Effect of Nonhost Cultivars on *Heterodera schachtii* Population Dynamics[1]

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Abstract: Broadcast plantings of nonhost cultivars (alfalfa, barley, bean, onion, potato, and wheat) in soil in redwood boxes (4.2 × 30 × 14 cm) infested with *Heterodera schachtii* reduced the initial nematode populations ($P = 0.05$). The reduction was greater with sugarbeets, a host, than with all other cropping treatments except onion, bean, and fallow ($P = 0.05$). After 80 days, when the root growth of all treatments had completely penetrated the soil, the nematode population was lower under onion than under wheat and barley ($P = 0.05$). The terminal nematode population (160 days) was lowest under onion, followed by bean, potato, fallow, and alfalfa. The nematode population was less under onion than under fallow, alfalfa, barley, and wheat ($P = 0.05$). Bean, potato, and fallow nematode populations were less than barley populations ($P = 0.05$). When broadcast plantings of these cultivars were simulated in microplots, the terminal population (100 days) was significantly lower under onion and bean than fallow ($P = 0.05$). However, no significant differences in reduction of *H. schachtii* population density were obtained when commercial row plantings of these crops were simulated in microplots. *H. schachtii* suppressed growth of barley, tomato, and sugarbeet, but not of bean, onion, alfalfa, or wheat in the greenhouse. Only the growth of sugarbeet was suppressed significantly in the field ($P = 0.05$).

Chemicals and crop rotation are the two major methods of controlling the sugarbeet cyst nematode (*Heterodera schachtii* Schm.). For over 30 years 1,3-dichloropropene has been used to control *H. schachtii* (10); more recently, a systemic nematicide, aldicarb (2 methyl-2-[methylthio]propionaldehyde *O*-[methylcarbamoyl]oxime), has provided excellent control (1). When chemicals are not used, a crop rotation with a nonhost cultivar for as long as 5 years will reduce the nematode population sufficiently to allow profitable sugarbeet yields. However, because cultivated land is becoming scarce, a lengthy rotation is often impractical, and the cost of chemical control may soon become prohibitive.

One manageable crop-rotation practice that has received minimal attention is the effect(s) of nonhost crops on sugarbeet nematode population dynamics (3, 4). We have long known that root diffusates of certain plants stimulate hatching of nematodes and that nematodes are attracted to these diffusates (4, 8). Since host plants (beets, broccoli, cauliflower, etc.) have a positive effect on the hatching of sugarbeet nematode larvae (12), one might suppose that some plants might have a neutral or even a negative effect on the hatching of larvae. There are many nonhost crops that may be used for rotational control of the sugarbeet nematode (7), but little is known about the effect of economically important nonhost crops on the population dynamics of *H. schachtii*. This study was initiated to compare the ability of selected nonhost crops to reduce populations of *H. schachtii*.

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MATERIALS AND METHODS

Effects of crop rotation on H. schachtii populations: Sandy loam dump dirt soil (moisture-holding capacity = 22%) infested with *H. schachtii* was collected from

a field that had previously been planted to sugarbeet. The soil was screened, thoroughly mixed and the nematode population (20.7 ± 1.3 encysted larvae/g soil) was determined by washing 250 ml of soil through a modified elutriator and collecting the cysts on a 45-mesh/in. screen (353-μm openings). Cysts were transferred to a 5-ml mortar tube and macerated to release the larvae from cysts and eggs, and the larvae were counted under a stereomicroscope.

Since the study was concerned primarily with reduction in the initial encysted *H. schachtii* population, it was important that only encysted larvae of the initial population be considered. Therefore any subsequent increase in *H. schachtii* on sugarbeet was included only in the terminal population.

The soil was placed in redwood containers (4.2 × 30 × 14 cm, inside measurement) and each planted with one of several nonhost crops (Sweet spanish onion, *Allium cepa* L.; Tender crop bean, *Phaseolus vulgaris* L.; Russet potato, *Solanum tuberosum* L.; Lahontan alfalfa, *Medicago sativa* L.; Springfield wheat *Triticum durum* Desf.; and Steveland barley, *Hordeum vulgare* L.). Controls were Tasco AH3 sugarbeet, *Beta vulgaris* L., and fallow. There were six replicates of each crop and the fallow. The experiment was conducted in a greenhouse at 22 ± 4 C with supplemental light to achieve a 19-hour day. Seeds were broadcast to ensure complete distribution of the roots throughout the soil. Twelve soil samples were collected with an auger from each container at 8-cm intervals to the bottom of the container after 40, 80, and 120 days. Each sample was thoroughly mixed, and the *H. schachtii* larval population was determined in the manner described. Larvae, free in the soil or infecting cultivars, were never considered since, as previously stated, this study was primarily concerned with the effect of nonhost cultivars on reduction of the potential infective population.

