Incidence of *Criconemella* spp. and Peach Orchard Histories in Short-Life and Non-Short-Life Sites in Georgia and South Carolina

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ABSTRACT

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Plant-parasitic nematode populations in soil and peach roots were determined in peach tree short-life (PTSL) and non-PTSL orchards in Georgia and South Carolina. *Criconemella xenoplax* was predominant in all orchards in both states. Other *Criconemella* spp. detected in this study included *C. ornata* and *C. sphaerocephala*, with the former occurring more frequently than the latter. Loamy sand soils were predominant in Georgia and South Carolina PTSL orchards, with pH and percent sand being greater in South Carolina. Soil textural class and *C. xenoplax* were common factors associated with PTSL orchards in Georgia and South Carolina.

Additional key words: *Prunus persica*, ring nematode

Bacterial canker (*Pseudomonas syringae* pv. *syringae* van Hall) (10,15) and/or cold injury (9,11) are responsible for the sudden collapse of peach trees (*Prunus persica* (L.) Batsch) associated with the peach tree short-life syndrome (PTSL) in the southeastern United States. Soil pH (14) and the ring nematode (*Criconemella xenoplax* (Raski) Luc & Raski) (9) are among the factors that predispose peach trees to PTSL. A nematicide treatment threshold of >50 *C. xenoplax* per 100 cm^3 of soil is recommended to commercial orchardists in South Carolina. Although control of *C. xenoplax* is considered essential in South Carolina for optimum peach production (16,17), in Georgia, its importance relative to other factors is uncertain. Some research in Georgia implicates *C. xenoplax* in PTSL (15), whereas in another study (R. E. Motsinger, *unpublished*), *C. ornata* (Raski) Luc & Raski was more common in short-life orchards. In this survey, we compared the incidence of *Criconemella* spp. and orchard histories in PTSL and non-PTSL orchards in Georgia and South Carolina.

MATERIALS AND METHODS

Nematode assay, 1983. Soils from PTSL and non-PTSL orchards in Georgia and South Carolina were assayed for plant-parasitic nematodes during late May and early June, respectively. Non-PTSL orchards were characterized as orchards where PTSL had never occurred and was not likely to occur because of the advanced age of the orchards. PTSL orchards were characterized from the history of the orchards and/or the presence of the disease that year. Eighty soil cores (2.5 cm in diameter × 30 cm deep, one probe per tree) were taken under the tree canopy from each of the nine PTSL and non-PTSL orchards in Georgia and from 10 PTSL and 11 non-PTSL orchards in South Carolina. The soil from each orchard was composited and divided among three laboratory locations (University of Georgia, Athens; USDA, Byron, GA; and Clemson University, Clemson, SC). At each location, each sample was further divided in half. Half of the samples were moistened and incubated for 72 hr (6), and half were processed without additional moisture. All samples were stored at 12.5 C until nematodes were extracted from a 100-cm^3 subsample by centrifugal flotation (4). Nematodes of the genus *Criconemella* were identified to species, but other soil-inhabiting nematodes were identified to genus only.

Characteristics such as soil pH, soil textural classification, tree age (since planting), rootstock, and presence or absence of a permanent ground cover between tree rows were recorded.

Nematode assay, 1984. Populations of *C. xenoplax* were determined under trees in PTSL and non-PTSL orchards in Georgia and South Carolina to determine similarities of nematode populations. In this study, non-PTSL orchards were orchards where trees were not showing typical PTSL symptoms in the spring of 1984. Five peach orchards showing PTSL symptoms and four non-PTSL orchards were sampled in Georgia in April, and five of each type were sampled in South Carolina in May. Within PTSL orchards for both states, five trees showing PTSL symptoms and five symptomless trees were randomly selected. In non-PTSL orchards, five random trees were selected. Eight soil cores, each 2.5 × 30 cm, were composited from under the canopy of each tree for a total of five samples each for symptomless PTSL trees, PTSL trees with symptoms, and non-PTSL trees. Nematodes were extracted by centrifugal flotation and counted. Because of variation in data, a $\log_{10}$ transformation was performed on the nematode population data. A general linear model analysis was performed on PTSL orchards regarding tree vigor within the two states. A schematic plot of the mean was also performed to compare the variation in *C. xenoplax* populations under the different tree types in the two states.

