Resistance to Meloidogyne hapla in Peanut[1]

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Abstract: Two hundred thirty-five cultivated varieties, breeding lines and plant introductions of *Arachis hypogaea* and 12 accessions of wild *Arachis* spp. were tested for resistance to *Meloidogyne hapla*. Eight of the cultivated peanut lines were only moderately susceptible and four of the wild peanuts exhibited resistance. No resistance-breaking *M. hapla* populations were found among 10 geographical isolates tested. *Key Words*: northern root-knot nematode, *Arachis hypogaea*, *Arachis* spp.

Meloidogyne hapla Chitwood has been associated with peanut damage in the field (9, 12). It may be the most prevalent root-knot nematode species on peanut in the Northeastern States (9) and it has also been found on peanut in some Southern States (5).

Struble (*unpublished data*, 1965) estimated an average annual yield reduction of 52% in nematode-infested soils in Caddo County, Oklahoma. More recently, differences in excess of 88% in yield and 30% in sound mature kernels have been observed between *M. hapla* infested and noninfested areas within the same field of Spanish peanuts (D. J. Banks, *unpublished data*, 1968). Yield increases of 35% have been obtained in Oklahoma Spanish peanuts following nematicide application in *M. hapla* infested soils (14).

Tyler (15) listed peanut as "highly

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resistant" to the root-knot nematode *Heterodera marioni* (Cornu) Goodey. After the revision of the genus *Meloidogyne* Goeldi (3) and determination of the host ranges of the different species, it became apparent that Tyler was not referring to *M. hapla* or to *M. arenaria* (Neal) Chitwood, but to a different species. Miller and Duke (12) reported that a peanut of "a foreign introduction with a purple skin" exhibited resistance to *M. arenaria*. Miller (11) also reported resistance of two peanut plant introduction lines to a *M. hapla* population occurring on one farm in Virginia, but found that the plants were not resistant to populations in another area. Ours is the first report of resistance in peanut to multiple geographical isolates of *M. hapla.*

MATERIALS AND METHODS

Inoculum used in this study was from stock colonies established and maintained on tomato, *Lycopersicon esculentum* Mill. 'Rutgers', from 12 egg masses of *Meloidogyne hapla* collected from peanut roots from a single field in Caddo County, Oklahoma.

The first phase of the investigation consisted of screening 235 cultivated lines, including varieties, breeding lines and plant introductions of *Arachis hypogaea* L., and 12 accessions of unidentified wild *Arachis* spp. for resistance to *M. hapla* in the greenhouse with temperatures ranging from 22 to 33 C. A listing of the various lines and their performance can be obtained from the third author. Seeds of the cultivated peanuts were obtained from W. K. Bailey, Oilseed and Industrial Crops Research Branch, Plant Science Research Division, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C. The wild species were obtained from the New Crops Research Branch of the USDA. The "P.I." (Plant Introduction) numbers are those assigned by the New Crops Research Branch, ARS, USDA. The "P" numbers are those assigned by the Oklahoma Experiment Station for the wild *Arachis* spp. The cultivated and wild peanuts were tested separately. The per plant level of inoculum was 1 g chopped very severely galled tomato roots which had been infected for at least 2 months. The inoculum was mixed thoroughly in 10-cm pots containing methyl bromide-treated soil before planting seed of cultivated lines. Wild peanuts were infested by placing the inoculum around the exposed root systems of 3- to 3.5-month-old rooted cuttings. Four replicates of each line or species were tested. *Arachis hypogaea* 'Spantex', which was found susceptible in preliminary tests, was included in each test as an inoculated check. Plant roots were rated visually for severity of galling (1, none; 2, trace; 3, moderate; 4, severe; 5, very severe) 30 days after inoculation.

The cultivated and wild peanuts that showed only a trace to moderate galling were re-tested at least twice. Those that consistently indicated resistance were further tested. Pieces of infected tomato roots that contained 40 nematode egg masses were placed around the exposed root system of each 10-day-old plant of the cultivated peanuts, and around 3- to 3.5 month-old rooted cuttings of the wild peanuts. Four replicates of each line or species were tested. The plants were grown in a controlled environment chamber operated under a 28-C, 16-hr day [light intensity 37,660 lx (3500 ft-c)] and 20-C night regime. After 30 days, plant roots were observed for necrosis and gall ratings were recorded. Following the procedure described by McBeth et al. (10), a 200-mg randomly selected root sample from each plant was stained with acid fuchsin. Pieces of stained roots were crushed between two glass slides. The total number of nematodes and the number of egg-laying females in each sample were determined by microscopic examination. Resistance or susceptibility levels were based on average gall ratings with < 3, resistant; 3 to 4, moderately susceptible; > 4, susceptible. Both tests were conducted four times.

