2022 Final Report: Maryland Soybean Board
Continued field evaluation of resistance sources for management of soybean cyst nematode

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Project Overview:

Soybean cyst nematode (SCN) (*Heterodera glycines*) consistently ranks as the most destructive pathogen of soybeans (*Glycine max* (L.) Merrill) across the United States (Allen et al. 2017). There may be several generations within a single growing season, and recalcitrant cysts and eggs can persist in the soil for long periods. SCN has been present in Delaware since 1979 and Maryland since 1980. Nematodes often go undiagnosed and can be very damaging to soybean production, reducing both yield and quality. Growers have relied heavily on resistant varieties, primarily using the PI88788 resistance source. Long-term exposure to this resistance gene has selected for SCN populations that can overcome this source of resistance. As resistance from the PI88788 gene loses effectiveness, growers need additional tools to manage nematode populations. In 2020, a field site was established at the Carvel Research and Education Center to conduct SCN related soybean research. Upon sample analysis, nematode populations in this field were found to have a 65% reproduction level on resistance source PI88788; this gene once kept reproduction well below 10%. The proposed project aimed to screen new resistance gene sources compared to PI88788 to monitor nematode reproduction and populations over the course of the season. Project objectives included: 1) Compare the performance of soybeans with resistance gene PI88788 to new resistance sources. 2) Assess resistance gene effects on field populations of soybean cyst nematode. 3) Share research findings through extension events and survey farmers regarding their concern towards soybean cyst nematode population increases and knowledge of resistance gene sources. This project funded ten percent effort of a research technician and soil samples to provide insight on SCN populations and other nematode species present. This data was complemented by a questionnaire distributed to farmers at extension events to gain insight on concern regarding SCN population increases and to assess awareness of soybean SCN resistance sources across the Mid-Atlantic. As we continue to explore approaches to manage the breakdown of resistance gene efficacy and subsequent increases in SCN populations, the goal of this project was to obtain data on resistance gene performance to expand potential management options for farmers.

Project Activities and Methods:

The first soybean variety with resistance gene PI88788 was launched in 1978. This gene remained highly effective for many decades, but in the 2000s, elevated reproduction began to be reported. Today >95% of soybean varieties still employ PI88788. Other resistance genes have been discovered but are more complicated to work with, and incorporation into high-yielding lines has been challenging. Peeking is a resistance source currently available across a few

maturity groups. Trials in Iowa indicated a 21 bu/a gain using Peeking over PI88788 (Tylka, 2020). The most recently released resistance source, PI89772, is currently only available in a 2.3 maturity, but holds promise. This resistance gene was first discovered in 1930. Breeding efforts over the past 25 years led to the release of the first commercial line in small quantities for the 2020 growing season. While this resistance source is currently only available in a maturity too low for our region, we are interested in observing nematode reproduction on this source to predict the efficacy of this resistance source as it becomes available in more maturity groups. From survey work in 2019-2020, a field site with high SCN pressure was identified at the Carvel Research and Education Center in Georgetown, DE, to conduct a soybean resistance gene source trial.

Objective 1. Assess resistance gene effects on field populations of soybean cyst nematode.

Based on survey work and 2020 field trials, a field with SCN pressure was established at the Carvel Research and Education Center in Georgetown, DE. Four hybrids with differing resistance genes were set up in a randomized complete block design with five replications. Treatments included PI89772, Peeking, and PI88788 resistance sources. Currently PI89772 is only available in a 2.3 maturity group bean. While it is unrealistic for this maturity group to be planted in our region, the goal was to assess nematode reproduction and the viability of this resistance gene so we have an idea about performance as it becomes available in maturity groups more appropriate to our region. Trial treatments included S23-G5X (PI89772, 2.3 maturity), S26-E3 (Peeking, 2.6 maturity), NK31-M7E3 (PI88788, 3.1 maturity), and GH3924X (PI88788, 3.9 maturity). Plots were 28 ft in length and 10 ft wide. After seed was planted, soybean seedlings were monitored for stand emergence, height, and disease symptoms throughout the duration of the trial. At the end of the season, the center two rows of each four row plot were harvested with a small plot combine and data on moisture, test weight, and yield were recorded.

