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Reproduction and Parasitism of *Pratylenchus neglectus* on Potato

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Abstract: An initial density (Pi) of 1,540 *Pratylenchus neglectus*/kg soil suppressed shoot growth of potato, *Solanum tuberosum* cv. Russet Burbank, in a greenhouse test at 3 weeks. After 6 weeks, shoot weights were reduced by Pi of 662 and 1,540 nematodes/kg soil, the final soil densities of *P. neglectus* were twice the respective Pi, and the numbers of nematodes per gram dry root were 5,363 and 7,981. In 1986–88 field microplot experiments with the Norchip cultivar, neither shoot nor root weight was suppressed by *P. neglectus.* In 1986 a Pi of 115 nematodes/kg soil suppressed the total number and weight of tubers per plant. In 1987 a Pi of 186 nematodes/kg soil suppressed the marketable and total number of tubers by 19 and 25%, respectively. In 1988 a Pi of 1,884 nematodes/kg soil reduced total and marketable weight by 18 and 19%, respectively. In 1986 and 1987 nematode population densities in the soil increased 34-fold and 27-fold, respectively. In 1988 the Pi of 1,884 nematodes/kg soil rose to 21,890/kg at midseason, then dropped to 4,370/kg at harvest. These studies show for the first time that *P. neglectus* reproduces well on potato and can cause yield losses. Because of its distribution and abundance, *P. neglectus* may be considered an economically important parasite of potato in Ontario.
Key words: potato, *Pratylenchus neglectus,* reproduction, root-lesion nematode, *Solanum tuberosum,* yield loss.

Pratylenchus neglectus (Rensch) Filipjev and Schuurmans Stekhoven occasionally is found in large numbers in some Ontario potato (*Solanum tuberosum* L.) soils, alone or in combination with other *Pratylenchus* spp. (14). In a survey of 50 potato fields representing over 5,600 ha in Simcoe County, Ontario, the nematode was found in seven fields at a median density of 320 nematodes/kg soil (14). In Wisconsin, *P. neglectus* was rarely found in potato soils and was not found in potato roots (6). *Pratylenchus neglectus* also was uncommon in Ohio potato fields with silty-loam soils, although the species was recovered from the roots (3). *Pratylenchus neglectus* was not found in potato soils in New Brunswick (9). Along with four other species of *Pratylenchus, P. neglectus* was regarded as sympatric through the upper Great Lakes basin of North America (19).

Little is known about the effect of *P. neglectus* on potatoes. Brodie (2) stated that this nematode species causes little damage. In Idaho, the potato cultivar Butte reduced populations of *P. neglectus* in both soil and roots within a 2-month period (4). Five years of cropping with Butte reduced *P. neglectus* in the soil and in roots of Russet Burbank potatoes grown the following year (5). In the Netherlands, potato yield increases associated with the use of systemic nematicides could not be ascribed to the control of *P. neglectus* (17).

The objectives of this study were to determine the reproductive potential of *P. neglectus* and its pathogenic effect on potatoes in the greenhouse and in field microplots.

MATERIALS AND METHODS

Greenhouse experiment: Tioga loamy sand (87.2% sand, 8.3% silt, 4.5% clay; pH 5.8, 1.3% organic matter) was collected from a commercial potato field near Alliston, Ontario, placed in a plastic box (45 cm long, 45 cm wide, 25 cm deep), and planted continuously to bean (*Phaseolus vulgaris* L. cv. Frenchie) at four crops per year for 3 years to increase the population density of *P. neg-*

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lectus (11). One day before use, half the soil was steam sterilized for 1 hour at 122 C and left to cool. The other half was kept in a plastic bag at 8 C.

