Nonvolatile Nematicide Control of *Heterodera schachtii* on Sugarbeet

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ABSTRACT

Aldicarb at 4.5 kg a.i./ha and terbufos at 9.0 kg a.i./ha were effective in controlling *Heterodera schachtii* initial soil population densities (Pi) of 2.8 and 4.9 eggs/cm³ soil. They became less effective at population densities of 7.2 and 12.9 eggs/cm³ soil. Placement of aldicarb (4.5 kg a.i./ha) 7.6-cm or 15.2-cm from the seed at time of planting did not significantly ($P < 0.05$) effect control of *H. schachtii*. A dosage rate of aldicarb at 9.0 kg a.i./ha was effective at 15.2-cm, but was phytotoxic when applied 7.6-cm from the seed. Because of its low solubility, terbufos gave effective nematode control only when applied 7.6-cm from the seed. Oxamyl control of *H. schachtii* was comparable to aldicarb only at the low population density (2.8 eggs/cm³ soil) at a rate of 9.0 kg a.i./ha. The distance of oxamyl from the seed did not affect the degree of control. Aldicarb applied in a 13-cm row band treatment was most effective at a rate of 4.5 kg a.i./ha. Because of its phytotoxicity at 9.0 kg a.i./ha in a 13-cm band, aldicarb was comparable (root yields) to a 9.0 kg a.i/ha rate of terbufos applied in a 25-cm band. Oxamyl gave moderate to poor control at both 4.5 and 9.0 kg a.i./ha.

Additional Key Words: aldicarb, terbufos, nematode population density, oxamyl, root yields, soil temperature, sugarbeet cyst nematode.

The sugarbeet cyst nematode, *Heterodera schachtii* Schmidt, is one of the most important plant pathogens affecting sugarbeet growth in the western United States. The use of the nonvolatle nematicide aldicarb has greatly aided growers in controlling *H. schachtii* on sugarbeet (5, 7-11). Scientists and growers are, however, continually seeking new and better control strategies, including the use of chemicals to control this nematode. As part of a continuing effort to determine the most efficacious method of controlling the sugarbeet cyst nematode, microplot studies were made to determine the effect of nematode population densities and application methods of nonvolatile nematicides aldicarb (2 methyl-2 {methylthio} propionaldehyde O {methycarbamoyl} oxime), oxamyl (Methyl N′, N′-dimethyl -N- {[methylcarbamoyl]oxy}-1-thiooxamimidate), and terbufos (S-{{[1.1-Dimethylethyl] thio}methyl}0,0-diethyl phiosphodithioate) on control of *Heterodera schachtii* on sugarbeet.

MATERIALS AND METHODS

The study was conducted at Logan, Utah, in 3.0 X 4.3 meter microplots, in a sandy loam soil (73% sand, 17% silt, 10% clay, pH 7.8).

Initial nematode population densities (Pi) were determined by 1) collecting soil samples with a 2.38-cm diameter oakfield probe, to a depth of 30-cm, on 30-cm centers, 2) extracting cysts with an elutriator, 3) separating cysts from soil debris by an alcohol flotation method (12), and 4) crushing cysts in water in a glass mortar tube and counting the eggs.

Microplot fertility was determined by the Utah State Testing Laboratory, Logan, Utah, and fertilizer was added to bring fertility levels to that used in commercial sugarbeet production (110 ppm potash, 60 ppm nitrates, 20 ppm phosphates) immediately before planting. A commercial sugarbeet selection (Tasco HA-14) was used. No herbicides were used and the plots were hand weeded. Plots were irrigated with a sprinkler irrigation system; 2.5-3.0-cm water was applied immediately after planting, and irrigations were made as deemed necessary. The plots were hand thinned to a stand (30-cm spacings) 28 days after planting. A thermograph recorded soil temperatures at a 15-cm depth, and plants in each experiment were grown for approximately 1154 degree-days (1), at a base temperature of 8 C (4). The sugarbeet rows were bedded immediately after thinning, and cultivated as needed until the beet canopy covered the rows.

Aldicarb, terfufos, and oxamyl were evaluated on *H. schachtii* Pi's of 2.8 (2.2-3.3), 4.9 (4.1-5.6), 7.2 (6.4-7.8), and 12.9 (11.4-13.1) eggs/cm^3 soil. Each nematicide was evaluated at rates of 4.5 and 9.0 kg/a.i./ha, and applied at time of planting with a chisel injecter that placed the chemicals 7.6- and 15.2-cm to the side of the seed at a depth of 7.6-cm. Because of differences in chemical solubility, (terbufos, 15 ppm; aldicarb, 6000 ppm; oxamyl, 280,000 ppm) (2), aldicarb and oxamyl were applied to one side of the seed and terbufos was applied in equal rates to both sides of the seed; the seed was planted on 56-cm center. Treatments, including nontreated controls, were replicated 6 times. Soil temperature at time of planting was 13 C. Sugarbeets were harvested the first of October, after 143 days growth, and root yields were determined and converted to metric tons/ha. Data were analyzed by a split plot analysis of variance.

