, SCN numbers decreased by 80% in plots where varieties with Peking SCN resistance was grown, but SCN numbers increased up to 900% on individual varieties with PI 88788 resistance. Put another way, SCN populations ranged from greater than 10% reproduction to 71% reproduction on PI 88788 (HG Type 2).

For many SCN populations, Peking offers much more SCN resistance than PI 88788, university trials show (see **https://bit.ly/SCN_trials**). Yet 95% of commercially available resistant varieties are based upon PI 88788, says Iowa State University nematologist and SCN expert Greg Tylka.

Here are a few things you may not know about SCN genetic resistance:

“The ‘yield drag’ associated with Peking SCN resistance (i.e., lower yields when grown in non-SCN fields) has diminished greatly over the years due to continued improvement of the yield potential of Peking varieties through plant breeding,” Tylka says. “Now, SCN very often ‘drags down’ yields of PI 88788 varieties more than any remaining ‘yield drag’ associated with Peking.

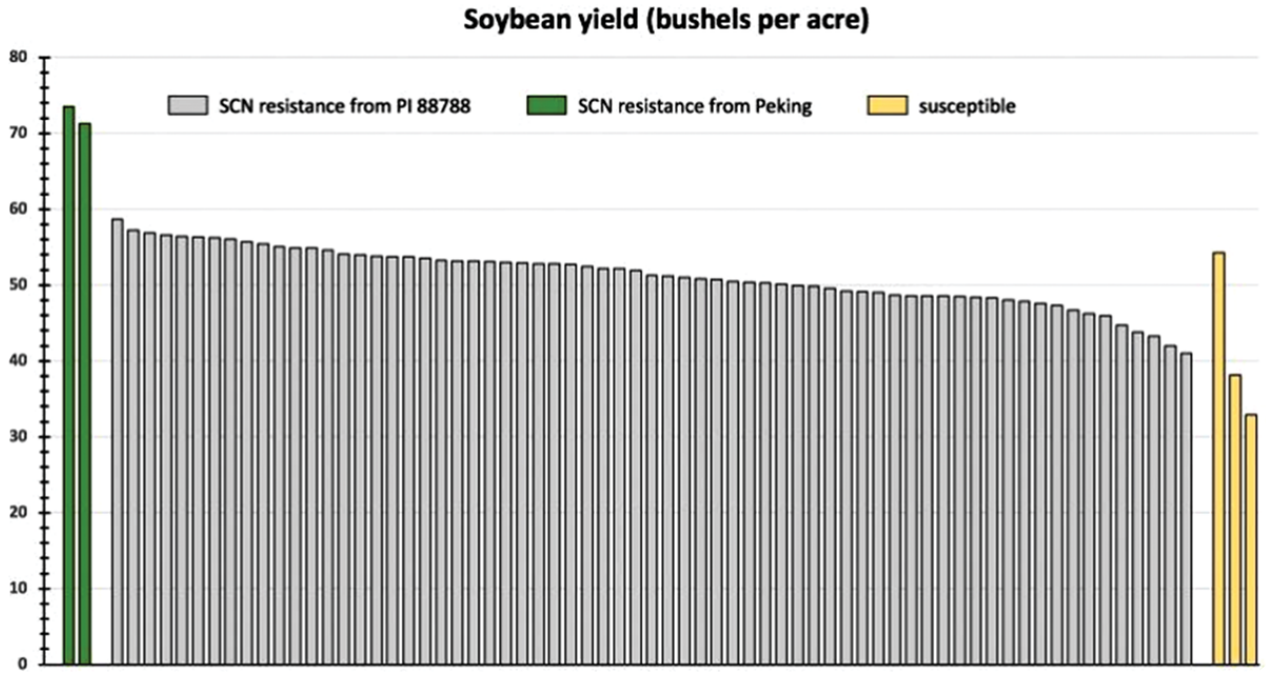
“It is hard to find or to understand the source of SCN resistance in seed literature, and the varieties change so frequently,” says Jason Bond, University of Southern Illinois Professor of Plant, Soil, and Agricultural Systems. “By the time you also consider weed traits and regional problems like Phytophthora, SCN resistance can get lost in variety selection priorities. And, we don’t have a lot of Peking varieties.”

