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Seasonal Dynamics and Yield Relationships of *Pratylenchus* spp. in Corn Roots[1]

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Abstract: The seasonal distribution of *Pratylenchus* spp. in seminal and adventitious roots and the relationship of maize yield variables to nematode densities were examined for irrigated maize in sandy soil in 1994 and 1995. Nematode populations in seminal roots were stable or declined ($P \leqslant 0.05$) during the growing season, whereas total numbers of nematodes in adventitious root systems increased in both years of the study. Late-season nematode densities in adventitious roots were better related to midseason densities in seminal than adventitious roots. Seed test weights were negatively related to *Pratylenchus* spp. densities in seminal roots in both years ($P \leqslant 0.05$) but inconsistently related to adventitious root populations. Maize yield was inversely related to early-season nematode densities in seminal roots in 1995 ($P \leqslant 0.03$). Regression analyses indicated a 1% loss in seed test weight for each 10-fold increase in nematode density and a 1% loss in seed yield for each 1,000 nematodes/g root.

Key words: lesion nematode, maize, population dynamics, *Pratylenchus neglectus*, *Pratylenchus scribneri*, yield loss, *Zea mays*.

Pratylenchus scribneri is a common pest of maize (*Zea mays*) is irrigated sandy soils in the north-central region of the United States (4,6,8,10). Yield-loss relationships have been described for this nematode using midseason and harvest population densities in roots (8). Preplant soil population density, in contrast, appears to be a poor predictor of damage. *Pratylenchus neglectus,* another inhabitant of sandy soils in the region (5), is less often associated with maize, and yield relationships have not been determined.

Seasonal distribution of *Pratylenchus* spp. in maize roots shifts between the seminal and adventitious root systems, which predominate early and late in the growing season, respectively (3). Through the first 6 weeks of root growth, nematode populations in seminal roots are developmentally advanced (3) and occur at higher densities (3,12) than those in adventitious roots. The objectives of this study were to examine the seasonal distribution of *P. scribneri* and *P. neglectus* in maize roots and the relationship between seed yield and nematode populations in seminal vs. adventitious root systems.

Materials and Methods

Nematicide experiments were conducted in separate, continuously cropped, irrigated maize fields in south-central Kansas in 1994 and 1995. Soils at both locations were Pratt loamy fine sand (94–98% sand, 0–1% silt, 2–5% clay; 1.0–1.2% organic matter; pH 5.2–6.0). *Pratylenchus* spp. were the predominant plant-parasitic nematodes present in both years of the study, with *P. scribneri* and *P. neglectus* present at the 1994 and 1995 locations, respectively. *Xiphinema americanum* was also present at both locations but remained at low population densities. Nematicide treatments and experimental design were identical between years and have been described previously (11). In addition to 32 plots in each nematicide study, data were collected from a contiguous grid of 16 four-row, 6.1-m-long untreated control plots.

Nematode soil densities were determined at planting and harvest from a composite sample of four 5-cm-diam. cores collected 15 cm deep from the middle two rows of each plot. Nematodes were extracted from 100-cm^3 subsamples of soil using a modified Christie-Perry technique (1). Root population densities of *Pratylen-*

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chus spp. were determined from two root systems collected from an inner row of each plot at monthly intervals during the growing season. Nematodes were extracted from 1-g and 5-g fresh weight subsamples of seminal and adventitious roots, respectively, using a modification of Russell's root incubation technique (7). Nematode numbers in roots were recorded on a dry root basis. Yield data, including number of ears, seed test weight (kg/liter), and total seed yield (kg/ha), were determined after hand-harvesting 4.5 m of the remaining inner row of each plot.

Seasonal trends in *Pratylenchus* spp. densities in roots were examined for untreated grid plots using regression analysis. Linear trends in $\log_{10}$-transformed nematode densities and total populations in roots were compared for seminal and adventitious root systems in each year of the study. Relationships between yield variables and nematode densities (absolute and transformed) at each sampling date were examined for all plots in each year by correlation and covariate analyses using the CORR and GLM procedures of SAS (SAS Institute, Cary, NC) software.

Results

Population dynamics of *Pratylenchus* spp. in untreated maize roots were consistent for both years of the study (Fig. 1). Nematode populations in seminal roots were nearly 10-fold those in adventitious roots across years and sampling dates. Intercept, but not slope, estimates from linear regressions of *Pratylenchus* spp. densities vs. days after planting differed between seminal and adventitious roots in both years ($P \leq 0.05$; Table 1). Numbers per gram root declined in both root systems during the 1995 growing season ($P \leq 0.05$). Late-season nematode densities in adventitious roots were better correlated with midseason seminal root densities ($r = 0.49$ to 0.77; $P \leq 0.001$) than with midseason adventitious root densities ($r = -0.05$ to 0.42; $P \leq 0.76$ to 0.003) for both years.

