PENETRATION AND DEVELOPMENT OF *MELOIDOGYNE INCOGNITA* RACE 1 AND *MELOIDOGYNE JAVANICA* IN SUSCEPTIBLE AND RESISTANT VEGETABLES

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Accepted:
27.II.1991
Aceptado:

ABSTRACT

Khan, A. A. and M. W. Khan. 1990. Penetration and development of *Meloidogyne incognita* race 1. and *M. javanica* in susceptible and resistant vegetables. Nematrópica 21:71–77.

Penetration and post-penetration development of *M. incognita* race 1 and *M. javanica* juveniles in roots of susceptible and resistant cabbage (*Brassica oleracea* var. *capitata*), cauliflower (*Brassica oleracea* var. *botrytis*), cucumber (*Cucumis sativus*), pepper (*Capsicum annuum*), and tomato (*Lycopersicon esculentum*) were examined for 30 days. Significant differences in rate of juvenile penetration, total juvenile penetration, and development of juveniles into mature females, were found between susceptible and resistant germplasm. Root penetration by second-stage juveniles of *M. incognita* race 1 and *M. javanica* in resistant germplasm was significantly less than in susceptible cultivars of the vegetables. Ingressed juveniles of *M. incognita* race 1 and *M. javanica* in the roots of resistant germplasm did not develop normally. The development of J_2 into J_3/J_4 or immature adults was delayed and only a few matured into adult females. Females in resistant germplasm were diminutive in size and abnormal in shape.

Key words: Brassica oleracea var. *botrytis, B. oleracea* var. *capitata*, cabbage, *Capsicum annuum*, cauliflower, cucumber, *Cucumis sativus, Lycopersicon esculentum, Meloidogyne incognita, M. javanica*, pepper, resistance, root-knot nematode, tomato.

RESUMEN

Khan, A. A., y M. W. Khan. 1990. Penetración y desarrollo de *Meloidogyne incognita* raza 1 y *M. javanica* en especies hortícolas susceptibles y resistentes. Nematrópica 21:71–77.

Se observó la penetración y desarrollo de post-penetración de larvas de *M. incognita* raza 1 y *M. javanica* en raíces de especies vegetales susceptibles y resistentes de repollo (*Brassica oleracea* var. *capitata*), coliflor (*Brassica oleracea* var. *botrytis*), pepino (*Cucumis sativus*), pimiento (*Capsicum annuum*) y tomate (*Lycopersicon esculentum*). Se encontraron diferencias significativas en la proporción de penetración de juveniles en relación al tiempo, penetración total del segundo estadío larvario, y desarrollo de las larvas a hembras maduras, entre germoplasmas susceptibles y resistentes. La penetración en la raíz de larvas infestivas de *M. incognita* raza 1 y *M. javanica* en germoplasmas resistentes se redujo significativamente en comparación con cultivares susceptibles. Larvas de ambas especies que lograron penetrar, no se desarrollaron normalmente. El desarrollo de J2 a J3, J4 o estadíos adultos inmaduros fue retardado y sólo algunos especímenes llegaron a hembras adultas. Las hembras en materiales resistentes eran pequeñas y de forma abnormal.

Palabras clave: Brassica oleracea var. *capitata, Brassica oleracea* var. *botrytis, Capsicum annuum*, coliflor, *Cucumis sativum, Lycopersicon esculentum, Meloidogyne incognita, M. javanica*, nematodos agalladores, pepino, pimiento, repollo, resistencia, tomate.

INTRODUCTION

Root-knot nematode juveniles readily penetrate plant roots near the apical meristem and are attracted to plants in response to stimuli emanating from roots (3,10). Root exudates play an important role in both attracting and repelling root-knot nematodes. Differences between attractiveness of juveniles of root-knot nematodes to susceptible and resistant plants have been reported (2,5,6,12). Some reports also show that penetration of juveniles into roots of susceptible and resistant cultivars did not differ, but further development of the nematodes in resistant cultivars was reduced and few galls developed (4,9,11). In an evaluation program, we found accessions and cultivars of tomato (*Lycopersicon esculentum* Mill.), pepper (*Capsicum annuum* L.), cucumber (*Cucumis sativus* L.), cauliflower (*Brassica oleracea* L. var. *botrytis*), and cabbage (*Brassica oleracea* L. var. *capitata*) resistant and immune to *M. incognita* race 1 and *M. javanica*. Our objectives were to compare the penetration and post-penetration development of *M. incognita* race 1 and *M. javanica* in roots of susceptible and resistant germplasm of five vegetables adapted to northern India in order to further understand the mechanism of resistance in these plants.

MATERIALS AND METHODS

Susceptible entries selected for the study were tomato cv. Pusa Ruby, pepper cv. Suryamukhi Green, cucumber cv. Point Sett, cauliflower cv. Snow Ball No. 16, and cabbage cv. Pride of Asia. Resistant entries were tomato cv. EC173898 (72T6), pepper cv. Jwala, cucumber cv. Improved Long Green, cauliflower cv. 74-6C, and cabbage cv. Sutton's Eclipse Drumhead.

