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Control of *Pratylenchus penetrans* on Potato with Metam-sodium Applied in Irrigation Water

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Abstract: In 1986, metam-sodium broadcast at 152, 76, 38, 19, and 9.5 kg a.i./ha suppressed the population density of 19,600 *Pratylenchus penetrans*/kg soil at planting by 100, 90, 63, 23, and 14%, respectively, and in 1987, with 1,370 *P. penetrans*/kg soil, by 99, 88, 57, 11, and 1%. At harvest, soil population densities increased 2.2-fold in 1986 and 13.9-fold in 1987. Rate of population increase was similar at all rates of nematicide except it was slower at 152 kg a.i./ha in 1987. In both years, shoot and root weights did not differ ($P = 0.05$). In 1986 the number of tubers in plots treated with 76 and 152 kg metam-sodium a.i./ha and the marketable tuber weight at the three highest rates did not differ significantly from the untreated control. However, 76 and 152 kg a.i./ha resulted in larger numbers of tubers relative to the three lowest rates of metam-sodium and in higher tuber weight relative to the two lowest rates. Yield differences were not statistically significant in 1987, probably because of low infestation levels.

Key words: chemigation, irrigation, metam-sodium, nematicide, potato, *Pratylenchus penetrans*, root-lesion nematode, *Solanum tuberosum.*

Pratylenchus penetrans Cobb is pathogenic to potato, *Solanum tuberosum* L. (3,8,13,14). Damage threshold densities of 1,000–2,000 nematodes/kg soil were reported (2,3,7,13). *Pratylenchus penetrans* occurs in 64% of the potato fields in Simcoe County, Ontario, at a median density of 1,700/kg soil (11). Population densities exceeded 2,000/kg in 47% of the fields, and 12% were infested with more than 10,000/kg (11).

Fumigants, especially when combined with systemic nematicides, give satisfactory control of *P. penetrans* in the Ontario potato crop (9,10). Oxamyl alone also provides protection from nematode damage and increases marketable yields by as much as 44.4% (12).

Metam-sodium applied in irrigation water controls nematodes and soil-borne fungi in potato (5,15,18) and other crops (17). The compound is used on 60% of the potato growing area in the state of Washington to control *Meloidogyne hapla* Chitwood, *M. chitwoodi* Golden, O'Bannon, Santo & Finley, and soil-borne fungi (G. Santo, pers. comm.). In Michigan, 20% of the growers apply metam-sodium broadcast at 178 kg a.i./ha through center pivot irrigation systems to control *P. penetrans* and *Verticillium dahliae* Kleb. (G. Bird, pers. comm.). Metam-sodium is also used on potato in Wisconsin (D. Rouse, pers. comm.).

The purpose of this study was to determine the efficacy of low and standard rates of metam-sodium, applied through a simulated overhead irrigation system, on control of *P. penetrans* on potato.

Materials and Methods

The experiments were conducted in 1986 and 1987 in microplots at the Agriculture Canada Research Station farm, Jordan Station, Ontario. Each microplot consisted of a clay drainage 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 (20% methyl isothiocyanate, 80% 1,3-D) broadcast at 130 liters a.i./ha. Each tile was filled with Tioga fine sandy loam (69% sand, 26% silt, 5% clay; 1.6% organic matter; pH 5.0) infested with *P. penetrans* collected from a grower's field near Alliston, Ontario. Each 10-kg batch of soil used to fill one microplot was mixed with 7.2 g of 10-10-10 (N-P-K) fertilizer, as recommended by the Ontario Potato Extension Specialist (S. Squire, pers. comm.).

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TABLE 1. Soil and root population densities of *Pratylenchus penetrans* in potato growing in microplots treated with metam-sodium broadcast applied in water, 1986 and 1987.

