

SCN RESISTANCE, CORN-SOYBEAN ROTATION, AND NEMATICIDES

Heterodera glycines, the soybean cyst nematode [SCN], has been and continues to be a major yield-limiting pest of soybean. Results from the [latest survey of disease and nematode pests in the Midsouth states](#) show it to be the major cause of pest-related soybean yield losses in the last 4 years.

Choosing soybean varieties with genetic resistance [or host plant resistance] to SCN has long been a major economical defense against this pest. The long-term effectiveness of genetic resistance to SCN is documented in a 2017 paper [[Rincker et al., Crop Sci., Jan. 2017](#)] titled “Impact of Soybean Cyst Nematode Resistance on Soybean Yield”. This presentation uses results from 11 years of yield tests that were conducted over 1,247 test-environment combinations in the north-central US and Canada. Analysis of the data from these studies showed that the yield advantage from using SCN-resistant varieties increased as initial SCN egg counts increased from as low as 100 eggs per 100 cm³ of soil.

Most SCN-resistant varieties derive their resistance genes from PI 88788 [[McCarville, Plant Health Progress, Vol. 18:146-155, 2017](#)]. The use of this PI as the sole source of resistance will continue to expose SCN populations to high selection pressure, and this could result in SCN populations that are better able to infect varieties that have this resistance source in their genotype. This shift in SCN population virulence compatibility could result in an increase in SCN problems in the future.

According to Rincker et al. in the above-cited article, “A focused effort to test multiple genotypes with varying resistance levels is needed to improve estimations of performance in environments from which we expect PI 88788-derived resistance to break down. An additional consideration is that the use of only PI 88788 as a source of resistance will continue to expose SCN populations to high selection pressure. Rotation of resistance sources and non-host crops remain important.”

The actual occurrence of this and its affect on soybean

yield is addressed in the above-cited McCarville et al. article titled “[Increase in SCN virulence and reproduction on resistant soybean varieties in Iowa from 2001 to 2015 and the effects on soybean yield](#)” that appears in Plant Health Progress, Vol. 18, p. 146-155. The authors used information from more than 25,000 experimental plots at 122 location-years spanning 15 years across Iowa to derive the following results and conclusions.

- Not all SCN-resistant varieties contain the same number or combination of resistance genes; thus, not all varieties provide the same level of suppression of SCN reproduction and damage.
- Common management of SCN populations in Iowa included the almost exclusive use of PI 88788-derived SCN-resistant soybean varieties and a corn-soybean rotation.
- Starting in 2010, more Peking-derived SCN-resistant soybean varieties were included in the studies. Three or four widely grown SCN-susceptible varieties were also included in the studies each year.
- Virulence of the SCN populations present in experimental fields was determined by conducting a race test prior to 2002 and an [HG Type test](#) from 2002 to 2015.
- Overall mean yields from SCN-resistant varieties almost always were greater than mean yields from SCN-susceptible varieties.
- Mean SCN egg population densities from SCN-resistant varieties were almost always lower than those from SCN-susceptible varieties at the end of the growing season.
- Increased virulence of SCN populations on PI 88788 began to be observed in 2001 and continued through 2015.
- A similar increase in SCN virulence on Peking was not observed during this same period.
- Increased virulence of SCN populations on PI 88788 coincided with an increase in reproductive factor [final SCN egg population density divided by the initial egg population density in each plot] on PI 88788-derived resistant varieties in the experiments.

