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# Effects of Fenamiphos on *Pratylenchus penetrans* and Growth of Apple[1]

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*Abstract:* A 3-year study was conducted to evaluate fenamiphos at 20.2 kg a.i./ha applied in both fall and spring or in spring only for the control of *Pratylenchus penetrans* on apple, *Malus domestica* cv. Granny Smith on M7a rootstock. The initial population densities of *P. penetrans* within the plot area were 89/250 $cm^3$ soil and 268/g root dry weight. Fenamiphos increased ($P < 0.05$) trunk diameter in years 2 and 3 and shoot length in years 1 and 2. Yield data obtained in year 3 showed that the spring only and the fall plus spring fenamiphos treatments increased ($P < 0.05$) yields by 36 and 80% with a net gain of $2,352 and $5,456/ha, respectively. Results suggest that *P. penetrans* may be of economic importance in Washington state.

*Key words:* apple, chemical control, fenamiphos, lesion nematode, *Malus domestica,* nematode control, *Pratylenchus penetrans.*

Pratylenchus penetrans (Cobb) Filipjev & Schuurmans Stekhoven is the most important nematode pest affecting apple (*Malus domestica* Borkh.) production worldwide (8). In the United States and Canada, growth and yield increases have been reported following control of *P. penetrans* (10–12). *Pratylenchus penetrans* is widely distributed in the major apple growing areas of Washington and has been associated with orchards exhibiting poor growth and yields (Santo, unpubl.). Fenamiphos, which is the only chemical registered for nematode control on bearing apples in Washington, has been reported to be effective in reducing *P. penetrans* soil and (or) root populations on apples in Canada and the northeastern United States (1,5,10,13). This study was undertaken to determine the efficacy of fenamiphos as a control agent for *P. penetrans* on apple, *M. domestica* cv. Granny Smith on M7a rootstock.

## MATERIALS AND METHODS

In the fall of 1986, plots were established in a commercial orchard in Mattawa, Washington, in which a block (ca. 8 ha) of 3-year-old Granny Smith apples on M7a rootstock was heavily infected with *P. penetrans* and exhibited severe stunting. An adjacent block of trees in the same field consisting of the same planting stock appeared normal in growth and the roots contained only a trace population of *P. penetrans.* The uniformity of stunted trees in the affected area, however, was not typical of damage caused by nematodes. The stunted trees may have been stressed by other factor(s), thereby increasing the susceptibility of the trees to the nematodes, although factors such as rootstock, cropping sequence, pesticide residue, soil type, soil chemistry, nutrition, and disease micro-organisms could not be associated with this problem area.

The soil texture was a loamy sand (81.6% sand, 17.0% silt, 1.4% clay; pH 6.9, 0.50% organic matter). Plots were irrigated with overhead sprinklers and maintained according to standard cultural practices (2).

Each plot consisted of a single row of 20 trees spaced 2.44 m apart. Rows were spaced 4.88 m apart. Each treatment was arranged in a randomized complete block with four replicates. A liquid formulation of fenamiphos was applied at 20.2 kg a.i./ha (184 g a.i/100 m in a band 0.91 m wide) in both the fall and following spring, and in spring only. Fenamiphos was applied with a pressurized power sprayer in 374 liters water/ha in a 91-cm band on both sides of the row and incorporated with 2.5 cm water within 48 hours after application. Consequently, 37.5% of each hectare was treated. Untreated plots served as controls. Applications were made each year from fall 1986 to spring 1989. Fall applications

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TABLE 1. Trunk diameter and shoot length of apple, *Malus domestica* cv. Granny Smith on M7a rootstock, 1987–89.

| Treatment† | Trunk diameter (cm) | Annual trunk diameter increase (cm) | Shoot length (cm) |
|---|---|---|---|
| | 1987 | | |
| 0 | 4.62 a | | 53.3 b |
| S | 4.88 a | | 62.2 a |
| F + S | 4.62 a | | 65.3 a |
| | 1988 | | |
| 0 | 5.24 b | 0.62 b | 75.6 b |
| S | 5.73 a | 0.85 ab | 82.4 a |
| F + S | 5.74 a | 1.12 a | 82.7 a |
| | 1989 | | |
| 0 | 6.15 b | 0.91 a | 47.3 a |
| S | 6.85 a | 1.12 a | 41.3 a |
| F + S | 6.83 a | 1.09 a | 48.1 a |

Values are means of four replicates (20 trees/replicate). Values in columns followed by the same letter do not differ at $P < 0.05$ according to Duncan's multiple-range test.

† Fenamiphos applied at 20.2 kg a.i./ha in a 91-cm band on both sides of the row (184 g a.i./100-m band). S = spring application; F = fall application; 0 = untreated control.

were made in November, and spring applications were made 15 April to 1 May after budbreak but before full bloom, when young actively growing roots were present (14).

Nematode soil and root samples were taken before treatments and after harvest. Samples were collected by removing the top 5 cm of soil and sampling with a shovel to a depth of 30 cm. At each sampling date, 10 trees not used in previous sampling were sampled at the drip-line. Soil was thoroughly mixed and nematodes were extracted from 250 $cm^3$ soil using a semiautomatic elutriator (4) and centrifugal flotation (9). The roots were washed free of soil, cut into 1 cm pieces, and placed in a mist chamber; nematodes were collected once a week for 2 weeks. After nematode extraction, roots were dried and weighed. Measurements of trunk diameter and shoot length were made after harvest each year. Trunk diameter was measured 30 cm above the soil surface, and shoot length was measured on 10 random shoots per tree. Because of low fruit production in 1987 and 1988, yields were measured only in 1989.