Objective 2. Assess seed treatment effects on field populations of soybean cyst nematode.

Within each of the 20 treatment plots, a plot-representative soil sample was collected by combining 30-40 soil cores per plot at three time points throughout the growing season (Figure 1). Plots were assessed for nematode populations at the time of planting, approximately 30 days after planting, and at harvest. Samples were submitted to the North Carolina Department of Agriculture Nematode assay service to be processed. Population counts were provided for SCN, root knot nematode, lesion, lance, ring, spiral, and stubby root nematodes. Additionally, plants were destructively sampled approximately 30 days after emergence to count live SCN females on the roots. Five plants were selected from row one of each plot and removed for assessment (Figure 2). Roots were cut from each plant, gently washed to remove debris, and brought back to the lab for root blasting. Once at the lab, roots

Figure 1: Collecting soil samples

were held over a sieve set and female cysts were collected and counted under the microscope (Figure 3).

Figure 2: Technician Lexi Kessler, M.S. digging plants to observe SCN female counts on plants 30 days after emergence.

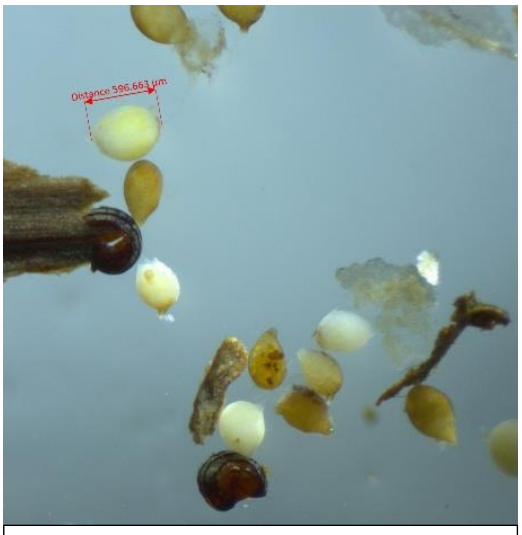

Figure 3: Cream to pale yellow colored SCN females under microscope magnification following root blasting.

Objective 3. Share research findings through extension events and survey farmers regarding their concern towards soybean cyst nematode population increases and knowledge of resistance gene sources.

Findings from this project were shared through the University of Delaware's Weekly Crop Update, which reaches over 700 growers, consultants, and stakeholders and provides a platform to discuss disease concerns and other production issues. In August 2022, a Nematode Field Day was organized and participants were able to view the field site and walk plots within this trial. Results were then shared at virtual nematode webinar hosted by the Koehler lab in December 2022.

At University of Delaware hosted field days and commodity meetings, growers were given a brief questionnaire to better understand concerns regarding nematode management and to investigate knowledge bases surrounding SCN resistance genes. In 2020, the United Soybean Board gave funding to the SCN Coalition to widen its reach to all states as data has shown that resistance gene PI88788, used in >90% of SCN-resistant soybean cultivars, is beginning to lose effectiveness. Dr. Koehler is a member of the SCN Coalition and questions used in this survey included a set of questions released by the SCN Coalition to understand grower choices, perceptions, and understanding of SCN host resistance.

Results and Discussion:

In the SCN trial field, a composite soil sample was collected for HG soil type analysis. This field was identified as HG type 2, Race 5 and the nematode population was able to reproduce at a 66% rate on the PI88788 resistance source (Table 1). This trial was conducted in 2021 and 2022. In 2022, varietal differences were observed in percent emergence at 28 days after planting, with highest emergence in S23-G5X and S26-E3 (Table 2). In 2021, emergence differences were observed at 14 and 28 DAP, with best emergence in GH3924X (Table 3). Soil samples were collected at the beginning, middle and end of season. Numerical SCN differences were observed at the end of the season where the PI89772 line had the lowest SCN populations in 2021 and 2022 (Figures 4 and 5). Nematode Reproductive factor was calculated (RF=final SCN count/initial SCN count) and PI89772 had the lowest numerical RF in 2021 (Table 3), in 2022 Peeking was the lowest numerical RF, followed by PI89772 (Table 2). Significant differences in yield were observed in both years. As anticipated due to harvest timing, the 2.3 and 2.6 maturity groups yielded lower than the 3.1 and 3.9 maturity groups. In 2022, despite having the lowest percent emergence, GH3924X had the highest yield (Table 2). Soybeans were harvested on November 7, 2022, which was well beyond the optimal harvest window for the lower maturity groups.

