Host Suitability of Selected Small Grain and Field Crops to *Criconemella xenoplax*

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ABSTRACT

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All soybean and sorghum cultivars tested were suitable hosts for the ring nematode, *Criconemella xenoplax*. Small grain cultivars and cotton were either poor hosts or nonhosts as compared to peach. The wheat cultivars Stacy, Coker 916, and Fla-302 were found to be nonhosts and appear to be allelopathic toward *C. xenoplax*. Rotation of land previously planted to peaches with wheat may prove to be an alternative preplant control method for *C. xenoplax* and the peach tree short life complex.

When peach orchards are terminated because of peach tree short life (PTSL), growers must select a crop to grow on the orchard site. Generally, in the southeastern United States, the orchard site will be planted to a crop other than peaches because it has been a common experience for a new peach planting on a known PTSL site to be stricken with the disease again (1). In Georgia, growers plant small grains, row crops, and occasionally pecans (*Carya illinoensis* (Wangenh.) K. Koch) on PTSL sites.

In field microplot studies, the development of PTSL in the peach (*Prunus persica* (L.) Batsch) cultivar Nemaguard did not occur unless the ring nematode, *Criconemella xenoplax* (Raski) Luc & Raski, was present (6,9). Limited host range studies indicate that this nematode prefers woody perennials to annuals, with some exceptions (5,11,12,14). Little is known about the host suitability of various small grain and row crops to *C. xenoplax*. The objective of this study was to assess the suitability of some small grain and row crops commonly planted in the southeastern United States as a host for *C. xenoplax*.

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MATERIALS AND METHODS

Field studies. The experiment was initiated in November 1986 at the USDA, ARS Southeastern Fruit and Tree Nut Research Laboratory in Byron, Georgia. The study was conducted on a Faceville sandy loam soil (pH 5.6) with a previous history of PTSL. Peaches had been absent from the experimental site for 2 yr and there was no previous history of small grain production. Small grain site preparation and plot size have been described elsewhere (10). The small grain cultivars used are listed in Table 1. The design of this field study was twofold. It was designed to determine relative susceptibility of different small grains to take-all disease (*Gaeumannomyces graminis* (Sacc.) von Arx & Olivier var. *tritici* Walker) and *C. xenoplax*. The take-all experiment (10) was designed with small grains arranged in a split-plot configuration and cultivars and fungal inoculum levels arranged in a strip-plot design within small grain plots. Treatments were replicated four times.

For the purpose of the present nematode study, only noninoculated small grain plots were utilized with the peach cultivars Nemaguard and Lovell and fallow plots included as controls. Small grain main plots and peach and fallow plots comprised a randomized complete block design that was replicated four times. Small grain plots, however, were further subdivided into cultivar subplots. Peach plots were planted with 15 seedlings per cultivar per replicate on a 5.0- × 3.1-m spacing in January 1987. Fallow plots were rotovated as necessary to destroy emerging weeds. All peach trees and small grains received annual applications of fertilizer as recommended by the Georgia Cooperative Extension Service. Plots were planted on 19, 20, and 23 November 1986, 1987, and 1988, respectively, and harvested 2 June 1987, 31 May 1988, and 30 May 1989. A preplant estimate of the population density for *Criconemella* spp. was obtained on 19 November 1986 by arbitrarily collecting 10 cores, each 2.5 cm in diameter × 30 cm deep, throughout each main small grain, fallow, and peach plot. Postharvest and/or postplant nematode population densities were determined on 8 June 1987, 26 May 1988, and 4 May 1989, by collecting six cores throughout each fallow plot and each small grain cultivar subplot not infested with fungal inoculum and two similar size cores each from within the drip line of three peach trees located in the middle of each peach plot. Small grain plots not infested with fungal inoculum were utilized to insure that nematode data reflected host status rather than susceptibility to take-all disease. The cores were composited by subplot, and nematodes were extracted from a 100-cm^3 subsample by elutriation (2) and centrifugation (3) using 250-μm-pore (60 mesh) and 38-μm-pore (400 mesh) sieves. Counts were adjusted for efficiency (67%) of extraction procedures. In November 1988, all small grain plots were planted to wheat (*Triticum aestivum* L. em Thell 'Stacy').

