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Reproductive and Damage Potentials of Two Populations of *Rotylenchulus reniformis* on Sweetpotato and Related Comparisons with *Meloidogyne javanica* on Tomato[1]

S. A. Walters and K. R. Barker[2]

Abstract: Two *Rotylenchulus reniformis* populations (North Carolina and Georgia) were compared on sweetpotato and tomato. 'Beauregard' sweetpotato and 'Better Boy' and 'Marion' tomato were excellent hosts for both *R. reniformis* populations. On Beauregard sweetpotato, the two populations did not differ in fecundity; however, on both tomato cultivars, the Georgia population reproduced at a higher rate than the North Carolina population ($P \leq 0.05$). *Meloidogyne javanica* reproduction was higher ($P \leq 0.05$) on Marion than on Better Boy. Neither population of reniform nematodes suppressed shoot growth of tomato or sweetpotato at any Pi (initial population density). Both populations of *R. reniformis,* however, restricted storage-root growth of Beauregard sweetpotato but enhanced shoot growth. When the Georgia population was evaluated in microplots with Pi levels of 0, 20,000, or 40,000 *R. reniformis*/500 cm^3 soil, total fruit weights of Better Boy tomato were not affected. In the greenhouse, Marion tomato fresh shoot and fruit growth (weights) was suppressed by *M. javanica,* but Better Boy was not affected. Root necrosis increased linearly with Pi on Beauregard sweetpotato grown in the greenhouse and became more pronounced as numbers of *R. reniformis* increased, regardless of the population. The cultivars of tomatoes evaluated were tolerant to the two populations of *R. reniformis* in a sandy soil and exhibited no root necrosis. Marion tomato was highly susceptible to *M. javanica,* while Better Boy was tolerant.

Key words: Ipomoea batatas, Lycopersicon esculentum, Meloidogyne javanica, nematode, reniform nematode, root-knot nematode, *Rotylenchulus reniformis,* sweetpotato, tomato, yield.

The susceptibility of tomato (*Lycopersicon esculentum*) (1,8,10–13) and sweetpotato (*Ipomoea batatas*) (3,6–8) to the reniform nematode (*Rotylenchulus reniformis*) has been reported. Verma and Prasad (16) found that initial inoculum levels as low as 100 *R. reniformis* per pot significantly limit tomato yield. *Rotylenchulus reniformis* was found to be more damaging to tomato than *Meloidogyne javanica* alone or combined with *R. reniformis* (12). These studies depicted *R. reniformis* as an important pathogen of tomato.

Rotylenchulus reniformis damages sweetpotato in the southeastern United States and throughout much of the tropical and subtropical areas of the world (3,6,8). The severity of this damage depends on initial nematode density and rate of increase (3). In addition to restricting sweetpotato yields, *R. reniformis* may impair storage-root quality by inducing roots to crack (7).

The first objective of this research was to determine the reproduction and yield responses of two *R. reniformis* populations, one from Georgia and one from North Carolina, on 'Beauregard' sweetpotato in a greenhouse test. The second objective was to determine whether two populations of *R. reniformis* differed in their effects on root-knot susceptible and resistant tomato cultivars and to compare these responses with those of *M. javanica.* A third objective focused on yield responses of 'Better Boy' tomato to high Pi levels (initial population densities) of the Georgia population of *R. reniformis* in microplots.

Materials and Methods

Greenhouse sweetpotato test: Beauregard sweetpotato was evaluated as a host for two *R. reniformis* populations (one from a North Carolina population on cotton in Scotland County and one from a Georgia population on cotton in Oconee County) at four Pi (0, 10,000, 20,000, and 40,000 eggs/pot). The experiment was a 2 × 4 fac-

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[2] Research Technician and Professor, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

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torial arranged in five randomized complete blocks. A 10-cm long Beauregard sweetpotato stem cutting was planted directly into each 15-cm-d (1,750 cm^3 volume) clay pot containing a moist, sterilized sand and soil moisture (85% sand, 10% silt, 5% clay). The soil was infested 1 week after planting with eggs extracted from sweetpotato roots for 4 minutes with a 1% NaOCl solution (5). Plants were watered twice daily and fertilized weekly with Peter's 20-20-20 (N-P-K) (W. R. Grace & Co., Fogelsville, PA).

