Response of Resistant and Susceptible Soybean Cultivars to Continuous Cropping in Area Infested with Cyst Nematode

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ABSTRACT

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Soybean management studies were conducted on soil infested with soybean cyst nematode. The field was identified in 1972 as having a high population of soybean cyst nematodes and also severe potash deficiency. The field was used for evaluating soybean breeding material in 1973, 1974, and 1975. In 1976, a management study was initiated to measure the effects of soybean cyst nematodes on soybean productivity. A cultivar resistant to race 3, Centennial, and a susceptible cultivar, Tracy, were grown continuously with and without a nematicide. They were also grown in a sequence of 2 yr of Centennial and 1 yr of Tracy and in a blend of 80% Centennial and 20% Tracy. A breeding line resistant to races 1, 3, and 4 was also included. After 5 yr, no treatment was superior to growing the cultivar Centennial continuously. Use of a nematicide reduced numbers of soybean cyst nematodes but did not result in increased seed yields.

The soybean cyst nematode (SCN) *Heterodera glycines* Ichinohe was recognized as causing injury to soybeans (*Glycine max* (L.) Merr.) in southeastern North Carolina in 1954. It has since been identified in nearly all states of the United States where soybeans are grown. Many assumptions have been made as to intensity of damage that might result from continuous cropping of soybeans in infested areas. Soon after cultivars resistant to SCN were introduced, areas within fields were recognized as being damaged by SCN. In recognition of the variability of the nematode, four races were described (2). Soybean growers in several states have been advised not to use resistant cultivars regularly but to alternate their use with susceptible cultivars to minimize the development of new races. No long-term field studies have been reported showing the effects of continuous cropping of resistant or susceptible soybean cultivars on SCN-infested soil.

Our study was initiated to observe soybean productivity on SCN-infested soils under differing management systems and SCN development on resistant and susceptible cultivars.

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MATERIALS AND METHODS

A field of Lee 68 soybeans showing SCN injury and severe potash deficiency was identified in 1972 on the Northeast Branch of the Mississippi Agriculture and Forestry Experiment Station at Verona. The soil type was Tuscumbia silt loam (pH of 7.0; phosphorus high, 72 ppm; potassium very low, 35 ppm). A 4-ha area was used for the evaluation of soybean breeding lines in 1973–1975, with one-half the area planted to a cultivar susceptible to SCN each year in an attempt to maintain a high SCN population. The present study was initiated in 1976 with plans to continue for 10 yr.

Five systems were established, each with four replicates. Individual plots were 16 rows measuring 16 × 32 m. There was a 6-m alley between replicates. Systems involved primarily the two cultivars Centennial (resistant to SCN race 3) and Tracy (susceptible). These cultivars differ by 4 days in maturity and have produced similar seed yields over a 5-yr period at this location, where SCN was not recognized as a problem. However, in

1972 in a planting adjacent to the present test site, D67-4601 (Tracy), which showed severe symptoms of potash deficiency and was severely infected with SCN (1,500 cysts per 250 cc of soil), produced 535 kg of seed per hectare; D70-3185 (Centennial), which showed neither symptom, produced 2,295 kg of seed per hectare.

Centennial was grown continuously in two systems (Table 1), with one receiving an application of 1,2-dibromo-3-chloropropane (DBCP; 13.5 kg a.i./ha injected 20 cm) before planting each year. Tracy was also grown continuously in two systems, with one receiving an application of DBCP each year. Another system included 2 yr of Centennial and 1 yr of Tracy. When the study was in progress, three sets of plots were used to permit having Tracy after 2 yr of Centennial each year. A fourth system included a blend of 80% Centennial and 20% Tracy, which was grown continuously. A breeding line resistant to SCN races 1, 3, and 4 was grown each year in the fifth system.

Potassium chloride was applied at 100 kg/ha each year. Plantings were made between 15 and 30 May each year, except that plots were replanted on 15 June in 1979.

Soil samples for determining cyst population were taken from the eight center rows of each plot in September each year, about 3 wk before soybean maturity. Each sample from a replicate represented 40 soil probes taken to a depth of 12–15 cm. The eight center rows of each plot were harvested to determine seed yields.

RESULTS AND DISCUSSION

Seed yields for Centennial with or without a nematicide were similar (Table 2). Seed yields for Tracy were significantly lower than yields for Centennial in three of the years. Cyst count for Tracy with a nematicide was lower than for Tracy with no nematicide (Table 3), but there was no increase in seed yield. These results agree with results obtained by Epps et al (1), who reported a reduction in cyst numbers from use of nematicides but did not obtain significant increases in seed yield.

There was an apparent population shift in nematodes between 1977 and 1976 because the cyst count on Centennial (no nematicides) increased from 5 to 174, while the shift on the SCN race 4 resistant breeding line was minimal (Table 3). Although there was an increase of cysts on Centennial in 1977, the number decreased in 1978 and appeared to stabilize.

Seed yield for the blend was similar to that for Centennial. Cyst number was lower in 1977 than in 1976 and appeared to stabilize. Studies at Stoneville in an area where *Phytophthora megasperma* var. *sojae* Hildeb. was a problem showed that a blend of 20–30% of a susceptible soybean with a resistant strain yielded as much as the resistant strain alone (Hartwig, *unpublished*). Nematologists have theorized that if a soybean susceptible to the original SCN population is grown at regular intervals, the likelihood of a shift in nematode population is minimized. The 5-yr mean seed yield for the blend was equal to, but not superior to, the 5-yr mean seed yield for Centennial. The cyst population over the past 3 yr also appears similar.

