

## Advising Growers in Selection of *Heterodera glycines*-Resistant Soybean Cultivars

L. D. YOUNG

**Abstract:** Female indices were measured on six soybean cultivars with resistance to *Heterodera glycines* derived from PI 88788. Cultivars were inoculated with four isolates of race 6, 3 of race 9, 2 of race 4, and one of race 14. Changes in female index from slightly < or > 10% of the test cultivars compared to 'Essex' resulted in a change of most of the race designations after at least three generations on 'Essex.' Variation due to race was the greatest source of variation in the analysis of the data and was three to nine times the second largest source of variation. In most cases, female indices for the cultivars within a race were not different ( $P = 0.05$ ). This study suggests that one cultivar can serve as a type cultivar for a common source of *H. glycines* resistance. Value of race designations was demonstrated.

**Key words:** *Glycine max*, *Heterodera glycines*, races, resistance, soybean, soybean cyst nematode.

The soybean cyst nematode *Heterodera glycines* Ichinohe is a serious pest of soybean (*Glycine max*). Planting cultivars that are resistant to the nematode and rotating soybeans with nonhost crops are the primary methods of limiting yield losses. Selection of resistant cultivars for planting is complicated by the genetic variability of the nematode. Riggs and Schmitt (3) described 16 races of the nematode. The race designation of a population of *H. glycines* is based on the number of females that develop on four soybean differentials (soybean lines with differing genes for resistance) relative to the number of females that develop on the standard susceptible 'Lee'. Young (6) reported the race differentials were not always good indicators of *H. glycines* reproduction on resistant cultivars derived from those differentials. For advisory purposes, Schmitt and Shannon (4) recommended that resistant cultivars be assigned a type designation such that cultivars derived from the same source of resistance would be of the same type. A popular representative or type cultivar would then be selected for each source of resistance, and results of its interaction

with *H. glycines* would be used to recommend other cultivars of the same type for use in infested fields.

'Bedford' (2) was the first commercial soybean cultivar with resistance to *H. glycines* races 3 and 14 derived from PI 88788. It was widely grown until other cultivars with similar resistance and higher yield potential were released. The objective of this study was to determine if Bedford is a suitable type cultivar for resistance to *H. glycines* derived from PI 88788.

### MATERIALS AND METHODS

Nine of the 10 *H. glycines* isolates used in this study were collected from infested fields in a 1988 survey (6). Isolate 87 (previously designated TN4 [5]) is a greenhouse-maintained population sampled from an infested field in 1987. The isolates (Table 1) were selected to represent races 4, 6, 9, and 14 of *H. glycines*. All isolates were cultured on 'Essex' soybean for at least three generations (approximately 3 months) after being taken from cold storage before they were used in this study and then maintained on Essex for the next 9 months. Females collected from 35-day-old plants were crushed with a Ten-Broeck tissue grinder to release eggs for inoculum. Steam-sterilized silt loam soil (30% sand, 63% silt, and 7% clay) was placed in 7.5-cm-diam. clay pots and infested with 1,000 eggs/pot. Two plants of either 'Asgrow 5403', Bedford, 'Coker 355', 'FFR

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<sup>1</sup> USDA ARS Soybean Research Unit, 605 Airways Blvd., Jackson, TN 38301-3201.

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E-mail: ldy4126@jackson.freenet.org

TABLE 1. Race designation of 10 *Heterodera glycines* isolates used to measure female indices on six soybean cultivars.

Isolate <sup>a</sup>	Race designation			
	1988 Survey	Trial (1993)		
		1	2	3
1	6	14	14	4
5	6	2	2	2
7	9	14	14	14
9	6	4	2	2
10	9	14	9	14
11	6	9	9	9
14	4	14	4	14
22	4	4	4	14
25	9	4	4	4
87	14	14	4	14

Race designations according to Riggs and Schmitt (3) and result from 10 replications for survey and four replications for each trial.

<sup>a</sup> The first nine isolates were obtained from a survey of *H. glycines* races in Tennessee (6); isolate 87 is a race 14 population maintained for greenhouse studies and was originally collected from an infested field in 1987. Race designation under survey column is the one obtained when the survey was completed.

565', 'Pioneer 9581', or 'TN 4-86' were grown in each pot. The four soybean differentials used to determine race ('Pickett,' 'Peking', PI 88788, and PI 90763) and the standard susceptible, Lee, were also included in each trial of the experiment. Each soybean line was replicated four times. Plants were grown for 35 days, and *H. glycines* females were extracted by elutriation (1). Roots were rubbed by hand during elutriation to remove females adhering to them. Trials were conducted in January, March, and September 1993.

The experimental design was a randomized complete block, and the experiment

was performed three times. A female index (FI) was calculated for each pot as  $100 \times (\text{number of females per pot}) \div (\text{mean number of females on Lee for that isolate})$ . Analysis of variance was performed on  $\log_e (FI + 1)$  transformed values.

