Soybean Cyst Nematode in the Midwest: Current Status and Future Directions*

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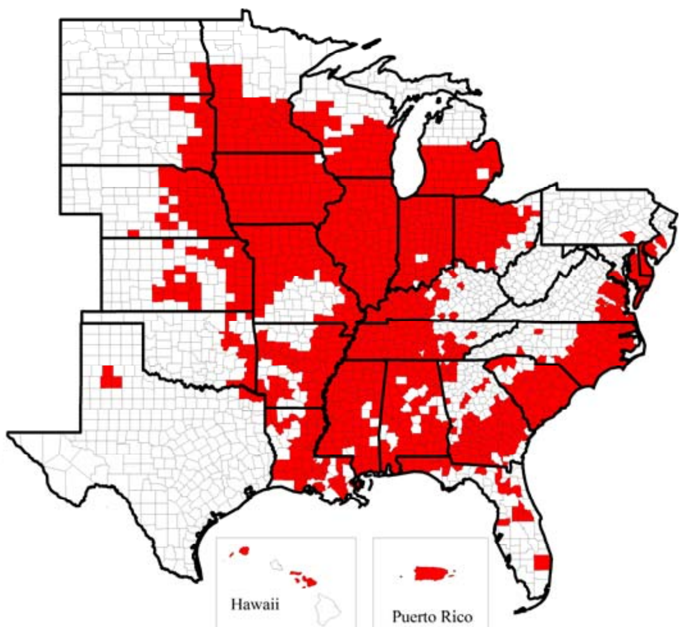
Introduction

The soybean cyst nematode (SCN) has plagued United States soybean production for several decades. The Midwest has been particularly hard hit since the 1980s. The nematode is still a serious yield-limiting pest of soybeans throughout the region, both directly by reducing yields, and indirectly by intensifying other serious soybean diseases.

SCN occurs widely throughout the Midwest. The nematode was found in nearly half of the fields in Indiana, three of every four fields in Iowa, and four of every five fields in Illinois in a random survey conducted in 1995-1996 (Workneh et al., 1999). The United States counties in which SCN has been found are shown in the map below.



Counties (in red) in the United States in which soybean cyst nematode has been discovered.

SCN is a microscopic worm. But the body of the adult SCN female swells and takes on a lemon shape and fills with eggs as an adult. When the SCN female dies, the body wall becomes a hardened cyst around the eggs. Eggs of SCN can stay alive and dormant (unhatched) within a cyst in the soil for a decade or more, so fields remain infested with the nematode even when soybeans are not grown for many years.

The life cycle of SCN can be completed in as few as 21 days under ideal conditions (Lauritis et al., 1983), so several generations can occur in a single growing season. Egg population densities (numbers) increase each year that susceptible soybeans are grown, regardless of the rainfall and

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temperature that occur during the growing season. Also, yield loss from SCN can occur without the appearance of any aboveground symptoms (Wang et al., 2003), making identification of infested fields difficult.

Integrated Management of SCN

For all practical purposes, SCN can never be eliminated from a field once it is present. But there are things that can be done to manage the nematode in order to maximize soybean yields and minimize reproduction of the nematode. It is much easier to keep SCN population densities low than it is to drive high population densities down.

Effective, long-term management of SCN involves an integrated, three-prong approach of scouting fields for SCN, and then growing SCN-resistant soybean varieties in rotation with nonhost crops in infested fields. Scouting fields to check for SCN is essential because it allows infestations to be discovered when SCN population densities are still low. Growing one year of corn, which is a nonhost crop, will decrease SCN population densities as much as 50 percent in Iowa, but the decrease in numbers is much less in second- and third-year corn. SCN-resistant soybean varieties produce high yields on SCN-infested fields (high yields relative to yields of non-resistant or susceptible varieties) and prevent increases in SCN population densities.

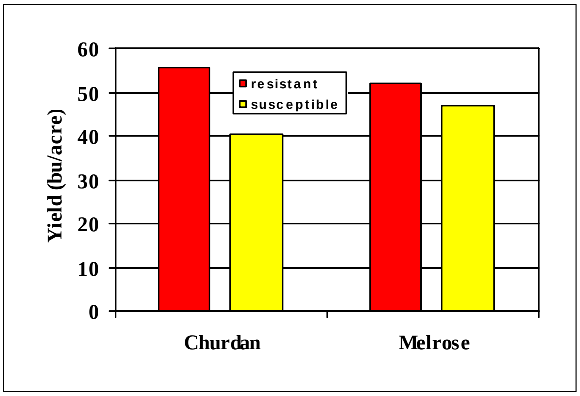
In addition to the basic SCN management strategies described above, controlling winter annual weed species that are hosts of SCN also is important (Johnson et al., 2008). And there are a few soil-applied nematicides available for management of SCN, although the economics of field-wide application of nematicides need to be considered before utilizing this management strategy.

