

***Globodera rostochiensis* Population Density Decline in Relation to Spatial Distribution around Resistant Potato Plants**

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Abstract: Golden nematode, *Globodera rostochiensis* (GN) population decline under resistant potatoes was related to cyst distance from plants 23 cm apart in rows 92 cm apart. GN decline, determined by sampling an infested field planted to the resistant cultivar 'Yankee Chipper', was 81.8% in cores 11.5 cm from plants within rows. Decline was 27.4% at 23 cm from plants between rows and 36.6% at 46 cm. Population decline of juveniles in cysts added to soil in bags was 90.3% for cysts 11.5 cm from plants within rows planted to the resistant cultivar 'Rosa'. Decline between rows was 83.5, 76.9, and 60.4% at 11.5, 23.0, and 46.0 cm from plants, respectively. Maximum decline within for rows 30.5, 46.0, 61.0, and 92.0 cm apart, respectively. Decline under fallow was 43.5%, significant which peaked 7 weeks AE. There was no effect of soil depth on population decline at any sampling position. Decreasing row spacing resulted in 79.9, 74.2, 73.4, and 66.1% GN population decline for rows 30.5, 46.0, 61.0, and 92.0 cm apart, respectively. Decline under fallow was 43.5%, significantly less than under potatoes. Potato root weight between rows was negatively correlated with row spacing and positively correlated with GN population decline.

Key words: golden nematode, resistance, potatoes, population dynamics, *Solanum tuberosum*.

Potato cultivars with the H₁ gene for resistance acquired from *Solanum tuberosum* ssp. *andigena* Juz. & Buk. have been widely used to manage the golden nematode (GN), *Globodera rostochiensis* Behrens Race 1 (Ro1 or R1A). Potato roots stimulate hatch of encysted juveniles from eggs by producing a host recognition factor which diffuses from the roots (8). In resistant plants, most invading juveniles do not develop and reproduce (5,9,14). As a result, GN population densities in soil decline by ca. 80% for each resistant potato crop grown (1,2,11).

Potato roots are not uniformly distributed throughout the plow layer and remain primarily within potato hills with little penetration into the furrow until late in the season (6,7). Limited horizontal root development may be due to location of fertilizer and moisture (15) or to soil compaction from machinery operating between potato rows (3). Storey (11) reported that the magnitude and timing of *G. rostochiensis* population dynamics in response to resistant or susceptible potatoes was related to the distribution pattern of cysts around plants. Population changes become smaller and occur later in the season with increasing distance from the seed piece. Storey (13) also found a positive correlation between potato root weight per volume of soil and hatch of eggs. As a result of the

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distribution pattern of potato roots, GN populations increased within hills but decreased by an average of 35% in the furrow when a susceptible cultivar was grown (12).

My objective was to determine *G. rostochiensis* population density decline under a resistant potato cultivar as a function of time, spatial distribution of cysts, and row spacing.

MATERIALS AND METHODS

Decline of GN population densities with time in relation to the spatial distribution of cysts around plants was investigated using two experimental approaches. In the first experiment, conducted at Farmingdale (Long Island), New York, four naturally infested silty clay loam field plots (14.3% sand, 52.5% silt, 33.2% clay, pH 5.1, 15.2 m × 9.1 m) were planted to the resistant cultivar 'Yankee Chipper'. These plots were core sampled (1.25 cm d) to 30 cm deep before planting and 3, 5, and 7 weeks after potato shoot emergence. Plants were 23 cm apart within rows with 92 cm between rows. Core samples were taken 11.5 cm between plants within rows and in the furrow 23 and 46 cm from plants in rows. Thirty plants per row in the center two rows of each plot were sampled. Cores were split into 0–10, 10–20, and 20–30 cm depths. Cysts were extracted from the bulked core samples with a modified Fenwick can (10) and were crushed to determine the decline in viable juveniles per cubic centimeter of soil over time.

The second experiment was conducted in a silty clay soil (9.1% sand, 46.9% silt, 44.0% clay, pH 5.0) in Prattsburg, New York. Nylon mesh bags (2 cm²) containing 25 cysts of uniform size and age (0.45–0.84-mm-d, produced in 1983) were buried 5 and 10 cm deep in each of four locations 11.5 cm between plants in rows and in the furrow 11.5, 23.0, and 46.0 cm from plants in the rows. The resistant potato cultivar 'Rosa' was hand planted 23 cm apart in rows 92 cm apart. A complete set of bags was removed every 2 weeks beginning 1 week after plant emergence and continuing for 10 weeks. Cysts were removed from the bags and crushed, and viable juveniles were counted.