Greenhouse experiment 1. Two-wk-old Nemaguard peach seedlings or one germinated 3-day-old wheat (cv. Coker 916), rye (*Secale cereale* L. 'Wrens Abruzzi'), barley (*Hordeum vulgare* L. 'Dawn'), triticale (× *Triticosecale* Wittm. 'Morrison'), oat (*Avena sativa* L. 'Coker 716' and 'Saia'), or cotton (*Gossypium hirsutum* L. 'McNair 220') seed were planted in plastic pots 15 cm in diameter, containing approximately 1,500 cm^3 of steam-pasteurized loamy sand (86% sand, 10% silt, 4% clay) in November 1986. Peach was used to verify nematode infectivity. Pots containing just soil were designated as a fallow treatment. Approximately 7 days later, the soil in each pot was inoculated with 2,000 *C. xenoplax* juveniles and adults in 40 ml of water. The nematode suspension was poured onto the soil surface that had been previously tilled to a depth of 1.0 cm. An additional 200 ml of water was applied to wash the nematodes into the soil. The isolate of *C. xenoplax*, from a PTSL orchard in Byron, Georgia, was cultured on Nemaguard peach seedlings grown in a sand:vermiculite (50:50 v/v) medium. Nematodes were extracted from the medium by using centrifugal flotation (3). Treatments were arranged in a randomized complete block with 10 and five replications for plant species and fallow, respectively, on benches in an air-conditioned greenhouse (25 ± 5 C). Plants were watered daily and fertilized every 2 wk (7). Six months after inoculation, all plants were harvested and nematodes extracted from the soil as described previously. The nematode reproduction factor (R = final population [Pf] density of all life stages divided by initial population [Pi] density of all life stages) was calculated as a measure of host status among the different plants. Based on the R-values, test plants were grouped into three host categories: $R = 0$, nonhost; $R = 0.01-1.99$, poor host; and $R > 2$, suitable host. Gravid females were also counted as an index of reproduction. Females were considered gravid when oocytes and/or eggs were detected in the ovary.

Greenhouse experiment 2. Wheat and triticale exhibited the most measurable effect on number of gravid females per 100 cm^3 soil; therefore, a second study was initiated to verify these findings and to test additional crops. In addition to Coker 916 wheat and Morrison triticale, one sorghum (*Sorghum vulgare* Pers.), four more wheat and triticale, and eight soybean (*Glycine max* (L.) Merr.) cultivars were tested (Table 3). Peach and fallow treatments were also included as previously described. Soybean and sorghum were included in this experiment because these would be the two field crops most likely to be planted after small grains in the southeastern United States. All soybean cultivars, except Hutton, possess resistance to the Southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood. This experiment was conducted in the same manner as the previous greenhouse test. The soil remaining after assays were made, except peach, was composited by treatment, mixed, and placed into plastic pots 10 cm in diameter. Soil for all treatments was planted to Nemaguard peach as a bioassay to detect levels of *C. xenoplax* not detectable by elutriation and centrifugation. Treatments were replicated four times, and the nematodes were extracted from the soil and counted after

Table 1. Relative density and mean population of *Criconemella* spp. and/or *C. xenoplax* in small grain, peach, and fallow field plots on four sampling dates[a]

		Number of *Criconemella* spp. per 100 cm^3 soil on 19 Nov. 1986	Number and incidence of *C. xenoplax* per 100 cm^3 soil					
			8 June 1987		26 June 1988		4 May 1989[b]	
Plant species	Cultivar		Total	Number of replicates[c]	Total	Number of replicates	Total	Number of replicates
Wheat	Fla 301	...	0	0	0	0	0	0
	Fla 302	...	0	0	19	2	0	0
	Coker 916	...	0	0	4	1	0	0
	Stacy	...	0	0	0	0	0	0
	Hunter	...	0	0	4	1	0	0
	Combined	15	0		5		0	
Triticale	Florico	...	0	0	4	1	0	0
	Morrison	...	4	1	8	1	0	0
	Beagle 82	...	8	1	11	2	0	0
	Councill	...	0	0	8	2	0	0
	AM 4105	...	0	0	4	1	0	0
	Combined	30	2		7		0	
Oat	Coker 716	...	0	0	8	2	0	0
	Coker 227	...	0	0	9	2	0	0
Simpson		...	8	1	0	0	0	0
	Combined	18	3		9		0	
Barley	Dawn	...	0	0	0	0	0	0
	Volbar	...	0	0	8	22	0	0
	Sussex	...	0	0	4	1	0	
	Combined	67	0		4		0	
Rye	Wrens Abruzzi	...	0	0	0	0	0	0
	Fla 401	...	0	0	0	0	0	0
	Pennington Wintergrazer	...	0	0	4	1	0	0
	Combined	22	0		1		0	
Peach	Lovell	...	23	1	15	2	401	4
	Nemaguard	...	8	2	15	1	683	4
	Combined	41	16[d]		15		542[d]	
Fallow		52	0	0	0	0	0	0

[a] Data are means of four replications per cultivar.
[b] All small grain subplots planted to Stacy wheat, November 1988.
[c] Represents number of replicates with *C. xenoplax*.
[d] Different ($P \leq 0.05$) from individual annual plant species and fallow mean according to linear contrast analysis.

6 mo as previously described.

Statistics. Field and greenhouse data were transformed using $\log_{10}(x + 1)$, and an analysis of variance was performed using the general linear model procedure of SAS (SAS Institute, Cary, NC). For the field data, the means of the combined peach treatments were contrasted with the individual small grain species means and with the fallow treatment mean. For the greenhouse data, appropriate pairwise contrasts were performed on individual annual species, the peach, and fallow means. Means within a plant species were analyzed using Duncan's multiple range test. Actual data were used for table presentation.

RESULTS

Field. *Criconemella* spp. were detected in all main plots in the preplant soil sampling in November 1986 (Table 1). After the first growing season, three *Criconemella* spp. were identified in different crop subplots; they included *C. xenoplax, C. ornata* (Raski) Luc & Raski, and *C. sphaerocephala* (Taylor) Luc & Raski (8). However, only the data for *C. xenoplax* are presented because this is the ring nematode reported to be associated with PTSL. The population density of *C. xenoplax* in all small grain cultivar subplots remained low throughout this study, whereas the population in peach was low until the third year. The number of *C. xenoplax* within a plant species did not differ significantly on any postplant sampling date. However, peach, in general, supported greater ($P \leq 0.05$) numbers of *C. xenoplax* than the small grain and fallow plots on the first and last postplant sampling dates. The incidence of *C. xenoplax* in small grain increased slightly from the first to second postplant sampling. *C. xenoplax* was not detected in any grain subplots on the last sampling date, after the grain plots were planted to Stacy wheat in November 1988. *C. xenoplax* was recovered from 100% of the Nemaguard and Lovell peach plots on the last sampling date. The number of *C. xenoplax* around peach increased approximately 98-fold compared to the previous 2-yr combined average, whereas no *C. xenoplax* were detected in the Stacy wheat or fallow plots over the same 3-yr period. *C. xenoplax* was not detected in Fla 301 wheat, Dawn barley, or Wrens Abruzzi or Fla 401 rye subplots during the first two postplant sampling dates, before planting Stacy wheat in November 1988. Typical PTSL symptoms (1) were detected in 17% and 5% of the Nemaguard and Lovell peach trees, respectively, in April 1989.

Table 2. Reproduction of *Criconemella xenoplax* on selected small grains, cotton, and peach cultivars in the greenhouse after 180 days

Plant species	Cultivar	R^a	Number gravid females of *C. xenoplax* per 100 cm^3 soil
Peach	Nemaguard	196.31[b]	4,637[b]
Barley	Dawn	0.90	32
Cotton	McNair 220	0.72	31
Rye	Wrens Abruzzi	0.18	7
Oat	Coker 716	0.06	4
	Saia	0.03	3
Triticale	Morrison	0.01	0
Wheat	Coker 916	0.01	0
Fallow	...	0.03	0

[a] R = reproductive factor ($^{Pf}/_{Pi}$); where Pi = initial population density of 133 *C. xenoplax* per 100 cm^3 soil.
[b] Different ($P \leq 0.01$) from individual annual plant species and fallow according to linear contrast analysis. Data are means of 10 replicates, except for fallow = five replicates.

