Resistance to the Peanut Root-Knot Nematode (*Meloidogyne arenaria*) in *Arachis hypogaea*[1]

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ABSTRACT

The peanut root-knot nematode [*Meloidogyne arenaria* (Neal) Chitwood race 1] causes significant economic losses throughout the peanut (*Arachis hypogaea* L.) production area of the southern United States. Chemicals for control of this pest are becoming increasingly limited, and there are no known sources of resistance within the U. S. *A. hypogaea* collection. The objectives of this research were to screen 1,321 plant introductions for resistance or hypersusceptibility based on egg-mass ratings in greenhouse tests and to conduct more intensive greenhouse studies of selected genotypes to evaluate this method for identifying resistance to the peanut root-knot nematode. Twenty-seven genotypes with low and eight genotypes with high egg-mass ratings were selected and reevaluated in a more intensive greenhouse experiment. Seventeen of the low selections supported fewer ($P \leq 0.05$) egg masses, and seven supported less egg production per gram of fresh root weight than Florunner. Three selections for high egg-mass ratings supported more nematode eggs per plant than the cultivar Florunner and had a greater host efficiency. One of these genotypes supported more nematode eggs per gram of fresh root weight than Florunner. These results show that resistance to *M. arenaria* exists in the cultivated peanut species and can be selected by rating egg-mass production on greenhouse-grown plants.

Key Words: *Arachis hypogaea*, *Meloidogyne arenaria*, peanut, nematode resistance.

The peanut root-knot nematode [*Meloidogyne arenaria* (Neal) Chitwood race 1] causes significant economic losses throughout the peanut (*Arachis hypogaea* L.) production area of the southern United States (Sturgeon, 1986). Chemicals for control of this pest are becoming increasingly limited and there are no known sources of resistance within the U. S. *A. hypogaea* collection.

Resistance to plant-parasitic nematodes is commonly defined as a reduction or inhibition of nematode reproduction (Taylor and Sasser, 1978; Fassuliotis, 1979). Approximately one-third of the U. S. germplasm collection of *A. hypogaea* has been examined for reaction to *M. arenaria* based on root galling response and no sources of resistance were identified (Miller, 1972; Minton and Hammons, 1975). However, galling response is not always indicative of nematode reproduction and may lead to erroneous measurements of resistance or susceptibility (Fassuliotis, 1979).

Less than five percent of the U. S. collection of *A. hypogaea* has been examined for resistance to *M. arenaria* by evaluating nematode reproduction (Holbrook *et al.*, 1983). Recent research has indicated that resistance to *M. arenaria* is prevalent in wild *Arachis* spp. (Baltensperger *et al.*, 1986; Nelson *et al.*, 1989; Holbrook and Noe, 1990) and, therefore, also may occur in the cultivated species (Baltensperger *et al.*, 1986; Holbrook and Noe, 1990).

The objectives of this research were to screen plant introductions for resistance and hypersusceptibility to the peanut root-knot nematode based on nematode reproduction and to conduct more intensive studies of these selections to evaluate this screening technique and quantify levels of resistance.

Materials and Methods

Seed for three groups of about 500 accessions were obtained from the USDA Southern Regional Plant Introduction Station, Experiment, GA without any specific selection criteria. Each group was tested for resistance to *M. arenaria*, using the greenhouse screening technique described by Holbrook *et al.* (1983) with three replications. Plants were grown in methyl bromide-treated loamy sand (85% sand, 11% silt, 4% clay). Each pot was inoculated with 3,000 eggs of *M. arenaria* race 1 which had been cultured on tomato (*Lycopersicon esculentum* Mill. cv. Rutgers) or eggplant (*Solanum melongena* L. cv. Black Beauty). Nematode inoculum was prepared using the NaOCl method (Hussey and Barker, 1973) and applied at 14 days after planting.

Approximately 70 days after inoculation, plants were uprooted and washed clean of soil. The roots were placed in 1,000-mL beakers containing 300 mL of 0.05% phloxine B solution for 3-5 min (Daykin and Hussey, 1985). Each plant was indexed for root-galls and egg -masses based on the following scale: 0 = no galls or no egg masses, 1 = 1-2, 2 = 3-10, 3 = 11-30, 4 = 31-100, 5 = more than 100 galls or egg masses per root system (Taylor

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and Sasser, 1978).

