Resistance to *Meloidogyne arenaria* in *Arachis* spp. and the Implications on Development of Resistant Peanut Cultivars[1]

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ABSTRACT

Peanut root-knot nematode (*Meloidogyne arenaria* (Neal) Chitwood race 1) is a serious pathogen in commercial peanut (*Arachis hypogaea* L.) production. There is no peanut cultivar with resistance to this nematode. The primary constraint in the development of resistant cultivars has been the absence of identified sources of resistance in *A. hypogaea* and related wild species. The objective of this study was to examine the wild *Arachis* spp. collection of the Coastal Plain Experiment Station for sources of resistance to *M. arenaria*. Thirty-six wild *Arachis* spp. genotypes were compared with the susceptible cv. Florunner for resistance to *M. arenaria* reproduction and galling response in two greenhouse tests. *A. monticola* Krap. et Rig., a member of the second-order gene pool, was the only wild species tested which did not have a gall index and egg-mass index significantly lower than that of *A. hypogaea*. There was no significant difference between *A. monticola* and A. hypogaea for the number of eggs per root system or per gram of fresh root weight. In addition, the host efficiency of *A. monticola* was 3.49, indicating a high level of susceptibility. All genotypes examined from the third-order gene pool species (*A. cardenasii* Krap. et Greg. *nom. nud.*, *A. duranensis* Krap. et Greg. *nom. nud.*, *A. helodes* Martius ex Krap. et Rig. and *A. villosa* Benth.) exhibited significantly less plant damage and nematode reproduction than *A. hypogaea*. Except for one *A. villosa* genotype, all entries from the third-order gene pool exhibited high levels of resistance to *M. arenaria* based on a host efficiency less than 1.00. All fourth-order gene pool accessions examined (*A. burkartii* Handro, *A. glabrata* Benth., and *A. hagenbeckii* Harms.) exhibited high levels of resistance to M. arenaria. These results indicate that resistance to *M. arenaria* is prevalent in both the third- and fourth-order gene pools of peanut. These results increase the probability of success in developing peanut cultivars with resistance to *M. arenaria* since species in the third-order gene pool are cross compatible with *A. hypogaea*. Based on genetic theory, these results also increase the probability of resistance to *M. arenaria* in the first-order gene pool. Therefore, further screening for resistance to *M. arenaria* in *A. hypogaea* is recommended.

Key Words: *Arachis hypogaea*, *Arachis* spp., *Meloidogyne arenaria*, peanut root-knot nematode, resistance.

Peanut root-knot nematode [*Meloidogyne arenaria* (Neal) Chitwood race 1] is a serious pathogen on peanut (*Arachis hypogaea* L.). Although selection and development has yielded 93 cultivars in 15 major crops which are resistant to *M. arenaria* (4), there is no peanut cultivar resistant to this nematode. The primary constraint in the development of resistant peanut cultivars has been the absence of identified sources of genetic resistance in *A. hypogaea* and related wild species.

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. Miller and Duke (8) reported that a peanut of "a foreign introduction with a purple skin" demonstrated good resistance to *M. arenaria* based on root galling. However, Miller (7) later found no resistance in 2,000 plant introductions screened in field trials in Virginia. Minton and Hammons (9) screened 512 peanut entries on the basis of galling and reported that all were susceptible to *M. arenaria*. Holbrook *et al.* (5) screened

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293 plant introductions on the basis of galling and nematode reproduction. Based on nematode reproduction, no high levels of resistance were observed.

Until recently, no information was available on resistance to *M. arenaria* in related wild species of peanut. In a study of two released cultivars of rhizomatous peanut with perennial forage potential, Baltensperger *et al.* (1) found high levels of resistance to *M. arenaria* reproduction in *A. glabrata* Benth. Unfortunately, this species is not cross compatible with *A. hypogaea*. Recently, Nelson *et al.* (10) identified resistance to *M. arenaria* reproduction in eleven wild species of peanut, ten genotypes belonging to undescribed species and two interspecific hybrids.

The objective of this study was to examine the wild *Arachis* spp. collection of the Coastal Plain Experiment Station, Tifton, GA, for sources of resistance to *M. arenaria*.

Materials and Methods

Thirty-six wild *Arachis* spp. genotypes were compared with the susceptible *A. hypogaea* cv. Florunner for resistance to *M. arenaria* reproduction and root galling response in two greenhouse tests. Cuttings were taken from field-grown wild species and rooted in methyl bromide-treated loamy sand (85% sand, 11% silt, 4% clay) under a greenhouse mist chamber. After about two months for root establishment, each pot was inoculated with eggs of *M. arenaria* race 1 which had been cultured on tomato (*Lycopersicon esculentum* Mill. cv. Rutgers). The methods used for nematode inoculation were as described by Holbrook *et al.* (5).

