Effects of Nematicides, Lime, and Herbicide on Peach Tree Short Life in Georgia

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Abstract: Peach tree mortality was 75% five years after planting on a site associated with peach tree short life and receiving no nematicide treatment, no lime, and with cultivation for weed control. Mortality was reduced to 29% by preplanting plus postplanting applications of DBCP (1,2-dibromo-3-chloropropane) and with herbicidal weed control. Preplanting applications of nematicides alone did not effectively reduce tree mortality or increase yield. Lime applications increased yield but did not affect tree growth or survival. Survival was higher with weed control by a herbicide than with control by disk cultivation. Populations of *Macroposthonia xenoplax* were correlated positively with tree mortality and negatively with yield. The other nematode consistently present at the site, *Tylenchorhynchus claytoni,* was not associated with either tree mortality or yield.

Peach tree short life (PTSL) has been a serious problem in growing peaches, *Prunus persica* (L.) Batsch, in the southeastern United States (17,21,22,23,24). In middle Georgia the average orchard life is about 8 years (18), in contrast to more than 15 years in areas with no PTSL problem. In southeastern orchards affected by PTSL, stand decline begins during the 3rd year, because trees that die after the 2nd year are not replaced. This continues until about 50% of the trees are lost; then the orchard is abandoned. Many orchards are ruined before they reach full production. This condition is most common when peach trees are planted where an earlier planting has recently died. The trees usually die shortly before or after leafing out in the spring. Trees can die from PTSL at any age although most die in their 3rd to 5th year. As many as 95% of the trees on a severe PTSL site may die within one year.

Factors reported to shorten tree longevity on sites associated with PTSL include fall (October-December) pruning (4,5,16, 19), root injury (11,13), *Pythium* root rot (10), *Clitocybe* root rot (21), winter injury (4,18), bacterial canker caused by *Pseudomonas syringae* Van Hall (7,14,24), nematodes (1,2,3,8,11,15), and rootstock (4,14). Tree survival may be affected by soil nutrition (21) and addition of lime (9,20,21,23).

Macroclimatic temperature patterns cannot be considered to be the sole cause of death because one tree may die while adjacent trees survive. Invasion and movement of *P. syringae* does not always result in bacterial canker (5,24). In a site studied by Weaver et al. (24) some trees died while others did not, although the bacterium was isolated from all trees. The possibility of a complex involving only temperature and *P. syringae* is therefore negligible. Since some areas are PTSL sites and others are not, a soil factor may be involved (19). Trees growing in soil with pH adjusted to 6.1 and above were less susceptible to *P. syringae* than trees growing in a soil with a pH of 5.6 (23). Nesmith and Dowler (16) reported that cold hardiness of peach was enhanced by DBCP (1,2-dibromo-3-chloropropane) fumigation. These findings further implicate a soil factor in the PTSL complex.

Nematodes have been shown to interfere with growth (8,11,13,14,15), yield (8), cold hardiness (6,16), and longevity (15) in *Prunus* spp. Chitwood (3) suggested that ring nematodes were a possible factor in the decline of peach orchards in North Carolina. *Macroposthonia xenoplax* (Raski, 1952) Loof and De Grisse, 1965 (= *Criconemoides xenoplax* Raski, 1952) has recently been associated with poor survival or growth of peach trees in North Carolina (1), South Carolina (16), and California (13,14), and *Macroposthonia curvatus* (Raski, 1952) Loof and De Grisse, 1965 (= *Criconemoides curvatus* Raski, 1952) was associated with peach decline in New Jersey (11). *Criconemoides* spp. were found in 86% of samples from 64 peach orchards in Georgia (10). Lownsbery et al. (13) reported that high populations of *M. xenoplax* increased the susceptibility of

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peach to *P. syringae* after 27 months in a lathhouse test. In a later test, the nematode increased bacterial canker susceptibility after 14 months (14). English and Devay (7) reported that soil fumigation increased growth and canker resistance of peach trees in California.

