Fall Fumigation of Potato with 1,3-Dichloropropene: Efficacy Against *Pratylenchus crenatus*, Yield Response, and Groundwater Contamination Potential

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ABSTRACT

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Plots in two commercial potato fields infested with *Pratylenchus crenatus* were fumigated in September 1984 with 94% 1,3-dichloropropene (1,3-D) at 0, 94, 117, or 140 L of formulated material per hectare. Population densities of *P. crenatus* 2 wk after fumigation were reduced by all rates of 1,3-D at both locations, and up to 96% control was obtained with 140 L/ha. Yields of the potato cultivar Superior during 1985, however, were not related to mean preplant population densities of *P. crenatus*, which ranged from 13 to 310/100 cm^3 of soil. In a separate experiment, plots in fields with shallow water tables (<4 m), were fumigated with 1,3-D (94 or 140 L of formulated material per hectare). Groundwater samples were taken from wells adjacent to fields and analyzed for 1,3-D and related hydrocarbons 1 day before, 1 wk after, and at about 3-wk intervals for 1 yr after fumigation. No detectable levels (>2 ppb) of 1,3-D or related hydrocarbons were found in groundwater samples after fumigation at either 94 or 140 L/ha. About 0.6 cm of rain fell during the first 17 days after fumigation, and a total of 89.7 cm fell during the sampling period. Relatively low levels of precipitation immediately after fumigation may have reduced the potential for groundwater contamination by 1,3-D and related hydrocarbons.

Pratylenchus spp. are parasites of potato in the northeastern United States and in many other potato-producing areas. *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans Stekhoven is acknowledged to be an important pest of potato that can cause substantial yield losses (3,4,12,13), particularly in combination with *Verticillium dahliae* Kleb. (11,15). *P. crenatus* Loof has been reported from commercial potato fields (5,7–9) but is not thought to be responsible for substantial yield losses (15). Little research has been carried out under field conditions documenting yield response of potato to this nematode, however, particularly at preplant populations higher than 100/cm^3 of soil that are commonly found in Suffolk County, New York (R. Loria, *unpublished*).

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The fumigant 1,3-dichloropropene (1,3-D) is registered for control of *P. penetrans* on potato. It is assumed to be similarly effective for control of *P. crenatus*, but research data to support this are not available. This fumigant and 1,2-dichloropropane (1,2-D), a contaminant in the fumigant formulation, have been found in groundwater after soil application (10,14). However, the potential for delivery of 1,3-D or related hydrocarbons to groundwater after a fall application with a shank-injector, the method typically used in commercial potato fields, has not been tested in the Northeast.

The objectives of this research were: 1) to evaluate the efficacy of 1,3-D against *P. crenatus*, 2) to determine the yield response of potato to this nematode under commercial conditions, and 3) to assess the potential for groundwater contamination by 1,3-D and related hydrocarbons when 1,3-D is shank-injected into tilled soil in the fall. A preliminary report of this research has been published (9).

MATERIALS AND METHODS

Efficacy evaluation and yield response. Fumigant efficacy was evaluated in two commercial potato fields in Suffolk County that were naturally infested with *P. crenatus*. Soils at these sites are Haven loam (coarse-silty, entic Haplorthod) or Bridgehampton silt loam (coarse loamy/sandy, typic Dystrochrept), with slopes generally less than 3%, pH 4.2–5.4, and 3–4% organic matter. Both soils are medium-textured and well-drained to moderately well-drained. Subsoils are deep and very well-drained, consisting of sand and gravel.

Small plots (9 × 30 m) were fumigated with 1,3-D (Telone II, 94%) at 0, 94, 117, and 140 L of formulated material per hectare in a randomized complete block design. Each fumigant rate was applied to eight replicate plots in one field (location 1) on 13 September 1984 and to six replicate plots in the other field (location 2) on 20 September 1984. The fumigant was shank-injected to a depth of 20 cm, and the soil was sealed using a drag.

