Control of Dagger and Lesion Nematodes in Apple and Plum Orchards with Fenamiphos, Carbofuran, and Carbosulfan

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ABSTRACT

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The effectiveness of fenamiphos, carbofuran, and carbosulfan for controlling dagger nematodes was evaluated for 2 yr in a bearing Delicious/MM.106 apple orchard. Carbofuran and fenamiphos were also compared over 5 yr in a newly established plum orchard. Nematicides were applied both to bare herbicide-treated ground beneath trees and to sod. When applied to bare ground, fenamiphos did not reduce *Xiphinema* sp. populations in either orchard but was effective against *Pratylenchus* sp. Conversely, carbofuran and carbosulfan applied to bare ground in the apple orchard reduced mean *Xiphinema* populations from 56 to fewer than two per 100 cm^3 of soil but failed to control *Pratylenchus*. Fenamiphos and carbofuran applied to sod in the apple orchard were effective against both nematode species. Annual applications of carbofuran in the plum orchard kept *Xiphinema* populations below two per 100 cm^3 soil in sod and below three per 100 cm^3 in the herbicide strip until the fifth year, when the latter population reached 15. Carbofuran treatments suppressed apple yield during the second year but had no significant effect on total apple production over a 3-yr period.

In the eastern United States, tomato ringspot virus (TmRSV) is transmitted by *Xiphinema americanum* Cobb (21) and *X. rivesi* Dalmasso (6). Large populations of these dagger nematodes are often present in fruit orchards (1,17), and numerous weed species commonly found in orchards can serve as TmRSV reservoirs (14,15). TmRSV causes apple union necrosis and decline (AUND) in some apple cultivars propagated on MM.106 rootstock (19,20) and brown line or Stanley constriction disease on plums (*Prunus domestica* L.) propagated on myrobalan (*P. cerasifera* Ehrh.) rootstock (3,11). Both diseases can kill affected trees. Losses to AUND and plum brown line can be avoided by selecting trees propagated on rootstocks resistant to TmRSV. Other control tactics are needed, however, to protect the many existing orchards planted with TmRSV-susceptible rootstocks.

In this study, postplant nematicides were evaluated for their effectiveness in reducing populations of the virus vectors *X. americanum* and *X. rivesi* in a commercial apple orchard and an experimental plum orchard. *Pratylenchus* populations were also monitored in the test orchards because *Pratylenchus* sp. (primarily *P. penetrans* Cobb) are the most common plant-parasitic nematode species in orchards and are known to restrict tree growth (8). Preliminary results from part of this work were reported earlier (18).

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MATERIALS AND METHODS

Test sites. A commercial orchard planted in 1974 with the apple cultivar Redchief Delicious on MM.106 rootstock was chosen for this trial because of the high nematode levels found in the orchard during a previous survey (17). Numerous trees in one end of the orchard were infected with TmRSV, but the portion of the orchard used for this experiment contained few trees with symptoms of AUND. Graft unions of all the trees were checked before the experiment was initiated and trees showing AUND symptoms were not included in the trial. The orchard soil was a well-drained Bath-Nassau complex of gravelly and shaley silt loam (22). Treatments were applied to single tree plots arranged in a randomized-block design with five replicates for each treatment and 10 replicates (two per block) for the control. Plots were 2.1 × 4.2 m with the long axis perpendicuar to the tree row and extending at least 1.2 m into the sod row middle on one side of the tree. The sod portions of the test plots were used to determine whether nematicidal activity on sod was similar to that on relatively bare, herbicide-treated ground. The grower kept the strip beneath the trees weedfree by using annual applications of paraquat and simazine. Some weeds persisted throughout the year, and surface weed coverage within the herbicide strip gradually increased from approximately 10% in spring to 40% by fall. Nematicides tested were carbofuran (Furadan 4F and Furadan 15G), carbosulfan (Advantage 4EC and Advantage 15G), and fenamiphos (Nemacur 3S).