In 1977, Tracy was grown after 1 yr of Centennial; in 1978, 1979, and 1980, it was grown after 2 yr of Centennial. In none of these years did the seed yield exceed the seed yield for Tracy grown continuously, nor was the cyst count lower than for continuous Tracy. If there were an advantage in maintaining a susceptible cultivar in the production program to maintain the original cyst population, the growing of a blend of 70–80% of an adapted resistant cultivar with 20–30% of a productive susceptible cultivar would be simpler to manage than to rotate resistant and susceptible cultivars. However, in this study, neither growing a susceptible cultivar every third year after 2 yr of a resistant cultivar nor growing the blend showed an advantage over growing Centennial continuously.

A different breeding line resistant to SCN race 4 was grown each year in an attempt to have a highly productive strain

Table 1. Soybean management study on soil infested with soybean cyst nematodes at Verona, MS, 1976–1980

	Soybean cultivar[b]				
Nematicide[a]	1976	1977	1978	1979	1980
No	C	C	C	C	C
Yes	C	C	C	C	C
No	T	T	T	T	T
Yes	T	T	T	T	T
No	C	C	T	C	C
No	C	T	C	C	T
No	T	C	C	T	C
No	B	B	B	B	B
No	L	L	L	L	L

[a] 1,2-dibromo-3-chloropropane (DBCP) applied at 13.5 kg a.i./ha before planting.
[b] C = Centennial; T = Tracy; B = blend (Centennial 80% + Tracy 20%); L = breeding line resistant to soybean cyst nematode races 1, 3, and 4.

Table 2. Seed yield of soybean cultivars[a] grown on soil infested with soybean cyst nematodes at Verona, MS, 1976–1980

	Seed yield (kg/ha)					
Nematicide	1976	1977	1978	1979	1980	Mean
No	C 2,883	C 2,490	C 2,688	C 2,210	C 2,660	2,566
Yes	C 2,862	C 2,425	C 2,785	C 2,105	C 2,608	2,562
No	T 2,514–[b]	T 2,218	T 2,748	T 1,842–	T 2,596	2,384
Yes	T 2,602–	T 2,150–	T 2,522–	T 1,800–	T 2,660	2,358
No	C 2,885	C 2,460	T 2,493	C 2,298	C 2,700	2,567
No	C 2,850	T 2,158–	C 2,896	C 2,358	T 2,535–	2,556
No	T 2,595–	C 2,553	C 2,820	T 1,760–	C 2,620	2,470
No	B 2,800	B 2,435	B 2,680	B 2,298	B 2,625	2,568
No	L 2,150–	L 2,120–	L 2,256–	L 1,290–	L 2,360–	2,037
LSD (0.05)	258	214	215	355	120	
CV	5%	6%	5%	12%	3%	
Date planted	20 May	17 May	25 May	15 June	25 May	

[a] C = Centennial; T = Tracy; B = blend (Centennial 80% + Tracy 20%); L = breeding line resistant to soybean cyst nematode races 1, 3, and 4.
[b] – = Treatments having a seed yield significantly lower than Centennial (no nematicide).

Table 3. Cyst count per 250 cc of soil planted with soybean cultivars[a] at Verona, MS, 1976–1980

	Number of cysts				
Nematicide	1976	1977	1978	1979	1980
No	C 5	C 174	C 54	C 56	C 66
Yes	C 5	C 143	C 28–[b]	C 49	C 62
No	T 391+	T 252	T 62	T 51	T 55
Yes	T 111+	T 190	T 37	T 59	T 73
No	C 17	C 173	T 70	C 47	C 52
No	C 4	T 291+	C 39	C 58	T 59
No	T 374+	C 13–	C 13–	T 41	C 28
No	B 119	B 63	B 30	B 64	B 78
No	L 3	L 30–	L 22–	L 18	L 2–
LSD (0.05)	105	116	25	NS[c]	42
CV	61%	54%	44%	65%	54%

[a] C = Centennial; T = Tracy; B = blend (Centennial 80% + Tracy 20%); L = breeding line resistant to soybean cyst nematode races 1, 3, and 4.
[b] – and + = Treatments having a cyst count significantly lower and higher, respectively, than Centennial (no nematicide).
[c] Not significant.

similar in maturity to Centennial and Tracy and equal in productivity. All were earlier in maturity, and several were susceptible to stem canker (caused by *Diaporthe phaseolorum* (Cke. & Ell.) Sacc. var. *caulivora* Athow & Cald.). The seed yield for the system growing the strain resistant to SCN race 4 was lower in each year than for Centennial. However, results showed that this type of SCN resistance was effective in maintaining the cyst population at a low level. These results illustrate that when an unadapted parent is used to correct one problem, susceptibility to a previously unrecognized problem may be introduced.

The analysis of variance for cyst counts showed a very high coefficient of variability (Table 3). Similar results have been obtained in other studies. The extreme variability of cyst populations within fields makes it difficult to recommend a specific program based upon cyst numbers in the soil. Riggs et al (4) reported no correlation between number of cysts and soybean seed yield. When adapted, productive soybean cultivars resistant to SCN are available, their use appears to be a sound management practice.

Soybeans have been grown continuously in the area of this study for at least 9 yr. Kerr (3) has reported a disease of *H. avenae* in England that permits near normal production of susceptible oat cultivars on nematode-infested soils. The decrease in cysts on Tracy after 1976 suggests that the SCN in this area may be attacked by a pathogen.

We plan to continue this study for another 5 yr. We also plan to grow a strain resistant to SCN race 4, similar in maturity and productivity to Centennial and resistant to stem canker, for the remainder of this study. An attempt will be made to determine whether a pathogen is attacking the nematode, and if so, to determine its identity.

LITERATURE CITED

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