Fifteen soil cores (2.5 × 15 cm) were collected and bulked from each plot for nematode assays. These soil samples were taken immediately before fumigation (P_1) and 2 wk after fumigation (P_2). Nematode population densities were assayed by incubating 100-cm^3 soil samples for 10 days on Baermann pans (2). Twenty to 25 adult female nematodes from each field were identified to species (6). Nematode densities were again determined the following spring, just before planting (P_3). Plots were planted to the potato cultivar Superior on 3 April 1985. Potato plants were maintained according to standard commercial practices, but no nematicidal insecticides were used for insect control. Rainfall was adequate for good plant growth; therefore, plots were not irrigated.

Ten plants from each plot were harvested on 1 August (location 1) and 2 August (location 2) 1985. Tubers were graded into four size classes and weighed. Postseason nematode densities (P_4) were determined from soil samples taken at harvest.

All nematode population data (P) were transformed using $\log_{10}(P + 1)$, and two-way analyses of variance were conducted. Regressions of population data (P_1, P_2, P_3, and P_4) against fumigant rates also were performed. In addition, percent control was calculated from prefumigation and postfumigation population densities in each plot as $100 \times (P_1 - P_2)/P_1$. Tuber yields were evaluated by two-way analysis of variance and regressed against preplant densities of *P. crenatus*.

Groundwater monitoring. Portions of two commercial potato fields in Suffolk County with water table depths <4 m were fumigated with 1,3-D. Four or five wells were installed on the periphery of each field; one was situated upstream and three or four were downstream of the anticipated flow of groundwater from the treated fields. The wells were installed and water samples collected and analyzed for *cis* and *trans* 1,3-D and 1,2-D, a contaminant in the fumigant formulation, using methods described by Loria et al (10). Plots (2.5 ha) were treated with 94 or 140 L of formulated material per hectare that was shank-injected to a depth of 20 cm on 13 September 1984. Water samples were collected on 19 September, then at about 21-day intervals for 1 yr after fumigation. Rainfall data were obtained from a weather station within 8 km of the field sites.

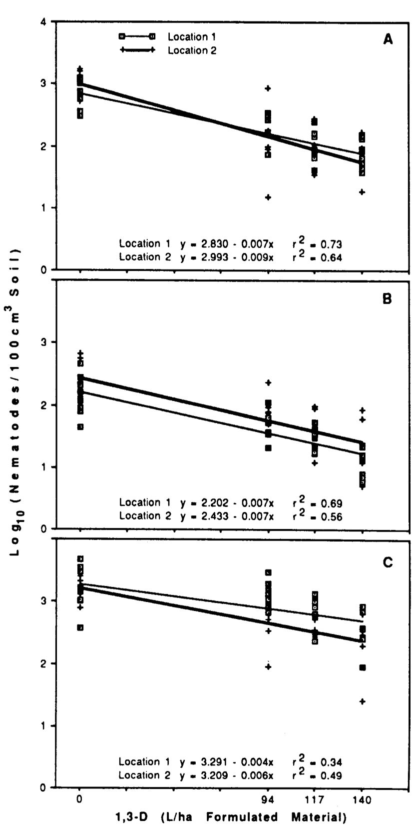

Fig. 1. Population densities of *Pratylenchus crenatus* in plots planted to potato fumigated on 13 September (location 1) or 20 September (location 2) 1984 with four rates of 1,3-dichloropropene **(A)** 2 wk after fumigation (October 1984), **(B)** before planting (April 1985), and **(C)** at harvest (August 1985).

RESULTS

The mean population densities (nematodes per 100 cm^3 of soil) of *P. crenatus* before fumigation were 620 at location 1 and 1,760 at location 2. Initial population densities did not differ ($P \leq 0.05$) among treatments at either location. *P. crenatus* was the only plant-parasitic nematode identified at these two locations with the assay method described. All rates of 1,3-D reduced population densities of *P. crenatus* at both locations (Fig. 1). Mean posttreatment population densities were less than 100 nematodes per 100 cm^3 of soil in plots treated with 140 L/ha at both locations (Fig. 1A). Percent control for 94, 117, and 140 L/ha was 67, 77, and 88 at location 1 and 86, 96, and 96 at location 2. Regression equations of *P. crenatus* population densities 2 wk after fumigation vs. 1,3-D rates were statistically significant ($P \leq 0.01$) at both locations (Fig. 1A).

