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Race Composition of *Meloidogyne incognita* and *M. arenaria* Populations in Vegetable Fields in Uttar Pradesh

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Abstract: A total of 1,256 populations of *Meloidogyne incognita* and 442 populations of *M. arenaria* were collected from vegetables in eight districts of Uttar Pradesh, India. Host differentials were used to identify the host race of each population. All four host races of *M. incognita* were present in six of the eight districts. In the other two districts, only host races 1, 2, and 4 were found. Although frequencies of occurrence of the races differed among districts, races 1 and 2 comprised 62% of all *M. incognita* populations evaluated. Only host race 2 of *M. arenaria* was found in this survey, and this race was found in all eight districts. This is the first report of *M. arenaria* host race 2 from India.

Key words: geographic distribution, *Meloidogyne arenaria, Meloidogyne incognita,* nematode, race, root-knot nematode, survey, vegetable.

Four host races of *Meloidogyne incognita* (Kofoid & White) Chitwood and two host races of *M. arenaria* (Neal) Chitwood occur in many parts of the world (7). In India, *M. incognita* and *M. arenaria* are two of the major plant-parasitic nematode species found on vegetables. Although all four host races of *M. incognita* have been reported from India (2), studies aimed at characterization of populations of this species have been limited (3–5,10). No attempts have been made to identify the host races of *M. arenaria* that occur in the country. The objective of this study was to characterize populations of both root-knot nematode species from vegetable crops in eight districts in Uttar Pradesh, the largest state on the Indo-Gangetic plains.

MATERIALS AND METHODS

Root-knot nematode (*Meloidogyne* spp.) populations associated with vegetable crops were collected from Aligarh, Bulandshahr, Ghaziabad, Meerut, Muzaffarnagar, Saharanpur, Dehradun, and Nainital districts in western Uttar Pradesh (Fig. 1). Five localities in each district and 10–15 fields distributed to cover the entire locality were selected at random for collection of the populations. Five to ten root samples were collected from each vegetable crop in each field. A total of 471 fields were surveyed and 4,757 root samples were collected. In most cases, one vegetable crop was present in each field. Sometimes all seven surveyed vegetables were not present in one locality. The vegetables surveyed were eggplant (*Solanum melongena* L.), tomato (*Lycopersicon esculentum* Mill.), pepper (*Capsicum annuum* L.), okra (*Abelmoschus esculentus* (L.) Moench.), cucumber (*Cucumis sativus* L.), cauliflower (*Brassica oleracea* L. var. *botrytis*), and cabbage (*Brassica oleracea* L. var. *capitata*). The collections from eggplant, pepper, okra, and cucumber were made during March through May, and from tomato, cauliflower, and cabbage during September through November in each year from 1984 to 1988. Each field was visited only once during the survey.

In the laboratory, root samples were washed under tap water and examined for the presence of galls and egg masses. Mature females were randomly collected from each sample, and 10 to 20 perineal patterns were examined for species identification (1). Single egg mass cultures of *M. incognita* and *M. arenaria* from each sample with single species populations were established in the glasshouse on tomato cultivar Pusa Ruby in winter and on eggplant cultivar Pusa Kranti in summer. In case of mixed species infection of a sample, a single egg mass culture for each species was established separately. Subculturing was done

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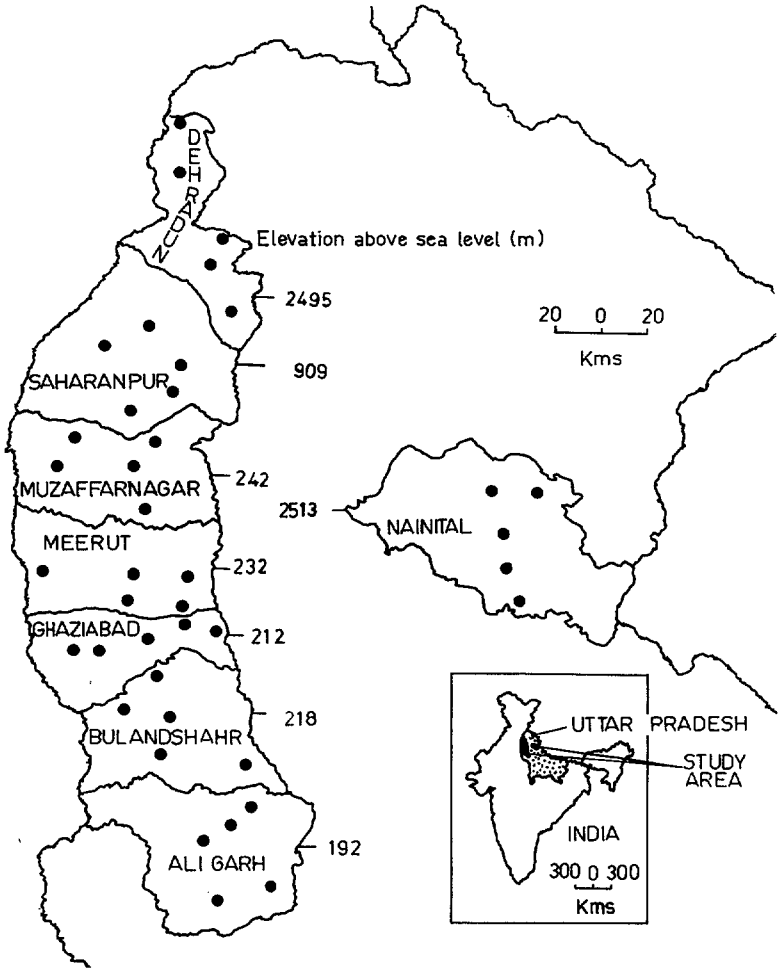

