Strip and Broadcast Treatments of Dichloropropene Compared for Controlling *Criconemella xenoplax* and Short Life in a Peach Orchard

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ABSTRACT

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A broadcast treatment of dichloropropene in soil before peach trees were planted was not more effective than a strip treatment (50% of surface area) for control of *Criconemella xenoplax* or improving tree growth, but the broadcast treatment was more effective for improving tree longevity and reducing *Pseudomonas syringae* pv. *syringae* infection. The effects were transitory, however, and tree mortality in all treatments was severe by the sixth year after planting. Broadcast treatments might improve yield during the first years of production but cannot be substituted for supplementary nematicide treatments after planting for significantly extending peach tree longevity.

Many reports have documented the importance of controlling the nematode *Criconemella xenoplax* (Raski) Luc & Raski for improved growth and longevity of peach trees (*Prunus persica* (L.) Batsch) (3,6–9,11,14–16). Because this nematode has not been controlled successfully by cultural practices or genetic resistance, chemical nematicides have been used. Relatively few nematicides have been effective for control of *C. xenoplax* when applied after planting (16), and when soil fumigants were used before peach trees were planted, they were effective for only 2–3 yr (11,16) and the nematode multiplied rapidly thereafter.

In the 1970s, South Carolina peach growers for reasons of economy customarily used strip treatments of dibromochloropropane (DBCP) or dichloropropene before planting and followed with DBCP 2 or 3 yr later. This approach was effective for promoting early tree growth and extending longevity, but potential benefits of broadcast treatments (treatment of the entire orchard floor) before planting had not been explored.

In an experiment beginning in 1978, we compared a strip treatment with a broadcast treatment of dichloropropene. Because use of DBCP as a postplanting nematicide was suspended, no postplanting nematicide was applied. The results of this comparison are reported.

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MATERIALS AND METHODS

Site preparation. The experimental site was on Lakeland sand (89% sand, 6% silt, and 5% clay) at the Clemson University Sandhill Research and Education Center near Columbia, SC. The soil was infested with *C. xenoplax* (200–300/100 cm^3 of soil), and few other plant-parasitic nematodes were present. Peach tree short life had been responsible for early removal of two peach orchards that had grown on the site previously. The last such orchard was removed in 1974, and natural vegetation had grown after orchard removal. In September 1977, dolomitic lime (4 t/ha) was applied to the soil surface and plowed in to a depth of 25 cm.

Plot design. The experimental orchard was divided into 12-tree plots with four replicates in a randomized complete block design. Within each plot, tree sites were assigned a spacing of 4.9 × 7.3 m and arranged in four rows with three trees each. Buffer rows of trees surrounded each plot on all four sides. In October 1977, 4 mo before the trees were planted, dichloropropene (Telone II) was applied at 327 L/ha, either in strips 2.45 m wide centered on the tree row (50% of the area was treated) or as a broadcast treatment in which the entire area of the plot was treated. The same number of tree sites was left untreated as a control. The nematicide was applied 25 cm deep by steel shanks spaced 25 cm apart, and the treated area was sealed immediately with a rotary cultivator to minimize escape of the nematicide into the air.

Plot establishment. Peach trees (cultivar Sunhigh on Lovell rootstock) were obtained from a commercial nursery and planted in February 1978. After planting, the trees were managed according to standard commercial practices for South Carolina, and recommended practices for control of the peach tree short-life syndrome (1) were followed except that no postplanting nematicide was applied to the soil. Irrigation (overhead sprinklers) was applied only during periods of severe summer drought.

Nematode assays. One soil assay for nematodes was made in April or May each year for the first 3 yr after planting to ascertain when plots became reinfested with *C. xenoplax*. *C. xenoplax* populations typically are higher in winter and spring than in summer and autumn (8). Soil cores from the top 6–15 cm of soil were taken by a 2.5-cm soil probe from the drip lines of four to six trees per plot, two probes per tree site. *C. xenoplax* populations typically are highest in the top 15 cm of soil in peach orchards (*unpublished*). Subsamples were combined before nematodes were extracted by elutriation (2) followed by centrifugation (4).

Tree growth. Trunk girth of each tree 20 cm above the soil line was measured at planting and after 1 yr to compare relative growth among the treatments. Later growth measurements were discontinued because cold injury in trunks and subsequent partial healing caused distortion of measurements in some plots.

