

Root Growth of Susceptible and Resistant Potato Cultivars and Population Dynamics of *Globodera rostochiensis* in the Field

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Abstract: *Globodera rostochiensis* population densities and potato root growth were measured in field plots of one susceptible and two resistant potato cultivars. Root growth and nematode densities were estimated from soil samples taken at three depths between plants within the rows, three depths 22.5 cm from the rows, and at two depths midway between rows (furrows). Four weeks after plant emergence (AE), nematode densities in the rows had declined 68% in plots of the susceptible cultivar and up to 75% in plots of both resistant cultivars. Significant decline in nematode densities in the furrows 4 weeks AE occurred only in plots of the susceptible cultivar. Total decline in nematode density in fallow soil was 50%, whereas in plots of the resistant cultivars, decline was more than 70% in the rows and more than 50% in the furrows. Nematode densities increased in the rows of the susceptible cultivar but declined in the furrows. We conclude that *G. rostochiensis* decline or increase is correlated with host resistance and the amount of roots present at any particular site.

Key words: potato root growth, population decline, *Globodera rostochiensis*, root diffusate, *Solanum tuberosum*.

Most studies of nematode-root growth relationships have been directed toward crop yield effects (2,6). Changes in root

growth with respect to nematode biology have only recently been investigated (5,8). Decline of *Globodera rostochiensis* (Woll.) population densities is closely related to potato root growth and potato root diffusate (PRD) production (12,13). The influence of root growth on the population biology of *G. rostochiensis* throughout the soil profile has not been considered, particularly

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TABLE 1. Root weights at three soil depths in the rows of three potato cultivars 4 weeks after plant emergence.

Cultivar	Grams of root per 500 cm ³ soil*		
	0-15 cm	15-30 cm	30-45 cm
Katahdin	1.15	0.34	0.26
Hudson	1.10	0.34	0.12
Rosa	1.16	0.58	0.39

* No significant difference among cultivars.

with respect to PRD production and host plant resistance. The response of nematode populations midway between the rows is especially important in managing *G. rostochiensis*.

Although potato cultivars resistant to *G. rostochiensis* have a common source of resistance, they differ considerably in growth habit (1). We compared the root growth of one susceptible and two resistant cultivars and studied the relationship of root growth to *G. rostochiensis* population dynamics.

MATERIALS AND METHODS

This experiment was conducted in 1984 at the Nematode Research Farm, Prattsburg, N.Y., on a silty clay soil (9.1% sand, 46.9% silt, 44.0% clay) naturally infested with *G. rostochiensis*. The susceptible potato cultivar 'Katahdin' and the resistant cultivars 'Hudson' and 'Rosa' were planted in three randomized blocks. Each plot consisted of five rows 0.9 m apart and 3.7 m long with two border rows and 2-m alleys between plots. Previously, all plots were disked, hilled, and fertilized with 220 kg/ha NPK (8:16:16). The plots were hand planted with tuber seedpieces placed 23 cm apart. One plot in each block was left fallow.

At weekly intervals for 4 weeks after emergence (AE), soil samples for root growth analysis were taken with a 7 × 15-cm auger that collected ca. 500 cm³ of soil at various sites and depths around potato plants. At 6 and 9 weeks AE, soil samples were taken only in the furrows (midway between potato rows). Samples were taken a) 0-15, 15-30, and 30-45 cm deep between plants within the rows, b) at the same depths in the sides of the rows 22.5 cm from the plants, and c) 0-15 and 15-30 cm deep in the furrows (45 cm from the

TABLE 2. Root weights 0-15 cm deep at the sides of the rows of three potato cultivars 1-4 weeks after plant emergence.

