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Host Suitability of Soybean Cultivars for *Meloidogyne incognita* and *M. arenaria*[1]

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Abstract: The suitability of five maturity group (MG) III and five MG IV soybean, *Glycine max*, cultivars as hosts for *Meloidogyne incognita* and *M. arenaria* was evaluated in a greenhouse. 'Forrest', a MG V cultivar, was used as the standard of comparison for *M. incognita* resistance. With *M. incognita*, root-gall and egg-mass indices and reproductive factors for 'Asgrow 3307', 'FFR 398', and 'Pioneer 9442' were comparable with those found on Forrest. *Meloidogyne arenaria* reproduction was lower ($P \leq 0.05$) on 'Stevens' than on the other cultivars studied except 'TN4-86'. When grown in a field infested with *M. incognita*, the relative ranking of the cultivars was similar to the greenhouse results.

Key words: *Glycine max*, host suitability, *Meloidogyne arenaria*, *Meloidogyne incognita*, root-knot nematode, soybean.

Soybean (*Glycine max* (L.) Merrill) is a major agricultural commodity in Arkansas. During the past 10 years, statewide average annual harvest of the crop was estimated at approximately 1.7 million ha (22). In general soybean cultivars in maturity groups (MG) V to VII are used in the state because of their stable yield performance (2). Earlier maturing cultivars (MG III and IV) may be grown successfully in some situations if they are planted relatively early in the season (13,20). Advantages of these cultivars include early planting and maturity dates and adaptation to a soybean–wheat double-cropping system. Cultivars in MG IV were recommended for Arkansas where soybean will be followed by a fall-seeded crop (19).

Preliminary investigations in 1986–88 on alluvial soils along the Red River in Arkansas, Louisiana, and Texas indicate that yields of these early maturing cultivars are comparable to yields of later maturing cultivars, particularly if the early cultivars are planted before 20 April (May, unpubl.). Coarse-textured or medium-textured soils are often used for production of MG III and IV cultivars because clay soils may be too wet to allow planting in April.

Meloidogyne incognita (Kofoid & White) Chitwood is an important pest of soybean in many parts of the southern United States (11). Additionally, *M. arenaria* (Neal) Chitwood has been shown to be virulent on soybean and may also limit yields where it occurs (7,18). Resistance to *M. incognita* and *M. arenaria* occurs in soybean cultivars (5,6,9–11,17,23,24), but few studies have included MG III or IV soybean cultivars because their primary range of adaptation is in areas where *M. incognita* and *M. arenaria* are not major problems. Because of interest in planting MG III and IV cultivars in April in the region drained by the Red River, this investigation was initiated to evaluate the suitability of several of those cultivars as hosts for *M. incognita* and *M. arenaria*.

Materials and Methods

Five MG III soybean cultivars (Asgrow 3307, Asgrow 3935, Fayette, FFR 398, and Williams 82) and five MG IV cultivars (Crawford, Pioneer 9442, Stevens, Terra Competitor, and TN4-86) were inoculated with *M. incognita* and *M. arenaria* in a greenhouse, and root galling and egg production were determined. The cultivar Forrest (MG V) was included in all experiments as a resistant standard (6). The cultivars also were evaluated in a field naturally infested with *M. incognita*.

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Greenhouse studies: Meloidogyne incognita race 3 and *M. arenaria* race 1, which had been maintained on tomato (*Lycopersicon esculentum* Mill. cv. Rutgers), were used in these studies. Individual seedlings of each cultivar were grown in 10-cm-d clay pots in methyl bromide-treated sandy loam soil in a greenhouse. Approximately 2 weeks after emergence, seedlings of each cultivar were selected and arranged on a greenhouse bench in a completely random design with six replications. Nematode inoculum was prepared by the NaOCl method (4). Ten milliliters of water containing 10,000 eggs was pipetted into three holes (0.5 cm d × 4 cm deep) in the soil around each seedling.

After 60 days, each plant was removed from the pot and the roots were washed free of soil and rated for galling. The root systems were stained with phloxine B (0.5 g stain/liter tapwater) for 15 minutes and rated for the presence of egg masses (3). Both gall and egg-mass ratings were made according to the following scale: 0 = no galls or egg masses per root system, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = > 100 galls or egg masses per root system (21). Eggs were extracted from each root system by the NaOCl method and total eggs per root system were counted. Reproductive factors (RF values) were calculated according to the formula RF = Pf/Pi where Pf = the final egg count and Pi = the initial inoculum level (16).

