Incidence of *Fusarium* and *Pythium* spp. in Peach Feeder Roots as Related to Dibromochloropropane Application for Control of *Criconemella xenoplax*

A. P. NYCZEPIR, Former Graduate Student, and S. A. LEWIS, Professor, Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29631

ABSTRACT

Nyczepir, A. P., and Lewis, S. A. 1984. Incidence of *Fusarium* and *Pythium* spp. in peach feeder roots as related to dibromochloropropane application for control of *Criconemella xenoplax*. Plant Disease 68:497-499.

Roots of peach trees in 10 commercial orchards with a history of peach tree short life were assayed for *Fusarium, Pythium,* and *Phytophthora* spp., *Criconemella xenoplax*, and feeder root necrosis. *Pythium* and *Fusarium* spp. were common in peach feeder roots, but *Phytophthora* spp. were not isolated. *C. xenoplax*, the predominant plant-parasitic nematode, occurred in more than 50% of all soil samples. Feeder root necrosis was severe in the presence of *C. xenoplax* but was not influenced by DBCP application.

Peach tree short life (PTSL) is severe in the sandy soils that run in a narrow band from southwest to northeast across South Carolina (18). In the Piedmont region, where heavier soils predominate, PTSL is less significant, except in areas where *Criconemella xenoplax* (Raski) Luc & Raski and sandy soil are present. The significance of *C. xenoplax* as a factor in the PTSL syndrome has been demonstrated (12).

Feeding of *C. xenoplax* causes malformation, discoloration, and a reduction in the number of functional feeder roots. Cortical tissue is easily removed when roots are rubbed or shaken in water (13). Certain fungi, especially *Cylindrocladium* (15), *Pythium* (5), *Phytophthora* (10), and *Fusarium* (6), may cause similar symptoms. In South Carolina, *C. xenoplax* is associated with feeder root necrosis (18), but fungi from feeder roots of peach trees growing in a number of PTSL sites have not been assayed. In this study, we investigated whether *Pythium, Phytophthora,* and *Fusarium* spp. are correlated with feeder root necrosis and dibromochloropropane (DBCP) application for control of *C. xenoplax* in South Carolina peach orchards.

Part of a dissertation submitted by the first author in partial fulfillment of the requirements for the Ph.D. degree in Plant Pathology at Clemson University.

Present address of first author: U.S. Department of Agriculture, ARS, Southeastern Fruit and Tree Nut Research Laboratory, P.O. Box 87, Byron, GA 31008.

Published with approval of the Director of the South Carolina Agricultural Experiment Station as Technical Contribution 2209.

Accepted for publication 14 December 1983.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

This article is in the public domain and not copyrightable. It may be freely reprinted with customary crediting of the source. The American Phytopathological Society, 1984.

MATERIALS AND METHODS

Site characteristics. *Pythium, Phytophthora,* and *Fusarium* spp. associated with peach feeder roots of Nemaguard rootstock were studied in orchards in Edgefield (five orchards), Saluda (two orchards), and Lexington counties (three orchards). Trees were 4–6 yr old and on sites with histories of PTSL. The soil received one postplant application of DBCP at 61 kg a.i./ha in the fall of 1976. The fumigant was chisel-injected on 20.3-cm centers at a point 55 cm from the trunk and to a depth of 10 cm, in bands 1.22 m wide on either side of the tree row.

Fumigation treatments were replicated 10 times in a randomized complete block experiment with a split-plot design. Orchards were whole plots and fumigation treatments were split plots. Within whole plots, five random trees were sampled every 4 mo for 1 yr beginning in July 1977. Two 500-cm^3 soil samples containing feeder roots were obtained within the tree row (one on either side of the tree) and designated as the nonfumigated treatment because a 1.10-m narrow strip was not fumigated due to equipment limitations. Two similar samples collected along the dripline were designated as the fumigated treatment. Therefore, each tree had two soil-root samples per treatment, making a total of 10 subsamples per treatment per orchard.

Fungi in roots. Roots and soil were carefully separated into plastic bags. Washed root samples were rated for necrosis. Samples received a plus rating (+) if feeder roots were necrotic. Five feeder root segments 1.5 cm long were selected randomly from each sample, surface-sterilized in 70% EtOH, and dried on paper towels. Segments were placed on a modified $P_{10}VP$ selective medium (11), incubated in the dark at 20 C, and examined after 48 hr for *Pythium* spp. and at 48-hr intervals for 10 days for *Phytophthora* spp. Segments on potato-dextrose agar surfactant medium (14) were incubated in the dark at 25 C and examined for *Fusarium* spp. after 10 days. The number of root segments infected by each fungus was recorded.