The first test was inoculated with 4500 eggs per pot on April 22, 1988 and harvested 70 days later. The second test was inoculated with 2700 eggs per pot on November 22, 1988 and harvested 90 days later. A randomized complete block design with four replications was used for each trial. At harvest, plants were uprooted and washed clean of soil. The roots were placed in 1,000 -mL beakers containing about 300 mL of 0.05% phloxine-B solution for 3-5 min. (3). Each plant was assigned a root-galling and an egg-mass rating based on the following index: 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. Roots were than blotted dry and weighed and eggs extracted for counting by treatment with 1.0% NaOCL (6). Eggs were stained with acid fuschin-acetic acid (2) before counting.

The reproductive factor, or host efficiency, was defined as the ratio of final *M. arenaria* egg count to the initial inoculum rate (11) and was calculated for each experimental unit. Nematode reproduction was the criterion upon which assessments of resistance were based.

All data were subjected to analysis of variance and genotypic means for gall index, egg-mass index and host efficiency were compared by the least significant difference (LSD). Egg count data were analysed using Duncan's multiple range test after performing a log (x + 1) transformation. Unless otherwise stated all differences referred to in the text were significant at P = 0.05.

Results and Discussion

Smartt and Stalker (12) divided the genus *Arachis* into four gene pools based on germplasm accessibility to *A. hypogaea*. The first-order gene pool consists of all land races, breeding lines and cultivars. There are no known sources of resistance to *M. arenaria* in the first-order gene pool.

Accessions of *A. monticola* Krap. et Rig. make up the second-order gene pool. Based on cross compatibility and chromosome number, *A. monticola* is the preferred wild *Arachis* spp. for introgression of genes into *A. hypogaea*. Unfortunately, *A. monticola* was the only wild species that did not have a gall index and egg mass index significantly lower than *A. hypogaea* cv. Florunner (Table 1). There was no significant difference between *A. monticola* and *A. hypogaea* for the number of eggs per root system or per gram of fresh root weight. In addition, the host efficiency of *A. monticola* was 3.49, indicating a high level of susceptibility.

The third-order gene pool consists of the diploid species of section *Arachis* and is somewhat accessible to *A. hypogaea*. Four species [*A. cardenasii* Krap. et Greg. *nom. nud.*, *A. duranensis* Krap. et Greg. *nom. nud.*, *A. helodes* Martius ex Krap. et Rig. and *A. villosa* Benth. (var. *A. correntina* Burkart and *A. villosa* Benth.)] from this gene pool were examined in this study. All genotypes from the third-order gene pool exhibited significantly less plant damage and nematode reproduction than *A. hypogaea* (Table 1). Except for one of the *A. villosa* genotypes (PI 210555), all of the entries from the third-order gene pool exhibited resistance to *M. arenaria* reproduction. The diploid wild species of section *Arachis* are cross compatible with *A. hypogaea*. Thus, these genotypes represent potential sources of resistance for improving cultivated peanut.

The fourth-order gene pool consists of related germplasm in sections other than *Arachis*. Three species (*A. burkartii* Handro, *A. glabrata* Benth., and *A. hagenbeckii* Harms.) from this gene pool were examined. The fourth-order gene pool accessions exhibited significantly less plant damage and nematode reproduction than *A. hypogaea* (Table 1). Based on host efficiency, all fourth-order gene pool accessions exhibited high levels of resistance to *M. arenaria*. Results for *A. glabrata* cv. Florigraze are in agreement with those reported by Baltensperger *et al.* (1). Smartt and Stalker (12) stated that efforts to use the fourth-order gene pool for introgression of genes into *A. hypogaea* will be expensive, with little chance of success.

Baltensperger *et al.* (1) first identified high levels of resistance to *M. arenaria* in the *Arachis* genus. They identified resistance to *M. arenaria* in *A. glabrata*, a species from the fourth-order gene pool which is not cross compatible with *A. hypogaea*. As these authors pointed out, Vavilov's "law of homologous series in heritable variation" states that traits found in one species of a genus are likely to occur in other species of that genus. The results of our study, and those of Nelson *et al.* (10), indicate that resistance to *M. arenaria* is prevalent in both the fourth-and third-order gene pools of peanut. These results increase the probability of success in developing peanut cultivars with resistance to *M. arenaria* since species in the third-order gene pool are cross compatible with *A. hypogaea*. These results also increase the probability of resistance to *M. arenaria* in the first order gene pool.

Most screening of *A. hypogaea* for resistance to *M. arenaria* was conducted prior to the development of a technique for rapid screening based on nematode reproduction (5). Thus, most *A. hypogaea* screening data is based on root galling which may not be an accurate measure of resistance to *M. arenaria*. Only a small fraction of the *A. hypogaea* collecttion has been screened for resistance to *M. arenaria* based on nematode reproduction (5). Results of this study indicate a prevalence of resistance to *M. arenaria* in wild *Arachis* spp. and thus a reasonable probability of resistance existing in *A. hypogaea*. Therefore, further screening for resistance to *M. arenaria* in the *A. hypogaea* collection should be conducted.

