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Occurrence and Distribution of Plant-Parasitic Nematodes Associated with Maize in Iowa

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Occurrence and Distribution of Plant-Parasitic Nematodes Associated with Maize in Iowa[1]

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Twenty-eight species of plant-parasitic nematodes were identified from the rhizosphere of 467 maize samples obtained from 72 counties. *Helicotylenchus pseudorobustus*, *Pratylenchus* spp., and *Xiphinema americanum* were found most frequently. The mean number of *Pratylenchus* spp. in roots from 339 samples was 3,413/gram of dry roots, with a maximum of more than 84,000. *Longidorus breviannulatus* and *Quinisulcius acutus* had the most marked distribution patterns, the former being found mainly in eastern Iowa and the latter mainly in the western part of the state. The least diverse (H^1) plant-parasitic nematode communities were in the sand and clay-loam soils.
INDEX DESCRIPTORS: Nematodes, *Zea mays* L., maize, nematode diversity.

Corn (*Zea mays* L.), more properly called maize, is Iowa's leading commodity. Although work with parasitic nematodes associated with the crop began in 1972, most studies have been on pathogenicity and control of a few species. An overview of the occurrence of these nematodes associated with maize roots in Iowa has never been made.

Nematologists have observed certain patterns of nematode occurrence and increase around various plants or crops. These patterns may be local or may occur over extensive areas in a state or country. Unfortunately, we know relatively little about the importance of most nematodes parasitizing maize. Documenting the occurrence of parasitic nematodes associated with maize will provide better direction for future research.

MATERIALS AND METHODS

A total of 467 samples obtained from 72 counties (Fig. 1) during the summers of 1972 through 1981 was included in this study. Samples were obtained in minisurveys or through submissions by farmers and agribusiness personnel for nematode analyses. No systematic surveys were made, and samples from experimental plots were not included. Although samples were not obtained randomly, the data represent a reasonable overview of nematode occurrence with maize in Iowa. Concentration of effort in any one soil type or area would depict different patterns.

Most samples were either collected singly with shovels or other sampling instruments projected into the rhizosphere, or were composites of several 2.5-cm diameter core samples collected within an area. Methods of collection were usually not known when samples were submitted for nematode analysis. Soil texture was analyzed using the procedures outlined by Troeh and Palmer (17).

Samples usually were processed within 24 hr. of collection or receipt. Five-hundred cm^3 of soil containing roots were thoroughly mixed. Nematodes were extracted from roots in 374 of the samples. One to two grams of fibrous roots were picked randomly, and the nematodes extracted by the 4-day shaker method (3), using streptomycin and $HgCl_2$ to minimize bacterial and fungal growth. After namatode extraction, the roots were dried at 90 C. Nematode population densities were calculated per gram of dry root. Nematodes were extracted from the soil by centrifugal-flotation (5) using 100 cm^3 of soil as the standard aliquant. Where the presence of *Longidorus* spp. was suspected (highly sandy soils), direct sieving or doubling the sugar concentration during the centrifugal-flotation procedure was used. Generally, no attempts were made to collect cysts.

Parameters in addition to actual numbers of nematodes recovered were used to interpret nematode occurrence relative to edaphic factors.

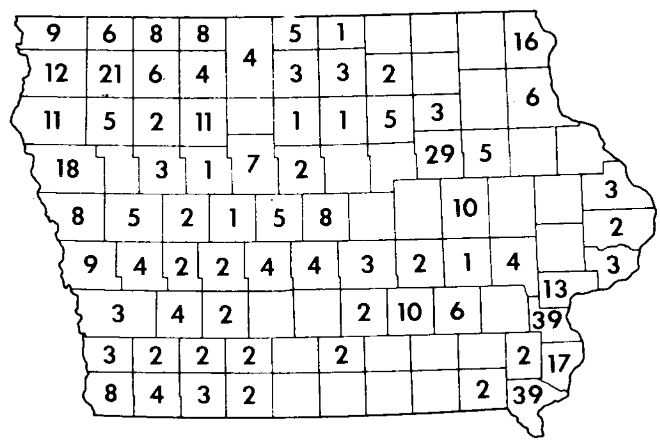

Fig. 1. Number of soil samples collected around maize in Iowa, 1972-1981. N = 467 samples.