This study was done primarily to determine the effect of preplanting and postplanting nematicide applications, dolomitic limestone treatments, and weed control by herbicide or by cultivation on growth, yield, and tree survival on a PTSL site. Also examined was the influence on nematode populations, soil pH, and discoloration of the tree trunk cambium and the relation between nematode population and yield and tree survival.

MATERIALS AND METHODS

An experimental site with a long history of PTSL was selected in Peach County, Georgia. Peach orchards had been planted on the site five times, and none had survived more than 4 or 5 years. To confirm the presence of PTSL, the orchard was rated in the spring for 2 years before beginning the experiment. The survey showed that 70% of the trees were dead or damaged and only 30% appeared unaffected.

All trees were removed from the site in August 1967, and the soil was prepared for planting. The experimental design was a randomized complete block with eight replications. Each plot consisted of three record trees, spaced 5 m apart, with one untreated tree separating plots in the row and an untreated buffer row between plots.

The soil was assayed for nematodes before preplanting treatment and annually thereafter. One soil core sample (2 cm in diameter and 30 cm deep) was taken from each side of each record tree in a plot. The six cores were composited, and a 150-cm^3 subsample was assayed for nematodes. Subsamples were treated with Electrasol (Economics Laboratory, Inc., St. Paul, MN) (25) and processed by the centrifugation-flotation technique (12). Nematodes were identified to genus and counted under a stereomicroscope. (Species determinations, made with a compound microscope, were confirmed by A. M. Golden, nematologist, USDA, SEA, AR, Beltsville, MD.)

There were six regimes of nematicide application: 1) none; 2) preplanting DBCP; 3) postplanting DBCP; 4) preplanting plus postplanting DBCP; 5) preplanting MBR-CP (67% methyl bromide plus 33% chloropicrin); and 6) preplanting MBR-CP plus postplanting DBCP. The 24 experimental treatments consisted of all possible combinations of the six nematicide regimes with lime or no lime and weed control by disk or herbicide. Preplanting treatments were applied to entire plots, and dolomitic limestone was broadcast on the soil surface at 6,720 kg/ha and disked to a depth of 20 cm in October 1967. Preplanting applications of DBCP at 67.8 kg/ha were injected 20 cm deep with a chisel applicator. Preplanting MBR-CP was applied at 336 kg/ha under a polyethylene sheet. 'Coronet' trees on rootstock of unknown parentage were planted in December 1967 and pruned to 45 cm high. The herbicide terbacil (3-tert-butyl-5-chloro-6-methyluracil) was applied at 2.2 kg/ha to a 1-m band on each side of the row in March 1968 and each spring (March-April) thereafter. Disking was done as needed in the cultivation treatment and in the middles of the herbicide plots to control summer weeds. Rye (*Secale cereale* L.) was planted between rows in winter to control soil erosion.

When nematode populations appeared to recover from the preplanting treatment, 1 and 3 years after planting, postplanting DBCP at 67.8 kg/ha was applied to each side of the row in a 2.3-m band. Application was by chisel injection 20 cm deep to within 30 cm of the tree trunks with chisels 30 cm apart.

Tree trunks were examined each spring for the brown discoloration of the cambial area that is indicative of winter injury (18, 19). A cut was made to expose the xylem at several points around the trunk, and the cambial region was examined immediately. The discoloration was rated from 9 (no discoloration) to 1 (total cambial discoloration).

Commercial picking crews harvested the fruit from each tree at each harvest date. Maturity, fruit size, and frequency of harvest were at the discretion of the grower. Fruit from each tree was weighed at each harvest.

Tree survival was recorded annually in spring (April), at harvest (June) and again in winter (December-February) when the trunks were measured. Trees that died in the first two growing seasons were replaced to maintain tree competition.

Average populations of *T. claytoni* and *M. xenoplax* in 1968, 1969, 1970, and 1971 were compared with average fruit yields in 1970, 1971, and 1972 and with accumulated tree death through 1972.

Data were arranged in a 2 × 2 × 3 × 2 factorial combination and subjected to analysis of variance and Duncan's multiple range test to determine significant differences among treatment means.

RESULTS AND CONCLUSIONS

Nematodes present before imposition of treatments were *M. xenoplax; Tylenchorhynchus claytoni* Steiner, 1937; *Helicotylenchus dihystera* (Cobb, 1893) Sher, 1961; *Pratylenchus brachyurus* (Godfrey, 1929) Filipjev and Schuurmans Stekhoven, 1941; *P. zeae* Graham, 1951; *Meloidogyne incognita acrita* (Kofoid and White, 1919) Chitwood, 1949; *Trichodorus christiei* Allen, 1957; *Xiphinema americanum* Cobb, 1913; *Aphelenchoides* spp.; *Paratylenchus* spp.; and *Psilenchus* spp. (Pretreatment nematode populations were determined by A. W. Johnson, nematologist, USDA, SEA, AR, Tifton, Georgia.)

M. xenoplax and *T. claytoni* were present throughout the experimental site during the test period. *M. incognita acrita* was found in three plots in 1968, and by 1972 it had spread generally along a drainage pattern to 21 of the 192 plots. Because of limited distribution, *M. incognita acrita* is unlikely to have been involved in the tree deaths. Other nematodes found in the pretreatment survey declined to very low populations after 1 year. They were probably parasitizing weeds or fungi or, if peach parasites, were not present in sufficient numbers to affect the peach trees.

Effects on nematode populations: M. xenoplax populations were lowered by preplanting nematicide treatments (Table 1). Suppression of nematodes was temporary,

TABLE 1. Main effects of nematicides, dolomite, and herbicide on soil populations of *Macroposthonia xenoplax* on a peach tree short-life site in Georgia.

		No. of *M. xenoplax* per 150 cm³ of soil				
		Date				
		6/68	10/69	4/70	9/70	10/71
Nematicide treatment*						
Preplanting	Postplanting					
None	None	64	108	113	362	60
None	DBCP	61	36	59	133	24
DBCP	None	9	110	35	291	85
DBCP	DBCP	15	31	26	118	33
MBR-CP	None	7	127	73	359	63
MBR-CP	DBCP	12	27	38	49	31
LSD (P = 0.05)		24	38	45	154	52
Lime treatment†						
No lime		19	54	77	263	57
Lime		36	92	38	75	42
LSD (*P* = 0.05)		14	22	26	89	
Weed control treatment						
Cultivation‡		29	75	47	413	58
Herbicide§		27	71	68	223	44
LSD (*P* = 0.05)						

*Nematicide treatment = DBCP (1,2-dibromo-3-chloropropane) at 67.8 kg/ha; MBR-CP (67% methyl bromide plus 33% chloropicrin) at 336 kg/ha.

†Lime = dolomite at 6720 kg/ha applied broadcast before planting.

‡Cultivation = disk cultivation as needed to control weeds.

§Herbicide = terbicil at 2.2 kg/ha to a 1-m band on each side of row annually.

however; within a year populations in treated plots returned to levels comparable to those in untreated plots. Postplanting nematicide treatments, alone or in combination with preplanting nematicide, usually reduced nematode populations below the levels in control plots or plots given only preplanting treatments.

Lime treatments resulted in higher *M. xenoplax* populations for the first 2 years of the test, but populations thereafter were lower in the limed plots than in the unlimed plots. Weed-control method did not affect populations of *M. xenoplax*.

Cambial discoloration: Preplanting nematicide treatment did not decrease cambium discoloration (Table 2). Trees in plots that received postplanting DBCP had less discoloration than those in plots that received preplanting DBCP or in unfumigated plots. Discoloration in plots that received preplanting MBR-CP was not statistically different from that in plots receiving other treatments. Discoloration was lower in plots receiving lime than in plots not receiving lime, and lower in herbicide plots than in cultivated plots. The treatment combination most effective in reducing cambium discoloration was preplanting MBR-CP plus postplanting DBCP plus lime and herbicide. Nearly as effective were preplanting MBR-CP and preplanting and postplanting DBCP with lime and herbicide.