Nematode populations. Nematodes were extracted from soil with a semiautomatic elutriator (2) and centrifugal-flotation (7). If soil moisture was low, soil samples were moistened with 80 ml water and incubated for 24 hr (8). Populations of *C. xenoplax* and other plant-parasitic nematodes were counted in a 1-ml aliquot from the nematode suspension.

RESULTS

Fungi in roots. *Fusarium oxysporum* Schlecht, *F. solani* (Mart.) Sacc., *F. roseum* (Corda) Sacc., 'Equiseti,' *F. roseum* Ell. & Ev., 'Acuminatium,' *Pythium irregulare* Buism., and *P. vexans* de Bary were isolated from feeder roots. *F. oxysporum* and *F. solani* occurred most commonly in orchards. *Fusarium* and *Pythium* spp. were present in all orchards, but *Fusarium* spp. were isolated more frequently and consistently than *Pythium* spp. Fumigation with DBCP did not significantly affect the frequency of *Fusarium* and *Pythium* isolations (Table 1). *Phytophthora* spp. were not found.

Seasonal sampling did not influence the frequency of *Pythium* spp. in feeder roots, but *Fusarium* spp. were isolated most often in July 1977 ($P = 0.05$) (Table 1).

Feeder root necrosis. Feeder root necrosis was extensive but was not affected by fumigation. *Fusarium* spp. were isolated most often from necrotic feeder roots.

Nematode populations. *C. xenoplax, Tylenchorhynchus claytoni* Steiner, *Meloidogyne incognita* (Kofoid & White) Chitwood, and *Scutellonema brachyurum* (Steiner) Andrássy were found. *C. xenoplax* was the most abundant and only plant-parasitic nematode present in more than 50% of all samples assayed on any one sampling date. Fumigation decreased ($P = 0.01$) the population of *C. xenoplax* but not of *M. incognita* (Table 2). The number of *C. xenoplax* was greater in July 1978 than in November 1977, whereas juveniles of *M. incognita* were fewer ($P = 0.05$) in March 1978 than on other sampling dates. Numbers of *T. claytoni* and *S. brachyurum* did not differ

Table 1. Incidence of *Fusarium* and *Pythium* spp. in necrotic and nonnecrotic Nemaguard peach feeder roots from 10 orchards, July 1977–July 1978

	Percent feeder roots infected with[w]			Percent necrotic feeder roots infected with[y]		Percent nonnecrotic feeder roots infected with	
Sampling date	*Fusarium*	*Pythium*	Soil treatment[x]	*Fusarium*	*Pythium*	*Fusarium*	*Pythium*
July 1977	47 a[z]	2.0 a	NF	25	0.8	19	1.2
			F	28	0.6	23	1.0
November 1977	39 b	1.5 a	NF	38	1.4	3	0.2
			F	28	1.0	7	0.6
March 1978	30 c	6.5 a	NF	20	5.4	9	1.8
			F	20	4.8	11	2.2
July 1978	36 bc	5.5 a	NF	23	3.2	13	3.2
			F	25	3.0	12	0.8
Mean	...	...	NF	27	2.7	11	1.6
			F	26	2.4	13	1.2

[w] Based on 1,000 1.5-cm segments per sampling date.
[x] NF = nonfumigated soil, F = soil fumigated with dibromochloropropane (61 kg a.i./ha) in the fall of 1976.
[y] Based on 10 1.5-cm segments per tree, five trees per orchard.
[z] Numbers within a column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

Table 2. Population of *Criconemella xenoplax* and *Meloidogyne incognita* in fumigated and nonfumigated soil from 10 peach orchards, July 1977–July 1978

	Nematodes/100 cm³ soil[u]			Nematodes/100 cm³ soil as influenced by fumigation[x]	
Sampling date	Cx[v]	Mi	Soil treatment[w]	Cx[y]	Mi
July 1977	123 ab[z]	21 a	F	64	14
			NF	181	27
November 1977	50 b	7 a	F	33	5
			NF	66	8
March 1978	200 ab	0 b	F	110	0
			NF	289	0
July 1978	295 a	34 a	F	224	33
			NF	365	35
Mean	...	...	F	108	13
			NF	225	18

[u] Based on 20 soil samples per orchard.
[v] Cx = *Criconemella xenoplax*, Mi = *Meloidogyne incognita*.
[w] NF = nonfumigated soil, F = soil fumigated with dibromochloropropane (61 kg a.i./ha) in the fall of 1976. Fumigation significantly ($P = 0.01$) reduced the population of *C. xenoplax* on all sampling dates.
[x] Based on 10 soil samples per orchard.
[y] Numbers within a sampling date are significantly different ($P = 0.01$) according to the Student *t* test.
[z] Numbers within a column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

between treatments or among sampling dates.