Nematode biomass (1) was calculated from measurements of adult females. Measurements were taken from preserved specimens or from previous calculations (9, 11). Although adult measurements inflate the actual biomass of the nematodes recovered, relative comparisons can be made. Prominence values (PV = density $\sqrt{}$frequency) (2) for species and diversities ($H^1 = -\sum_{i=1}^{s} p_i \log p_i$) (13) of nematode communties were used where appropriate.

RESULTS

Nematodes Found

Twenty-eight species of nematodes, including six of *Pratylenchus*, were associated with maize (Table 1). The species of *Pratylenchus*, treated as one here, were *P. agilis* Thorne and Malek, *P. alleni* Ferris, *P. flakkensis* Seinhorst, *P. hexincisus* Taylor and Jenkins, *P. neglectus* (Rensch) Filipjev and Schuurmans Stekhoven, and *P. scribneri* Steiner. *Helicotylenchus pseudorobustus*, *Pratylenchus* spp., and *Xiphinema americanum* were the three most frequently found nematodes in the soil. As expected from other work with maize, *Pratylenchus* spp. and *Hoplolaimus galeatus* were the most frequently found nematodes in the roots (Table 2). The occurrence of *Ditylenchus* spp. in the roots was surprising, but the large numbers obtained the few times it was found in nondecayed roots indicated that a parasitic association existed.

Usually, there was little relationship between the numbers of *Pratylenchus* spp. in the soil and in the roots from the same sample. Although a large soil population usually indicated a large population in the roots, sometimes a sample with less than 20 *Pratylenchus* spp./

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Table 1. Frequency, maximum numbers, and means of plant-parasitic nematodes/100 cm^3 soil around maize roots in Iowa. N = 467 samples.

Nematode	Times found	Frequency percent	Maximum number	Mean number[a]
Helicotylenchus pseudorobustus (Steiner) Golden	315	67.5	2,570	123
Pratylenchus spp.	310	66.4	2,110	105
Xiphinema americanum Cobb	275	58.9	512	45
Hoplolaimus galeatus (Cobb) Filipjev & Schuurmans Stekhoven	87	18.6	382	43
Tylenchorhynchus spp.	82	17.6	280	39
T. nudus Allen	48	10.3	266	36
T. spp. unidentified	17	3.6	280	44
T. agri Ferris	12	2.6	210	56
T. martini Fielding	3	0.6	10	7
T. striatus Allen	2	0.4	10	10
Quinisulcius acutus (Allen) Siddiqi	72	15.4	700	87
Longidorus breviannulatus Norton & Hoffmann	46	9.9	150	26
Paratylenchus spp.	41	8.8	1,140	136
P. spp. unidentified	25	5.4	1,140	201
P. projectus Jenkins	11	2.4	100	39
P. microdorus Andrássy	3	0.6	10	10
Gracilacus audriellus (Brown) Raski	2	0.4	40	40
Criconemella spp.	34	7.3	660	62
C. ornata (Raski) Luc & Raski	14	3.0	660	101
C. spp. unidentified	14	3.0	140	35
C. rustica (Raski) Luc & Raski	3	0.6	70	33
C. informis (Micoletzky) Luc & Raski	1	0.2	22	22
C. macrodorus (Taylor) Luc & Raski	1	0.2	60	60
C. xenoplax (Raski) Luc & Raski	1	0.2	30	30
Heterodera (juveniles)	17	4.0	144	20
Paratrichodorus minor (Colbran) Siddiqi	14	3.0	110	34
Xiphinema chambersi Thorne	3	0.6	10	8
Helicotylenchus platyurus Perry	1	0.2	10	10
Hemicycliophora uniformis Thorne	1	0.2	12	12

[a]From samples containing the nematode.