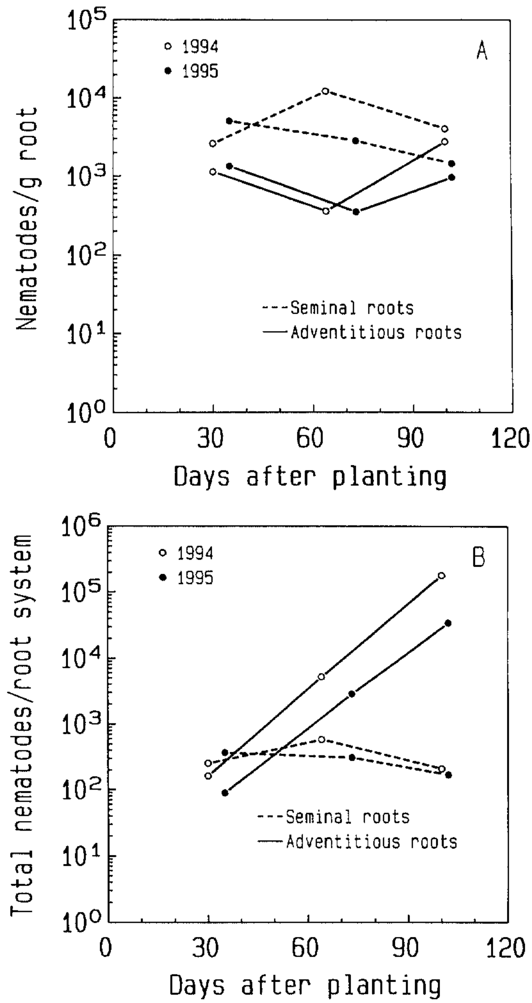

FIG. 1. Seasonal distribution of *Pratylenchus* spp. in untreated seminal and adventitious maize roots during 1994 and 1995 ($n = 16$). A) Nematodes per gram root. B) Total nematodes per root system.

Pratylenchus spp. populations in seminal roots averaged 68%, 16%, and 0.5% of the total root population for early-, mid-, and late-season sampling dates, respectively, across years (Fig. 1). Total numbers of nematodes in seminal roots declined during 1995 ($P \leq 0.005$), whereas total numbers in adventitious roots increased during both years ($P \leq 0.001$; Table 1; Fig. 1). Slope and intercept estimates from linear regressions of total nematode populations vs. days after planting differed between seminal and adventitious root systems in both years ($P \leq 0.05$; Table 1).

TABLE 1. Comparison of slopes and Y-intercepts for linear regressions of *Pratylenchus* spp. densities (log_{10}-transformed) in untreated maize roots vs. days after planting during 1994 and 1995 ($n = 48$).

Root system	Slope		Y-intercept		R^2	
	1994	1995	1994	1995	1994	1995
			Nematodes/g root			
Seminal	0.001 a[a]	−0.009 a	3.53 a	3.91 a	0.01	0.30**
Adventitious	0.004 a	−0.005 a	2.64 b	3.08 b	0.04	0.09*
			Total nematodes/root			
Seminal	−0.004 b	−0.007 b	2.61 a	2.74 a	0.07	0.16**
Adventitious	0.041 a	0.036 a	0.93 b	0.63 b	0.91**	0.84**

* $P \leq 0.05$, ** $P \leq 0.01$.
[a] Means followed by the same letter for root system within year are not significantly different using paired *t* tests ($P \leq 0.05$).

Preplant soil population densities of *Pratylenchus* spp. were not correlated with yield variables or with root populations from untreated plots in either year of the study. Correlations of nematode and corn variables were strongest for nematode populations in seminal roots (Table 2). Negative correlations were observed for seed test weight (kg/liter) with both early- and late-season *Pratylenchus* spp. densities and total populations in seminal roots ($P \leq 0.05$). Only early-season nematode numbers from seminal roots were consistently correlated with seed test weights across years. Covariate analysis indicated that slope estimates for seed test weight vs. early-season *Pratylenchus* spp. densities were not different between years ($P \leq 0.15$), despite 14% lower test weights in 1995 compared to 1994 ($P \leq 0.001$; Fig. 2). The common slope estimate across years was −0.009 ($P \leq 0.001$), indicating a 1% reduction in seed test weight for each 10-fold increase in nematode density.