RESULTS

Nematode assay, 1983. Seven genera of plant-parasitic nematodes were commonly detected in one or more PTSL and non-PTSL orchards in Georgia and South Carolina by all three laboratories. The genera were *Criconemella, Helicotylenchus, Meloidogyne, Tylenchorhynchus, Paratrichodorus, Pratylenchus*, and *Xiphinema*. *Criconemella* was the only genus present in all orchards in both states (Table 1). Three *Criconemella* spp. were identified: *C. xenoplax, C. ornata*, and *C. sphaerocephala* (Taylor) Luc & Raski. *C. xenoplax* and *C. ornata* occurred in almost all orchards in Georgia and South Carolina, but *C. xenoplax* were always more numerous than *C. ornata*. The mean number of *C. xenoplax* was about the same in PTSL as in non-PTSL orchards in Georgia but was two times greater in PTSL than in non-PTSL orchards in South Carolina. The number of *C. ornata* and *C. sphaerocephala* was low in all orchards, but *C. ornata* showed a trend toward being slightly higher in PTSL than in non-PTSL orchards in both states.

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Mean differences between number of *Criconemella* spp. extracted via centrifugal flotation of incubated (moistened) and nonincubated soil suggest that wetting soil increased the number of *Criconemella* spp. per 100 cm^3 of soil with all samples, except for Georgia non-PTSL soil. Differences were not as great as expected. A 1.5-fold increase in recovery rate in incubated soil compared with nonincubated soil was expected (6).

Orchards with >50 *C. xenoplax* per 100 cm^3 of soil were analyzed separately to determine if an association existed between orchards in Georgia and South Carolina. In both states, a greater percentage of PTSL than of non-PTSL orchards exceeded the threshold of >50/100 cm^3 of soil, even though the mean numbers of *Criconemella* spp. and *C. xenoplax* in the PTSL orchards were lower (Table 2).

Orchard characteristics. Orchard characteristics for Georgia and South Carolina PTSL and non-PTSL orchards are presented in Tables 3 and 4, respectively. Four soil textural classifications sampled in this study were of a sandy consistency and included loamy sand (LS), sandy loam (SL), sandy clay loam (SCL), and sand (S). In Georgia PTSL orchards, LS soils were sampled most frequently (45%), followed by SL (33%) and SCL (22%) soils. In non-PTSL orchards, LS and SL soils occurred 33% of the time, followed by S (23%) and SCL (11%) soils. Most soil types sampled in PTSL orchards in South Carolina, as in Georgia, were LS (60%), followed by S (20%), SL (10%), and SCL (10%) soils (Table 4). In non-PTSL orchards, SL (55%) were sampled more frequently than LS (27%), S (18%), and SCL (0%) soils. There was no relationship between percent sand and soil pH regarding orchard type in both states. The pH and percent sand of soils in South Carolina PTSL orchards tended to be higher than in the soils in PTSL orchards in Georgia.

Nemaguard and Lovell were the only rootstocks in orchards sampled in Georgia, with the former occurring as often in PTSL as in non-PTSL orchards (65 and 67%, respectively). The mean tree age was 8 yr in non-PTSL and 5 yr in PTSL orchards. Lovell, Nemaguard, and Halford rootstocks were present in orchards sampled in South Carolina. Lovell was the predominant rootstock in PTSL (70%) and non-PTSL (82%) orchards; Nemaguard was present in 20 and 8%, respectively, of the orchards, whereas Halford was present in 10% of the PTSL orchards and non-PTSL orchards. The mean tree age was similar in both PTSL and non-PTSL orchards in South Carolina.

Eighty-nine percent of the PTSL orchards and 78% of the non-PTSL orchards in Georgia had ground cover. In South Carolina, only 40% of the PTSL and 64% of the non-PTSL orchards had ground cover. These data suggest that South Carolina growers cultivate their orchard floors more than do Georgia growers.