100 cm^3 soil would contain several thousand/g of dry root.

Soil Texture

Ectoparasitic nematodes are governed mostly by the soil environment. Once inside the root, endoparasites are governed by the root environment. When prominence values (PV) were calculated from numbers of nematodes in the soil, *H. pseudorobustus* and *Pratylenchus* spp. had the highest PVs overall, but the PVs varied greatly with soil texture (Table 3). When nematode biomass was used in calculations, the main change in ranking was that *X. americanum* had nearly twice the PV of any other nematode in most soil textures (data not given). The PVs for *X. americanum* were distributed relatively evenly in all soil textures. Although PVs for *H. pseudorobustus* were distributed over all soil textures, they were especially large in the silty clay loams and the sandy loam soils.

Densities of *Pratylenchus* spp. and *Hoplolaimus galeatus* in the roots generally increased as the percentage of silt or sand increased (Table 4). The class intervals of numbers of *Pratylenchus* spp. between 1 and 5,000 are intentionally uneven compared with succeeding class intervals. The need for a division at 1,000 is because, as working hypothesis, numbers below 1,000/g of dry root are thought not to be economically important to the crop in most situations (unpublished data). As the numbers increase, especially to more than 5,000/g of dry root, observations and controlled tests indicate that there is an increased probability that damage is occurring or will occur in most situations. The erratic and less frequent occurrence of *H. galeatus* makes it less certain where injury thresholds might occur for this species.

Distribution

If enough samples could be taken and processed, most species reported herein probably could be found in most counties. The kinds and numbers of nematodes recovered probably indicate the most frequently occurring ones and those with the largest populations. The four most frequently found nematodes (Table 1) occurred in all parts of the state. Except for species found rarely or occasionally, the distribution patterns of *Longidorus breviannulatus* and *Quinisulcius acutus* were the most striking. The former was found in seven counties, mostly in the eastern half of Iowa, and the latter was found mostly in western Iowa (Fig. 2).

Community Diversity

The diversity indices (H^1) of nematode communities in soils of different textures were generally similar whether nematode numbers

Table 2. Frequency, maximum numbers, and means of plant-parasitic nematodes/g of dry maize root in Iowa. N = 374 samples.

Nematode	Times found	Frequency percent	Maximum number	Mean number[a]
Pratylenchus spp.	339	90.6	84,687	3,413
Hoplolaimus galeatus	56	15.0	2,547	468
Ditylenchus sp.	4	0.9	2,000	618

[a]From samples containing the nematode.

Table 3. Prominence value of numbers of nematodes in 100 cm³ soil associated with maize in Iowa, 1972-1981. Total N = 374 samples.

	Soil texture[a] and number of samples taken									
Nematode	C 6	SiC 3	SiCL 69	CL 65	SiL 43	L 42	SCL 3	SL 21	LS 21	S 101
Helicotylenchus pseudorobustus	71	40	121	68	46	67	8	122	53	14
Pratylenchus spp.	38	65	35	17	210	98	19	131	65	10
Xiphinema americanum	14	28	31	13	33	13	11	21	43	11
Quinisulcius acutus	0	0	5	1	20	6	8	7	19	3
Hoplolaimus galeatus	2	0	<1	<1	5	2	0	3	28	8
Tylenchorhynchus spp.	0	0	<1	6	1	4	7	14	10	4
Tylenchorhynchus nudus	0	0	<1	6	<1	3	7	3	5	<1
Tylenchorhynchus agri	0	0	0	0	0	<1	0	6	1	<1
Paratylenchus, Gracilacus spp.	0	0	<1	<1	14	6	0	3	<1	<1
Criconemella spp.	0	0	0	0	<1	0	0	2	20	5
Longidorus breviannulatus	0	0	0	0	0	<1	0	0	<1	5
Paratrichodorus minor	0	0	0	0	0	0	0	0	<1	2