The plum trees used in this study were interplanted 13 April 1982 in a 4-yr-old Stanley plum orchard where trees showed typical symptoms of Stanley constriction disease (3). The orchard soil type was Bath gravelly silt loam (22). Treatments were applied to two-tree plots, each containing one Oullins and one NY 56.713.1 plum, both on myrobalan rootstocks. Planting holes were dug with an auger without otherwise working the soil. Three nematicide treatments and two groundcover management strategies were tested in a factorial design with four replicates. Treatments were applied to a 1.5 × 1.5 m area around each tree for the first 3 yr and to a 2.1 × 2.1 m area in subsequent years.

Treatments and application methods. Plots in both orchards were measured and the corners were marked before nematicides were applied. Liquid nematicide treatments were applied with a pressurized 8-L hand sprayer using the equivalent of 300 L of solution per treated hectare. Granular nematicides were measured in small calibrated vials, and the materials were sprinkled uniformly over the entire plot area. None of the nematicides were allowed to contact tree limbs or foliage.

In the apple orchard, nematicide treatments were applied to the same plots on 7 May 1982 and 29 April 1983. None of the nematicides were incorporated into the soil except the granular nematicides applied to the herbicide strip in 1982. These were lightly incorporated with a garden rake immediately after application. The first rain (0.40 cm) occurred 12 days after the 1982 treatments were applied. The 1983 treatments were followed within 12 hr by 0.25 cm of rain and within the subsequent 3 days by another 0.43 cm of rain.

In the plum orchard, carbofuran, fenamiphos, and an untreated control were compared on trees growing in a grass-and-weed sod and on trees growing in a strip treated with herbicide. Carbosulfan (Advantage 4L) was used instead of carbofuran in 1982. Nematicide application and subsequent rainfall dates for the plum orchard were 27 April 1982 (0.2 cm rain within 24 hr after treatment), 3 June 1983 (3.0 cm within 12 hr), 22 May

1984 (0.6 cm within 36 hr), 9 May 1985 (0.1 cm within 80 hr), and 29 May 1986 (2.2 cm within 65 hr). Treatments were incorporated with a garden rake in 1982 but not in subsequent years. Herbicide treatments consisted of paraquat and oryzalin applied in spring, followed by paraquat treatments as needed. Glyphosate was applied to resistant weeds persisting into late summer. Weed coverage in the herbicide-treated plum plots was less than 10% of the surface area. Plots not treated with herbicides contained a ground cover of mixed broad leaves and grasses, with the latter increasing in dominance each year. The sod plots were mowed with a lawn mower several times each season.

Data collection and analysis. Nematode samples were collected from the herbicide-treated section of each single-tree apple plot on 19 July 1982 and on 7 October 1983. On the latter date, 2–5 g of apple roots were collected from each tree and a sample was also collected from the sod section of each apple plot. Each soil sample was a composite from three random sites within the sample area. The 1983 apple root samples were collected from at least two sites near the trunk of each tree. In the plum orchard, nematode samples consisting of composites from two sites beside each of the two trees were collected from each plot on 30 July 1982, 2 November 1983, 29 October 1985, and 30 October 1986. In both orchards, a spade was used to expose the soil profile down to 15 cm below the surface and a trowel was used to collect a sample across the lower 10 cm of the exposed profile.

Nematodes were extracted and counted at the Cornell Nematode Diagnostic Laboratory. *Xiphinema* spp. were extracted by sugar-flotation centrifugation. *Pratylenchus* spp. were extracted from soil by the Baermann tray method and from roots by shaking root samples in 100 ml of tap water for 72 hr (12). Nematodes were not identified to species. However, *P. penetrans* is known to be the most common *Pratylenchus* species in New York orchards (1,8). Mixtures of *X. americanum* and *X. rivesi* have been identified in several Hudson Valley orchards, but in 1981 all of the 67 *Xiphinema* taken from five locations in the apple orchard used for this experiment were identified as *X. americanum* (L. B. Forer, *personal communication*). The $\log_{10}(X + 0.5)$ transformation was used for all statistical analyses of nematode count data. Mean separations for transformed data were determined using the modified LSD (separations determined only if F is significant, $P = 0.05$). Factorial analyses (three herbicide treatments $\times$ two ground covers) were used for data from the plum orchard.

Trunk diameters in the apple block were measured before initiation of the experiment in April 1982. In 1982, 1983, and 1984, total fruit weight was determined for each plot by harvesting all fruit from each treated tree and from one control tree in each replicate. Harvest data were statistically analyzed using the April 1982 trunk cross-sectional area as a covariant in the statistical analyses and mean separations were determined using the modified LSD.