Table 3. Reproduction of *Criconemella xenoplax* on selected grain, soybean, and peach cultivars in the greenhouse after 180 days

Plant species	Cultivar	R^x	Number gravid females of *C. xenoplax* per 100 cm^3 soil
Peach	Nemaguard	246.12[y]	1,104[y]
Soybean	Delta Pine 417	33.62 a[z]	294 a[z]
	Cobb	15.36 ab	147 a
	Kirby	21.86 ab	147 a
	Coker 368	24.90 ab	129 a
	Hutton	14.65 ab	119 a
	Coker 6738	14.25 b	110 a
	Wright	26.98 ab	110 a
	Braxton	11.90 b	74 a
	Combined	20.44	141
Triticale	Councill	1.71 a	30 a
	Morrison	1.90 ab	38 a
	Beagle 82	0.87 ab	9 ab
	Florico	0.74 ab	5 b
	AM 4105	0.52 b	8 ab
	Combined	1.15	18
Sorghum	Pioneer 8333	4.15	21
Wheat	Fla 301	0.08 a	2 a
	Coker 916	0.03 a	0 a
	Fla 302	0.08 a	0 a
	Stacy	0.06 a	0 a
	Hunter	0.10 a	0 a
	Combined	0.07	<1
Fallow	...	0.16	0

[x] R = reproductive factor ($^{Pf}/_{Pi}$); where Pi = initial population density of 133 *C. xenoplax* per 100 cm^3 soil.
[y] Different ($P \leq 0.01$) from individual annual plant species and fallow according to linear contrast analysis. Data are means of 10 replicates, except for fallow = five replicates.
[z] Means within a plant species and column followed by the same letter are not significantly different ($P = 0.05$) using Duncan's multiple range test.

Greenhouse 1. Reproduction of *C. xenoplax* was greater ($P \leq 0.01$) on Nemaguard peach ($R = 196.31$) than on other annual plant species and fallow soil treatment (Table 2). The greatest ($P \leq 0.01$) number of gravid females were detected in peach soil when compared to other treatments. No gravid females were detected in Morrison triticale, Coker 916 wheat, or fallow soil.

Greenhouse 2. Again, Nemaguard peach was the best ($P \leq 0.01$) host for *C. xenoplax* and yielded the greatest ($P \leq 0.01$) number of gravid females in the soil when compared to other annual plant species cultivars and fallow soil (Table 3). Gravid females were detected in all plant cultivars except four wheat cultivars (Coker 916, Fla 302, Stacy, and Hunter) and the fallow soil. Among the field crops tested, soybean cultivars were better hosts for *C. xenoplax* than sorghum. The population density of *C. xenoplax* increased on peach in most soils previously planted to field and small grain crops. The greatest ($P \leq 0.01$) increase, however, occurred in fallow soil ($R = 547.62$) compared to other plant species mean treatments (Table 4). No *C. xenoplax* was detected on peach grown in soil in which Stacy, Coker 916, and Fla-302 wheat had previously grown.

DISCUSSION

All small grain cultivars tested were either poor hosts or nonhosts for *C. xenoplax* as compared to peach. In the field study, numbers of *C. xenoplax* in soil were either relatively low or undetected around all crops grown after the 1987 and 1988 growing seasons. Relative incidence of *C. xenoplax* either remained stable or increased slightly by the second year. This suggests that *C. xenoplax* was able to survive and/or reproduce at a slow rate in the presence of some small grain cultivars. The sudden increase in population density around Lovell and Nemaguard peach demonstrates the rate at which this nematode is able to increase on these peach rootstocks. Two hypotheses may be given to account for the low population density on peach on the first and second postplant sampling dates: 1) the peach seedlings were relatively small when planted (<31 cm long) and had a limited root system on which to support nematodes and, 2) the land was fallow for several years before this test, which resulted in a decrease in the nematode density to such a low level that it took 3 yr to recover under a known host. The nematode population increase in the third year was accompanied by the loss of some trees to PTSL. A greater number of Nemaguard trees exhibited PTSL symptoms than Lovell trees, which is why the latter is the recommended rootstock for PTSL sites (15). In contrast, Stacy wheat appears to be a nonhost to *C. xenoplax. C. xenoplax* was not detected in any of the Stacy wheat and fallow subplots on any sampling date or in subplots of Fla 301 wheat, Dawn barley, and Wrens Abruzzi and Fla 401 rye on the first two consecutive sampling dates. *C. xenoplax* was not detected in any of the other small grain plots on 4 May 1989 after planting to Stacy wheat, where low levels of the nematode were present 1–2 yr previously. Greenhouse data substantiates that all small grains, except sorghum, are either poor hosts or nonhosts for *C. xenoplax*. The cultivars that were nonhosts for *C. xenoplax* include Stacy, Coker 916, and Fla-302 wheat. The mode of action of control in these cultivars appears to be allelopathic in nature since no *C. xenoplax* were detected in the respective soils replanted to peach as compared to the fallow and other plant soil treatments after 6 mo. It has been demonstrated that some wheat cultivars are allelopathic to certain weed species (4,13). Incorporating this type of allelopathy may have potential as a management practice that could reduce the use of herbicides (13). Where nematodes are concerned, allelopathic species of plants could be incorporated into an integrated control management plan (e.g., crop rotation) as a means of reclaiming and replanting old peach land having a history of PTSL or preventing a location from becoming a PTSL site.

Controlling *C. xenoplax* should reduce the incidence of PTSL and prolong tree life (6,9,15). Possibly, land previously planted to wheat could be used as a preplant nematicide treatment.

Table 4. Reproduction and final population density of *Criconemella xenoplax* on Nemaguard peach in soil previously planted to selected grain and soybean cultivars in the greenhouse after 180 days

Prior annual species planted	Cultivar	R^w	Number of *C. xenoplax* per 100 cm^3 (Pf)
Soybean	Kirby	8.48 ab^x	24,656 a^x
	Wright	6.23 bc	22,356 ab
	Coker 6738	11.58 a	21,942 ab
	Hutton	7.53 abc	14,674 bc
	Braxton	9.07 ab	14,341 bc
	Coker 368	3.74 de	12,374 c
	Delta Pine 417	2.68 e	11,960 c
	Cobb	4.80 cd	9,798 c
	Combined	6.76	16,513
Sorghum	Pioneer 8333	39.83	21,988
Triticale	Florico	53.43 a	5,290 a
	Councill	18.36 b	4,186 a
	Morrison	16.06 b	4,048 a
	Beagle 82	32.12 ab	3,726 a
	Am 4105	3.33 c	230 b
	Combined	24.72	3,496
Wheat	Fla-301	100.36 a	1,104 a
	Hunter^y	39.43 a	552 a
	Coker 916^y	0 b	0 b
	Stacy^y	0 b	0 b
	Fla-302^y	0 b	0 b
	Combined	27.96	331
Fallow^y		547.62^z	11,500^z

$^w R$ = reproductive factor ($^{Pf}/_{Pi}$); where Pf = final *C. xenoplax* population density per 100 cm^3 soil.

^{x} Means within an annual plant species followed by the same lower case letter are not signficantly different ($P = 0.05$) using Duncan's multiple range test. Data are means of four replicates.

^{y} Gravid females of *C. xenoplax* were not detected in soil prior to replanting with peach.

^{z} Different ($P \leq 0.01$) from individual annual plant species according to linear contrast analysis.

In central Georgia, wheat is usually rotated with soybeans or sorghum, both of which were suitable hosts to *C. xenoplax*, based on cultivars tested. Presently, other sorghum cultivars are being evaluated for resistance to *C. xenoplax* and efforts to identify the mode of action of control in wheat is being pursued. If a plant chemical and/or organism associated with wheat is identified, this could possibly be utilized as a biocontrol method against *C. xenoplax*.

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