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Table 1. ***Meloidogyne arenaria*** **reproduction and galling on wild** ***Arachis spp.*** **and** ***A. hypogaea*** **cv. Florunner.**

Species	Georgia no.	PI no.[a]	Gall Index[b]	Egg-mass Index[b]	Eggs per plant[c]		Host efficiency[d]	Eggs/g fresh root weight[c]	
			First-Order Gene Pool						
A. hypogaea	Florunner	--	5.00	5.00	30,270	a	7.57	1809	ab
			Second-Order Gene Pool						
A. monticola[e]	83	263393	4.00	4.20	11,520	ab	3.49	5667	a
			Third-Order Gene Pool						
A. cardenasii	57	262141	0.12	0.00	100	defg	0.04	71	defgh
A. duranensi	8A	219823	0.50	0.00	180	cdefg	0.50	22	defgh
A. helodes	55	262275	1.50	0.37	610	cdefg	0.22	214	cdefgh
A. helodes	71	262275	1.37	0.00	80	defg	0.02	38	defgh
A. villosa (correntina)	50	261870	0.67	0.00	20	fg	0.01	3	gh
A. villosa	53	261872	0.00	0.00	70	defg	0.02	30	defgh
A. villosa (correntina)	6	210555	3.00	1.62	4480	bcd	1.34	522	cde
A. villosa (correntina)	62	262808	1.0	0.37	1945	cde	0.53	324	cdefg
A. villosa	72	210554	2.12	0.62	1554	defg	0.58	296	defgh
A. villosa (correntina)	73	261871	1.00	0.50	2080	cdef	0.75	646	cdefgh
A. villosa	74	210554	2.00	1.40	2496	bcd	0.62	470	cde
			Fourth-Order Gene Pool						
A. burkartii	30	--	0.50	0.00	350	cdefg	0.13	210	cdefgh
A. burkartii	52	261851	0.86	0.00	160	cdefg	0.06	99	cdefgh
A. glabrata	14	118457	1.50	0.00	100	efg	0.04	67	defgh
A. glabrata (Florigraze)	156	--	.14	0.00	46	fg	0.02	14	fgh
A. glabrata (Florigraze)	160	--	1.43	0.00	0	g	0.00	0	h
A. glabrata (Florigraze)	161	--	0.50	0.00	40	efg	0.01	22	efgh
A. glabrata	42	163452	0.25	0.00	351	efg	0.13	115	defgh
A. glabrata	45	231319	1.75	0.50	480	cdefg	0.18	508	cdefgh
A. glabrata	46	231321	1.00	0.25	275	cdefg	0.09	37	defgh
A. glabrata	77	262839	0.62	0.50	2977	bc	0.81	361	bcd
A. hagenbeckii	27	--	2.62	0.50	1180	cdefg	0.44	300	cdefgh
A. hagenbeckii	43	231318	1.00	0.00	0	g	0.00	0	h
A. hagenbeckii	44	231318	0.37	0.00	270	cdefg	0.10	132	cdefgh
			Undefined Gene Pool						
Arachis sp.[f]	12	229736	0.50	0.00	735	cdefg	0.26	389	cdefgh
Arachis sp.	13	229736	1.00	0.00	23	fg	0.01	7	fgh
Arachis sp.	20	--	1.25	0.00	100	efg	0.04	72	defgh
Arachis sp.	21	162801	1.33	0.00	120	efg	0.03	56	efgh
Arachis sp.	23	--	0.40	0.00	88	defg	0.03	50	defgh
Arachis sp.	28	258943	1.87	1.25	3580	bc	1.15	1578	abc
Arachis sp.	3	243334	0.75	0.12	430	cdef	0.16	418	cdef
Arachis sp.	60	262842	0.50	0.00	620	cdefg	0.23	977	cdefgh
Arachis sp.	80	262844	1.25	0.00	520	cdef	0.15	63	cdefgh
Arachis sp.	78	--	0.00	0.00	105	defg	0.03	31	defgh
Arachis sp.	8c	--	1.25	0.50	8420	defg	3.12	5668	defgh
$LSD_{0.05}$			1.22	0.71			1.68		

a. U.S. Plant Inventory Number.
b. Gall index and egg-mass index: 0, 0 galls or egg masses per plant; 1, 1 or 2; 2, 3 to 10; 3, 11 to 30; 4, 31 to 100; and 5, more than 100 galls or egg masses per plant.
c. Means in columns followed by the same letter are not significantly different (P=0.05) according to Duncan's multiple range test.
d. Host efficiency = final egg count / initial egg inoculum rate.
e. This material may be introgresed with *A. hypogaea*.
f. Undefined species.

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