Host Suitability and Susceptibility of Glycine max cv. Bedford to Race 1 of Heterodera glycines

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Abstract: Populations of *Heterodera glycines* identifiable as race 1 reproduced on the race 1 resistant 'Bedford' soybean. A Beaufort County, North Carolina, population had an index of parasitism of 112% on Bedford in greenhouse tests. Indices of parasitism for this population on race 1 resistant cultivars Pickett 71, Centennial, and Forrest were less than 10%. The Beaufort County population had significantly greater reproduction on Bedford in microplots than did populations of race 3 or race 4. In field tests, a race 1 population suppressed yields of Bedford but not yields of Centennial. Based on these data, Bedford is no longer recommended in North Carolina as a race 1 resistant cultivar. *Key words:* host resistance, soybean cyst nematode, nematode management, soybean, reproduction.

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Heterodera glycines Ichinohe, 1952, a major limiting factor to soybean (*Glycine max*) production, is widespread in the soybean production area of eastern North Carolina, with more than 30% of the acreage infested in some counties (1). Principle management practices used in North Carolina to reduce losses due to this pathogen are crop rotation, use of resistant cultivars, and soil treatment with nematicides.

Five races of *H. glycines* have been described (5,7), along with reports of extensive variation in virulence within the species (8,10). Several soybean cultivars have been released with resistance to races 1 and 3 of *H. glycines;* in 1979 the cultivar Bedford was released with resistance to races 1, 3, and 4 (6).

During the 1980 growing season, two fields planted to Bedford were found exhibiting severe symptoms of cyst nematode damage. Populations of *H. glycines* isolated from both fields were subsequently identified as race 1 by the currently approved system (5). These findings prompted further investigations into the effectiveness of the Bedford resistance to North Carolina populations of *H. glycines* characterized as race 1. The results of those studies are presented herein.

MATERIALS AND METHODS

Populations of *H. glycines* races 1 and 3 used in greenhouse or microplot tests were maintained on *Glycine max* (L.) Merr cv. Lee 74; the population of Race 4 was maintained on cv. Pickett 71. Inoculum for each test was collected by washing roots with a high pressure stream of water and collecting mature cysts on a 250-μm sieve. Eggs and juveniles were freed from cysts by gentle crushing with a ground-glass tissue grinder.

The index of parasitism (IP) (9) of a race 1 population isolated from Bedford in Beaufort County was determined on selected soybean cultivars under greenhouse conditions. Soybean seeds were germinated in vermiculite, then transplanted singly to 10-cm-d pots filled with a steam-pasteurized loamy sand soil (82.9% sand, 10.6% silt, 6.5% clay). Each pot was infested by adding a suspension of 4,000 eggs and juveniles of *H. glycines* to the transplant hole prior to transplanting. Plants were harvested after 45 days at 24 $\pm$ 4 C, and immature and mature cysts were washed from the roots and counted. Eight replications of each treatment were arranged in a completely randomized design in the greenhouse.

Reproduction of the Beaufort County race 1 population was compared to reproduction of a race 3 and race 4 population in microplots (2). Microplots were established in a Norfolk loamy sand (87% sand, 9% silt, 4% clay) and infested with a suspension of 500 eggs and juveniles/500 cm^3 soil of the appropriate population. Plots were immediately planted to either Bedford or Lee 74. All plots were fertilized according to soil test recommendations and irrigated as needed. The experimental design was a randomized complete block, replicated four times. Population densities were

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transformed to $\log_{10}$ (X + 1) prior to statistical analysis.

Composite soil samples (eight 2.5-cm cores/plot) were collected 6 weeks after planting and at harvest to determine nematode population densities. Aliquots of 500 cm^3 from each sample were processed for cysts, eggs, and juveniles by a combination of elutriation and centrifugation (3). All plots were harvested for grain yield in November 1981.

In 1981 an experiment was established in a race 1 infested field (preplant population densities ranged from 925 to 2,055 eggs and juveniles/500 cm^3) in Lenoir County, North Carolina. Effect of the cyst nematode was determined by comparing yields from phenamiphos treated plots (2 kg a.i./ha) to yields from untreated plots planted to Bedford, race 1 susceptible 'Coker 156,' or race 1 resistant Centennial soybeans. The experimental design was a randomized block with four replications. Yield data were analysized by the Student's T test for paired observations.

RESULTS

Under greenhouse conditions, the Beaufort County population of race 1 reproduced as well on Bedford (IP = 112%) as it did on the susceptible Lee 74. On soybean cultivars Pickett 71, Centennial, and Forrest (all possessing genes for resistance to race 1), this race 1 population had IPs < 10% (Table 1).

In the microplot test, midseason population densities were less than one cyst/500 cm^3 soil for all treatments. High soil temperatures (> 35 C at 10 cm) during June 1981 are believed to have suppressed initial population development. By the end of the growing season, nematode population densities had increased substantially. The final population density of race 1 was significantly greater on Bedford than were final population densities of races 3 or 4 (Table 2). There were no significant differences among the final population densities of the three races on Lee 74, but each population had a significantly higher population density on Lee 74 than on Bedford.

