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# Effects of Fumigant and Nonfumigant Nematicides on *Pratylenchus penetrans* and Yield of Potato

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*Abstract:* In 1984–85 metham-sodium and the combination of 1,3-dichloropropene plus aldicarb decreased ($P = 0.05$) soil population densities of *Pratylenchus penetrans* at planting, midseason, and at harvest relative to the untreated control. These treatments increased ($P = 0.05$) marketable potato tuber yield from 27% to 46% in 1984 and from 23% to 37% in 1985, as compared with the control. In 1984 oxamyl (10% granular and 24% liquid) applied immediately after planting increased ($P = 0.05$) only the total yield; oxamyl applied 2 weeks after planting failed to control *P. penetrans* and to increase total or marketable yields. Oxamyl (10 G) applied 2 weeks after planting decreased ($P = 0.05$) Pf. In 1985 oxamyl (10 G) reduced ($P = 0.05$) *P. penetrans* population densities at midseason and harvest, whereas oxamyl (24 L) reduced only harvest population densities. In 1985 neither formulation of oxamyl increased tuber yield.

*Key words:* aldicarb, fumigation, nematicide, oxamyl, potato, *Pratylenchus penetrans,* root-lesion nematode, *Solanum tuberosum,* 1,3-dichloropropene.

*Pratylenchus penetrans* Cobb infests 64% of potato (*Solanum tuberosum* L.) fields in Ontario's main potato production area near Alliston, at a median density of 1,695/kg soil (11). Forty-seven percent of these fields contain early fall population densities in excess of 2,000/kg soil, with 12% over 10,000/kg soil. Initial densities of 1,850 *P. penetrans*/kg of soil suppress the marketable yield of the Russet Burbank cultivar by 15.7% in microplots (8).

Neither crop rotation nor resistant or tolerant cultivars provide acceptable control (9); however, several nematicides (10,12,18) provide control in Ontario. Elsewhere, increased potato yields result from the use of nematicides to control root-lesion nematodes (2,4,5) or *Meloidogyne chitwoodi* Golden, O'Bannon, Santo & Finley (16). In the Netherlands, incorporation of oxamyl (10 G) at 5.0 kg a.i./ha broadcast shortly before or at planting is recommended for control of *Globodera* spp. in potato (1).

This paper reports on the effect of fumigant and nonfumigant nematicides on soil population densities of *P. penetrans* and potato yield in Ontario.

## Materials and Methods

In 1984 and 1985 plots were established in a grower's field that had been in a potato–rye (*Secale cereale* L.) rotation for many years. The soil was a Tioga fine sandy loam (69% sand, 26% silt, 5% clay; 1.6% organic matter; pH 5.0). The experimental design was a randomized complete block with five replicates. Each plot, 2.7 × 6.0 m, consisted of two rows, 6.0 m long and 0.9 m apart, with Russet Burbank potato plants spaced 0.3 m in the row. The plots were rerandomized in another area of the field in 1985.

On 1 May 1984 metham-sodium at 3.1 and 4.5 g a.i./m row (34.2 and 49.4 kg a.i./ha broadcast) was applied with a hand injector, 15 cm deep at 20-cm intervals, as a single line in the center of the row for a total of 30 injections/6 m row. 1,3-dichloropropene (1,3-D) at 8.2 g a.i./m row (90.8 kg a.i./ha broadcast) was injected on the same day, followed on 24 May by aldicarb (15 G) at 0.21 g a.i./m row (2.2 kg a.i./ha row) as a mixture of 8.4 g of aldicarb (15 G) and 200 g soil (for carrying purposes) applied in furrow (10 cm deep and 5 cm wide) per 6-m row. Immediately after the aldicarb treatment, whole certified size B seed potato was planted in all plots.

In 1984 oxamyl (10 G) was applied by

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TABLE 1. Effect of nematicides on plant vigor, soil population densities of *Pratylenchus penetrans* at planting, midseason, and at harvest, and tuber yield of 'Russet Burbank' potato at Alliston, Ontario, in 1984.

| Treatment | Application rate (kg a.i./ha) | Plant vigor† (11 July) | *P. penetrans* (no./kg soil) Planting (Pi) | Midseason (Pm) | Harvest (Pf) | Tuber yield (t/ha) Marketable (> 7.0 cm) | Total |
|---|---|---|---|---|---|---|---|
| Metham-sodium | 49.4 | 55.7 b | 360 d | 1,630 d | 6,280 c | 21.5 ab | 36.4 a |
| | 34.2 | 55.6 b | 2,020 c | 7,240 c | 11,640 b | 20.3 abc | 33.7 ab |
| 1,3-D + aldicarb (15 G) | 90.8 + 2.2 | 66.5 a | 7,040 b | 310 d | 1,920 c | 23.4 a | 35.0 a |
| Oxamyl (10 G) | 5.0 | 48.5 bc | 57,880 a | 12,540 bc | 19,420 ab | 18.0 bcd | 29.6 bc |
| (24 L) | 4.3 | 52.2 bc | 39,800 a | 23,800 ab | 28,320 ab | 17.8 bcd | 28.5 c |
| (10 G) pp‡ | 5.0 | 43.8 cd | 33,240 a | 34,280 ab | 14,760 b | 14.2 d | 21.5 d |
| (24 L) pp‡ | 4.3 | 42.6 cd | 22,760 a | 15,780 ab | 24,360 ab | 15.2 d | 22.7 d |
| Control | | 38.0 d | 37,740 a | 40,080 a | 37,840 a | 16.0 cd | 23.2 d |
| SE | | 1.7 | 3,730 | 2,480 | 1,980 | 0.69 | 1.02 |