Table 1: Results from sending a nematode sample for race and HG typing.

Indicator Line= Source of Resistance	Rep 1	Rep 2	Rep 3	Rep 4	Female index (FI)=	≥10%
1) PI 548402 (Peking)	12	11	18	19	7.7%	-
2) PI 88788	116	151	134	112	66.2%	+
3) PI 90763	3	4	2	1	1.3%	-
4) PI 437654	0	0	0	0	0%	-
Pickett	40	35	41	60	22.7%	+

HG type: 2
Race: 5

Comments: This SCN population is able to reproduce at a low level (<10%) on PI 548402 (Peking) and PI 90763, and at a high level (>60%) on PI 88788 and Pickett. The population was unable to reproduce on PI 437654.

Table 2: Emergence, Reproductive Factor, and Yield Data from 2022 SCN Resistance Gene Trial in Georgetown, DE

	% Emergence 14 DAP	% Emergence 28 DAP	Nematode Reproductive Factor	Yield (bu/a)
S23-G5X	57.5	87.4 a	5.9	29.1 b
S26-E3	60.5	90.5 a	3.3	33.4 b
NK31 - M7E3	57.8	80.8 b	7.3	35.2 b
GH3924X	62.1	77.9 b	20.6	51.2 a
LSD (α=0.05)	ns	5.7	ns	6.9
***p*-value**	0.9	0.0013	0.17	0.0035

Table 3: Emergence, Reproductive Factor, and Yield Data from 2021 SCN Resistance Gene Trial in Georgetown, DE

	% Emergence 14 DAP	% Emergence 28 DAP	Nematode Reproductive Factor	Yield (bu/a)
S23-G5X	61.2 b	65 c	1.87	29.4 d
S26-E3	68.7 a	72 b	4.23	41.0 c
NK31 - M7E3	57.6 c	64.5 c	3.5	53.7 b
GH3924X	67.9 a	74.8 a	6.6	57.5 a
LSD (α=0.05)	2.6	2.6	ns	2.23
***p*-value**	0.03	0.04	0.43	0.00001