Means for egg-mass ratings were calculated and 27 resistant selections were made based on a mean rating less than or equal to three (≤ 30 egg masses). Eight susceptible selections had mean ratings of five (> 100 egg masses) and had been noted during screening to appear to support more nematode reproduction than other accessions with ratings of five.

Resistant and susceptible selections were further evaluated in a greenhouse experiment using a randômized complete-block design with eight replications. Germinated seedlings were inoculated with 3,500 eggs per plant on 4 January 1991 and evaluated 68 days later. Egg-mass and root-gall ratings were obtained on eight replications using the previously described procedure. Roots were blotted dry and weighed, and eggs were collected by treatment with 1.0% NaOCl (Hussey and Barker, 1973) and counted for four replications.

The host efficiency was calculated as the ratio of final number of *M. arenaria* eggs per root system to the initial inoculum level. Nematode reproduction was the criterion upon which assessments of resistance were based.

All data were subjected to analysis of variance and genotypic means were compared by Fisher's protected least significant difference (LSD). Unless otherwise stated, all differences referred to in the text were significant at P≤0.05.

Results and Discussion

A complete list of results for preliminary screening of the 1,321 accessions can be obtained from the corresponding author. Most accessions were highly susceptible as indicated by the large means for egg-mass indices (Table 1). Significant differences among entries were detected even though standard deviations were large. Correlations of root-gall and egg-mass indices were significant but moderate, indicating that selection based on low gall indices may not result in selections which support lower egg-mass production

Table 1. Summary statistics from preliminary greenhouse screening of three groups of *Arachis hypogaea* plant introductions for resistance to *Meloidogyne arenaria*.

Group	Number of accessions	Root-gall index[a] Effect of accession	Mean	Standard deviation	Egg-mass index[a] Effect of accession	Mean	Standard deviation	Correlation of root-gall and egg-mass indices
A	444	**	4.6	0.8	**	4.3	1.3	0.67**
B	390	*	4.5	0.9	**	3.8	1.5	0.73**
D	487	**	4.5	1.0	**	3.5	1.6	0.57**

[a]Root-gall and egg-mass index on 0-5 scale: 0 = no galls or egg mases; 1 = 1-2; 2 = 3-10; 3 = 11-30; 4 = 31-100; and 5 = more than 100 galls or egg masses per root system.

*,** Significant at 0.05 and 0.01 levels, respectively.

Twenty-seven accessions were selected based on a mean egg-mass index of three or less. Eight accessions with a mean egg-mass index of five were selected because they appeared to be hypersusceptible. Intensive retesting of these selections indicated that 17 of the selections for low egg-mass rating had lower egg-mass ratings than the cultivar Florunner (Table 2). Seven of the selections for low-egg mass rating supported lower levels of nematode reproduction per gram of fresh root weight than Florunner. These results indicate that screening based on egg-mass ratings is effective for selecting for lower levels of nematode reproduction per gram of fresh root weight.

These results also demonstrate that moderate levels of resistance to *M. arenaria* exists in the U. S. germplasm collection of *A. hypogaea*. This study, and the study reported by Holbrook et al. (1983), represent evaluations of nematode reproduction on approximately 25% of the U. S. peanut germplasm collection. Although no high levels of resistance (egg-mass index ≤ 2) were identified in these studies,

Table 2. *Meloidogyne arenaria* reproduction and root galling on resistant and susceptible selections from screening of 1,321 *Arachis hypogaea* plant introductions.

