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Evaluation of Soybean Cultivars for Production in *Meloidogyne arenaria* Race 2-infested Soil[1]

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Abstract: Field trials with 56 soybean cultivars and breeding lines from public and private sources were conducted from 1986 through 1988 at a site infested with *Meloidogyne arenaria* race 2. Differences ($P < 0.05$) among yields were found each year and yields were negatively correlated ($P < 0.01$) with root-knot nematode galling. All entries were galled and the highest-yielding entries, 'Kirby' and 'Coker 6738', were determined to have average yield reductions of 56% and 62%, respectively, when compared with uninfested sites over the 3-year period.

Key words: Glycine max, Meloidogyne arenaria, root-knot nematode, soybean, resistance.

Soybean (*Glycine max* (L.) Merr.) cultivars and breeding lines have been evaluated annually for agronomic traits and susceptibility to pathogens at various sites throughout the soybean production area of Florida (9). At a site infested with a race 2 population of *Meloidogyne arenaria* (Neal) Chitwood (2), evaluations for root-knot nematode galling and yield responses were performed from 1986 through 1988 on 56 entries from public and private sources. Nineteen cultivars were evaluated each year for continuity. The purpose of these studies was to identify soybean cultivars that may be suitable for production in soils infested with this increasingly important pest of soybean (5). Data from similar studies for 1982 through 1985 have been published (7).

MATERIALS AND METHODS

Experiments were conducted at a site naturally infested with *M. arenaria* near Allentown, Santa Rosa County, Florida. The soil was a loamy sand (80% sand, 12% silt, 8% clay; pH 6.0, < 2% organic matter) fertilized each year with 200 kg/ha of 10-30-60 (N-P_2O_5-K_2O) at the rate of 200 kg/ha. Plots were arranged in a randomized complete block design with four replicates per entry in 1986 and 1987 and three replicates per entry in 1988. Each plot consisted of three rows, 8.2 m long and 0.9 m apart. Alleys, 1 m wide, established at the time of planting separated the blocks. Nematode population density per 10 cm^3 soil across each experimental block was assayed immediately before planting to determine the levels of infestation. A single soil core, 2.5 cm d and 20 cm deep, was taken from the center of each plot. The cores from the block were mixed and the nematodes were extracted from a 100-cm^3 subsample by centrifugal flotation (4).

Approximately 30 soybean seeds per meter of row were planted on 23 May 1986, 3 June 1987, and 15 June 1988. The cultivars and breeding line from public sources were Bedford, Braxton, Gordon, Jeff, Kirby, Lamar, Leflore, Sharkey, Thomas, Wright, and GA 79-402. Other soybeans were provided by Asgrow Seed Company, Kalamazoo, Michigan; Coker's Pedigreed Seed Company, Hartsville, South Carolina; Jacob Hartz Seed Company, Stuttgart, Arkansas; Hyperformer Seed Company, Memphis, Tennessee (entries prefixed HSC); Northrup King Company, Minneapolis, Minnesota (entries prefixed NK); and H. J. Underwood Company, Inc., Clinton, North Carolina (entries prefixed EHJU).

Plots were cultivated and hand-weeded when necessary. Root-knot galling in each plot was scored on 26 August 1986, 18 September 1987, and 27 September 1988. Two groups of four plants from each border row were rated according to the following scale: 0 = no galling, 0.2 = < 5%, 1 = 5–25%, 2 = 26–50%, 3 = 51–75%, and 4 = > 75% of the root surface galled. The

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middle row of each plot was harvested at maturity on 5 December 1986, 26 October 1987, and 17 October 1988. The harvest delay in 1986 was due to a prolonged period of wetness. Yields were adjusted to 13% moisture content. Immediately following the 1987 harvest all plots were sampled for *M. arenaria* juveniles. Seven soil cores were taken along the harvested row of each plot. The cores were mixed and the nematodes were extracted by centrifugal flotation from a 100-cm^3 soil subsample. All data were subjected to analysis of variance and means were separated ($P < 0.05$) by Duncan's multiple-range test. Companion studies (3) were conducted with the same cultivars and breeding lines during the same 3 years, but in sites without pathogenic nematode populations at the University of Florida Agricultural Research and Education Center in Marianna and at the University of Florida North Florida Research and Education Center in Quincy.

Results and Discussion

In addition to *M. arenaria*, *Helicotylenchus dihystera* (Cobb) Sher, *Hoplolaimus galeatus* (Cobb) Filipjev & Schuurmans Stekhoven, *Paratrichodorus porosus* (Allen) Siddiqi, and *Pratylenchus scribneri* Steiner were present at the test sites, but in numbers considered too low to influence soybean production. Preplant levels of second-stage infective juveniles of *M. arenaria* were < 10/10 cm^3 soil each year.

