Damage and Reproductive Potentials of *Pratylenchus brachyurus* and *P. penetrans* on soybean[1]

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Abstract: Damage and reproductive potentials of *Pratylenchus brachyurus* and *P. penetrans* on soybean, *Glycine max*, cvs. Essex, Forrest, and Lee 68, were determined in microplot tests. Cultivar Essex was generally tolerant to *P. brachyurus*. Yield of Forrest was suppressed linearly with increasing P_i's in the sandy soil (r = –0.92) and loamy sand soil (r = –0.99). Low to moderate P_i's in the sandy clay loam gave an increase in yields as compared to plants without nematodes. Yield was not affected by this nematode in muck. Lee 68 was very sensitive to *P. penetrans* in microplots. Yield vs. P_i was fitted by a quadratic model (r = 0.82) with yield decreasing sharply as P_i's were increased. The reproduction of both species decreased with increases in P_i. Lee 68 was a good host for *P. penetrans*, whereas Essex and Forrest were fair to poor hosts for *P. brachyurus*. *Key words: Glycine max*, population dynamics, yield losses, threshold, edaphic factors.

Several *Pratylenchus* species, including, *P. brachyurus* (Godfrey) Filipjev and Schuurmans-Stekhoven (10), *P. scribneri* Steiner (17,18), *P. agilis* Thorne and Malek (18), *P. alleni* Ferris (7), and *P. penetrans* (Cobb) Filipjev and Schuurmans-Stekhoven (4,22) affect growth and yield of soybean, *Glycine max* (L.) Merr. Infection of soybean by *P. penetrans* may enhance the development of many small *Rhizobium* nodules but suppress N_2 fixation (8). Soybean yield losses resulting from these nematodes vary with nematode species, cultivar, and season. For example, *P. brachyurus* had no effect on yield of 'Lee' soybean in an experiment one year, but caused a 31% loss in the subsequent year (19). Similarly, the effects of this species on the growth and yield of selected soybean cultivars differed considerably (11). There is some evidence that crop damage associated with *Pratylenchus* spp. may be the result of their interactions with fungi and bacteria (12,16).

Host efficiency or suitability of soybean cultivars varies among the species of *Pratylenchus*. Lee cultivar has been shown to support greater reproduction of *P. brachyurus* than *P. zeae* (6). 'Peking' soybean gave even poorer reproduction of the latter.

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Yet, both cultivars resulted in similar populations of *P. brachyurus* (6).

The increased need for efficient crop and pest management systems makes it necessary to relate nematode densities to crop performance. The objectives of this study were to (i) characterize the host efficiency and susceptibility of two soybean cultivars to *P. brachyurus* in four soil types, (ii) determine the damage thresholds of soybean to *P. brachyurus* and *P. penetrans,* and (iii) characterize the relationships of nematode density to crop productivity.

MATERIALS AND METHODS

Pratylenchus brachyurus: A population of *P. brachyurus* originally isolated from soybean was cultured on this plant in the greenhouse. Microplots (3) were established in an Appling sandy clay loam soil (53% sand, 17% silt, 30% clay) (Research Farm Unit 2, Raleigh, NC); a Norfolk loamy sand (87% sand, 9% silt, 4% clay) (Central Crops Research Station near Clayton, NC); a Lakeland sand (93% sand, 3% silt, 4% clay) (near Grifton, NC); a muck (71% sand, 22% silt, 7% clay) (near Wenona Community, NC). The microplots at each location were fumigated each year with about 50 g methyl bromide/m^2. Roots infected with adults and juveniles were chopped and added to infested soil. Aliquants containing the desired nematode densities were used as inoculum. The Appling and Norfolk soils were infested with the soil and roots and planted on 27 May 1978 and 7 May 1979. The Lakeland and muck soils were infested in the same way and planted on 28 May 1978 and 8 May 1979. Plots were limed and fertilized according to soil test recommendations. The P_i's were 0, 30, 60, 120, and 240/500 cm^3 of soil in 1978 and 0, 110, 330, 1000 and 3000/500 cm^3 in 1979. All plots were infested with 1,000 *Glomus macrocarpus* spores per microplot in 1978 and 400/microplot in 1979. A split plot design was used with cultivars ('Essex' and 'Forrest') as whole plots and inoculum density as sub-plots. The treatments were replicated five times.