FIG. 1. Districts of Uttar Pradesh surveyed for species and races of root-knot nematodes. Survey localities indicated by ●.

after 2 months by inoculating new plants with at least 15 egg masses.

North Carolina differential host tests (9) were conducted to distinguish the races present. After race identification, the frequency of occurrence of each race in each district was calculated.

RESULTS

Of 4,757 root samples collected from 471 fields, 1,738 root samples were found infected with root-knot nematodes, of which 1,001 samples were infected with single species populations and 737 samples showed mixed populations of either two or three species (*M. incognita*, *M. javanica* (Treub) Chitwood, *M. arenaria*, and *M. hapla* Chitwood). Forty root samples that contained single populations of *M. javanica* or *M. hapla* were excluded from race identifications.

A total of 1,256 populations of *M. incognita* and 442 populations of *M. arenaria* were isolated from this survey. All four host races of *M. incognita* were found in all districts, except in Dehradun and Nainital, where no race 3 populations were recovered (Table 1). *Meloidogyne incognita* race 1 was the most frequently identified race in this survey, and 35% of the *M. incognita* populations were race 1. Races 2, 3, and 4 made up 27, 18, and 21% of *M. incognita*

TABLE 1. Number and frequency of host races of *Meloidogyne incognita* associated with vegetables in districts of Uttar Pradesh, 1984–1988.

	Number of populations isolated†							
	Cabbage	Cauli-flower	Cucumber	Eggplant	Okra	Pepper	Tomato	% frequency
				Aligarh				
Race 1	—	2 (2)‡	11 (14)	50 (61)	10 (12)	9 (11)	0 (0)	82 (38)§
Race 2	—	0 (0)	6 (9)	30 (46)	0 (0)	8 (12)	22 (33)	66 (30)
Race 3	—	0 (0)	0 (0)	27 (77)	1 (3)	7 (20)	0 (0)	35 (16)
Race 4	—	0 (0)	26 (72)	5 (14)	0 (0)	5 (14)	0 (0)	36 (16)
				Bulandshahr				
Race 1	1 (2)	—	5 (12)	5 (12)	6 (14)	12 (29)	13 (31)	42 (38)
Race 2	0 (0)	—	0 (0)	6 (33)	0 (0)	7 (39)	5 (28)	18 (16)
Race 3	0 (0)	—	0 (0)	8 (19)	12 (29)	22 (52)	0 (0)	42 (38)
Race 4	0 (0)	—	0 (0)	8 (100)	0 (0)	0 (0)	0 (0)	8 (8)
				Ghaziabad				
Race 1	—	—	—	27 (39)	8 (12)	28 (40)	6 (9)	69 (45)
Race 2	—	—	—	9 (43)	10 (48)	0 (0)	2 (9)	21 (14)
Race 3	—	—	—	0 (0)	0 (0)	0 (0)	10 (100)	10 (7)
Race 4	—	—	—	25 (48)	8 (15)	15 (29)	4 (8)	52 (34)
				Meerut				
Race 1	—	—	3 (7)	11 (24)	15 (32)	13 (28)	4 (9)	46 (23)
Race 2	—	—	34 (65)	0 (0)	7 (13)	6 (11)	6 (11)	53 (26)
Race 3	—	—	0 (0)	22 (49)	17 (38)	6 (13)	0 (0)	45 (22)
Race 4	—	—	10 (17)	20 (35)	11 (19)	17 (29)	0 (0)	58 (29)
				Muzaffarnagar				
Race 1	3 (5)	5 (8)	0 (0)	0 (0)	7 (11)	48 (76)	0 (0)	63 (26)
Race 2	0 (0)	0 (0)	40 (39)	18 (17)	25 (24)	21 (20)	0 (0)	104 (42)
Race 3	0 (0)	0 (0)	20 (29)	11 (15)	20 (29)	7 (10)	12 (17)	70 (29)
Race 4	0 (0)	0 (0)	0 (0)	7 (100)	0 (0)	0 (0)	0 (0)	7 (3)
				Saharanpur				
Race 1	—	8 (8)	32 (31)	21 (21)	5 (5)	25 (25)	10 (10)	101 (69)
Race 2	—	0 (0)	0 (0)	0 (0)	0 (0)	7 (100)	0 (0)	7 (5)
Race 3	—	0 (0)	2 (10)	11 (55)	7 (35)	0 (0)	0 (0)	20 (14)
Race 4	—	0 (0)	0 (0)	7 (41)	0 (0)	0 (0)	10 (59)	17 (12)
				Dehradun				
Race 1	4 (25)	0 (0)	—	5 (31)	0 (0)	7 (44)	0 (0)	16 (22)
Race 2	10 (36)	2 (7)	—	11 (39)	5 (18)	0 (0)	0 (0)	28 (39)
Race 3	0 (0)	0 (0)	—	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Race 4	0 (0)	3 (11)	—	7 (25)	6 (21)	0 (0)	12 (43)	28 (39)
				Nainital				
Race 1	—	—	0 (0)	3 (19)	6 (38)	7 (43)	0 (0)	16 (14)
Race 2	—	—	0 (0)	14 (37)	6 (16)	11 (29)	7 (18)	38 (34)
Race 3	—	—	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Race 4	—	—	5 (9)	15 (26)	7 (12)	9 (15)	22 (38)	58 (52)