Syngenta is about to release an SCN-resistant soybean variety under the Northrup King and Golden Harvest brands that was developed using the breeding line PI 89772, a source of resistance first published in 1994, Tylka says. “We don’t know how different it is from Peking in terms of specific resistance genes. PI 89772 has never been used in any resistant variety available for farmers to grow, as far as I know.”

“By definition, an SCN-resistant variety should allow less than 10% reproduction of the nematode,” Tylka says. “In other words, a resistant variety should stop 90% of a field’s SCN from reproducing. Varieties with PI 88788 resistance aren’t hitting the mark. In some fields, one out of every two nematodes (50%) can reproduce on PI 88788.

“If they can find them, farmers should grow varieties with Peking SCN resistance, alternating with high-yielding PI 88788 SCN-resistant varieties that allow only low SCN reproduction,” Tylka says. He publishes an annual list (**https://bit.ly/2YiaOhU**)

of SCN-resistant varieties in Maturity Groups 0 to 3.9.



A southeast Iowa study found a 42% yield difference between the average of the lowest-yielding SCN-susceptible variety (yellow bars, far right, 41.8 bu/ac) and the average of the top-yielding Peking SCN-resistant varieties (green bars, far left, 72.4 bu/ac). Source: Iowa State University (see ***https://bit.ly/32cBrWJ****).*

Broad Crop Rotations Based on Non-SCN Host Crops

"Crop rotation is always one of the first and most important tools in almost any plant pathology situation," Todd says. "SCN eggs don't emerge at the same time; and some eggs won't emerge for years. This non-synchronized egg dormancy supports the wisdom of a broader non-host crop rotation. Kansas has more rotation options for non-host crops (wheat and sorghum, in particular), and a significant amount of double-cropped acreage, particularly in southeastern Kansas."

In Nebraska, an effective crop rotation to reduce SCN might include corn, wheat, sorghum, and alfalfa—all non-SCN hosts, Nebraska's Jackson-Ziems says.

"SCN populations decline most rapidly under high population densities, but the rate of decline can be very slow at low population densities, so there are diminishing returns for lengthy rotations," Todd says. "In Kansas, one to two years without a soybean crop are recommended if the SCN population density is above 4,000 eggs per 100 cm^3 soil. The real issue is how quickly populations recover. Given a suitable environment and a susceptible soybean variety, several years of declining population densities can be erased in a single season."

Even so, soybean cyst eggs can survive in the soil for 10 years or more, and a cyst can contain up to 600 eggs, making SCN difficult to manage long term, according to Illinois research.



Fall control of winter annuals is key since that is when a majority of soybean cyst nematode (SCN) reproduction occurs. Source: Design Pics Inc /Alamy Stock Photo.

Rotate Sources of Genetic SCN Resistance

"Always be aware of what sources of resistance you're planting," Todd says. "It's no longer good enough to just select 'resistant' varieties. Ask your seed rep about the availability of alternate resistance sources, like Peking. It has long been recommended that varieties with different resistance sources be rotated in SCN-infested fields, and we've seen some success with this strategy in research trials. But availability of those alternate sources is the limitation. Many states include information about resistance sources in their performance tests,

but this info is not always supplied by the seed companies."

If you can't find non-PI 88788 varieties such as Peking, Nebraska's Jackson-Ziems recommends at least switching varieties to another soybean with PI 88788 resistance. "It is hard to find in our maturity groups in Nebraska, and some of the early Peking varieties had undesirable agronomic traits, which have since been addressed, but which may have scared off farmers and agronomists with long memories."

"Never plant the same variety to the same field twice, in order to reduce your chances of using the same source of SCN resistance," says Kansas State's Jardine.

Consider Adding a Seed Treatment on Your Resistant Variety

Never use a seed treatment to replace a resistant variety; use it on a resistant variety. "Run your own strip trials to determine the benefits in your particular circumstances," Todd recommends. "Because there are numerous SCN strains, your situation likely differs from others."

"Seed treatments may give a 1 to 5 bu/ac yield increase, but ineffective resistance (PI 88788) may result in 10 or 15 bu/acre yield loss," says Iowa State's Tylka. "Seed treatments can vary tremendously in their yield effects, and none can replace good resistant varieties."

Iowa State University field evaluations of five SCN seed treatments found a 0 to 5 bu/ac soybean yield increase where the cost breakeven point was 1 to 2 bu/ac. The study spanned between 9 and 36 site-years' of data on SCN seed treatments in Iowa. Overall, "the effects of ILeVO on SCN reproduction and soybean yield were variable in these field studies," the scientists concluded. Results from the university's study on ILeVO seed

treatment efficacy are summarized at **https://bit.ly/Ilevo**.

