Host Range of *Pratylenchus hexincisus* and its Pathogenicity on Corn, Soybean, and Tomato

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ABSTRACT

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Forty-four species or cultivars of small grains, legumes, vegetables, or weeds were tested for susceptibility to *Pratylenchus hexincisus.* One to 10 plants were inoculated with 2,000 *P. hexincisus* in the greenhouse 3 days after emergence. After 3 mo, *P. hexincisus* was recovered from the roots of all plants except smooth brome and orchard grass. Final populations of *P. hexincisus* per pot were larger than the initial population in 12 plant species. Of these 12 species, tomato, garden pea, white Dutch clover, velvetleaf, and soybean contained more *P. hexincisus* per gram dry root than the susceptible host, corn. Pathogenicity of *P. hexincisus* on corn, soybean, and tomato was demonstrated in greenhouse experiments organized according to a split-plot design. An inoculum of 5,000 *P. hexincisus* per plant significantly decreased the root and top biomass of corn, soybean, and tomato after 3 mo. An inoculum of 20,000 *P. hexincisus* per plant significantly decreased the height and top and root biomass of corn plants in all three monthly samplings.

Additional key words: Pratylenchus hexincisus, nematode resistance, pathogenicity.

Pratylenchus hexincisus Taylor and Jenkins was first described from specimens associated with sweet corn (*Zea mays*) in Maryland (12). Since then, this species has been found associated with grasses, legumes, and weeds (8,9,11). *P. hexincisus* has been found associated with corn and soybean (*Glycine max*) in the upper Midwest (3,6,11,14,15), and it is known to be a factor contributing to yield losses in the area (10,13). Field tests usually are confounded by other parasitic organisms, including other nematodes. The objectives of the research were to evaluate the pathogenicity of *P. hexincisus* on corn, soybean, and tomato and to determine its host range under controlled conditions.

MATERIALS AND METHODS

The *P. hexincisus* used in all tests originally was obtained from field corn in Iowa and was increased on corn in the greenhouse. Steam-sterilized sandy soil (86% sand, 11% silt, 3% clay; 2.5%

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TABLE 1. Numbers of *Pratylenchus hexincisus* after 3 mo in plants inoculated with 2,000 ± 100 nematodes per pot

Plants	Numbers of *Pratylenchus hexincisus* per: gram dry root	100 cm³ soil	pot[a]	P_f/P_i[b]
GRAMINEAE				
Agrostis alba L. Redtop	18	2	148	.07
Agrostis tenuis Sibth. Bentgrass	28	2	344	.17
Avena sativa L. 'E-76' Oats	193	6	227	.11
Bromus inermis Leyss. Smooth brome	0	2	30	.01
Dactylis glomerata L. 'Pot' Orchardgrass	0	1	15	.01
Echinochloa crusgalli (L.) Barnyardgrass	143	1	76	.04
Festuca arundinacea Schreb. 'Alta' or 'Kent 31' Fescue	183	2	113	.06
F. rubra L. Red fescue	13	5	100	.05
Hordeum vulgare L. Barley	28	2	70	.04
Lolium perenne L. Ryegrass	44	3	323	.16
Panicum dichotomiflorum Michx. Fall panicum	207	19	637	.31
Phalaris arundinacea L. Reed canarygrass	90	7	729	.36
Phleum pratense L. Timothy	309	76	2,944	1.47
Poa pratensis L. Kentucky bluegrass	56	1	104	.05
Secale cereale L. 'Balboa' Rye	468	4	795	.40
Setaria lutescens (Weigel) Hubb. Yellow foxtail	28	1	142	.07
S. magna Griseb. Giant foxtail	45	6	256	.13
S. viridis (L.) Beauv. Green foxtail	93	5	387	.19
Sorghum sundanense (Piper) Stapf. 'Piper' Sudan grass	194	21	1,268	.63
S. vulgare Pers. 'H-25' Sorghum	94	14	1,077	.54
Triticum aestivum L. 'Arthur j7' Wheat	310	5	808	.40
Zea mays L. 'Pioneer Brand 216 × 238' Corn	3,192	152	20,893	10.45
LEGUMINOSAE				
Coronilla varia L. 'Emerald' Crown-vetch	64	3	202	.10
Glycine max (L.) Merr. 'Corsoy' Soybean	4,176	61	7,881	3.90
Lespedeza stipulacea Maxim. 'Sericea' Korean clover	30	0	14	.01
Lotus corniculatus L. 'Empire' Birdsfoot trefoil	22	2	43	.02
Medicago sativa (Sown) L. 'Ranger' Alfalfa	18	4	100	.05
Melilotus officinalis (L.) Desr. Yellow sweet clover	24	12	271	.13
Phaseolus limensis Macf. 'Fordhook 242' Lima bean	2,527	13	2,276	1.14
Pisum sativum L. Garden pea	102,433	53	57,215	28.61
Trifolium hybridum L. Alsike clover	322	5	385	.19
T. pratense L. 'Medium' Red clover	62	3	193	.09
T. repens L. White Dutch clover	5,422	44	5,382	2.69
CRUCIFERAE				
Brassica oleracea L. 'Copenhagen Marketer' Cabbage	1,958	139	6,998	3.50
B. oleracea L. var. *botrytis* L. Cauliflower	605	27	1,870	.94