Maize seed yield (kg/ha) was negatively correlated ($P \leq 0.05$) with early-season

TABLE 2. Pearson correlation coefficients for absolute *Pratylenchus* spp. population densities in maize roots on three dates vs. yield variables during 1994 and 1995 ($n = 48$).

Sampling date	Number of ears[a]		Seed test weight[b]		Seed yield[c]	
	1994	1995	1994	1995	1994	1995
			Nematodes/g seminal roots			
Early	0.07	−0.17	−0.32*	−0.44**	0.05	−0.30*
Midseason	−0.06	−0.06	0.09	−0.23	−0.02	−0.04
Late	−0.04	0.21	−0.11	−0.48**	−0.11	−0.19
			Total nematodes/seminal root system			
Early	0.03	−0.10	−0.33*	−0.40**	0.03	−0.08
Midseason	−0.08	0.01	0.02	−0.22	−0.05	0.01
Late	−0.11	0.22	−0.09	−0.50**	−0.17	−0.21
			Nematodes/g adventitious roots			
Early	0.03	−0.07	−0.27	−0.13	0.08	−0.03
Midseason	−0.16	−0.07	−0.09	−0.11	−0.11	−0.03
Late	−0.06	0.12	0.20	−0.29*	0.08	0.03
			Total nematodes/adventitious root system			
Early	0.04	−0.07	−0.21	−0.09	0.09	−0.18
Midseason	−0.18	−0.02	−0.05	−0.13	−0.13	−0.03
Late	0.07	0.12	0.12	−0.27	0.05	0.04

* $P \leq 0.05$, ** $P \leq 0.01$.
[a] Number of ears per 4.5-m row.
[b] Kg/liter.
[c] Kg/ha.