RESULTS

Carbofuran and carbosulfan were better than fenamiphos for controlling *Xiphinema* within the herbicide-treated strip in the apple orchard (Table 1). Both

Table 1. Effects of postplant nematicides applied in spring of 1982 and 1983 on populations of *Xiphinema americanum* and *Pratylenchus* sp. nematodes in sod and in herbicide-treated strips beneath apple trees

	Number of nematodes per 100 cm³ of soil						Number of *Pratylenchus*/g of apple roots
	X. americanum			*Pratylenchus* sp.			
	Herbicide strip		Sod	Herbicide strip		Sod	
Nematicide and rate (a.i.)/ha	1982	1983	1983	1982	1983	1983	1983
Control	56 c[z]	49 b	72 c	35 b	57 b	115 d	33 a
Carbofuran (Furadan 4F), 11.2 kg	10 a	2 a	3 ab	4 a	25 b	2 a	47 b
Carbofuran (Furadan 15G), 11.2 kg	10 a	1 a	1 a	15 b	43 b	4 a	28 b
Carbosulfan (Advantage 4EC), 11.2 kg	15 ab	1 a	3 ab	20 b	40 b	22 bc	13 b
Carbosulfan (Advantage 15G), 11.2 kg	34 bc	3 a	19 bc	27 b	34 b	80 cd	12 ab
Fenamiphos (Nemacur 3S), 16.8 kg	40 bc	52 b	3 ab	2 a	2 a	5 ab	1 a

[z] Mean separations were determined from the LSD ($P = 0.05$) for $\log_{10}(X + 0.5)$ transformed data. Means presented are retransformed ([inverse $\log_{10} X$]−0.5). Numbers within columns followed by the same letter do not differ significantly.

Table 2. Effects of ground cover and annual nematicide applications on populations of *Xiphinema* and *Pratylenchus* sp. nematodes in a plum orchard

	Number of *Pratylenchus*/100 cm³ of soil		Number of *Xiphinema*/100 cm³ of soil			
Nematicide and rate (a.i.)/ha	1982	1983	30 July 1982	2 Nov. 1983	29 Oct. 1985	30 Oct. 1986
Grand means for nematicide						
Control	5.2 b[x]	4.5 b	1.4	1.4	8.0	38.4 b
Fenamiphos (Nemacur 3S), 16.81 kg	0.5 a	0.3 a	0.4	4.4	18.6	43.2 b
Carbofuran (Furadan 4F),[y] 6.73 kg	0.9 a	2.8 b	0.9	1.2	2.3	4.0 a
Grand means for ground cover						
Treatments applied to sod	0.9	4.3 B	0.9	1.5	3.0 A	7.6 A
Treatments applied to herbicide-treated strip	2.5	0.6 A	0.7	2.7	16.5 B	47.4 B
Observed F values[z]						
Nematicide effects	6.34*	4.33*	1.47	1.73	3.46	6.69*
Ground cover effects	3.40	6.81*	0.22	0.85	7.11*	9.57*
Nematicide/ground cover interaction	1.94	1.75	2.80	2.57	1.17	0.45

[x] The $\log_{10}(X + 0.5)$ transformation was used for statistical analyses. Mean separations were determined for transformed means using LSD ($P = 0.05$). Means presented are retransformed ([inverse $\log_{10} X$]−0.5). Means for nematicide or for ground cover within columns and followed by the same letter do not differ significantly.

[y] Carbosulfan (Advantage 4L) was used instead of carbofuran in 1982.

[z] The required F ($P = 0.05$) is 3.68, 4.54, and 3.68 for nematicide effects, ground cover effects, and interaction effects, respectively. Observed F values indicating significant differences between means are followed by asterisks.

formulations of carbofuran caused a more rapid decrease in *Xiphinema* populations than did the 15G formulation of carbosulfan. After two seasons, however, *Xiphinema* populations were similar for all carbofuran and carbosulfan treatments. Fenamiphos was ineffective against *Xiphinema* when applied to the herbicide-treated strip but was just as effective as carbofuran when applied to sod. Comparison of *Pratylenchus* numbers extracted from apple roots in 1983 showed nematicides had similar effects on populations in apple roots and in the soil surrounding the herbicide-treated strip.