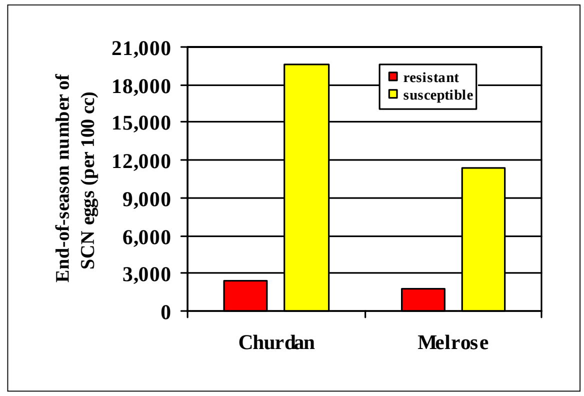
SCN-resistant Soybean Varieties

There is no “legal” definition of SCN resistance, nor is there any government entity that evaluates and verifies that soybean varieties described as resistant to SCN suppress reproduction of the nematode and/or offer any particular level of yield when grown on SCN-infested fields.

In an article in the scientific journal *Crop Science*, Schmitt and Shannon defined SCN-resistant soybeans as those in greenhouse testing that allow less that 10 percent reproduction relative to the amount of SCN reproduction that occurs on a susceptible (non-resistant) variety (Schmitt and Shannon, 1992). Soybeans that allow 10 percent or more reproduction, but less than 30 percent, were designated moderately resistant in that article (Schmitt and Shannon, 1992). In general, these definitions are accepted in the scientific community and the soybean seed industry. But at least one seed company uses their own, unique numerical scale for SCN resistance based on the amount of SCN reproduction that occurs on their varieties, another company only verifies that the main SCN resistance gene is present in varieties they describe as “SCN resistant” but does not ever assess SCN reproduction on their varieties, and a third company has described soybean varieties as having “field resistance” to SCN although such a concept has never been described for SCN on soybeans. Unique, company-specific designations of SCN resistance are confusing and hamper SCN management efforts when the ability of the varieties to support SCN reproduction is not precisely defined.

There are at least four different soybean breeding lines, called sources of resistance, used to develop SCN-resistant soybean varieties. Almost all SCN-resistant soybean varieties available for the Midwest have SCN resistance genes from the breeding line PI 88788 (Shier, 2008; Tylka, 2007). None of the resistant soybean varieties completely stop SCN reproduction. But SCN-resistant varieties that suppress nematode reproduction not only produce greater yields than susceptible varieties in SCN-infested fields, they also prevent large increases in SCN population densities (see bar graphs below). And minimizing SCN reproduction will allow for profitable long-term production of soybeans in SCN-infested fields.





Yield (left graph) and end-of-season SCN population densities (right graph) of SCN-resistant (red bars) and susceptible (yellow bars) soybean varieties grown in two field experiments in Iowa in 2007 (Tylka et al., 2008).

HG Type

Low-level reproduction of SCN populations on resistant soybeans can result in development of SCN populations with increased reproduction on the resistant varieties through selection. And the increased SCN reproduction can reduce yields of SCN-resistant soybean varieties.

The ability of an SCN population to reproduce on sources of SCN resistance can be assessed in an HG type test, which is a greenhouse experiment. The number or numbers in the HG type designation for an SCN population correspond directly to the sources of SCN resistance (the HG type indicator lines) on which the SCN population has 10 percent or greater reproduction relative to the reproduction that occurs on a standard SCN-susceptible soybean variety included in the test (Niblack et al., 2002). Only soybean lines that are used as sources of SCN resistance in soybean breeding lines or released varieties are included as HG type indicator lines (Table 1).

The number “2” is a critical number in HG type test results because the “2” in the HG type designation indicates that the SCN population had 10 percent or greater reproduction on PI 88788. And as stated earlier, most SCN-resistant soybean varieties available to growers in the Midwest have SCN resistance from PI 88788.

Is SCN Building Up on PI 88788 SCN Resistance?

Surveys have been conducted and are ongoing in several Midwest states to determine the HG type of SCN populations to assess how well the nematode populations can reproduce on the various sources of SCN resistance. In a survey published in 1991, 34 percent (15 of 44) of the

Table 1. HG type indicator lines, which also are sources of SCN resistance for soybean varieties.

HG indicator line	source of SCN resistance
1	PI 548402 (Peking)
2	PI 88788
3	PI 90763
4	PI 437654
5	PI 209332
6	PI 89772
7	PI 548316 (Cloud)

tested SCN populations in Illinois had 10 percent or greater reproduction on PI 88788 (Sikora and Noel, 1991). But 65 percent of 260 SCN populations from Illinois surveyed in 2005 had 10 percent or greater reproduction on PI 88788 (Niblack et al., 2008). In Missouri, nearly 60 percent of 183 SCN populations obtained in a random survey of the state in 1998 had 10 percent or greater reproduction on PI 88788 (Niblack et al., 2003), but 78 percent of 45 samples collected from Missouri in 2005 had 10 percent or greater reproduction on PI 88788 (Mitchum et al., 2007). It is now fairly common in many states for SCN populations to have greater than 10 percent reproduction on PI 88788.

Are SCN-resistant Varieties with PI 88788 Failing?

