

Pathogenic Variability Among Isolates of *Meloidogyne javanica* on *Capsicum annum*¹

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Abstract: *Meloidogyne javanica* isolates were collected from nine districts of Uttar Pradesh. These isolates showed pathogenic variability when inoculated on the pepper cultivars California Wonder and Suryamukhi Green. *Meloidogyne javanica* that infected Suryamukhi Green but not California Wonder were designated as pepper race 1 and the populations that infected both the cultivars were designated pepper race 2. Race 1 was more frequent than race 2 in Almora, Pauri Garhwal, Basti, Gorakhpur, and Deoria, whereas race 2 was more frequent than race 1 in the Dehradun, Farrukhabad, Hardoi, and Sitapur districts. The overall frequencies were 70% and 30% for race 1 and race 2, respectively, in the study area.

Key words: *Capsicum annum* cultivars, isolate, *Meloidogyne javanica*, race, root-knot nematode, pathogenic variability, pepper.

Root-knot nematodes, *Meloidogyne* species, constitute a major group of plant-pathogenic nematodes affecting crop production and substantially reducing food quality. Among these, *M. incognita* (Kofoid & White) Chitwood and *M. javanica* (Treub) Chitwood are worldwide in distribution and occur in varied warm-temperate and tropical climates and agro-ecosystems. Some of the early evidence of pathogenic variation within species involved differences in parasitism on cotton among isolates of *M. incognita*, ranging from non-parasitism to severe parasitism (Martin, 1954). Goplen et al. (1959) found that within a species certain populations react differentially on a given host. These variants have been referred to as races, biotypes, or pathotypes. Four host races have been recognized in *M. incognita*, two in *M. arenaria* (Neal) Chitwood, and two in *M. chitwoodi* O'Bannon, Santo, & Finely populations from different parts of the world (Khan and Khan, 1991; Santo and Pinkerton, 1985; Sasser, 1980). Pathogenic variability is not fully described in *M. javanica* populations; however, some indications about the existence of host races in *M. javanica* have been provided by some investigators (Eisenback and Triantaphyllou, 1991; Khan, 1997; Rammah and Hirschmann, 1990; Stephan, 1988). Patel et al. (1993) and Sharma et al. (1995) designated pathotypes/races 1, 2, and 3 of *M. javanica* based on ability to parasitize groundnut and/or pepper from the state of Gujarat in India.

The purpose of this study was to determine if variation in parasitism of pepper exists among *M. javanica* populations from the state of Uttar Pradesh.

MATERIALS AND METHODS

Three regions of the Uttar Pradesh state of India characterized as a hilly region, central region and east-

ern region, and differing in agro-climatic conditions, were selected for a systematic survey. Three districts from each region, three localities from each district, and five fields from each locality were identified for collection of root samples from seven commonly grown vegetables—eggplant (*Solanum melongena* L.), tomato (*Lycopersicon esculentum* Mill.), okra (*Abelmoschus esculentus* (L.) Moench.), cucumber (*Cucumis sativus* L.), cauliflower (*Brassica oleracea* L. var. *botrytis*), cabbage (*Brassica oleracea* L. var. *capitata*), and pepper (*Capsicum annum* L.). Five to ten root samples were collected at random in each field. A total of 135 fields were surveyed and 975 root-knot nematode infected root samples were collected. In general, only one vegetable crop was found in each field. Sometimes all seven surveyed vegetables were not present in one locality. Each field was visited only once during the survey. Root samples were brought to laboratory and processed for species identification. Four to five fully developed egg masses and corresponding females were dissected randomly from each root sample separately. Perineal patterns of females were prepared and their characteristics were microscopically examined to determine the species (Chitwood, 1949). Only egg masses of *M. javanica* were preserved for the identification of races; egg masses of the other species were discarded.

All isolates identified as *M. javanica* were maintained on tomato cv. Pusa Ruby by inoculating a single egg mass near the roots of a 3- to 4-week-old seedling growing in 12-cm-diam. clay pots filled with autoclaved soil. Plants were kept on benches within a greenhouse and labeled to denote host, region, district, and locality. Subculturing of each population was done after 2 to 3 months. All nematode populations were tested for their pathogenicity on pepper cultivars California Wonder, recognized as a non-host (Taylor and Sasser, 1978), and Suryamukhi Green, recognized as a susceptible host to this species (Khan and Khan, 1991). Seedlings of both cultivars of pepper were grown separately in 12-cm-diam. clay pots containing 2 kg autoclaved sandy loam soil (67% sand, 24% silt, 9% clay; pH 7.7; 2% OM). Five pots of each cultivar were inoculated with 5,000 freshly hatched second-stage juveniles (J₂) taken from single egg mass cultures of each *M. javanica* population. In-

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oculation pots then were arranged in complete randomized blocks on greenhouse benches.

