

Evaluation of Soybeans Resistant to *Heterodera glycines* Race 5 for Yield and Nematode Reproduction¹

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Abstract: Two soybean breeding lines (D82-2397A and J82-190) resistant to *Heterodera glycines* race 5 produced higher yields ($P = 0.05$) than the race 4-resistant cultivar Bedford for 2 years when planted in a field infested with *H. glycines* race 5 at Tiptonville, Tennessee. Yields were not different between D82-2397A and Bedford when planted in fields infested with race 3, race 9, or with no cyst nematodes. D82-2397A will be released as a cultivar in 1988.

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

Continuous planting of soybean, *Glycine max* (L.) Merr., cultivars resistant to race 4 of the soybean cyst nematode (SCN), *Heterodera glycines* Ichinohe, may lead to development of SCN populations that suppress yields of these cultivars. In 1982, a population of SCN race 5 was reported to reproduce equally on both susceptible and race 4-resistant cultivars (5). Reproduction on the cultivar Bedford (SCN race 3 and 4 resistant) ranged from 38 to 70% of reproduction on susceptible cultivar Essex in greenhouse tests in soils collected from 17 soybean fields (6). These fields had been planted with race 4-resistant cultivars annually for 3-6 years before the greenhouse tests.

D82-2397A and D82-2397B, resistant and susceptible, respectively, to race 5 were developed as near-isogenic selections from the cross Bedford × D72-8927 (E. E. Hartwig, unpubl.). These lines were selected from an F_3 line that was segregating for resistance to race 5. J82-190 is a race 5-resistant selection from a cross of Forrest × D72-8927. Based on greenhouse screening, D82-2397A is resistant to SCN races 3, 4, and 5, whereas J82-190 is resistant to races 3 and 5.

Our objective was to evaluate these race 5-resistant breeding lines for seed yield and SCN reproduction when planted in fields infested with SCN races 3, 5, or 9 (3,4) and in an uninfested field.

MATERIALS AND METHODS

Two randomized complete block designed experiments, one each in 1986 and 1987, were conducted at various sites in Arkansas, Mississippi, and Tennessee. All data were taken from the center two rows of four-row plots that were 6 m long and 0.9 m apart. Twelve 1.9-cm-d soil cores were taken 15 cm deep in the root rhizosphere of each plot at 35, 60, and 120 days after planting to determine SCN population densities. Cysts were extracted from 450-cm³ samples by elutriation (1). Gravid brown cysts and white females were counted, except that white females only were counted 35 days after planting. Population densities were also determined at planting time in 1987.

Cultural practices consisted of conventional tillage before planting, broadcast application of trifluralin (0.84 kg a.i./ha in 75 liters water), and fertilization according to soil test recommendations (2). Acifluorfen (0.28 kg a.i./ha) plus bentazon (0.56 kg a.i./ha) were broadcast for postemergence weed control. Yields and cyst densities were subjected to analysis of variance procedures, and means were separated by Duncan's multiple-range test ($P = 0.05$). Cyst numbers were transformed to $\log_{10}(X + 1)$ before analysis to reduce variance heterogeneity associated with widely different

Received for publication 12 February 1988.

¹ Contribution of Agricultural Research Service, U.S. Department of Agriculture.

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We thank Dr. Grover Shannon, Asgrow Seed Company, Marion, Arkansas, for his assistance with the tests at Wheatley, Arkansas.

TABLE 1. Mean number with standard error (SE) of *Heterodera glycines* females on five soybean genotypes used for race identification when grown in field soil from five locations.

Location	Essex		Forrest		Peking		PI 88788		PI 90763		Race†
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Tiptonville, TN	151	26	115	30	10	7	96	20	0	0	5
Wheatley, AR 1986	255	64	195	42	11	3	62	17	0	0	5
Wheatley, AR 1987	782	92	546	64	148	26	59	10	35	11	9
Woodland Mills, TN	381	58	415	65	63	4	3	1	19	7	9
Grand Junction, TN	405	45	1	1	1	0	10	3	1	1	3

Data are means of four replications with females collected 35 days after planting.

† Race designations according to Riggs and Schmitt (4); however, Essex and Forrest soybeans were substituted, respectively, for Lee and Pickett in their scheme.

nematode reproduction rates among cultivars. SCN races were identified using the scheme of Riggs and Schmitt (4), except that Essex and Forrest were substituted, respectively, for Lee and Pickett.

In 1986, cultivars Bedford, Essex, and Forrest and breeding lines D82-2397A, D82-2397B, and J82-190 were grown in SCN-infested fields at Wheatley, Arkansas, and Tiptonville, Tennessee, and in an uninfested field at Stoneville, Mississippi. The Tiptonville site (Worthen silt loam, pH 6.8) was infested with race 5 (Table 1) and had been planted with Bedford since 1979. Plots were planted 19 June and received adequate rainfall. The Wheatley site (Crowley silt loam, pH 7.6) was infested with race 5 and had a planting history of 1 year of rice followed by 2 years of race 4-resistant soybeans since 1979. Asgrow brand A5474 soybean was grown in 1985. Plots were planted 23 May and were irrigated when rainfall was insufficient after soybeans began flowering. The uninfested Stoneville site (Bosket fine sandy loam, pH 6.8) was planted 4 June and had a history of 1 year of soybean yield plots followed by 1 year of soybean grown for production. It was irrigated as needed after soybeans began flowering.