Mean population densities were reduced substantially because of overwintering mortality and ranged from 10 to 180 nematodes per 100 cm^3 of soil at location 1 and from 30 to 310 nematodes per 100 cm^3 of soil at location 2 (Fig. 1B). Regression equations of preplant population densities against fumigant rates used the previous fall were significant ($P \leq 0.01$) at both locations (Fig. 1B).

Mean total and marketable yields were 496 and 444 q/ha at location 1 and 549 and 489 q/ha at location 2. Neither total nor marketable yields of potato were affected significantly ($P \leq 0.05$) by preplant population densities of *P. crenatus* at either location (Table 1). Regression equations of population densities at harvest against fumigant rate were significant ($P \leq 0.01$) at both locations (Fig. 1C). However, mean population densities increased in all plots and were 400 nematodes per 100 cm^3 of soil in plots treated with 140 L/ha at location 1.

About 0.6 cm of rain fell during the first 17 days after fumigation, and a total of 89.7 cm fell during the sampling period. No detectable (>2 ppb) levels of *cis* 1,3-D, *trans* 1,3-D, or 1,2-D were found in water samples taken from any of the wells before or up to 1 yr after fumigation.

DISCUSSION

These data indicate 1,3-D provides good control of *P. crenatus* at rates of 140 L of formulated material per hectare. This nematode, however, did not cause yield losses in potato at preplant population densities of up to 310/100 cm^3 of soil, five times the suggested

Table 1. Preplant population densities (P_3) of *Pratylenchus crenatus* and potato yields in plots treated with four rates of 1,3-dichloropropene (1,3-D) at two locations

1,3-D (L/ha formulated material)	P_3 (nematodes/ 100 cm^3 soil)	Yield (q/ha)	
		Marketable	Total
Location 1			
0	180	445	502
94	50	430	484
117	30	464	513
140	13	436	483
F value		1.03	1.02
Significance		NS	NS
Location 2			
0	310	490	546
94	90	477	539
117	50	508	564
140	30	480	549
F value		0.41	0.18
Significance		NS	NS

economic damage threshold for control of *P. penetrans* (4). Our results reinforce data from microplot studies conducted in Ohio that indicate that *P. crenatus* is not a serious pest of potato at preplant population densities of up to 65 / 100 cm^3 of soil (15). Additional research is needed to evaluate yield losses attributable to preplant population densities of up to 1,500 *P. crenatus* per 100 cm^3 of soil, which have been found in Suffolk County (D. A. Florini and R. Loria, *unpublished*).

Because damage thresholds developed for *P. penetrans* cannot be applied to *P. crenatus*, nematode control recommendations for potatoes must be based on correct identification of species. Species identification in the genus *Pratylenchus* requires extensive training and is very time consuming. Unfortunately, such identification generally is not available from nematode diagnostic services.

Data presented here also indicate that 1,3-D did not cause groundwater contamination when shank-injected in the fall into tilled soil at rates of up to 140 L/ha of formulated material. Soil temperature and moisture were favorable for dispersal of the fumigant, and little precipitation occurred within 3 wk of fumigation. These conditions contrast with those that occurred after spring applications of 1,3-D, when both 1,3-D and 1,2-D were found to contaminate groundwater (10). In the latter study, cool soil temperatures at the time of fumigation and heavy precipitation immediately after the fumigant was applied provided conditions very favorable for delivery of the fumigant to the groundwater. These data suggest environmental conditions at, and subsequent to, application of 1,3-D may be critical determinants of the potential for groundwater contamination by this fumigant.

The previous study (10) also differed from the work described here in that the fumigant was injected into an established cover crop with an experimental sweep-shank applicator. Tillage before fumigation improves dispersal of soil fumigants and may therefore affect their degradation rates.

Proposed pesticide labeling designed to prevent groundwater contamination uses soil characteristics and depth to the water table as the primary criteria for determining the potential for pesticide delivery to groundwater (1). However, climatic conditions may also play an important role in determining if groundwater contamination will occur. Though accurate long-term forecasting of weather conditions is not now possible, historical records of temperature and precipitation are generally available and may be useful in scheduling applications of 1,3-D or other soil fumigants where the potential for groundwater contamination exists.

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