Numbers of nematodes in the soil and root samples were determined on 11 July and 1 November 1978 in the Appling and Norfolk soils, on 12 July and 20 October 1978 in the Lakeland and muck soils, on 15 October 1979 in the Norfolk and Appling soils, and on 18 October 1979 in the muck and Lakeland soils. Ten to twelve soil cores 2.5-cm d were taken 15–20 cm deep from each plot. Nematodes were extracted from 500 cm^3 soil samples by a combination of elutriation and centrifugal flotation (2). The roots extracted from the soil samples were placed in a mist chamber (2) for 5 d. Data were subjected to regression analyses to compare P_i against yields. The numbers of nematodes (X) were converted to $\log_{10}(X+1)$ for statistical analysis. Yields and nematode numbers were subjected to an analysis of variance and treatment means were compared with the Waller-Duncan K-ratio t-test.

Pratylenchus penetrans: Experiments with varying P_i's of *P. penetrans* were conducted in a Fuquay loamy sand (91% sand, 3% clay, and 6% silt) in 1974 and 1975. The nematode population was originally isolated from potato and increased on soybean in the greenhouse. Four P_i's, 0, 670, 1,310, and 2,450/500 cm^3 of soil were used for the first year. Infected greenhouse soybean plants and the infested soil were divided to give the desired nematode densities. Similar aliquants of healthy plant roots and noninfested soil were utilized to standardize the amounts of roots and soil added per plot. All plots were seeded to 'Lee 68' soybean. Management and harvest of plots were similar to those described for *P. brachyurus.*

In 1975, P_i's (nematodes which survived from the previous year) in each plot were determined by extracting from soil by elutriation and centrifugation (2) and from root fragments by Seinhorst mist (2). Similar nematode assays were made at mid-season and at harvest. Plots were seeded without any additional treatments and managed as in other tests.

The treatments consisting of four replications each were arranged in a randomized block design. Data were subjected to analysis of variance, and treatment mean comparisons were done by Waller-Duncan K-ratio t-test. Regression analyses were also used to relate nematode numbers to yield.

Table 1. Yield of 'Essex' and 'Forrest' soybeans (*Glycine max*) grown in microplots infested with *Pratylenchus brachyurus* as influenced by soil types.

Cultivar	Inoculum per 500 cm³ soil†		Yield (g/microplot)* Soil type and year							
			Appling		Lakeland		Muck		Norfolk	
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979
Essex	0	0	100a	310a	256a	222a	230ab	206a	448a	378a
	30	110	154a	319a	264a	264a	208b	236a	406ab	326a
	60	330	113a	266a	280a	226a	260a	224a	313b	298a
	120	1000	120a	264a	226a	246a	244ab	192a	322b	324a
	240	3000	138a	342a	278a	226a	240ab	192a	444a	352a
Forrest	0	0	130a	303a	310a	298a	254a	296ab	480a	432a
	30	110	163a	370a	180b	262ab	243a	382a	350bc	364a
	60	330	126a	360a	232ab	248ab	232a	298ab	362bc	334a
	120	1000	94a	296a	204b	196b	246a	278b	314c	336a
	240	3000	140a	258a	188b	204b	246a	356ab	376b	310a

*Means in a column within a cultivar followed by the same letter are not significantly different ($P = 0.05$) according to the Waller-Duncan K-ratio t-test.
†Inoculum was infested soil root pieces containing eggs, juveniles, and adults.

RESULTS AND DISCUSSION

Pratylenchus brachyurus: Essex soybean was generally tolerant to *P. brachyurus* (Table 1). Exceptions involved yield suppression ($P = 0.05$) at $P_i = 60$ and 120 in the Norfolk soil and $P_i = 30$ in the muck, but greater nematode densities did not affect yield. The nematode reproduced on Essex, but it is a relatively poor host (Table 2) according to the criteria of Seinhorst (20).

In 1978, *P. brachyurus* suppressed yield ($P = 0.05$) of Forrest in the Lakeland and Norfolk soils (Table 1). In 1979, a P_i of 1,000 was required to suppress yields ($P = 0.05$) in the Lakeland soil. The 1979 trends in the Norfolk were similar to 1978 but were not significant. There was a linear relationship between P_i and yield in both soils (Fig. 1A-B). This nematode did not cause any yield loss ($P = 0.05$) of Forrest either year in the Appling soil and only at P_i of 1,000 in the muck soil in 1979. The relationship between P_i against yield was adequately described by a quadratic model in 1979 in the Appling soil (Fig. 1C). This relationship apparently resulted from a stimulatory effect of low nematode numbers on plant yield. This type of response has been reported for other nematode species (21). Whether soil type per se or the interrelation of other edaphic factors related to soil type are most important is not clear, but the latter is probably more important (13).

Reproductive rate was inversely proportional to inoculum level (Table 2). The decrease ($P = 0.05$) occurred between P_i 110 and 330 for Essex in all soils tested and for Forrest in the Appling soil. This change ($P = 0.05$) occurred between P_i 330 and 1,000 on Forrest in the Norfolk soil and between 110 and 1,000 in the Lakeland and muck soils.

Forrest is also a poor host according to Seinhorst's criteria (20). Reproductive rate decreased as P_i increased, and the populations were not maintained above P_i of 1,000 for either cultivar. Populations of *P. brachyurus* from the field were low (9) as would be expected with poor hosts. Although Forrest was susceptible to *P. brachyurus,* it has been reported to be resistant to *P. scribneri* (1).

Pratylenchus penetrans: Lee 68 was

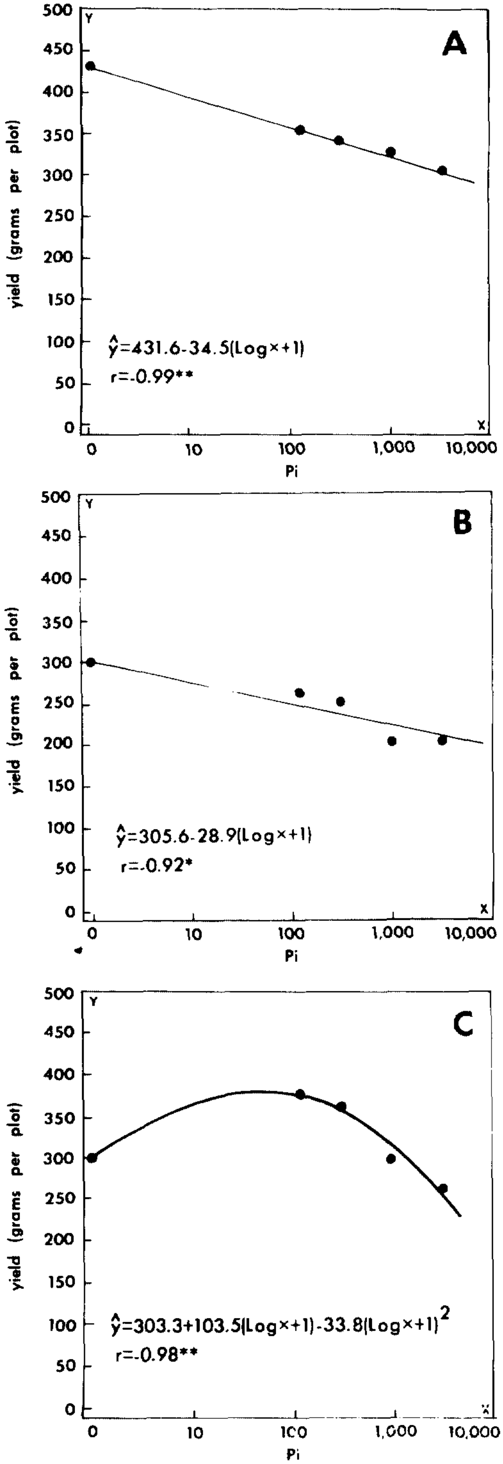

Fig. 1(A-C). Relationship of initial densities of *Pratylenchus brachyurus* and soil type to 1979 yield of 'Forrest' soybean. A) Norfolk sandy loam. B) Lakeland sand. C) Appling sandy clay loam. Y = predicted yield in g/plot, X = initial numbers of nematodes/500 cm³, * = significant at $P = 0.05$, ** = significant at $P = 0.01$.

Table 2. Reproduction factors of *Pratylenchus brachyurus* as influenced by soybean (*Glycine max*) cultivar and soil type (1979).

Soil	Cultivar	RF per Pi*			
		110	330	1000	3000
Appling	Essex	3.1a	1.6b	0.8b	0.3b
	Forrest	9.6a	1.7b	0.6b	0.2b
Lakeland	Essex	6.5a	1.8b	0.7b	0.2b
	Forrest	4.6a	2.5ab	1.0b	0.4b
Muck	Essex	2.1a	0.3b	0.2b	0.2b
	Forrest	3.4a	0.9ab	0.3b	0.2b
Norfolk	Essex	8.3a	2.3b	1.4b	0.3b
	Forrest	4.4a	3.2a	0.6b	0.3b

*RF (reproduction factor) = final population/initial population. Means with the same letter among P_i's (initial number of nematodes per 500-cm^3 soil) (rows across table) within cultivar are not significantly different at $P = 0.05$ according to the Waller-Duncan K-ratio t-test.

found to be very sensitive to *P. penetrans* (Table 3, Fig. 2). The lowest P_i (670 nematodes/500 cm^3 soil) caused some loss in yield, but the intermediate density (1,300 nematodes/500 cm^3 soil) was required to cause a loss ($P = 0.05$) in 1974. Results in yield losses for both years were similar and were combined for developing a quadratic model to relate P_i to yield (Fig. 2).

This species reproduced readily on soybeans, but the greatest reproductive rate occurred with the lowest P_i (Table 3). In contrast to the host efficiency of soybean to *P. brachyurus,* soybean was a good host (20) for *P. penetrans* in which P_f was always greater than P_i. This work was done in a loamy sand soil and is in agreement with other research (14,15).

Both *P. penetrans* and *P. brachyurus* were most damaging to soybean in the sandy soils. Our results are consistent with field observations in North Carolina whereby large numbers of *Pratylenchus* spp. were associated with soybean damage. This influence of soil type on disease development has long been recognized (13), with *P. brachyurus* being favored by loam to sandy soils (5).

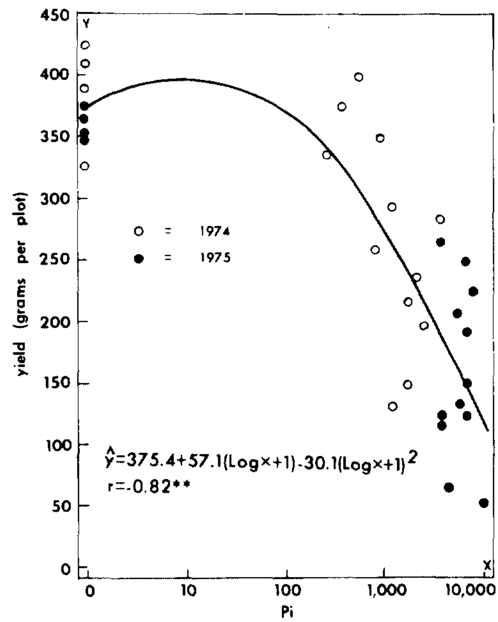

Fig. 2. Effects of initial densities of *Pratylenchus penetrans* on the yield of 'Lee 68' soybean (combined data from two experiments—1974 and 1975).

Table 3. Interactions of 'Lee 68' soybean (*Glycine max*) with *Pratylenchus penetrans* (1974).

Initial density (no. nematodes per 500 g soil)	Yield (g/plot)	RF per P_i*
0 (check)	388a†	
670	337ab	9.2a†
1310	265bc	3.0ab
2450	208c	1.6b

*RF (reproduction factor) = final population/initial population.

†Means within a column followed by same letter are not significantly different ($P = 0.05$), according to Waller-Duncan K-ratio t-test.

More cultivars should be tested for their response to several species of *Pratylenchus.* This information would be important for delivery systems so that growers could use tolerance to *Pratylenchus* species rather than having to use nematicides for control. Further information is also required on environmental parameters and edaphic factors so that the models developed by us could be modified. More information is also needed on the life history of the nematodes, especially as influenced by environmental and edaphic factors.

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