A similar study, on adjacent microplots, studied the effects of row banding of the three nematicides on control of *H. schachtii*. Initial Pi's were 4.9 (4.2-5.8), 8.2 (7.5-9.0), and 13.4 (12.6-14.8) eggs/cm³ soil. Chemical application rates were 4.5 and 9.0 kg/a.i./ha. Aldicarb and oxamyl were applied in a 13-cm band and terbufos in a 25-cm band. All were centered directly over the row, and covered with 3.0-4.0-cm soil. Seeds were planted in the center of the band to a depth of 2.0-cm. (Due to differences in chemical solubility, preliminary studies had shown that maximum nematode control was obtained at these band widths). Soil temperature at time of planting was 15 C. Plots were harvested after 139 days growth, and data analyzed as described above.

RESULTS AND DISCUSSION

Effect of chemical application method on nematode control

Aldicarb and terbufos, at rates of 4.5 and 9.0 kg a.i./ha, respectively, effectively ($P < 0.05$) controlled *H. schachtiii* when Pi was 2.8 eggs/cm³ soil. Application of 9.0 kg a.i./ha of aldicarb was, however, phytotoxic to sugarbeet when placed 7.6-cm from the seed, thus reducing root yields (Tables 1,2); aldicarb was less phytotoxic, and sugarbeet yields increased when placed 15.2-cm from the seeds.

Table 1. Comparative control of *Heterodera schachtii* on sugarbeet with chisel injector applications of nonvolatile nematicides applied 7.6-cm deep and 7.6-cm to side of seed bed.

		Yield (metric tons/ha)				
	Rate	Initial nematode population'				Pop. densities LSD
Treatments*	(kg/a.i./ha)	2.8	4.9	7.2	12.9	($P < 0.05$)
Aldicarb	4.5	56.9	51.7	46.9	42.1	4.1
Aldicarb	9.0	50.6	46.9	41.7	40.6	4.3
Oxamyl	4.5	42.7	36.2	32.4	24.2	6.3
Oxamyl	9.0	49.5	44.6	40.3	32.3	5.8
Terbufos	4.5	53.6	43.2	37.6	25.3	5.9
Terbufos	9.0	55.7	50.7	43.9	37.7	4.6
Untreated Control	—	34.4	30.6	22.6	18.2	6.2
LSD	($P < 0.05$)		5.4	4.9	5.8	4.4

Data analyzed with split plot analysis of variance.
*Aldicarb and oxamyl applied to single side of seed bed. Terbufos applied to both sides of seed bed. Treatments and plantings made at 13 C.
'Pi = eggs/cm³ soil
Plants harvested and yields obtained after 143 days.

There were significant ($P < 0.05$) differences in nematode control and sugarbeet yield as initial Pi increased. Terbufos was effective only when 9.0 kg a.i./ha was placed close to the seed at planting. Aldicarb was effective at the lower rate (4.5 kg a.i./ha) in all instances except when the chemical was placed at a distance of 15.2-cm from the seed and the nematode Pi was high (12.9 eggs/cm³ soil).

Table 2. Comparative control of *Heterodera schachtii* on sugarbeet with chisel injector applications of nonvolatile nematicides applied 7.6-cm deep and 15.2-cm to side of seed bed.

		Yield (metric tons/ha)				Pop. densities
	Rate	Initial nematode population[†]				LSD
Treatments*	(kg/a.i./ha)	2.8	4.9	7.2	12.9	($P < 0.05$)
Aldicarb	4.5	54.7	50.5	41.3	37.7	4.2
Aldicarb	9.0	57.4	54.2	49.3	45.3	3.6
Oxamyl	4.5	38.8	35.5	27.7	21.2	5.4
Oxamyl	9.0	47.4	43.1	39.4	29.9	6.9
Terbufos	4.5	52.2	38.9	27.6	19.6	7.7
Terbufos	9.0	55.9	47.3	33.5	24.7	7.2
Untreated Control	—	32.1	28.9	20.9	17.1	4.5
LSD	($P < 0.05$)		6.7	7.7	7.9	7.1

Data analyzed with split plot analysis of variance.
*Aldicarb and oxamyl applied to single side of seed bed. Terbufos applied to both sides of seed bed. Treatments and plantings made at 13 C.
†Pi = eggs/cm³ soil
Plants harvested and yields obtained after 143 days.

Oxamyl gave poor sugarbeet nematode control at both 4.5 and 9.0 kg a.i./ha chemical rates, and yields were only significantly ($P < 0.05$) better than the untreated control. Oxamyl became significantly less effective ($P < 0.05$) as the initial nematode population density increased, but its effectiveness did not vary with placement at any nematode population density.

Effect of Row Band Application of Nonvolatile Nematicides on Nematode Control

Maximum sugarbeet yields resulted from aldicarb applications of 4.5 kg a.i./ha at a *H. schachtii* Pi of 4.9 and 8.2 eggs/cm³ soil; aldicarb was less effective at a Pi of 12.9 eggs/cm³ soil (Table 3). Sugarbeet yields from terbufos applied at 4.5 kg a.i./ha were significantly less ($P < 0.05$), while the higher rate (9.0 kg a.i/ha) was comparable to the lower rate (4.5 kg a.i./ha) of aldicarb at the three nematode population densities. Oxamyl was less effective than either aldicarb or terbufos at both chemical rates and all nematode population densities.