† Dash (—) indicates vegetable not surveyed in this district.
‡ % frequency of this race shown in parentheses for the vegetables in this row.
§ % frequency of the races in a district shown in parentheses of this column.

populations, respectively. *Meloidogyne arenaria* was found in all eight districts, and all populations of this species were host race 2.

There were differences in the relative frequency of occurrence of races of *M. incognita* within districts (Table 1). Race 1 was found in greatest frequencies in the districts of Aligarh, Ghaziabad, and Saharanpur, whereas race 2 was most frequently found in Muzaffarnagar. In Bulandshahr and Meerut, races 1 and 3

occurred in approximately equal frequencies, whereas in Dehradun, races 2 and 4 were equal in occurrence. Race 4 was the predominant host race found in Meerut and Nainital, where over 28 and 50%, respectively, of the *M. incognita* populations were this race. Race 2 made up all 442 populations of *M. arenaria* evaluated.

Both *M. incognita* races 1 and 2 were recovered from all vegetables surveyed (Table 1). Race 3 was found on eggplant, tomato, pepper, okra, and cucumber, and race 4 was found on all vegetables except cabbage. On eggplant, race 1 was most frequently identified, followed in frequency by races 4, 2, and 3. Race 4 was found most often on tomato, and race 1 was found most often on pepper and cauliflower. Frequencies of occurrence of races 1 and 3 were similar on okra. On both cucumber and cabbage, race 2 was identified most frequently.

Meloidogyne arenaria race 2 was present on all the vegetables. Its frequency was 100% on all the vegetables, because it was the only race detected in all the populations of this species.

Discussion

Races of *M. incognita* and *M. arenaria* appear to be consistent across geographical regions, although the relative dominance of individual species and races varies within regions (10). The diversity of crops and cropping systems in India, along with its long agricultural history and varied climate, suggest that India is an important geographical region for documentation of *Meloidogyne* species variability. This survey has demonstrated the existence of all four races of *M. incognita* but only race 2 of *M. arenaria* in the survey area. The apparent prevalence of *M. incognita* races 1 and 2, compared with the other two races, may indicate both a cropping history and an altitude effect on populations. The information obtained from growers indicated that most of the fields observed had been under vegetable cultivation for several years. Race 3 was not found in the districts with the highest elevations. Dehradun district has an elevation range of 1,967 to 3,022 m above sea level, whereas Nainital ranges from 2,456 to 2,570 m above sea level. The absence of race 3 from these areas may reflect a specific temperature requirement for this race.

The overall trends found in this survey appear to parallel those seen in other parts of the world. Race 1 of *M. incognita* is recognized as the most widely distributed race worldwide (10). Similarly, races 3 and 4 have generally been the least frequently encountered (8,10). *Meloidogyne arenaria* race 2 is more frequently encountered than race 1 worldwide (6). Peanut, which is attacked by *M. arenaria* race 1, is not grown in the study area.

This study indicates the widespread and diverse nature of the *M. incognita* populations that are associated with vegetables in eight districts of India. Because the number of populations that were collected and identified to race was relatively large, these results may be useful in developing cropping system strategies and in development of species or race-specific resistant crop varieties. Although a much lower number of *M. arenaria* populations was found, it appears that race 2 of this species is the only race that is widely distributed in this region. Consequently, crop production strategies aimed at management of this race should have broad geographical utility.

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