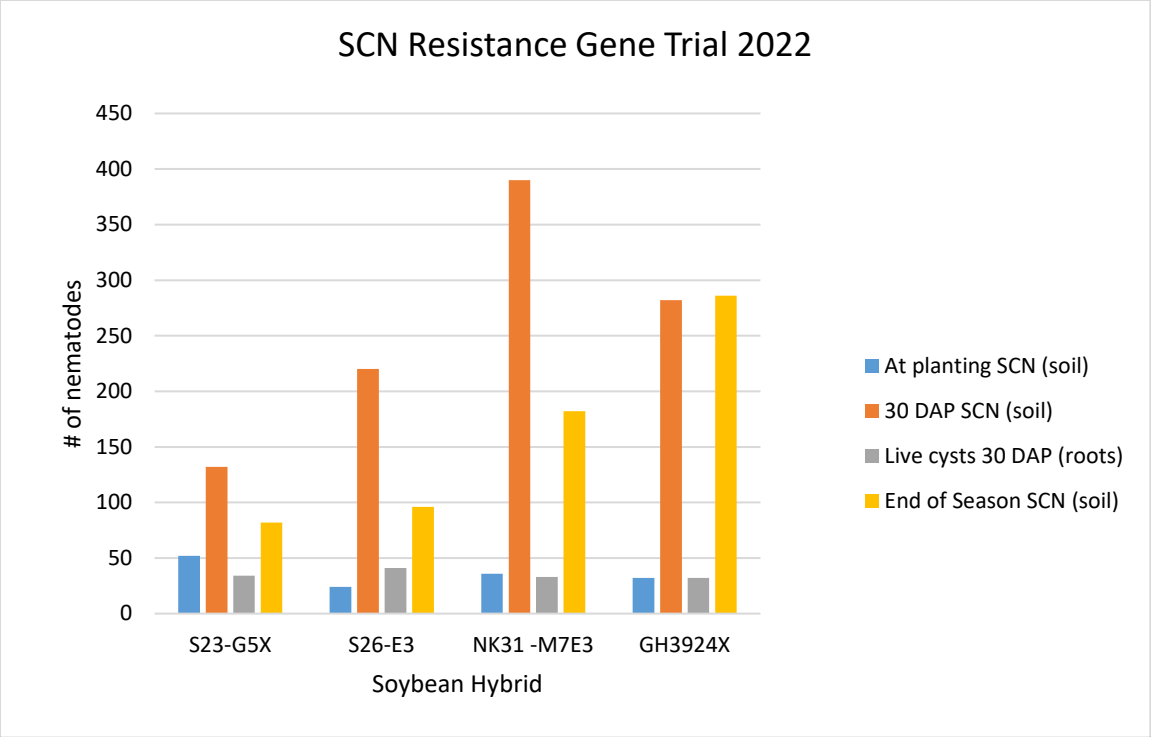

Figure 4: Differences in SCN counts at planting, 30 DAE, and at the end of the season.

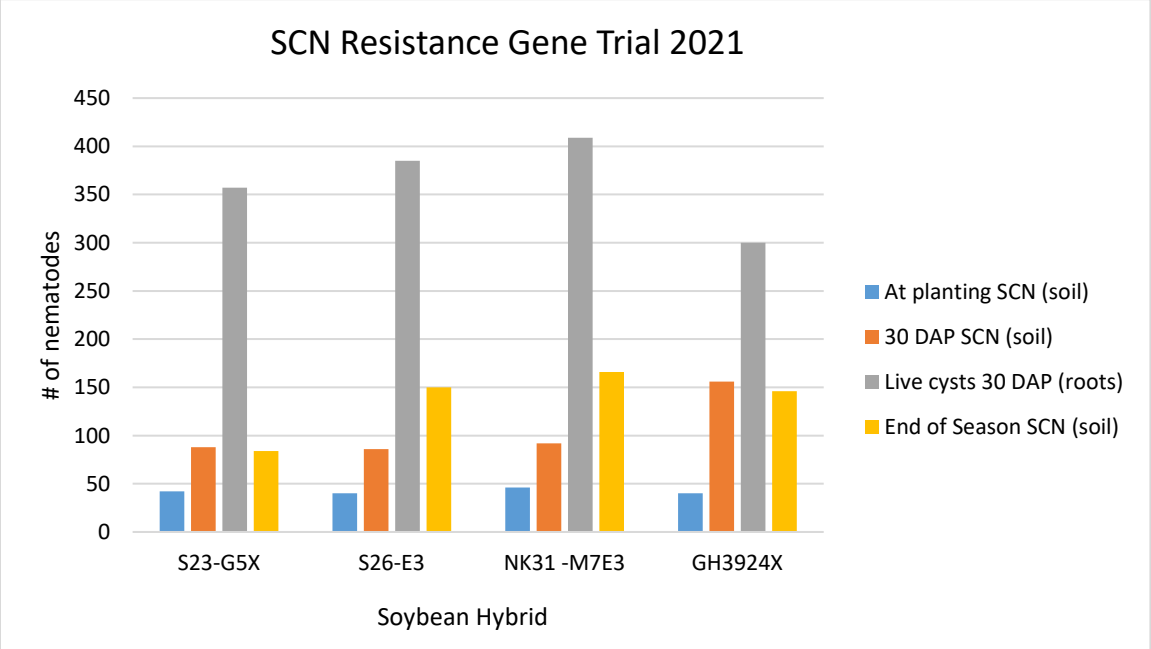

Figure 5: Differences in SCN counts at planting, 30 DAE, and at the end of the season.

