Relative Resistance of Sixteen Southern Pea Cultivars to Root-Knot

WESLEY WITCHER, Professor, Department of Plant Pathology and Physiology, and WAYNE L. OGLE, Professor, Department of Horticulture, Clemson University, Clemson, SC 29634-0377

ABSTRACT

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Each of 16 commonly grown cultivars of southern pea were inoculated with a population of *Meloidogyne arenaria* race 1 or a population of *M. incognita* race 3. Both nematodes produced some galls on plants of all cultivars. Nine of the 16 cultivars were resistant to *M. incognita* race 3, and nine were resistant to *M. arenaria* race 1. All cultivars had fewer galls caused by *M. arenaria* than by *M. incognita*.

Southern pea (*Vigna unguiculata* (L.) Walp. subsp. *unguiculata*) (cowpea) is an important food crop in most southern states in the United States and in many other nations. World production is about 5 million hectares annually (6). In South Carolina, most home gardeners produce a southern pea (an improved-type cowpea) for home use, but commercial production varies from year to year. Root-knot is one of several diseases that reduce yield of southern peas. In the late 1800s, Orton (20) discovered root-knot nematode on several crops. He and Webber reported that Iron cowpea was highly resistant to root-knot caused by *Heterodera radicicola* Müller (20).

Because of the importance of root-knot on southern pea, various methods of control have been tried. In 1923, Godfrey (8) recommended steam sterilization of the soil, crop rotations, and use of the four listed resistant cultivars. Kendrick reported that cultivar Calva Blackeye was resistant (13). Tyler (19) compiled various reports of nematode resistance in southern pea cultivars that showed that acceptable resistant cultivars differed from area to area. Chitwood (3) reclassified the family Heteroderinae and described six species at that time. In their review article, Chitwood and Oteifa (4) listed nine *Meloidogyne* Goeldi species. Sasser (15) studied five *Meloidogyne* species on numerous host plants and concluded that the species *M. incognita* (Kofoid & White) Chitwood, *M. hapla* Chitwood, *M. arenaria* (Neal) Chitwood, *M. exigua* Goeldi, and *M. javanica* (Treub.) Chitwood were composed of biotypes.

In 1978, Taylor and Sasser (17) established races of *Meloidogyne* species.

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Because of the existence of races and new species classifications, most of the work before 1978 devoted to screening southern pea cultivars for resistance to root-knot is of limited value. The purpose of this study was thus to determine the relative resistance of 16 cultivars of southern pea to root-knot caused by *M. arenaria* race 1 and *M. incognita* race 3.

MATERIALS AND METHODS

Seeds of 16 commonly grown cultivars of southern pea were secured from plant breeders and commercial companies and maintained for purity by W. L. Ogle. Populations of *Meloidogyne incognita* race 3 and *M. arenaria* race 1, obtained from Stephen A. Lewis, were maintained in the greenhouse on tomato plants (Rutgers) for a year before the study began. Lewis reexamined the nematodes and confirmed purity of species at the harvest of our last test on southern pea.

Washed Columbia sand was treated for 24 hr with methyl bromide (112 g/108-L barrel), aired for 1 wk, and used to fill 324 plastic pots (10 cm diameter) to within 2 cm of the top. Each of the 16 southern pea cultivars was seeded in 18 pots (two seeds per pot) for a total of 288 pots. The remaining 36 pots later were planted to Rutgers and Better Boy tomatoes (18 each) for inoculum checks. Plants were maintained in the greenhouse at 23–32 C, and about 50 ml of Hoagland's solution was added per pot per week. At the early three-leaf stage, the plants were thinned to one per pot. Eggs of each nematode species were extracted by the NaOCl-extraction method (11) and diluted to 1,000 eggs per milliliter. A 5-ml aqueous suspension of *M. arenaria* eggs was pipetted at the soil line against the stem of each of six plants of each cultivar. Six additional plants of each cultivar were inoculated in like manner with a suspension of eggs of *M. incognita*. Six plants of each cultivar received 5 ml of sterile water and served as controls. Pots containing each species of nematode were randomized in replicates within their treatment area, but to prevent contamination, the treatments (two species and the controls) were separated on the greenhouse benches. We used a randomized complete block design with six replicates. The pots were placed on inverted ceramic saucers to decrease the probability of contamination from water along the boards on the bench. Plants were maintained in the greenhouse for 55 days. Plants were watered with about 15 ppm of 20-20-20 Peter's fertilizer once a week to keep the plants healthy.

Plants were watered about 1 hr before they were taken from the pots. The sand was shaken back into the pots as the plants were removed. The tops were removed just above the first lateral roots, and the tops and roots were weighed immediately. Roots were then stained in Phloxine-B (0.15 g/L) and examined with a magnifying glass. Total numbers of galls and egg masses on each plant were recorded. Also, galls and egg masses were rated using an index of 0–5 (17). The study was repeated twice. Seeds for the three tests were planted in July, September, and December, respectively. Examination of roots and recording of results were in September, November, and February. A statistical analysis of the data was conducted for each test, then data were pooled and analyzed. Means were separated using Duncan's new multiple range test after significance attributed to cultivar was found ($P < 0.05$).

