

Resistance to the Reniform Nematode in Selected Soybean Cultivars and Germplasm Lines¹

R. T. ROBBINS AND L. RAKES²

Abstract: Reproduction indices from multiple tests were conducted to show the suitability of several soybean cultivars and germplasm lines as hosts of the reniform nematode *Rotylenchulus reniformis*. Sixteen soybean germplasm lines of 45 reported as resistant to soybean cyst nematode were also resistant to reniform nematode. Cultivars Peking and Pickett, and PI 90763, used as differentials in the standardized soybean cyst nematode race determination test, were resistant to reniform nematode. The differential PI 88788 and the soybean cyst nematode susceptible test standard cv. Lee were susceptible. The 16 soybean cultivars most commonly grown in Arkansas in 1992 were susceptible, whereas cv. Cordell, with PI 90763 in its parentage, and cv. Hartwig, with PI 437654 in its parentage, were resistant.

Key words: breeding, germplasm, *Glycines max*, reniform nematode, reproductive index, resistance, *Rotylenchulus reniformis*, soybean, susceptibility.

Rebois et al. (4) found an association between resistance in soybean (*Glycines max*) to the reniform nematode (*Rotylenchulus reniformis*) and the soybean cyst nematode (*Heterodera glycines*). However, several cultivars resistant to *H. glycines* were at least partially susceptible to the reniform nematode (2,5). Robbins et al. (5) reported that of the 30 soybean cultivars most commonly grown in Arkansas in 1990, five were resistant to *R. reniformis* and also resistant to *H. glycines*.

The objective of this study was to further evaluate the relationship between the resistance of soybean to soybean cyst nematode and reniform nematode by examining the reproduction of reniform nematode on (i) 45 germplasm lines previously designated by Anand and Gallo (1) as resistant to the soybean cyst nematode; (ii) the differentials used in the standardized soybean cyst nematode race test of Golden et al. (3); (iii) the 16 most commonly grown cultivars in Arkansas in 1992 (G. Cloud, pers. com.); and (iv) the cultivars Hartwig and Cordell with resistance to *H. glycines* derived from PI 437654 and PI 90763, respectively.

MATERIALS AND METHODS

Soybean seeds were germinated in flats of vermiculite, and single seedlings were transplanted at the cotyledon stage into 10-cm-diam. clay pots containing 500 cm³ fine sandy loam (91% sand, 5% silt, 4% clay; <1% O.M.). The soil in each pot was inoculated with ca. 1,000 vermiform reniform nematodes placed in three 1-inch-deep depressions. The *R. reniformis* population was from an Arkansas isolate obtained from a Jefferson County, Arkansas cotton field in 1986, maintained in a greenhouse on cotton cv. DP-50, and increased on soybean cv. Braxton for these studies. Greenhouse ambient air temperature ranged from 28 to 34°C. All test pots were watered twice daily (8 am and 4 pm) and fertilized once a week with soluble 20-20-20 (N-P-K). Final nematode populations for each pot were determined by combining the soil (sieving, sucrose centrifugation extraction) and root (sodium hypochlorite shaker extraction) populations as reported by Robbins et al. (5). A reproductive index (RI = final population/initial population) was calculated for each entry in all tests. Because of the variation in RI, data were transformed to log₁₀(x + 1) values for analyses, although actual RI are presented. Statistical analyses were conducted for each test individually and for all tests combined. ANOVA and Duncan's Multiple-Range tests were conducted

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² Professor and Research Assistant, Department of Plant Pathology, Nematology Laboratory, University of Arkansas, Fayetteville, AR 72701.

with SAS (SAS Institute, Cary, NC) procedures.

In the first test, 45 germplasm lines identified as resistant to *H. glycines* (1), the cv. Forrest as a resistant (poor host) check, and cv. Braxton and Lee 74 as susceptible (excellent host) checks were tested as described above for host suitability for *R. reniformis*. The experimental design was a randomized complete block with eight replications per treatment. The test was conducted twice, from 17 July 1993 until 21 September 1993 when harvest began and from 9 February 1994 until harvest starting 11 April 1994. One block (48 pots) was harvested per work-day beginning on the harvest date for each test.

In the second test, in addition to the five soybean lines used for *H. glycines* race determination (Lee, Peking, Pickett, PI 88788, and PI 90763), PI 437654, the germplasm line resistant to all *H. glycines* races, and the cultivar Forrest were included as resistant checks, the cv. Braxton was included as a susceptible check, and infested fallow checks were included. The experimental design was completely randomized with eight replications per treatment. The experiment was repeated four times. The duration of these tests was ca. 10 weeks.