Ten 12.5-cm-d clay pots were each filled with 920 g nematode-infested soil; 10 pots were filled with 920 g heat-sterilized soil; and 10 pots each received a mixture of 460 g nematode-infested and 460 g heat-sterilized soil. Two soil cores (2.5 cm d, 10 cm deep, and weighing 30 g each) were taken from each pot to determine nematode initial densities. A depression was made with a 7.0-cm-d clay pot in the center of each larger pot, and a small (34–44 g) whole potato seed tuber (Foundation-grade Russet Burbank) was planted in each of the 30 pots and covered with soil. All 30 pots were arranged in a randomized complete block design in a greenhouse maintained at 25 C. Supplementary light (75 hlx at bench level) was provided by two high-pressure Na lamps.

Numbers and lengths of emerged shoots were determined after 3 weeks of growth. Fresh shoot, root, and tuber weight were determined after 6 weeks; dry weights of shoots and roots also were measured after oven drying for 6 days at 95 C. Final nematode population densities in the soil were counted after extraction from 50-g subsamples for 7 days at 22 C with the Baermann pan method (18). Nematodes were extracted from roots in a mistifier for 2 weeks.

Field microplot experiments: The experiment was carried out in each of 3 years. In 1986 and 1987 soil was removed from the same commercial field as in the greenhouse experiment; in 1988, the soil was saved from the 1987 experiment and stored in plastic bags at 5 C until use. Each year the soil was sieved to remove coarse roots and debris, thoroughly mixed, and divided into two equal portions; one portion was steam sterilized for 1 hour at 122 C to eliminate the nematode. Ten kilograms of either nematode-infested or steam-sterilized soil were placed in clay drainage tiles (20 cm i.d. and 30 cm long) which were buried vertically in fumigated field soil on 1.5-m centers. To ensure the presence of microflora in the steam-sterilized soil, 33.5 g air-dried soil was mixed with each 10 kg of soil, as well as 7.2 g of 10-10-10 (N-P-K) fertilizer (equivalent to the recommended 780 kg/ha of 15-15-15). Resistance-block moisture-temperature sensors were placed in two tiles at depths of 15 and 30 cm to indicate when additional moisture was required. Each of the two treatments (nematode-infested or steam-sterilized soil) was replicated 20 times for a total of 40 completely randomized microplots (tiles).

On 26 May 1986 and 1987 and on 24 May 1988, immediately after filling the tiles, two soil cores (2.5 cm d and 20–25 cm long) were removed from each tile and the initial nematode densities (Pi) were determined with the Baermann pan method (18). The holes left after sampling were filled by stirring, and a new hole was dug in the center of each tile to a depth of 12.5 cm with a bulb planter. In each year, one whole Elite-grade Norchip potato seed tuber (50–60 g) was placed on the bottom of each microplot and sprinkled with 0.23 g disulfoton (Disyston G15) for insect control and the holes were refilled.

Fifty days after planting, soil cores were taken as at planting to determine midseason population densities (Pm). Weeds were controlled by frequent cultivation between the plots and by hand weeding in and around the tiles. All plants were inspected frequently for symptoms of *Verticillium* wilt and other diseases caused by fungi. Insects were controlled with insecticide sprays (carbaryl, cypermethrin, or pirimicarb) according to local recommendations. Rainfall and temperature data were recorded daily at the Climatological Station, Vineland Station, Ontario, 3.2 km from the experimental site. No supplementary irrigation was required in 1986; in 1987 each tile received 1 liter of water on 2 June, another 500 ml on 15 June, and overhead irrigation equivalent to 800 ml on 22 June. In 1988 1 liter of water was added to each tile on 21 June and 15 July.

At harvest, 140–142 days after planting, the tops were cut off and fresh and oven-dried (6 days at 95 C) weights determined. Roots and tubers were separated from the

TABLE 1. Effect of two initial soil population densities of *Pratylenchus neglectus* on growth of Russet Burbank potato and nematode reproduction after 6 weeks in a greenhouse pot experiment.

