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Root-knot Nematode Resistance in Cucumber and Horned Cucumber

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Abstract. **Cucumber (*Cucumis sativus* L.) and horned cucumber (*C. metuliferus* Naud.) germplasm were evaluated for their resistance to root-knot nematodes (*Meloidogyne* spp.). All 24 *C. metuliferus* cultigens evaluated were resistant to all root-knot nematodes tested—*M. incognita* (Kofoid and White) Chitwood race 3, *M. arenaria* (Neal) Chitwood race 2, and *M. hapla* Chitwood. All 884 *C. sativus* cultigens (cultivars, breeding lines, and plant introduction accessions) tested were resistant to *M. hapla* and few to *M. incognita* race 3. Only 50 of 884 *C. sativus* cultigens evaluated were somewhat resistant to *M. arenaria* race 2 and *M. incognita* race 3. A retest of the most resistant *C. sativus* cultigens revealed that LJ 90430 [an accession of *C. sativus* var. *hardwickii* (R.) Alef.] and 'Mincu' were the only cultigens that were moderately resistant to *M. arenaria* race 2. LJ 90430 was the only cultigen, besides the two retested *C. metuliferus* cultigens, that was resistant to *M. javanica* (Treub) Chitwood. All *C. sativus* cultigens retested, including LJ 90430, were highly susceptible to *M. incognita* races 1 and 3. The two *C. metuliferus* cultigens retested were highly resistant to all root-knot nematodes tested—*M. arenaria* race 2, *M. incognita* races 1 and 3, and *M. javanica*.**

Cucumber is one of the three most important horticultural food crops in North Carolina (North Carolina County Agents' Estimates, 1990). Root knot is the most economically important cucumber disease in North Carolina, causing an average annual yield loss of 11% (St. Amand and Wehner, 1991). Cucumber is considered to be one of the most susceptible major vegetables to root-knot nematodes (Fassuliotis, 1979). Root knot is predominantly caused by four *Meloidogyne* species: *M. incognita, M. arenaria, M. javanica*, and *M. hapla* (Fassuliotis, 1982). Cucumber cultivars resistant to one or more of those species would be useful to growers by providing disease control with reduced nematicide use. *Meloidogyne hapla* is not a problem on cucumbers grown in North Carolina, but field-grown cucumbers in Canada were significantly damaged by *M. hapla* (Zimmer and Walkof, 1968).

Much effort has been invested in identifying resistance to root-knot nematodes in many crop species, including cucumber (Fassuliotis, 1979). Forty-two cucumber cultivars were tested by Winstead and Sasser (1956). All were resistant to *M. hapla* and susceptible to *M. incognita, M. incognita "acrita," M. javanica*, and *M. arenaria*. The U.S. Dept. of Agriculture (USDA) germplasm collection (289 cucumber accessions in 1963) was evaluated by Fassuliotis and Rau (1963). All accessions were susceptible to *M. incognita "acrita"* and were marked by profuse galling and nematode reproduction.

The African horned cucumber is highly resistant to root-knot nematodes. Norton and Granberry (1980) reported that *C. metuliferus* was highly resistant to the root-knot nematodes *M. incognita, M. arenaria*, and *M. javanica*. Wehner et al. (1991) found that *C. sativus* 'Sumter' was more susceptible than *C. metuliferus* to *M. incognita, M. arenaria*, and *M. javanica*. Other *Cucumis* species, including *C. anguria* L., *C. ficifolius* A. Rich., *C. longipes* Hook., and *C. heptadactylus* Naud., are resistant to *Meloidogyne* spp. (Fassuliotis, 1967).

Although there has been much progress in selecting and breeding for root-knot resistance in many other important horticultural crops, no progress has been made in cucumber, and attempts to produce viable interspecific hybrids between cucumber and several related resistant wild *Cucumis* spp. have failed (Fassuliotis, 1979). Successful gene exchange between *C. sativus* and related wild species is difficult using conventional hybridization techniques, since *C. sativus* has a different chromosome number than other related wild *Cucumis* spp.

Screening methods have been standardized for evaluating root-knot resistance, and several have been useful (Fassuliotis, 1979). Evidence of the existence of races for some *Meloidogyne* spp. demonstrated a need to reevaluate cultigen response to specific races (Taylor and Sasser, 1978).