Treatment (kg a.i./ha)	In soil (no./kg)			In roots at harvest (no.)	
	At planting	At midseason†	At harvest‡	Per root system	Per g dry root
			1986		
0.0	19,600 a y	21,310 a y	40,990 a x	5,810 a	1,670 a
9.5	16,900 a y	17,330 a y	31,140 ab x	5,050 a	1,590 a
19.0	15,120 a y	17,620 a y	23,410 b x	2,800 b	1,020 b
38.0	7,170 b y	7,000 b y	13,920 c x	1,370 c	480 c
76.0	1,950 c y	1,440 c y	7,010 d x	335 d	130 d
152.0	0 d y	30 d y	240 e x	30 e	10 e
			1987		
0.0	1,370 a z	3,540 a y	17,090 a x	6,800 a	13,230 a
9.5	1,550 a z	4,040 a y	14,690 a x	4,710 a	10,570 a
19.0	1,220 a z	2,220 b y	13,000 a x	3,610 a	7,620 a
38.0	590 b y	1,000 c y	6,640 b x	2,110 b	4,840 b
76.0	170 c z	630 d y	4,400 b x	2,690 b	3,930 b
152.0	20 d y	40 e y	310 c x	75 c	160 c

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

† 42 days after planting.

‡ 133 days after planting.

The above-ground air temperature and soil temperature 20 cm deep were 22.5 and 12.5 C on 13 May 1986 and 18.0 and 14.0 C on 14 May 1987. Soil moisture was 8.8% both years. All microplots except the untreated control received 265 ml water. The treatments, applied in 565 ml water, were 0.51 g a.i. of metam-sodium (equivalent to 152 kg a.i./ha applied in 2.5 cm water/ha); 0.26 g (76 kg a.i./ha); 0.13 g (38 kg a.i./ha); 0.06 g (19 kg a.i./ha); and 0.03 g (9.5 kg a.i./ha). The experimental design was a randomized complete block with 20 replicates.

Nineteen days after chemical treatment, two soil cores (2.5 cm d × 25 cm deep) were taken from all microplots to determine nematode response to each treatment. A Baermann pan method was used to extract nematodes (22). A whole potato seed tuber (Norchip cultivar, elite grade), weighing ca. 54 g, was planted in the center of each microplot 12.5–15.0 cm deep with the aid of a flower-bulb planter. Mid-season nematode population densities were determined 42 days after planting.

Weeds were controlled by frequent cultivation between the plots and by hand-weeding close to and in the microplots. Insects were controlled with a spray of carbaryl 22 August 1986 and with cypermethrin 21 July 1987. Rainfall and temperature data were recorded daily at the Climatological Station, Vineland Station, Ontario, 3.2 km from the experimental site. No supplementary irrigation was required in 1986; in 1987 each microplot received 1 liter of water at planting, 500 ml 13 days later, and 2.5 cm at 20 days with overhead irrigation.

At harvest, 133 days after planting in both years, the shoots were harvested to determine fresh and oven-dried weights. Roots and tubers were separated from the soil by sieving. Final nematode population densities in the soil were determined from each microplot with a modified Oostenbrink method of extraction (22). Nematodes were extracted from roots for 2 weeks in a mistifier (20) after which the roots were oven-dried (6 days at 95 C) and weighed. Each tuber was weighed and measured; those less than 50 mm were classified as unmarketable.

Nematode count data were transformed before statistical analysis ln (x + 200) (16). Regression analyses of nematode soil population densities over the growing season

TABLE 2. Numbers and weights of tubers of potato grown in microplots at Jordan Station, Ontario, treated broadcast with different rates of metam-sodium, 1986 and 1987.