Two-week-old seedlings of each entry except cucumber were transplanted individually to 8-cm-diam paper cups filled with a potting medium of washed sand and autoclaved soil (4:1). Seedlings then were inoculated with 1 000 freshly hatched second-stage juveniles (J2) of *M. javanica* or *M. incognita* race 1, that had been cultured on tomato cv. Pusa Ruby. Cucumber seeds were sown directly in the cups and inoculated 2 weeks later. Cucumber was not tested against *M. incognita* race 1 because no resistant germplasm was available. Plants were maintained at 22-30 C.

Nine experiments were conducted. Each experiment included 30 replications of resistant and susceptible cultivars of one vegetable inoculated with one nematode species. Five randomly selected plants from

each vegetable/nematode combination were removed from cups 1, 2, 3, 7, 15, and 30 days after inoculation. Roots were rinsed in water, stained with acid fuchsin, and examined under a binocular microscope to determine the number of J2, third and fourth-stage juveniles (J3/J4), and adult females. The shape and size of the females also were noted. A *t*-test ($P = 0.01$) was used to compare total nematode numbers at 30 days in roots of the susceptible and resistant cultivars of each vegetable.

RESULTS

Juvenile penetration by *M. javanica* and *M. incognita* race 1 was much greater in susceptible than in resistant germplasm of all the vegetables at all time intervals (Table 1). However, numbers of juveniles that penetrated the roots at a given time interval differed among vegetables.

In resistant tomato, EC173898 (72T6), no juveniles of either *M. javanica* or *M. incognita* race 1 had penetrated by 15 days. Five *M. incognita* race 1 and 10 *M. javanica* were observed in the roots at 30 days but had not developed beyond J2. In contrast, 312 J2 of *M. javanica* and 454 J2 of *M. incognita* race 1 had penetrated susceptible Pusa Ruby; 205 *M. javanica* and 243 *M. incognita* race 1 had matured into females. In pepper cv. Jwala, immune to *M. javanica*, no *M. javanica* juveniles or females were observed, but at 30 days, 33 juveniles and five females were observed in roots of susceptible Suryamukhi Green. Fewer juveniles and females of *M. incognita* race 1 were observed in roots of Jwala than in roots of Suryamukhi Green. The females were abnormal in shape and small in size. The difference in numbers of juveniles observed in susceptible and resistant germplasm was highly significant.

Numbers of nematodes at all developmental stages were less in resistant than in susceptible cauliflower and cabbage. In cauliflower cv. Snow Ball No. 16, susceptible to both nematodes, the number of juveniles of *M. javanica* and *M. incognita* race 1 observed in roots after 7 days was 350 and 291, respectively, in contrast to 196 and 195 in resistant 74-6C. After 30 days, 112 and 96 females of *M. javanica* and *M. incognita* race 1, respectively, were found in Snow Ball 16, but no females were observed in 74-6C. Similar observations were made for both *M. javanica* and M. incognita race 1 in roots of resistant and susceptible cabbage. In the roots of resistant Sutton's Eclipse Drumhead, J2 did not develop after penetration and no females were found.

In cucumber, numbers of *M. javanica* J2 in the roots of resistant Improved Long Green were less than in susceptible Point Sett. Improved Long Green cucumber was the only resistant entry on which adult females of *M. javanica* were found. However, more were observed in susceptible cucumber than in resistant cucumber at 15 and 30 days (Table 1). The shape of the females was abnormal in the resistant cucumber and they appeared diminutive in size.

Table 1. Numbers of *Meloidogyne javanica* and *M. incognita* race 1 in roots of susceptible and resistant germplasm of tomato (*Lycopersicon esculentum*), pepper (*Capsicum annuum*), cauliflower (*Brassica oleracea* var. *botrytis*), cabbage (*Brassica oleracea* var. *capitata*), and cucumber (*Cucumis sativus*).

	M. javanica								*M. incognita* race 1							
	Susceptible germplasm				Resistant germplasm				Susceptible germplasm				Resistant germplasm			
Time (days)	J2	J3/J4	Mature females	Total	J2	J3/J4	Mature females	Total	J2	J3/J4	Mature females	Total	J2	J3/J4	Mature females	Total
								L. esculentum[v]								
1	231	0	0	231	0	0	0	0	235	0	0	235	0	0	0	0
2	280	0	0	280	0	0	0	0	288	0	0	288	0	0	0	0
3	305	0	0	305	0	0	0	0	317	0	0	317	0	0	0	0
7	316	125	0	441	0	0	0	0	337	119	0	456	0	0	0	0
15	40	210	136	386	0	0	0	0	35	246	155	436	0	0	0	0
30	22	85	205	312**	10	0	0	10	0	211	243	454**	5	0	0	5
								C. annuum[w]								
1	0	0	0	0	0	0	0	0	140	0	0	140	5	0	0	5
2	1	0	0	1	0	0	0	0	184	0	0	184	43	0	0	43
3	10	0	0	10	0	0	0	0	197	0	0	197	80	0	0	80
7	11	0	0	11	0	0	0	0	282	0	0	282	90	0	0	91
15	20	0	0	20	0	0	0	0	177	80	10	267	110	14	0	124
30	31	2	5	38	0	0	0	0	40	110	72	222**	155	19	5	179
								B. oleracea var. *botrytis*[x]								
1	187	0	0	187	156	0	0	156	161	0	0	161	138	0	0	138
2	226	0	0	226	180	0	0	180	218	0	0	218	158	0	0	158
3	252	0	0	252	184	0	0	184	230	0	0	230	185	0	0	185
7	270	80	0	350	196	0	0	196	245	46	0	291	195	0	0	195
15	180	115	30	325	187	16	0	203	146	117	43	306	152	9	0	161
30	82	105	112	299**	175	32	0	207	76	114	96	286**	134	14	0	148