Nematode-root necrosis correlation. *C. xenoplax* was the only nematode associated with feeder root necrosis. Necrotic feeder roots appeared more often in soil samples infested with *C. xenoplax* than in those not infested (Table 3) or infested with other nematodes. An increase in feeder root necrosis (as in November 1977) corresponded to a decrease in *C. xenoplax* populations per sample, whereas the percentage of samples infested with the nematode increased. Nonnecrotic feeder roots corresponded to decreases in nematode populations and percent infested samples during the same sampling period.

Nematode-fungus correlation. *Fusarium* and *Pythium* spp. were isolated more frequently in *C. xenoplax*-infested soil regardless of soil treatment (Table 4), with the exception of *Pythium* frequency in fumigated soil on the first two sampling dates. The presence of *C. xenoplax* was associated with the incidence of *Fusarium* spp. more than *Pythium* spp. regardless of sampling date.

DISCUSSION

In this 10-orchard study, *Fusarium* and *Pythium* spp. were found in peach feeder roots in both fumigated and nonfumigated soils. The fungi were not influenced by fumigation with DBCP. This is understandable because DBCP suppresses soil-inhabiting fungi only when used at three times the concentration required for nematode control (4). The time of year samples were obtained influenced the frequency of *Fusarium* spp. in roots. *Fusarium* spp. was more common when soil temperatures were warm.

Fusarium spp. have previously been monitored in peach decline sites but have not been identified (6,16). The species found in South Carolina peach orchards may be pathogenic or saprophytic on a number of hosts, given the proper environmental conditions (1). A synergistic interaction between *C. curvata* (Raski) Luc & Raski and *F. oxysporum* was reported on carnation, which resulted in earlier wilting and death of the plant (3). Although *F. oxysporum* and *F. solani* cause wilts of plants, their importance on peach is uncertain. *F. oxysporum* reduced peach seedling growth, which was further reduced in the presence of *Hoplolaimus galeatus* Cobb in the greenhouse; the effects on feeder roots were not reported (17). Hendrix et al (5) stated that *P. irregulare* and *P. vexans* were associated with feeder root necrosis and the short-life disease of peach in Georgia. Although these two species were found in our sites, their contribution to feeder root necrosis appeared to be negligible. Their frequency in roots was low in fumigated and nonfumigated soil. Results from our study tend to substantiate work by Mircetich (9), which suggested that these two species were saprophytes of the necrotic cortical tissue.

C. xenoplax was the only nematode associated with feeder root necrosis in PTSL sites. *Meloidogyne incognita, S. brachyurum*, and *T. claytoni* were present but in fewer than 50% of all soil samples, indicating these nematodes were either poor competitors on peach roots or that Nemaguard rootstock is not a suitable host. Incidence of *M. incognita* was probably low because Nemaguard rootstock is resistant to this nematode.

The low numbers and frequency of *C. xenoplax* in November 1977 corresponds to the time of maximum feeder root necrosis and indicate that the numerical decline may have resulted from fewer feeding sites on the roots. Feeding by *C. xenoplax* seems to be associated with an increase in the incidence of feeder root necrosis; however, nematode numbers may decline if root necrosis is extensive.

C. xenoplax feeds primarily from the cortical region of peach roots, which results in wounds that may act as sites of entry for other microorganisms. Feeder root necrosis may be increased by *Fusarium*, which was more prevalent in the presence of *C. xenoplax* than *Pythium*. *C. xenoplax* may not be the sole cause of feeder root necrosis, but its

Table 3. Feeder root necrosis of Nemaguard peach trees as related to *Criconemella xenoplax* in fumigated and nonfumigated soil from 10 orchards, July 1977–July 1978

			Necrotic feeder roots		Nonnecrotic feeder roots	
Sampling date	Soil treatment[x]	Total root necrosis[y] (%)	*C. xenoplax*/ 100 cm^3 soil[z]	Soil samples with *C. xenoplax*[z] (%)	*C. xenoplax*/ 100 cm^3 soil	Soil samples with *C. xenoplax* (%)
July 1977	NF	62	219	48	156	34
	F	60	106	29	97	23
November 1977	NF	89	77	68	35	9
	F	85	38	49	23	6
March 1978	NF	77	305	61	472	18
	F	74	146	37	204	15
July 1978	NF	67	569	59	199	26
	F	66	289	50	210	25
Mean	NF	74	293	59	216	22
	F	71	145	41	134	17

[x] NF = nonfumigated soil, F = soil fumigated with dibromochloropropane (61 kg a.i./ha) in the fall of 1976.
[y] Based on 10 root samples per treatment per orchard.
[z] Based on ten 100-cm^3 soil samples per treatment per orchard.