Effectiveness of carbofuran and fenamiphos against *Pratylenchus* (as measured by recovery from soil) was the reverse of their effectiveness against *Xiphinema*. In the herbicide-treated plots, fenamiphos was more effective against *Pratylenchus* than any other treatment except carbofuran 4F in 1982. In the sod plots, fenamiphos and both formulations of carbofuran were equally effective against *Pratylenchus*.

In the plum orchard, populations of both *Xiphinema* and *Pratylenchus* were low in 1982 when trees were planted (Table 2). *Pratylenchus* populations were not monitored after 1983 because the impact of this nematode is expected to be greatest on young trees. *Xiphinema* populations increased gradually in most treatments, but unusually large increases occurred in herbicide/fenamiphos plots between 1983 and 1985 (11 vs. 80 nematodes per 100 cm^3) and in herbicide/control plots between 1985 and 1986 (15 vs. 90 nematodes per 100 cm^3). *Xiphinema* populations remained below two per 100 cm^3 of soil in sod/carbofuran plots and below three per 100 cm^3 in herbicide/carbofuran plots until the fifth year, when the latter population reached 15. By 1985, *Xiphinema* populations were consistently higher for treatments in herbicide-treated plots than for corresponding treatments in sod plots. Carbofuran applied to sod effectively controlled *Xiphinema* through 1986.

Nematicide treatments caused no significant differences in apple tree growth as determined by statistical analyses of changes in trunk diameter from April 1982 to harvest in 1983. Apple yield fluctuated greatly from year to year because trees were overcropped in 1983 and therefore had a poor return bloom in 1984. None of the nematicide-treated plots had significantly higher yields than the control plots in 1982 or 1983 (Table 3). However, carbofuran 4F suppressed yield in 1982 and carbofuran 15G did the same in 1983. Although 1984 yields in the carbofuran treatments were higher than in the controls, the yield difference can be attributed to the suppressed yield in the carbofuran treatments in 1983 and the resulting better fruit set in 1984. Treatments had no significant effect on total yield over the 3 yr from 1982 through 1984.

DISCUSSION

In our experiments, fenamiphos was less effective than carbofuran for controlling *Xiphinema* except when it was applied to sod in the apple orchard. Other researchers (13) have also reported that fenamiphos is ineffective against *Xiphinema*. The increased *Xiphinema* control achieved with fenamiphos applied to sod is of no practical value because most apple and plum growers maintain an herbicide strip beneath trees and because the current fenamiphos label requires this nematicide to be incorporated into soil either by mechanical cultivation or by sprinkler irrigation. Mechanical incorporation would be feasible in a strip but not in sod, and most eastern growers do not have access to sprinkler irrigation.

Carbofuran would be effective for reducing *Xiphinema* populations in orchards but is not currently registered for use on apples or plums. However, carbofuran did not completely eliminate *Xiphinema* populations even where applied yearly from the time of orchard establishment. Thus, regular use of carbofuran might reduce the probability of *Xiphinema*-vectored transmission of TmRSV, but the small numbers of *X. americanum* or *X. rivesi* surviving carbofuran treatments could still effect a low rate of virus transmission. In our test orchard, the high rate (11.2 kg/ha) of carbofuran 15G formulation had the beneficial effect of leveling out 1982 and 1983 apple yields. Other proven methods of chemically thinning apple fruit are available, however, and a nematicide-induced reduction in fruit set would usually be undesirable. The lower rate of carbofuran (6.7 kg/ha) used in the plum orchard was still effective against *Xiphinema* and might be less likely to reduce fruit set in apples. Effects of carbofuran on fruit set might also differ for apples propagated on other clonal rootstocks.

Xiphinema populations in the plum orchard increased more rapidly in herbicide-treated plots than in sod plots. In the apple orchards in this study and in an earlier survey (17), *Xiphinema* populations were higher in sod than in herbicide-treated strips. The differences noted between the apple and the plum orchards may be caused by differences in sampling years, crop host plants (apple vs. plum), herbicides (simazine vs. oryzalin), or the long-term effects of the nematicides on soil microflora and microfauna in the plum orchard where nematicides were applied for 5 consecutive years.

