Soil Fumigation and Fall Pruning Related to Peach Tree Short Life

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Part of thesis submitted in partial fulfillment of the requirement for the MS degree, Clemson University. Published with the approval of the Director of the S. C. Agricultural Experiment Station as Technical Contribution No. 1166.

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Accepted for publication 27 September 1974.

ABSTRACT

Soil was fumigated with 1,2-dibromo-3-chloropropane in October 1972 under 2-year-old peach *(Prunus persica* 'Coronet') trees in a problem orchard infested with *Criconemoides xenoplax*. Trees in fumigated soil showed improved vigor, increased tree survival, and increased cold-hardiness, as measured by electrolytic conductance. Fall pruning decreased cold-hardiness, vigor, and survival. The nematode population in fumigated soil was 50% of that in check soil. A second fumigation in May 1973 resulted in much better nematode control and a significant reduction in the severity of late-summer defoliation attributed to *Xanthomonas pruni*. Check trees with high or low nematode population showed no significant differences in defoliation. These results suggest that fumigation may have benefits in addition to nematode control.

Phytopathology 65:277-280

Peach tree short life (PTSL) has been a problem to peach growers for more than 100 years (1, 19). The problem is most often associated with old peach sites, where new plantings closely follow removal of peach trees. Numerous causal agents have been implicated in the premature death, including nematodes, fungi, fall pruning, and winter injury (4, 6, 15, 16, 19). In 1960, Edgerton and Parker (7) showed that control of the nematode, *Pratylenchus penetrans,* with the nematicide DD improved cold-hardiness of cherry, *Prunus cerasus*. Other investigators (1, 3, 5, 8, 10, 13, 20) have demonstrated that soil fumigation before planting, combined with postplant soil fumigation at 2- to 3-year intervals, results in increased growth, vigor, and longevity. Currently, plant pathologists in the southeastern U.S. are suggesting soil fumigation in soils where nematodes are a problem (2, 14, 17). Growers are urged not to prune trees before January 1, because several studies indicate that fall pruning is a potentially damaging practice for peach trees (3, 4, 6, 15, 16, 20).

The present study was conducted in an attempt to evaluate the effects of soil fumigation and fall pruning on peach trees growing in a commercial orchard where PTSL symptoms were present.

MATERIALS AND METHODS.—In October 1972, 2-year-old peach trees [*Prunus persica* (L.) Batsch 'Coronet'] on seedling rootstock, growing in a problem orchard infested with *Criconemoides xenoplax* Raski were fumigated with 1,2-dibromo-3-chloropropane (DBCP) [Nemagon, 1.45 kg/liter (12.1 lb/gal), at 46.7-65.5 liters/hectare (5-7 gal/acre)]. A measured amount of fumigant was injected in each square foot under the tree canopy at a depth of 10-15 cm with a Maclean hand fumigun, and the pore was sealed by tamping. Although soil moisture was considered adequate at the time of fumigation, unsatisfactory control of nematodes resulted, and a second application was made in May 1973.

Routine grower practices were used on the check trees, except that no fumigation was applied. Twenty test trees were pruned in mid-November, and the check trees and trees in fumigated soil were pruned late in February. The 60 trees were distributed in a completely random design of 20 trees per treatment.

One month after fumigation, and periodically thereafter, the population of plant-parasitic nematodes was determined by Jenkins' method (11). Soil was removed at the dripline of selected trees to a depth at which feeder rootlets were found (usually 5 to 15 cm). Then a core of soil, 4 to 5 cm in diameter and parallel to the root, was removed with a garden trowel.

The state of cold-acclimation by the trees was monitored during dormancy by using the electrolytic conductance method described by Ketchie et al. (12). A conductivity cell measured electrolytes released from dormant twig tissue exposed to varied degrees of cold. A household freezer, equipped with a circulating bath, was used to lower the temperature to −12 and −23 C. The concentration of electrolytes diffusing from the cells could then be determined by the calculations proposed by Flint, Boyce, and Beattie (9). This concentration is related to the sensitivity of the tissue to cold. The value obtained is an Index of Injury (I_t), in which a higher numerical value indicates more cold damage.

Relative tree vigor and survival were monitored on a rating scale of 1 to 9, in which 1 = dead trees and 9 = the most vigorous trees. All data were statistically analyzed (18).