Plants were harvested 15 weeks after soil infestation. Numbers of *R. reniformis* vermiform nematodes and eggs in soil (4,9) and numbers of eggs in roots (5) were determined. Fresh weights of shoots, fibrous roots, and storage roots were also determined. Data were analyzed utilizing the GLM, REG, and CORR procedures of SAS (14).

Greenhouse tomato test: The two populations of *R. reniformis* were compared with each other and with *M. javanica* on two tomato cultivars for nematode reproduction and effects on tomato plant growth. The experiment was established as a 2 × 3 × 6 factorial treatment arrangement with two cultivars, 'Marion' (susceptible to all four major *Meloidogyne* species) and Better Boy [VFN hybrid, probable *M. incognita* resistance (15)], three nematode populations (the North Carolina and Georgia populations of *R. reniformis* described above and a North Carolina population of *M. javanica*), and six Pi (0, 2,500, 5,000, 10,000, 20,000, and 40,000 eggs/plant) in four randomized complete blocks. Two seeds were directly sown into each 15-cm-d (1,750 cm^3) clay pot containing moist, sterilized loamy sand soil (85% sand, 10% silt, 5% clay). Plants were thinned at the cotyledon stage to one per pot. Soil in each pot was infested at the two-leaf stage (14 days after planting) with one treatment combination of Pi and nematode population. Eggs were extracted from sweetpotato roots with 1% NaOCl for 4 minutes (5). Plants were watered twice daily and fertilized twice weekly as in the previous experiment.

Plants were harvested 14 weeks after soil infestation and rated for percentage of roots galled and percentage necrosis of each root system (2). Numbers of juveniles (*M. javanica*), vermiform nematodes (*R. reniformis*), and eggs in soil (4,9) were determined as well as the numbers of eggs in a 5-gram subsample of roots (5). Fresh shoot, fruit, and root weights also were measured. Data were analyzed with the GLM and CORR procedure of SAS (14).

Microplot tomato test: A microplot experiment was conducted at the Central Crops Research Station, Clayton, North Carolina, in 1992 to evaluate the effects of the Georgia population of *R. reniformis* described previously on Better Boy tomato. The soil in the microplots was a Fuquay sand (92% sand, 7% silt, 1% clay; pH 5.9; <0.5% organic matter). Fiberglass microplots were fumigated with ca. 98 g a.i. methyl bromide + 2 g a.i. chloropicrin/m^2 in November, prior to spring planting. Microplots were 76-cm-d and 50–55 cm deep. Three Pi (0, 20,000, and 40,000 nematodes/500 cm^3 soil) were established to a depth of 20 cm, and treatments were placed in three randomized complete blocks. Infested soil and infected roots were used as inoculum. Roots were cut into 3-cm pieces and mixed with soil. Total numbers of nematodes, vermiform nematodes (4,9), and eggs (5) were determined per cm^3 soil. The amount of infested soil and infected roots needed to obtain the correct inoculum level was mixed with approximately 1,000 chlamydospores of the mycorrhizal fungus *Glomus macrocarpus*. The soil and root mixture was incorporated into the soil of each microplot, respective of the treatment, to a depth of 20 cm. The control treatment received a moist, sterile sand soil mixture (85% sand, 10% silt, 5% clay). Two Better Boy tomato plants (3–4 leaf stage) were transplanted into each microplot after inoculum incorporation. Two months before planting, 2,240 kg/ha dolomitic limestone was added to microplots to minimize blossom-end rot. During the growing season, plants were fertilized twice with 12-6-24 (750 kg/ha) and $NaNO_3$ (1,000 kg/ha).