After 60 days, plants were removed from pots and the roots washed with water. The number of galls and egg masses were counted, and gall indices (GI) and egg mass indices (EMI) were rated on a 0-to-5 scale (Taylor and Sasser, 1978). The isolates of *M. javanica* that did not infect California Wonder (GI/EMI = 0) but infected Suryamukhi Green with GI/EMI < 1 were designated as pepper race 1; those isolates that infected both the cultivars with GI/EMI < 1 were designated as pepper race 2.

RESULTS

Of 975 *Meloidogyne*-infected root samples collected from 135 fields, 295 root samples were found infected with *M. javanica*, with the rest of the 680 samples being infected with *M. incognita*, *M. arenaria*, or *M. hapla*. Out of 975 samples, 684 were infected with a single species and 291 showed mixed populations of either two or three species. A total of 295 *M. javanica* isolates, irrespective of single or mixed populations, were tested for pathogenic variability on pepper.

California Wonder was not infected by 207 of the populations of *M. javanica* as the GI/EMI was nil. California Wonder was, however, infected by 88 populations of *M. javanica* with GI/EMI > 1. Suryamukhi Green was infected by all the populations with GI/EMI > 1 (Table 1).

Among the districts, frequency of pepper race 1 was highest in the Sitapur district followed by Gorakhpur, Basti, Hardoi, Farrukhabad, Deoria, Pauri-Garhwal, Dehradun, and Almora. Pepper race 2 frequency was also highest in the Sitapur district followed by Gorakhpur, Hardoi, Farrukhabad, Basti, Deoria, Dehradun, Pauri-Garhwal, and Almora. When pepper race frequency was compared among the vegetables, both pepper races of *M. javanica* showed highest frequency on

eggplant (30.4% and 30.7%) and lowest on cabbage (3.9% and 3.4%), respectively (Table 2).

DISCUSSION

Meloidogyne javanica is a common and important root-knot nematode species. It has a wide host range and is considered a major agricultural pest. The species, however, is generally regarded as non-pathogenic to pepper (Taylor and Sasser, 1978). Despite this belief, there are several reports on the infection of *M. javanica* on pepper from many parts of the world (Eisenback and Triantaphyllou, 1991; Rammah and Hirschmann, 1990; Stephen, 1988). During surveys of vegetable fields in three different regions of Uttar Pradesh state, pepper fields also were found infected with *M. javanica*. A similar report was made from Iraq (Stephan, 1988). Rammah and Hirschmann (1990) made a comparative study of morphological characters of different populations of *M. javanica* collected from the United States, Morocco, and Egypt. No major morphological differences were found, but the populations differed in their pathogenicity on pepper and peanut (Rammah and Hirschmann, 1990). One group of populations failed to infect pepper, another group was pathogenic on peanut, and a third group was non-infective on both pepper and peanut. According to Eisenback and Triantaphyllou (1991), some populations of *M. javanica* infected and reproduced on pepper but rarely on peanut. These populations were informally designated as “pepper race” and “peanut race” of *M. javanica* (Eisenback and Triantaphyllou, 1991). Recently, Sharma et al. (1995) determined three races (1, 2, and 3) in *M. javanica* on groundnut. In artificial inoculation tests Khan and Khan (1991) reported that among 14 cultivars of pepper tested, 10 were rated as immune or resistant but 4 were susceptible to this nematode species.

The present study suggests two possibilities. The first is related to pathogenic variability in *M. javanica* popu-

TABLE 1. Frequency of pepper races of *Meloidogyne javanica* in Uttar Pradesh state of India.

