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Fosthiazate for Suppression of *Pratylenchus penetrans* in Potato on Prince Edward Island

J. Kimpinski, W. J. Arsenault, and J. B. Sanderson[1]

Abstract: The impacts of fosthiazate on potato (*Solanum tuberosum*) tuber yields and populations of root lesion nematodes (primarily *Pratylenchus penetrans*) were studied during 1991–1994 in experimental plots on Prince Edward Island. Tuber yields were greater in treated plots when compared to untreated plots by 8% and 30% during 1991 and 1993, respectively. Numbers of nematodes in roots were reduced by the treatments in every year, and nematode populations in soil were suppressed in 1991, 1993, and 1994. Tuber yields in 1993 and 1994 were higher, and nematode counts in soil and roots in 1991, 1993, and 1994 were lower in plots treated with the emulsifiable concentrate formulations of fosthiazate than in plots treated with the granular formulations. Yields of plots treated with fosthiazate did not differ consistently from yields of plots treated with aldicarb. The results indicated that fosthiazate should be useful for potato production in the Maritime region of Canada.
Key words: aldicarb, fosthiazate, management, nematode, potato, *Pratylenchus penetrans*.

The major nematode parasite of potato (*Solanum tuberosum*) in the Maritime region of Canada is the root lesion nematode, *Pratylenchus penetrans.* Applications of nematicides have usually resulted in tuber yield increases when nematode populations were large (Kimpinski, 1979; Kimpinski and Thompson, 1990). Chemical management of nematodes in commercial potato fields and in experimental plots have resulted in 10% to 40% tuber yield increases (Kimpinski, 1982). Nematicide trials with aldicarb and oxamyl often reduced nematode numbers at the end of the growing season by as much as 90% when compared to untreated plots (Kimpinski, 1986).

The use of aldicarb is now restricted in the Maritime region, and chemical management of nematodes, especially with fumigants, is expensive. Thus, growers in the region require access to more information on effective nematicides. Fosthiazate (ISK Biosciences), a relatively new organophosphorus nematicide, has been used in field trials to manage *Meloidogyne arenaria* in peanut in Georgia (Minton et al., 1993) and *M. javanica* in flue-cured tobacco in Florida (Rich et al., 1994). In both cases, yields were increased in plots treated with fosthiazate. The purpose of these trials was to assess the impact of fosthiazate on potato tuber yields and root lesion nematodes at an experimental field site on Prince Edward Island.

Materials and Methods

Tests were conducted during 1991–1994 at different field sites in each year at the Harrington Farm of the Charlottetown Research Centre on Prince Edward Island.

The soil types were fine sandy loams (average of 70% sand, 20% silt, 10% clay, 2.8% organic matter; pH 5.1–6.1), and the dominant plant-parasitic nematode was *Pratylenchus penetrans.* Red clover (*Trifolium pratense*) was planted in the previous year at each site to maintain populations of root-lesion nematodes. Occasional occurrences of *P. crenatus* and *Meloidogyne hapla* in roots were not considered of consequence to this study.

In early May, the soil was moldboard-plowed 20 cm deep, disked twice to 15 cm deep, and harrowed 15 cm deep. Individual plots consisted of four rows, 6 m long and 0.9 m apart. Elite-III seed pieces of either Superior or Russet Burbank cultivars were planted in rows at 25-cm and 35-cm intervals, respectively. Cultural and fertilizer practices similar to those used in commercial production were followed (Atlantic Canada Potato Guide, 1993). Untreated check plots were managed in the same fash-

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[1] Agriculture and Agri-Food Canada Research Centre, Charlottetown, Prince Edward Island, C1A 7M8, Contribution No. 862.
E-mail: kimpinskij@em.agr.ca
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ion as plots that received treatments of granular fosthiazate. The seed pieces were placed in open rows, the fosthiazate treatments were applied, and the seed pieces were covered. During July 1991 and August 1994, deltamethrin insecticide was applied at the recommended rate to foliage in all plots for control of Colorado potato beetles (*Leptinotarsa decemlineata*) and potato flea beetle (*Epitrix cucumeris*). In July 1992 and early August 1993, deltamethrin and azinphos-ethyl were applied to foliage for insect control to half the site as the main plots in a split-plot design to ascertain if interactions occurred between foliar treatments and soil applications of fosthiazate.

On 19 June 1991, Superior and Russet Burbank seed pieces were planted. Fosthiazate 10% granular or 900 EC formulations were applied in the furrow 5 cm to one side of the tubers at rates of 0.77, 0.98, and 1.42 kg a.i./ha. The experimental design was a randomized complete-block with four replicates in which the seven nematicide treatments (includes untreated check) and the two potato cultivars were investigated simultaneously.

On 28 May 1992, Superior seed pieces were planted and fosthiazate 10% granular was applied in the furrow 5 cm to one side of the tubers at rates of 0.77 or 1.42 kg a.i./ha. For treatments with the liquid, fosthiazate 900 EC formulation was applied in a 10-cm band (split in parallel 5-cm bands on each side of the row) at 0.77 and 1.42 kg a.i./ha, or in a 20-cm band (split into parallel 10-cm bands on each side of the row) at 1.42 and 2.94 kg a.i./ha. Aldicarb 15% granular and phorate 15% granular were applied in-furrow 5 cm to one side of the tubers at 2.24 and 3.69 kg a.i./ha, respectively, at planting. The experimental design was a split-plot with three replicates in which the foliar treatments of deltamethrin followed by azinphos ethyl applied to half the site were the main plots and the nine soil treatments (includes untreated check) were the subplots.

On 15 June 1993, the 900 EC formulation of fosthiazate was broadcast at five levels (2.5, 3.4, 5.0, 6.7, or 13.5 kg a.i./ha) and rototilled to a depth of 20 cm. On 16 June 1993, Superior seed pieces were planted, and the 2.5- and 3.4-kg a.i./ha levels were then followed by a 20-cm band treatment (split into parallel 10-cm bands on each side of the row) at 2.5 and 3.4 kg a.i./ha, respectively. The 900 EC formulation at 1.42 kg a.i./ha was applied at planting in a 20-cm band (split into parallel 10-cm bands on each side of the row), and a similar rate of the 10% granular formulation was applied in the furrow 5 cm to one side of the tubers. Aldicarb 15% granular and phorate 15% granular were applied in the furrow 5 cm to one side of the tubers at 2.24 and 3.69 kg a.i./ha, respectively, at planting. The foliar applications of deltamethrin and azinphos and the experimental design were the same as in 1992.

On 16 June 1994, the 900 EC formulation of fosthiazate was broadcast on plots at rates of 4.5, 6.7, and 7.5 kg a.i./ha, and rototilled to a depth of 20 cm. Superior was planted on 17 June 1994, and fosthiazate 10% granular or aldicarb 15% granular was applied in the furrow 5 cm to one side of the tubers at 0.77 and 2.24 kg a.i./ha, respectively. The experimental design was a randomized complete-block with six treatments (including untreated check) and four replicates.

Soil nematode populations in each plot were assayed from a composite sample of 15 cores (2.5-cm diam. and 20 cm deep) taken from the outside rows 2 weeks before harvest. A 50-g subsample was placed in a modified Baermann funnel (Barker, 1985) at 22 °C. Nematodes in roots were assayed by placing 10 g of fresh roots from each sample in a mist chamber (Hooper, 1986) at 22 °C. Emerged nematodes were counted after seven days. A sample of unprocessed soil and the processed root sample were dried for 48 hours at 100 °C and numbers of nematodes were expressed per kilogram of dry soil or per gram of dry root. Harvest dates were 24, 14, 8, and 7 October from 1991 to 1994, respectively.

Data were transformed to $\log_{10}(x + 1)$ for analyses of variance (Snedecor and Cochran, 1989) to assess effects of the chemical treatments on tuber yields and nematode populations. Treatment sums of squares were partitioned into single-degrees-of-freedom orthogonal contrasts to examine differences between treated and untreated plots, and between plots treated with either granular or emulsifiable concentrate formulations of fosthiazate (Steel and Torrie, 1960). Since the treatment levels and methods of application varied each year, the data from each year were analyzed separately.