A Wisconsin evaluation of CruiserMaxx Vibrance and Clariva Complete seed treatment (biological SCN treatment) was published in *Agronomy Journal* at **https://bit.ly/WI_study_SCN**.

Biological Control Treatments

A variety of biological control treatments (nematode fungi or bacteria that specifically attack a given nematode) are available and will become more common. "The ones available now drop the populations gradually," says Kathy Lawrence, Auburn University plant pathologist.

Control Winter Annual Weeds

Control your winter annual weeds as some are SCN hosts. Ohio State University research found that SCN could reproduce on henbit, purple deadnettle, and field pennycress. Fall control is key, since that is when a majority of SCN reproduction on winter annuals occurs. Studies examining SCN control on henbit found that glyphosate reduced more cysts than did 2,4-D.

Reduce Field-to-Field Soil Movement

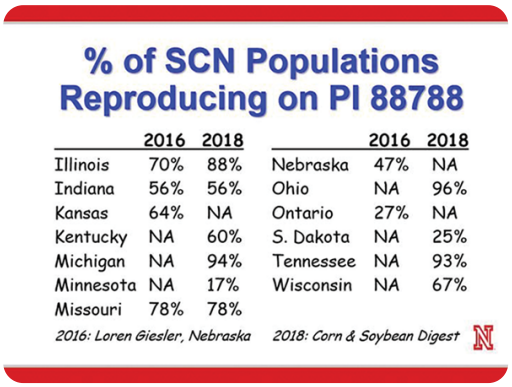
It's important to reduce field-to-field soil movement on equipment, Iowa State's Tylka says, but wind and water erosion will still move soil on the most diligently managed farms.

"There will be transgenic control options in the more distant future," says Kansas State's Todd, "but in the meantime, it's vital to maintain and track your SCN population, and don't stop testing for SCN."

Battling SCN is a lifelong effort, Jardine says. “Fields with SCN have been planted to native grasses for 10 years, but within two years of soybeans, their SCN counts had economically damaging levels.”

Resistance to the Resistance

“SCN is widely adapting to resistant varieties that we sometimes incorrectly assume protect soybeans from the nematode,” says Tamra Jackson-Ziems, University of Nebraska nematologist and Extension plant pathologist. Similar to weeds’ growing herbicide resistance, this cyst “is now resistant to the most common source of genetic resistance (PI 88788), rendering it ineffective in many areas. In Nebraska, about half of soybean cyst populations can reproduce on PI 88788 lines. In other states, that figure may approach 100%. These results were very consistent, and they illustrate the staggering amount of yield loss that SCN can cause when resistance from PI 88788 is overcome.”



Just as weeds have developed resistance to herbicide chemistries, soybean cyst nematode (SCN) has largely developed resistance to a once-effective source of SCN genetic resistance: PI 88788. This source comprises 95% of available varieties, so diligence is required in selecting other sources. Source: Loren Giesler, University of Nebraska.

An Iowa State University SCN field test found nearly $200 per acre lost income from growing varieties with PI 88788 SCN resistance. The farmer who hosted the SCN trial

grew two different soybean varieties with PI 88788 SCN resistance in the remainder of the field surrounding the experiment, and the varieties yielded 50 bu/ac. If one of the varieties with Peking SCN resistance (resistance still effective) in the experiment had been grown in the field, the farmer would have earned nearly $200 per acre more (based on 22 bu/acre yield difference between the Peking varieties and the PI 88788 varieties grown by the host farmer and $9/bu soybeans). Details of this research can be found at **https://bit.ly/2KAbEPZ**.

Just as farmers have had to modify weed control tactics because of herbicide resistance, soybean growers need to refine their soybean variety selection practices and crop rotations to reflect the PI 88788 resistance.

"Almost all SCN-resistant soybean varieties were developed from the same soybean breeding line, or 'source of resistance,' named PI 88788. These resistant varieties controlled over 90%, of SCN reproduction for many years, but SCN populations have become resistant to the resistance. "If there is not a drastic change, I see yield losses of 15 to 30 bu/ac because SCN has adapted really well to the widely used PI 88788 resistance," Tylka says.

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