RESULTS.—During the winter 1972-1973, significantly greater cold-hardiness was shown by trees in fumigated soil than by those pruned in November (Table 1). In general, check trees were less hardy than fumigated trees. Although differences occurred at both

TABLE 1. Cold-hardiness of Coronet peach trees at two temperature incubation levels as affected by soil fumigation with DBCP (1,2-dibromo-3-chloropropane) and fall pruning

Treatment[y]	Temperature (C)	Index of cold injury[z]				
		24 Jan	7 Feb	21 Feb	15 Mar	Avg
Check	−12	1.3	8.95 b	2.6	22.0 ab	8.7 ab
Fall-pruned	−12	1.1	7.96 b	.8	31.3 a	10.3 a
DBCP (fumigated)	−12	2.7	4.56 a	1.6	15.8 b	6.2 b
Check	−23	17.7	35.4	22.1	86.7	40.6 a
Fall-pruned	−23	20.4	35.4	18.4	88.2	40.6 a
DBCP (fumigated)	−23	17.7	28.6	18.4	81.2	36.5 b

[y]Treatments: checks were pruned in mid-February; fall pruning was done in mid-November; DBCP fumigation [46.7-65.5 liters/hectare (5-7 gal/Acre)] was done twice, first in October 1972, and again in May 1973.

[z]Figures indicate Index of Cold Injury (I_t), in which higher values indicate greater cold injury. Raw data are based upon conductance (electrolyte leakage from dormant twig tissue) measurements [Ketchie, et al. (12)]. The data reported here were calculated from the raw data by the equations of Flint et al. (9). Figures followed by the same letter are not significantly different ($P = 0.05$) as determined by Duncan's multiple range test.

TABLE 2. Effects of fall pruning and soil fumigation on survival and vigor of two-year-old Coronet peach trees, spring 1973

Treatment[y]	Tree death (%)	Vigor[z]
Check	15	6.9 a
Fall-pruned	40	5.1 b
DBCP (fumigated)	5	7.8 a

[y]Treatments: checks were pruned in mid-February; fall-pruning was done in mid-November; DBCP fumigation [46.7-65.5 liters/hectare (5-7 gal/Acre)] was done twice, first in October 1972, and again in May 1973.

[z]Values represent relative amounts of tree vigor, in which 1 = dead tree to 9 = most vigorous tree. Numbers followed by same letter are not significantly different as determined by Duncan's multiple range test, $P = 0.05$.

temperatures, the most consistent differences among treatments were at −12 C. By 1 February, chilling requirements had been met, and the general trend was for trees to lose and gain hardiness in response to temperature changes. By mid-March, limited hardiness remained. The decrease in cold hardiness determined on 7 February probably resulted from unusually warm temperatures which occurred during the previous week.

In mid-March, several of the trees began to wilt shortly after floral and leaf buds opened, while others had smaller and more chlorotic leaves than normal. Some of these trees collapsed within 2 weeks after leaf set, and others slowly declined from March through August. Discoloration of the cambial zone was extensive in xylem and phloem tissue from the soil line well into the scaffold limbs. Forty percent of the fall-pruned trees, 15% of the check trees, and 5% of the trees in fumigated soil died. Vigor of fall-pruned trees decreased significantly (Table 2).

The population of *C. xenoplax* was reduced about 50% by a single fumigation in the fall of 1972. After the second fumigation, in May 1973, much better control was achieved (Table 3).

In June, considerable defoliation from bacterial spot, caused by *Xanthomonas pruni*, was noted (Fig. 1). Trees in fumigated soil tended to have less defoliation than those in other treatments (Table 4). No significant differences in defoliation between fall-pruned and check trees were observed.

DISCUSSION.—It is generally accepted that cold injury is associated with major tree losses on PTSL sites. Because the reduction in cold-hardiness observed in fall-pruned trees was followed by substantial tree losses attributed to cold injury, it is assumed that fall pruning predisposes trees to cold injury. Other studies (3, 4, 6, 15, 16, 20) associate increased tree mortality with fall pruning. Whether greater cold-hardiness can be attributed to the 50% reduction in population of *C. xenoplax* through soil fumigation is not known. It has been demonstrated that *Pratylenchus penetrans* reduces cold-hardiness of cherry trees (7), but similar studies of *C. xenoplax* on peach have not been reported. If nematode

TABLE 3. Effect of fall pruning and soil fumigation on numbers of *Criconemoides xenoplax* recovered per 100 cc soil, 1973-1974

Treatments[y]	Nematode population (no./100 cc of soil)[z]					
	Feb '73	Apr	June	Sept	Oct	Jan '74
Check	980	540	730	38	251	514
Fall-pruned	940	540	630	47	184	1,126 *
DBCP (fumigated)	460 *	280 *	258 *	1 *	29 **	4 **

[y]Treatments: checks were pruned in mid-February; fall-pruning was done in mid-November; DBCP fumigation [46.7-65.5 liters/hectare (5-7 (gal/Acre)] was done twice, first in October 1972, and again in May 1973.

