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# Effect of Oxamyl Treatment of Potato Seed Pieces on *Pratylenchus penetrans* and Yield

TH. H. A. OLTHOF AND J. L. TOWNSHEND[1]

*Abstract:* In the first 2 years of a 3-year (1987–89) microplot study, aqueous solutions of oxamyl (32 mg/ml) were applied to cut potato (*Solanum tuberosum* cv. Russet Burbank) tubers, grown in fine sandy loam infested with *Pratylenchus penetrans.* The seed-piece treatment alone and the seed-piece treatment followed by three foliar sprays generally reduced ($P = 0.05$) population densities of *P. penetrans* in the soil at midseason and in the soil and roots at harvest, compared to the control. In 1989, all seed pieces treated with oxamyl at 96 mg/ml or at 32, 64, and 96 mg/ml followed by a polymer sticker : water (1:4) dip failed to emerge. Only oxamyl at 64 mg/ml reduced ($P = 0.05$) midseason soil population densities of *P. penetrans.* A pre-plant soil treatment with 1,3-D reduced ($P = 0.05$) numbers of *P. penetrans* at planting each year and increased ($P = 0.05$) tuber yields in 1988 and 1989 compared to the control. In 1989, tuber yields from the sticker treatment and the oxamyl seed-piece treatment at 64 mg/ml were lower ($P = 0.05$) than those in the 1,3-D treatment and similar to those from the untreated control, possibly because of phytotoxicity. Oxamyl treatment of potato seed pieces to control *P. penetrans* does not appear practical for field production.
*Key words:* nematicide, nematode, oxamyl, potato, *Pratylenchus penetrans,* root-lesion nematode, seed piece, *Solanum tuberosum,* 1,3-dichloropropene.

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The pathogenicity of the root-lesion nematode *Pratylenchus penetrans* Cobb on potato (*Solanum tuberosum* L.) has been documented (2,5,12), and damage threshold densities of 1,000–2,000 nematodes/kg soil have been reported (1,2,4,12). In Simcoe County, Ontario, 64% of the potato fields were infested with a median density of 1,700 *P. penetrans*/kg soil (10). In 47% of the fields, population densities of *P. penetrans* exceeded 2,000, and in 12% of the fields, numbers exceeded 10,000/kg soil (10).

Soil fumigants, especially when combined with nonvolatile nematicides, satisfactorily controlled *P. penetrans* in Ontario potato production fields (8,9). Oxamyl alone provided protection from *P. penetrans* damage and increased marketable yield by as much as 44.4% (11); however, in other experiments the compound was less effective (8,9). In a greenhouse study, soaking cut seed pieces or whole tubers in various concentrations of oxamyl reduced numbers of *P. penetrans* in soil and roots and increased plant growth (23). In field tests, potato seed pieces dipped in oxamyl generally decreased numbers of *P. penetrans* but did not increase yields (18,19). Soaking potato seed pieces with oxamyl before planting has also been attempted to control the golden nematode *Globodera rostochiensis* Woll. (3,7,15) and other plant-parasitic nematodes (16).

The objective of this study was to confirm in field microplots that oxamyl applied to potato seed pieces controls *P. penetrans* and enhances plant growth, as observed in a greenhouse study (23).

## MATERIALS AND METHODS

Separate experiments were conducted for 3 years at Jordan Station, Ontario, in field microplots. Each microplot consisted of a clay drain tile (20-cm-i.d., 30-cm long) buried 28 cm deep in soil treated the preceding fall by shank injection with a fumigant nematicide DD-MENCS (20% methyl isothiocyanate + 80%, 1,3-dichloropropene) broadcast at 130 liters/ha, to prevent contamination. The experimental design each year was a randomized-complete block with 20 replicates.