The objective of this research was to evaluate the *C. sativus* and *C. metuliferus* germplasm collection for resistance to three root-knot nematode species—*M. incognita* race 3, *M. arenaria* race 2, and *M. hapla*. The most resistant and susceptible cultigens from the initial screening [14 plant introduction (PI) accessions, 12 cultivars, and 6 breeding lines of *C. sativus* and 2 PI accessions of *C. metuliferus*] were retested for resistance to 4 root-knot nematodes—*M. incognita* race 1, *M. incognita* race 3, *M. arenaria* race 2, and *M. javanica*.

Two greenhouse experiments were conducted: a germplasm evaluation and a retest of the most resistant or susceptible 34 cultigens.

Evaluating the germplasm collection. A greenhouse experiment was conducted to evaluate 924 cultigens for resistance to three species of root-knot nematodes—*M. incognita* race 3, *M. arenaria* race 2, and *M. hapla*. Thirty-six breeding lines, 136 cultivars, and 728 PI accessions of *C. sativus* and 24 PI accessions of *C. metuliferus* were tested. Old cultivars were obtained from the National Seed

Table 1. Origin and resistance of cultigens used in germplasm evaluation for root-knot nematode resistance in *Cucumis* spp.[z]

Cultigen	Cultigen (no.)
Origin	
C. sativus	900
Accessions	728
Turkey	170
P.R. China	93
Yugoslavia	63
Iran	59
India[y]	46
Japan	43
Former USSR	40
Czechoslovakia	31
Netherlands	18
USA	15
Other	150
Breeding lines[y]	36
Cultivars	136
Current	17
NSSL	31
No data obtained	16
C. metuliferus	24
Accessions	24
Zimbabwe	22
S. Africa	2
Resistance	
C. sativus	900
Highly (1% to 10% root galling)	2
Moderately (11% to 20% root galling)	1
Slightly (21% to 40% root galling)	47
Susceptible (>40% root galling)	834
C. metuliferus	24
Highly (1% to 10% root galling)	24
Moderately (11% to 20% root galling)	0
Slightly (21% to 40% root galling)	0
Susceptible (>40% root galling)	0

[z]Cultivars and breeding lines were obtained from cucumber breeders and commercial seed companies; plant introduction accessions from the Regional Plant Introduction Station, Ames, Iowa; and old cultivars from the National Seed Storage Lab. (NSSL), Fort Collins, Colo. Cultigen resistance is based on data obtained from *Meloidogyne incognita* race 3 and *M. arenaria* race 2.

[y]Included is LJ 90430 (a breeding line of *C. sativus* var. *hardwickii*).

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Storage Laboratory (NSSL), Fort Collins, Colo., new cultivars from seed companies, and breeding lines from state experiment stations. PI accession seeds were obtained from the North Central Plant Introduction Station, Ames, Iowa, originally collected from diverse locations around the world (Table 1).

In our tests, all *C. sativus* and *C. metuliferus* plants were grown from seed in 15-cm-diameter (1.8-liter) clay pots on benches in a greenhouse. Five seeds of each cultigen were sown in pots containing a 1 sand : 1 soil (v/v; 85% sand, 10% silt, 5% clay) steam-sterilized mixture. Plants were thinned to two per pot at the two-leaf stage and to one per pot at the three-leaf stage. Fertilizer (200 mg N/kg) was supplied twice daily by drip irrigation. Greenhouse temperatures averaged 35C day/27C night.

Meloidogyne incognita race 3, *M. arenaria* race 2, and *M. hapla* populations were maintained in the greenhouse on tomato (*Lycopersicon esculentum* L. 'Rutgers') for use as inoculum. Inoculum was prepared using Hussey and Barker's technique (1973) and was standardized to 200 eggs/ml of water, so that 25 ml of suspension would contain ≈5000 eggs. A 25-ml suspension of eggs was poured on the soil around the base of each plant. After all plants had been inoculated, each pot was topped with 13 mm of moist potting medium to protect eggs from desiccation.

Root-knot nematode damage was determined on washed roots (Nijs and Hofman, 1983) 9 weeks after inoculation (11 weeks after planting) using the gall index system (0% to 100% of roots covered with galls) (Barker et al., 1986). The gall index system was a modification of that used by Taylor and Sasser (1978). Percentage of galled roots was used to determine resistance as follows: 0% = immune, 1% to 10% = highly resistant, 11% to 20% = moderately resistant, 21% to 40% = slightly resistant, and >40% = susceptible.