Region	District	Total infected roots samples with <i>M. javanica</i>	<i>M. javanica</i> pepper race 1		<i>M. javanica</i> pepper race 2	
			Infected samples	Frequency	Infected samples	Frequency
Hilly	Almora	18	13	6.28	5	5.68
	Pauri Garhwal	24	18	8.70	6	6.82
	Dehradun	23	16	8.70	7	7.95
Central	Farrukhabad	32	22	10.63	10	11.36
	Hardoi	34	23	11.11	11	12.50
	Sitapur	59	40	19.32	19	21.59
Eastern	Basti	34	24	11.59	10	11.36
	Gorakhpur	43	31	4.98	12	13.64
	Deoria	28	20	9.66	8	9.09
Total		295	207	70.17	88	29.83

Frequency (%) of race 1 and race 2 of *M. javanica* was calculated from total infected samples of the respective race.

TABLE 2. Frequency of occurrence of pepper races of *Meloidogyne javanica* on vegetable crops in Uttar Pradesh state of India.

Vegetable crops	Total infected roots samples with <i>M. javanica</i>	<i>M. javanica</i> pepper race 1		<i>M. javanica</i> pepper race 2	
		Infected samples	Frequency	Infected samples	Frequency
Pepper	39	28	13.52	11	12.50
Eggplant	90	63	30.43	27	30.68
Tomato	60	45	21.73	15	17.05
Okra	48	30	14.49	18	20.45
Cucumber	26	18	8.69	8	9.09
Cauliflower	21	15	7.24	6	6.82
Cabbage	11	8	3.86	3	3.40
Total	295	207	70.17	88	29.83

Frequency (%) of race 1 and race 2 of *M. javanica* was calculated from total infected samples of the respective race.

lations and the second to the variations in susceptibility of cultivars to single populations of *M. javanica*. Thus two races of *M. javanica*, pepper race 1 and pepper race 2, were observed in the state of Uttar Pradesh. This confirms the findings of Sharma et al. (1995). However, a large number of populations of *M. javanica* should be evaluated to differentiate host races as it is a second most common and widespread species of root-knot nematodes of the world. This information may be useful in developing cropping pattern strategies for the management of root-knot nematodes.

LITERATURE CITED

- Chitwood, B. G. 1949. Root-knot nematodes—part I. A revision of the genus *Meloidogyne* Goldi, 1887. Proceedings of the Helminthological Society of Washington 16:90–104.
- Eisenback, J. D., and H. H. Triantaphyllou, 1991. Root-knot nematode *Meloidogyne* species and races. Pp. 191–274 in W. R. Nickle, ed. Agricultural nematology. New York: Marcel Dekker.
- Goplen, B. P., E. H. Stanford, and M. W. Allen. 1959. Demonstration of physiological races within three root-knot nematode species attacking alfalfa. Phytopathology 49:653–656.
- Khan, B. 1997. Pathogenic variability in *Meloidogyne incognita* and *M. javanica* populations and their interactions. Ph.D. thesis, Aligarh Muslim University, India.
- Khan, A. A., and M. W. Khan. 1991. Suitability of some cultivars of pepper as hosts for *Meloidogyne javanica* and races of *M. incognita*. Nematologia Mediterranea 18:51–53.
- Martin, W. J. 1954. Parasitic races of *Meloidogyne incognita* and *Meloidogyne incognita acrita*. Plant Disease Reporter Supplement 227: 86–88.
- Patel, D. J., B. A. Patel, and H. V. Patel. 1993. Pathotypes of *Meloidogyne javanica* in India. Nematologia Mediterranea 21:207–208.
- Rammah, A., and H. Hirschmann, 1990. Morphological comparison of three host races of *Meloidogyne javanica*. Journal of Nematology 22:56–58.
- Santo, G. S., and J. N. Pinkerton. 1985. A second race of *M. chitwoodi* discovered in Washington. Plant Disease 69:361.
- Sasser, J. N. 1980. Root-knot nematodes: A global menace to crop production. Plant Disease 64:36–41.
- Sharma, S. B., D. H. Smith, and D. McDonald. 1995. Host races of *Meloidogyne javanica*, with preliminary evidence that the 'Groundnut race' is widely distributed in India. International Arachis Newsletter 15:45–46.
- Stephan, Z. A. 1988. New race of *Meloidogyne javanica* from Iraq. International Nematology Network Newsletter 5:21.
- Taylor, A. L., and J. N. Sasser, 1978. Biology, identification, and control of root-knot nematodes (*Meloidogyne* species). Raleigh, NC: North Carolina State University Graphics.