

Resistance in Commercial Soybean Cultivars to Six Races of *Heterodera glycines* and to *Meloidogyne incognita*¹

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Abstract: Soybean cultivars grown in pots in the greenhouse were tested for resistance by inoculation with *Meloidogyne incognita* or one of six races of *Heterodera glycines*. Selected cultivars were tested against each nematode isolate. The numbers of cultivars tested against each *H. glycines* race and the numbers resistant and (or) moderately resistant were as follows: Race 2—114 tested, 1 resistant and 9 moderately resistant; race 3—170 tested, 56 resistant and 17 moderately resistant; race 4—89 tested, 1 resistant and 13 moderately resistant; race 5—106 tested, 4 moderately resistant; race 6—95 tested, 10 resistant and 25 moderately resistant; race 14—81 tested, 2 resistant and 10 moderately resistant. No cultivar was resistant to all races. *Meloidogyne incognita* was tested on 139 cultivars; 50 were resistant.

Keywords: *Glycine max*, *Heterodera glycines*, *Meloidogyne incognita*, race, root-knot nematode, soybean, soybean cyst nematode.

Soybean cyst nematode, *Heterodera glycines* Ichinohe (SCN), has been reported in 26 states in the United States. In many of these states (e.g., Arkansas) the infestation is widespread, whereas in other states (e.g., Kansas) the infestation is very limited (3). SCN damage to soybean (*Glycine max* (L.) Merr.) can result in yield suppression. Many resistant cultivars with resistance to SCN are now available. Providing information on the resistance of available cultivars has become a problem with the increasing number of SCN races (2).

Commercial cultivars have been tested in Arkansas against races 2-6 and 14 and against *Meloidogyne incognita* (Kofoid and White) Chitwood during the past 4 years. A number of cultivars were tested more than 1 year. This paper is a compilation of the results of those tests.

MATERIALS AND METHODS

Seeds of all soybean cultivars were germinated in vermiculite and transplanted, one per pot, into fine sand in 7.5-cm-d clay pots. The seedlings were inoculated 2 days later. There were 5-10 replications of each cultivar, depending on the test. Tests were

not repeated the same year, but a number of cultivars were tested for 2-4 years.

All *H. glycines* races used were collected from Arkansas soybean fields. Inoculum of *H. glycines* races 2-6 and 14 (2) was maintained on soybean cultivars Lee or Pickett. Females and cysts were extracted from stock cultures and caught on a 250- μ m-pore sieve; cysts were then broken in a blender. The resulting suspension of eggs and second-stage juveniles was used as inoculum. The inoculum, 4,000 eggs and juveniles per pot, was applied with a repeating syringe to the sand near the root of each seedling.

The plants were maintained in a greenhouse at 24-30 C for 5 weeks. Females and cysts were recovered from each root and counted. Lee and the race host differentials, Pickett, Peking, PI 88788, and PI 90763, were used as checks. Cultivars were rated resistant if the index of females and (or) cysts recovered per root system was 9 or less (< 10% of the number of females and cysts on Lee), as moderately resistant if the index was 10-25, and susceptible if the index was > 25.

Root-knot nematode inoculum was maintained in a greenhouse on tomato (*Lycopersicon esculentum* Mill. cv. Rutgers). Inoculum was obtained by the sodium hypochlorite procedure (1). About 10,000 eggs and second-stage juveniles were applied around the roots of each plant grow-

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TABLE 1. Average indices† of six races of *Heterodera glycines* and of *Meloidogyne incognita* on commercial soybean cultivars.