- There was a significant negative linear relationship between soybean yield and reproductive factor for the 2006-2015 period. According to the authors' calculations, the average yield loss from SCN would be about 1.2 bu/acre for each unit increase in reproductive factor.
 - After 2001, virulence on PI 88788 increased 1.6% per year, while virulence on Peking did not increase significantly over the same period.
 - SCN reproduction in the experiments was greatest in hot, dry years [Caveat: [In a 3-year field study conducted at Stoneville, Miss.](#), irrigation of an SCN-susceptible variety grown on an SCN-infested site did not increase yield above that from a nonirrigated treatment].
 - Abiotic factors may be less important drivers of nematode reproduction when varieties display a high level of effective resistance to SCN, such as those varieties with Peking-derived resistance.
 - SCN virulence was significantly correlated to SCN reproduction on both PI 88788- and Peking-derived resistant varieties.
 - Higher initial SCN population densities led to greater yield loss from susceptible varieties. For resistant varieties, the initial SCN population density was less important for yield loss than was the degree to which an SCN population reproduced on the variety.
 - Virulence to the PI 88788 source of resistance is increasing in Iowa farm fields. This increased virulence correlated with increased SCN reproduction on commercial varieties with PI 88788-derived resistance, which in turn will result in measurable yield losses on these varieties.
 - Yield of both PI 88788- and Peking-derived SCN-resistant varieties increased at a rate that was 60 to 100% greater than that for SCN-susceptible varieties over the 2001-2015 period. Thus, initial "yield drag" associated with SCN-resistant varieties was overcome through breeding efforts that resulted in agronomic improvement in subsequently-released SCN-resistant varieties.
 - Increased virulence of SCN populations on PI 88788 threatens the long-term effectiveness of soybean resistance to SCN. Thus, it is perhaps unlikely that the inherent yield potential of SCN-resistant varieties with PI 88788 resistance can continue to increase at a rate that keeps pace with or exceeds this rate of increasing virulence and subsequent yield loss caused by SCN populations that have adapted to this resistance source.
 - The authors concluded that "the results show an increase in virulence of SCN populations on PI88788 across a wide geographical range (the state of Iowa) from 2001 to 2015 and the associated consequences of increased SCN reproduction and decreased yield of PI 88788-derived SCN-resistant soybean varieties." "It is clear that major changes in SCN management are critically needed since the effectiveness of PI 88788 SCN resistance as a management practice very likely will continue to diminish if new sources of resistance do not become widely available quickly. Long-term, sustainable SCN management will require a multifaceted, integrated pest management [IPM] approach that includes use of nonhost crops, nematode-protectant seed treatments, conventionally bred soybean varieties with resistance from multiple, different breeding sources, and varieties with transgenic SCN resistance, if they become available."
- All of the above-listed IPM tools for managing SCN may not be effective. In a 2017 article titled "[Corn and Soybean Yield Response to Tillage, Rotation, and Nematicide Seed Treatment](#)" by Mourtzinis et al. [Crop Science, Vol. 57:1704-1712], the use of nematicides as a component of SCN management was addressed. Results reported in this article follow.
- Field studies were conducted from 2013 through 2015 within a long-term corn-soybean rotation site that was established in 1983.
 - Treatments included tillage [conventional and no-tillage], corn-soybean rotation sequences [14 sequences representing each phase of seven different corn and soybean crop rotations], and nematicide/nemastat seed treatments applied to soybean [control (no nematicide), abamectin (Avicta 500 used in 2013) and *Pasteuria nishizawae* (Clariva pn, used in 2014 and 2015), and *Bacillus firmus* (Poncho-insecticide/Votivo-nemastat)].
 - An SCN-resistant soybean variety was grown each

year, with PI 88788 being the source of resistance.

- Rotations that involved consecutive years of soybean had the greatest SCN populations in the soil, whereas nematode populations were lowered with increasing number of consecutive years of corn.
- Tillage treatment did not affect SCN egg counts in the soil. Thus, tillage or lack of tillage should not be viewed as an effective management tool for SCN.
- The more frequent the rotation of corn and soybean with each other, the greater the yields of each crop.
- Nematicide seed treatment did not result in increased soybean yield or affect SCN population in any year of the study. Thus, the additional cost of using a nematicide seed treatment was not justified in this environment [SCN egg counts were >7500 eggs per 100 cm³ in consecutive years' soybean plots].
- The lowest soybean yields were measured in consecutive years of soybean regardless of seed treatment. Again, use of nematicide seed treatments was not justified.
- Lower SCN populations in frequent corn-soybean rotations vs. in long-term continuous soybeans, coupled with the lack of nematicide effect on SCN populations, imply that crop rotation vs. continuous soybean cropping is more important for managing SCN populations and their effect on soybean than is the decision about nematicide seed treatment use.