Nematode assay, 1984. Populations of *C. xenoplax* were greater ($P=0.01$) under trees showing symptoms than under symptomless trees in PTSL orchards in Georgia (Table 5). In non-PTSL

Table 1. Relative density and mean populations of seven nematode genera in peach tree short-life (PTSL) and non-PTSL orchards in Georgia (May 1983) and South Carolina (June 1983)

Genus Species	Georgia[a]				South Carolina[b]			
	PTSL		Non-PTSL		PTSL		Non-PTSL	
	No.[c]	Percent[d]	No.	Percent	No.	Percent	No.	Percent
Criconemella spp.	103	100	113	100	124	100	76	100
xenoplax[e]	58	100	56	100	58	100	28	91
ornata[e]	9	100	6	100	10	100	4	91
sphaerocephala[e]	<1	11	1	22	1	40	<1	9
Paratrichodorus spp.	3	89	3	100	1	60	3	82
Xiphinema spp.	17	78	7	78	5	80	7	91
Helicotylenchus spp.	7	78	13	78	6	80	7	91
Pratylenchus spp.	6	67	3	89	15	80	24	82
Tylenchorhynchus spp.	8	56	11	67	28	80	20	82
Meloidogyne spp.	3	56	5	67	3	70	7	82

[a] Mean for nine PTSL and nine non-PTSL orchards, six subsamples per orchard.
[b] Mean for 10 PTSL and 11 non-PTSL orchards, six subsamples per orchard.
[c] Average number of nematodes per 100 cm^3 of soil as determined by laboratories in Athens and Byron, GA, and Clemson, SC.
[d] Percentage of samples containing the nematode genus and/or species.
[e] Species identification based on mature females only.

Table 2. Incidence and population of *Criconemella xenpolax* in peach tree short-life (PTSL) and non-PTSL orchards in Georgia (May 1983) and South Carolina (June 1983)

State	Orchard	Total orchards	Orchards containing >50/100 cm^3 soil (%)	Mean no. of nematodes in orchards with populations >50/100 cm^3 soil	
				Total *Criconemella* spp.	*C. xenoplax*
Georgia	PTSL	9	78	153	97
	Non-PTSL	9	56	220	112
South Carolina	PTSL	10	80	132	100
	Non-PTSL	11	27	231	102

Table 3. Comparison of orchard characteristics from nine peach tree short-life (PTSL) and nine non-PTSL orchards in Georgia (May 1983)

Orchard	PTSL						Non-PTSL					
	pH	Sand (%)	Soil textural class[a]	Rtsk.[b]	Tree age (yr)	Sod[c]	pH	Sand (%)	Soil textural class	Rtsk.	Tree age (yr)	Sod
1	6.7	84	LS	N	4	+	6.0	84	LS	N	7	+
2	6.3	86	LS	N	3	+	5.5	80	LS	N	5	−
3	5.8	66	SL	···	6	+	5.3	84	LS	N	11	−
4	5.0	77	SL	L	9	+	4.5	66	SL	···	···	+
5	4.4	64	SCL	L	···	+	4.9	89	S	···	···	+
6	6.0	84	LS	N	7	+	5.2	90	S	L	7	+
7	6.2	64	SCL	L	6	+	6.2	72	SL	L	8	+
8	5.2	80	LS	N	3	+	5.1	78	SL	N	3	+
9	6.2	79	SL	N	2	−	6.0	54	SCL	···	14	+

[a] LS = loamy sand, SL = sandy loam, SCL = sandy clay loam, and S = sand.
[b] Rtsk. = rootstock, N = Nemaguard, and L = Lovell.
[c] Sod (ground cover): + = present and − = absent.