(continued)

TABLE 1 (continued)

Plants	Numbers of *Pratylenchus hexincisus* per: gram dry root	100 cm^3 soil	pot[a]	P_f/P_i[b]
CHENOPODIACEAE				
Beta vulgaris L. 'Detroit Dark Red' Beet	369	24	2,224	1.11
Chenopodium album L. Lambsquarters	343	90	2,617	1.31
C. lanceolatum Muhl. Pigweed lambsquarter	25	16	284	.14
MALVACEAE				
Abutilon theophrasti Medic. Velvetleaf	4,205	177	12,606	6.30
SOLANACEAE				
Capsicum annuum L. 'Bell' Pepper	28	2	46	.02
Lycopersicum esculentum Mill. 'Bonny Best' Tomato	205,675	1,338	598,205	299.10
UMBELLIFERAE				
Daucus carota L. 'Imperator #408' Carrot	34	2	39	.02
COMPOSITAE				
Helianthus annuus L. Sunflower	159	5	429	.21
POLYGONACEAE				
Polygonum hydropiper L. Smartweed	350	60	2,507	1.25

[a] 1,500 cm^3 soil + roots.
[b] P_f = final population; P_i = initial population.

TABLE 2. Height, top and root weights, and numbers of *Pratylenchus hexincisus* per gram (dry weight) of root of greenhouse-grown corn, soybean, and tomato plants 3 mo after inoculation

Test and treatment	Height[z] (cm)	Top weight[z] (g)	Root weight[z] (g)	*P. hexincisus/g* dry root[z]
First test				
Corn				
5,000 ± 200				
P. hexincisus + corn	90.0 a	20.6 a	5.6 a	3,757
Wash water + corn	110.5 a	27.1 b	7.5 b	0
Corn only	100.8 a	25.1 b	7.7 b	0
Second test				
Corn				
20,000 ± 400				
P. hexincisus + corn	51.5 a	11.8 a	2.7 a	25,956 a
5,000 ± 200				
P. hexincisus + corn	133.0 b	33.2 b	4.2 a	4,036 b
Wash water + corn	156.0 b	45.8 c	7.8 b	0
Corn only	152.0 b	50.0 c	8.2 b	0
Soybean				
5,000 ± 200				
P. hexincisus + soybean	82.0 a	5.5 a	0.8 a	8,046
Wash water + soybean	79.0 a	7.4 a	1.1 b	0
Soybean only	71.0 b	7.9 a	1.1 b	0
Tomato				
5,000 ± 200				
P. hexincisus + tomato	66.5 a	12.0 a	1.6 a	11,447
Wash water + tomato	69.9 a	22.5 b	3.1 b	0
Tomato only	65.0 a	20.3 b	2.6 b	0

[z] Means with common letters within a column for a given test and host are not significantly different, $P = 0.05$, according to Duncan's multiple range test.

organic matter; pH 7.0) was used in all tests. All plants were fertilized with N-P-K (6-10-4) at 6 g per 15-cm-diameter clay pot 1 mo after planting.