The effects of ground cover on the efficacy of carbosulfan and carbofuran against *Pratylenchus* and of fenamiphos against *Xiphinema* may reflect complex host-parasite-toxicant interactions. All of the nematicides we tested are considered contact materials and can inhibit or kill nematodes when applied to soil (2,5). These nematicides are also systemic in plants and have been reported to move basipetally after foliar application (4,5,7), although tests on basipetal translocation have not been consistent (2,10). Assuming basipetal translocation does occur, nematodes feeding on sprayed plants may be exposed to higher concentrations of toxicant in plant roots than would be possible when the nematicides are diluted throughout a large volume of soil. Ingestion of nematicides from treated plants may also be more lethal to nematodes than surface contact with nematicides in soil. Differences between nematicide activity in our herbicide-treated and sod plots may have occurred because foliar absorption and basipetal transport to the plant roots could have occurred in our sod plots but not where nematicides were applied to bare ground beneath trees. Carbofuran did not control *Pratylenchus* populations in apple roots (Table 1). However, root samples were not taken from sod where carbofuran would be expected to reduce root infection if it is basipetally transported and kills *Pratylenchus* feeding on foliarly treated plants.

Foliar absorption by sod plants might slow both mechanical removal of the toxicant from soil by leaching and

Table 3. Effects of nematicide applications on fruit yield over 3 yr in an apple orchard treated with postplant nematicides in spring of 1982 and 1983

	Mean yield (kg/tree)			
Nematicide and rate (a.i.)/ha	1982	1983	1984	Total
Control	78 a[y]	178 a	20 b	276[z]
Carbofuran (Furadan 4F), 11.2 kg	59 b	162 a	71 a	292
Carbofuran (Furadan 15G), 11.2 kg	67 ab	142 b	63 a	272
Carbosulfan (Advantage 4EC), 11.2 kg	74 ab	174 a	12 b	260
Carbosulfan (Advantage 15G), 11.2 kg	82 a	176 a	39 ab	297
Fenamiphos (Nemacur 3S), 16.8 kg	79 a	175 a	19 b	273

[y] Range separations were determined from the LSD ($P = 0.05$). Numbers within columns followed by the same letter do not differ significantly. Trunk cross-sectional area at the start of the trial was used as a covariant in statistical analyses of yield.

[z] The F statistic for means in this column was not significant ($P = 0.05$).

metabolic removal by soil microorganisms. Variability in effectiveness of nematicides applied to sod (as noted between our apple and our plum trials) should be expected because the plant composition of sod is highly variable and each plant species may differ in its rate of absorption, translocation, and metabolism of the toxicants and in its relative acceptability as a nematode host (4).

The differences in susceptibility of *Xiphinema* and *Pratylenchus* to the nematicides applied to herbicide-treated strips may also reflect species differences in how much of each toxicant is absorbed through the nematode cuticle. The concentration of nematicide required to inhibit motility of *P. vulnus* Allen & Jensen in aqueous suspensions is 100 times greater for carbofuran than for fenamiphos (9), whereas *Aphelenchus avenae* Bastian was equally susceptible to carbofuran and to fenamiphos in sand cultures (16). If *P. penetrans*, like *P. vulnus*, is less sensitive to carbofuran than to fenamiphos, *P. penetrans* may have encountered nematicidal concentrations of carbofuran only while feeding on treated sod. Similarly, *Xiphinema* appears less sensitive to fenamiphos than to carbofuran but may have ingested lethal doses of fenamiphos from treated plants.