Differences ($P < 0.05$) in galling scores were found among the cultivars and breeding lines in 1987 and 1988, but not in 1986 (Table 1). Differences ($P < 0.05$) in yields were found among all entries in all 3 years. Average galling scores of 3.6, 2.6, and 2.9 and average yields of 343, 872, and 801 kg/ha were recorded for the 19 entries common to all tests in 1986, 1987, and 1988, respectively. Yields were negatively correlated ($P < 0.01$) to the amount of galling across all entries each year from 1986 to 1988 with r values of -0.38 (df = 130), -0.77 (df = 134), and -0.52 (df = 115), respectively. Over the 3-year period the relationship of the yield of the 19 common cultivars to galling was expressed by $Y = 2{,}053 - 468X$, $r = -0.78$ (df = 204, $P < 0.01$), where Y = kg/ha and X = galling score. The galling scores for the most susceptible entries, such as Cobb, Deltapine 417, Deltapine 566, and NKS69-96 were consistently high and never less than 3.3 in any year of testing. Galling on the least susceptible entries was more variable, however, with Coker 6738 ranging from 1.5 to 3.3 and Kirby ranging from 1.5 to 2.8. These higher ranges were not significantly different from those produced on the most susceptible entries. This seasonal variability in galling of the less susceptible cultivars has been noted previously (7). Among the 19 common cultivars, the lowest average yield over the 3-year period was harvested from Cobb (177 kg/ha) and the highest from Coker 6738 (1,244 kg/ha). Coker 6738 was among the highest yielding in each year of testing, as were Kirby and Hartz 6385 which averaged 1,195 kg/ha and 921 kg/ha, respectively, over the 3 years.

There were differences ($P < 0.05$) in the number of infective juveniles of *M. arenaria* among entries following harvest in 1987 (data not presented), ranging from 40/10 cm^3 soil under Deltapine 105 to 158/10 cm^3 under Kirby. However, there were no significant relationships between the number of soil infesting juveniles and either galling or yield across cultivars. A lack of such relationship to galling and yield of soybean has been reported previously for *M. arenaria* (7) and *M. incognita* (Kofoid & White) Chitwood (6).

No cultivar or breeding line evaluated in the 3 years of testing exhibited significantly less galling or yielded greater than Kirby, the most productive cultivar in 7 years of field testing in soil infested with *M. arenaria* race 2 (7). In companion studies conducted with the same cultivars and breeding lines at sites in north Florida where soils were not infested with *M. arenaria* (3), yields of Kirby were more than double those achieved over the 3 years in these tests (Table 2). Galling and yield re-

TABLE 1. Galling† on, and yield of, soybean cultivars and breeding lines grown in soil infested with *Meloidogyne arenaria* race 2.

Entry	1986		1987		1988	
	Galling	Yield (kg/ha)	Galling	Yield (kg/ha)	Galling	Yield (kg/ha)
			Maturity Group V			
Bedford	3.0 a	155 ef	2.0 f–i	684 f–i		
Coker 485	3.2 a	242 c–f	3.3 a–e	555 g–k	2.6 a–f	860 b–k
Coker 6995					2.1 c–f	818 b–k
Deltapine 105			3.9 a	499 g–j	3.0 a–f	808 b–k
Deltapine 415					2.9 a–f	892 b–j
Deltapine 675	2.9 a	122 ef	2.6 c–h	555 g–k		
Hartz 5164			1.7 hi	962 b–g	2.5 a–f	1,332 ab
Hartz 5370	3.3 a	518 a–e	2.1 f–i	1,239 a–e		
			Maturity Group VI			
Asgrow 6785			1.8 g–i	1,591 a	2.6 a–f	1,101 a–e
Centennial	3.5 a	134 ef	2.8 b–g	814 d–h	3.2 a–e	1,196 a–d
Coker RA 606	3.6 a	329 b–f	3.3 a–e	518 g–j	3.6 a–c	587 e–l
Coker RA 680	3.3 a	271 c–f	2.8 b–g	721 e–i	3.1 a–f	724 c–l
Coker 686	3.6 a	384 b–f	2.3 e–i	1,406 ab	2.8 a–f	1,101 a–e
Deltapine 506	3.5 a	276 c–f				
Deltapine 566	3.9 a	139 ef	3.6 a–c	425 g–j	3.7 ab	304 j–i
Deltapine 726			3.6 a–c	536 g–j	3.0 a–f	577 e–l
EHJU 5					2.1 c–f	1,107 a–g
EHJU 7					1.9 d–f	1,080 a–f
EHJU 9					2.9 a–f	199 l
EHJU 11					3.3 a–e	1,206 a–d
GA 79-402	3.0 a	346 b–f				
Hartz X6200			3.7 ab	481 g–j		
Hartz X6370			1.6 hi	1.387 ab		
Hartz 6130	2.8 a	564 a–d	1.5 i	1,295 a–d		
Hartz 6383R	3.2 a	460 a–f				
Hartz 6385	2.9 a	575 a–c	1.6 hi	1,128 a–f	2.2 b–f	1,059 a–g
HSC B2J					2.6 a–f	1,248 a–d
HSC Baldwin					3.1 a–f	933 b–i
Jeff	3.1 a	172 d–f				
Lamar					3.5 a–c	692 d–l
Leflore	3.6 a	129 ef	2.9 af	721 e–i	3.7 ab	986 a–h
NK S69-96	3.7 a	124 ef	3.3 a–e	370 h–k	3.5 a–c	483 g–l
Sharkey					4.0 a	398 h–l
			Maturity Group VII			
Asgrow 7986			3.3 a–e	536 g–j	2.9 a–f	751 b–l
Braxton	2.9 a	427 b–f	1.7 hi	1,258 a–d	2.1 c–f	346 i–l
Coker 627	3.0 a	420 b–f				
Coker 6727	2.7 a	715 ab	1.6 hi	1,350 a–c	1.9 d–f	870 b–j
Coker 6847	3.5 a	254 c–f	2.6 c–h	1,184 a–f	2.7 a–f	1,070 a–g
Deltapine 417	3.8 a	81 f	3.4 a–d	462 g–j	3.5 a–c	357 i–l
Deltapine 497	4.0 a	67 f	3.8 ab	111 j		
EHJU 3					3.9 a	399 h–l
Gordon	2.6 a	715 ab	1.6 hi	1,406 ab	1.8 ef	724 c–l
Hartz 7110	2.8 a	581 a–c	1.8 g–i	1,332 a–d		
Hartz 7126	3.6 a	129 ef	2.8 b–g	721 f–i	3.5 a–c	587 e–l
NK S74-40					3.3 a–e	67 l
HSC Starr					3.5 a–c	388 i–l
Thomas					3.6 a–c	671 d–l
Wright	2.6 a	619 a–c				