After 160 days, all sugarbeet plants were harvested and air-dried for 2 days, and the soil was removed from the roots and retained in the containers. Ten days after the plants were harvested, the soil was again thoroughly mixed and the nematode populations were determined as before. Then each container was replanted with twenty 14-day-old sugarbeet seedlings. Ten of these seedlings were harvested 14 days after planting and stained with an acid fuchsin–lactophenol solution to determine the degree of nematode infection. The remaining plants were grown in the containers for 70 days, harvested, and plant weights and number of nematode females per plant were determined.

A similar study was made in microplots under simulated field conditions. Each of 12 field plots (3.04 × 4.27 m) was divided into six microplots (1.2 × 1.4 m) and planted to Lahontan alfalfa, Steveland barley, Sweet spanish onion, or Tender crop bean. Controls were Tasco AH3 sugarbeet plantings and fallow. Each cultivar was planted in two ways, row and broadcast croppings, and each treatment was replicated six times. After emergence, enough plants were removed to provide a 30-cm fallow border around each microplot. All plantings received standard fertilization and irrigation, and row-planted sugarbeets were thinned at 42 days. Soil samples were collected on 30-cm centers to a depth of 20 cm with a soil auger from each microplot, 0, 50, and 100 days after planting, and the nematodes were extracted and counted.

Pathogenicity of H. schachtii on nonhost cultivars: A final study was made to determine whether *H. schachtii* is pathogenic to any of the nonhost crops used in the other studies under greenhouse and field conditions. Germinated seeds of Lahontan alfalfa, Springfield wheat, Steveland barley, Sweet spanish onion, Tender crop bean, and Moscow tomato (*Lycopersicon esculentum* Mill., a reported host of *H. schachtii*) (12), and Tasco AH3 sugarbeet were planted into plastic containers (two per container) and inoculated with 50 *H. schachtii* larvae per seed. There were eight replicates of each inoculated and uninoculated cultivar. After 12 weeks growth at 22 ± 4 C, under greenhouse conditions similar to those previously described, top and root weights were determined.

In the field, seeds of Lahontan alfalfa, Steveland barley, Moscow tomato, Tender crop bean, and Tasco AH3 sugarbeet were row-planted in soil infested with *H. schachtii* (3.9 ± 0.32 larvae/g soil) and in uninfested soil in plots similar to those

TABLE 1. Effect of host and nonhost cultivars on population dynamics of *Heterodera schachtii* under greenhouse conditions.

Cultivar	Encysted larvae/g soil[a]				LSD ($P = 0.05$)
	40 days	80 days	120 days	160 days	
Sugarbeet	11.4	3.9	1.8	24.7	4.7
Barley	16.6	12.2	11.2	10.9	3.2
Wheat	16.5	12.9	9.7	10.2	3.9
Alfalfa	15.7	10.0	9.3	8.2	3.1
Fallow	14.9	9.0	8.3	7.9	2.7
Potato	15.3	9.6	7.6	6.8	2.6
Bean	14.0	9.4	6.8	5.8	2.8
Onion	14.2	8.2	6.5	4.2	2.4
LSD ($P = 0.05$)	3.7	2.9	2.6	2.8	

[a]Initial encysted larva population = 20.7 ± 1.3.
[b]Terminal population includes reproductive increase on sugarbeet.

described in the population study. The plantings were maintained by standard farming practices. After 84 days, the plants were harvested, and total plant weights were determined.

RESULTS AND DISCUSSION

Effects of nonhost plantings on H. schachtii population dynamics (greenhouse experiment): There was a reduction ($P = 0.05$) of the encysted *H. schachtii* population after 40 days' growth of all crops or fallow in redwood containers in the greenhouse (Table 1). The reduction in nematode population in soil occurring with sugarbeet was arithmetically greatest, and was significantly greater ($P = 0.05$) than that in all other plantings except onion, bean, and fallow. Roots of all plantings had completely penetrated the soil at 80 days, and the lowest number of the initial nematode population was again observed in sugarbeet plantings, which was significantly lower ($P = 0.05$) than in all other plantings and fallow. Sugarbeet was followed by onion, bean, fallow, alfalfa, potato, barley, and wheat in relation to soil nematode population reduction. The nematode population was less ($P = 0.05$) in onion plantings than in barley, wheat, and bean, and was less ($P = 0.05$) in fallow than in wheat. After 120 days in sugarbeet planting, the *H. schachtii* population had declined from the initial 20.7 to 1.8 larvae/g soil, while the greatest decline in nonhost cultivars was in onion plantings, which declined from 20.7 to 6.5 larvae/g soil. Decline in the nematode population density between 80 and 120 days was significant ($P = 0.05$) only in the sugarbeet planting, indicating the importance of root diffusates on hatching, attraction, and movement of *H. schachtii* larvae out of the egg, into the soil, and into the sugarbeet. However, some unhatched eggs persisted 120 days with sugarbeet, indicating that root diffusates are not entirely effective and that other factors may be involved in this complex relationship. After 120 days, when the reproductive index was first considered, the downward population trend under sugarbeet had reversed, but soil population levels with nonhost plants remained low. Final soil populations were higher ($P = 0.05$) in wheat and barley plantings than in fallow soil, which indicates the possibility of the existence of a

TABLE 2. Effect of nonhost cultivars on population dynamics of *Heterodera schachtii* under microplot conditions.

