

Response of Soybean Lines to Differentially Selected Cultures of Soybean Cyst Nematode *Heterodera glycines* Ichinohe¹

S. C. ANAND and G. S. BRAR²

Abstract: Eight soybean cyst nematode, *Heterodera glycines* Ichinohe, cultures were developed by their continuous selection on soybean lines with various level of resistance. Each soybean line was inoculated with eggs and larvae of the eight cultures. Female development was much higher on 'Essex' and 'Forrest' than the other lines. The development of nematode cultures selected on Essex and Forrest was low on the other six soybean lines compared with the lines on which they were selected. PI 89772 and PI 90763 had a high level of resistance to the culture selected on PI 88788, whereas cultures selected on PI 89772 and PI 90763 reproduced very little on PI 88788 and PI 209352. Cultures selected on PI 87631-1, PI 209332, and 'Cloud' gave response similar to that of PI 88788. The use of various sources for resistant variety development program is discussed. **Key words:** *Glycine max* L., races, resistance.

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Since its discovery in 1954 by Winstead et al. (10) in North Carolina, the soybean cyst nematode (SCN) *Heterodera glycines* Ichinohe, has become a major pest of soybeans (*Glycine max* L.) in the southern and eastern United States. Ross and Brim (7) determined PI 90763, PI 84751, 'Ilsøy,' and 'Peking' to be resistant to SCN. Epps and Hartwig (1) reported several other lines with high levels of resistance to field populations of SCN. Golden et al. (2) described four physiological races by their differential response on five soybean lines. Miller (4) reported 11 biotypes of SCN using several legumes as differentials. Recently Riggs et al. (6), using an index rating system, differentiated up to 36 races. Continuous development of an SCN population on resistant soybean lines was found to change the parasitic capabilities of the nematodes (3,5,9,11). Little is known about the host-parasite relationship for the new races and biotypes of the SCN. The present research was undertaken to study the response of soybean lines to various SCN pathotypes which were selected by their continuous reproduction on different known resistant sources.

MATERIALS AND METHODS

Soil was collected from a field at the

Rhodes Memorial Research Farm, located near Clarkton, Missouri. This particular field, used for several years for SCN screening, was known to have high populations of races 3 and 4. Seven soybean lines possessing various degrees of resistance to SCN were grown in 15-cm-d pots containing this infested soil. These soybean lines were 'Forrest,' PI 88788, PI 89772, PI 90763, PI 87631-1, PI 209332, and 'Cloud.' 'Essex,' a susceptible cultivar was included as a check. After 30 days, plants were removed from the pots and the soil was gently removed from the roots. Fifty white females from each line were picked from the roots with a pair of tweezers and added to another pot containing methyl bromide sterilized soil. The pots were sown with the same soybean line from which the cysts were picked. After 35-40 days, the plants were pulled and the white females on the roots returned to the pot. This process was continued for 10 cycles. After the fourth cycle, cultures were transferred to a 30-cm-d pot (volume 21 liters) and maintained in a water bath at $26.6 \text{ C} \pm 2$.

The cross-inoculation studies among different soybean lines were conducted in micropots (20 cm × 2.5 cm) containing previously sterilized soil. Pots were kept at 24-27 C in the water-controlled temperature tanks during the first test and at 27-29 C during the second test. Three thousand eggs and larvae from each cyst culture were added to a pot when the seedlings reached the first trifoliate stage. Thirty days after inoculation, the micropots were soaked in water and the plants removed

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¹Contribution from the Missouri Agricultural Experiment Station. Journal Series Number 8999. University of Missouri, Columbia.

²Associate Professor and Research Associate, University of Missouri-Columbia, Delta Center, Portageville, MO 63873.

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from the pots. Roots were blasted with a strong water jet and the dislodged white females were collected on a 60-mesh sieve. The females per plant were counted under a stereoscope.

The experiment was arranged in a split plot design with soybean lines as mainplots and cyst cultures as subplots. Four replications were used in the first test with another four replications as the second test. The data for four replications in each test were statistically analyzed. Analyses of variance were also computed by combining the data for the eight replications. The means were compared with the respective LSD. The index of parasitism (2) was calculated by considering the number of white females on Essex as 100.

RESULTS

Greater numbers of cysts developed on the roots in the second test which was kept at a temperature slightly higher than that of the first test. In general, the two tests showed a similar trend, thus the results of the combined analyses of eight replications are considered in the remaining discussion. Number of white females/plant was significantly affected by soybean line, SCN culture, and soybean line × culture interaction (Table 1).

Cyst cultures selected on Essex and Forrest developed better on those lines than

Table 1. Analyses of variance for number of white females per plant infected with various populations of *Heterodera glycines* (SCN).

Source of variation	df	Mean squares
Replication	7	70,554**
Soybean line	7	492,227**
Error (a)	49*	8,179
SCN populations	7	99,149**
Soybean line × populations	49	31,489**
Error (b)	392*	1,986

*Coefficient of variation for soybean lines and SCN populations are 84% and 42%, respectively.
**Significant at 0.01 level.

on others (Table 2). The SCN culture selected on PI 88788 developed better on Forrest, PI 87631-1, Cloud, PI 209332, and PI 88788 than on PI 89772 and PI 90763. On the other hand, cultures selected on PI 89772 and PI 90763 developed very little on PI 88788 and PI 209332. Cultures selected on PI 87631-1, PI 209332, and Cloud gave responses almost similar to that of the PI 88788 culture.