Two experiments were conducted to determine whether the level of resistance in the wild peanuts would be reduced at high inoculum levels. In the first test, 3.5-month-old rooted cuttings of the wild *Arachis* spp. P-237, P-246 and P-258, with Spantex as a control, were inoculated with 0, 40, 80 and 160 egg masses per plant, replicated 10 times. In the second test, the above lines were used, with the wild *A. repens* Handro (P-983) as a control. Each of eight replications of 4-month-old rooted cuttings were inoculated with 5 g of chopped infected tomato roots. Data on galling, necrosis and root weight were obtained in the first experiment, but only data on galling were collected in the second, 30 days after inoculation.

To determine whether resistance-breaking *M. hapla* biotypes exist among selected geographical isolates in Oklahoma (collection sites listed in Table 1), 3.5-month-old cuttings of *Arachis* sp. P-246, grown singly in 10-cm

pots, were each inoculated with 40 egg masses of the different populations in the manner previously described. Nine isolates from peanut and one from the common dandelion, *Taraxacum officinale* Weber, were used with four replicates each. One cutting of the susceptible cultivar Spantex was inoculated with each isolate as a check. The plants were grown for 30 days in the controlled-environment chamber, then their roots were rated for galling.

RESULTS

Eight of the cultivated lines of *A. hypogaea* showed moderate susceptibility, and four of the wild *Arachis* spp. showed resistance, to *M. hapla*. No correlation between root necrosis and galling was observed.

The average nematode recovery in moderately susceptible cultivated peanuts is given in Table 2. The lowest gall rating, 3.0, was recorded for F416; compared to 4.2 in the susceptible control. An average of 54.8 nematodes per 200-mg root sample, with no egg-laying females, was recovered from F416, compared to 152.6 nematodes, with 11.1 egg-laying females, from Spantex. Generally, roots with the highest gall rating also had the greatest nematode development.

TABLE 1. Galling of resistant (P246) and suceptible (cultivar 'Spantex') peanuts as influenced by geographical isolates of *Meloidogyne hapla*.

Isolate No.	Oklahoma collection site[a]	Gall rating	
		Arachis sp. P-246[b]	*A. hypogaea* Spantex [c]
1	Black Farm, Atwood	2.0	4.0
4	Cain Farm, Holdenville	2.1	4.0
6	Davis Farm, Rush Springs	2.2	4.0
7	Majors Farm, Hydro	2.1	4.0
8	Repp Farm, Ft. Cobb	2.4	4.0
9	Ross Farm, Prague	2.0	3.5
10	Scott Farm, Ft. Cobb	2.2	4.0
14	Shackelford Home, Stillwater	2.6	5.0
15	von Dirickson Farm, Ft. Cobb	2.0	3.5
16	Wells Farm, Sickles	2.1	4.5

[a]All isolates were collected from peanut except No. 14, which was from common dandelion, *Taraxacum officinale* L.
[b]Data are means of four replications.
[c]Data are from single check plants for each isolate.

TABLE 2. *Meloidogyne hapla* recovered from peanut.[a]

Peanut	Gall rating	Nematodes recovered/200 mg roots	
		Egg-laying females	All other stages[b]
Cultivated lines			
Spantex	4.2	11.1	152.6
P.I. 295268	3.9	0.4	106.6
Dixie Runner	3.7	0.1	114.6
P.I. 288169	3.5	0.6	90.8
P.I. 288151	3.4	0.6	82.2
P.I. 295974	3.4	0.1	69.9
P.I. 295197	3.4	0.6	84.7
NC4X	3.2	1.5	59.0
F416	3.0	0.0	54.8
Wild lines			
Arachis sp. P-250	2.7	0.4	51.3
Arachis sp. P-258	2.3	0.4	37.0
Arachis sp. P-237	2.1	0.1	23.3
Arachis sp. P-246	1.6	0.0	15.2
Spantex (control)	4.3	10.6	129.2

[a]Values are averages of four trials with four replicates/trial.
[b]Includes all larval stages, males and females w/o eggs.