	0	662/kg soil	1,540/kg soil
	Growth of potato		
Shoots†			
Number	4.9 a	4.7 a	4.6 a
Total length (mm)	111.8 a	74.8 ab	60.2 b
Shoot weight (g)			
Fresh	53.6 a	48.3 b	47.4 b
Oven-dried	4.66 a	3.83 b	3.88 b
Root weight (g)			
Fresh	13.9 a	12.5 a	12.3 a
Oven-dried	0.58 a	0.54 a	0.54 a
Tuber weight (g)	44.0 a	45.3 a	46.8 a
	Nematode reproduction		
P. neglectus/kg soil			
Initial density (Pi)	0	662 a y	1,540 b y
Final density (Pf)	0	1,480 a x	2,860 b x
P. neglectus in roots			
Number/root system	0	2,664 a	4,194 b
Number/g dry root	0	5,363 a	7,981 a

All data are means of 10 replicates.
Row means followed by common letters a or b, and column means followed by common letters x or y are not significantly different ($P = 0.05$), according to Duncan's multiple-range test.
† Shoot numbers and lengths recorded 3 weeks after planting.

soil by sieving. Soil was assayed for *Verticillium dahliae* Kleb. by plating 12 50-mg subsamples on soil-pectate-Tergitol agar and counting fungal colonies after incubation for 2 weeks at 25 C. Final nematode densities (Pf) in the soil were determined from each tile as before. Nematodes were extracted for 2 weeks in a mistifier from washed and weighed root systems, which were then oven dried and weighed. Each tuber was weighed and measured and those less than 50 mm d were classified as unmarketable.

Statistical analysis: All data were subjected to analysis of variance and treatment means were compared by Duncan's multiple-range test (16). Unless otherwise stated, differences referred to in the text were significant at $P = 0.05$.

RESULTS

Greenhouse experiment: Three weeks after planting, *P. neglectus* at Pi of 1,540 nematodes/kg soil had suppressed the total length of the shoots, whereas the reduction at Pi of 662 nematodes/kg soil was not significant (Table 1). After 6 weeks of growth, shoot weights were reduced by both Pi but root and tuber weight was not affected by either. The Pf after 6 weeks averaged twice the Pi for both initial densities of *P. neglectus.* The number of *P. neglectus* per root system was higher in potato plants grown at Pi of 1,540 nematodes/kg than in those grown at Pi of 662 nematodes/kg soil.

Field microplot experiments: Neither shoot nor root weight was affected by *P. neglectus* in any of the 3 years (Table 2). In 1986, with Pi of 115 *P. neglectus*/kg soil, the total number and weight of tubers per plant was suppressed, relative to the control. In 1987, when the Pi was 186/kg soil, both the marketable and total number of tubers was decreased. In 1988, when the Pi was 1,884 *P. neglectus*/kg soil, both marketable and total weight of the tubers were suppressed. No colonies of *Verticillium dahliae* were observed on any of the 12 plates.

In 1986 and 1987, there was an increase in the soil density of *P. neglectus* at midseason and harvest. In 1988, however, the

TABLE 2. Effect of *Pratylenchus neglectus* on growth and tuber yield of Norchip potato and nematode reproduction after 140–142 days of growth in microplots at Jordan Station, Ontario, 1986–88.

	1986		1987		1988	
	0	115/kg soil	0	186/kg soil	0	1,884/kg soil
	Growth and yield of potato					
Shoot weight (g)						
Fresh	108.3	113.1	124.2	219.4	779.8	549.3
Root weight (g)						
Fresh	2.0	2.4	3.15	2.96	6.13	6.15
Oven-dried	0.30	0.31	0.49	0.42	0.81	0.79
No. tubers/plant						
Marketable (> 50 mm)	12.1	11.2	12.0*	9.7	12.3	11.7
Total	21.6*	17.1	21.1*	15.9	27.4	26.0
Weight of tubers/plant (g)						
Marketable (> 50 mm)	1,963	1,804	2,054	1,802	1,963*	1,585
Total	2,121*	1,897	2,186	1,909	2,185*	1,788
	Nematode reproduction					
P. neglectus/kg soil						
Initial density (Pi)	115 a		186 a		1,884 a	
Midseason density (Pm)	1,377 b		3,136 b		21,890 b	
Final density (Pf)	3,974 c		4,997 c		4,370 a	
P. neglectus in roots						
Number/root system	1,114		1,888		5,198	
Number/g dry root	3,458		5,308		6,326	