Data are means of five replicates. Column means followed by the same letters are not significantly different ($P = 0.05$), according to Duncan's multiple-range test. Nematode data were subjected to (log [x + 200]) transformation and plant vigor to arcsine transformation. SE were calculated on untransformed data.

† Visual rating of plant vigor (height and spread of plant tops): 5 = highest, 1 = lowest.

‡ Applied 2 weeks after planting.

hand in two 15-cm-wide bands immediately after planting, at 75 mg a.i./m row (5.0 kg a.i./ha broadcast), mixed with a soil carrier, and raked into the top 3–5 cm of soil. Similarly, oxamyl (24 L) at 65 mg a.i./m row (4.3 kg a.i./ha broadcast) was sprayed with a knapsack sprayer on the soil in two 15-cm-wide bands. The same rates of oxamyl were also applied to separate plots 2 weeks after planting.

In 1985 the same design was used except for the oxamyl treatments. Plots treated with oxamyl immediately after planting received a second postplant application of the chemical at the same rate 2 weeks later. In 1985 fumigants were applied on 30 April and planting was on 23 May.

Three weeks after planting, all plots received a 20-3-15 (N-P-K) fertilizer at 1,100 kg/ha broadcast, followed by hilling. Cultural practices and control of weeds, diseases, and insect pests followed recommendations for the area (6). In 1984 the experimental plots received supplementary water whenever the surrounding commercial potato crop was irrigated by overhead sprinkler system; in 1985 there was no provision for irrigation.

Soil samples were collected by taking six random cores 2.5 cm d × 20 cm deep in each row for a total of 12 cores/plot and pooled for determination of nematode population densities at planting (Pi), midseason (Pm), and at harvest (Pf). Nematodes were extracted from 50-g subsamples for 7 days at 22 C with the Baermann pan method (17). On 11 July 1984 and 1985, the number of missing plants was recorded and plant vigor (height and spread of plant tops) was visually rated on a scale of 1–5, where 5 is highest and 1 is lowest. On 3 October in both years, all plots were hand harvested and yields were graded into marketable tubers (at least 7.0 cm long) and culls. Nematode data were transformed (log [x + 200]) (14) and vigor ratings were converted to percentages and arcsine-transformed. The data were subjected to analysis of variance, and Duncan's multiple-range test was used to evaluate differences between means when the $F$-value was significant. Unless otherwise stated, all differences were significant at the $P = 0.05$ level of probability.

## RESULTS

In both years, stand percentages determined 7 weeks after planting exceeded 99%. In 1984 plant vigor rated 7 weeks after planting was greatest following the 1,3-D + aldicarb treatment, followed by the metham-sodium treatments (Table 1).

Oxamyl applied immediately after planting also increased plant vigor, relative to the control, but postplant (pp) treatments did not. In 1985 only the 1,3-D + aldicarb treatment and both rates of metham-sodium increased plant vigor (Table 2).

In 1984 both rates of metham-sodium and the combination of 1,3-D + aldicarb reduced population density relative to the control at all three sampling dates (Table 1). At midseason, none of the oxamyl treatments except oxamyl (10 G) applied immediately after planting affected Pm. At harvest, oxamyl (10 G) applied 2 weeks after planting decreased Pf, compared with the control. Marketable yield was increased only by the high rate of metham-sodium and the combination treatment; total yield was increased by all treatments except by oxamyl applied 2 weeks after planting (Table 1).

In 1985 both rates of metham-sodium resulted in a decrease in the Pi (Table 2). At midseason, all treatments except oxamyl (24 L) had suppressed the Pm; at harvest, all treatments resulted in lower population densities than the control. Both marketable and total yield were increased only by the fumigants and the combination treatment (Table 2).

## Discussion

Metham-sodium and 1,3-D + aldicarb provided control of *P. penetrans* and increased yield. In 1984 metham-sodium suppressed the Pi more than did 1,3-D + aldicarb. Aldicarb applied immediately after planting in the 1,3-D-treated soil prevented nematode population buildup in 1984. In previous experiments, aldicarb applied over methyl isothiocyanate also resulted in much lower Pf values than did any other treatment, including 1,3-D alone (10). Aldicarb decreased nematode population densities more than did oxamyl, although the overall effect of aldicarb on tuber yield is not different from that of oxamyl (4).