Georgia no.	PI no.[a]	Root-gall index[b]	Egg-mass index[b]	Eggs per plant	Host efficiency[c]	Eggs/g fresh root weight
			Resistant selections			
125B	259572	3.0	2.6	13,600	3.9	3,147
495D	270974	3.5	3.0	22,800	6.5	4,409
75B	242100	4.1	3.4	30,160	8.6	4,536
402A	196736	4.1	3.1	35,760	10.2	4,794
465A	210833	4.5	3.4	36,720	10.5	5,070
186B	259639	3.6	3.1	28,080	8.0	5,574
102B	247378	4.4	2.9	26,440	7.5	5,577
321D	270786	3.6	2.6	29,040	8.3	5,685
38B	239040	4.1	3.7	40,160	11.5	5,745
383D	270849	4.2	3.3	25,280	7.2	5,768
489D	270967	3.2	2.7	38,560	11.0	6,854
10B	230193	3.1	2.9	25,440	7.3	7,000
327D	270792	3.1	2.9	27,440	7.8	7,099
363A	196687	3.6	3.0	35,360	10.1	7,183
460A	210828	4.2	3.2	63,440	18.1	7,405
46B	240553	4.4	3.7	49,200	14.1	7,626
150B	259597	4.4	3.2	57,520	16.4	7,719
161A	155113	4.4	3.2	46,720	13.3	7,827
448B	261957	4.7	4.5	53,120	15.2	7,900
353A	196672	4.4	3.5	56,000	16.0	8,235
368D	270834	4.7	3.8	38,000	10.9	8,486
476D	270954	3.1	2.9	30,800	8.8	8,592
326D	270791	4.4	3.9	58,880	16.8	9,396
193D	269063	4.7	4.6	66,400	19.0	10,343
328D	270793	3.6	3.1	89,280	25.5	13,005
76B	242101	4.2	3.8	89,440	25.5	14,882
9B	230192	4.2	3.8	96,160	27.5	17,161
			Susceptible selections			
290A	183389	4.7	4.4	78,880	22.5	8,881
312A	196622	4.9	4.2	70,320	20.1	11,225
342D	270807	4.7	3.8	137,280	39.2	12,777
72A	145681	4.5	4.5	164,960	47.1	13,314
232D	269106	5.0	5.0	30,880	37.4	13,747
401D	270870	5.0	4.7	118,800	33.9	14,773
144A	153331	4.7	4.1	121,440	34.7	15,898
25D	268885	5.0	5.0	146,240	41.8	20,771
			Check cultivar			
Florunner		4.4	4.3	66,800	19.1	12,998
$LSD_{0.05}$		0.9	0.9	69,073	19.7	7,341

a. U.S. Plant Inventory Number.
b. Root-gall and egg-mass index on 0-5 scale: 0, no galls or egg masses; 1, 1-2; 2, 3-10; 3, 11-30; 4, 31-100; 5, more than 100 galls or egg masses per root system.
c. Host efficiency = final egg count / initial egg inoculum rate (3,500 eggs/pot).

moderate levels of resistance (egg-mass index ≤ 3) were observed. Still higher levels of resistance may be available in the 75% of the collection which has not been examined for nematode reproduction.

Three of the eight susceptible selections supported more nematode eggs per plant and had a greater host efficiency than Florunner (Table 2). Only one of these accessions (PI 268885) supported more nematode reproduction per gram of fresh root weight than Florunner. The greater host efficiency of PI 270807 and PI 145681 were the result of larger root systems.

A correlation of 0.49 was observed between egg-mass index ratings and eggs per gram of fresh root weight (Table 3). A much lower correlation (0.29) was observed between gall index ratings and eggs per gram of fresh root weight. Some of the accessions included in this study also have been examined in a field with a high level of *M. arenaria* (unpublished data). In general, resistant lines identified in greenhouse trials exhibited levels of resistance in the field which significantly inhibited nematode population increases throughout the season. Good correlations between greenhouse and field evaluations for nematode resistance in wild *Arachis* species also were observed by Nelson *et al.* (1989).

Taylor and Sasser (1978) stated that an egg-mass index of two or less would be needed for effective resistance to root-knot nematodes in peanut. This conclusion was based on the

Table 3. Correlations of root-gall index, egg-mass index, root weight, and egg counts from a greenhouse test.

	Root-gall index	Egg-mass index	Fresh root weight	Egg count	Eggs per g root weight
Root-gall index		0.74**	0.51**	0.39**	0.29**
Egg-mass index			0.51**	0.55**	0.49**
Fresh root weight				0.69**	0.24**
Egg count					0.81**

Correlations of root-gall index and egg-mass index were based on 285 observations, and all others were based on 144 observations.

**Significant at 0.01 level.

short life cycle of the nematode relative to the host. The results of this study and field observations of selected genotypes (unpublished data), indicate that an egg-mass index of three or less will result in significant levels of resistance to *M. arenaria* in peanut.

In summary, this research is the first report of resistance to *M. arenaria* in the U. S. *A. hypogaea* germplasm collection. The results indicate that resistance to *M. arenaria* in peanut can be identified by rating egg-mass production in a greenhouse environment. The resulting selections should then be evaluated for nematode egg production per gram of fresh root weight to select for the highest levels of resistance.

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