Supplement to Journal of Nematology 21, No. 4S:703–706. 1989.

Effect of Fenamiphos Placement on *Tylenchulus semipenetrans* and Yield in a Florida Citrus Orchard[1]

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Abstract: Grapefruit trees on sour orange rootstock on the east coast of Florida were treated with 22.3 kg a.i./ha fenamiphos (broadcast equivalent) in 1.52-m bands extending from the dripline to beneath the canopy, in 1.52-m bands extending from the dripline toward the row middle, or left as untreated controls. During the course of the experiment, mean density of feeder roots and *Tylenchulus semipenetrans* in control plots was 3.8 and 5.8 times greater, respectively, in samples from beneath tree canopies than from 90 cm beyond the dripline on the top of beds. Population densities of *T. semipenetrans* in each zone (under canopy vs. row middle) were smallest when treatment occurred in that zone. Nematode levels beneath the canopy were 11% of control levels 19 weeks following treatment when fenamiphos was applied beneath the canopy and 52% of controls when treated at the dripline. The number of female *T. semipenetrans* per gram root weight was also reduced under the canopy by the under-canopy treatment. Fruit yield 5 months following nematicide application was not affected by treatment. Percentage change in yield between that harvest and a harvest 16 months after treatment was +17% in the under-canopy treatment, −1% in the dripline treatment, and −17% in the untreated controls.

Key words: chemical control, citrus, citrus nematode, fenamiphos, *Tylenchulus semipenetrans.*

Chemical treatment of soil to control nematode and arthropod pests is common in Florida citrus orchards. Nearly one-third (81,000 ha) of the citrus acreage was treated with aldicarb in 1985 (11) and approximately 8,100 ha were treated with fenamiphos in 1987 (Mobay Chemical Company, pers. comm.). Granular formulations of these compounds are applied in bands that are incorporated with light disking or are shanked into the soil. Mechanical incorporation of granular nematicides into the soil beneath the tree canopy is difficult with existing equipment in orchards where tree branches extend to the ground; consequently, the bands are frequently placed along the driplines of trees. Because citrus feeder roots as well as the citrus nematode, *Tylenchulus semipenetrans* Cobb, in the shallow (<1 m) soil profile are most abundant beneath the tree canopy (2,4,6), nematicide placement beyond this zone is likely to produce less overall effect than under-canopy treatment. Fewer roots are available in row middles to absorb these systemic chemicals. Chemical applications in row middles also increase losses to leaching and the potential for groundwater contamination. Chemicals translocated from the treatment band to beneath the canopy are reduced in concentration and provide a lower level of control than that achieved beneath the treated zone (L. W. Timmer, D. T. Kaplan, and L. W. Duncan, unpubl.). Thus, it is likely that the benefit to the tree resulting from treatment of the soil with systemic pesticides is dependent on proper placement.

This experiment was conducted to evaluate the efficacy of fenamiphos against *T. semipenetrans* and the yield response of citrus when the compound is applied in bands at the dripline extending either toward the row middle or toward the trunk of the tree.

MATERIALS AND METHODS

Fourteen-year-old grapefruit trees on sour orange rootstock were treated on 27 August 1986 with fenamiphos (15 G) at a broadcast equivalent rate of 22.3 kg a.i./ha. Trees were growing in double rows on bedded soil in an orchard near Fort Pierce on Florida's east coast. Tree spacing was 6 × 9.1 m. Fenamiphos was applied in a band 1.52 m wide on the soil surface and incorporated with 3 cm of rainfall within 1 hour of application so that additional surface irrigation was not applied. Treatment bands

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Received for publication 15 March 1989.

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TABLE 1. Effect of fenamiphos placement pattern on population levels of *Tylenchulus semipenetrans* in a Florida grapefruit orchard.

	Nematodes/100 cm^3 soil†		Fresh root weight (g)		Females/g root weight	
Treatment	Under canopy	Row middle	Under canopy	Row middle	Under canopy	Row middle
			14 November 86 (11 weeks post-treatment)			
Under-canopy	337 a	639	2.33	0.29	204 a	136
Row-middle	2,127 b	251	2.10	0.53	272 ab	68
Control	2,252 b	318	2.46	0.93	430 b	181
			5 January 87 (19 weeks post-treatment)			
Under-canopy	387 a	1,057	2.74	0.69	181 a	487
Row-middle	1,807 b	292	2.30	0.79	294 ab	2,324
Control	3,453 c	354	2.46	0.56	612 b	136
			13 August 87 (50 weeks post-treatment)			
Under-canopy	473 a	1,158				
Row-middle	1,322 b	978				
Control	3,505 c	964				
			18 March 88 (81 weeks post-treatment)			
Under-canopy	1,639 a	1,563	2.73	0.55	48 a	66
Row-middle	2,782 bc	750	2.05	0.77	106 b	35
Control	3,871 c	1,471	2.28	0.52	98 b	59

All data are means of 12 replicates. Means in a column subset followed by the same letter or no letter are not significantly different according to Duncan's multiple-range test ($P \leq 0.05$).

† Mean juveniles and males recovered following 48 hours on Baermann funnels.

were oriented from the dripline 1.52 m toward the trunk (under-canopy treatment) or 1.52 m toward the middle of the bed (row-middle treatment). Both sides of two-tree plots were treated, and untreated plots served as controls. Treatments were replicated 12 times and arranged in a randomized complete block design.

