Improved Peach Tree Longevity with Use of Fenamiphos in Peach Tree Short-Life Locations

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ABSTRACT

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Most rates and application schedules of fenamiphos improved tree longevity ($P = 0.05$) compared with no postplant treatment. In two experiments, only one of 28 nontreated trees was productive by the ninth year, while several of the fenamiphos treatments resulted in 100% productive trees. In a third experiment, the percent of productive trees depended upon the preplant treatment and the length of the interval before postplant fenamiphos treatments were initiated. Discontinuation of postplant fenamiphos treatments after 2 or 3 consecutive years caused *Criconemella xenoplax* numbers to increase significantly and generally resulted in fewer productive trees 4 yr later. The 6.72 kg/ha/application treatment applied as two fall plus one spring application provided the longest beneficial effect resulting in 88–100% productive trees by the beginning of the ninth year.

The peach tree short-life complex (PTSL) can cause death of peach trees (*Prunus persica* (L.) Batsch), often just as they begin their most productive years (1–3,8,9). The potential for extensive, sudden tree death is considered to be greatest when large numbers of the ring nematode, *Criconemella xenoplax* (Raski) Luc & Raski, are present (3,4,6,12). Fumigating the soil before planting followed by postplant treatments with dibromochloropropane (DBCP) every 2–3 yr partially alleviated this problem (1,10). In 1979, all uses of DBCP in peach orchards were cancelled. For the next few years, no nematicides were registered for use on bearing peach trees. In locations where trees are susceptible to PTSL, most nonfumigants were shown to not provide improved tree survival or adequate nematode control (7,11). Multiple fall applications of a relatively high rate of fenamiphos reduced *C. xenoplax* numbers and improved tree survival during a 3-yr period (7).

The objective of the following research was to more extensively evaluate different rates and application schedules of fenamiphos over a period of consecutive years for effectiveness in extending productiveness of trees in PTSL locations.

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MATERIALS AND METHODS

Location history and preparation. Experiments were conducted at three locations at the Sandhills Research Station near Jackson Springs, NC. Peaches had been grown in all three locations previously. In location D4W, trees had died of PTSL and were removed in the summer of 1980. Location E2B had been planted in peaches three times from 1958 to 1973 and was in sod (primarily *Cynodon dactylon* (L.) Pers. [common bermuda-grass]) until the summer of 1979. F1A was planted in peaches in 1967 and trees were removed in the fall of 1978. The soil type at all three locations was a Candor sand with organic matter ranging from 1.2 to 1.6%. Soil pH at all locations in the fall of 1981 ranged from 5.6 to 5.9. At least 1 yr before planting trees, old roots were removed, lime was applied to achieve a pH of 6.0–6.5, and the soil was deep plowed (30–45 cm) and subsoiled to a depth of 60–75 cm in each location. In October, before the planting of trees, locations E2B and F1A were broadcast-fumigated with 467 L of 1,3-dichloropropane-1,2-dichloropropene (D-D) per hectare. Location D4W was divided into thirds approximately 0.25 ha each. One-third received no preplant treatment. One-third received 6.72 kg of fenamiphos (Nemacur 3) per hectare broadcast (applied in 374 L water/ha) and incorporated to 15-cm depth 2 wk before planting trees, followed by a second application of the same rate applied to a 1.5-m strip on both sides of the tree row 1 mo after planting trees. The final third was broadcast-fumigated with 374 L/ha of 1,3-dichloropropene (Telone II) in November 1982.

Trees were planted in March 1980 in locations E2B and F1A and in March 1983 in location D4W. All trees were propagated on Lovell seedling rootstock. The scions used were cultivars Winblo, Lovell, and Emery in locations E2B, F1A, and D4W, respectively. Standard cultural and pest management practices were used, except in F1A. Trees in F1A were used for production of peach seed and thus were only moderately pruned with no fruit thinning done.

Plot design. Trees were planted on a spacing of 3.65 × 6.10 m. F1A consisted of five six-tree replications arranged in a completely randomized design. All data were taken on the four center trees of each replication. Treatments in E2B were arranged in a randomized complete block design. There were four four-tree replications with all data recorded on the two center trees. D4W was a systematically arranged split-plot in that the main effects (preplant soil treatments) were not replicated. The secondary treatments consisted of postplant treatments arranged in a randomized complete block design. Secondary treatment units were three five-tree replications, with all data recorded on the three center trees.