Baseline SCN populations ranged from 40-46 juvenile nematodes per 500 cc soil in 2021 and 24-52 in 2022, with no difference in averages across each of the treatments. At 30 days after emergence, populations increased in all plots in both seasons. Five weeks prior to harvest, no significant SCN population differences were present among treatments. The lowest numerical amount of nematodes was observed in the soybean with resistance gene PI89772 in both years. In addition to soil samples, five plants per plot were dug up 30 days after planting (DAP) to sample for SCN cysts via a root blasting protocol. Counts were higher in 2021, but no differences among soybean hybrid were observed in either year. Plots were harvested on November 5, 2021 and November 7, 2022, which favored the higher maturity groups. Dectes stem borer was present in the field and some stems of the early maturity varieties had been broken off prior to harvest, moisture in the early maturity groups was also low, (8-10%). Since these maturity groups are not realistic for the region, we were most interested in performance regarding nematode populations. While not separating statistically, PI89772 had the lowest numerical SCN value at the end of the season in both years. If this resistance source is introduced into soybean maturity groups appropriate for the region, it would be a promising tool to rotate from complete reliance on PI88788.

Across 2021-2022, questionnaire surveys were completed covering >8000 acres of production. In 2021, forty four percent of respondents had submitted a soil sample within the past year, but 20% had never sampled for nematodes. In 2022 surveys, twenty five percent of respondents had submitted a soil sample within the past year, but 50% had never sampled for nematodes. One hundred percent of respondents in both years felt that SCN is reducing their soybean yields. In 2021 responses, crop rotation was the primary management approach, follow by SCN resistant varieties (55%), seed treatments (44%), or nematicide application (44%). In 2022 responses, 50 percent were using crop rotation and soil testing, followed by seed treatment (25%). Root knot nematode was the second most concerning nematode to respondents in both years, followed by lesion nematode.

References:

Allen TW, Damicone JP, Dufault NS, et al. 2018. Southern United States soybean disease loss estimates for 2017.

Tylka, G. 2020. Income in SCN-infested Fields can be $200 per acre less with PI88788 than with Peking reistance. Iowa State ICM News. https://crops.extension.iastate.edu/cropnews/2020/01/income-scn-infested-fields-can-be-200-acre-less-pi-88788-peking-resistance

Project Budget:

Research Technician (10% effort) ($43,000/yr)	=$4,300
Fringe benefits 30%	=$1,290
Nematode Soil Sample Processing (40 samples at $20 each)	=$800
Misc. supplies (sample drying bags, field stakes, etc)	=$300
Total Proposed Budget	**=$6,690**

Research Dissemination and MSB Recognition:

-August 18, 2022: Nematode Field Day, Carvel Research and Education Center
-December 5, 2022: Mid Atlantic Nematode Meeting, Virtual

Public Summary:
Soybean cyst nematode (SCN) (*Heterodera glycines*) is consistently ranked among the top destructive soybean pathogens across the United States and is the most significant nematode pest affecting soybeans in Delaware and the Eastern Shore of Maryland. SCN has been present in Delaware since 1979 prompting growers to rely on resistant varieties, primarily using the PI88788 resistance source. However, additional control strategies are needed as SCN populations have begun reproducing readily on these once resistant cultivars. A five-replication field trial was conducted in 2021 and 2022 to evaluate two additional resistance genes, Peking and PI89772, compared to lines with PI88788, for stand emergence, control of SCN, and yield differences. Soybean maturity group had the largest impact on yield, but the PI89772 resistance gene had the lowest numerical value of SCN at the end of the season in both years and numerically lower nematode reproductive factor than PI88788. If PI89772 is introduced to maturity groups appropriate for the region, this resistance source should be considered as an option to alternate with PI88788 in effort to reduce in-season nematode population increases.

Please contact Alyssa Koehler (akoehler@udel.edu) with any additional questions.