The cultivars and breeding lines used in 1986 were again grown in 1987, except that Bay was substituted for Essex as the susceptible check. Sites were Grand Junction, Tiptonville, and Woodland Mills, Tennessee; Stoneville, Mississippi; and Wheatley, Arkansas. The Grand Junction site (Loring silt loam, pH 6.2) was naturally

infested with race 3 (22 cysts/450 cm³ soil) and had a planting history of 1 year of soybean plots followed by 1 year of race 3-susceptible soybean grown for production. Plots were planted 13 May and received less than adequate rainfall. The Tiptonville site (278 cysts/450 cm³ soil) was an area adjacent to the 1986 site; plots were planted 29 May and received adequate rainfall. Plots were planted at Woodland Mills (Routon silt loam, pH 6.5) on 14 May. The field was infested with race 9 (84 cysts/450 cm³ soil) and had a planting history of Forrest soybean for 2 years. Adequate rainfall was received at this location. At Stoneville an area adjacent to the 1986 site was used. Plots were planted 21 May and were irrigated as needed after soybean began flowering. The Wheatley site (Crowley silt loam, pH 7.9), not the field that was used in 1986, was infested with race 9 (19 cysts/450 cm³ soil) and was planted 13 May. Planting history was rice in 1986 preceded by 2 years of race 4-resistant soybean. Rainfall was supplemented with irrigation.

RESULTS AND DISCUSSION

Yields of D82-2397A were consistently high at all locations (Table 2). Races 3 and 5 did not reproduce well on this breeding line; thus it is resistant to these races. It may possess some resistance to race 9, since it had fewer ($P = 0.05$) cysts than Bay at all sampling dates at Wheatley in 1987 and at 60 days after planting at Woodland Mills. J82-190 also yielded well at all locations, except at Woodland Mills where the yield was less ($P = 0.05$) than those of D82-

TABLE 2. Mean seed yields and cyst densities on seven soybean genotypes grown in five fields† in 1986 and 1987.

Soybean	Yield (kg/ha)	<i>Heterodera glycines</i> cysts/450 cm ³ soil‡		
		35 DAP	60 DAP	120 DAP
Tiptonville, TN 1986 (race 5)				
Essex	1,495 b	63 a	168 a	485 a
Forrest	1,821 b	15 a	83 b	225 a
Bedford	1,488 b	15 a	92 b	457 a
D82-2397A	2,250 a	5 a	32 c	57 b
D82-2397B	1,795 b	40 a	92 b	242 a
J82-190	2,437 a	12 a	27 c	65 b
Tiptonville, TN 1987 (race 5)				
Bay	2,328 bc	620 a	668 a	133 a
Forrest	2,201 bc	115 b	470 b	92 ab
Bedford	2,101 c	237 b	362 b	230 a
D82-2397A	2,619 a	18 c	107 c	10 b
D82-2397B	2,382 ab	148 b	423 b	113 a
J82-190	2,582 a	25 c	110 c	22 b
Wheatley, AR 1986 (race 5)				
Essex	1,256 c	47 a	140 a	223 a
Forrest	1,781 b	30 a	45 a	103 a
Bedford	2,170 ab	23 a	48 a	208 a
D82-2397A	2,379 a	22 a	27 a	13 b
D82-2397B	2,049 ab	13 a	40 a	130 a
J82-190	2,231 a	27 a	17 a	22 b
Wheatley, AR 1987 (race 9)				
Bay	3,397 a	214 a	315 a	182 a
Forrest	3,347 a	72 b	142 ab	174 a
Bedford	3,797 a	34 bc	64 bc	32 b
D82-2397A	3,597 a	25 bc	75 bc	36 b
D82-2397B	3,656 a	21 bc	35 c	23 b
J82-190	3,067 a	14 c	62 bc	33 b
Woodland Mills, TN 1987 (race 9)				
Bay	2,511 bc	88 a	328 a	107 ab
Forrest	1,858 d	58 a	255 a	108 a
Bedford	2,687 b	3 b	20 c	25 bc
D82-2397A	2,705 b	62 a	108 b	62 ab
D82-2397B	3,120 a	0 b	25 c	8 c
J82-190	2,204 c	103 a	242 ab	97 ab
Grand Junction, TN 1987 (race 3)				
Bay	1,492 a	80 a	105 a	127 a
Forrest	1,310 a	0 b	2 b	3 b
Bedford	1,364 a	7 b	3 b	3 b
D82-2397A	1,300 a	2 b	2 b	3 b
D82-2397B	1,360 a	3 b	2 b	5 b
J82-190	1,410 a	0 b	2 b	2 b

Means within a column for each test location and year followed by the same letter are not different (DMRT, $P = 0.05$); means of three replicates except Wheatley, AR 1987 which had four replicates.

† Different fields were used at Wheatley in 1986 and 1987.

‡ Number of gravid cysts and females for three different sampling days after planting (DAP); at 35 DAP only white females were counted. Mean numbers of cysts/450 cm³ soil for all plots at planting in 1987 were 278, 19, 84, and 22 for Tiptonville, Wheatley, Woodland Mills, and Grand Junction, respectively.

2397A, D82-2397B, and Bedford. Yields of D82-2397A and J82-190 were higher ($P = 0.05$) than those of Bay, Essex, and Forrest at all race 5 sites and were higher than yields of Bedford at the race 5 site at Tiptonville in both years. D82-2397A was the highest yielding soybean in both years at the uninfested site at Stoneville, but its yield was greater than that of Essex only in 1986 ($P = 0.05$).

Although the extent of hectareage infested with race 5 is unknown, D82-2397A will be released as a cultivar for planting in race 5-infested fields because it had fewer cysts and higher yields than other cultivars when grown in race 5-infested fields in these experiments.

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