[z]*–Data significantly different from check as measured by LSD ($P = 0.05$).

**–Data significantly different from check at 1% level, as measured by LSD ($P = 0.01$).

Nematodes were recovered from soil samples by the centrifugal-flotation technique of Jenkins (11).

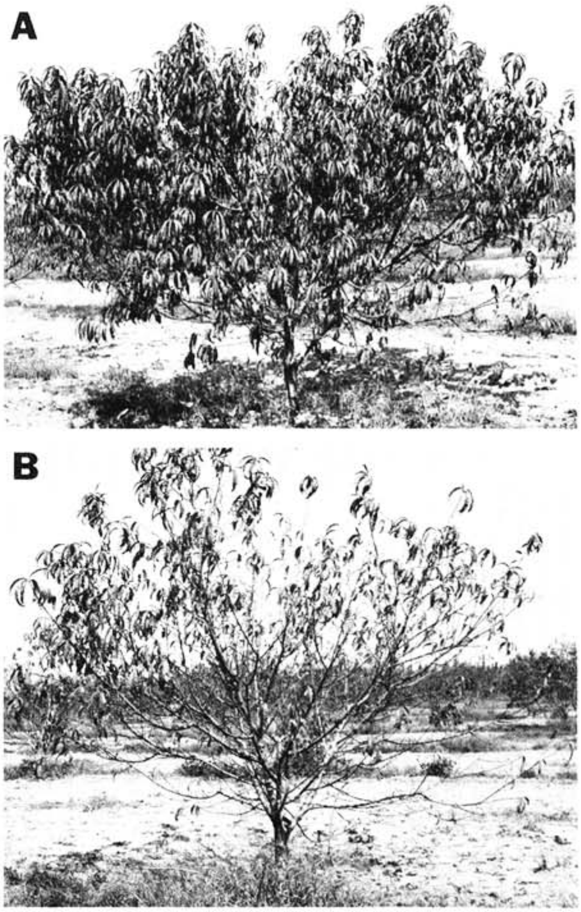

Fig. 1-(A, B). Variations in defoliation of Coronet peach trees in October 1973: **A)** fumigated tree; **B)** nonfumigated control.

control was responsible for the improved cold-hardiness observed in response to fumigation, improved effectiveness of nematode control might further improve cold-hardiness. This study is being continued to determine whether or not this hypothesis is true. The significant rise in nematode numbers following fall pruning in 1973 is not understood, but it may indicate that roots of fall-pruned trees are more active or serve as a more attractive host for the nematodes than do roots of nonpruned trees. These results support previous findings that fall pruning is a damaging practice, while fumigation helps alleviate PTSL. Although we did not have a treatment designed to determine the effect of combining fumigation and fall pruning, we did observe 40-60% tree loss in a commercial 4-year-old Red Haven orchard where the grower had fumigated as recommended, then pruned in early December.

Reasons for the significant reduction in late-summer defoliation after fumigation are not known. Nematode numbers were not correlated with severity of defoliation. Much variation in both nematode population and severity of defoliation was present. Where the grower had fumigated nearby Coronet trees with Nemagon, similar responses were observed. These data suggest that soil

TABLE 4. Effects of fall pruning and soil fumigation on the degree of peach tree defoliation attributed to bacterial spot during 1973

	Defoliation[z]		
Treatment[y]	June	Sept	Oct
Check	2.5	3.2 ab	4.0 a
Fall-pruned	3.3	3.3 a	3.7 a
DBCP (fumigated)	2.2	2.4 b	2.6 b

[y]Treatments: checks were pruned in mid-February; fall-pruning was done in mid-November; DBCP fumigation [46.7-65.5 liters/hectare (5-7 gal/acre)] was done twice, first in October 1972, and again in May 1973.

[z]Values represent relative amounts of defoliation, in which 1 = less than 10% defoliation to 5 = more than 90% defoliation. Values followed by same letter are not significantly different as measured by the LSD ($P = 0.05$).

fumigation affects the resistance of Coronet trees to bacterial spot, perhaps indirectly by its effects on the bacteria, nematodes, or other soil organisms; or perhaps directly by affecting host resistance to the pathogen. Similarly, nematicidal fumigation helps alleviate bacterial canker of peach in California, while increased susceptibility of nematode-infested trees to the bacterium has been shown experimentally (5, 8, 13).

From these data we conclude that fumigation of peach orchards infested with *C. xenoplax* should be encouraged, and that improvements in tree survival and cold-hardiness with reduced incidence of defoliation by bacterial spot may be expected. Additionally, fall pruning should be avoided, because this appears to predispose peach trees to cold injury.

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