The effect of four row-spacing regimes on *G. rostochiensis* population decline was

examined in plots (3.7 × 7.6 m) at Farmingdale. Spacing treatments consisted of 92.0, 61.0, 46.0, and 30.5 cm between rows with 23.0 cm between resistant Yankee Chipper plants in the row. Fallow plots were included. Plots were randomly arranged in the field with 3.7-m borders. Twenty 50-cm³ soil samples per plot were bulked and processed as before to determine viable juveniles before planting and after harvest (10 weeks). One 2,500-cm³ soil core 0–15 cm deep was removed from the middle of the center furrow in each plot immediately before harvest; the soil was screened and potato root fragments were weighed to estimate root distribution between rows as affected by row spacing.

RESULTS

G. rostochiensis population density decline on resistant potatoes was related to cyst distribution relative to plants and plant rows (Table 1). Decline of GN population densities 11.5 cm from plants within rows was significantly higher (81.8%) than the decline between rows at positions 23.0 cm (27.4%) and 46.0 cm (36.6%) from plants. There was no effect of soil depth on population decline.

Population decline of juveniles in cysts placed in soil in bags was dependent on distance of the cysts from potato plants and on time (Table 2). There was no effect of soil depth as measured on percentage decline; each value is an average of decline at 5 and 10 cm deep. The greatest decline (90.3%) occurred 11.5 cm from potato plants within rows. Between rows, decline decreased as distance from potato plants increased. GN population density declined over time from 49.5% at 1 week to 85.8% at 10 weeks. Linear contrasts indicated that decline within the row was greater than between rows ($P = 0.05$), decline 11.5 cm from plants was greater than at greater distances ($P = 0.05$), and GN population density decline at 46 cm in the center of the furrow was less than at distances closer to plants ($P = 0.01$).

Decreasing the distance between rows of resistant potatoes keeping plant spacing constant within rows resulted in a negative correlation between row spacing and GN population density decline ($P = 0.05$) (Table 3); decline under fallow was 43.5%.

TABLE 1. Population density decline (%) of *Globodera rostochiensis* in relation to spatial distribution of cysts around resistant 'Yankee Chipper' potato plants at Farmingdale, New York.

Depth (cm)	11.5 cm from plant within the row	23.0 cm from plant between rows	46.0 cm from plant between rows
0-10	73.4	55.1	39.0
10-20	86.3	42.9	48.4
20-30	85.7	15.9*	22.4
Mean	81.8 a	27.4 b	36.6 b

Each decline value represents the mean of three observation times (3, 5, and 7 weeks after shoot emergence). Means followed by the same letter are not significantly different ($P = 0.05$) (AOV: Duncan's multiple-range test). * Indicates a population increase.

Linear contrasts confirmed that decline under fallow was less than decline under potatoes ($P = 0.05$) and that 92 cm was the least effective row spacing for inducing decline of GN populations ($P = 0.05$). Weight of roots recovered from furrow centers was negatively correlated with row spacing and positively correlated with percentage GN population decline ($P = 0.05$).

DISCUSSION

Decline of GN populations is influenced by egg hatch stimulated by potato root diffusates (PRD). The most rapid decline in GN population density occurs within potato rows, and the rate of decline decreases with increasing distance from plants. Most of the decline had occurred within 3 weeks of plant emergence at both test locations. PRD production appears to be dependent on the physiological age of potato plants (4), peaking 3 weeks after shoot emergence

TABLE 3. Effect of row spacing of resistant 'Yankee Chipper' potato plants on *Globodera rostochiensis* juvenile population density decline.

Row spacing (cm)	Root wt (g)*	Decline (%)†
30.5	0.73 ± 0.15	79.9 ± 6.0
46.0	0.67 ± 0.21	74.2 ± 7.2
61.0	0.35 ± 0.21	73.4 ± 6.2
92.0	0.15 ± 0.07	66.1 ± 12.1
Fallow	0	43.5 ± 0.5

Linear contrasts: Fallow decline less than decline under potatoes ($P = 0.01$). Decline at 92.0 cm less than other potato treatments ($P = 0.05$). * Root fresh weight per 2,500-cm³ soil core 15 cm deep between rows. † Means of up to three replications with one standard deviation.

despite continued root growth (D. Raws-thorne, pers. comm.). Maximum reduction of juveniles in cysts in bags occurred by 3 weeks after plant emergence within rows and continued to increase for up to 7 weeks further away from plants. Although PRD production is highest at 3 weeks after plant emergence, roots continue to grow and produce PRD, eventually reaching cysts further from the row and causing some egg hatch. The role of PRD diffusion through soil in this process is not currently understood. The greater hatch of eggs at Prattsburg than at Farmingdale may have been caused by the cyst source (introduced cysts versus natural infestation) or to density effects on hatching of eggs. Cyst population densities at Farmingdale gave egg densities ranging from 0.2 to 1.1 eggs/cm³ soil. The density of *G. rostochiensis* in the Prattsburg plot was ca. 57.0 eggs/cm³ soil in addition to the bagged inoculum added.