Soybean lines were also compared against each culture for their index of parasitism (Table 3). Compared to Essex, PI 88788 and PI 209332 were resistant to the cyst cultures selected on PI 89772 and PI 90763, whereas PI 89772 and PI 90763 did not support high cyst populations, com-

Table 2. Number of white females per plant-root for 64 cross inoculations among eight soybean lines and eight populations of *Heterodera glycines*.

Inoculated soybean line	SCN populations selected* on								Mean
	Essex	Forrest	PI 88788	PI 89772	PI 90763	PI 87631-1	PI 209332	Cloud	
Essex	104 a†	222 a	315 a	382 a	221 a	291 a	341 a	347 a	278
Forrest	95 a	217 a	178 b	407 a	257 a	192 b	74 d	231 b	206
PI 88788	5 b	7 b	97 c	17 c	9 c	69 e	127 c	68 e	50
PI 89772	22 b	38 b	5 d	125 b	57 bc	10 f	4 e	13 f	34
PI 90763	16 b	51 b	4 d	157 b	78 b	12 f	2 e	19 f	42
PI 87631-1	11 b	20 b	169 b	42 c	33 bcd	155 bc	175 b	131 cd	95
PI 209332	4 b	8 b	142 bc	16 c	9 d	103 de	163 bc	95 de	67
Cloud	12 b	16 b	153 b	43 c	27 cd	119 cd	181 b	150 c	87
Mean	34	72	133	148	86	119	133	132	

*SCN populations developed after 10 cycles of selections.

†Comparisons between soybean lines for the same SCN population. Values followed by same letter are not significantly different at *P* = .05. LSD for comparison between soybean lines, between SCN cultures, and between soybean lines for the same culture are 32, 16, and 47, respectively.

Table 3. Index of parasitism (number of cysts relative to 100 cysts on Essex) of various populations of *Heterodera glycines* selected* on one soybean line and tested on the other lines.

Soybean Line	Populations selected on							
	Essex	Forrest	PI 88788	PI 89772	PI 90763	PI 87631-1	PI 209332	Cloud
Essex	100	100	100	100	100	100	100	100
Forrest	91	98	56	106	116	66	22	67
PI 88788	5	3	31	4	4	24	37	20
PI 89772	21	17	2	33	26	3	1	4
PI 90763	15	23	2	41	35	4	1	5
PI 87631-1	11	9	54	11	15	53	51	38
PI 209332	4	4	45	4	4	35	48	27
Cloud	12	7	49	11	12	54	53	43

*SCN populations developed after 10 cycles of selections.

pared to the cultures selected on PI 88788, PI 87631-1, PI 209332, and Cloud.

DISCUSSION

Female development varied tremendously with soybean lines. Essex showed maximum infection by SCN. Forrest, although resistant to races 1 and 3, had more white females on its roots than did other soybean lines, suggesting that these lines possessed a higher level of SCN resistance. The cyst culture selected on PI 88788 produced 97 females on PI 88788 but only 5 and 4 females on PI 89772 and PI 90763, respectively. It is evident that PI 89772 and PI 90763 possess a high degree of resistance to the pathotypes of SCN that are virulent on PI 88788. Conversely, little female development was observed on PI 88788 when inoculated with SCN selected on PI 89772 and PI 90763. The response of PI 87631-1, PI 209332, and Cloud were the same as PI 88788 when treated against cultures selected on PI 89772 and PI 90763. Of these soybean lines, PI 209332 had a higher level of resistance to the culture selected on PI 90763. Our results agree with those of McCann et al. (3) for PI 88788 and PI 89772 but disagree for PI 90763. It is likely that soybean line PI 90763R used by McCann et al. (3) was different from our line PI 90763.

The work of Golden et al. (2) on the classification of races was based on screening of differentials with field populations of SCN. These populations could have been extremely variable. Miller (4) demonstrated that several races of SCN could be recovered

from a field. PI 88788, which was classified as susceptible to race 4 (2), has been found in our studies to have a high degree of resistance to cultures selected on Forrest and PI 90763. Triantaphyllou (9) reported both qualitative and quantitative differences among races of SCN. Thomas et al. (8) indicated that several genes were responsible for resistance in crosses involving susceptible, moderately resistant, and resistant soybean lines. The wide range of cyst reproduction of different cultures on soybean lines in this study suggests the presence of a large number of genes controlling resistance to SCN.

Peking was the donor parent for resistance to races 1 and 3 in Pickett and Forrest. PI 88788 contributed resistance to race 4 in 'Bedford.' Continuous use of soybean varieties with resistance from PI 88788 is likely to increase the pathotypes of SCN which are virulent on it. Zirakparvar and Norton (11) observed an increase in index of parasitism through selection on the resistant soybean cultivars. Since PI 89772 and PI 90763 have a high level of resistance to the culture developed on PI 88788, they would be useful as a source of resistance in variety development. If the resistance factors to SCN in PI 89772 and 90763 are positioned on a locus or loci which differ from the one in PI 88788, it would be possible to combine the two sources to achieve greater resistance. However, if the resistance in the soybean lines is due to multiple alleles on the same locus, they will have to be rotated to provide adequate protection to the SCN biotypes present in the soil.

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