RESULTS

In the first test, uninoculated plants of cultivar Zipper Cream varied in weight from 3.0 to 30.5 g. Inoculated plants of cultivar California 5 Blackeye ranged from 1.2 to 25.0 g. Plants seeded in September and inoculated in November generally were smaller than those in the other two tests. Weights of inoculated plants were not significantly different ($P = 0.05$) from those not inoculated in the combined tests.

Because some galls had several egg masses and some had none, number of galls was used for rating resistance of cultivars. Results of gall counts on plants inoculated with *M. incognita* are presented in Table 1. Nine of the 16 cultivars tested were statistically more resistant ($P = 0.05$) to *M. incognita* than the other seven, regardless of the rating system used, and we rated them resistant. The resistant cultivars were not significantly different from each other. In each test and pooled analysis, the same cultivars were resistant; therefore, the pooled analysis was used for presentation. Number of galls per plant varied among individuals within a cultivar. (In test 1, the variation in Big Boy was from 11 to 338 galls.)

Results of inoculation with *M. arenaria* are shown in Table 2. Maximum numbers of galls were not as great as on those inoculated with *M. incognita*. In tests 1, 2, and 3, maximum numbers of galls caused by *M. arenaria* on a plant were 225, 171, and 105, respectively, whereas those caused by *M. incognita* were 432, 387, and 473, respectively. In this study, Colossus, Colossus 80, California No. 5 Blackeye, Hercules, Magnolia Blackeye, Mississippi Purple, Mississippi Silver, Pinkeye Purple Hull, and Worthmore were resistant to *M.*

Table 1. Mean ratings of 16 southern pea cultivars 55 days after inoculation with 5,000 *Meloidogyne incognita* race 3 eggs in three greenhouse tests using two rating systems[w]

	Mean number of galls per gram of root				Taylor-Sasser rating system (0–5)[x]			
Cultivar	Test 1	Test 2	Test 3	Overall mean[y]	Test 1	Test 2	Test 3	Overall mean
Colossus-80	1.5	14.3	2.4	6.0 e[z]	2.8	4.2	3.5	3.5 d
California No. 5 Blackeye	5.9	9.2	3.3	6.1 e	3.7	4.0	4.2	3.9 bc
Zipper Cream	4.4	17.8	2.1	8.1 e	3.8	4.3	3.8	4.0 bc
Colossus	3.5	17.6	3.3	8.1 e	3.2	4.0	3.7	3.6 bc
Mississippi Silver	5.5	17.3	3.9	8.9 e	4.0	4.2	3.8	4.0 bc
Mississippi Purple	3.7	18.9	4.1	8.9 e	3.2	4.3	4.0	3.8 bcd
Hercules	2.6	21.3	3.0	8.9 e	3.3	4.8	3.5	3.9 bc
Magnolia Blackeye	5.7	19.9	3.8	9.8 e	4.0	4.3	4.0	4.1 b
Worthmore	10.6	18.0	4.5	11.0 e	4.3	4.0	3.7	4.0 bc
Big Boy	15.6	23.1	22.3	20.3 d	4.5	4.5	5.0	4.7 a
Brown Crowder	16.9	35.9	12.8	21.8 cd	5.0	5.0	4.7	4.9 a
Knuckle Purple Hull	26.7	27.1	17.5	23.8 bcd	5.0	4.7	5.0	4.9 a
Pinkeye Purple Hull	19.3	27.0	25.8	24.1 bcd	5.0	4.5	5.0	4.8 a
Cream-40	26.8	47.8	17.5	30.7 bc	4.7	4.8	5.0	4.8 a
Dixielee	23.8	50.9	19.6	31.4 b	5.0	3.8	5.0	4.6 a
Purple Tip Crowder	33.9	48.2	43.8	41.9 a	5.0	4.8	5.0	4.9 a

[w] In each test, six plants (one per pot) were averaged together.
[x] 0 = No galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = >100 galls (17).
[y] All three tests were averaged together and analyzed as one study.
[z] Numbers followed by the same letter are not significantly ($P = 0.05$) different according to Duncan's new multiple range test.

Table 2. Mean rating of 16 southern pea cultivars 55 days after they were inoculated with 5,000 *Meloidogyne arenaria* race 1 eggs in three greenhouse tests using two rating systems[w]