Field study: The cultivars that were evaluated in the greenhouse were planted in a field in southwestern Arkansas infested with *M. incognita* race 3. The field had been in continuous cotton production for the past 5 years. No irrigation was used. The soil was a Caspiana silt loam (50% sand, 45% silt, 5% clay; 0.6% organic matter; pH 7.8). Each soybean cultivar was evaluated in a randomized complete block design with four replications. Individual plot size was four rows (91-cm row spacing) by 15 m long with 1-m-wide alleys between replications. Cultural practices were according to University of Arkansas Cooperative Extension Service recommendations for soybean production (14) except that the planting date was 16 April. All cultivars except Forrest and Crawford, which were slightly later maturing, were harvested on 9 September; Forrest and Crawford were harvested on 28 September. Seed were allowed to air dry to a common moisture percentage and were weighed.

Soil samples consisting of 16 individual cores taken 15 cm deep with a 2.5-cm-d soil probe were collected from each plot for nematode assay at planting time and at harvest. Nematodes were extracted from a 250-cm^3 aliquant of each sample by sugar-flotation-centrifugation (8). On 8 August six soybean plants were selected at random from each plot and roots were dug and rated for galling. To avoid counting individual galls on these roots and to facilitate field ratings, a 0–10 scale was used where 0 = no roots galled and 10 = 100% of the root system galled (1).

Data were subjected to least squares analysis of variance, and all means were separated using Duncan's multiple-range test ($P \leq 0.05$) (12).

Results and Discussion

Cultivars differed in root galling and egg-mass production with both nematode species (Table 1). Asgrow 3307, Pioneer 9442, and FFR 398 were similar in both galling and egg-mass production to the resistant standard, Forrest. Although *M. incognita* race 3 reproduced on these cultivars, the galling and egg-mass indices were less ($P \leq 0.05$) than those occurring on the remaining cultivars. Galling and egg-mass production were relatively high for all cultivars in tests with *M. arenaria* race 1 (Table 1). The *M. arenaria* egg-mass index on Stevens was lower than all other cultivars except TN4-86. The trend for egg counts was similar to the trends for the root-gall and egg-mass ratings (Table 2). The RF values for FFR 398, Pioneer 9442, and Asgrow 3307, as well as Forrest, were < 1.0 in response to *M. incognita,* whereas the RF values were substantially > 1.0 for *M. arenaria* on all cultivars.

TABLE 1. Root galls and egg-mass development on maturity groups III and IV soybean cultivars after inoculation with *Meloidogyne incognita* race 3 and *M. arenaria* race 1 in a greenhouse.

	Gall index†		Egg-mass index†	
	M. incognita	*M. arenaria*	*M. incognita*	*M. arenaria*
	Maturity group III			
Williams 82	4.7 ab	4.8 ab	3.8 abc	4.8 ab
Asgrow 3935	4.0 bcd	5.0 a	4.0 abc	5.0 a
Fayette	3.5 cd	4.8 ab	3.0 cd	4.7 ab
FFR 398	3.3 de	5.0 a	2.2 de	4.8 ab
Asgrow 3307	2.2 f	4.7 ab	1.5 e	4.5 ab
	Maturity group IV			
Terra Competitor	5.0 a	5.0 a	4.5 ab	4.7 ab
Stevens	4.7 ab	4.0 c	4.8 a	3.7 c
Crawford	4.7 ab	4.5 abc	4.2 abc	4.7 ab
TN4-86	4.3 abc	4.2 bc	3.5 bc	4.0 bc
Pioneer 9442	3.2 de	4.8 ab	2.2 de	4.8 ab
Forrest‡	2.5 ef	5.0 a	1.8 de	4.6 ab

Means within columns followed by the same letter do not differ ($P \leq 0.05$) by Duncan's multiple-range test.
† Rating scale: 0 = no galls or egg masses per root system, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5 = > 100 galls or egg masses per root system.
‡ Maturity group V cultivar used as standard of comparison.

Soybean cultivar rankings for host suitability to *M. incognita* race 3 in the field study were similar to the rankings in the greenhouse study. Pioneer 9442, Asgrow 3307, FFR 398, Fayette, and Forrest exhibited lower root galling than other cultivars (Table 3). Plant-parasitic nematode species found in soil samples collected at planting included *Paratrichodorus christiei* Allen, *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans-Stekhoven, *Tylenchorhynchus ewingi* Hopper, and *Helicotylenchus* spp. as well as *M. incognita*. Population densities of all species at planting were < 100/250 cm³ soil, and counts are not reported. Population densities of *M. incognita* second-stage juveniles at harvest (data not shown) in general paralleled results from root-gall ratings. Population levels of the other plant-parasitic nematode species also increased

TABLE 2. Reproduction of *Meloidogyne incognita* race 3 and *M. arenaria* race 1 on maturity groups III and IV soybean cultivars in a greenhouse.