The experiment was a split-plot treatment arrangement in a randomized complete-block design with three replications for *M. incognita* race 3 and *M. arenaria* race 2 and one replicate for *M. hapla*. Whole plots were the three nematode species, and subplots were the 924 cultigens. Data were subjected to analysis of variance using SAS (SAS Inst., Cary, N.C.), and cultigen means were tested using Fisher's least significant difference (LSD).

Retesting the extreme cultigens. In the second experiment, we verified results from Expt. 1 using the most resistant or susceptible 34 *Cucumis* cultigens (14 accessions, 12 cultivars, and 6 breeding lines of *C. sativus* and 2 PI accessions of *C. metuliferus*) for resistance to four root-knot nematodes (*M. incognita* race 1, *M. incognita* race 3, *M. arenaria* race 2, and *M. javanica*).

The experiment was conducted in a greenhouse at ≈35C day/24C night. The same procedures and cultural practices were followed as in Expt. 1.

Roots were rated 11 weeks after planting (9 weeks after inoculation) using the gall index system as described for Expt. 1, after which egg masses on roots were stained red with phloxine B (Hartman and Sasser, 1985). Egg

Table 2. Root-knot nematode resistance (percent galls) in selected *Cucumis* cultigens evaluated with three species of *Meloidogyne* in the germplasm evaluation experiment. Cultigens ranked in order by resistance.[z]

Rank	Cultigen	Origin	Roots affected (%) Mean	Ma2	Mi3	Mh
Resistant						
1	Green Thumb[y]	Harris Seed	1	1	---	---
2	PI 482454[x]	Zimbabwe	2	1	2	1
3	PI 482456[x]	Zimbabwe	2	2	---	---
4	PI 482449[x]	Zimbabwe	2	2	2	0
5	PI 482450[x]	Zimbabwe	2	3	2	---
6	PI 482440[x]	Zimbabwe	2	4	1	0
7	PI 482442[x]	Zimbabwe	3	3	2	1
8	PI 482453[x]	Zimbabwe	3	4	2	1
9	PI 482452[x]	Zimbabwe	3	4	2	0
10	PI 482444[x]	Zimbabwe	3	4	3	---
11	PI 482439[x]	Zimbabwe	3	5	1	0
12	PI 482455[x]	Zimbabwe	3	5	1	1
13	Southern Pickler	Arkansas AES[w]	3	5	1	---
14	PI 482446[x]	Zimbabwe	3	6	1	0
15	PI 292190[x]	South Africa	4	2	6	0
16	PI 482458[x]	Zimbabwe	4	3	4	0
17	PI 482451[x]	Zimbabwe	4	4	3	0
18	PI 202681[x]	South Africa	4	4	3	0
19	PI 482460[x]	Zimbabwe	4	4	4	0
20	PI 482461[x]	Zimbabwe	4	5	2	0
21	PI 482459[x]	Zimbabwe	6	3	8	0
22	PI 482443[x]	Zimbabwe	6	4	9	0
23	PI 482435[x]	Zimbabwe	6	5	6	1
24	PI 482441[x]	Zimbabwe	6	6	6	0
25	PI 482448[x]	Zimbabwe	6	6	6	0
26	PI 482462[x]	Zimbabwe	6	7	5	0
Moderately resistant						
27	LJ 90430	USDA, La Jolla, Calif.	19	5	33	0
Slightly resistant						
28	PI 261608[y,x]	Spain	29	42	16	1
29	PI 422186[y,x]	Czechoslovakia	32	35	29	0
30	PI 211975[y,x]	Iran	33	38	27	0
31	PI 368560[y,x]	Yugoslavia	33	33	33	1
32	PI 292012[x]	Israel	33	37	30	1
33	PI 432867[y,x]	P.R. China	34	35	33	1
34	PI 249550[y]	Iran	35	19	50	1
35	PI 167043[x]	Turkey	35	33	36	1
36	PI 436610[x]	P.R. China	35	43	30	1
37	Mincu[v]	Minnesota AES[u]	36	34	37	1
42	Delcrow[y,v]	NSSL[t]	37	32	42	0
60	Gy 4[y,v]	N.C. State Univ.	39	45	32	0
Susceptible						
90	M 41[y,v]	N.C. State Univ.	42	42	42	0
245	Producer	NSSL	49	38	59	1
267	Sumter[s]	Clemson Univ.	50	48	52	1
276	Dharampur-I[r]	Nepal	50	46	55	0
289	Double Yield[q]	NSSL	50	58	42	1
340	Poinsett[p]	Clemson Univ.	51	49	53	0
343	H-19[o]	Arkansas AES	51	36	67	0
374	Gy 14A[y]	N.C. State Univ.	52	37	68	0
395	M 21	N.C. State Univ.	53	46	59	0
407	Sprint 440	Asgrow Seed	53	50	56	1
419	Slice[y,v]	Clemson Univ.	53	58	48	1
443	Wisconsin SMR 12	Wisconsin AES[n]	54	37	70	0
445	Sumter[s]	Clemson Univ.	54	41	67	2
512	Dasher II	PetoSeed	55	51	59	2
515	Marketmore 76	Cornell Univ.	55	55	55	0
615	Wisconsin SMR 18	Wisconsin AES	58	55	61	1
632	Calypso	N.C. State Univ.	58	55	60	1
665	Poinsett 76	Cornell Univ.	58	51	65	1
709	Clinton	N.C. State Univ.	59	53	65	1
845	Sumter	Clemson Univ.	64	74	50	0
894	PI 137836	Iran	68	73	62	0
895	PI 357859	Yugoslavia	68	63	72	1
896	PI 178884	Turkey	68	63	73	1
897	PI 368551	Yugoslavia	68	72	64	0
898	PI 264667	Germany	68	62	75	1
899	PI 308915	Former USSR	69	82	57	---
900	PI 179260	Turkey	70	83	61	0
901	Early Cluster	NSSL	70	67	73	0
902	PI 192940	P.R. China	71	73	68	2