TABLE 2. Population density decline (%) of *Globodera rostochiensis* with time in relation to distance from resistant 'Rosa' potato plants at Prattsburg, New York.

Position*	Weeks after emergence						\bar{x}
	1	3	5	7	9	10	
11.5 cm w/in row	52.2	93.7	97.1	99.6	99.4	99.6	90.3
11.5 cm between	55.5	69.4	83.7	97.1	96.9	98.1	83.5
23.0 cm between	48.4	70.9	66.6	97.3	97.8	80.0	76.9
46.0 cm between	41.8	49.3	50.4	85.2	70.0	65.4	60.4
\bar{x}	49.5 a	70.8 b	74.5 b	94.8 c	91.0 c	85.8 c	

Each decline value represents the mean of two observations. Cysts in nylon bags. Means followed by the same letter are not significantly different ($P = 0.05$) (AOV: Duncan's multiple-range test). Linear contrasts: Decline within rows greater than between rows ($P = 0.05$). Decline 11.5 cm from plants greater than 23.0 and 46.0 cm from plants ($P = 0.05$). Decline 46.0 cm (furrow center) less than other positions ($P = 0.01$). * Distance from plants within or between 92.0-cm rows.

Because PRD production is greatest in the root zone during the first few weeks after plant emergence, it is not surprising that close plant spacing increases the rate of GN population decline on resistant potatoes. The rate of *G. rostochiensis* population density decline was negatively correlated with row spacing. Close row spacing increases the number of plants and roots per unit of soil, which increases the volume of soil and number of cysts exposed to peak PRD production. Most of the *G. rostochiensis* population decline which occurred in the 30.5-cm row spacing may have taken place early in the season, with differences in the effects of row spacing decreasing with time and increasing root growth until the experiment was ended at 10 weeks after plant emergence. The possibility that one or more closely spaced plantings of resistant potato cultivars may result in *G. rostochiensis* population density decline comparable to that achieved by soil fumigation remains to be investigated.

LITERATURE CITED

1. Brodie, B. B. 1982. Possible use of potato as a trap crop for controlling *Globodera rostochiensis* populations. *Journal of Nematology* 14:432 (Abstr.).
2. Cole, C. S., and H. W. Howard. 1962. Further results from a field experiment on the effect of growing resistant potatoes on a potato root eelworm (*Heterodera rostochiensis*) population. *Nematologica* 7:52-61.
3. DeRoo, H. C., and P. E. Waggoner. 1961. Root development of potatoes. *Agronomy Journal* 53:15-17.
4. Evans, K. 1982. Effects of host variety, photoperiod, and chemical treatments on hatching of *Globodera rostochiensis*. *Journal of Nematology* 14:203-207.
5. Hoopes, R. W., R. E. Anderson, and W. F. Mai. 1978. Internal response of resistant and susceptible potato clones to invasion by potato cyst nematode *Heterodera rostochiensis*. *Nematropica* 8:13-20.
6. Kotcon, J. B., D. I. Rouse, and J. E. Mitchell. 1984. Dynamics of root growth in potato fields affected by the early dying syndrome. *Phytopathology* 74:462-467.
7. Lesczynski, D. B., and C. B. Tanner. 1976. Seasonal variation of root distribution of irrigated, field-grown Russet Burbank potato. *American Potato Journal* 53:69-78.
8. O'Brien, D. B., and E. G. Prentice. 1931. A nematode disease of potatoes caused by *Heterodera schachtii* (Schmidt). *West of Scotland Agricultural College Bulletin* 2.
9. Parrott, D. M. 1981. Evidence for gene-for-gene relationships between resistance gene H₁ from *Solanum tuberosum* ssp. *andigena* and a gene in *Globodera rostochiensis*, and between H₂ from *S. multidissectum* and a gene in *G. pallida*. *Nematologica* 27:372-384.
10. Spears, J. M. 1968. The golden nematode handbook. USDA Handbook 353.
11. Storey, G. W. 1984. The effect of oxamyl and the growing of susceptible and resistant potato cultivars on the population dynamics of *Globodera rostochiensis* throughout the soil profile. *Annals of Applied Biology* 104:131-141.
12. Storey, G. W. 1982. Spatial population dynamics of potato cyst nematode *Globodera rostochiensis* (Woll.) in sandy and peaty loam during the course of a growing season. *Nematologica* 28:219-232.
13. Storey, G. W. 1982. The relationship between potato root growth and reproduction of *Globodera rostochiensis* (Woll.). *Nematologica* 28:210-218.
14. Trudgill, D. L., and D. M. Parrott. 1973. Effects of growing resistant potatoes with gene H₁ from *Solanum tuberosum* ssp. *andigena* on populations of *Heterodera rostochiensis* British pathotype A. *Annals of Applied Biology* 73:67-75.
15. Weaver, J. E. 1926. Root development of field crops. New York: McGraw-Hill.