Tioga fine sandy loam (69% sand, 26% silt, 5% clay; pH 5.0, 1.6% organic matter), naturally infested with *P. penetrans* from a

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[1] Nematologists, Research Station, Agriculture Canada, Vineland Station, Ontario, Canada L0R 2E0.
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TABLE 1. Soil and root population densities of *Pratylenchus penetrans* in potato grown in 1987 and 1988 in microplots treated with 1,3-D and oxamyl.

| Treatment† | Application rate (a.i.) | Nematodes in soil (no./kg) Planting 1 June 1987 | Nematodes in soil (no./kg) Planting 2 June 1988 |
|---|---|---|---|
| 1,3-D | 0.097 g/kg | 0 b | 0 b |
| 1,3-D + oxamyl foliar spray | 0.097 g/kg + 2.15 kg/ha | 0 b | 2 b |
| Oxamyl seed-piece soak | 32 mg/ml | 1,900 a | 19,070 a |
| Oxamyl seed-piece soak + oxamyl spray | 32 mg/ml + 2.15 kg/ha | 1,920 a | 18,820 a |
| Control | — | 1,760 a | 16,200 a |

Data are means of 20 replicates. Column means followed by the same letters are not different ($P = 0.05$) according to Duncan's multiple-range test on data subjected to a ln (x + 200) transformation.

† 1,3-D applied 5 weeks before planting. Oxamyl seed-piece soak treatments were applied 2–3 hours before planting, and foliar sprays were applied twice at biweekly intervals starting 49–52 days after planting.

grower's field near Alliston, Ontario, was used to fill the microplots in all experiments. Before each experiment, soil was sieved (1-cm pores) to remove root debris and mixed three times for 3 minutes each in a cement mixer to obtain uniform distribution of nematodes. Each 10-kg soil used to fill one microplot was mixed with 7.2 g of a recommended 10-10-10 (N-P-K) fertilizer (S. Squire, pers. comm.). For treatments requiring soil fumigation, 10-kg aliquots of soil in plastic bags were injected at four ports with 1,3-D at 0.097 g/kg soil (97.8 kg a.i./ha broadcast). The bags remained sealed for 2 weeks, then were opened and aerated for 3 weeks.

On 1 June 1987 and 1989 and 2 June 1988, after filling the tiles with either 1,3-D-treated or *P. penetrans*-infested, nontreated soil, two soil cores (2.5-cm-d × 25-cm deep) were collected from each microplot to determine initial nematode population densities (Pi). Nematodes were extracted from 50-g soil subsamples for 7 days at 22 C with the Baermann pan method (21).

On 2 June 1987 and 3 June 1988, 2–3 hours prior to planting, 40 cut potato seed pieces (50–70 g) cv. Russet Burbank were soaked 20 minutes in a 32 mg/ml aqueous solution of oxamyl (formulated as Vydate 24 L such that 133.5 ml of Vydate equals 32 mg a.i. oxamyl). Oxamyl was diluted with water to obtain 32, 64, and 96 mg/ml aqueous solutions. In 1989, untreated seed pieces and seed pieces soaked in oxamyl solutions of 32, 64, and 96 mg/ml were air-dried for 2 hours, submerged for 2–3 seconds in a polymer sticker : water (1:4) mixture, and dried with a hair dryer (22). Application of the sticker and subsequent drying were repeated twice, and the treated seed pieces were stored in paper bags at 22 C for 24 hours before planting. A single seed piece was placed in the center of each microplot in a hole 12.5-cm deep made with a flower-bulb planter and covered with soil.

Each microplot received 1 liter of water at planting and subsequently as needed to supplement rainfall. Weeds in alleys between the microplots were controlled by frequent cultivation, and those in the microplots were removed by hand. Insects were controlled with spray applications of cypermethrin (1987), pirimicarb (1988), and fenvalerate (1989). Midseason nematode population densities (Pm) were determined in mid-July each year. Plant vigor was rated visually 20 July 1987 and 28 June 1988. A foliar treatment of oxamyl (0.43 mg a.i. oxamyl/10 liters water) was applied to two treatments biweekly beginning 21 July 1987 and 25 July 1988. A surfactant (Triton B), at 13 ml/10 liters of spray, was added as a sticker.

The shoots were harvested 132–135 days after planting and weighed. Microplots were lifted with a shovel, and roots and tubers were separated from the soil by sieving. Final nematode population densities

TABLE 1. Extended.