Host-range tests. A total of 44 species or cultivars representing small grains, legumes, vegetables, and weeds (Table 1) was tested for susceptibility to *P. hexincisus* under greenhouse conditions. The designs were completely randomized, with four replications, each consisting of one to 10 plants, depending on the species, growing in a 15-cm-diameter clay pot. Two tests consisting of 18 and 26 plant species were conducted from 2 March to 10 June and from 25 April to 8 August 1978, respectively. A third test, from 27 October 1978 to 4 February 1979, consisted of those species that had less than 10 *P. hexincisus* per gram dry root in the previous tests.

Seeds were germinated on damp filter paper in petri dishes in the laboratory and transferred to 15-cm-diameter pots. Ten milliliters of water containing 2,000 ± 100 nematodes were pipetted into a 3-cm-deep hole near the seedlings 3 days after planting. A corn hybrid which is known to be susceptible (Pioneer Brand 216 × 238) was used as a check host in all tests.

Three months after inoculation, the plants were cut at the soil line, roots and soil were removed from each pot, and the soil was gently shaken from each root system and mixed thoroughly. The root system and 100 cm^3 of soil from each pot were transferred in polyethylene bags to the laboratory. Adhering soil particles were washed from the roots, and 1–2 g of roots from each root system were randomly selected and cut into 1.5-cm segments for nematode extraction by the shaker method (1). *P. hexincisus* was extracted from the 100 cm^3 soil samples by using the centrifuge-flotation method (4). The roots were dried at 90 C for 5 days. Numbers of *P. hexincisus* were calculated per gram dry root and per root system.

Pathogenicity tests. Pathogenicity tests of this nematode on corn, Pioneer Brand 216 × 238; soybean, Corsoy; and tomato, Bonny Best were conducted for 3 mo in the greenhouse. In the first test, three treatments with four replications and three sampling times were arranged in a split-plot design. The four treatments were: 25 ml of water containing 5,000 ± 200 nematodes pipetted into the soil above the planted seed and covered with soil; 25 ml of nematode-free wash water collected during the nematode extraction (hereafter called "nematode wash water") was added to the pots to monitor effects of microbial contaminants on plant growth; corn plants (checks) without nematodes or nematode wash water; and 5,000 ± 200 nematodes added at 2.5-cm depth in pots without corn to measure the survival of *P. hexincisus*.

There were 12 experimental units per treatment, each consisting of one corn plant growing in a 15-cm-diameter clay pot. Four pots from each treatment were chosen monthly for 3 mo and the entire root system was removed from each pot. Procedures for the extraction of nematodes from roots and soil were carried out as in the host-range experiment.

At each sampling, plant height was measured, and the foliage and roots of each plant were dried at 90 C for 5 days. Weights of the dried roots used in nematode extractions were added to the total root weights. Discolored root segments were washed with distilled water for 5 min and placed in water agar and potato dextrose agar plates for isolation of suspected pathogenic fungal and bacterial contaminants.

Microscopic examinations were made of root tissue of plants inoculated with *P. hexincisus*. Free-hand sections were cut with a razor blade, stained with acid-fuchsin (5), and cleared with lactophenol. Fine rootlets were stained whole.

In a second test, the same procedures were used for soybean and tomato, and the experiment was repeated for corn with the following differences: an additional treatment that consisted of corn seedlings inoculated with 20,000 ± 400 nematodes, and no host-free survival test.