Soybean cultivar	Race 2		Race 3		Race 4		Race 5		Race 6		Race 14		<i>M. incognita</i>		
	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index‡	No. eggs/plant
A5474	2	46	1	1	3	47	1	45	1	14	1	16	1	3.0	2,000
A5618			1	42	1	30							1	5.0	
A5939			1	13	1	23							1	5.0	21,600
A5974	1	23	1	1			1	79	1	20			2	3.9	20,100
A5980	3	40	3	12			2	72	1	4	1	37	1	1.3	1,200
A6242	2	18	2	9			1	53	1	9	1	6	2	2.4	8,500
A6381	1	200	1	85			1	26	1	85	1	133	1	0.7	800
A6520	2	23	4	5	2	38	2	77	2	66	1	17	1	0.0	0
A6785	1	87	1	42			1	39	1	120			1	1.0	1,000
A7372	3	118	3	121	1	35	1	126			1	180	1	5.0	
A7986	1	99	1	47			1	67	1	120					
Acco 401			1	56	1	87									
AgriPro 55			1	69	1	90									
AgriPro 70			2	103	1	66							2	0.0	240
AgriPro 71			1	48	1	64							1	3.0	
AgriPro 350			1	70	1	176			1	93					
AW 42	1	16	1	1			1	72	1	17			1	4.3	14,400
Bedford	4	31	12	4	7	16	2	87	2	56	1	10	4	0.9	770
Bossier	1	316	1	103			1	93			1	13			
Bragg	2	131	3	76	1	27	1	81	1	249	1	148	3	1.6	800
Braxton	2	104	3	120	1	45	2	139	1	252	1	136	3	0.7	0
Brysoy 9			1	66	1	55							2	3.1	
Buck 500	1	158	1	96			1	67			1	113	1	1.0	4,400
Centennial	2	131	4	4	1	38	2	55	1	18	1	172	4	0.9	1,300
Coker 156	2	126	5	95	1	30	2	77	1	148	1	163	4	1.6	5,440
Coker 237	2	54	4	116	1	55	2	71	1	175	1	136	4	2.2	4,410
Coker 317	1	90	2	13	1	115	1	35			1	142	1	2.3	2,600
Coker 355	4	29	4	8	1	16	2	86	1	16	1	68	2	2.4	12,100
Coker 368	1	91	1	< 1			1	54	1	20			1	1.0	1,100
Coker 425	4	120	3	108			2	93	1	148	1	116	2	3.3	9,400
Coker 485	4	84	3	4			2	41	1	16	1	133	2	0.7	525
Coker 575	1	190	1	14			1	14			1	184	1	0.0	400
Coker 596	1	181	1	16			1	43			1	145	1	0.0	0
Coker 627	2	85	2	8			1	75	1	20	1	136	2	0.5	650
Coker 686	2	47	2	8			2	49	1	18	1	109	2	0.4	2,000
Coker 738	1	78	1	1			1	42	1	25			1	1.0	400
Columbus			1	47	1	15							1	5.0	

TABLE 1. Continued.

Soybean cultivar	Race 2		Race 3		Race 4		Race 5		Race 6		Race 14		<i>M. incognita</i>		
	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index‡	No. eggs/plant
Crawford			1	71	1	32							1	5.0	
Dare			1	94	1	28							1	3.2	
Davis	3	46	3	63	1	34	2	74	1	35	1	104	3	3.4	22,900
DPL 105	4	106	4	116	1	88	2	64	1	178	1	157	2	1.9	3,200
DPL 246	2	70	2	135	1	80									
DPL 296			1	79	1	57									
DPL 345	2	96	3	56	1	81	2	116	1	32	1	163	3	3.9	25,900
DPL 386			1	87	1	121									
DPL 403			1	91	1	20							1	2.5	
DPL 415	1	124	1	1			1	60	1	30			1	3.7	8,400
DPL 416			1	53	1	75									
DPL 417	3	89	3	120	1	61	1	143			1	148	1	0.0	0
DPL 439			1	67	1	42							1	4.4	
DPL 497	2	121	3	80	1	140	2	96	2	100	1	124	1	0.0	0
DPL 506	1	94	1	58			1	123	1	120			1	4.7	92,400
DPL 566	2	137	2	65			2	53	1	50	1	66	2	2.3	21,300
DPL 675	1	29	1	2			1	96	1	6			1	3.3	22,200
Egyptian	1	32	1	1			1	119	1	14					
Epps	2	20	2	7			2	64	1	25	1	18	1	3.7	11,000
Essex	4	91	4	100	1	57	2	94	1	170	1	163	3	2.1	4,600
FFR 559			1	28	1	144			1	94					
FFR 560	1	9	1	9			1	44			1	13	1	0.3	0
FFR 561	2	141	3	70	1	11	2	67	2	99	1	190	2	2.9	8,500
FFR 562	1	59	1	94			1	51			1	122	1	2.7	12,800
FFR 668	1	51	1	121			1	123			1	171	1	0.0	0
FFR 711	1	90	1	142			1	175			1	154	1	2.7	2,000
FFR 771	2	113	2	97			2	67			1	172	2	1.2	16,900
Forrest	2	76	3	5	2	44	2	21	1	52	1	157	3	1.5	1,200
Gasoy 17			2	153	1	47							2	2.8	27,600
Gordon	2	65	2	10			2	37	1	17	1	148	2	1.0	200
Govan			2	166	1	49							2	0.6	240
GS 333			1	2	1	19							1	2.7	
GS 737			1	50	1	27							1	3.5	
GS 791			1	85	1	74									
Hartz 5164	1	31	1	2			1	125	1	14					
Hartz 5171	2	129	2	7			2	27	1	8	1	157	2	2.5	13,400

TABLE 1. Continued.

Soybean cultivar	Race 2		Race 3		Race 4		Race 5		Race 6		Race 14		<i>M. incognita</i>		
	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index‡	No. eggs/plant
Hartz 5252	2	146	2	6			2	29	1	3	1	106	2	1.0	525
Hartz 6130	2	25	2	5			2	80	1	19	1	6	2	0.4	475
Hartz 6383	2	136	2	8			2	39	1	11	1	78	2	0.4	600
Hartz 7110	1	87	1	< 1			1	29	1	18			1	1.0	12,000
Hartz 7126	2	96	2	12			2	46	1	39	1	116	1	5.0	56,400
Hartz 8112	2	94	2	52			2	103	1	157	1	107	2	4.0	29,200
Helena 401			1	94	1	89									
Hill			1	53	1	40							2	2.5	
Hood 75			1	75	1	44							1	5.0	
Jeff	4	35	4	5	1	22	2	102	1	4	1	19	2	0.9	825
Johnson	1	95	1	109			1	89	1	129			1	2.3	4,800
Lancer			2	237	1	27							3	1.6	1,600
Lee	2	100	11	100	6	100	5	100	1	100	1	100	1	4.3	38,400
Lee 74	2	93	3	114	1	100	2	64	1	73	1	142	3	1.3	20,566
Leflore	2	19	2	9			2	91	1	6	1	10	1	0.0	0
Lloyd	1	35	2	4			1	74	1	30			3	4.4	106,500
Mack	2	87	3	7	1	53	2	86	1	10	1	101	2	0.0	720
McNair 3152			2	2	1	29							2	3.0	7,920
McNair 3167			2	2	1	31							1	5.0	
McNair 500			1	73	1	47							2	1.7	
McNair 600			1	71	1	17							1	5.0	
McNair 700	2	97	3	107	2	71							1	2.3	
McNair 710			1	66	1	28							1	4.7	
McNair 770			1	1	1	96									
Mitchell			1	44	1	48							1	4.7	
MV 100			1	4	1	69									
MV 101			1	2	1	16							1	2.7	
NAPB 503			1	2	1	95									
NAPB 505			1	81	1	45							1	5.0	
NAPB 517			1	69	1	139			1	93					
NAPB 607			1	3	1	40							1	4.0	
NAPB 611			1	< 1	1	104									
NAPB 705			1	1	1	34							1	4.7	
Narrow	2	62	4	24	2	61	2	48	2	58	1	127	2	4.4	7,400
Nathan	4	42	3	25			2	52	1	30	1	27	2	0.9	300
Peking	4	24	11	< 1	6	48	2	2	2	5	1	53	2	4.3	67,200

TABLE 1. Continued.