| Nematodes in soil (no./kg) | | | | Number of nematodes in roots at harvest | | | |
|---|---|---|---|---|---|---|---|
| Midseason | | Harvest | | Per root system | | Per g dry root | |
| 15 July 1987 | 18 July 1988 | 14 Oct. 1987 | 12 Oct. 1988 | 1987 | 1988 | 1987 | 1988 |
| 5 d | 0 c | 160 d | 130 c | 260 c | 0.3 d | 280 c | 0.1 c |
| 5 d | 0 c | 120 d | 10 c | 170 c | 0.2 d | 120 c | 0.1 c |
| 780 b | 20,920 b | 19,470 b | 30,430 a | 10,620 b | 42,500 a | 8,610 b | 16,960 a |
| 490 c | 22,720 b | 12,050 c | 21,650 b | 8,290 b | 13,800 c | 5,310 b | 5,320 b |
| 2,560 a | 29,610 a | 41,240 a | 30,210 a | 34,930 a | 32,380 b | 22,290 a | 14,480 a |

(Pf) in the soil at harvest were determined from each microplot as described previously (21). Nematodes were extracted from roots for 2 weeks in a mistifier (20), and the roots were oven-dried 6 days at 95 C and weighed. Tubers were graded as marketable and unmarketable (less than 7.0-cm long) and weighed.

Nematode data were transformed by ln (x + 200) (14) before analysis of variance (17). Data with significant ($P = 0.05$) $F$-values were subjected to Duncan's multiple-range test. Plant vigor data were analyzed by Friedman's nonparametric test (24). Only significant ($P \leq 0.05$) differences will be discussed, unless otherwise indicated.

## RESULTS

Fumigation with 1,3-D reduced numbers of *P. penetrans* in the soil to near or below detectable levels in 1987 and 1988 (Table 1). Foliar applications of oxamyl did not provide additional control over the 1,3-D treatment. Oxamyl as a seed-piece soak and in combination with a foliar spray reduced Pm compared to the untreated control both years. In 1987, Pm in the seed-piece soak plus foliar treatment was lower than those in the seed-piece soak treatment. At harvest in both years, nematode densities were lower in the seed-piece soak treatment plus foliar spray treatment as compared to the seed-piece soak treatment. At harvest in 1988, the number of *P. penetrans* in the soil planted to soaked seed pieces did not differ from those in the untreated control. In 1987, the numbers of *P. penetrans* per root system in the seed-piece soak treatment alone and soaked seed-piece plus foliar treatment were lower than those in the untreated control. In 1988, the number of *P. penetrans* per root system in the seed-piece soak treatment was higher than those in the control, but the number per root system in the seed-piece plus foliar treatment was lower than those in the control. In 1987, the number per gram dry root was lower in both the seed-piece soak treatment and the seed-piece soak plus foliar treatment than those in the control. In 1988, however, only the seed-piece soak plus foliar treatment resulted in lower numbers of *P. penetrans* per gram dry root compared to the control (Table 1).

In 1989, 1,3-D reduced numbers of *P. penetrans* in the soil to near or below detectable level (Table 2). Differences in numbers of *P. penetrans* in the soil were observed among the oxamyl, sticker, and control treatments at planting. At midseason, *P. penetrans* population densities in the soil were lower than those in the control in all treatments, except sticker and oxamyl seed-piece soak at 32 mg/ml. There was no plant emergence in the oxamyl seed-piece soak at 96 mg/ml or the oxamyl seed-piece soak plus sticker treatments. At harvest, the Pf in the 64 mg/ml seed-piece soak treatment was lower than those in the 32 mg/ml seed-piece soak treatment or the

TABLE 2. Soil and root population densities of *Pratylenchus penetrans* in potato grown in microplots filled with *P. penetrans*-infested soil or soil treated with 1,3-D and planted to untreated potato seed pieces or those soaked in sticker or oxamyl in 1989.

| | | Nematodes in soil (no./kg) | | | Number of nematodes in roots at harvest | |
|---|---|---|---|---|---|---|
| Treatment† | Application rate (a.i.) | Planting 1 June | Midseason 14 July | Harvest 12 Oct. | Per root system | Per g dry root |
| 1,3-D | 0.097 g/kg | 0 d | 0 c | 20 d | 0 b | 0 b |
| Sticker | 1:4 dil. in water | 2,130 c | 3,730 a | 14,320 b | 450 a | 1,710 a |
| Oxamyl seed-piece soak (SPS) | 32 mg/ml | 3,600 a | 3,800 a | 14,890 b | 470 a | 1,100 a |
| Oxamyl (SPS) | 64 mg/ml | 2,200 bc | 1,500 b | 6,700 c | 610 a | 1,740 a |
| Control | — | 3,470 a | 4,850 a | 23,720 a | 560 a | 2,510 a |