Postplant treatments. Fenamiphos was diluted in water and applied in 374 L/ha (40 gal/acre). Postplant applications were initiated in the fall of 1981 in F1A (end of second growing season), the fall of 1982 in E2B (end of third growing season), and in D4W at intervals of 6–24 mo after planting. A tractor-driven herbicide applicator with a single, flat-fan nozzle was used to apply the treatment to the soil surface in a 1.5-m band from the tree trunk on each side of the tree row. Application pressure was 193–220 kPa (28–32 psi). Fenamiphos was incorporated by shallow (5–7 cm) disking, including the nontreated controls, immediately after application.

Nematode assays. Soil samples for nematode assays were taken from each tree in each replication and a composite sample for the replication consisting of 500 cm^3 was assayed. Samples consisted of 3–4 probes per tree on each side of the tree row to a depth of 15–20 cm. Nematodes were extracted by using a semiautomatic elutriator and centrifugal-flotation as previously described (7). Each year samples were taken in early fall (August/September) and spring (April) before the first fall and spring postplant applications. Nematode data are reported as the initial number before the first postplant treatment and then as the mean number of all subsequent spring and fall samples between the dates indicated. Soil samples were assayed for larvae representing at least 10 genera. The vast majority detected were *Criconemella* sp. Second most common, but less than 10% of the nematode larvae detected, were *Meloidogyne* spp. Only numbers for *Criconemella* sp. are reported.

In September 1987, separate peach-root and soil samples were taken from each of the three experimental locations. Nematodes were extracted from these six samples and approximately 30 mature and immature ring nematode larvae from each sample were identified to species. All were *C. xenoplax*.

Tree condition. Tree condition was evaluated each May using a rating scale of 0–5. Trees rated 0 were considered to be healthy, whereas a rating of 4 indicated a dead tree, and 5 indicated the tree had been removed. Trees rated 0–2 were considered productive (capable of bearing quality fruit).

RESULTS

***C. xenoplax* numbers.** Significantly fewer *C. xenoplax* were detected in the root zone of trees treated postplant with fenamiphos for 2 or 3 consecutive years than in the root zone of nontreated trees (Tables 1 and 2). Similar results occurred in location D4W (Table 3). When fenamiphos treatments were discontinued after 2 or 3 consecutive years, *C. xenoplax* numbers significantly increased, compared with the numbers when treatments were continued.

Tree condition. Postplant fenamiphos treatments significantly improved tree longevity ($P = 0.05$) as measured by percent productive trees (Tables 1, 2, and 3). In locations E2B and F1A, only one of 28 nontreated trees was productive (Tables 1 and 2) and only three trees were alive by May 1988. The greatest percent of productive trees in location F1A (Table 1) occurred where fenamiphos was applied each year as two fall or two fall plus one spring application. Treatments of one fall application or one fall plus one spring application resulted in fewer ($P = 0.05$) productive trees. The least effective treatment, although significantly better than the control, was a single fall application of fenamiphos (13.44 kg/ha). Discontinuation of fenamiphos after 3 consecutive years resulted in fewer productive trees compared with trees on which fenamiphos was continued. However, this was only significant for the two-fall-application treatment. Discontinuation of fenamiphos

Table 1. Number of *Criconemella xenoplax* and percent productive trees at location F1A when fenamiphos was applied for 7 consecutive years (continued) versus discontinuation after 3 consecutive years (discontinued)

Postplant fenamiphos rates/ha/application and application schedule[u]	*C. xenoplax* per 100 cm^3 of soil[v]: Mean no. before treatment Sept. 1981	Mean no.[w] Apr. 1982 through Sept. 1984	Mean no.[x] Apr. 1985–Apr. 1987: Continued	Discontinued	Productive trees (%)[v,x] May 1988: Continued	Discontinued
No postplant treatment	67	353	···	···	0	0
13.44 kg (1F)	10	68	28*[y]	132	67	38
6.72 kg (2F)	39	72	27*	174	100*[y]	63
13.44 kg (1F), 6.72 kg (1S)	88	33	18*	299	67	38
6.72 kg (2F1S)	47	18	3*	46	100	88
LSD ($P = 0.05$)	42	22	NS[z]	242	44	31

[u] 1F = one fall application, 2F = two fall applications (September/October), and 1S = one spring application (April).
[v] Nematode numbers transformed to $\log(X+1)$ and percent productive trees to arcsin $\sqrt{\text{percentage}}$ for statistical analysis. *C. xenoplax* not assayed after April 1987.
[w] Mean of five four-tree replications.
[x] Discontinued and continued consisted of two and three four-tree replications, respectively. Discontinuation of treatments began after the spring application in April 1984.
[y] * = Mean of continued different from mean of discontinued ($P \leqslant 0.05$) according to Student's *t* test.
[z] NS = not significant.

was most detrimental where one fall or one fall plus one spring application had been used for 3 consecutive years.