Cultivar	Grams of root per 500 cm ³ soil			
	1 wk	2 wk	3 wk	4 wk
Katahdin	0.03	0.05	0.10	0.46
Hudson	0	0	0.05	0.62
Rosa	0.04	0.04	0.05	0.65
LSD ($P = 0.05$)	NS*	NS	NS	0.20

* Not significant.

plants). Each sample consisted of two subsamples that were separately dry sieved to remove as much of the roots as possible. Fresh root weights were recorded after washing roots free of soil and blotting them dry with absorbent paper.

Population densities of *G. rostochiensis* were determined before planting (Pi), 4 weeks after emergence (P4), and at harvest (Pf) in soil samples taken within rows and in the furrows. The soil was air-dried and sieved, and cysts were extracted from two 250-cm³ subsamples using a USDA cyst extractor (9). The number of viable eggs per gram of soil was determined by crushing cysts and visually counting viable eggs.

RESULTS

Root growth—in the rows: Root growth in the rows 4 weeks AE was greatest in the top 15 cm of soil and decreased with increase in soil depth, but there were no differences among cultivars at any depth (Table 1). Much less root growth occurred at the side of the rows (22.5 cm from plants) than within rows as root weights indicated little or no root growth below 15 cm 4 weeks AE. Root weights in the top 15 cm of soil at the side of the row of the susceptible cultivar Katahdin were significantly less than those of the resistant cultivar Rosa (Table 2).

Root growth—in the furrows: Roots were first detected in the furrows 5 weeks AE, but there was no measurable root growth until 6 weeks AE. Even at 9 weeks AE, root growth 15-30 cm deep was minimal. However, root weights in the furrows of Hudson plots were significantly greater at both depths 9 weeks AE than root weights in the furrows of Katahdin or Rosa plots (Table 3). Root weights 15-30 cm deep in the

TABLE 3. Root weights at two soil depths midway between the rows of three potato cultivars 6 and 9 weeks after plant emergence.

Cultivar	Grams of root per 500 cm ³ soil			
	0-15 cm deep		15-30 cm deep	
	6 wk	9 wk	6 wk	9 wk
Katahdin	0.02	0.09	0.0	0.05
Hudson	0.04	0.21	0.0	0.09
Rosa	0.01	0.10	0.0	0.01
LSD (<i>P</i> = 0.05)	NS*	0.03	ND†	0.012

* Not significant.
 † Not determined.

furrow of Rosa plants 9 weeks AE were significantly greater than those of Katahdin.

Nematode populations—in the rows: The number of viable eggs per cm³ soil 4 weeks AE had significantly declined in plots planted to potatoes compared to fallow plots (Table 4). A positive correlation existed between root growth and nematode population decline within the rows of all cultivars 4 weeks AE (*r* = 0.70, *P* = 0.01). The amount of population decline was significantly greater in the top 30 cm of soil than below 30 cm where fewer roots ex-

TABLE 4. Population dynamics of *Globodera rostochiensis* at different depths in fallow soil and in the rows of three potato cultivars 4 and 16 weeks after plant emergence.

Depth (cm)	Viable eggs			
	Katahdin	Hudson	Rosa	Fallow
4 weeks after emergence*				
0-15	0.32	0.25	0.22	0.88
15-30	0.36	0.44	0.47	0.82
30-45	0.65	0.76	0.88	0.89
\bar{x}	0.44	0.48	0.52	0.86
LSD (<i>P</i> = 0.01) 0.24				
16 weeks after emergence†				
0-15	5.40	0.06	0.12	0.49
15-30	4.61	0.11	0.22	0.68
30-45	2.97	0.11	0.34	0.73
\bar{x}	4.33	0.09	0.23	0.63
LSD (<i>P</i> = 0.01) 1.01				

* Number of viable eggs per cm³ soil 4 weeks after plant emergence divided by initial number of viable eggs per cm³ soil (*P*₄/*P*_i).

† Number of viable eggs per cm³ soil 16 weeks after plant emergence divided by initial number of viable eggs per cm³ soil (*P*₁₆/*P*_i).

Correlation of root weight and nematode decline, *r* = 0.70, *P* = 0.01.

