

VIRULENCE PROFILES OF SOYBEAN CYST NEMATODE

Ann MacGuidwin ^{1/}

Soybean Cyst Nematode

The soybean cyst nematode, *Heterodera glycines*, is a common pest of soybean in Wisconsin and the U.S. The SCN is undetected in many fields and may be one of the most widespread diseases affecting soybean. Yield losses of up to 30% can occur with no apparent symptoms on soybean stand or plant vigor. Population densities build slowly over time, usually in a very patchy pattern. Declining or stagnant yields or delayed canopy closure are subtle clues that should raise suspicion of SCN. Confirmation during July of the soybean year can be made by visual inspection of soybean roots for the presence of white females. Diagnosis at other times or during the rotation year must be made from soil tests conducted in a laboratory.

Damage thresholds for initiating management of SCN vary with soil type and location, but a general guideline for action is 150 eggs per 100 cc soil. The most effective and economical means of reducing yield loss due to SCN is to plant a resistant variety. Studies in Wisconsin and other states in the north central region showed that resistant varieties yielded more than susceptible varieties in almost every field infested with SCN. There are a wide range of varieties to choose from and most combine SCN resistance with traits of herbicide or disease resistance.

Extensive screening of soybean from China and Russia revealed seven lines with resistance to SCN. Of these, three lines are ancestors of the varieties in maturity groups suitable for Wisconsin conditions: P.I. 548402 ("Peking"), P.I. 88788, and P. I. 437654. Resistance to SCN, conferred by several different genes, is manifested after nematodes enter roots. Juveniles are lured into resistant plants and begin to feed, but are trapped inside roots as host resistance reactions begin. Rapid death of the cells chosen as the feeding site leaves nematodes stranded without food. These plant defense responses are triggered by chemical signals given off by SCN. Not all nematodes produce signals that are recognized by the plant and these individuals go on to feed, reproduce, and pass their "lucky" genes to their offspring. Almost all populations of SCN have some individuals capable of evading resistance reactions.

Virulence Profiling of SCN Populations

There are two schemes for characterizing ability of a SCN population to develop in resistant plants – the SCN race and the Hg (*Heterodera glycines*) type schemes. The objective of both schemes is to determine if a population is virulent (able to evade resistance reactions) against the SCN resistance genes used in modern breeding programs. The methods to determine race or Hg type are similar. Nematode eggs are added to pots of the soybean lines used in the test (4 lines for the race test or 7 lines for the Hg type test plus a standard susceptible line) and allowed to grow for 30 days. The plants are then harvested, the nematodes removed from the roots, and counted. The number of nematodes recovered from each line is divided by the number recovered from the standard susceptible line and multiplied by 100. This percentage is called the female index, or FI. Populations that have an FI less than 10% are considered to lack virulence for the resistance genes carried in that line. Populations that have an FI greater than 10% are considered to be virulent for those resistance genes.

^{1/} Professor, Dept. of Plant Pathology, Univ. of Wisconsin-Madison.

Profiling the virulence of SCN populations is accomplished by simultaneously testing the population against multiple soybean lines, each carrying a unique set of resistance genes. For the race scheme, the population earns pluses and minuses determined by the 10% rule (less than 10% = not virulent, > 10% = virulent) on four soybean lines, for a total of 16 possible races (Table 1).

Table 1. SCN race scheme.

Race	"Pickett"	"Peking"	P.I.88788	P.I.90763
1	-	-	+	-
2	+	+	+	-
3	-	-	-	-
4	+	+	+	+
5	+	-	+	-
6	+	-	-	-
7	-	-	+	+
8	-	-	-	+
9	+	+	-	-
10	+	-	-	+
11	-	+	+	-
12	-	+	-	+
13	-	+	-	-
14	+	+	-	+
15	+	-	+	+
16	-	+	+	+

The Hg type scheme is similar except that seven soybean lines are used (Table 2). The standard susceptible line used for comparison in both schemes is "Lee 74". The naming convention for populations in the Hg type scheme is the number of all lines with an FI greater than 10% (e.g., an Hg type 1.2.3 is virulent against resistance genes in P.I. 548402 ("Peking"), PI 88788, and PI 90763).

Table 2. Soybean lines used in the Hg type test.