In location E2B, all treatments of two fall plus one spring application were better ($P = 0.05$) than the control, but there were no differences ($P = 0.05$) among the continuous fenamiphos treatments (Table 2). Only one of eight nontreated trees was alive and productive by May 1988. Discontinuation of fenamiphos after 2 consecutive years of treatment resulted in significantly fewer productive trees for some treatments by May 1988 (Table 2).

In location D4W, all trees planted in the nonpreplant-treated area and not receiving postplant applications of fenamiphos were nonproductive by May 1988 (Table 3). The areas treated with fenamiphos near time of planting or with 1,3-dichloropropene in November 1982 had 11 and 67% productive trees, respectively, although no postplant treatments were applied (Table 3). Application of fenamiphos as yearly postplant treatments improved ($P = 0.05$) the percentage of productive trees, but the percentage was affected by the interval between planting and initiation of postplant treatments (Table 3). Although not significantly different ($P = 0.05$), the two fall applications generally resulted in more productive trees than did the one fall plus one spring treatment (Table 3). Where no preplant treatment was used, the best postplant treatment was the one initiated no later than the first fall (September 1983) after the trees

Table 2. Effects of rates and postplant application schedules at location E2B on number of *Criconemella xenoplax* and percent productive trees when fenamiphos was applied for 6 consecutive years (continued) versus discontinuation after 2 consecutive years (discontinued)

Postplant fenamiphos rates/ha/application and application schedule[t]	*C. xenoplax* per 100 cm³ of soil[u]: Mean no.[v] before treatment Sept. 1982	Mean no.[v] Apr. 1983 through Sept. 1984	Mean no.[w] Apr. 1985–Apr. 1987: Continued	Discontinued	Productive trees (%)[v,w]: May 1986 Continued	May 1986 Discontinued	May 1987 Continued	May 1987 Discontinued	May 1988 Continued	May 1988 Discontinued
No postplant treatment	266	333	168[x]	168[x]	25	25	13	13	13	13
3.36 kg (2F)	237	120	231	266	100	100	100	75	75	50
3.36 kg (2F), 6.72 kg (1S)	123	57	51*[y]	263	100	75	100	75	100*[y]	0
6.72 kg (2F)	111	80	150*	446	100	100	100	75	75	50
13.44 kg (1F)	129	60	79*	318	100	100	100	75	50	25
6.72 kg (2F1S)	157	13	2*	311	100	100	100	100	100	100
13.44 kg (1F), 6.72 kg (1S)	104	27	11*	338	100	100	100	75	100*	0
10.08 kg (2F)	343	46	25*	327	100	100	100	50	100*	25
20.16 kg (1F)	196	57	44*	166	100	100	100	100	75	50
10.08 kg (2F), 6.72 kg (1S)	150	23	3*	138	100	100	100	100	100	50
LSD ($P = 0.05$)	NS[z]	106	198	NS	NS	NS	55	NS	70	94

[t] 1F = one fall application, 2F = two fall applications (September/October), and 1S = one spring application (April).
[u] Nematode numbers transformed to $\log(X + 1)$ and percent productive trees to arcsin $\sqrt{\text{percentage}}$ for statistical analysis. *C. xenoplax* not assayed after April 1987.
[v] Mean of four two-tree replications.
[w] Discontinued and continued consisted of two two-tree replications each. Discontinuation of treatments began after the spring application in April 1984.
[x] Sample from only one tree in one replication; other trees were dead by September 1984.
[y] * = Mean of continued different from mean of discontinued ($P \leqslant 0.05$) according to Student's t test.
[z] NS = not significant.