TABLE 1. Continued.

Entry	1986		1987		1988	
	Galling	Yield (kg/ha)	Galling	Yield (kg/ha)	Galling	Yield (kg/ha)
			Maturity Group VIII			
Cobb	3.4 a	96 f	3.3 a–e	203 ij	3.4 a–d	231 kl
Coker 368	3.9 a	101 f	3.4 a–d	536 g–j	3.5 a–c	887 b–j
Coker 488	3.9 a	125 ef				
Coker 6738	3.3 a	841 a	1.5 i	1,350 a–c	1.6 f	1,541 a
Deltapine X878					3.9 a	493 f–l
Hartz X8300			2.4 d–i	841 c–h		
Hartz 8112	3.6 a	348 b–f	3.2 a–e	351 h–j		
Kirby	2.8 a	833 a	1.7 hi	1,443 ab	2.6 a–f	1,310 a–c

Data are means of four observations in 1986 and 1987 and three observations in 1988. Means followed by the same letter within a column are not significantly ($P < 0.05$) different according to Duncan's multiple-range test.

† Galling rated on a scale of 0 = no galling, 0.2 = < 5%, 1 = 5–25%, 2 = 26–50%, 3 = 51–75%, and 4 = > 75% root surface galled.

sponses in these tests show that the level of resistance of Kirby, or any other cultivar, is insufficient for productive yields in soils infested with this nematode. Hence, until more resistant soybean cultivars have been developed, alternative cropping strategies must be employed for the management of *M. arenaria* race 2. Although the value of cropping with maize (*Zea mays* L.) to suppress populations of this nematode may be dependent on cultivar (8,10), recent studies have demonstrated the nonhost status of sorghum (*Sorghum bicolor* (L.) Moench) to *M. arenaria* race 2 and thus its suitability as a management crop (1). Other nonhost crops such as cotton (*Gossypium hirsutum* L.) and peanut (*Arachis hypogaea* L.) require investigation of their potential as rotation crops for the management of *Meloidogyne arenaria* race 2.

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TABLE 2. Comparative 3-year average yields of soybean cultivars grown in sites with no significant nematode infestation or in sites infested with *Meloidogyne arenaria* race 2, 1986–88.

	Yield (kg/ha)		Yield difference (% of uninfested)
	Uninfested site†	Infested site‡	
Kirby	2,735	1,195	56
Coker 6738	3,279	1,244	62
Coker 686	3,129	964	69
Coker 6727	3,241	978	70
Gordon	3,133	948	70
Hartz 6385	3,068	921	70
Coker 6847	3,492	836	76
Centennial	3,272	715	78
Braxton	3,261	677	79
Leflore	3,187	612	81
Coker 485	2,852	522	81
Coker RA 680	3,095	572	82
Hartz 7126	2,861	479	83
Coker 368	3,224	508	84
Coker RA 606	3,228	478	85
NK S69-96	3,370	326	90
Deltapine 566	2,953	289	90
Deltapine 417	3,333	300	91
Cobb	3,000	177	94

† Average yields of 22 observations at Agricultural Research and Education Center, Marianna, Florida; and North Florida Research and Education Center, Quincy, Florida.

‡ Average yields of 11 observations at *Meloidogyne arenaria* race 2-infested site in Santa Rosa County, Florida.

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