Continued on next page

Table 2. Continued.

Rank	Cultigen	Origin	Roots affected (%) Mean	Ma2	Mi3	Mh
903	PI 257487	P.R. China	71	64	78	0
904	PI 169328	Turkey	71	71	71	1
905	Tiny Dill	New Hampshire	72	70	75	1
906	PI 264228	France	75	75	---	---
907	PI 182192	Turkey	78	78	---	0
908	Black Diamond	Hollar Seed	87	---	87	---

[z]Data are means of three replications of one plant each for *M. arenaria* race 2 (Ma2) and *M. incognita* race 3 (Mi3), but for *M. hapla* (Mh), data are from one replication of one plant each, since all cultigens evaluated were resistant. Only *M. arenaria* race 2 and *M. incognita* race 3 are used in the computation of the overall mean. Gall index represents percentage of root system damaged by nematode galls. Resistance ratings based on overall gall index: 1% to 10% = resistant, 11% to 20% = moderately resistant, 21% to 40% = slightly resistant, and >40% = susceptible.
[y]Escape observed for *M. arenaria* race 2.
[x]Accession of *C. metuliferus*.
[w]Arkansas AES = Arkansas Agricultural Expt. Station, Fayetteville.
[v]Escape observed for *M. incognita* race 3.
[u]Minnesota AES = Minnesota Agricultural Expt. Station, St. Paul.
[t]NSSL = National Seed Storage Lab., Fort Collins, Colo.
[s]Wisconsin AES = Wisconsin Agricultural Expt. Station, Madison.

Table 3. Root-knot nematode resistance (percent galls) from retest study in which 34 *Cucumis* cultigens were evaluated against four species of *Meloidogyne*.[z]

Rank	Cultigen	Origin	Roots affected (%) Mean	Ma2[y]	Mi1[y]	Mi3[y]	Mj[y]
1	PI 482452[x]	Zimbabwe	5	2	7	4	5
2	PI 482443[x]	Zimbabwe	6	5	5	6	7
3	LJ 90430	USDA, La Jolla, Calif.	29	11	55	44	8
4	Southern Pickler	Arkansas AES[w]	54	23	59	69	63
5	Mincu	Minnesota AES[v]	55	18	75	64	63
6	Ohio MR 17	Ohio AES[u]	60	39	72	62	66
7	Producer	NSSL[t]	60	26	71	77	67
8	Gy 4	N.C. State Univ.	61	43	65	68	66
9	Poinsett	Clemson Univ.	62	39	76	69	65
10	Dharampur-I	Nepal	62	43	73	71	62
11	M 41	N.C. State Univ.	63	51	73	69	59
12	PI 220169	Afghanistan	63	57	64	68	63
13	PI 432864	Japan	64	53	72	74	55
14	Sumter	Clemson Univ.	64	57	69	70	58
15	PI 344350	Turkey	64	50	72	70	65
16	Wisconsin SMR 18	Wisconsin AES[s]	65	51	74	70	65
17	National Pickling	NSSL	65	56	70	74	61
18	Nepal Local 7	Nepal	66	60	73	69	60
19	Chinese Long Green	NSSL	66	54	75	73	63
20	Early Russian	NSSL	66	56	79	67	63
21	PI 211975	Iran	66	65	69	68	63
22	Delcrow	NSSL	67	54	75	69	68
23	PI 176953	Turkey	67	61	76	67	63
24	PI 483342	P.R. China	67	56	74	71	67
25	PI 326594	Hungary	67	65	70	59	74
26	PI 206425	Turkey	68	58	72	76	64
27	PI 308915	Former USSR	68	52	77	78	64
28	PI 478364	P.R. China	68	63	73	70	66
29	PI 319216	Egypt	69	58	76	71	70
30	PI 357865	Yugoslavia	69	63	74	71	69
31	Double Yield	NSSL	71	61	74	76	72
32	PI 261608	Spain	71	61	78	74	72
33	PI 169351	Turkey	72	60	77	77	72
34	Green Thumb	Harris Seed	73	63	79	77	74
Mean			60	48	64	66	60
LSD (5%)			10	12	9	10	10
CV(%)			14	21	10	13	13