Fruits were harvested weekly starting 70 days after transplanting. Fifteen soil cores (2.5-cm-d × 20 cm deep) were collected from each microplot at midseason (70 days after transplanting) and harvest (120 days after transplanting). Numbers of nematodes were determined from 500-cm^3 subsamples. Soil samples were processed by elutriation (4) and centrifugation (9). Roots were collected during elutriation, and numbers of eggs on roots were determined (5). Data were subjected to the GLM and REG procedures of SAS (14).

Results

Greenhouse sweetpotato test: Beauregard sweetpotato was an excellent host for both *R. reniformis* populations, which did not differ in fecundity ($P \leq 0.05$) on this plant (Table 1). Both populations of *R. reniformis* stimulated shoot growth ($P \leq 0.05$). Fresh shoot growth was positively correlated with total numbers of *R. reniformis* per pot for Georgia ($r = 0.66$, $P = 0.002$) and North Carolina ($r = 0.57$, $P = 0.0086$) populations of *R. reniformis*.

Rotylenchulus reniformis suppressed ($P \leq 0.05$) storage-root growth of Beauregard sweetpotato, regardless of the population. Storage-root growth was suppressed linearly with increasing Pi for the Georgia population ($R^2 = 0.34$, $P = 0.007$) (Fig. 1A). No significant relationship was detected between storage-root growth and Pi for the North Carolina population.

Root necrosis was positively correlated with transformed numbers of *R. reniformis* for both the North Carolina ($r = 0.81$, $P = 0.0001$) and the Georgia ($r = 0.70$, $P = 0.0007$) populations. Root necrosis was dependent on Pi for the North Carolina ($P = 0.0019$) and Georgia ($P = 0.0144$) populations. Root necrosis increased linearly with Pi ($R^2 = 0.64$, $P = 0.0001$) for both populations (Fig. 1B).

Greenhouse tomato test: The Georgia population of *R. reniformis* reproduced more readily ($P = 0.0003$) on both tomato cultivars than did the North Carolina population (Table 2); however, fresh shoot and fruit growth was not suppressed by either population.

Meloidogyne javanica reproduced more on Marion than on Better Boy. Numbers of *M. javanica* eggs in roots ($P = 0.0333$), eggs in soil ($P = 0.0301$), numbers of juveniles ($P = 0.0133$), and nematode totals ($P = 0.0069$) differed between cultivars. In contrast, nematode reproduction did not differ ($P \leq 0.05$) on the two cultivars inoculated with the two population of *R. reniformis*. Reniform nematodes reproduced similarly on the root-knot-resistant tomato cultivar compared with the susceptible cultivar (Table 2).

Necrosis was not observed on tomato roots infected with either population of *R. reniformis*. In contrast, on tomato inoculated with *M. javanica*, root necrosis was significant for cultivar ($P = 0.0001$), Pi ($P = 0.0037$), and cultivar × Pi ($P = 0.0069$). Growth of both shoot (weight) ($P = 0.0004$) and fruit (weight) ($P = 0.0438$)

Table 1. Development of two populations of *Rotylenchulus reniformis* on 'Beauregard' sweetpotato in a greenhouse test.

	North Carolina population (×1,000)				Georgia population (×1,000)			
Pi†	Eggs in roots	Eggs in soil	Vermiforms in soil	Total	Eggs in roots	Eggs in soil	Vermiforms in soil	Total
0	0	0	0	0	0	0	0	0
10,000	113	455	1,192	1,761	86	584	1,629	2,299
20,000	196	307	904	1,407	152	373	541	1,066
40,000	92	438	992	1,522	139	474	1,095	1,708

Data are means of five replications of one plant/15-cm-d clay pot. Plants were harvested approximately 105 days after incoculation. Populations did not differ ($P \leq 0.05$) for total number of nematodes, eggs in roots, eggs in soil, and vermiforms in soil. "Total" is the mean of the sum of vermiforms and eggs in soil and eggs in roots.