Data are means of 20 replicates. Column means followed by the same letters are not different ($P = 0.05$) according to Duncan's multiple-range test on data subjected to a ln (x + 200) transformation.
† 1,3-D applied 5 weeks before planting. Oxamyl seed-piece soak treatment was applied 24 hours before planting.

sticker treatment. Because no plants emerged in the oxamyl seed-piece soak at 96 mg/ml or the oxamyl seed-piece soak plus sticker treatments, the Pf at harvest in the essentially fallow soil was lowest in these treatments, except for the 1,3-D treatment. There were no differences in the numbers of nematodes in the roots of plants from the sticker treatment and seed-piece soak treatments at 32 and 64 mg/ml (Table 2).

In 1987, no differences in shoot and root weight were observed; however, in 1988, shoot weight of plants in 1,3-D-treated soil was greater than that in all other treatments (data not shown).

In 1987, plant vigor of the seed-piece soak treatment was lower than that of plants grown in 1,3-D-treated soil. In 1988, plant vigor in the seed-piece soak plus foliar spray treatment was lower than that in any other treatment (Table 3). There were no differences in the yield of tubers among the treatments in 1987. In 1988, total and marketable tuber yields were greater in 1,3-D-treated soil and in the 1,3-D-treated soil

TABLE 3. Growth of plants and weights of potato tubers grown in microplots filled with *Pratylenchus penetrans*-infested soil or soil treated with 1,3-D and planted to untreated potato seed pieces or those soaked in oxamyl, with or without oxamyl spray, 1987 and 1988.

| | | Plant vigor‡ | | Tubers (g/plant) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1987 | | 1988 | |
| Treatment† | Application rate (a.i.) | 20 July 1987 | 28 June 1988 | Total | Marketable (> 7.0 cm) | Total | Marketable (> 7.0 cm) |
| 1,3-D | 0.097 g/kg | 2.8 a | 2.4 a | 2,470 a | 2,120 a | 2,235 a | 1,745 a |
| 1,3-D + oxamyl foliar spray | 0.097 g/kg + 2.15 kg/ha | 2.9 a | 2.4 a | 2,640 a | 2,190 a | 2,195 a | 1,840 a |
| Oxamyl seed-piece soak | 32 mg/ml | 2.6 b | 2.1 a | 2,440 a | 1,970 a | 1,615 b | 1,215 b |
| Oxamyl seed-piece soak + foliar spray | 32 mg/ml + 2.15 kg/ha | 2.7 ab | 1.7 b | 2,490 a | 1,950 a | 1,660 b | 1,240 b |
| Control | — | 2.8 ab | 2.3 a | 2,350 a | 1,930 a | 1,680 b | 1,240 b |

Data are means of 20 replicates. Column means followed by the same letters are not different ($P = 0.05$) according to Duncan's multiple-range test.
† 1,3-D applied 5 weeks before planting. Oxamyl seed-piece soak treatment was applied 2–3 hours before planting, and oxamyl foliar spray treatments were applied twice at biweekly intervals starting 49–52 days after planting.
‡ Visual rating of plant vigor (height and spread of plant tops): 3 = highest, 1 = lowest. Data are means of actual scores. Column means followed by the same letters are not different ($P = 0.05$) according to Newman-Keuls procedure for ranked data.

TABLE 4. Growth of plants and weights of potato tubers grown in microplots filled with *Pratylenchus penetrans*-infested soil or soil treated with 1,3-D and planted to untreated potato seed pieces or those soaked in sticker or oxamyl in 1989.

| | | Shoot | Root | Tubers (g/plant) | |
|---|---|---|---|---|---|
| Treatment† | Application rate (a.i.) | Fresh weight (g) | Fresh weight (g) | Total | Marketable (> 7.0 cm) |
| 1,3-D | 0.097 g/kg | 1,203 a | 6.1 a | 1,862 a | 1,479 a |
| Sticker | 1:4 dil. in water | 218 c | 1.5 bc | 686 c | 384 c |
| Oxamyl seed-piece soak | 32 mg/ml | 645 b | 2.7 b | 1,238 b | 862 b |
| Oxamyl seed-piece soak | 64 mg/ml | 310 bc | 2.8 b | 732 c | 421 c |
| Control | — | 274 bc | 1.2 c | 998 bc | 666 bc |

Data are means of 20 replicates. Column means followed by the same letters are not different ($P = 0.05$) according to Duncan's multiple-range test.