All data are means of 20 replicates.
* = row significant differences ($P = 0.05$) according to F-test.
Column means followed by common letters a, b or c are not significantly different ($P = 0.05$), according to Duncan's multiple-range test.

population increased nearly 12-fold at midseason, then declined sharply to a level which, at harvest, was not different from the Pi. The larger number of *P. neglectus* in the roots in 1988 appears to reflect the relatively high Pi in that year (Table 2).

DISCUSSION

These studies establish for the first time that some potato cultivars are not only good hosts of *P. neglectus* but also suffer yield losses at low to moderate initial densities. Frequent visual inspections of the plants during the growing season and soil assays after harvest failed to detect the presence of *Verticillium* wilt. These observations and the virtually total absence of *Rhizoctonia, Erwinia,* or other soil-borne organisms in the field from which the experimental soil was taken (Lazarovits, pers. comm.) make involvement of other pathogens highly unlikely.

The observation that the Russet Burbank and Norchip cultivars were good hosts of *P. neglectus* under greenhouse conditions and in field microplots, respectively, contrasts with the reports from Idaho (4,5) that the Butte cultivar reduces the population density of *P. neglectus* in the soil. It is possible that potato cultivars differ greatly in their host status for *P. neglectus,* as was shown to some degree for *P. penetrans* (12). It is also possible that races or strains that differ in pathogenicity and (or) reproduction potential exist in *P. neglectus,* as was reported for *P. penetrans* (10).

Although the Pi in 1988 was 10 times and 16 times the Pi in 1987 and 1986, respectively, the Pf in the soil as well as the number per gram of root did not differ greatly among the 3 years. This similarity might be an indication of the occurrence of the equilibrium density (1) for this host–parasite relationship. The large reduction in Pf relative to Pm in 1988 may also have been due to above-average temperatures in July and August 1988 (Stevenson, pers. comm.), which accelerated plant senescence resulting in premature death of shoots and roots.

The results indicate that low initial densities of *P. neglectus* can result in potato yield losses. After 6 weeks of growth in 12.5-cm-d pots in the greenhouse, all potato root systems had become potbound. It is believed that differences in growth due to nematode parasitism, including tuber yield, could not be fully expressed. In microplots in 1986, a Pi of 115 *P. neglectus*/kg soil suppressed total tuber yield by nearly 12% and in 1988, at a Pi of 1,884/kg soil, total and marketable yield were reduced by 22 and 24%, respectively. Irrigation of the microplots prevented drought stress which might have exacerbated yield loss, as has been reported for *P. penetrans* on potato (13).

It appears that the damage threshold of Russet Burbank and Norchip to *P. neglectus* is lower than it is to *P. penetrans*. In a previous study (12), marketable yield of Russet Burbank was suppressed by 15.7% at a Pi of 1,850 *P. penetrans*/kg soil, whereas the yield of Norchip was not affected. Tuber yield of Katahdin was suppressed by 14% at a Pi of 1,700 *P. penetrans*/kg (8) and marketable yields of Sebago were reduced by 12% at a Pi of 2,000/kg soil (15). There is a clear need to determine the pathogenic equivalence (7) of *P. neglectus* relative to *P. penetrans* for interpreting counts from diagnostic soil samples containing both species.

In Ontario, 7 of 50 potato fields surveyed were infested with *P. neglectus* at population densities ranging from 100 to 2,300/kg soil, with a median infestation of 320/kg soil (14). In view of the observations that initial population densities of 115 and 186 *P. neglectus*/kg soil in 1986 and 1987 resulted in reductions in total tuber yields of 12 and 22%, respectively, it appears that *P. neglectus* is more damaging to potato than has been believed (2) and may be considered an economically important parasite of potato in parts of Ontario.

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