[z]Data for each root-knot nematode species or race are gall index means of five replications of one plant each. Mean is the gall index mean of all root-knot nematodes for each cultigen and represents the resistance rating. Gall index represents percentage of root system containing nematode galls. Resistance ratings based on overall gall index: 1% to 10% = resistant, 11% to 20% = moderately resistant, 21% to 40% = slightly resistant, and >40% = susceptible.
[y]Ma2 = *M. arenaria* race 2, Mi1 = *M. incognita* race 1, Mi3 = *M. incognita* race 3, and Mj = *M. javanica*.
[x]Accession of *C. metuliferus*.
[w]Arkansas AES = Arkansas Agricultural Expt. Station, Fayetteville.
[v]Minnesota AES = Minnesota Agricultural Expt. Station, St. Paul.
[u]Ohio AES = Ohio Agricultural Expt. Station, Columbus.
[t]NSSL = National Seed Storage Lab., Fort Collins, Colo.
[s]Wisconsin AES = Wisconsin Agricultural Expt. Station, Madison.

masses were counted using Hadisoeganda and Sasser's method (1982). The egg index system used was a modification of that used by Sasser et al. (1984). Percentage of roots covered with egg masses was used to determine resistance as follows: 0% = immune, 1% to 10% = resistant, 11% to 50% = moderately resistant, and >50% = susceptible.

The experiment was a split-plot treatment arrangement in a randomized complete-block design with five replications. Whole plots were the four nematodes and subplots were the 34 cultigens. Gall index and egg mass data were analyzed using SAS's GLM and CORR procedures. Cultigen and nematode means were tested using Fisher's LSD.

Evaluating the germplasm collection. All *Cucumis* cultigens evaluated were highly resistant to *M. hapla*, with little difference in root galling from the most (*C. metuliferus*) to the least resistant (*C. sativus*) cultigens.

Selected cultigens evaluated, including the most root-knot resistant, the most susceptible, and current cultivars, are listed in Table 2. The complete data set will be entered into the Germplasm Resources Information Network (USDA, Washington, D.C.).

All *C. metuliferus* accessions evaluated were found to be highly resistant (1% to 10% of roots galled) to all root-knot nematodes tested (Table 2). Those data confirm the work of others (Fassuliotis, 1967, 1970; Norton and Granberry, 1980; Wehner et al., 1991), who showed that *C. metuliferus* was resistant to the *Meloidogyne* spp. causing root knot. However, introducing resistance into *C. sativus* from *C. metuliferus* may be difficult due to cross incompatibilities.

Only four *C. sativus* cultigens ('Southern Pickler', LJ 90430, PI 249550, and PI 401733) were highly or moderately resistant to *M. arenaria* race 2, and 108 (e.g., SC 10, 'Delcrow', and 'Mincu') were slightly resistant to *M. arenaria* race 2. Most cultigens evaluated were susceptible (768 of 881). The most susceptible cultigen was PI 179260 (83% of roots galled). For *M. arenaria* race 2, data were not obtained for 19 cultigens due to seed germination or plant growth problems.

Seven *C. sativus* cultigens ('Southern Pickler', PI 220169, PI 357865, PI 261608, PI 226510, PI 137848, and PI 432848) were highly or moderately resistant to *M. incognita* race 3. About 100 cultigens (e.g., Gy 4, LJ 90430, and 'Mincu') were slightly resistant to *M. incognita* race 3. Most cultigens evaluated (766 of 878) were susceptible to *M. incognita* race 3. 'Black Diamond' was the most susceptible (87% of roots galled). No data were obtained for 22 cultigens for *M. incognita* race 3 resistance.