Control of *Globodera* spp. in the Netherlands is achieved by incorporating oxamyl into the soil just before or at planting (1). Since crop damage by *P. penetrans* is correlated with age of plant (or size of root system) when attacked (7), the temporal and spatial distribution of the chemical was improved. Oxamyl was applied 2 weeks after planting on the assumption that it would take that much time for the tubers to sprout and the compound to be carried by rainwater to the newly formed roots. In terms of total yields, single postplant applications of oxamyl were inferior to similar rates of oxamyl treatment applied immediately after planting. In 1985 therefore, treatments immediately after planting and 2 weeks later were combined, resulting in a doubling of the rate in a split application. In general, satisfactory nematode control at midseason and harvest was achieved with oxamyl (10 G); however, neither marketable nor total yield was increased (Table 2).

The application of oxamyl in granular or liquid form in bands on the soil surface followed by incorporation immediately after planting, as recommended for *Globodera* spp. (1), is inferior to in-furrow placement or foliar sprays in the control of *P. penetrans* in potato. Previously, when oxamyl (24 L) was applied preplant in-furrow at 33 mg a.i./m row (2.2 kg a.i./ha broadcast) followed by five foliar sprays at 0.43 kg a.i./ha/application, marketable yields of Russet Burbank potato, grown in soil with a Pi of 10,700 *P. penetrans*/kg soil, were increased by 44 or 39%, respectively, compared with the untreated control (12). Oxamyl (10 G) at 2.2 kg a.i./ha applied in furrow at planting reduces populations of *P. penetrans* in the roots and rhizosphere and increases potato yields (4). Why a broadcast application, either immediately after planting or 2 weeks later, is relatively ineffective for *P. penetrans* is probably related to its failure to provide an immediate reduction in the number of nematodes when the plant is young and vulnerable. Once the plant reaches a certain age and size, its tolerance to the root-lesion nematode is likely to increase, as was shown for alfalfa (7).

In 1985 population densities as low as

TABLE 2. Effect of nematicides on plant vigor, soil population densities of *Pratylenchus penetrans* at planting, midseason, and at harvest, and tuber yield of 'Russet Burbank' potato at Alliston, Ontario, in 1985.

| Treatment | Application rate (kg a.i./ha) | Plant vigor† (11 July) | *P. penetrans* (no./kg soil) Planting (Pi) | Midseason (Pm) | Harvest (Pf) | Tuber yield (t/ha) Marketable (> 7.0 cm) | Total |
|---|---|---|---|---|---|---|---|
| Metham-sodium | 49.4 | 62.8 ab | 40 c | 380 c | 2,190 b | 23.5 a | 28.7 a |
| | 34.2 | 66.7 a | 400 c | 650 bc | 1,820 b | 21.4 ab | 27.4 a |
| 1,3-D + aldicarb (15 G) | 90.8 + 2.2 | 63.2 ab | 630 bc | 430 c | 1,090 b | 21.0 ab | 26.6 a |
| Oxamyl (10 G)‡ | 5.0 + 5.0 | 53.4 bc | 2,900 a | 210 c | 820 b | 18.7 bc | 25.2 ab |
| (24 L)‡ | 4.3 + 4.3 | 56.3 abc | 4,020 a | 1,380 ab | 2,730 b | 19.0 bc | 25.5 ab |
| Control | | 50.5 c | 2,320 ab | 2,610 a | 16,040 a | 17.1 c | 21.8 b |
| SE | | 1.6 | 415 | 240 | 1,133 | 0.89 | 0.93 |

Data are means of five replicates. Column means followed by the same letters are not significantly different ($P = 0.05$), according to Duncan's multiple-range test. Nematode data were subjected to a (log [x + 200]) transformation and plant vigor to arcsine transformation. SE were calculated on untransformed data.

† Visual rating of plant vigor (height and spread of plant tops): 5 = highest, 1 = lowest.

‡ Applied immediately after planting and 2 weeks later.

2,320 *P. penetrans*/kg soil at planting caused losses of 24% in total yield and 27% in marketable yield, compared with the treatment with metham-sodium at 49.4 kg a.i./ha. In previous studies, there were appreciable losses in potato yields, even with low Pi values (8,13), but this was not the case in 1984. In 1984 the experimental plots inadvertently received supplementary irrigation which was applied in the surrounding commercial crop and Pi values as high as 7,040 *P. penetrans*/kg soil (Table 1) were not associated with marketable yield losses. In 1985 no such irrigation was provided. That potato root systems damaged by root-lesion nematodes are much less able to cope with moisture stresses than healthy plants has been shown (3).

In 1984 the chemical costs per hectare were $250 (Can.) and $350 for metham-sodium at 34.2 and 49.4 kg a.i./ha broadcast, respectively, and about $300 for the combination of 1,3-D and aldicarb. The average increase in marketable tuber yield with 34.2 kg a.i./ha broadcast of metham-sodium for 1984 and 1985, relative to the nontreated control, was 26.0% or 4.3 t, worth about $430, for a profit of $180/ha. For metham-sodium at 49.4 kg a.i./ha broadcast and the combination treatment, yield gains averaged 35.9% and 34.6%, or 5.95 and 5.65 t, for gains of $245 and $265/ha, respectively.

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