The average nematode recovery in resistant wild peanuts is given in Table 2. *Arachis* sp. P-246 had the lowest gall rating, 1.6, compared to 4.3 in the susceptible control. An average of 15.2 nematodes per 200-mg root sample, with no egg-laying females, was recovered from *Arachis* sp. P-246 compared to 129.2 nematodes, with 10.6 egg-laying females, from Spantex. Data collected from the other resistant *Arachis* spp. also showed a positive correlation between gall rating and nematode development and recovery.

Table 3 lists the average gall ratings of three resistant wild *Arachis* spp. subjected to different levels of nematode inoculum. Compared to the susceptible control, gall ratings of *Arachis* spp. P-258, P-237 and P-246 were significantly less at all inoculum levels. There was a general increase in gall rating as the inoculum level was increased, but increases were not all significant. For instance, the 40-egg-mass inoculum level caused significantly less galling than the 80-egg-mass level in Spantex and *Arachis* sp. P-258, but not in *Arachis* spp. P-237 and P-246. The gall rating at the 80-egg-mass level was significantly less than

TABLE 3. Average gall ratings of resistant wild *Arachis* spp. inoculated with varying levels of *Meloidogyne hapla*[X].

No. of egg masses/plant	*Arachis* spp.[Y]			
	A. hypogaea	P-258	P-237	P-246
0	1.0 a	1.0 a	1.0 a	1.0 a
40	4.1 b	1.8 b	2.0 b	1.8 b
80	4.8 c	2.4 c	2.1 b	2.1 bc
160	5.0 c	2.5 c	2.4 c	2.3 c

Grams of chopped infected tomato root/plant	*Arachis* spp.[Z]			
	P-983	P-258	P-237	P-246
5	5.0	2.8	2.5	2.4

[X]Within species, similar letters indicate no significant differences at P=0.05 with Duncan's multiple range test; among species, lines indicate no significant differences at P = 0.05 with Duncan's multiple range test.
[Y]Values are averages of 10 replicates.
[Z]Values are averages of 8 replicates.

the rating at the 160-egg-mass level only in *Arachis* sp. P-237.

When 5 g of chopped infected tomato root were used as inoculum, the gall rating of *Arachis* sp. P237 was not significantly different from that of *Arachis* spp. P-246 and P-258. The gall rating of *Arachis* sp. P-258, however, was significantly greater than that of *Arachis* sp. P-246.

No significant differences in gall rating of *Arachis* sp. P-246 caused by the 10 *M. hapla* isolates were obtained (Table 1). Based on galling, this peanut was resistant to all of the nematode isolates. The roots of the susceptible Spantex were severely galled.

DISCUSSION

This study has demonstrated the resistance of the wild *Arachis* spp. P-237, P-246, P-250 and P-258, and the moderate susceptibility of the cultivated peanut lines F416, 'NC4X', 'Dixie Runner', P.I. 288151, P.I. 288169, P.I. 295197, P.I. 295268 and P.I. 295974 to *M. hapla*. Resistance or moderate susceptibility was characterized by lower gall ratings, accompanied by recovery of fewer egg-laying females and larvae and retardation of nematode development. On this basis, it was possible to use galling alone as an indicator of resistance or susceptibility in initial screening trials.

The decline in nematode population in resistant and less susceptible plants 30 days after inoculation could have been due to the resistance of the roots to nematode invasion as Christie (4) found in lantana and as Goplen and Stanford (8) found in one alfalfa stock. This could also be attributed to the inability of the nematodes to survive after entering the roots. This is similar to Barrons' (1) observation on the 24 resistant plants with which he worked. Since no apparent correlation between resistance and degree of root necrosis was obtained, it is probable that the nature of resistance in peanut is more complex than that observed in cotton (2) and tomato (7, 13) in which resistance was attributed to a hypersensitivity-type reaction of root-knot-infected tissues.

Although fumigation and crop rotation have been used to control *M. hapla* in peanut (6), use of resistant varieties would provide a more effective and economical approach. Thus far, all attempts to hybridize the resistant wild species of *Arachis* with *A. hypogaea* have failed due to embryo abortions. With the use of special breeding techniques, we hope that the resistance or moderate susceptibility found in this study can be incorporated into commercially acceptable peanut varieties.

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