Treatment (kg a.i./ha)	1986				1987			
	Tubers (no./plant)		Tuber (g/plant)		Tubers (no./plant)		Tuber (g/plant)	
	Total	Marketable†	Total	Marketable†	Total	Marketable†	Total	Marketable†
0.0	30 ab	13 ab	2,412 abc	2,162 abc	36	13	2,252	1,966
9.5	24 b	11 b	1,985 d	1,793 c	38	14	2,228	1,905
19.0	25 b	12 b	2,041 cd	1,840 c	34	13	2,299	2,012
38.0	25 b	11 b	2,212 bcd	1,993 bc	33	13	2,257	1,999
76.0	33 a	15 a	2,560 ab	2,305 ab	31	14	2,390	2,153
152.0	36 a	14 a	2,779 a	2,469 a	28	14	2,137	1,906
					NS	NS	NS	NS

Data are means of 20 replicates. Column means followed by the same letters are not significantly different ($P = 0.05$) according to Duncan's multiple-range test.
† Larger than 50 mm.

were calculated (19) and the slopes were compared (21).

RESULTS

In 1986 rates of 38 kg metam-sodium/ha and higher reduced nematode population densities in soil at planting and at midseason, relative to the control; final densities were less at rates of 19 kg/ha and higher (Table 1). In 1987 rates of 38 kg/ha or higher reduced soil population densities at planting and at harvest relative to the control, whereas 19 kg/ha or higher resulted in a decrease at midseason. Nematode root counts followed a similar pattern as those in soil in response to metam-sodium (Table 1). In 1986 a comparison of the regression equations of the increase in nematode soil population densities over the growing season did not differ ($P = 0.05$). In 1987, however, the slope of the regression equation ($y = 5.31 + 0.007$ [days] $r = 0.98$) at 152 kg/ha was smaller ($P = 0.05$) than the control ($y = 7.40 + 0.018$ [days] $r = 0.99$) ($F = 41.9$, df 1,2).

Shoot and root weights did not differ ($P = 0.05$) in either year. In 1986 the two highest rates of metam-sodium resulted in larger total and marketable numbers of tubers and greater total and marketable weight of tubers per plant than were produced by plants grown at the three and two lowest rates, respectively (Table 2). The yield of the untreated control did not differ ($P = 0.05$) from any of the treatments except in respect to total tuber weight relative to the lowest rate (Table 2). None of the yield differences in 1987 were significant ($P = 0.05$) (Table 2).

DISCUSSION

Substantial control of *P. penetrans* was achieved at planting with metam-sodium at less than half the recommended manufacturer's rate of 152–178 kg a.i./ha. This was the case especially in 1986 when initial densities were high (19,600/kg soil). Although in both years relatively little additional kill was achieved with rates in excess of 76 kg a.i./ha, the 10% survival in 1986 still represented 1,950 *P. penetrans*/kg soil at planting, which is close to the damage threshold (13). In most *P. penetrans*-infested fields (11), however, a treatment that causes 90% kill would result in an initial density below the damage threshold.

The results agree with relationships established for rates of metam-sodium and amounts of irrigation water (1). A rate of 89 kg a.i./ha, applied with 25 mm water, results in a metam-sodium concentration of 350 μg/ml down to a depth of 25 cm, which represents the depth of the infested soil in the microplots (1). As *P. penetrans* occurs mainly in the top 25 cm in potato fields (6), 89 kg a.i./ha should be sufficient to achieve the killing concentration of 350 μg/ml (1).

In 1986 yields in the plots treated with the three lowest rates of metam-sodium

tended to be smaller than yields from the untreated control plots which contained 19,600 *P. penetrans*/kg soil at planting. Apart from this anomaly for which no explanation can be offered, nematode population densities in the soil at planting generally decreased and yields increased as the dosage of metam-sodium doubled. In 1987 no differences in yield were obtained, probably because damage thresholds of 1,000–2,000/kg of soil (2) were not exceeded. The excessive heat in June, July, and August 1987 may be responsible for a lower yield, relative to 1986. Net assimilation for potato plants fell to zero above 30 C (4). Daily maxima in June–August exceeded 30 C on 20 days in 1987, but on only 6 days in 1986.

These microplot experiments have demonstrated that metam-sodium applied in irrigation water at half the recommended rate suppressed the population density of *P. penetrans* in the soil 8–10-fold, relative to the untreated control.

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