Twenty-two Years of Soybean Cyst Nematode - A Farmer's Observations
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<u>Key Observations:</u> After discovering that my 160 acre farm in southwestern Michigan had a serious soybean cyst nematode (SCN) problem, I started a 22-year research program to learn how to manage this pest. The following are the highlights of this project:

- The average annual bean yield of the top five SCN resistant varieties was 14 bushels greater than that of SCN susceptible varieties.
- Beginning in 2010, SCN populations increased significantly on resistant varieties derived from the PI 88788 source of resistance.
- In 2010, SCN populations did not increase on varieties derived from Peking (PI 548402).
- In SCN infested fields, bean yields on both susceptible and resistant varieties were lower in years with less than 20 inches of rain during the growing season than in years with greater than 20 inches of rain.
- At-harvest populations of SCN were higher during in years with less than 20 inches of rain during the growing season than in years with greater than 20 inches of rain.
- The research and numerous miscellaneous observations have assisted me in developing ways to increase my bean yields and lower SCN populations.

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In 1998, I was a retired Navy Senior Chief Engineer farming 160 acres in Edwardsburg, Michigan, while working as an inspector at the Hummer plant in Mishawaka, Indiana. My farming system consisted of a three-year rotation with corn, soybeans and wheat on coarse textured soil with a pH ranging from 6.3-6.8. The Edwardsburg area receives approximately 20 inches of rain during the soybean growing season. In a good year, soybean yields on the farm should be 40 bushels per acre or greater. In 1998, I realized that there was a serious problem with my soybeans and contacted my local Extension office. Soil samples were collected and sent to Michigan State University. The results indicated that the problem was caused by the soybean cyst nematode (SCN).

As a result of the problem identification, I decided to conduct on-farm research to determine the best way for me to manage SCN. Research with SCN resistant varieties began in 1999 and continued through 2010. Four fields, each approximately 25 acres, were used for the research.

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Each soybean field in the project was in a three-year rotation with corn/soybean-wheat/idle and used once every four years for the research.   An average of twenty-two soybean varieties were tested each year between 1999 and 2008.   At least one SCN susceptible variety was included every year.   In most years, each variety was planted in an eight-row field-long strip. In some years each variety was planted in four-row, field-long strips and replicated four times. Each strip was combined separately, and yields calculated on a bushel per acre (bu/A) basis. While the number of resistant and susceptible varieties varied each year, the five highest yielding SCN resistant varieties were identified, considered as the *Top Five Club*. The average bean yield of each year's *Top Five Club* was compared with the average yield of the SCN susceptible varieties.

The annual average soybean yield for the *Top Five Club* ranged from 14 bu/A in 1999 to 52 bu/A in 2006 (Table 1). The average SCN susceptible variety yield ranged from 7 bu/A in 1999 to 38 bu/A in 2006 and 2010. Over the eleven years, the average yield of the *Top Five Club* resistant varieties was **14 bu/A** greater than that associated with the susceptible varieties.   The highest at-harvest SCN population density associated with the susceptible varieties was 70,230 SCN eggs per 100 cm^3 soil) in 2002. Overall, the at-harvest number of SCN eggs per 100 cm^3 of soil from the *Top Five Club* resistant varieties was about ten-fold less than those from the SCN susceptible varieties.

Table 1. 1999 to 2010 soybean yield and at-harvest soybean cyst nematode population densities associated with resistant and susceptible varieties.

Year	Resistant[1] (bu/A)	Susceptible[2] (bu/A)	At-harvest resistant variety SCN population[3]	At-harvest susceptible variety SCN population[3]
1999	14	7	1,244	26,560
2000	37	14	38	4,800
2001	26	9	550	11,750
2002	27	13	4,433	70,230
2003	39	20	656	29,600
2004	34	24	1,618	12,547
2005	37	22	6,680	39,700
2006	52	38	11,186	39,000
2007	44	25	736	33,000
2008	17	8	5,147	32,010
2009	23	14	147	13,720
2010	48	38	713	432
Average	33	19	2,762	28,447

[1]Average yields of the top five resistant varieties.
[2]Yield of susceptible variety or average yield of two susceptible varieties.
[3]SCN eggs per 100 cm^3 of soil.

Most of the SCN resistant varieties evaluated in the trials were derived from PI 88788 as the source of nematode resistance. Resistant varieties derived from Peking (PI 548402) and Hartwig PI (437654 x PI 88788) were also evaluated in some years. One year there were three Peking varieties in the trial. One behaved as a resistant variety. Another was highly susceptible to SCN and turned out that it was not derived from the correct Peking source of resistance. The third variety yielded 63 bu/A, had an at-harvest SCN population density of 39,000 SCN eggs per 100 cm^3 of soil, and a massive lateral root system. A variety derived from Hartwig x PI 88788 resulted in very low at-harvest SCN eggs over a period of several years. Its yields, however, were variable because the maturity group was not appropriate for Edwardsburg.