## RESULTS AND DISCUSSION

Culturing the nematode isolates on Essex resulted in changes in race designations from those obtained in the survey (Table 1). In trial one, only one of the nine isolates remained the same; three were unchanged in the second trial, and none were the same in the third trial as in the survey. Even the standard race 14 isolate 87 was classified as race 4 in one of the trials. The only difference in methodology between experiments was that plants were grown in sterilized soil infested with eggs in this study and plants were grown in soil taken directly from the field in the survey study. The changes were due to small changes in FI on PI 88788 or PI 90763 from negative ( $<10$ ) to positive ( $\geq 10$ ) reaction (3) or vice versa.

Variation in FI among trials was significant (Table 2) and may have been due, in part, to differences in temperature and other culture conditions among trials. In the analyses by individual trial, variation due to race ranged from 40%–70% of total sums of squares, and the mean squares for this source of variation were three to nine times the value of the second largest source of variation. Most of the other sources of variation in the analyses also

TABLE 2. Analysis of variance for female indices of 10 *Heterodera glycines* isolates on six soybean cultivars resistant to race 14 of the nematode.

Source of variation	df	Mean square	F	P
Trial	2	6.27	13.10	0.0001
Replications (trial)	9	0.61	1.28	0.2445
Cultivar	5	5.43	11.36	0.0001
Race	3	57.00	119.21	0.0001
Isolate (race)	12	2.39	5.00	0.0001
Race $\times$ soybean	15	1.48	3.09	0.0001
Soybean $\times$ isolate	60	0.68	1.41	0.0255
Pooled error	613	0.48		

were significant ( $P = 0.05$ ). Due to the magnitude of the variation due to race and the significant trial effect, data on the FI of each soybean were grouped by race for each trial of the experiment (Table 3).

In 52 of 60 comparisons in the individual trials, the other cultivars did not differ from Bedford in FI ( $P = 0.05$ ). Most of the cultivars were susceptible (4) to the race 2 isolates, and several cultivars were moderately susceptible to the race 4 isolates. The

TABLE 3. Female indices of 10 *Heterodera glycines* isolates grouped by race on six soybean cultivars tested on three trial dates in 1993.

Cultivar	Female index <sup>a</sup>		
	Trial		
	1	2	3
		Race 2	
Asgrow 5403	43	82	84
Bedford	57	76	68
Coker 355	55	60	43
FFR 565	53	56	45
Pioneer 9581	48	45	30 <sup>b</sup>
TN 4-86	44	74	50
n <sup>c</sup>	4	8	8
		Race 4	
Asgrow 5403	41	31	25
Bedford	41	31	14
Coker 355	33	32	21
FFR 565	53	26	37 <sup>b</sup>
Pioneer 9581	37	27	39 <sup>b</sup>
TN 4-86	19 <sup>b</sup>	24	12
n <sup>c</sup>	12	16	8
		Race 9	
Asgrow 5403	11	15	7
Bedford	13	15	12
Coker 355	10	20	20
FFR 565	30	19	37 <sup>b</sup>
Pioneer 9581	12	20	10
TN 4-86	8	18	8
n <sup>c</sup>	4	8	4
		Race 14	
Asgrow 5403	13	24	21
Bedford	14	21	18
Coker 355	15	18	18
FFR 565	28 <sup>b</sup>	27	19
Pioneer 9581	34 <sup>b</sup>	26	18
TN 4-86	8 <sup>b</sup>	20	13
n <sup>c</sup>	20	8	20

<sup>a</sup>Female index = (number of females on a soybean cultivar/number of females on Lee soybean) × 100.

<sup>b</sup>Different ( $P = 0.05$ ) from female index of Bedford for that trial when analysis of variance was performed using natural logarithm transformed data.

<sup>c</sup>Number of observations for each cultivar in a trial for each race of *Heterodera glycines*.

cultivars were either resistant or moderately resistant to races 9 and 14 except for FFR 565 and Pioneer 9581 in one trial each and with one isolate each.

The suggestion by Schmitt and Shannon (4) that a carefully chosen cultivar be used as a designated type for a group of cultivars with a common source of resistance, and that it be used for selection of cultivars to manage the various *H. glycines* races, is supported by this study. The type cultivar concept was proposed for advisory purposes to help eliminate confusion created by introduction of the 16-race system and the fact that certain cultivars (ones derived from PI 88788) designated as resistant to race 4 were actually resistant to other races such as race 14. It was believed that the concept was more practical and easier to use for extension programs than the 16-race system. If growers knew the utility of the type cultivars in their area, it would be easier for them to understand the proper use of cultivars with similar resistance as they were introduced by seed companies. This would be particularly true when several races exist within a locale.

Bedford is suitable as the designated type for Maturity Group (MG) V and perhaps MG IV and VI, cultivars with resistance derived from PI 88788. However, since Bedford is no longer widely grown, one of the more popular cultivars such as Asgrow 5403 would be a better choice for a more current type. Other cultivars would be needed for type cultivars in other maturity groups because growers using cultivars of those maturity groups may not be familiar with MG V cultivars. The study also shows that race designations are useful in detecting variation among *H. glycines* populations and can be used in selecting cultivars to plant in infested fields if the type cultivar concept is not used in state extension programs.

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