[a]C = clay, SiC = silty clay, SiCL = silty clay loam, CL = clay loam, SiL = silty loam, L = loam, SCL = sandy clay loam, SL = sandy loam, LS = loamy sand, S = sand.

or nematode biomasses were used in the calculations, although there were some differences in the degree of significance (Table 5). The least diverse communities were in the sand and clay loam soils. Except for loamy sands when numbers were used in the calculations, there were no significant differences among other soils.

DISCUSSION

Many inherent biotic and abiotic factors that affect nematode populations have been reviewed (9, 10). In addition, husbandry practices such as tillage (15), cropping systems (6), application of fertilizers (4), and incorporation of organic matter either as fertilizer or soil improvement (7) have profound effects on nematode populations. These factors undoubtedly influenced the results of the present study even though cause-and-effect relationships frequently are not known.

The large PVs of *H. pseudorobustus* and *X. americanum* over a wide range of soil textures (Table 3) indicate they can occur most anywhere suitable hosts occur. Both maize and soybeans, which are dominant

Table 4. Numbers of ***Pratylenchus*** spp. and ***Hoplolaimus galeatus*** recovered from roots of maize in Iowa, 1972-1981. Total N = 277 samples.

Nematodes/g of dry root	Soil texture[a] C	SiC	SiCL	CL	SiL	L	SCL	SL	LS	S
					Pratylenchus spp.					
0			3(5)	1(4)	2(6)	1(4)	1(33)	2(12)		12(14)
1-999	1(33)	2(67)	51(84)	19(79)	14(39)	13(46)	2(67)	10(59)	8(57)	31(34)
1,000-4,999	2(67)	1(33)	5(8)	3(13)	13(36)	7(25)		3(18)	5(36)	23(26)
5,000-9,999			2(3)		1(3)	3(11)		1(6)		12(14)
10,000-14,999					2(6)					6(7)
15,000-19,999				1(4)	1(3)	2(7)				1(1)
20,000-24,999					2(6)	1(4)			1(7)	1(1)
25,000-29,999										1(1)
30,000-34,999										1(1)
35,000-39,999								1(6)		
>40,000					1(3)	1(4)				1(1)
Total	3	3	61	24	36	28	3	17	14	88
% of 277	1	1	22	9	13	10	1	6	5	32
					Hoplolaimus galeatus					
0										
1-99			1(50)	2(100)	2(50)	2(33)		2(100)	2(25)	5(22)
100-199			1(50)		1(25)	2(33)			3(38)	4(17)
200-299						1(18)			1(13)	
300-399										2(9)
400-499						1(18)				2(9)
500-599										
600-699					1(25)					
700-799									1(13)	2(9)
800-899										1(4)
900-999										1(4)
>1,000									1(13)	6(22)
Total			2	2	4	6		2	8	23
% of 277			1	1	1	2		1	3	8

[a]C = clay, SiC = silty clay, SiCL = silty clay loam, CL = clay loam, SiL = silty loam, L = loam, SCL = sandy clay loam, SL = sandy loam, LS = loamy sand, S = sand.
[b]Numbers in parentheses are the percentages of the number occurring in a given soil texture.

Table 5. Diversities (H^1) of plant-parasitic nematode communities in soils around maize in Iowa, 1972-1981.