† Pi = initial population density per pot of *R. reniformis* eggs extracted from sweetpotato roots.

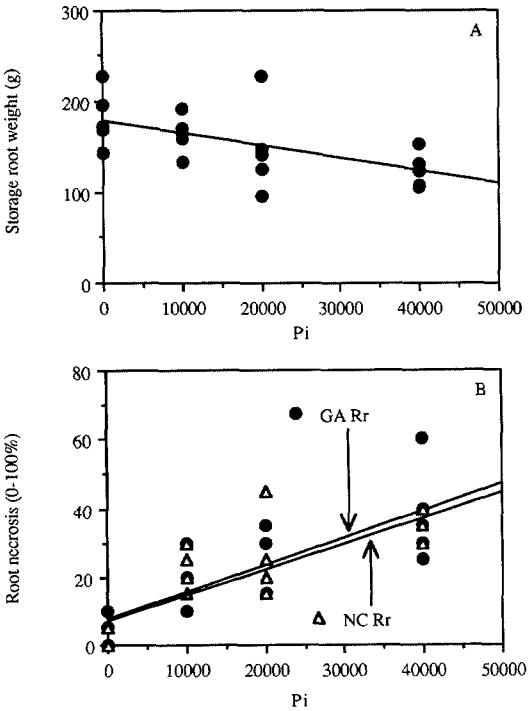

FIG. 1. Responses of Beauregard sweetpotato to selected initial populations (Pi) of *Rotylenchulus reniformis* in a greenhouse test. A) Effects of the Georgia population of *R. reniformis* on storage-root weight ($y = 179.4 - 1.4^{-3}$ (Pi), $R^2 = 0.34$, $P = 0.007$, n = 20). B) Relationship between two *R. reniformis* populations and root necrosis. For the Georgia population (GA Rr), ($y = 7.2 + 7.9^{-4}$ (Pi), $R^2 = 0.64$, $P = 0.0001$, n = 20), and the North Carolina population (NC Rr), ($y = 7.0 + 7.4^{-4}$ (Pi), $R^2 = 0.64$, $P = 0.0001$, n = 20).

was suppressed by *M. javanica*. Fresh shoot and fruit weights were negatively correlated with gall indices and necrosis ratings: $r = -0.76$ with $P = 0.0001$ with gall indices with either fresh shoot or fruit weights; and fresh shoot ($r = -0.84$, $P = 0.0001$) and fruit weights ($r = -0.74$, $P = 0.0001$) correlated with necrosis ratings.

Microplot tomato test: Better Boy tomato was an excellent host for the Georgia population of *R. reniformis* in microplots (Fig. 2). Quadratic models adequately described the relationship between Pi and numbers of nematodes for midseason ($R^2 = 0.88$, $P = 0.002$) and final population densities ($R^2 = 0.91$, $P = 0.0007$) (Fig. 2). *Rotylenchulus reniformis* did not suppress fruit growth of Better Boy tomato in microplots. No damage was seen on Better

TABLE 2. Reproduction of *Meloidogyne javanica* and two populations of *Rotylenchulus reniformis* on tomato in clay pots infested at six initial population (Pi) densities.

Pi (eggs/pot)	Total nematodes (×1000)†		
	GA Rr	NC Rr	Mj
	Marion		
0	0	0	0
2,500	508	98	808
5,000	822	281	184
10,000	217	265	412
20,000	614	360	49
40,000	313	397	162
	Better Boy		
0	0	0	0
2,500	329	183	31
5,000	552	138	11
10,000	552	231	18
20,000	643	387	13
40,000	212	100	11

Data are means of four replications of one plant each per 15-cm-d clay pot. Plants were harvested approximately 98 days after inoculation.