Soybean cultivar	Race 2		Race 3		Race 4		Race 5		Race 6		Race 14		<i>M. incognita</i>		
	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index‡	No. eggs/plant
Pershing	2	111	2	90			2	109	1	154	1	122	2	2.0	4,500
Pickett	4	89	10	3	6	116	2	55	2	40	1	148	2	3.2	24,700
Pickett 71			1	1	1	60							3	3.4	2,160
P 5482	3	83	2	92			1	31			1	64	1	1.0	600
P 5683			1	1	1	97									
Pioneer 9531	1	55	2	11			1	67			1	22	1	0.3	600
Pioneer 9561	3	88	3	92			1	83			1	80	1	0.0	200
Pioneer 9571	4	30	1	8			2	87	1	17	1	14	2	1.5	800
Pioneer 9581	1	22	1	2			1	94	1	18			1	1.0	1,900
Pioneer 9591	1	85	1	38			1	81	1	64					
Pioneer 9691	1	76	1	< 1			1	53	1	11			1	1.3	2,800
Pioneer 9791	1	132	1	93			1	64	1	143			1	5.0	51,600
Pyramid	1	30	1	< 1			1	163	1	12					
RA 405	1	131	3	91			1	101			1	124	1	5.0	96,000
RA 451	4	88	1	107			2	141	1	129	1	124	2	3.2	7,600
RA 452	1	199	2	93			1	236	1	172			1	5.0	7,800
RA 480	2	125	1	96			2	99	1	228	1	106	2	3.0	4,200
RA 501A			1	50	1	20							1	5.0	
RA 603			2	60	1	50							1	3.0	
RA 604	1	42	1	28	1	65	1	47			1	133	1	2.7	
RA 605			3	21	1	9							1	1.8	
RA 606	4	53	3	21			2	69	1	26	1	122	2	2.5	8,700
RA 680	2	53	1	5	1	72	2	64	1	19	1	169	2	0.5	1,000
RA 701			1	15	1	22							1	0.8	
RA 701A			1	< 1	1	86									
RA 701B			1	1	1	114									
RA 702	2	126	2	5			2	16	1	67	1	151	2	1.0	500
RT 503									1	88					
RT 563									1	84					
RT 593									1	121					
RT 613									1	126					
RT 713									1	75					
Sampson	2	92	2	77			2	80	1	50	1	68	2	2.0	32,800
Sanaloma	2	108	2	83			2	98	1	115	1	102	2	2.2	32,200
Sharp	2	50	1	110											
Shiloh	2	25	4	47			2	84	2	57	1	69	2	1.7	4,800

TABLE 1. Continued.

Soybean cultivar	Race 2		Race 3		Race 4		Race 5		Race 6		Race 14		<i>M. incognita</i>		
	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index	No. tests	Av. index‡	No. eggs/plant
Sohoma			2	98	1	45							2	3.0	21,360
Spartan	3	75	2	121			1	30	1	48			1	4.3	99,600
Star	2	103	2	110			2	80	1	117	1	136	2	1.0	1,600
Stevens	1	139	1	101			1	129			1	107	1	0.0	5,600
Stutts			1	21	1	160			1	121					
Sumpter			4	14	1	130	1	72			1	113	1	0.0	0
Tracy			2	143	1	44							2	3.6	22,560
Tracy M	2	73	3	102	1	44	2	80	1	194	1	154	2	3.4	9,800
TV 505			1	59									1	5.0	
TV 515	4	79	3	5			2	36	1	17	1	119	1	0.0	600
TV 553	4	89	3	12			2	33	1	8	1	148	1	0.0	400
TV 606			1	38	1	55							1	2.3	
TV 616	2	99	2	37			2	107	1	91	1	101	2	2.9	17,700
TV 708	2	104	2	108	1	27							1	4.0	
TV 768	2	118	1	128											
TV 774	2	76	1	243											
TV 790	2	98	1	96											
TV 808	2	70	1	8											
TV 794	2	64	1	57											
Wilstar 480			1	50	1	25							2	4.4	14,000
Wilstar 550	2	104	3	63	1	37	2	64	1	120	1	181	2	4.2	4,200
Wilstar 780	2	118	4	80	2	93	2	90	2	95	1	175	2	4.9	19,800
YK 503	2	97	2	46			2	57	1	126	1	130	2	4.2	12,400
YK 563	1	129	1	91			1	22			1	85	1	2.3	0
YK 577	1	60	1	< 1			1	47	1	8			1	0.7	700
YK 593	4	86	3	12			2	106	1	27	1	178	2	0.5	900
YK 613	2	96	2	8			2	33	1	3	1	126	2	3.7	50,100
YK 701	1	44	1	5			1	79	1	30			1	2.0	1,800
YK 757	1	40	1	3			1	81	1	23			1	2.3	1,100
Young	2	59	2	91			2	82	1	127	1	178	2	2.0	19,200