B. oleracea var. *capitata* [y]

1	195	0	0	195	132	0	0	132	182	0	0	182	122	0	0	122
2	244	0	0	244	172	0	0	172	222	0	0	222	164	0	0	164
3	270	0	0	270	180	0	0	180	245	0	0	245	156	0	0	156
7	201	72	0	273	175	0	0	175	262	40	0	302	146	0	0	146
15	166	80	40	286	165	0	0	165	202	95	23	320	145	0	0	145
30	105	75	107	287**	155	15	0	170	177	45	85	307**	45	11	0	56

C. sativus [z]

1	182	0	0	182	172	0	0	172
2	295	0	0	295	190	0	0	190
3	325	0	0	325	227	0	0	227
7	190	301	0	491	245	83	0	328
15	42	204	216	462	175	196	15	386
30	0	174	290	464**	27	94	106	227

Each value is the mean of five replications.

**Significant difference (P = 0.01) between total nematode numbers at 30 days in roots of susceptible and resistant germplasm of the vegetable according to t test.

[v]Pusa Ruby = cultivar susceptible to *M. javanica* and *M. incognita*; EC173898 (72T6) = germplasm resistant to both.

[w]Suryamukhi Green = cultivar susceptible to *M. javanica* and *M. incognita*; Jwala = cultivar immune to *M. javanica* and resistant to *M. incognita*.

[x]Snow Ball No. 16 = cultivar susceptible to *M. javanica* and *M. incognita*; 74-6C = germplasm resistant to both.

[y]Pride of Asia = cultivar susceptible to *M. javanica* and *M. incognita*; Sutton's Eclipse Drumhead = cultivar resistant to both.

[z]Point Sett = cultivar susceptible to *M. javanica*; Improved Long Green = cultivar resistant to *M. javanica*.

DISCUSSION

Mechanism(s) of resistance to root-knot nematodes are complex and in many cases are understood poorly (7). *Meloidogyne incognita* in some incompatible reactions with plants may fail to penetrate, penetrate only for a short period, penetrate in low numbers, or penetrate in numbers equal to those in compatible plants but fail to develop. Hypersensitivity of the cells damaged by the migrating nematode and several biochemical mechanisms of incompatibility have been observed (1). In the present study, marked differences between resistant and susceptible plants were observed in the rates of J2 penetration and development and in the numbers of females that attained maturity. These observations were consistent regardless of the nematode or the vegetable involved and were observed at all the time intervals. However, the number of juveniles observed in roots at a given time interval varied among vegetables.

The attraction of root-knot nematode juveniles in soil towards host roots, and the development of ingressed juveniles within roots into mature adults, are distinct stages of infection. Compatibility between the nematode and the host root at each stage is vital for establishment of a successful host-parasite relationship (1). Attraction and repulsion of juveniles prior to root penetration are governed by the nature of root exudates (3,5,6,12). A consistent difference observed between resistant and susceptible germplasm in the number of ingressed juveniles indicated that root exudates of susceptible cultivars may have differed from exudates of resistant germplasm.

Incompatibility governed mainly by biochemical mechanisms influences the post-penetration development of ingressed juveniles (7). In the immune accession of tomato, *M. javanica* and *M. incognita* juveniles did not develop into adults. In resistant germplasm of pepper, few juveniles of *M. incognita* race 1 matured into females. Pepper cv. Jwala is immune to *M. javanica* and no juveniles were observed. In resistant germplasm of cabbage and cauliflower, no juveniles of *M. incognita* race 1 or *M. javanica* matured into adult females, but total root penetration was quite high in comparison to tomato and pepper. In the resistant cucumber, about 50% of *M. javanica* J2 developed into females, though the cultivar had been rated as resistant according to Canto-Saénz scheme of host suitability (8). Degree of resistance and host plant/root-knot nematode combination seem to be critically important in this respect. Although the nature of the incompatibility and the mechanism(s) involved were not studied, our findings support the hypothesis of Canto-Saénz (1) that incompatibility between host and nematode operates both at pre- and post-penetration stages of juveniles in resistant germplasm.

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Received for publication:

27.XII.1989

Recibido para publicar: