Root-Knot Nematode Resistance in Soybeans

W. BIRCHFIELD, Research Plant Pathologist, USDA, ARS, Department of Plant Pathology and Crop Physiology, and B. G. HARVILLE, Associate Professor, Department of Agronomy, Louisiana State University, Baton Rouge 70803

ABSTRACT

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Twenty-four soybean cultivars/accessions were tested for resistance to the root-knot nematode *Meloidogyne incognita wartellei* in southwestern Louisiana, where soybean yields were low. Resistance was based on root-knot nematode buildup in the soil, percentage of soybean roots galled, percentage of chlorosis and necrosis on the soybean foliage, and yields. Nematode soil population increased least on Braxton, LA 78-17717, LA 78-17908, Centennial, LA 75-1794, and LA 75-1799. Fewest root galls occurred on LA 75-1794, LA 75-1799, LA 78-17717, and Centennial. Least chlorosis and necrosis occurred on LA 75-1697, LA 75-17941, LA 75-1799, LA 77-10700, Centennial, and LA 78-17908. Highest yields were obtained from LA 75-1697, LA 75-1794, Braxton, Forrest, and Centennial, which averaged 14.1, 11.2, 11.2, 11.2, and 10.8 bu/A, respectively. Yields among the soybean entries were negatively correlated with percentage of chlorosis and necrosis of the foliage and percentage of galled roots but not with soil populations of juveniles. Soil populations were positively correlated with the root-gall index but not with percentage of chlorosis and necrosis on the foliage. Root-gall index, however, was positively correlated with the amount of chlorosis and necrosis on the foliage.

Martin (7) and Martin and Birchfield (8) discovered a root-knot nematode in the *Meloidogyne incognita* group that is severely pathogenic to soybeans, but females did not reach maturity on the sweet potato cultivar Centennial, which is considered susceptible to *M. incognita*. Boquet et al (1,2) referred to this new root-knot nematode as the Wartelle race, in reference to terminology defined by Golden (3) and Golden et al (5).

Golden and Birchfield (4) described this same soybean pathogen and named it *M. incognita wartellei*, a new root-knot nematode. Major differences between this new root-knot nematode and *M. incognita incognita* and *M. incognita acrita* are that females have a delicate stylet with small rounded knobs sloping posteriorly, the dorsal esophageal gland orifice is further back (5 μm) from the base of the stylet, and the excretory pore is often two to three stylet lengths (sometimes more) from the anterior end. Williams et al (10) reported that the soybean cultivar Bragg, considered resistant to *M. incognita*, produced low seed yields when exposed to this new root-knot nematode in the field, even when grown after soil fumigation. They noted breeding lines that yielded well when exposed to the new root-knot nematode had only moderate resistance to galling and nematode population increases. Basic sources of resistance in these lines the root-knot nematode came from soybean cultivars Hill, Palmetto, and Laredo. Boquet et al (1) crossed D69-6344 and D69-8178, soybeans resistant and susceptible, respectively, to the root-knot nematode. The F_1 plants were moderately resistant to low population densities but moderately to highly susceptible when the population density was greater. Susceptibility was partially dominant. Inheritance of resistance was a qualitative character conditioned by one major gene with at least one modifying gene.

No commercial soybean cultivar is known to produce a profitable yield in fields heavily infested with *M. incognita wartellei.*

This report describes the reactions of selected soybean cultivars and advanced breeding lines to *M. incognita wartellei* and further identifies soybean resistance and tolerance to this nematode.

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MATERIALS AND METHODS

In 1982, we tested 24 soybean cultivars/accessions for *M. incognita wartellei* resistance in the field. Nineteen entries were advanced breeding lines, four were commercial cultivars resistant to *M. incognita incognita*, and one a commercial cultivar susceptible to *M. incognita incognita*. Cultivar Bragg was entered as the resistant and Davis as the susceptible soybean standard. Two-row plots 6 m long with 1 m between rows were planted on 11 May 1982. The test site was Lintonia fine sandy loam soil in a field heavily infested with *M. incognita wartellei* in St. Landry Parish, LA, where the soybean cultivar Davis had yielded poorly in 1981. The field plot was a randomized complete-block experimental design with four replicates. Data were taken from both rows of each plot. Nematode counts were made from the soil at planting and from the root zone of all entries on 19 August 1982, 3 mo after planting. Nematodes were extracted with the modified Seinhorst sieving technique described by Williams et al (9,10). Roots of four soybean plants of each replicated entry were observed on 19 August and plants were rated on a scale of 1–4, where 1 = 0–25% of roots with galls, 2 = 26–50%, 3 = 51–75%, and 4 = 76–100% (a modified Horsfall-Barratt system [6]). The percentage of chlorotic and necrotic foliage was estimated on 20 August. Each plot was rated on a scale of 0–4, where 1 = 0–25% of foliage yellow or dead, 2 = 26–50%, 3 = 51–75%, and 4 = 76–100% (6). Seed yields were obtained by harvesting the entire plots on 20 September. Seeds were adjusted to 13% moisture, weighed, and yields expressed in bushels per acre.

RESULTS

The soil population, root-gall index, foliage chlorosis index, and bean yields are shown in Table 1. Nematode population buildup among entries varied from 590 to 6,720/500 cm^3 of soil. Lowest nematode populations were on LA 78-17717, Braxton, LA 78-17908, and LA 75-1794; the highest population occurred on cultivar Davis. Bragg was intermediate to most entries in population increase.