None of the populations tested had any significant effect on yields in the microplot tests (Table 2), although yields were lowest in race 1 infested plots for both cultivars. In the Lenoir County field test, yields of Bedford and Coker 156 were significantly lower in untreated, as compared to phenamiphos treated, plots (Table 3). The race 1 population in these plots had no effect on the yields of Centennial.

Table 1. Index of parasitism (IP) of race 1 *Heterodera glycines* on selected cultivars on *Glycine max**

Cultivar	Resistance	IP †
Lee 74	None	100.0% a
Bedford	races 1, 3 & 4	112.0% a
Pickett 71	races 1 & 3	1.2% b
Forrest	races 1 & 3	1.3% b
Centennial	races 1 & 3	7.1% b

*Population isolated from Bedford soybeans, Beaufort County, North Carolina.

†Index of parasitism (IP) = $\frac{\text{Av. no. cysts per plant}}{\text{Av. no. cysts from Lee 74}} \times 100$

(Ref. 11). Data are means of eight replications; means no. cysts per Lee 74 was 274 ± 48. Means followed by the same letter are not significantly differenct according to Duncans multiple-range test ($P = 0.01$).

DISCUSSION

Bedford soybean was not resistant to the North Carolina populations of *H. glycines* race 1 in any of our tests. Although reproduction of race 1 on Bedford in the microplot test was less than 10% of the reproduction on Lee 74, we do not believe that a cultivar that supports a population increase of 2170% can be classified as resistant. Other investigators have observed significant reproduction (IP = 39%) of race 1 on Bedford (G. Noel, pers. commun.). That the race 1 population in the Lenior County test significantly suppressed Bedford yields provides further evidence of the lack of useful levels of resistance. We are not aware of any reports providing evidence in support of the original claim (6) that Bedford is resistant to race 1 populations of *H. glycines*.

Ability of some race 1 populations to overcome the reported resistance in Bedford may be due in part to the inadequacies of the current race identification system (5). Extensive variation is known to exist among

Table 2. Reproduction of races 1, 3, and 4 of *Heterodera glycines* on soybean cvs. Bedford and Lee 74, and soybean yields in microplots. Reproduction is based on the number of cysts and eggs and juveniles recovered from soil and on the P_f/P_i* ratio.

Cultivar	Race	Numbers/500cm³ soil†			
		Cysts	Eggs & juveniles (1000s)‡	P_f/P_i‡	Plot(g)
Bedford	1	77 b	10.8 b	21.7 b	363 a
	3	25 a	2.0 a	4.0 a	576 a
	4	11 a	1.4 a	2.8 a	427 a
	noninfested	0	0	0	423 a
Lee 74	1	1365 a	140.0 c	280.0 c	380 a
	3	828 c	55.2 bc	110.4 c	443 a
	4	326 c	39.5 bc	69.1 bc	425 a
	noninfested	0	0		457 a

*P_f/P_i equals final nematode population density (eggs and juveniles/500 cm³ soil) divided by initial population density (500 eggs and juveniles/500 cm³ soil).

†Data are means of four replications. Means followed by the same letter are not significantly different according to Duncan's multiple-range test ($P = 0.05$ for no. cysts, P_f/P_i, and yield $P = 0.01$ for eggs & juveniles.)

‡Data transformed to Log (X+1) for statistical analysis; nontransformed data presented.

Table 3. Yield response of soybean cvs. Bedford, Coker 156, and Centennial to *Heterodera glycines* race 1 in field plots in Lenoir County, North Carolina.

Cultivar	Yield (kg/ha)	
	Untreated	Phenamiphos (2 kg a.i./ha)
Bedford	1,123 ± 105	1,735 ± 109**
Coker 156	1,594 ± 91	1,843 ± 169*
Centennial	2,340 ± 75	2,273 ± 181 NS

**Significant at $P = 0.01$.

*Significant at $P = 0.07$.

populations of *H. glycines* (8,10); thus it is possible that Bedford may be resistant to other populations identifiable as race 1. We concur with Riggs and his coworkers (10) that the current race identification system needs to be revised.

Reproduction of races 3 and 4 on Bedford in microplots increased the initial population densities by 400% and 280%, respectively. Young (12) also reported reproduction of race 4 populations on Bedford and demonstrated that the reproduction rate can be increased significantly in response to selection on Bedford. It is likely that race 3 populations will behave in a similar manner (9,11). Thus, while Bedford may suffer little or no yield loss due to these populations (4), it will support at least a moderate cyst population density.

Based on these data, Bedford is no longer being recommended as a race 1 resistant cultivar in North Carolina. Its use in a rotation system for management of races 3 and 4 requires further evaluation in light of Bedford's ability to support substantial reproduction of these races.

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