Table 4. Comparison of orchard characteristics from 10 peach tree short-life (PTSL) and 11 non-PTSL orchards in South Carolina (June 1983)

	PTSL						Non-PTSL					
Orchard	pH	Sand (%)	Soil textural class[a]	Rtsk.[b]	Tree age (yr)	Sod[c]	pH	Sand (%)	Soil textural class	Rtsk.	Tree age (yr)	Sod
1	6.2	87	LS	N	11	−	5.7	73	SL	L	7	+
2	6.1	85	LS	L	6	−	5.5	87	LS	L	9	−
3	6.7	91	S	N	6	+	6.6	85	LS	N	9	+
4	6.5	86	LS	L	5	−	6.8	86	LS	N	7	−
5	6.4	84	LS	L	4	−	6.3	70	SL	L	7	−
6	6.8	84	LS	L	6	+	6.8	90	S	L	8	−
7	6.5	66	SCL	L	7	+	6.5	78	SL	L	9	+
8	6.4	76	SL	L	7	+	6.6	64	SL	L	6	+
9	4.9	82	LS	L	9	−	6.6	68	SL	L	6	+
10	5.7	92	S	H	5	−	5.0	68	SL	L	7	+
11	...	...	...	...	...	...	6.4	90	S	L	6	+

[a] LS = loamy sand, SL = sandy loam, SCL = sandy clay loam, and S = sand.
[b] Rtsk. = rootstock, N = Nemaguard and L = Lovell.
[c] Sod (ground cover): + = present and − = absent.

Table 5. Populations of *Criconemella xenoplax* around healthy and/or dying trees in peach tree short-life (PTSL) and non-PTSL orchards in Georgia (April 1984) and South Carolina (May 1984)

		No. of *C. xenoplax*/100 cm³ soil		
			South Carolina	
Orchard	Tree vigor[a]	Georgia	Dry	Wet[b]
		PTSL Orchards		
1	S	410	175	320
	H	167	433	1,200
2	S	232	331	462
	H	217	500	608
3	S	380	116	246
	H	222	145	272
4	S	162	86	154
	H	81	229	364
5	S	628	153	228
	H	33	279	185
Mean[c]	S	362	172	282
	H	144	317	526
		Non-PTSL orchards		
6	G	153	69	221
7	G	2	50	50
8	G	417	297	1,068
9	G	122	80	158
10	G	...	32	29
Mean		173	106	306

[a] S = Trees showing PTSL symptoms; G and H = symptomless trees. Five S trees and five H trees per PTSL orchard per state and five G trees per non-PTSL orchard per state were sampled.
[b] Wet (incubated) soil represents soil to which 20 ml of water per 100 cm³ of soil was added and left at 12.8 C for 72 hr.
[c] Means are significantly ($P = 0.01$) different according to general linear model analysis.

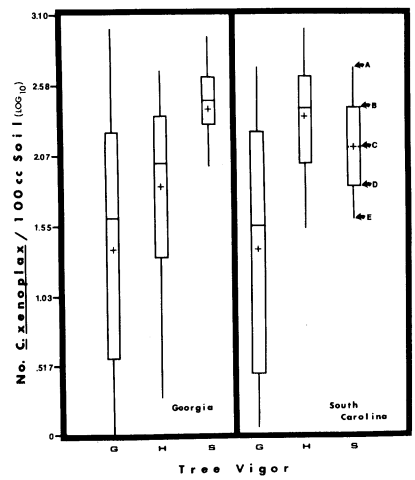

Fig. 1. Population ($\log_{10}$) of *Criconemella xenpolax* per 100 cm³ of soil around symptomless (H) and dying (S) peach trees in selected peach tree short-life (PTSL) and symptomless trees (G) in selected non-PTSL orchards in Georgia (April 1984) and South Carolina (May 1984). A = upper boundary (maximum), B = 75th percentile, C = mean (+) and median (−), D = 25th percentile and E = lower boundary (minimum).

orchards, mean populations under trees were less than in PTSL orchards showing symptoms but only slightly lower than in PTSL orchards under symptomless trees. Based on a $\log_{10}$ transformation, the variation of *C. xenoplax* populations under trees without symptoms in non-PTSL orchards was greater than that under trees either with or without symptoms in PTSL orchards (Fig. 1).