† SCN index = (number of females or cysts from cultivar)/(number of females or cysts from Lee) × 100. Cultivars with indices of 0–9 were considered resistant, 10–25 moderately resistant.

‡ Root-knot index: 0 = no galls, 1 = 1–2 galls/root system, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = > 100. Cultivars with gall rating of 11.5 or less were considered resistant unless egg counts were above 5,000/root system; if gall ratings were above 1.5 but egg counts were < 2,000, the cultivars were considered resistant.

ing in fine sand in 10.5-cm-d clay pots. After 7 weeks, root-knot galling was rated on a scale of 0 to 5 (0 = no galls; 1 = 1–2 galls per root system; 2 = 3–10; 3 = 11–30; 4 = 31–100; and 5 = > 100 galls). After the root systems were rated they were treated with 10% sodium hypochlorite for recovery of eggs (1). Cultivars with gall ratings of 1.5 or less and an egg count below 3,000 per root system, or an egg count less than 2,000 per root system regardless of gall rating, were classed as resistant to *M. incognita*.

RESULTS AND DISCUSSION

Of 175 cultivars tested, 74 were good hosts to all of the races of *H. glycines* and to *M. incognita*. The number of cultivars with resistance varied with the nematode and race (Table 1). Of 170 cultivars tested against SCN race 3, 56 were resistant and 17 moderately resistant. Race 2 was tested on 114 cultivars; 1 was resistant and 9 were moderately resistant. None of the cultivars tested were resistant to race 5, but 4 were moderately resistant. Race 6 was tested on 95 cultivars; 10 were resistant and 25 were moderately resistant. Race 4 was tested on 89 cultivars; 1 was resistant and 13 were moderately resistant. Race 14 was tested on 81 cultivars; 2 were resistant and 10 were moderately resistant. Of 139 tested against *M. incognita*, 50 were resistant. Peking is included as a *H. glycines*-resistant check but is not included in the numbers of resistant cultivars.

Resistance to soybean cyst nematode race 3 was common and the level of resistance of individual cultivars was higher. This suggests that race 3 is the "wild type" with the fewest or no genes to help it overcome

resistance (4). The second highest number of resistant cultivars recorded was to race 6, which parasitizes only Pickett among the host differentials. Pickett, a derivative of Peking, apparently has fewer genes for resistance than Peking (unpubl.) and may have fewer than PI 88788 and PI 90763. Race 5 parasitized only two host differentials (Pickett and PI 88788) and there were fewer cultivars with resistance to it than to any other SCN race tested. Races 2 (Pickett, Peking, and PI 90763) and 14 (Pickett, Peking, and PI 88788) parasitize three host differentials and race 4 parasitizes four (Pickett, Peking, PI 88788, and PI 90763); there were about equal numbers of cultivars with resistance to each of them.

The most reliable indices are those from cultivars tested at least two times. Reports of tests for resistance to *H. glycines* races other than races 1–4 were not found. This report provides information on the susceptibility or resistance of many cultivars to two newly described races (races 6 and 14). It also provides cyst indices and *M. incognita* root-gall ratings for a large number of recently released cultivars tested in one location by one protocol.

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