In the third test, in addition to the 16 soybean cultivars most commonly grown in Arkansas in 1992 (Northrup King S59-60, Davis, Pioneer 9641, Hartz 6686, Asgrow 5979, Hartz 5566, Pioneer 9592, Asgrow 6297, Delta and Pine Land 415, Delta and Pine Land 105, Hartz 5164, Asgrow 6785, Asgrow 5885, Asgrow 5403, Hutcheson, Bedford), Hartwig and Forrest were included as resistant checks, Braxton was included as a susceptible check, and an infested fallow check also was included. The experimental design was completely randomized with five replications per treatment. The experiment was conducted twice, from 30 June 1993 to 30 August 1993 and from 2 March 1994 to 12 June 1994.

In the fourth test, the cv. Hartwig with soybean cyst nematode resistance from PI

437654, the cv. Cordell with soybean cyst resistance from PI 90763, Braxton as a susceptible check, and infested fallow were evaluated. Each of the four treatments was replicated 20 times in a completely randomized design. The experiment, which was not repeated, began 17 March 1994 and ended 17 May 1994.

Cultivars and germplasm lines with reproduction indices (RI) less than 1 were assumed to be highly resistant (non-hosts); those with RI greater than 1 but less than 20 were termed resistant (poor hosts), those with RI greater than 20 but less than 120 were termed moderately susceptible (good hosts), and those with high RI (120 or greater) were termed susceptible (excellent hosts). The use of the cultivars Braxton and Lee 74 as susceptible checks and the cultivar Forrest as a resistant check was based on a report by Robbins et al. (5).

RESULTS

Sixteen of the 45 soybean germplasm lines had an RI equal to or less than the resistant check Forrest ($P \leq 0.01$) and are designated resistant (Table 1). The remaining lines had higher RI's and are designated susceptible or moderately susceptible. The susceptible checks Braxton and Lee 74 were among those lines with the highest RI. The germplasm lines with RI significantly lower than both susceptible checks and higher than the resistant check Forrest are termed moderately susceptible. The same 16 germplasm lines were found to be resistant in both tests, and the data given were combined from both tests.

The soybean cyst nematode race test standard cv. Lee 74 and the susceptible check cv. Braxton had a very high RI, the soybean cyst nematode race differential PI 88788 had a high RI, and the race differentials Peking, Pickett, PI 90763, and the resistant check PI 437654 all had an RI as low or lower than the resistant check Forrest (Table 2). The race standard Lee is designated as very susceptible, the differential PI 88788 is designated as susceptible, and the differentials Peking, Pickett, and PI 90763 are designated as resistant.

TABLE 1. Resistance ratings of selected soybean germplasm lines based on reproductive indices of *Rotylenchulus reniformis* in potted glasshouse cultures. Data are the averages of two tests with a total of 16 replications.

Entry	Resistance rating ^a	Reproductive index ^b
Braxton	S	308.1 a
PI 398680	S	265.5 ab
PI 407944	S	210.1 abc
PI 437488	S	203.1 abc
Lee 74	S	190.0 abcd
PI 92720	S	200.4 abcd
PI 88788	S	173.8 abcde
PI 79609	S	189.8 abcde
PI 398682	S	174.1 abcde
Patoka	S	167.7 abcde
PI 54591	S	162.6 abcde
PI 438496B	S	159.3 abcdef
PI 438183	S	168.6 abcdef
PI 417094	S	141.5 abcdefg
Columbia	S	128.7 abcdefg
PI 408192-2	S	137.6 abcdefgh
PI 209332	MS	106.6 bcdefgh
PI 200495	MS	101.6 bcdefgh
PI 79693	MS	97.1 bcdefghi
PI 89008	MS	109.8 bcdefghi
PI 437770	MS	88.4 bcdefghi
Ilsoy	MS	86.6 bcdefghi
PI 438503A	MS	81.6 cdefghi
PI 87631-1	MS	99.9 defghi
Cloud	MS	68.9 efghi
PI 89014	MS	71.8 efghi
PI 407729	MS	56.2 fghi
PI 91138	MS	83.4 ghi
PI 437655	MS	74.5 hi
PI 417091	MS	60.3 hi
PI 416762	MS	60.4 i
Forrest	R	15.3 j
PI 303652	R	11.0 jk
PI 404198B	R	5.1 jkl
Peking	R	5.3 jkl
PI 339868B	R	5.4 jkl
PI 404166	R	4.0 jkl
PI 438498	R	4.1 jkl
PI 438489B	R	3.2 kl
PI 84751	R	4.3 kl
PI 437679	R	3.1 kl
PI 404198A	R	5.6 kl
PI 437654	R	6.1 kl
PI 438497	R	2.8 kl
PI 89772	R	3.4 kl
PI 437725	R	3.2 kl
PI 437690	R	2.4 l
PI 90763	R	6.3 l
CV ^c		62.3 (6.0)

Data followed by the same letter are not significantly different ($P \leq 0.01$) according to Duncan's Multiple-Range Test.