Cultivar	Mean number of galls per gram of root				Taylor-Sasser rating system (0-5)[x]			
	Test 1	Test 2	Test 3	Overall mean[y]	Test 1	Test 2	Test 3	Overall mean
Colossus-80	4.0	5.5	1.6	3.7 e[z]	3.3	4.2	3.5	3.7 abc
Hercules	4.4	7.4	2.1	4.6 de	3.5	3.0	3.5	3.3 cd
Mississippi Purple	3.9	7.7	2.6	4.7 cde	3.8	3.7	3.3	3.6 abc
California No. 5 Blackeye	8.9	3.9	3.3	5.4 cde	2.8	2.8	3.3	3.0 d
Magnolia Blackeye	4.1	7.3	5.2	5.5 cde	3.5	4.3	3.3	3.7 abc
Worthmore	6.8	7.4	2.3	5.5 cde	4.0	4.0	3.2	3.7 abc
Colossus	4.9	9.9	2.5	5.8 cde	3.6	4.0	3.7	3.7 abc
Mississippi Silver	5.5	7.7	4.2	5.8 cde	3.7	3.3	3.5	3.5 bc
Pinkeye Purple Hull	7.1	7.6	2.6	5.8 cde	4.3	3.2	3.0	3.5 bc
Zipper Cream	3.2	14.3	3.8	7.1 bcd	3.7	4.0	3.5	3.7 abc
Cream-40	9.8	10.4	3.0	7.7 bc	4.0	3.7	3.2	3.6 abc
Brown Crowder	10.2	9.8	4.4	8.1 b	4.3	4.0	3.5	3.9 ab
Big Boy	11.4	9.9	8.1	9.8 ab	4.2	3.8	4.0	4.0 a
Knuckle Purple Hull	5.9	22.9	5.1	11.3 a	4.2	4.3	3.7	4.1 a
Dixielee	14.7	13.2	6.3	11.4 a	4.5	3.6	4.0	4.0 a
Purple Tip Crowder	15.3	16.4	5.6	12.4 a	3.8	4.8	3.5	4.1 a

[w] Mean of six plants (one per pot).
[x] 0 = No galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = >100 galls.
[y] Mean of 18 plants, all three tests analyzed as one study.
[z] Numbers followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's new multiple range test.

incognita. Dixielee, Knuckle Purple Hull, and Purple Tip Crowder were susceptible. When ratings of plants inoculated with *M. arenaria* race 1 were compared with ratings used by Hadisoeganda and Sasser (9), using their criterion that 4.0 or less means slightly resistant (SR), all cultivars in our tests were at least SR except Knuckle Purple Hull and Purple Tip Crowder. In controls, a few galls were found on 11, 7, and 0 plants in tests 1, 2, and 3, respectively.

DISCUSSION

The larger size of galled roots might explain why some inoculated plants weighed more than controls of the same cultivar. However, the tremendous variation in weights of controls indicates a need for greater replication if effect of nematode infection on southern pea is to be shown by fresh plant weight.

Several studies have been made to determine relative resistance of southern pea cultivars to root-knot nematodes (1,10,18), and recently, several have involved known nematode races (7,9,12, 14,16). Our results agree with those of Hare (10) for Mississippi Purple and Mississippi Silver and with those of Fery and Dukes (7) for Mississippi Silver and Colossus. Six cultivars in our study, California Blackeye, Colossus, Magnolia Blackeye, Mississippi Purple, Mississippi Silver, and Zipper Cream, were also studied by Hadisoeganda and Sasser (9). Five of these were resistant to *M. incognita* in both studies. Colossus was rated resistant in our studies but susceptible in theirs. However, when working with two biological populations, there may be genetic differences between the two nematode populations, the two cultivar populations, or both. Swanson and Van Gundy (16) found that seeds of California No. 5 Blackeye from one source were resistant to *M. incognita* race 3 but those from another source were not. This finding indicates that seed sources and nematode populations may vary markedly. Both Hadisoeganda and Sasser's (9) and our studies show that five of the cultivars are resistant to both nematode species according to the criterion that a gall or egg mass rating of <4.0 shows some resistance.

Dukes et al (5) pointed out that resistance does not confer immunity. In this study, eight of the nine cultivars showing significantly fewer *M. incognita* galls would be rated slightly resistant (SR) according to Hadisoeganda and Sasser (9). Cultivars inoculated with *M. arenaria* reacted differently from those inoculated with *M. incognita*. Big Boy, Brown Crowder, Cream-40, and Zipper Cream may have some resistance, but they were not clearly separated into resistant or susceptible. The two rating systems used arranged the cultivars slightly differently. The disadvantage of the Taylor-Sasser system (17) is with cases involving nonuniform root systems. For example, 11 galls represent an index rating of 3. If one plant of a cultivar with 11 galls weighs 2 g and another weighs 35 g, should they both rate 3? The system of percentages set forth by Barker et al (2) eliminates this problem but presents another. When deciding what percentage of the root system is galled, the researcher must make a subjective evaluation for every root examined. Accurate total gall counts take time and require refrigeration of roots for several days if many plants are involved, and under most conditions, the difference would not justify the extra effort. However, we prefer this system because a total count more accurately separates fine, but perhaps biologically significant, differences among lines. Also, on large root systems, 100 galls might not be as damaging to the plant as 10 would be on a root system only 5% as large.

This study shows relative resistance of 16 commonly grown southern pea cultivars to one isolate each of two species of nematodes. It can be used as a guide if populations of these species and races are present, but the cultivars should be screened against other races and species to enable growers to select cultivars resistant to the nematodes present in their area.

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