	M. incognita		*M. arenaria*	
	Eggs/plant ($\times 10^{-3}$)	RF†	Eggs/plant ($\times 10^{-3}$)	RF†
	Maturity group III			
Asgrow 3935	30.7 abc	3.1	333.3 ab	33.3
Williams 82	29.6 abc	3.0	158.8 cde	15.9
Fayette	12.3 bc	1.2	256.0 abcd	25.6
FFR 398	3.9 c	0.4	371.5 a	37.1
Asgrow 3307	1.1 c	0.1	205.7 bcde	20.6
	Maturity group IV			
Terra Competitor	63.5 a	6.3	258.0 abcd	25.8
Crawford	40.6 ab	4.1	152.7 cde	15.3
Stevens	40.4 ab	4.0	84.1 e	8.4
TN4-86	19.7 bc	2.0	115.6 de	11.6
Pioneer 9442	4.6 c	0.5	281.5 a	28.1
Forrest‡	2.7 c	0.3	263.6 abcd	26.4

Means within columns followed by the same letter do not differ ($P \leq 0.05$) by Duncan's multiple-range test.
† Reproductive factor (RF) = final egg count ÷ initial inoculum level.
‡ Maturity group V cultivar used as standard of comparison.

TABLE 3. Root-gall ratings, Pf values, and seed yields of maturity groups III and IV soybean cultivars grown in a field infested with *Meloidogyne incognita* race 3.

	Root-gall rating†	Pf‡	Seed yield (kg/ha)
Maturity group III			
Asgrow 3935	5.5 b	412 b	1,168 cde
Williams 82	3.1 d	195 b	1,121 cde
Asgrow 3307	1.0 ef	130 b	1,007 de
Fayette	1.6 e	122 b	866 e
FFR 398	1.4 ef	105 b	1,644 bc
Maturity group IV			
Stevens	6.9 a	328 b	1,387 cd
TN4-86	6.9 a	249 b	2,067 b
Terra Competitor	6.4 a	1,111 a	1,906 b
Crawford	4.0 c	312 b	1,718 bc
Pioneer 9442	0.5 f	110 b	2,027 b
Forrest§	0.8 ef	157 b	3,013 a

Means within columns followed by the same letter do not differ ($P \leq 0.05$) by Duncan's multiple-range test.

† Rating scale: 0 = no root galling to 10 = 100% of roots galled.

‡ Second-stage juveniles per 250 cm^3 soil at harvest.

§ Maturity group V cultivar used as standard of comparison.

by harvest, but there were no statistical differences among soybean cultivars with respect to population densities of these species. Soybean yields were not correlated to cultivar root-gall ratings (Table 3). Forrest, a MG V cultivar resistant to *M. incognita* race 3, yielded more ($P \leq 0.05$) than any of the other cultivars. Fayette, which did not differ from Forrest in the greenhouse, had the lowest seed yield in the field experiment. At the end of June 1988, year-to-date cumulative precipitation was approximately 24 cm less than the 1951–80 average for the nearest NOAA weather reporting station (Hope 3NE, index no. 3428). Monthly precipitation for July was 3 cm greater than the 30-year average. It is possible that climatic conditions positively influenced the yield of Forrest and negatively influenced the earlier maturing cultivars, because Forrest began reproductive growth in mid-July, approximately 4–6 weeks later than the other cultivars. In general the MG III cultivars produced less seed than the MG IV cultivars. Additional field evaluations will be necessary to assess the importance of resistance to root-knot nematodes in performance of MG III and IV cultivars.

Asgrow 3307, FFR 398, Pioneer 9442, and possibly Fayette may be suitable for planting in fields infested with *M. incognita* race 3. Although some differences in host suitabilities for *M. arenaria* race 1 were found, none of the cultivars could be considered resistant to this species. Greenhouse screening of soybean cultivars is an adequate indicator of resistance to *M. incognita* from a practical standpoint (15), and results of our field experiment paralleled the results of our greenhouse studies. Greenhouse screening of additional MG III and IV cultivars will help provide practical information on their suitability as hosts for *M. incognita* race 3 and *M. arenaria* race 1.

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