Tree mortality: Tree death (Table 3) in plots that received preplanting and postplanting DBCP was lower than in plots that received no nematicide or received preplanting DBCP only. Tree death in plots receiving preplanting MBR-CP only was the same as in plots receiving no nematicide, preplanting DBCP only, or postplanting DBCP. Liming did not affect tree death, but herbicide treatment reduced tree death below that in cultivated plots. The treatment combination giving lowest tree death was preplanting and postplanting DBCP plus herbicide.

Fruit yields: Trees in plots receiving preplanting and postplanting DBCP, and in plots receiving MBR-CP and postplanting DBCP, yielded more fruit than trees in plots receiving only preplanting DBCP or no nematicide (Table 4). Liming increased yield over no liming, and herbicide application increased yields over cultivation. The treatment combination that had the highest yielding trees was preplanting MBR-CP plus postplanting DBCP, lime, and weed control by cultivation.

Association of nematode populations: Populations of *T. claytoni* were not correlated with yield or tree death. *M. xenoplax*

TABLE 2. Cambium discoloration ratings for trees growing in plots treated with nematicides, dolomite, and herbicide on a peach tree short-life site in Georgia.

Nematicide treatment*		Discoloration rating†				Average (main effects) for nematicide treatment
		Lime‡		No lime		
Preplanting	Postplanting	Cultivation§	Herbicide‖	Cultivation	Herbicide	
None	None	4.1 a-e¶	2.9 c-f	2.9 e-f	2.9 c-f	3.0 b
DBCP	None	2.5 d-f	4.2 a-e	1.9 f	3.7 a-f	3.1 b
None	DBCP	3.8 a-f	4.4 a-d	3.1 b-f	4.7 a-c	4.0 a
DBCP	DBCP	4.1 a-e	5.3 a	3.6 a-f	4.8 a-c	4.4 a
MBR-CP	None	3.5 a-f	5.0 a	2.3 e-f	3.5 a-f	3.6 a b
MBR-CP	DBCP	4.0 a-e	5.4 a	4.5 a-d	3.3 a-f	4.3 a
Average		3.7 b	4.5 a	2.9 c	3.8 b	

Average (main effects) for lime treatment = 4.1 a; for no-lime treatment = 3.4 b
Average (main effects) for herbicide treatment = 4.2 a; for cultivation treatment = 3.3 b

*DBCP (1,2-dibromo-3-chloropropane) at 67.8 kg/ha; MBR-CP (67% methyl bromide plus 33% chloropicrin) at 336 kg/ha.

†1 = total discoloration, 9 = no discoloration.

‡Dolomite at 6720 kg/ha applied broadcast before planting.

§Disk cultivation as needed to control weeds.

‖Terbicil at 2.2 kg/ha to a 1-m band on each side of row annually.

¶Numbers followed by the same letter do not differ significantly as measured by Duncan's multiple-range test ($P = 0.05$).

TABLE 3. Tree death of peach trees planted in plots treated with nematicides, dolomite, and herbicide on a peach tree short-life site in Georgia.

Nematicide treatment*		Percentage tree death				Average (main effects) for nematicide treatment
		Lime†		No lime		
Preplanting	Postplanting	Cultivation‡	Herbicide§	Cultivation	Herbicide	
None	None	42 a-c‖	50 a-c	75 a b	67 a-c	58 a-c
DBCP	None	67 a-c	58 a-c	75 a b	63 a-c	66 a
None	DBCP	50 a-c	38 b c	46 a-c	50 a-c	46 b-d
DBCP	DBCP	46 a-c	38 b c	42 a-c	29 c	39 d
MBR-CP	None	54 a-c	46 a-c	79 a	63 a-c	60 a b
MBR-CP	DBCP	42 a-c	38 b c	42 a-c	46 a-c	42 c d
Average		50 a	44 a	60 a	53 a	

Average (main effects) for lime = 47.2 a; for no lime = 56.3 a
Average (main effects) for herbicide = 48.6 b; for cultivation = 54.9 a

*DBCP (1,2-dibromo-3-chloropropane) at 67.8 kg/ha; MBR-CP (67% methyl bromide plus 33% chloropicrin) at 336 kg/ha.
†Dolomite at 6720 kg/ha applied broadcast before planting.
‡Disk cultivation as needed to control weeds.
§Terbicil at 2.2 kg/ha to a 1-m band on each side of row annually.
‖Numbers followed by the same letter do not differ significantly as measured by Duncan's multiple-range test ($P = 0.05$).

populations, however, were generally correlated negatively with yield and positively with tree death (Table 5).