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LITERATURE CITED

1. Braun, A. J., Palmiter, D. H., and Keplinger, J. A. 1966. Nematodes found in apple orchards in the Hudson Valley, 1956–1965. Plant Dis. Rep. 50:783-786.
2. Bunt, J. A. 1975. Effect and mode of action of some systemic nematicides. Meded. Landbouwhogesch. Wageningen 127 pp.
3. Cummins, J. N., and Gonsalves, D. 1986. Constriction and decline of 'Stanley' prune associated with tomato ringspot virus. J. Am. Soc. Hortic. Sci. 11:315-318.
4. DiSanzo, C. P. 1981. Effect of foliar application of carbofuran and a related compound on plant-parasitic nematodes under greenhouse and growth chamber conditions. J. Nematol. 13:20-24.
5. DiSanzo, C. P. 1982. Effect of foliar applications of carbofuran and a related compound on plant-parasitic nematodes under microplot and field conditions. J. Nematol. 14:208-212.
6. Forer, L. B., Powell, C. A., and Stouffer, R. F. 1984. Transmission of tomato ringspot virus to apple rootstock cuttings and to cherry and peach seedlings by *Xiphinema rivesi*. Plant Dis. 68:1052-1054.
7. Griffin, G. D. 1975. Control of *Heterodera schactii* with foliar application of nematicides. J. Nematol. 7:347-351.
8. Mai, W. F., Parker, K. G., and Hickey, K. D. 1970. Root diseases of fruit trees in New York State. II. Populations of *Pratylenchus penetrans* and growth of apple in response to soil treatment with nematicides. Plant Dis. Rep. 54:792-795.
9. Marban-Mendoza, N., and Viglierchio, D. R. 1980. Behavioral effects of carbofuran and phenamiphos on *Pratylenchus vulnus*. I. Motility and dispersion. J. Nematol. 12:102-114.
10. Marban-Mendoza, N., and Viglierchio, D. R. 1980. Behavioral effects of carbofuran and phenamiphos on *Pratylenchus vulnus*. III. Penetration and development. J. Nematol. 12:119-129.
11. Mircetich, S. M., and Hoy, J. W. 1981. Brownline of prune trees, a disease associated with tomato ringspot virus infection of myrobalan and peach rootstocks. Phytopathology 71:30-35.
12. Niblack, T. L., and Hussey, R. S. 1985. Exercise 34: Extracting nematodes from soil and plant tissue. Pages 201-206 in: Plant Nematology Laboratory Manual. B. M. Zuckerman, W. F. Mai, and M. B. Harrison, eds. Univ. Mass. Agric. Exp. Stn. Amherst 212 pp.
13. Niles, R., Yoder, K. S., and Elliot, A. P. 1983. The effect of Nemacur 3S on plant parasitic nematodes and apple growth and yield in Virginia, 1982. Fungic. Nematic. Tests 38:1.
14. Powell, C. A., Forer, L. B., and Stouffer, R. F. 1982. Reservoirs of tomato ringspot virus in fruit orchards. Plant Dis. 66:583-584.
15. Powell, C. A., Forer, L. B., Stouffer, R. F., Cummins, J. N., Gonsalves, D., Rosenberger, D. A., Hoffman, J., and Lister, R. M. 1984. Orchard weeds as hosts of tomato ringspot and tobacco ringspot viruses. Plant Dis. 68:242-244.
16. Pree, D. J., Townshend, J. L., and Archibald, D. E. 1987. Sensitivity of acetylcholinesterases from *Aphelenchus avenae* to organophosphorous and carbamate pesticides. J. Nematol. 19:188-193.
17. Rosenberger, D. A., Harrison, M. B., and Gonsalves, D. 1983. Incidence of apple union necrosis, tomato ringspot virus, and *Xiphinema* vector species in Hudson Valley orchards. Plant Dis. 67:356-360.
18. Rosenberger, D. A., and Meyer, F. W. 1985. Differential reduction of *Xiphinema* and *Pratylenchus* populations in a bearing apple orchard with carbofuran, carbosulfan, and phenamiphos. (Abstr.) Phytopathology 75:1304.
19. Rosenberger, D. A., and Meyer, F. W. 1985. Development of apple union necrosis and decline in apple trees inoculated with tomato ringspot virus. (Abstr.) Phytopathology 75:1312.
20. Stouffer, R. F., and Uyemoto, J. K. 1976. Association of tomato ringspot virus with apple union necrosis and decline. Acta Hortic. 67:203-208.
21. Teliz, D., Grogan, R. G., and Lownsberry, B. F. 1966. Transmission of tomato ringspot, peach yellow bud mosaic, and grape yellow vein viruses by *Xiphinema americanum*. Phytopathology 56:658-663.
22. Tornes, L. A. 1979. Soil survey of Ulster County, New York. U.S. Dep. Agric. Soil Conserv. Serv. (with Cornell Univ. Agric. Exp. Stn.), Washington, DC. 273 pp.