Most *C. sativus* cultigens were susceptible to the root-knot nematodes tested, with a mean for *M. arenaria* race 2 and *M. incognita* race 3 of 52% of roots with galls. Some cultigens differed in resistance to the two nematodes, however. For example, PI 220169 had an average gall index of 68% for *M. arenaria* race 2 and 8% for *M. incognita* race 3. Considering both nematodes, no data were collected for 16 cultigens; of the 884 cultigens evaluated, 834

were susceptible (94%). 'Tiny Dill' was the most susceptible cultigen overall (72% of roots galled). Only two cultigens were highly resistant ('Southern Pickler' and LJ 90430). 'Southern Pickler' was the most resistant cultigen overall (5% of roots galled by *M. arenaria* race 2, and 1% by *M. incognita* race 3). Forty-seven cultigens were slightly resistant to root knot.

Retesting the extreme cultigens. The two *C. metuliferus* cultigens reevaluated (PI 482452 and PI 482443) were highly resistant to all nematodes, with a mean of 5% and 6% of roots galled, respectively (Table 3). The *C. sativus* cultigen most resistant to all nematode species was LJ 90430, with 29% of its roots galled. [LJ 90430 is an accession of *C. sativus* var. *hardwickii* (R.) Alef.] LJ 90430 was highly resistant to *M. javanica*, as were the two *C. metuliferus* cultigens (Table 3). LJ 90430 was moderately resistant to *M. arenaria* race 2 (11% of roots galled), but was susceptible to *M. incognita* races 1 and 3. The two *C. metuliferus* cultigens had the fewest egg masses per plant, a result that indicated high resistance, not immunity. LJ 90430 had fewer egg masses per plant than either of the *C. metuliferus* cultigens for *M. javanica* and an average of three egg masses per plant for *M. arenaria* race 2.

The *C. sativus* cultigens that were slightly resistant in the germplasm evaluation experiment were not resistant in the retest experiment. All were susceptible, considering both the percentage of roots galled and number of egg masses. For example, PI 211975 was resistant to *M. incognita* race 3 in the germplasm evaluation experiment but not in the retest experiment.

Two cultigens chosen from the germplasm evaluation for *M. arenaria* race 2 resistance—'Delcrow' and Nepal Local 7—were susceptible, with 54% and 60% of their roots galled, respectively. PI 308915, chosen as the most susceptible cultigen in the first study to *M. arenaria* race 2, was not the most susceptible cultigen in the retest experiment. Twenty cultigens had a higher percentage of root galls, and 10 cultigens had more egg masses. The cultigens that were chosen for overall susceptibility in the germplasm evaluation (Dharampur-I, PI 483342, and PI 169351) were susceptible to all four root-knot nematodes in the retest.

Several *C. sativus* cultigens were somewhat resistant to *M. arenaria* race 2 (LJ 90430, 'Mincu', 'Southern Pickler', 'Producer', 'Ohio MR 17', and 'Poinsett'). LJ 90430 and 'Mincu' were moderately resistant, and all others were slightly resistant. 'Southern Pickler' and some of its parental lines, 'Mincu' and 'Producer', were moderately resistant to *M. arenaria* race 2, possibly indicating a common genetic basis for resistance.

Of 32 *C. sativus* cultigens evaluated, 31 were susceptible to *M. javanica* (Table 3), including several important cultivars and breeding lines ('Poinsett', 'Sumter', Wisconsin SMR 18, and Gy 4). LJ 90430 was the only resistant *C. sativus* cultigen (8% of roots galled). Its high level of resistance was not significantly different from that of the *C. metuliferus* cultigens (Table 3).

None of the *C. sativus* cultigens evaluated were resistant to either of the *M. incognita* races tested, with at least 40% of the roots galled and at least 50 egg masses. LJ 90430 was the least susceptible (55% and 44% of roots galled for *M. incognita* races 1 and 3, respectively), but the presence of large numbers of egg masses (1120 and 352 for *M. incognita* races 1 and 3, respectively) indicated no resistance to *M. incognita*.

In conclusion, all *C. metuliferus* cultigens were resistant to root-knot nematodes, and LJ 90430 was the most resistant *C. sativus* cultigen to those species of root-knot nematodes evaluated. The inheritance of the resistance in LJ 90430 remains to be determined.

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