Results

In 1991, tuber yields were greater in plots treated with the 10% granular or 900 EC formulations of fosthiazate at 0.77 kg/ha than in untreated plots (Table 1). The single-degrees-of-freedom orthogonal contrast analysis indicated that tuber yields were significantly higher and nematode populations were lower in the treated plots than in untreated plots (Table 1,C1). In addition, the nematode numbers were reduced more by the emulsifiable concentrate treatments than by the granular treatment (Table 1,C2).

In 1992, nematode populations in roots were lower in treated plots than in untreated plots, but tuber yields and nematode populations in soil did not respond to the treatments (data not shown).

In 1993, tuber yields were higher in five of the fosthiazate emulsifiable concentrate treatments and in the aldicarb treatments than in the untreated plots (Table 2). Nematode counts in roots, with the exception of the phorate treatment, were lower in treated plots. In soil, the fosthiazate granular treatment and the aldicarb and phorate treatments did not reduce nematode numbers significantly. The split applications consisting of a broadcast treatment followed by row treatment did not show an improvement over the other treatments applied at one time. The orthogonal contrast analysis indicated that tuber yields were higher and nematode populations were smaller in treated plots than in untreated plots (Table 2,C1), and that the EC formulations of fosthiazate were more efficient than the granular formulation (Table 2,C2). There was no interaction between the foliar insecticide treatments and the nematicide treatments.

In 1994, the orthogonal contrast analysis indicated that nematode populations were smaller in treated plots than in untreated plots (Table 3,C1). Also, tuber yields were greater and nematode populations were smaller in plots receiving the EC formulation than in plots treated with the granular formulation (Table 3,C2).

Discussion

The significant tuber yield increases in 2 of 4 years, and the consistent suppression of nematode populations when fosthiazate was

Table 1. Effect of fosthiazate treatments on potato tuber yields and numbers of *Pratylenchus penetrans*, 1991.

Treatment[a]	Rate (kg a.i./ha)	Total yield[b] (mt/ha)	Numbers of nematodes[c]	
			Per gram of root	Per kilogram of soil
Check	0	39.1 b[d]	12,970 a	26,980 a
10 G	0.77	44.3 a	7,940 ab	19,500 ab
10 G	0.98	39.8 b	4,100 bcd	10,890 b
10 G	1.42	42.1 ab	5,560 abc	18,280 ab
900 EC	0.77	44.3 a	2,400 cd	1,820 cd
900 EC	0.98	41.1 ab	960 e	2,180 c
900 EC	1.42	41.9 ab	1,650 de	880 d
Significant contrasts ($P \leq 0.05$)[e]		C1	C1, C2	C1, C2

[a] Applied in the furrow on June 19 at planting 5 cm to the side of tubers as a 10% granular (10 G), or as a 90% emulsifiable concentrate (900 EC).

[b] Data combined from Russet Burbank and Superior cultivars (cultivar × treatment interaction not significant).

[c] Nematode data were obtained 2 weeks prior to harvest on October 24 and are back-transformed means. Each number is the mean of eight replicates.

[d] Means within a column followed by the same letter are not different ($P \leq 0.05$) according to Duncan's multiple-range test.

[e] C1 = untreated vs. mean of other treatments; C2 = granular vs. emulsifiable concentrate.

TABLE 2. Effect of nematicide treatments on Superior potato tuber yields and numbers of *Pratylenchus penetrans*, 1993.