Root galling was extensive on most entries. Average percentage of galled

Table 1. Soybean reactions to the root-knot nematode *Meloidogyne incognita wartellei*

Cultivar or line	Larvae/ 500 cm^3 soil	Root-gall index[x]	Chlorosis index[x]	Seed yields (bu/A)	Varietal yields[y] (bu/A)
LA 75-1697	4,750 abc[z]	2.75	1.00 a	14.1	45.5
LA 75-1794	1,280 a	1.50	1.00 a	11.2	42.9
Braxton	760 a	2.25	1.75 ab	11.2	n/a
Forrest	1,560 ab	2.50	2.25 ab	11.2	43.8
Centennial	1,200 a	2.00	1.50 ab	10.8	52.2
LA 77-7378	2,960 abc	3.25	1.75 ab	9.0	43.3
LA 78-14643	6,440 bc	3.75	2.50 abc	7.4	42.0
LA 78-11332	1,520 a	3.25	2.75 abc	7.2	43.2
LA 77-10799	4,440 abc	2.25	1.00 a	6.8	42.7
LA 77-7376	3,575 abc	3.00	3.00 abc	6.6	43.7
LA 78-17737	1,600 ab	3.00	3.25 bc	6.4	43.1
LA 75-1799	1,400 a	1.50	1.00 a	5.9	41.4
LA 77-10700	4,640 abc	3.25	1.00 a	5.8	42.7
LA 79-11553	1,940 abc	3.25	2.00 ab	5.6	45.6
LA 78-17908	1,110 a	2.50	1.50 ab	5.5	46.6
Bragg	3,350 abc	2.25	1.75 ab	5.3	42.4
LA 78-12589	1,840 ab	3.25	2.50 abc	5.0	45.2
LA 77-10796	1,840 ab	3.00	2.00 ab	4.7	43.3
LA 77-10797	4,440 abc	...	...	...	...
LA 78-11388	3,160 abc	3.25	3.25 bc	4.6	40.2
LA 78-17781	1,880 abc	3.25	1.75 ab	4.8	42.4
LA 76-483	1,880 abc	2.75	2.50 abc	4.4	44.2
LA 74-3854	1,850 abc	2.25	3.00 abc	4.3	45.5
LA 78-17717	590 a	1.75	3.00 abc	4.1	43.0
Davis	6,720 bc	3.50	3.25 bc	2.0	42.3

[x] Based on percentage of roots with galls/chlorotic and necrotic foliage in four classes, where 1 = 0–25%, 2 = 26–50%, 3 = 51–75%, 4 = 75–100%.

[y] Varietal yields (2-yr average) in fields without root-knot nematodes.

[z] Values in columns followed by different letters are significantly ($P = 0.05$) different according to Duncan's multiple range test.

Table 2. Correlation coefficients of soybean reactions to the root-knot nematode *Meloidogyne incognita wartellei*

	Larvae/ 500 cm^3 soil	Root-gall index	Foliage chlorosis and necrosis index
Yield (bu/A)	−0.15[a]	−0.310	−0.620
	0.45	0.110	0.005
Larvae/500 cm^3 soil		0.590	0.070
		0.001	0.720
Root-gall index			0.400
			0.040

[a] Top values = correlation coefficients, bottom values = percentage probability level.

roots ranged from 1.50 to 3.50 on a scale of 1–4. LA 75-1794, LA 75-1799, LA 78-17717, and Centennial had the lowest average root-gall indices. Differences in the amount of root galling among entries were not statistically significant.

Entries varied greatly in expression of premature chlorosis and necrosis; LA-1794, LA 75-1799, Centennial, and LA 77-10799 had the lowest indices for this disease symptom (Table 1).

Yields ranged from 2.0 to 14.1 bu/A among the entries when exposed to *M. incognita wartellei.* These soybean cultivars/accessions yielded 40.0–52.2 bu/A when grown in fields without this nematode (Table 1). LA 75-1697, LA 75-1794, Braxton, Forrest, and Centennial had highest yields, but none of the yields were economically significant. The susceptible check cultivar Davis yielded only 2 bu/A and cultivar Bragg, resistant to *M. incognita incognita*, yielded only 5.3 bu/A.

There was great variation among the 24 entries tested in all factors used to measure resistance. Foliage chlorosis, presumably a symptom of root-knot nematode disease, was not significantly correlated with larval counts in the soil, but the root-knot nematode gall index positively correlated with the foliage symptoms (Table 2).

DISCUSSION

The root-knot nematode, *M. incognita wartellei*, causes a severe disease of all commercial soybean cultivars and should be suspected in fields where cultivars Bragg, Centennial, and Forrest yield poorly. These commercial cultivars are resistant to the root-knot nematode *M. incognita incognita.*

LA 75-1794 was among the top entries according to all measurements for determining resistance. LA 75-1794 may serve as a source of resistant germ plasm for further breeding and selection for resistance to *M. incognita wartellei.*

Differences in yields and symptoms among 24 entries field tested for resistance to *M. incognita wartellei* were striking and variable. Some entries were more tolerant than others. These supported larger nematode populations; their roots were heavily galled but produced higher yields than entries supporting fewer parasites, less obvious root galls, and foliage chlorosis. Only field tests with heavy root-knot nematode infestations permit detection of such tolerance.

Foliage symptoms of root-knot nematode disease may be used effectively, according to this test, to evaluate resistance to the disease in soybeans. Care must be taken to ensure that other causal agents of soybean foliar disease are not present. The maturity grouping of varieties in reference to foliage disease expression must be considered and the correct time for making foliage disease measurements closely figured.

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