Table 4. Incidence of *Fusarium* and *Pythium* spp. in peach feeder roots compared with the presence or absence of *Criconemella xenoplax* in fumigated and nonfumigated soil from 10 orchards, July 1977–July 1978

		Percent feeder roots infected in[y]			
		Nonfumigated soil		Fumigated soil[z]	
Sampling date	*C. xenoplax*[x]	*Fusarium*	*Pythium*	*Fusarium*	*Pythium*
July 1977	Present	33	2	28	1
	Absent	5	0.2	16	1
November 1977	Present	28	1	14	1
	Absent	8	0.2	11	1
March 1978	Present	15	7	15	5
	Absent	5	1	8	2
July 1978	Present	26	5	20	3
	Absent	4	1	6	1
Mean	Present	26	4	19	3
	Absent	6	1	10	1

[x] Based on four 100-cm^3 soil samples per tree, two samples per soil treatment, five trees per orchard.
[y] Based on ten 1.5-cm segments per tree, five trees per orchard.
[z] Soil fumigated with dibromochloropropane (61 kg a.i./ha) in the fall of 1976.

frequent association is greater than either *Fusarium* or *Pythium* spp. alone.

ACKNOWLEDGMENTS

We wish to thank P. E. Nelson, Pennsylvania State University, and A. F. Schmitthenner, Ohio Agricultural Research & Development Center, for their assistance in identifying the *Fusarium* and *Pythium* isolates, respectively, to species.

LITERATURE CITED

1. Booth, C. 1971. The genus *Fusarium*. Commonwealth Mycological Institute, Kew, Surrey, England. 237 pp.
2. Byrd, D. W., Barker, K. R., Ferris, H., Nusbaum, C. J., Griffin, W. E., Small, R. H., and Stone, C. A. 1976. Two semi-automatic elutriators for extracting nematodes and certain fungi from soil. J. Nematol. 8:206-212.
3. Ferraz, S., and Lear, B. 1976. Interaction of four plant parasitic nematodes and *Fusarium oxysporum* f. sp. *dianthi* on carnation. Experientiae 22:272-277.
4. Good, J. M., and Rankin, H. W. 1964. Evaluation of soil fumigants for control of nematodes, weeds, and soil fungi. Plant Dis. Rep. 48:194-199.
5. Hendrix, F. F., Jr., Powell, W. M., and Owens, J. H. 1966. Relation of root necrosis caused by *Pythium* species to peach tree decline. Phytopathology 56:1229-1232.
6. Hine, R. B. 1961. The role of fungi in the peach replant problem. Plant Dis. Rep. 45:462-465.
7. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Rep. 48:692.
8. Lawrence, E. G., and Zehr, E. I. 1978. Improvement of techniques for determining populations of *Macroposthonia xenoplax* in dry soil. Phytopathology 68:1102-1105.
9. Mircetich, S. M. 1971. The role of *Pythium* in feeder roots of diseased and symptomless peach trees and in orchard soils in peach tree decline. Phytopathology 61:357-360.
10. Mircetich, S. M., and Keil, H. L. 1969. Peach root rot caused by *Phytophthora cinnamomi*. (Abstr.) Phytopathology 59:1041.
11. Mircetich, S. M., and Matheron, M. E. 1976. Phytophthora root and crown rot of cherry trees. Phytopathology 66:549-558.
12. Nyczepir, A. P., Zehr, E. I., Lewis, S. A., and Harshman, D. C. 1983. Short life of peach trees induced by *Criconemella xenoplax*. Plant Dis. 67:507-508.
13. Seshadri, A. R. 1964. Investigations on the biology and life cycle of *Criconemoides xenoplax* Raski, 1952 (Nematoda: Criconematidae). Nematologica 10:540-562.
14. Steiner, G. W., and Watson, R. D. 1965. Use of surfactants in the soil dilution and plate count method. Phytopathology 55:728-730.
15. Weaver, D. J. 1971. Association of two *Cylindrocladium* species with "Short Life" of peach trees in Georgia. Phytopathology 61:1095-1096.
16. Weaver, D. J., and Wehunt, E. J. 1975. Effect of soil pH on susceptibility of peach to *Pseudomonas syringae*. Phytopathology 65:984-989.
17. Wehunt, E. J., and Weaver, D. J. 1972. Effect of nematodes and *Fusarium oxysporum* on the growth of peach seedlings in the greenhouse. (Abstr.) J. Nematol. 4:236.
18. Zehr, E. I., Miller, R. W., and Smith, F. H. 1976. Soil fumigation and peach rootstocks for protection against peach tree short-life. Phytopathology 66:689-694.