Fruit yield and size. Spring frost damage resulted in only partial crops of fruit during the third, fifth, and sixth years after planting, and fruit yield per tree therefore was determined only in the fourth year (1981). Treatment effect on fruit size was determined by weighing a composite of 30 randomly selected fruits per tree when the fruit were harvested.

Tree mortality. In April and again in late summer each year, trees were examined for symptoms of peach tree short life (1). Although some diseased trees survived, mortality was the major criterion recorded.

Bacterial canker. Bacterial canker of peach caused by *Pseudomonas syringae* pv. *syringae* van Hall sometimes is associated with the short-life syndrome and was observed in twigs of trees in this experiment in April 1980. A rating scale of 1 = no infected twigs, 2 = 1–10 infected twigs, and 3 = more than 10 infected twigs per tree was applied. Because the symptoms were observed only after they were well advanced, diagnosis was not confirmed by isolation of the pathogen

(14); determinations were based on symptoms described by others (10,13) and as seen in other experimental and commercial peach orchards in South Carolina.

Statistical analysis. Analysis of variance was conducted for tree mortality, nematode assays, growth, fruit yield and size, and bacterial canker ratings. Broadcast and strip treatments were compared with the control and with each other using single-degree-of-freedom comparisons.

RESULTS

Nematode control. *C. xenoplax* populations were reduced to less than 50/100 cm^3 of soil in all treated plots during the first year (1978) but began to increase in some plots by 1979. By 1980, *C. xenoplax* was reestablished in all plots and had returned to a high population by 1981 (Table 1). The method of dichloropropene use did not significantly affect the time of reestablishment of the population or the number of nematodes in the plots.

Tree growth. Growth rate for trees in strip- and broadcast-treated plots was almost the same during the first year after planting (Table 1). Size of trees in treated soil also did not differ significantly from the control. Dry weather in June and July 1978 slowed the rate of growth in all plots; possible effects of preplant treatments on growth might have been counterbalanced by effects of dry weather.

Tree mortality. The first symptoms of short life in the orchard appeared in spring 1980, 2 yr after the trees were planted. Seven control trees and six in the strip treatment died in 1980. In control plots, additional trees died each year through 1984, 6 yr after the experiment began (Table 2). The rate of tree mortality in the strip treatment lagged behind the control, but by 1984, the number of dead trees exceeded the number in control plots. In contrast, no trees in the broadcast treatment died until 1982, but tree mortality was extensive in 1983 and 1984.

Fruit yield and size. Yield and size of fruit were measured in 1981 only—the second year of production—because of cold damage to the crop in other years. Yield of fruit per surviving tree in the strip treatment was similar to that for trees in the broadcast treatment (Table 3). Only the yield of fruit from the broadcast treatment was significantly different from the control ($P = 0.05$) in paired comparisons. When both yield per tree and tree mortality were considered, fruit yield per plot was 50% greater in the broadcast than in the strip treatment (Table 3), but the difference observed was significant only at $P = 0.13$ in paired single-degree-of-freedom comparisons.

Fruit size as determined by weight in grams was not significantly affected by any treatment.

Bacterial canker. Each treatment significantly affected ($P = 0.05$) the number of twigs with symptoms of bacterial canker caused by *P. syringae* pv. *syringae* (Table 1). Infections were most numerous on trees in nonfumigated soil. Most infections killed 1-yr-old twigs, but some extended into 2-yr-old wood. None killed large limbs. The few infections seen in the broadcast treatment were limited to 1979 twig growth, and none caused permanent injury to the trees.

DISCUSSION

The peach tree short-life syndrome is limited in South Carolina to soils that are infested with the nematode *C. xenoplax*, and the nematode's importance in tree mortality was demonstrated by Nyczepir et al (9). Economic effects of this disease are especially acute because severe tree losses often occur just as the trees are entering their productive years. Nematode control by preplant soil fumigation usually is effective for up to 2 yr, and as this experiment showed, some tree losses may be delayed by a preplanting treatment with an effective nematicide. As others have reported (11,12,16,17), repeated nematicide applications are necessary to maintain productive orchards until trees have reached their full productive capacity.