Results of this study confirm the important relationship between nematode population densities (Pi), nematicide, and method of application. All chemicals showed good nematicidal activity under some conditions. Differences in the effectiveness of aldicarb, terbufos, and oxamyl can be attributed partly to differences in nematicidal activity, but differences in solubility are apparently also important. The low solubility of terbufos may account for the best control occurring when the chemical was placed to both sides of the seed at a distance of 7.6-cm. The opposite is true for oxamyl; control is excellent immediately after application, but the high solubility apparently results in rapid loss of residual and nematicidal activity when chemical activity is critical for root protection (4,8). The solubility of aldicarb undoubtedly contributes to its effectiveness; it is soluble enough to give the necessary control and still maintain its residual activity over a period necessary for nematode control. This agrees with a previous report outlining the behavior of aldicarb and oxamyl in the soil (3).

Table 3. Comparative control of *Heterodera schachtii* on sugarbeet with row band applications of nonvolatile nematicides.

Treatments*	Rate (kg/a.i./ha)	Yields (metric tons/ha) A†	B†	C†	Pop. densities LSD ($P < 0.05$)
Aldicarb	4.5	54.7	52.1	45.2	6.3
Aldicarb	9.0	49.7	47.3	41.5	5.7
Oxamyl	4.5	37.9	31.2	20.5	6.8
Oxamyl	9.0	43.1	37.9	26.2	5.0
Terbufos	4.5	46.2	40.2	31.6	7.1
Terbufos	9.0	53.6	51.3	44.7	7.7
Untreated control	—	28.5	22.1	16.7	4.9
LSD ($P < 0.05$)		7.4	6.2	6.9	

Data analyzed with split plot analysis of variance.
*Aldicarb and oxamyl applied in 13-cm band; terbufos applied in 25-cm band.
Treatments and plantings made at 15 C.
†Initial nematode populations (Pi): A = 4.9 eggs/cm³ soil; B = 8.2 eggs/cm³ soil; C = 13.4 eggs/cm³ soil. Plants harvested and yields obtained after 139 days.

This study confirms findings of other studies (5, 7, 8, 11). Results also explain why a chemical application may be effective under certain field conditions and not under others. These results should lead to improved nematode control through a better understanding of the nematode-nematicide-plant relationship. It is important to have an understanding of the nematode biology (3, 4, 6), and the physical limitations of the control methodology in order to achieve optimum nematode control and maximum crop yields.

LITERATURE CITED

1. Arnold, C. Y. 1960. Maximum-minimum temperatures as a basis for computing heat units. Proceed. Am. Soc. Hort. Sci. 76:682-692.
2. Bromilow, R. H. 1980. Behaviour of nematicides in soils and plants. *in* Nematicides. Pp. 87-116. Factors affecting the application and use of nematicides in W. Europe. Proc. Assoc. Appl. Biologists. Hapenden, Herts, UK.
3. Cooke, D. A., and I. J. Thomason. 1979. The relationship between population density of *Heterodera schachtii*, soil temperature, and sugarbeet yields. J. Nematol. 1:124-128.
4. Griffin, G. D. 1987. Factors affecting the biology and control of *Heterodera schachtii* on sugarbeet. Proc. Amer. Soc. Sugar Beet Technol., Phoenix, Az. pp. 31.
5. Griffin, G. D. 1985. Differential chemical control of *Heterodera schachtii* on sugarbeet. Phytopathology 75: 1304 (abstract).
6. Griffin, G. D. 1981. The relationship of plant age, soil temperature, and population density of *Heterodera schachtii* on the growth of sugarbeet. J. Nematol. 13:184-190.
7. Griffin, G. D., and T. G. Gessel. 1973. Systemic nematicide control of *Heterodera schachtii* on sugarbeet. Plant Dis. Reptr. 57:942-945.
8. Jorgenson, E. C. 1969. Control of the sugar beet nematode, *Heterodera schachtii* with organophosphate and carbamate nematicides. Plant Dis. Reptr. 53:625-628.
9. Jorgenson, E. C., and G. D. Griffin. 1960. Evaluation of telone and D-D in relation to planting time and fallowing for control of sugarbeet nematode, *Heterodera schachtii* Schmidt. J. AM. SOc. Sugar Beet Tech. 9:515-518.
10. Kontaxis, D. G., and I. J. Thomason. 1978. Chemical control of *Heterodera schachtii* and sugar beet production in Imperial Valley, California. Plant Dis. Reptr. 62:79-82.
11. Roberts, P. A., and I. J. Thomason. 1981. Sugarbeet Pest Management: Nematodes. Div. Agric. Sci., Univ. Cal. Special Pub. No. 3372. 30 pp.
12. Seinhorst, J. W. 1974. Separation of *Heterodera* cysts from dry organic debris using ethanol. Nematologica 20:367-369.