Nematode population levels were assessed before treatment and on four dates during 19 months following treatment (Table 1). Samples following treatment consisted of four soil cores (2.3 × 30 cm) from beneath the canopy of each tree and composited for each plot resulting in eight cores per sample. Similar samples were obtained from each plot at a distance of 60 cm from the tree dripline toward the bed middle. All sampling was done on the tops of beds. Before treatment, one soil sample per treatment was obtained by compositing four cores of soil from beneath the tree canopies of each replicate plot. Each sample was weighed and mixed, and a 60-cm^3 subsample was processed for 48 hours on a Baermann funnel. Fibrous roots were washed from the remainder of the sample, weighed, and processed to recover root stages of *T. semipenetrans* (1). Nematode counts were log transformed before statistical analysis by ANOVA and Duncan's multiple-range test; untransformed means are reported.

On 30 January 1987 and 2 January 1988, trees were harvested and yields were recorded as numbers of 41-kg boxes of fruit per two-tree plot. Percentage changes in box yields between years were calculated and arc sin transformed data were analyzed using Dunnet's procedure (two-tail) to detect treatment effects relative to an untreated control.

RESULTS AND DISCUSSION

Placement of fenamiphos beneath the tree canopy resulted in increased efficacy and host response ($P \leq 0.05$) relative to the row-middle treatment (Table 1). Eleven weeks following treatment, soil population densities of migratory stages of the nematode under the tree canopies that received under-canopy treatments were approximately 15% of the population densities in the untreated control or the row-middle treatments. Subsequent measurements demonstrated that treatment of the row middles reduced under-canopy population levels to approximately half the level of those in untreated controls. The large, natural variability among the smaller populations that occurred in the row middles prevented accurate measurement of treatment effects that may have occurred in that zone.

Fenamiphos applied under canopy reduced the adult female nematode population densities in contrast to previous reports (3). Nineteen weeks after treatment, females per gram fresh root weight in the under-canopy treatment were less than a third of those in untreated control plots. Under-canopy levels were approximately half ($P \leq 0.05$) of both the untreated control and the row-middle treatment at the end of the experiment.

No significant increases were measured in root abundance following treatment. However, there was a trend beginning 19 weeks following treatment for greater root abundance within fenamiphos-treated zones.

Eighty-one weeks following treatment under the tree canopy, migratory stages of the nematode were still less than half as abundant as under control trees. The row-middle treatment effect declined to a nonsignificant level by 81 weeks post-treatment. The data suggest the possibility of alternate year treatments if soil is treated beneath the tree canopy and if pretreatment population levels are only moderately high. The winter and spring population levels of >3,000 nematodes/100 cm^3 soil measured in the present study are relatively high for orchards on Florida's east coast, and it is not known whether population densities in the under-canopy treatments during the second year post-treatment represent an economically damaging level. Similarly, treatment timing may be critical in achieving successful alternate year nematicide treatment. In this study, fall application preceded an anticipated fall nematode population growth period (5,7). By reducing the level of females on roots in autumn when root growth is greatest, the normal spring increase in population density also may have been depressed even if the nematicide toxicity was diminishing. Conversely, if the nematicide is applied before the spring period of population growth, its toxic effect may be reduced substantially by the time of the fall root flush. Subsequent population growth on these new roots may be high enough to result in faster resurgence than that measured in this study. An advantage with spring soil treatment in Florida, however, is that rainfall frequency is lowest during this period, permitting better management of chemical movement in the soil through careful irrigation practices (9).

TABLE 2. Effect of fenamiphos placement pattern on mean boxes of grapefruit (41 kg/box) per two-tree plot during two seasons (standard error of mean in parentheses).

	Year 1	Year 2†	Change (%)‡
Under-canopy	12.7 (0.84)	14.4 (0.51) a	17 a
Row-middle	12.0 (0.62)	11.9 (0.61) b	−1 b
Control	13.2 (0.62)	10.8 (0.89) b	−17 b

† All data are means of 12 replicates. Means in a column subset followed by the same letter are not significantly different according to Dunnet's procedure to compare all means against an untreated control ($P \leq 0.05$).

‡ All data are means of 12 replicates. Computation of percentage change from mean annual yields results in slightly different estimates.

No treatment effects on yield were measured 19 weeks following treatment (Table 2). Fruit yield the second year following treatment was 33% greater than control yield ($P \leq 0.01$) for the under-canopy treatment and was 10% higher (n.s.) in the row-middle treatment. Although second-year yields declined from levels the previous year by more than 17% in control plots, they remained constant in plots treated in row middles and increased an average of 17% in plots with under-canopy treatments.

Results of this study support the possibility of increased efficacy and tree response to nematicide placement in zones of highest feeder root density and nematode abundance. Placement of systemic chemicals in zones of highest root concentration should also reduce nematicide movement into deeper soil horizons. However, care must be taken in the development of such systems. While appropriate application equipment can be designed to incorporate granular nematicides beneath the citrus tree canopy, this experiment did not measure the effect of cutting shallow feeder roots during incorporation. Such a practice can aggravate root sprouting on some rootstocks. The availability of liquid nematicides that can be incorporated via irrigation may address some of these concerns. Liquid formulations have the advantage of being able to treat the zones of high root-nematode abundance, whether applied through herbicide booms, irrigation equipment, or, when possible, as aboveground systemic applications (6,8,10).

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