The decision whether to use a nematicide treatment in *C. xenoplax*-infested peach orchard soil is usually determined by economics—whether the cost of treatment is likely to be repaid by increased production over time. In the experiment reported here, tree longevity and productivity clearly increased with the use of dichloropropene. In addition to those killed, many trees in control plots sustained various amounts of cold injury in woody tissues and the productive capacity was correspondingly reduced. The comparatively low yield from control plots and large plot-to-plot variation was caused primarily by cold injury that resulted in reduced bearing surface. Profitable peach production in this orchard site would not have been possible without dichloropropene or another effective nematicide because of the amount of early tree mortality.

This research shows that tree survival

Table 1. Reinfestation by *Criconemella xenoplax* of soil in a peach orchard treated before planting with dichloropropene, bacterial canker rating, and growth response of newly planted trees in treated and untreated soil[a]

	C. xenoplax/100 cm^3 soil			
Dichloropropene	April 1980[b]	May 1981[b]	Stem diam. (mm) March 1979[b]	Bacterial canker rating[c]
Broadcast	241	271	32	1.5
Strip	265	550	33	2.0
Control	272	522	30	2.3

[a] Trees planted in February 1978, 4 mo after treatment with dichloropropene in strips 2.45 m wide or broadcast at 346 L/ha.

[b] Differences among treatments are not significant at $P = 0.05$.

[c] Rated on a scale of 1 = no infected twigs, 2 = 1–10 infected twigs, and 3 = >10 infected twigs per tree in April 1980. Means for each treatment are significantly different from the others ($P = 0.05$).

Table 2. Mortality of peach trees from the short life syndrome (1980–1984) as related to preplanting broadcast or strip treatments of dichloropropene in soil infested with *Criconemella xenoplax*

	Cumulative mortality (%)[a]				
Dichloropropene	1980	1981	1982	1983	1984
Broadcast	0	0	2*[b]	15*	42*
Strip	12	12	21*	52	81
Control	15	24	52	62	77

[a] Cumulative percentage of trees that died among 12 trees per plot replicated four times. Trees were planted in 1978.

[b] * = Significantly different from the control ($P = 0.05$). Means for broadcast and strip treatments were significantly different in 1983 and 1984 only.

Table 3. Yield and size of peach fruit by tree and plot as affected by broadcast or strip preplanting treatments of dichloropropene in soil infested with *Criconemella xenoplax*

	Yield (kg) per		
Dichloropropene	Tree	Plot[a]	Weight (g/fruit)
Broadcast	26.2*[b]	302*	119
Strip	20.9	201*	106
Control	10.4	76	101

[a] Yield of fruit per plot is adjusted for tree mortality (Table 2).

[b] * = Significantly different from the control ($P = 0.05$). Yield difference per plot in broadcast versus strip treatment is significant at $P = 0.13$.

may be improved further when dichloropropene is applied as broadcast rather than as strip treatments before peach trees are planted. The reason for improved survival is unclear because nematode populations became reestablished as quickly in broadcast-treated as in strip-treated plots. However, the improved survival was of only marginal value because tree losses in all treatments were severe by the sixth year after planting. Whether the additional expense of a broadcast preplanting treatment is justified depends on many variables, including cost of the nematicide treatment, prices of fruit at harvest, and many factors related to weather and farm management. The broadcast treatment might be more economically attractive with a less frost-sensitive cultivar than Sunhigh and with closer tree spacing because more fruit might have been produced during the first years of production.

A broadcast preplanting treatment might provide greater assurance of recovery of costs, but it probably could not be counted on to bring trees into their most profitable years without additional measures to prolong tree life. Because all other practices known to be helpful for prolonging tree life except nematicides after planting (1) were used in this site, other corrective practices probably cannot be relied on to overcome deficiencies in nematode control.

The experimental observations of Lownsbery et al (5) that parasitism by *C. xenoplax* increases susceptibility to *P. syringae* pv. *syringae* appeared to be confirmed in this field test. More twigs suffered from bacterial canker in control trees than in those growing in fumigated soil. The fewer infections in broadcast-treated than in strip-treated soil are not accounted for by differences in nematode control in the nematicide-treated area but might reflect physiological effects resulting from nematode parasitism of roots outside the treated area in the strip-treated plots.

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