^a S = susceptible (excellent host), MS = moderately susceptible (good host with significantly lower reproduction indices than the excellent hosts), R = resistant (poor host) reniform ratings determined by significant differences.

^b Reproductive index = Final population of eggs from roots and vermiform nematodes in 500 cm³ soil/inoculum of 1,000 vermiform nematodes.

^c CV from RI; CV from transformed RI ($\log_{10} [x + 1]$) in parentheses.

All 16 cultivars most commonly grown in Arkansas in 1992, Northrup King S59-60 (RI = 288.3), Davis (RI = 277.8), Pioneer 9641 (RI = 225.0), Hartz 6686 (RI = 224.8), Asgrow 5979 (RI = 211.1), Hartz 5566 (RI = 186.5), Pioneer 9592 (RI = 174.5), Asgrow 6297 (RI = 173.4), Delta and Pine Land 415 (RI = 172.8), Delta and Pine Land 105 (RI = 152.4), Hartz 5164 (RI = 149.3), Asgrow 6785 (RI = 146.8), Asgrow 5885 (RI = 134.9), Asgrow 5403 (RI = 132.1), Hutcheson (RI = 125.3), and Bedford (RI = 74.2), were more susceptible than the resistant checks Forrest (RI = 5.7) and Hartwig (RI = 2.3). The susceptible check cv. Braxton had an RI of 291.2, and the fallow-infested check had an RI of 0.4. RI were calculated from combined data of both tests.

Reproductive indices of Braxton, Hartwig, Cordell, and inoculated fallow were 101.77, 0.28, 0.07, and 0.08, respectively. These results clearly indicate that the *H. glycines*-resistant Cordell and Hartwig have a high level of resistance to the reniform nematode.

DISCUSSION

The RI values provide a useful tool in evaluating the level of resistance in soybean to the reniform nematode. The soybean lines with very low RI are considered resistant, whereas lines with significantly higher RI are considered susceptible. Within several lines some individual plants appeared to be resistant and others susceptible, e.g., in the soybean cyst nematode differential tests the RI of one pot of Braxton was 36, the four next lowest RI were from 74 to 84, while the remaining 27 pots had RI from 117 to 844; PI 90763 had pots with RI of 209, 183, and 28 with the remaining 29 RI ranging from 0.7 to 8.6; Peking had one pot with an RI of 155 while the remaining pots had RI ranging from 0.9 to 12.6; PI 90763 had pots with RI of 78.2, 29.6, 9.8, and 8.9 while the remaining RI ranged from 0.6 to 3.2. When pure seed sources have been used, intra-line variation is probably the result of a heterogenous soybean gene pool. This seems to be especially common in tests for resistance to reniform nematode and could result from segregation of the soybean pop-

TABLE 2. Resistance ratings of soybean cultivars and lines used as differentials in the standardized test for soybean cyst race determination based on the reproductive indices of *Rotylenchulus reniformis*. Data are the average of four tests with a total of 32 replications.

Entry	Reproductive rating ^a	Reproductive index ^b
Lee	S	313.18 a
Braxton	S	297.38 a
PI 88788	MS	152.43 b
Forrest	R	11.39 c
Pickett	R	10.27 c
Peking	R	9.83 cd
PI 437654	R	15.97 de
PI 90763	R	6.47 e
Inoc. fallow		0.33 f
CV		28.99

Data followed by the same letter are not significantly different ($P \leq 0.01$) according to Duncan's Multiple-Range Test.

^a S = susceptible (excellent host), MS = moderately susceptible (good host with significantly lower reproduction indices than the excellent hosts), R = resistant (poor host) reniform ratings determined by significant differences.

^b Reproductive index = Final population of eggs from roots and vermiform nematodes in 500 cm³ soil/inoculum of 1,000 vermiform nematodes.

ulation because few soybean lines have been tested and selected for resistance to the reniform nematode.

Several contemporary cultivars with soybean cyst nematode resistance have PI 88788 in their parentage. These are more susceptible to reniform nematode than

cultivars derived from Peking (Forrest, Centennial), PI 437654 (Hartwig), or PI 90763 (Cordell). For management of reniform nematode, care should be taken to select cultivars with soybean cyst nematode resistance derived from sources other than PI 88788. When soybean is to be used as a rotation crop to reduce reniform numbers before cotton production, use of resistant cultivars such as Forrest, Centennial, Sharkey, Stonewall (5), and the highly resistant Hartwig, or Cordell are recommended to optimize suppression of reniform nematode populations.

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