† 1,3-D applied 5 weeks before planting. Oxamyl seed-piece soak treatment was applied 24 hours before planting.

plus oxamyl spray treatment than in the other treatments, but there were no differences among other treatments (Table 3).

In 1989, fresh shoot weight of plants grown in 1,3-D-treated soil was greater than in other treatments (Table 4). The sticker treatment resulted in smaller shoot weight than the seed-piece soak treatment at 32 mg/ml. Root weight was also greatest in the microplots filled with 1,3-D-treated soil. Root weights of plants grown in soil planted to tubers soaked in oxamyl at 32 and 64 mg/ml were greater than those in the untreated control. Tuber yields in 1,3-D-treated soil were greater than those in the other treatments. Yields from plots planted with seed pieces soaked with oxamyl at 32 mg/ml were greater than those resulting from seed-piece treatments with oxamyl at 64 mg/ml or with sticker, but not different from the control (Table 4).

## DISCUSSION

In 1987 and 1988, soaking potato seed pieces for 20 minutes in an oxamyl solution of 32 mg/ml prior to planting reduced soil and root population densities of *P. penetrans* compared to the untreated control. The oxamyl soak treatment plus three foliar spray applications of oxamyl at 0.72 kg a.i./ha caused greater suppression of *P. penetrans* than the soak treatments alone. However, there was no yield increase due to the oxamyl treatments in either year. In 1987, the damage threshold of about 2,000 *P. penetrans*/kg soil at planting (4,12) was not exceeded, and in 1988, when the Pi was very high, nematode control with oxamyl was not adequate to protect the crop.

The nematode control obtained in the field microplots in 1987 and 1988 was much lower than that reported from greenhouse experiments (23). Perhaps the concentration of oxamyl in the field microplots was diluted by leaching more than occurred in the smaller volumes of soils in pots in the greenhouse. To overcome this potential problem, larger dosages of oxamyl and a polymer sticker (22) were utilized in the 1989 experiments. However, no plants emerged from tubers soaked in oxamyl at 96 mg/ml or oxamyl-treated plus sticker-soaked seed pieces. Our results corroborate those of others (15) who reported that cut potato seed pieces soaked in oxamyl at 100 mg/ml failed to produce plants, whereas little, if any, adverse effects on emergence occurred with 50 mg/ml. Toxicity in potato plants after a 15-minute seed-piece soak in oxamyl at 8 mg/ml has been reported (3). Severe toxicity in potato plants was observed in response to 5-minute exposures to oxamyl at 18 and 24 g/liter (16).

In our experiment in 1989, all combinations of oxamyl seed-piece soaks and sticker resulted in failure of plant emergence. Perhaps the sticker maintained a concentration of oxamyl toxic to bud development from the seed piece. The sticker could also have caused phytotoxicity by shielding the buds from adequate moisture necessary for development. Although oxamyl at 64 mg/ml provided nematode control at midseason and 32 and 64 mg/ml suppressed *P. penetrans* in the soil at harvest, neither concentration resulted in increased tuber yield compared to the untreated control.

Although results from greenhouse experiments indicated that soaking cut or whole potato tubers in 32 mg oxamyl/ml for 20 minutes prior to planting decreased *P. penetrans* and increased potato growth (23), results from our microplot studies did not consistently confirm these findings. Results from a related study (6), in which potato seed pieces were also soaked in 32 mg oxamyl/ml for 20 minutes, showed that a higher concentration of oxamyl remained in the soil in small greenhouse pots than in large field microplots. Furthermore, the concentration of the oxamyl in small potted greenhouse plants was probably higher than in large, microplot-grown plants, and this may have contributed to nematode control (6).

Although potato tuber soak treatments reduced populations of *P. penetrans* in many cases in this study, the reductions were relatively small compared to those obtained using soil drenches, foliar sprays, or both (8,11). More oxamyl is used per unit area with soil drenches and sprays, but foliar sprays appear to be more efficient at delivering oxamyl to plant roots. In a soak application study (6), only 1% of the oxamyl found in the plant and soil was in the roots 25 days after application, compared to 12–15% 12 days after foliar application (13). Based on our results and previous studies (18,19), oxamyl treatment of potato seed pieces to control *P. penetrans* does not appear to be practical in field situations.

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