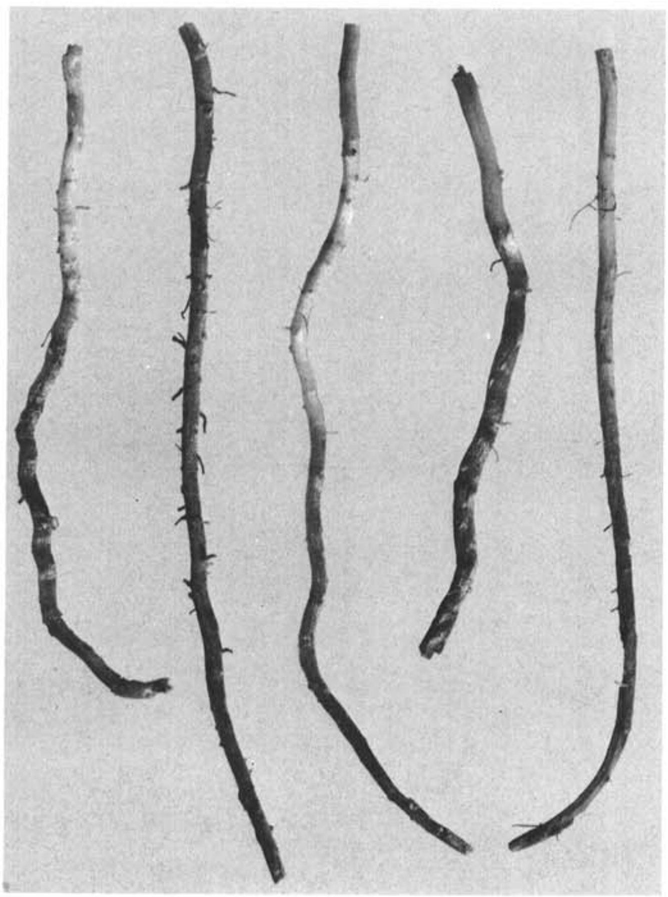
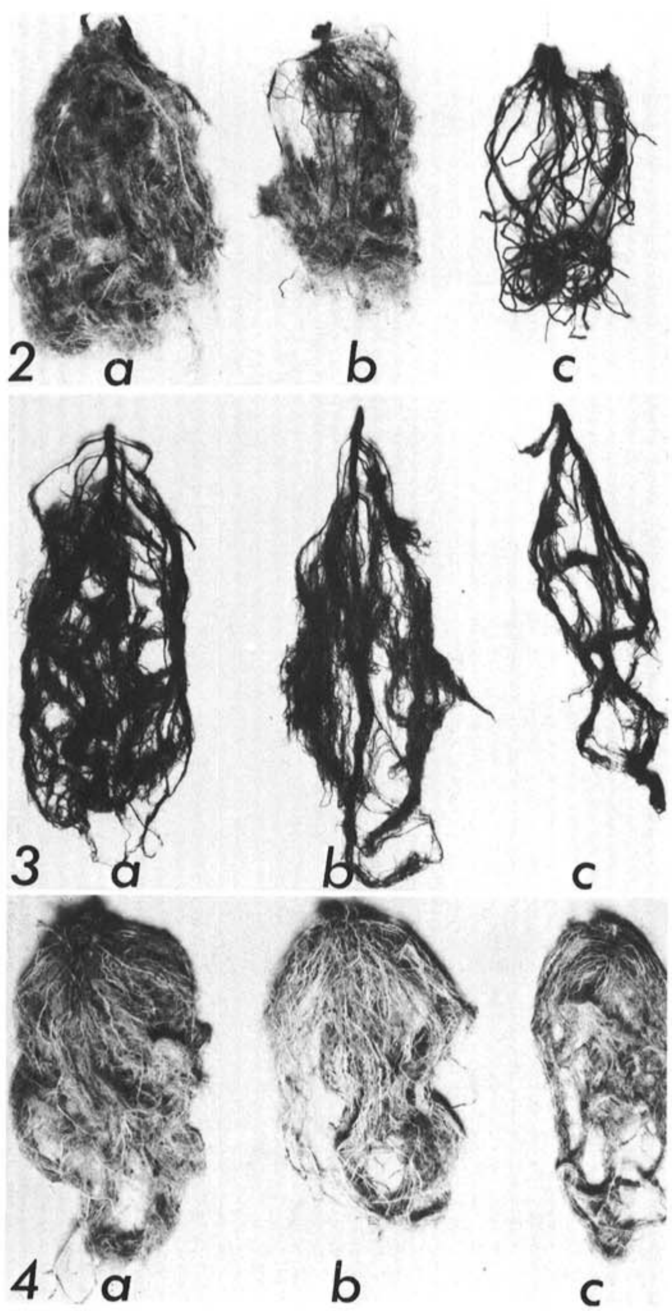


Fig. 1. Brown lesions and pruned fibrous roots caused by *Pratylenchus hexincisus* on coarse roots of corn 2 mo after inoculation.