## RESULTS AND DISCUSSION

Trees in the fenamiphos-treated plots had greater ($P < 0.05$) trunk diameters than did untreated trees in years 2 and 3 after the first application; however, differences in annual increases in trunk diameter were not observed in year 3 (Table 1). In previous trials with annual applications of fenamiphos on older apple trees infected with *P. penetrans*, significant increases in trunk diameter were not observed until year 3 (Santo, unpubl.). Significant ($P < 0.05$) differences in shoot growth were observed in years 1 and 2 but not 3 (Table 1). The lack of difference in the annual increase in trunk and shoot growth in 1989 could be attributed to the greater allocation of plant resources toward yield production in the fenamiphos treatments (14) (Table 2).

Apple yields were significantly ($P < 0.05$)

TABLE 2. Yield and net return of apple, *Malus domestica* cv. Granny Smith on M7a rootstock, 1989.

| Treatment† | Yield (t/ha) | Gross return ($/ha)‡ | Treatment cost ($/ha)§ | Net return ($/ha) | Net gain ($/ha) |
|---|---|---|---|---|---|
| 0 | 14.46 c | 8,922 | 0 | 8,922 | 0 |
| S | 16.62 b | 12,106 | 832 | 11,274 | 2,352 |
| F + S | 26.00 a* | 16,042 | 1,664 | 14,378 | 5,456 |

Values are means of four replicates (20 trees/replicate). Values followed by the same letter do not differ at $P < 0.05$ according to Duncan's multiple-range test.

* Differs from untreated at $P < 0.01$.

† Fenamiphos applied at 20.2 kg a.i./ha in a 91-cm band on both sides of the row (184 g a.i./100-m band). S = spring application; F = fall application; 0 = untreated control.

‡ Price grower received for Granny Smith apples in 1988 was $617/t.

§ Three annual applications (each 21 liters/ha) of fenamiphos at $13.21/liter.

TABLE 3. Population density of *Pratylenchus penetrans* in roots on different sampling dates from apple, *Malus domestica* cv. Granny Smith on M7a rootstock, 1986–89.

| | *Pratylenchus penetrans*/g root dry weight | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1986 | 1987 | | 1988 | | 1989 | |
| Treatment† | Oct | May | Nov | Apr | Nov | May | Oct |
| 0 | 233 a | 68 a | 74 a | 231 a | 136 a | 146 a | 106 a |
| S | 161 a | 106 a | 65 a | 170 a | 184 a | 199 a | 170 a |
| F + S | 162 a | 21 a | 36 a | 11 b | 123 a | 80 a | 198 a |

Values are means of four replicates. Values in columnns followed by the same letter do not differ at $P < 0.05$ according to Duncan's multiple-range test. Data were transformed to log (x + 1).

† Fenamiphos applied at 20.2 kg a.i./ha in a 91-cm band on both sides of the row (184 g a.i./100-m band). S = spring application; F = fall application; 0 = untreated control.

increased 36% by the spring only treatment and 80% by the fall plus spring fenamiphos treatment in year 3 (Table 2). The application of fenamiphos both in the fall and spring resulted in 32% higher yields than the spring only treatment and more than doubled the net return (Table 2).

Except for 1988, differences ($P < 0.05$) in nematode population densities between the treatments were not evident (Tables 3, 4). More differences may have been observed, especially in the roots, if nematode samples had been taken at midseason. Depending on the type of soil, organophosphates such as fenamiphos have half-lives of 1 week to 2 months (6). Homeyer (7) reported that in humic sandy soil, 10 kg a.i. fenamiphos/ha provided effective control of *Meloidogyne incognita* for up to 3–4 months in the field. At field concentrations fenamiphos is not known to kill nematodes directly, and nematodes may be able to recover from the initial effects of the chemical and resume normal activity (3). Consequently, nematode population densities taken at the end of the growing season may not be an accurate measurement of control.

The results of this study indicate that fenamiphos applications improve growth and yield of *P. penetrans*-infected apples in Washington. Additional studies are needed to compare registered, lower rates and multiple applications of fenamiphos and to determine the effects of soil type, rootstocks, and the volume of irrigation water required after application to optimize control.

TABLE 4. Population density of *Pratylenchus penetrans* in soil on different sampling dates from apple, *Malus domestica* cv. Granny Smith on M7a rootstock, 1986–89.

| | *Pratylenchus penetrans*/250 cm³ soil | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1986 | 1987 | | 1988 | | 1989 | |
| Treatment† | Oct | May | Nov | Apr | Nov | May | Oct |
| 0 | 126 a | 393 a | 20 a | 170 a | 73 a | 40 a | 63 a |
| S | 71 a | 311 a | 4 a | 15 b | 33 ab | 16 a | 82 a |
| F + S | 71 a | 126 a | 0 a | 2 b | 12 b | 29 a | 68 a |

Values are means of four replicates. Values in columns followed by the same letter do not differ at $P < 0.05$ according to Duncan's multiple-range test. Data were transformed to log (x + 1).

† Fenamiphos applied at 20.2 kg a.i./ha in a 91-cm band on both sides of the row (184 g a.i./100-m band). S = spring application; F = fall application; 0 = untreated control.

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