The effect of nematodes on yields seemed to be delayed. The populations in 1968 correlated only with the yields in 1970. Populations in 1969 were correlated negatively and significantly with yields in 1970 ($P = 0.1$), 1971 ($P = 0.01$), and 1972 ($P = 0.01$) and positively with tree death through 1972 ($P = 0.001$). Populations in 1970 were not correlated with the 1970 yields but were correlated negatively with yields in 1971 ($P = 0.05$) and 1972 ($P = 0.001$) and positively with tree death through 1972 ($P = 0.001$). Nematode populations in 1971 were not

TABLE 4. Total fruit harvested from peach trees planted in plots treated with nematicides, dolomite, and herbicide on a peach tree short-life site in Georgia.

Nematicide treatment*		Kg per tree				Average (main effects) for nematicide treatment
		Lime†		No lime		
Preplanting	Postplanting	Cultivation‡	Herbicide§	Cultivation	Herbicide	
None	None	57.4 a-d‖	51.7 b-f	30.2 e-f	47.2 b-f	46.6 c
DBCP	None	42.1 d-e	64.1 a-d	29.4 f	55.0 a-e	47.7 c
None	DBCP	49.7 b-c	62.0 a-d	43.4 c-f	59.1 a-d	53.5 b c
DBCP	DBCP	58.4 a-d	68.5 a-c	55.0 a-e	54.8 a-e	59.2 a b
MBR-CP	None	43.8 c-f	67.5 a-d	43.1 c-f	60.0 a-d	58.6 b c
MBR-CP	DBCP	79.2 a	71.5 a b	60.4 a-d	64.3 a-d	68.9 a
Average		55.1 b	64.2 a	43.6 c	56.7 a b	

Average (main effects) for lime = 59.7 a; for no lime = 50.1 b
Average (main effects) for herbicide = 60.5 a; for cultivation = 49.3 b

*DBCP (1,2-dibromo-3-chloropropane) at 67.8 kg/ha; MBR-CP (67% methyl bromide plus 33% chloropicrin) at 336 kg/ha.
†Dolomite at 6720 kg/ha applied broadcast before planting.
‡Disk cultivation as needed to control weeds.
§Terbicil at 2.2 kg/ha to a 1-m band on each side of row annually.
‖Numbers followed by the same letter do not differ significantly as measured by Duncan's multiple-range test ($P = 0.05$).

TABLE 5. Coefficients for correlation of average *Macroposthonia xenoplax* populations in 4 years (1968-71) with average yield in 3 years (1970-72) and with mortality for peach trees planted on a short-life site.

M. xenoplax population compared (year)	Coefficient of correlation between *M. xenoplax* populations and indicated tree characteristic			
	Yield (kg/tree)			Mortality (%)
	1970	1971	1972	Through 1972
1968	−0.56***	−0.3 ns	−0.15 ns	—
1969	−0.33*	−0.55***	−0.60***	+0.70****
1970	+0.01 ns	−0.52**	−0.65****	+0.73****
1971	—	−0.34 ns	−0.59***	+0.57***

NOTE: Not significant at $P = 0.1$; *, **, ***, and ****, respectively, significant at $P = 0.1$, $P = 0.05$, $P = 0.01$, and $P = 0.001$.

correlated with yields in 1971 but were with yields in 1972 ($P = 0.01$) and with tree death through 1972 ($P = 0.01$).

Trees died rapidly in this study as in commercial orchards in Georgia. The trees usually collapsed after spring foliation. No symptom could be used to determine a moribund tree or diagnose the cause of death.

Our results strongly indicate that *M. xenoplax* influences the susceptibility of the tree to PTSL. In our tests, tree deaths were reduced by use of preplanting plus postplanting nematicides and by use of herbicide rather than disk cultivation.

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