<u>Hg Type</u>	<u>Soybean Line</u>
1	P.I. 548402 ("Peking")
2	P.I. 88788
3	P.I. 90764
4	P.I. 437654
5	P.I. 209332
6	P.I. 89772
7	P.I. 548316

Methods

Fifteen SCN populations from 13 counties were evaluated using Hg type testing. None of the populations had ever been exposed to a SCN resistant variety in the field. Nematodes were cultured in the growth chamber on a SCN susceptible variety to increase population densities. Three replications of the seven differential soybean lines were compared to “Lee 74” for nematode development expressed as the Female Index (FI). All tests were conducted in a growth chamber with a 12/12 hour photoperiod and air temperature of 28°C for 30 to 32 days. The tests were repeated at least once for most populations.

Results

Thirteen of the fifteen populations tested to date were virulent on P.I. 88788 (Table 3). These populations were be classified as either race 3 or 6 (“Pickett” is not included in the Hg type test, so it is not possible to identify races distinguished by their reaction to “Pickett”). Four of fifteen populations were virulent on “Peking” (P.I. 548402). No population was virulent on P.I. 437654.

The Hg type test and the race test use development of adults as evidence of virulence. We conducted one experiment to compare, for P.I. 88788, egg production versus development of adults (Table 4). Egg production was a more conservative indicator than female development for one population, less conservative for one population, and about the same for two populations.

Implications

Most populations of SCN are composed of some individuals that are not affected by the resistance genes carried in P.I. 88788, the most common source of SCN resistance in varieties bred for Wisconsin conditions. These findings are very similar to a study conducted in Missouri in 2005, but researchers there attributed the result to the fact that P.I. 88788 has been used extensively. Our data represent variation inherent in the populations because the SCN came from farms that had never grown SCN resistant varieties. These data warrant caution about overuse of varieties with P.I. 88788 resistance and suggest that rotating P.I. 88788 resistance with either “Peking” or “Hartwig” (P.I. 437654) is advisable for some populations.

There are two reasons that the data should not be interpreted as a call to abandon P.I. 88788 resistance all together. First, virulence profiles are based on success of the nematode rather than success of the crop to withstand nematode parasitism. Commercial varieties derived from the P.I.s carry many other traits that can confer the ability to tolerate SCN feeding, so yield data should be examined before deciding on the best soybean genetics to use. Evaluations of commercial varieties with P.I. 88788 resistance show that they perform well and are important tactics for managing SCN in Wisconsin. Second, there is concern that overuse of “Hartwig” resistance (CystX) could select for the very small proportion of the population that is already able overcome that source of SCN resistance. Data from laboratory studies have shown that SCN populations virulent on P.I. 437654 were also virulent on other resistance genes.

Table 3. Results of Hg type tests for Wisconsin populations of SCN

SCN population	Trial	# females on Lee	FI on P.I. 88788	Hg type	Race
Waushara-1	1	107	1	0	3
Columbia-1	1	289	7	7	2 or 11
	2	234	30	1.2.5.7	
Shawano-1	1	98	8	7	4 or 16
	2	79	3	6	
	3	74	8	7	
	4	284	40	1.2.3.5.7	
Dunn -1	1	76	6	5.7	3
Dunn-2	1	69	12	2.5.7	1 or 5
Walworth-1	1	134	55	1.2.3.5.6.7	4 or 16
	2	249	62	1.2.3.5.6.7	
Waupaca-1	1	131	10	1.2.5.6	2 or 11
	2	98	36	1.2.5.6.7	
	3	96	32	1.2.3.5.6.7	
Dane-1	1	278	24	2.7	1 or 5
Sauk-1	1	131	35	2.5.7	1 or 5
	2	124	63	2.5.7	
Juneau-1	1	85	81	2.5.7	1 or 5
	2	298	79	2.5.7	
Racine-1	1	122	7	0	1 or 5
	2	176	17	2.5.7	
Racine-2	1	94	19	2.5.7	1 or 5
Buffalo-1	1	95	54	2.5.7	1 or 5
	2	78	52	2.5.7	
	3	169	73	2.5.7	
Grant-1	1	154	47	2.5.7	1 or 5
	2	62	16	2.7	
Washington-1	1	89	11	2.5.7	1 or 5
	2	64	28	2.5.7	

Table 4. Comparison of FI based on cysts versus egg counts.

Population	FI cysts	FI eggs
Sauk	26	41
Buffalo	105	108
Grant	41	22
Dane	29	15

Future Work

We are continuing virulence profiling using populations from additional counties. We are also simulating the overuse of resistant varieties with these populations in growth chamber studies to see how quickly (if at all) virulence profiles shift. Other studies are identifying the range of yield responses represented in commercial varieties with P.I. 88788 resistance when challenged with SCN populations from different counties in Wisconsin.