TABLE 5. Population dynamics of *Globodera rostochiensis* at different depths in fallow soil and midway between the rows of three potato cultivars 4 and 16 weeks after plant emergence.

Depth (cm)	Viable eggs			
	Katahdin	Hudson	Rosa	Fallow
4 weeks after emergence*				
0-15	0.65	0.83	0.88	0.84
15-30	0.36	0.71	0.54	0.81
\bar{x}	0.46	0.77	0.71	0.83
LSD (<i>P</i> = 0.01) 0.17				
16 weeks after emergence†				
0-15	0.37	0.31	0.55	0.54
15-30	0.09	0.11	0.13	0.35
\bar{x}	0.23	0.21	0.34	0.45
LSD (<i>P</i> = 0.01) 0.25				

* Number of viable eggs per cm³ soil 4 weeks after plant emergence divided by initial number of viable eggs per cm³ soil (*P*₄/*P*_i).

† Number of viable eggs per cm³ soil 16 weeks after plant emergence divided by initial number of viable eggs per cm³ soil (*P*₁₆/*P*_i).

isted. There were no differences in decline in nematode population with depth in fallow plots.

Final nematode population densities (16 weeks AE) in the rows were significantly less than initial densities in plots of the resistant cultivars and in fallow plots. There were no differences in nematode decline with depth 16 weeks AE. In plots of the susceptible cultivar, Katahdin, final nematode population had increased several fold, but with decreasing magnitude as depth increased. Nematode population decline was greatest under the resistant cultivars and, although varying with position and depth within the soil profile, tended to be greater under Hudson (69-94%) than Rosa (45-88%).

Nematode populations—in the furrows: Nematode population decline at both depths in the furrows 4 weeks AE was significantly greater in Katahdin plots compared with other cultivars and fallow plots (Table 5). At harvest (16 weeks AE), nematode decline in the furrows of Katahdin plots was significantly greater than decline in fallow plots only at 15-30 cm deep. Nematode decline in the furrows was greater below 15 cm deep in all plots. Population densities in the furrows of Katahdin plots declined 63% at 0-15 cm and 93% at 15-30 cm.

DISCUSSION

Our results are similar to those reported by other workers (10–12) except for the data on nematode population decline in the furrows. Storey (12) suggested that the inconclusive data he obtained for population changes in the furrows may have been caused by bulking of samples. Although Stelter (10) observed population increase and decline in the furrows of a susceptible and resistant cultivar, respectively, he used smaller row spacings and did not present data on root growth. Greater decline in nematode populations in the furrows of the susceptible cultivar than in fallow plots suggests that movement of PRD occurred in the soil.

The role of PRD movement in soil in stimulating hatch of *G. rostochiensis* is unclear. Earlier work suggested that the hatching factor present in PRD is unstable (3). Our results suggest that PRD moves into the furrows affecting *G. rostochiensis* decline, particularly early in the growing season. Later in the season when roots extend into the furrow, it is not known if these roots produce sufficiently active PRD to cause egg hatch. Although maximum PRD production is known to occur during the first few weeks of growth, it continues, but with reduced potency of the hatching stimulant, for at least 8 weeks AE (13).

From root growth data, it was possible to estimate the amount of soil directly affected by potato root growth. By assuming a cylindrical shape for the rows and triangular for the furrows, it was estimated that 70% of the available soil volume was exploited by potato roots 4 weeks AE. This value has been used in a predictive model for the population dynamics of *G. rostochiensis* in which predicted population changes closely approximated actual observations (4).

Using the sampling method described, only minor differences in the root growth of Hudson and Rosa were seen. Because root weight was the only parameter measured, we could not assess the influence of

other root growth characteristics. Hudson root systems generally developed more slowly than Rosa root systems. Increased nematode decline under Hudson is probably associated with its comparatively longer vegetative growth phase, compared with Rosa, resulting in the production of a more active PRD for a longer time (7).

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