† Sum of eggs from soil, eggs from roots, and vermiform nematodes from soil per 15-cm-d (1,750 cm^3) clay pot. GA Rr = Georgia population of *Rotylenchulus reniformis*, NC Rr = North Carolina population of *R. reniformis*, and Mj = *Meloidogyne javanica*. Significant effects from ANOVA were as follows: cultivar ($P = 0.0105$), nematode population ($P = 0.0001$), Pi ($P = 0.0001$), and nematode population × Pi ($P = 0.0071$); other interaction effects were not significant.

Boy tomato, even though at harvest (mid-September), the microplots infested with 40,000 *R. reniformis*/500-cm^3 soil had an average of 116,000 nematodes/500-cm^3 soil.

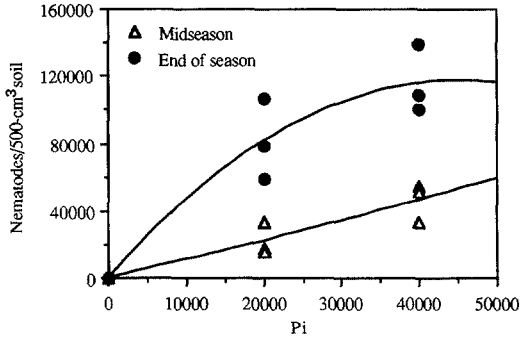

FIG. 2. Relationship between initial inoculum density (Pi) and midseason (70 days after transplanting) and final (120 days after transplanting) population densities of a Georgia population of *Rotylenchulus reniformis* on Better Boy tomato [$y = -3.58 + 1.08$ (Pi) $+ 2.06^{-6}$ $(Pi)^2$, $R^2 = 0.88$, $P = 0.002$, n = 9 and $y = -1.18 + 5.2$ (Pi) $- 5.77^{-5}$ $(Pi)^2$, $R^2 = 0.91$, $P = 0.0007$, n = 9, for midseason and final population densities, respectively].

Discussion

Neither population of *R. reniformis* suppressed shoot growth of the cultivars of tomato or sweetpotato; however, both populations of *R. reniformis* restricted storage-root growth and increased the incidence of root necrosis on Beauregard sweetpotato. Storage-root restriction was dependent on Pi for the Georgia population, which agrees with findings that damage to sweetpotato depends on the initial inoculum level (3). Neither *R. reniformis* population differed in reproduction on Beauregard sweetpotato. *Rotylenchulus reniformis* stimulated shoot growth of Beauregard sweetpotato, regardless of the population. The Georgia population reproduced more on tomatoes than did the North Carolina population; however, tomato was not more susceptible to the Georgia population even though it reproduced to a higher final population density than did the North Carolina population because fresh shoot and fruit growth of tomato was not suppressed by either population. In microplots, numbers of nematodes almost tripled from the initial inoculum density, and still no damage was seen. Better Boy supported high numbers of *R. reniformis* without incurring significant suppression of shoot growth or fruit development. An earlier study (16) indicated that tomato yield was significantly restricted with inoculum levels as low as 100 *R. reniformis* per pot, but our study indicates that tomato can withstand large numbers of this parasite without incurring any observable yield loss in a sandy soil under North Carolina conditions.

Although both tomato cultivars (Marion and Better Boy) were excellent hosts of *R. reniformis,* in greenhouse and microplot tests, they suffered no yield loss. In contrast, our *M. javanica* population severely damaged Marion tomato; thus, *M. javanica* was a more severe pathogen of tomato than *R. reniformis*. However, an earlier report (12) indicated that *R. reniformis* was a more severe pathogen of tomato than *M. javanica*. This discrepancy may result from differences in soil types, cultivars, nematode populations or species (with higher levels of virulence), or environmental influence. *Rotylenchulus reniformis* reproduced so well on tomato that we are currently using this host for increasing inoculum for other experiments.

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