Treatment[a]	Rate (kg a.i./ha)	Total yield (mt/ha)	Numbers of nematodes[b]	
			Per gram of root	Per kilogram of soil
Check	0	31.1 d[c]	9,730 a	4,020 a
Fosthiazate 10 G	1.42	36.5 cd	1,180 b	3,250 a
Fosthiazate 900 EC B20	1.42	31.6 d	140 cd	250 c
Fosthiazate 900 EC BC	5.00	41.8 abc	110 cd	630 bc
Fosthiazate 900 EC BC	6.70	44.9 ab	110 cd	550 bc
Fosthiazate 900 EC BC	13.50	46.4 a	90 d	350 c
Fosthiazate 900 EC 2.5 BC + 2.5 R[d]	5.00	40.2 bc	280 c	670 bc
Fosthiazate 900 EC 3.4 BC + 3.4 R[d]	6.80	41.3 abc	300 c	350 c
Aldicarb 15 G	2.24	40.7 abc	210 cd	2,050 ab
Phorate 15 G	3.69	33.9 d	5,260 a	1,920 ab
Significant contrasts ($P \leq 0.05$)[e]		C1, C2	C1, C2	C1, C2

[a] Applied in the furrow at planting on June 16 as a 10% granular (10 G) or 15% granular (15 G), and as a 90% emulsifiable concentrate (900 EC) in parallel, 10-cm (B20) bands 5 cm to the side of tubers, or broadcast (BC) and worked into the soil 1 day prior to planting.
[b] Nematode data were obtained 2 weeks prior to harvest on October 8 and are back-transformed means (n = 6).
[c] Means within a column followed by the same letter are not different ($P \leq 0.05$) according to Duncan's multiple-range test.
[d] Split application of BC worked into the soil 1 day prior to planting and followed the next day by a row treatment (R) 5 cm to the side of tubers.
[e] C1 = untreated vs. mean of other treatments; C2 = granular vs. emulsifiable concentrate.

applied indicated that this chemical should be useful in the management of nematodes in potato fields in the Maritime region. The emulsifiable concentrate formulation should be preferred since it suppressed nematode populations more efficiently than the granular formulation. The higher rates of fosthiazate did not result in consistent tuber yield improvements and better suppression of nematodes than the lower rates, and the additional expense may not justify the added input.

In general, fosthiazate was as good as aldicarb for increasing potato tuber yields and decreasing nematode populations. Previous work showed that aldicarb suppressed nematode populations and increased crop yields in the Maritime region of Canada (Kimpinski and Johnston, 1995; Kimpinski and Sanderson, 1989). However, aldicarb and its me-

TABLE 3. Effect of nematicide treatments on Superior potato tuber yields and numbers of *Pratylenchus penetrans*, 1994.

Treatment[a]	Rate (kg a.i./ha)	Total yield (mt/ha)	Numbers of nematodes[b]	
			Per gram of root	Per kilogram of soil
Check	0	32.8 ab[c]	2,820 a	19,010 a
Fosthiazate 10 G	0.77	33.1 ab	1,170 ab	10,890 ab
Fosthiazate 900 EC BC	4.50	39.1 ab	130 c	5,600 b
Fosthiazate 900 EC BC	6.70	38.4 ab	90 c	5,140 b
Fosthiazate 900 EC BC	7.50	40.0 a	110 c	4,160 b
Aldicarb 15 G	2.24	32.3 b	310 bc	7,550 ab
Significant contrasts ($P \leq 0.05$)[d]		C2	C1, C2	C1, C2

[a] Applied in the furrow on 17 June at planting 5 cm to the side of tubers as 10% granular (10 G) or 15% granular (15 G) formulations, or as 90% emulsifiable concentrates (900 EC) broadcast and worked into the soil 1 day prior to planting.
[b] Nematode data were obtained 2 weeks prior to harvest on October 7 and are back-transformed means (n = 4).
[c] Means within a column followed by the same letter are not different ($P \leq 0.05$) according to Duncan's multiple-range test.
[d] C1 = untreated vs. mean of other treatments; C2 = granular vs. emulsifiable concentrate.

tabolites have been found in groundwater at a few locations in eastern Canada (Anonymous, 1987), and the use of this pesticide is now restricted (Kimpinski and Thompson, 1990). Aldicarb is also acutely toxic to mammals (Marshall, 1985), while, in comparison, fosthiazate is less toxic to mammals and safer to use (Woods et al., 1991). We conclude that fosthiazate should be an asset for potato production and a suitable alternative to aldicarb in the Maritime region of Canada.

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