Cultivar	Encysted larvae/g soil[a]			
	Broadcast planting		Row planting	
	50 days	100 days[b]	50 days	100 days[b]
Sugarbeet	1.7	4.2	1.5	3.8
Barley	3.1	2.3	2.9	2.0
Alfalfa	2.8	2.0	2.6	1.7
Fallow	2.3	1.9	2.7	1.7
Bean	1.8	1.1	2.6	1.6
Onion	1.5	1.0	2.8	1.8
LSD 0.05	0.6	0.7	1.2	0.7

[a]Initial encysted larval population = 3.7 ± 0.32.
[b]Terminal population includes reproductive population on sugarbeet.

negative hatching factor. The final soil population levels of *H. schachtii* were less ($P = 0.05$) with onion than in fallow soil, which suggests that onion root diffusate possibly stimulates hatching.

The density of infection of sugarbeet by *H. schachtii* paralleled the final nematode population density in the host and nonhost plantings (Table 3), when 14-day-old sugarbeet seedlings were transplanted into the soils from this experiment. The infection rate was significantly less with soil which had grown onion than with soil from all other cultivars except bean, potato, and wheat ($P = 0.05$). Larval infections in sugarbeet seedling were significantly less from both onion and bean soil than from fallow soil. In most instances, the size of final populations and level of subsequent larva infections closely paralleled subsequent sugarbeet growth and the ultimate number of females/g root; sugarbeet growth was poorest in soil previously planted to sugarbeet and best in soil in which onions had been grown.

Effects of nonhost plantings on H. schachtii population dynamics (field experiment): Population changes in microplot broadcast plantings were similar to those in greenhouse broadcast plantings, though smaller (Table 2). The nematode population decrease was greater ($P = 0.05$) with onion and bean than with any of the other cropping including fallow. In the commercial row plantings, however, there were no significant differences in nematode populations after 50 or 100 days between any of the cultivars and fallow soil. Lower root density with the row plantings than with broadcast plantings possibly accounted for this difference.

Pathogenicity of H. schachtii on nonhost cultivars: Under greenhouse conditions *H. schachtii* suppressed ($P = 0.05$) the growth of barley, tomato, and sugarbeet (6, 9, 12), but under field conditions plant growth was reduced only in sugarbeet ($P = 0.05$). In the greenhouse, weights of sugarbeet, tomato, barley, bean, alfalfa, onion, and wheat plants inoculated with *H. schachtii* were respectively, 76, 79, 83, 90, 98, 99, and 105% of the weights of uninoculated control plants. This compared with plant weights of 68, 89, 93, 97, and 101% of uninoculated control plants for sugarbeet, tomato, barley, bean, and alfalfa under field conditions.

These results indicate that nematode population dynamics are affected differently by different nonhost cultivars and suggest that yield losses can be reduced by improved crop rotations. The reduction in the population level of *H. schachtii* was greatest under broadcast plantings of onions and beans, but the microplot studies suggest that this reduction may be less with the customary commercial row plantings. Soil disturbances (plowing, discing, etc.) involved in annual cropping affect nematode populations, and reductions in nematode populations may be greater following annual crops than following perennial crops, because of the more frequent soil disturbance. The experiments described here showed that barley maintained a higher nematode population than did alfalfa. However, I have observed higher populations in alfalfa than in barley plantings under field conditions. This may be a result of the more frequent disturbance of barley soil than of alfalfa soil. In addition, the decomposition and putrefaction of barley residue may be detrimental to *H. schachtii*. Other factors, such as aeration, soil type,

TABLE 3. Effects of host and nonhost cultivars on infection and parasitism by *Heterodera schachtii* in subequent plantings of sugarbeet under greenhouse conditions.[a]

Cultivars	Larvae/ sugarbeet seedling[b]	Females/g root[c]	Sugarbeet weights (g)[c]	
			Roots	Tops
Sugarbeet	26.7	10.0	4.4	28.8
Barley	18.7	8.8	4.9	43.8
Fallow	13.9	5.0	6.8	48.9
Alfalfa	13.7	7.7	6.2	49.7
Wheat	12.8	6.8	6.3	54.8
Potato	12.0	5.0	8.1	55.6
Bean	9.4	3.0	10.2	65.6
Onion	8.7	3.3	8.8	66.9
LSD 0.05	4.2	2.4	2.8	19.2

[a]Sugarbeet seedlings were planted in soil 10 days after harvest of host and nonhost crops grown for 160 days.

[b]Fourteen-day-old seedlings were transplanted into soil in which host and nonhost cultivars had been grown previously. Infection levels were determined at 14 days.

[c]Fourteen-day-old sugarbeet seedlings were planted in *Heterodera schachtii*-infested soil and grown for 70 days.

and pH, are also known to affect nematode hatching, and should be given close consideration (4, 5, 11). Differences in geographic and environmental conditions, length of growing season, and differences in nematode populations in relation to virulence (2), reproduction, maturation, and hatching may also be influential.

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