Table 3. Number of *Criconemella xenoplax* and percent productive trees at location D4W as affected by time of initiation of postplant fenamiphos treatments in combination with different preplant treatments

Postplant fenamiphos 6.72 kg/ha/application[y]: Application schedule	Initiation of treatment	No preplant treatment[z] (*C. xenoplax*/100 cm³ soil): Mean no. at start of postplant treatments	Mean no. after first fenamiphos application through Apr. 1987	Productive trees May 1988 (%)	Fenamiphos preplant[z] (*C. xenoplax*/100 cm³ soil): Mean no. at start of postplant treatments	Mean no. after first femaniphos application through Apr. 1987	Productive trees May 1988 (%)	1,3-Dichloropropene preplant[z] (*C. xenoplax*/100 cm³ soil): Mean no. at start of postplant treatments	Mean no. after first fenamiphos application through Apr. 1987	Productive trees May 1988 (%)
No postplant treatment	···	5	264	0	11	231	11	1	220	67
2F	Sept. 1983	1	15	67	23	51	100	1	3	100
1F1S	Sept. 1983	1	44	44	2	7	83	1	5	78
2F	Sept. 1984	538	71	44	236	13	100	34	14	100
1F1S	Sept. 1984	534	93	33	130	9	100	12	6	89
1S1F	Apr. 1985	356	71	33	139	22	50	97	35	89
LSD ($P = 0.05$)		478	163	66	213	46	49	75	51	36

[y] 1F = one fall application, 2F = two fall applications (September/October), and 1S = one spring application (April).
[z] Data are means of three three-tree replications within each preplant treatment. Preplant treatments not replicated. Preplant fenamiphos treatment consisted of 6.72 kg/ha broadcast and disk-incorporated 2 wk before planting trees. Second application of the same rate applied to a 1.5-m band on each side of the tree row 1 mo after planting. 1,3-Dichloropropene applied November 1982 at broadcast rate of 374 L/ha. Trees lost due to mechanical injury excluded from the data reported. Nematode numbers transformed to $\log(X + 1)$ and percent productive trees to arcsin $\sqrt{\text{percentage}}$ for statistical analysis. *C. xenoplax* not assayed after April 1987.

were planted. In the fenamiphos preplant-treated area, initiation of postplant treatments could be delayed until the end of the second growing season (September 1984). If this treatment was delayed until the start of the third growing season (April 1985), significant loss of productive trees occurred. Where 1,3-dichloropropene was used preplant, the initiation of postplant treatments could be delayed until at least the beginning of the third growing season (April 1985) without reducing (P = 0.05) the percent of productive trees.

DISCUSSION

Postplant use of fenamiphos can substantially improve tree survival up to at least the beginning of the ninth growing season. For increased survival of productive trees, postplant fenamiphos treatments should be initiated before ring nematode numbers become great or trees are weakened.

Discontinuation of fenamiphos after 2 or 3 consecutive years of treatment generally resulted in fewer productive trees 4 yr later. The 6.72 kg/ha/application treatment applied as two fall plus one spring application provided the longest beneficial effect. Tree condition up to 3 yr (1987) after discontinuation of treatments was not different (P = 0.05) from condition of trees on which treatments had been continued (Table 2). Trees 3–5 yr old are generally most susceptible to PTSL (4,9). However, older trees also may be affected, as illustrated in location E2B where significant tree death did not occur until the winter after the eighth growing season. Thus, treatments with fenamiphos for 2–3 consecutive years when trees are 2–3 yr old, then again at intervals of 2–3 yr, may be needed to economically reduce losses from PTSL.

The use of preplant soil treatment for managing PTSL is very important as previously reported (9,11,12). Fenamiphos used near the time of planting and in subsequent postplant treatments also may be effective for managing PTSL. This may be especially useful when lack of fumigation equipment, soil conditions, or time of planting preclude using a preplant soil fumigant.

In the Southeast, fluctuating winter temperatures are thought to cause the cold injury that ultimately causes tree death (5). The coldest periods on record in North Carolina occurred in December 1983 (−15 C) and January 1985 (−20 C). Average daily temperatures were above normal (15–20 C) during the 2 wk before these sudden temperature drops. During these two winters, 30–40% of the peach trees in the Sandhills of North Carolina were killed (Ritchie, *unpublished*). Thus, the potential for PTSL was great during these experiments, but some treatments were effective under these extreme conditions.

Results from these three experiments and from observations where fenamiphos has been used on large blocks of trees indicate that postplant use of fenamiphos can improve tree survival in PTSL locations. Best results have occurred when fenamiphos is used before *C. xenoplax* increases to high levels (>100 nematodes/100 cm^3 of soil) and trees become weakened, and when used as multiple yearly applications for at least 2 consecutive years.

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