The Iowa State University (ISU) SCN-resistant Soybean Variety Trial Program annually evaluates the yield and SCN control of many SCN-resistant soybean varieties in field experiments conducted at numerous locations throughout Iowa (Tylka et al., 2008). The resistant varieties are grown in replicated plots at each location, soil samples are collected from each plot at planting and at harvest to determine SCN population densities, and commonly grown SCN-susceptible varieties are included in each experiment. An HG type test is conducted on the SCN population at each of the experimental locations.

Almost all of the SCN-resistant varieties evaluated in the ISU SCN-resistant Soybean Variety Trial Program have SCN resistance genes from PI 88788. And many of the variety trial locations are infested with SCN populations capable of 10 percent or greater reproduction on PI 88788 (as indicated by the results of the HG type tests). Yet most of the SCN-resistant varieties usually yield greater than the susceptible varieties at these locations.

The variety trial results illustrate that HG type test results are not always useful in determining which source of SCN resistance will do well in an SCN-infested field. For example, in 2007, at a variety trial conducted near Cambridge, in central Iowa, the field was infested with an SCN population that had 24.3 percent SCN reproduction on PI 88788 and only 0.1 percent reproduction on Peking. These HG type test results would seem to indicate that an SCN-resistant variety with resistance from PI 88788 would *not* be as good of a choice for this field as a soybean variety with SCN resistance from another source, like Peking. But at that location, the soybean variety with Peking SCN resistance (Pioneer 93M53) yielded 56.8 bushels per acre and the three top-yielding SCN-resistant varieties (each with PI 88788 SCN resistance) averaged 65 bushels per acre, which was 10 bushels per acre more that the three top-yielding susceptible varieties.

At the Mason City (north central Iowa) variety trial location in 2007, the field was infested with an SCN population that had less than 10 percent reproduction on both PI 88788 and Peking in the HG type test. The two best-yielding SCN-resistant varieties in the trial, which produced 52 to 54 bushels per acre, had Peking SCN resistance. These results are quite different than the results obtained at Cambridge in 2007.

And at the variety trial experiment near Vincent, Iowa, in north central Iowa in 2007, there was an SCN population with 13.4 percent reproduction on PI 88788 and 0.1 percent reproduction on Peking in the HG type test. Three of the top four yielding varieties at that location, yielding 51 to 55 bushels per acre, were varieties with SCN resistance derived from Peking.

So what do the 2007 variety trial results from Cambridge, Mason City, and Vincent, Iowa, tell us? The results illustrate that the HG type of an SCN population in a field may or may not be a good predictor of yield for SCN-resistant soybean varieties growing in SCN-infested fields. Sometimes it's just not simply about the HG type of the SCN population.

SCN Management in the Future

How will we manage SCN in the future? The foundation of SCN management likely will always be based on scouting fields to discover SCN infestations when population densities are low, then growing SCN-resistant soybean varieties in rotation with nonhost crops in SCN-infested fields. Control of alternative hosts like winter annual weeds will continue to be necessary as well.

Hopefully there will be many more SCN-resistant varieties with SCN resistance genes from several different sources in the future. And there might be SCN-resistant varieties with resistance based on some molecular genetic technology like gene silencing through RNA interference (RNAi). Genetically engineered SCN resistance likely will be 100% effective, useful against all SCN populations (HG types), and will be much less vulnerable to loss of effectiveness (buildup of the nematode) over time than the SCN-resistant varieties that currently are available.

Soil amendments, seed treatments, and foliar sprays may be developed or discovered in the future to suppress SCN reproduction and/or increase yield of soybean varieties. Currently, products named N-Viro Soil, Agri-Terra, N-Hibit™, and ProAct™ are advertised to reduce SCN population densities. In 2007, the effects of N-Hibit™ seed treatment on soybean yield and SCN population densities were assessed in experiments at nine locations throughout Iowa. At two locations, plots with SCN-susceptible soybean varieties treated with N-Hibit™ yielded 2 to 3 bushels per acre more than untreated plots, but there was no difference in yield in the other seven experiments and no effect on end-of-season SCN population densities in any of the experiments. Nine additional experiments were conducted throughout Iowa in 2008, and yield and SCN population density results from these experiments will be available in late 2008 or early 2009.

Summary

SCN is a very damaging, long-lived, and widespread pest of soybeans in the Midwest. Successful, long-term management of SCN requires scouting fields to catch infestations when

SCN population densities are relatively low, and then growing SCN-resistant soybean varieties in rotation with nonhost crops such as corn. SCN-resistant soybean varieties provide greater yields than susceptible varieties and prevent increases in SCN population densities. Almost all SCN-resistant soybean varieties available to soybean growers in the Midwest possess SCN resistance genes from PI 88788, and SCN populations commonly can reproduce greater than 10 percent on PI 88788. Growers should try to rotate SCN-resistant varieties with different sources of resistance if at all possible to slow selection of SCN populations with increased reproduction on SCN-resistant varieties. But results of variety trial field experiments reveal that SCN-resistant varieties with PI 88788 SCN resistance continue to yield well and prevent increases in SCN population densities even in fields with SCN populations with greater than 10 percent reproduction on PI 88788. Growers who have managed SCN with resistant soybean varieties for several years should collect soil samples from fields and determine the SCN population densities to assess whether nematode population densities are increasing.

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