Kandel et al. ([Plant Dis. 101:2137 \(2017\)](#)) reported results from a 3-year (2013-2015) study conducted at seven locations (18 total field experiments) in 4 midwestern US states and Ontario, Canada. In the study, five soybean cultivars with differing levels of SCN resistance and differing SCN resistance sources were evaluated with and without ILeVO (fluopyram) seed treatment for sudden death syndrome (SDS). Experiments were conducted in fields with a history of both SCN and SDS; SCN was present in all experimental fields. Major results follow.

- SCN reproduction was greatest in plots planted to cultivars with no SCN resistance source.
- Cultivars with no SCN resistance source had the lowest yield at all locations; in some cases, yield

reduction was as much as 50%.

- The results emphasize the importance of rotating soybean cultivars with different sources of SCN resistance. Thus, producers should not only sample fields to determine SCN presence, but also determine the [HG type](#) of SCN in each field.
- Average yield from the treatment that had base fungicide/insecticide/nematicide +ILeVO-treated seed was 3 bu/acre (6%) greater than yield from the treatment that had only the base seed treatment.
- SCN resistance source influenced SDS development across a broad geographical area, and cultivars with no SCN resistance source had greater SDS disease severity. The authors surmised that conditions that favor SCN may also favor infection by the SDS pathogen and associated yield losses attributed to SDS.
- The authors concluded that although proper SCN management can reduce SDS disease severity, producers should not rely on SCN resistance for SDS management.

All of the above-cited results from studies involving SCN management strongly support: 1) rotating soybean with corn (or likely any grain crop) vs. continuous soybean and using SCN-resistant varieties are the two most effective management practices when growing soybeans in soil with a known population of SCN; 2) rotating soybean varieties with different SCN resistance sources [if available] should be considered as an important component for long-term SCN management; 3) using a nematicide seed treatment may not be justified or cost-effective; and 4) development of SCN-resistant varieties with a resistance source other than PI 88788 should be considered a priority in SCN-resistant variety development.

According to the above-cited research results, SCN is already and will continue selecting for resistance to the present genetic management strategy used against it, which is almost solely based on the PI 88788 source of resistance. Thus, SCN management strategies must take into account that varieties with SCN resistance derived from multiple sources should be rotated when possible. This means that breeding efforts should place a priority on developing SCN-resistant varieties



using multiple resistance sources. The above needed strategy is akin to using herbicides, fungicides, and insecticides with differing modes of action in order to prolong the effectiveness of current management tools for all soybean pests.

In a 2017 Crop Science article titled “[Pyramiding of alleles from multiple sources increases the resistance of soybean to highly virulent soybean cyst nematode isolates](#)”, authors Brzotowski and Diers offer the following points and conclusions.

- Current genetic resistance to SCN is narrow, and breeders must implement new strategies to effectively manage the pathogen.
- The objective of their study was to evaluate the effect of stacking novel and common SCN resistance alleles on the reproduction of SCN isolates that can overcome multiple resistance sources.
- Their results indicate that PI 468916 and PI 567516C are alternative sources that can be used by breeders to enhance and diversify SCN resistance.
- Combining resistance alleles from the above two PI's with those from PI 88788 conferred resistance or partial resistance to highly virulent SCN isolates.
- Their results indicate that stacking resistance sources improves resistance to SCN and can be a useful strategy for future breeding efforts that will provide needed options for protecting soybean yields from SCN damage.

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