Soil texture	Number of samples	H^1 Biomass	H^1 Number
Loam	42	0.83 a	0.74 b
Loamy sand	21	0.83 a	0.96 a
Sandy loam	21	0.80 a	0.81 ab
Silty loam	43	0.70 a	0.70 b
Silty clay loam	69	0.69 a	0.73 b
Clay loam	64	0.53 b	0.53 c
Sand	91	0.53 b	0.62 bc

Figures followed by the same letter in each column are not significantly (P = 0.05) different by Duncan's Multiple Range test.

crops in Iowa, are good hosts for these nematodes. Although *H. pseudorobustus* has a large PV in sandy loam soils, the largest PVs generally occurred more often in soils of greater rather than lesser clay content (Table 3). This is consistent with the general observations that *H. pseudorobustus* is found most consistently in soils of north-central Iowa, where heavier soils predominate, while occurence of other nematode species is more erratic. *X. americanum* has a relatively large biomass. Although it moves little in finely textured soil (14), this species is widespread, probably because it lives in the soil crumbs as Jones et al. (8) have found for other relatively large nematodes.

Popultions of *Pratylenchus* spp. above 5,000/g of dry root generally were found more often in soils of lesser rather than of greater clay content (Table 4). If the working hypothesis is real that numbers of *Pratylenchus* spp. below 1,000/g of dry root are not apt to be pathogenic in most instances and that numbers between 1,000 and 5,000 are marginal, then 38% of the samples contained populations that could cause marginal or definite problems. If numbers over 5,000 *Pratylenchus*/g of dry root actually are pathogenic, then problem populations exist in about 16% of the samples received. Because crop loss due to nematodes depends also on rainfall and vigor of plants, populations in the 1,000 to 5,000 range will be damaging in some years and not in others. This has been the general experience in Iowa. However, nematodes occur in polyspecific communities, and combinations of nematodes can increase the degree of damage over that of a single species (12). Finding resistance for widespread nematodes such

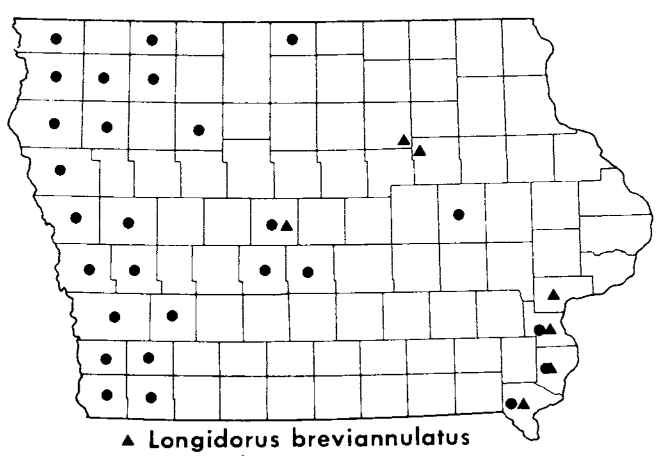

Fig. 2. Known distribution of *Longidorus breviannulatus* and *Quinisulcius acutus* around maize in Iowa.

as *Pratylenchus* spp., even when numbers might be marginal for crop loss, would be of great benefit in those years when environmental factors allow marginal populations to become injurious.

The low diversities of nematode communities in sand and clay loam soils are not surprising. In highly sandy soils, there is a lack of buffering, resulting in greater fluctuations in temperature and moisture, thus minimizing buildup or establishment of species incapable of thriving in this unstable habitat. In heavier soils, such as clay loams, lack of good aeration probably inhibits some nematodes such as *X. americanum*, which requires good oxygen levels (18). *Helicotylenchus pseudorobustus* seems to thrive better in the clay loams than do other plant-parasite nematodes.

The predominance of *Q. acutus* in western Iowa (Fig. 2) is not explainable. Although the species occurs widely in the United States, it is especially common in the Midwest. It is a common species of the prairies and plains (16) and less common in woodlands. The distribution of *Q. acutus* in Iowa may be related to the native prairie vegetation. *Longidorus breviannulatus* is restricted to or increases greatly only in highly sandy soils. The largest concentrations of these soils in Iowa are in the southeastern counties, with a smaller concentration northwest of Waterloo.

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