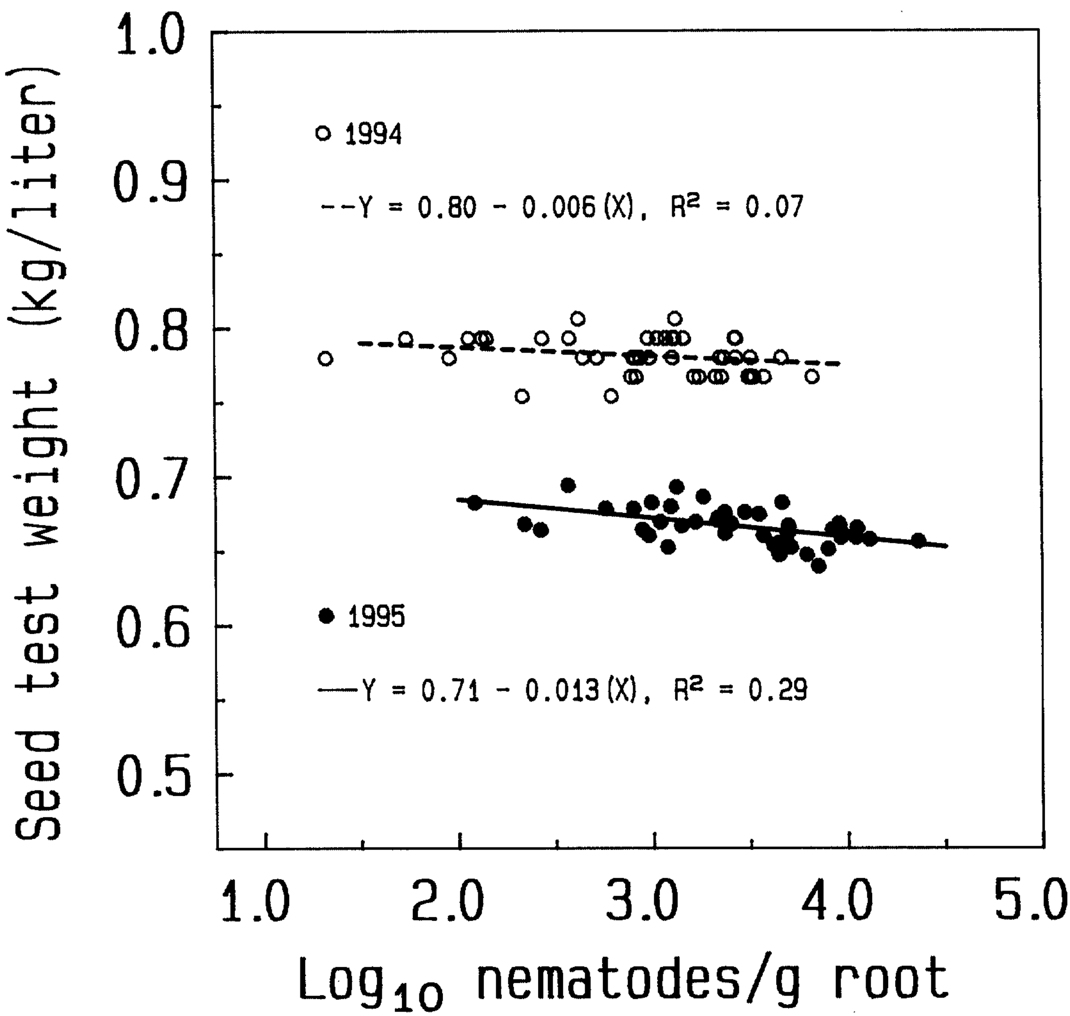

FIG. 2. Relationship of maize seed test weight and early-season *Pratylenchus* spp. densities in seminal roots for *P. scribneri* in 1994 and *P. neglectus* in 1995 (n = 44).

Pratylenchus neglectus densities in seminal roots in 1995 (Table 2). Regression analysis predicted a 1% loss in yield for each 1,000 nematodes/g root. Combination of covariates within and across years did not improve yield-loss relationships.

Discussion

Higher nematode densities in seminal roots compared to adventitious roots have been reported for *P. neglectus* in wheat (9), and *P. hexincisus* and *P. scribneri* in maize (3,12). Georgi et al. (3) reported that seminal root populations of *P. hexincisus* were more developmentally advanced than those in adventitious roots through the first 6 weeks after planting as a result of the precursory availability of the seminal roots. In the present study, *P. scribneri* and *P. neglectus* densities remained higher in seminal roots through 100 days after planting. Following the first 30 days, however, all of the population increase occurred in adventitious roots. Since nematode populations in seminal roots declined during this time, a portion of this increase appeared to be due to migration of populations from seminal to adventitious roots.

The seminal roots of monocotyledons

predominate during seedling establishment, but their contribution to the plant decreases rapidly after the seedling stage (2,3). On the early-season sampling dates (approximately 1 month after planting) in this study, seminal roots still comprised 40% to 50% by weight of the root system and contained nearly 70% of the nematode population. It was this segment of the nematode population that provided the best predictor of subsequent yield loss. Conversely, the importance of late-season *Pratylenchus* spp. population densities in adventitious roots should not be disregarded based on observed yield increases (10% across both years of the current study) in response to 30-day postplant nematicide application.

Yield loss in this study was relatively minor and, when detectable, agreed with a damage relationship previously reported for *P. scribneri* on irrigated maize from South Dakota (8). However, that estimate of approximately 1% loss per 1,000 nematodes/g root was based on harvest populations, and likely involved only adventitious roots. Late-season population densities of *P. neglectus* in adventitious roots were also negatively correlated with seed test weights in the present study. It is important to note that late-season densities of *P. scribneri* in adventitious roots were nearly identical to early-season densities in seminal roots in 1994 and that late-season *Pratylenchus* spp. population densities were similar between the two root systems in both years. Autocorrelations among sampling dates complicated the partitioning of damage, but the data do provide some evidence that early-season damage to the seminal roots of maize negatively impacts seed production. Since late-season nematode population densities have little predictive significance, this observation provides a basis for improvement of current yield-loss prediction.

As with the South Dakota study (8), preplant *Pratylenchus* spp. soil population densities were not a useful predictor of subsequent root population densities or yield loss. In northern latitudes, this may be explained by the fact that more than 50% of the population can be in residual dead root fragments at the time of planting (4). In Kansas, however, fewer than 10% of *P. scribneri* populations typically overwinter in maize roots (Todd, unpubl.). In the absence of any strong predictive value for preplant population densities, the observed relationship between early-season *Pratylenchus* spp. population densities in seminal roots and maize yield could be exploited to avert subsequent yield losses. The potential advantage of a postplant nematicide application has been demonstrated for *P. scribneri* in maize (11), and the current study suggests that recommendations for treatment should be based on early-season sampling of seminal roots.

Finally, seed test weight appeared to be a better indicator of damage due to *Pratylenchus* spp. than absolute seed yield. Serious reductions in test weight would have an economic impact independent of yield loss due to potential price deductions based on seed quality.

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