In 2010, the twelfth year of the project, something strange happened. The SCN population increased during the growing season an average of 441.2-fold on resistant varieties derived from PI 88788 (Table 2). The increase was only 5.8-fold, 0.6-fold and 0.0-fold on the susceptible, Peking and Hartwig-derived varieties, respectively.   This was evidence that the SCN population in this field had developed resistance to resistance. Overall SCN data from the entire farm appeared to indicate that there was a relationship between the number of times a field was planted to a resistant variety and the at-harvest SCN egg populations.

Table 2. 2010 SCN populations and soybean yields associated with four different soybean genetics.

Soybean variety	At harvest cysts[1]	SCN change[2]	Yield (bu/A)
Susceptible	9.0	5.8	37.6
PI 88788	21.7	441.2	42.4
PI 548402 x PI 88788	1.0	0.6	48.0
PI 437654 x PI 88788	0.0	0.0	31.8[3]

[1]At-harvest SCN cysts per 100 cm^3 of soil.
[2]At-planting SCN eggs per 100 cm^3 soil divided by the SCN eggs per 100 cm^3 soil at-harvest.

In the ten-year period between 1999 and 2008 there were six years with 20 inches or more of rain during the soybean growing season in Edwardsburg (May through September) and four years with 15 inches or less of rain (Table 3). When the soybean yields associated with the two rain regimes were compared, the bean yields were low in the dry years, as expected. In the dry years, the average bean yield associated with the susceptible varieties was 13.2 bu/A; whereas the average yield associated with the resistant varieties was 23.6 bu/A. In the years with 20 inches or more of rain, the susceptible varieties averaged 22 bu/A and the resistant varieties averaged 38.7 bu/A. In the dry years, the average at-harvest SCN population associated with the susceptible cultivars was 50,784 SCN eggs/cup of soil. The average at-harvest SCN eggs per cup of soil in the dry years was 4,310 per cup of soil for the resistant varieties. In the years with 20 inches or more of rain during the growing season, there was an average of only 21,785 and 2,442 eggs per 100cm^3 of soil for the susceptible and resistant cultivars, respectively.

Table 3. Twenty-two years of growing season rainfall (inches) and associated soybean yield (bushels per acre) under SCN infested field conditions.

Year	May	June	July	August	September	Total	Yield
2020	7.34	6.1	5.49	3.51	3.05	25.49	44.3
2019	4.98	5.94	3.16	1.16	5.66	20.91	22.5
2018	7.64	5.6	1.68	6.12	2.76	23.80	59.2
2017	5.73	1.76	2.92	2.03	2.90	15.34	57.9
2016	2.42	4.52	3.65	14.3	3.95	28.84	53.3
2015	4.2	3.2	3.33	3.08	1.60	15.41	48.0
2014	6.96	9.25	3.8	4.24	4.05	28.31	45.0
2013	3.32	3.96	2.92	2.16	1.68	14.04	16.5
2012	1.89	1.66	6.37	3.8	2.73	16.45	30.0
2011	6.48	3.99	3.35	2.39	6.16	22.37	25.0
2010	8.64	4.91	5.12	1.50	1.82	21.99	51.1
2009	3.00	6.8	1.7	7.7	0.9	20.1	23.8
2008	2.8	5.14	2.43	1.91	20.82	33.1	17.9
2007	1.7	4.4	3.84	10.77	1.77	22.48	45.5
2006	6.36	1.92	6.78	4.19	1.55	20.8	58.1
2005	0.46	3.5	3.95	1.65	2.39	11.05	37.6
2004	6.91	5.6	2.82	4.51	1.23	21.07	35.7
2003	6.9	1.0	5.65	2.6	5.35	21.5	42.3
2002	5.2	2.9	1.7	2.7	1.7	14.2	27.3
2001	4.4	4.35	1.55	7.58	3.2	21.1	24.4
2000	7.0	6.1	3.7	2.48	3.86	23.1	52.7
1999	2.1	6.33	3.9	3.0	0.15	15.48	17.0

The rain, at-harvest nematode population and bean yield data for the twenty-two years from 1999 to 2020 shows a more complex picture than just the amount of rain. It appears to indicate that the time when the rain occurs during the growing season has a significant impact on bean yield. In general, soybeans do not like drought or wet feet. On my farm, it appears that drought can be defined as any month when the rain fall average is less than 0.5 inches per week. Optimal growing conditions are created by a stable one inch of rain each week throughout the growing season. Fourteen days of no rain at the R1 to R3 stage, or too much rain during this period stage can be detrimental. Fourteen days of no rain at pod-fill can result in about 10% pod drop. Too much rain at pod fill can increase bean diameter to the point of splitting the pod. When this occurs, it is important to harvest as soon as possible to get this bonus yield before it ends up on the ground.

During the past twenty-two years I have learned a lot about nematodes, the environment and growing agronomic crops from my on-farm research. I sincerely hope that some of my observations are beneficial to you.