Because of dry weather, soil samples in South Carolina, but not in Georgia, required incubation before assay in 1984. A greater number of *C. xenoplax* were extracted from soil that was wetted and incubated than from soil left dry (Table 5). Mean populations in both dry and wetted soils from PTSL orchards were greater ($P = 0.01$) under symptomless trees than under trees showing symptoms. There was more variability in populations of *C. xenoplax* under symptomless trees in non-PTSL orchards than in PTSL orchards with or without symptoms in both Georgia and South Carolina. (Fig. 1).

DISCUSSION

The relative density of *Criconemella* spp. in PTSL and non-PTSL orchards in Georgia and South Carolina was greater than that of all other genera of plant-parasitic nematodes detected in 1983. *C. xenoplax* and *C. ornata* occurred in almost 100% of the orchards, but *C. xenoplax* was the more prominent species. *C. xenoplax* is pathogenic on peach (7) and predisposes trees on Nemaguard rootstock to cold injury (9). *C. ornata* and *C. sphaerocephala*, on the other hand, are associated primarily with grasses (5,12,13) and/or such agronomic crops as peanut (*Arachis hypogaea* (L.) (3,8). According to Ratanaworabhan and Smart (12), *C. ornata* was parasitic and pathogenic on centipedegrass (*Eremochloa ophiuroides* (Munro) Hack) after 5.3 mo but had no effect on Lovell peach 4.3 mo after inoculation in a greenhouse study. However, Lownsbery et al (7) and Barker and Clayton (1) demonstrated that it took at least 12 and 18 mo, respectively, before a marked decrease in root weight of Lovell rootstock growing in *C. xenoplax*-infested soil was observed. Results of this study suggest that peach may be a better host for *C. xenoplax* than *C. ornata* since *C. xenoplax* was always more prominent

than *C. ornata* in both states and orchards. *C. ornata* was slightly more prevalent in PTSL than in non-PTSL orchards, but whether it could be associated with PTSL is not known.

In South Carolina >50 *C. xenoplax* per 100 cm^3 of soil is the threshold level at which nematode control is recommended to commercial orchardists. The mean population of *Criconemella* spp. was above the threshold level in PTSL and non-PTSL orchards in both states. However, the percent incidence of *C. xenoplax* >50 occurring in individual orchards was greater for PTSL than for non-PTSL orchards. For statewide figures, percent incidence appears to be more useful than mean numbers alone, because a few high numbers would inflate the means, whereas the percent incidence would not be affected. The South Carolina action threshold level appears applicable for Georgia based on the incidence of >50 *C. xenoplax* between orchards.

Orchards planted to Lovell rootstock, with a soil pH of 6.5–7.0, and not clean-cultivated between tree rows usually survive longer on PTSL orchards (2,17). Georgia and South Carolina peach growers use similar cultural practices, with the exception of soil pH and a permanent ground cover between tree rows. In South Carolina, orchards were planted predominately with Lovell rootstock, if the information we obtained from growers was correct, had soils with pH generally greater than 6.1, and clean cultivation was practiced. Nemaguard rootstock, lower soil pH, and the presence of permanent ground cover predominated in Georgia. We are not certain why some preventative measures toward PTSL are practiced and others are not.

C. xenplax was the more prominent species in all orchards in 1984, as in the 1983 study, but population trends under known PTSL and non-PTSL trees differed between the two states. Differences in trends are thought to be partially due to time of year and soil moisture. The South Carolina samples were collected in May and were considerably drier. Variation in *C. xenoplax* populations under specific tree types also occurred within orchards. The greatest variability occurred in non-PTSL orchards in both states. This suggests that the *C. xenoplax* population in PTSL orchards had probably been established longer than in the non-PTSL orchards. This is a possible indication that an orchard will succumb to PTSL.

In conclusion, Georgia and South Carolina have similar PTSL situations, with *C. xenoplax* appearing to be a common factor. Although differences were observed in soil pH and rootstock, both of which have been related to the incidence of PTSL, it is uncertain if these factors directly affect PTSL or indirectly affect it by influencing the population of *C. xenoplax*. Further investigations are also needed to determine if *C. ornata* or other ectoparasitic nematodes are involved with the PTSL syndrome in the southeastern United States.

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