Figs. 2–4. Effects of *Pratylenchus hexincisus* on corn, soybean, and tomato roots after 3 mo of growth in 15-cm-diameter pots in the greenhouse. **2,** Corn: **a,** check plant; **b,** inoculated with 5,000 *P. hexincisus*; **c,** inoculated with 20,000 *P. hexincisus*. **3,** Soybean: **a,** check plant; **b,** inoculated with nematode wash water; **c,** inoculated with 5,000 *P. hexincisus*. **4,** Tomato: **a,** check plant; **b,** inoculated with nematode wash water; **c,** inoculated with 5,000 *P. hexincisus*.

RESULTS

Host range tests. *P. hexincisus* was recovered from the roots of all 44 plant species or cultivars tested except smooth brome and orchardgrass (Table 1). Final populations (P_f) of *P. hexincisus* per pot were larger than the respective initial population (P_i) with 12 species, and of these, tomato, garden pea, white Dutch clover, velvetleaf, and soybean supported more *P. hexincisus* per gram dry root than did the corn check (Table 1). Final populations of *P. hexincisus* per pot in tomato and garden pea were larger than in corn.

Pathogenicity tests. Heights and top and root weights of corn plants with $P_i = 20{,}000$ *P. hexincisus* were significantly ($P = 0.05$) less than those of plants in the check and wash-water treatments in all three samplings. In both tests, root and top weights of corn plants with $P_i = 5{,}000$ *P. hexincisus* were significantly ($P = 0.05$) less than those in the check and nematode wash-water treatments at the third sampling (Table 2). Root weights of soybean and root and top weights of tomato plants with $P_i = 5{,}000$ *P. hexincisus* were significantly ($P = 0.05$) less than those of plants in the check and nematode wash water at the third sampling (Table 2). Over time, there was consistant decrease in numbers of *P. hexincisus* in the absence of the host.

Dark brown discrete lesions developed in fibrous and coarse corn roots within 60 days after inoculation (Fig. 1). Lesions nearly covered the entire root system by 90 days, especially in plants with $P_i = 20{,}000$ nematodes (Fig. 2c). Pruning of the fibrous roots occurred in all hosts by the end of the 3rd mo and was severe in corn plants inoculated with 20,000 nematodes (Figs. 2–4). *P. hexincisus* abundantly invaded the fibrous roots of corn, soybean, and tomato and were observed only in the cortical parenchyma. Considerable sloughing of the cortical tissue occurred in the fibrous roots.

Root cultures were examined for fungal and bacterial growth. Only a few colonies of *Murogenella, Rhizopus,* and *Penicillium,* species generally are not known to be pathogenic on corn roots, were observed.

DISCUSSION

Norton and Hinz (10) reported *P. hexincisus* to be a contributing factor affecting corn decline in sandy soils in Iowa. In this study, the height, top weight, and root weight of corn, soybean, and tomato plants were differentially affected by a given population level of *P. hexincisus*. In the second test the corn plants were affected more severely than the tomato and soybean plants (Table 2). Similar results have been reported with different *Pratylenchus* spp. by Dickerson (2) and Miller (7). These results indicate that different plant species have varying reactions and tolerances to a given species of *Pratylenchus.* Although it is difficult to extrapolate greenhouse data to field conditions, up to 35,000 *P. hexincisus* per gram dry root have been associated with poor corn yields in Iowa. Other stresses, such as moisture, low fertility, and other organisms, including nematodes, can reduce the number of nematodes necessary to cause measurable injury in the field. The demonstrated ability of *P. hexincisus* to reduce plant growth in the greenhouse in the absence of other parasitic organisms adds credibility to the concept that this species is a major contributing factor to reduced yields in fields in which large nematode populations occur.

Associations of this nematode with important field crops such as wheat, barley, oats, rye, soybeans, peas, flax, and alfalfa and with different weed species under field conditions have been reported (9,11,13). The results of this host-range study also indicate that *P. hexincisus* has an extensive host range, including many weeds. From the evidence presented, certain cultivars of crops such as soybean, garden pea, and white Dutch clover should not be used in rotation with corn to control this nematode. Rotation with resistant crops will not result in the desired control unless susceptible weed plants such as velvetleaf, smartweed, and lambsquarters are controlled.

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