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Populations of *Criconemella xenoplax* on Peach Interplanted with Certain Herbaceous Plants[1]

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Abstract: Peach trees growing in field microplots infested with *Criconemella xenoplax* were interplanted with centipedegrass, goosegrass, sicklepod, marigold, buckhorn plantain, showy crotalaria, or perennial ryegrass, or left with weed-free soil as the control. Buckhorn plantain reduced nematode numbers, but not to levels acceptable for commercial control. Marigold, sicklepod, and goosegrass reduced nematode numbers on some sampling dates but not on others. Other plants had no effect or appeared to stimulate populations. In greenhouse tests, no plants clearly suppressed the nematode population, but all reduced the growth of peach seedlings.

Key words: allelopathy, biological control, *Criconemella xenoplax*, nematode, peach, *Prunus persica*.

The ring nematode *Criconemella xenoplax* (Raski) Luc & Raski is a common root parasite of peach trees (*Prunus persica* (L.) Batsch) in the southeastern United States. It reduces the rate of growth, decreases productivity, and is of major importance in early tree mortality that is characteristic of the peach-tree-short-life syndrome (8,10, 11,16).

Without nematicides, *C. xenoplax* is difficult to control in peach orchards. All commercial peach rootstocks are susceptible to the nematode (14), crop rotation is ineffective, and some ground covers support population increases (15,17).

Some plants have been reported to suppress plant-parasitic nematodes. For example, showy crotalaria (*Crotalaria spectabilis* Roth) followed by oats (*Avena sativa* L.) reduced numbers of root-knot nematodes (*Meloidogyne* sp.) in peach orchards (5). Interplanting marigold (*Tagetes patula* L.), castor bean (*Ricinus communis* L.), and chrysanthemum (*Chrysanthemum moriflorum* Ramata) with tomato reduced populations of *M. incognita* (Kofoid & White) Chitwood and *Pratylenchus alleni* Ferris (2). Creeping red fescue (*Festuca rubra* L.), tall fescue (*F. arundinacea* Schreb.), redtop (*Agrostis alba* L.) (13), and marigold (6) have been used to suppress *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans Stekhoven. Marigold also reduced populations of the reniform nematode, *Rotylenchulus reniformis* Linford & Oliveira (1).

We know of only two reports of the use of vegetation to suppress *C. xenoplax*. Meyer et al. (7) found that populations of *C. xenoplax* were reduced when peach was interplanted with nimblewill (*Mulhlenbergia schreberi* G. F. Gmel), whereas Nyczepir and Bertrand (9) found that growing wheat (*Triticum aestivum* L.) before planting peach trees reduced numbers of *C. xenoplax*. Planting wheat in orchard sites before peach trees are planted might help to delay buildup of large populations of *C. xenoplax* (9).

The need to find alternatives to chemical control for *C. xenoplax* prompted us to study certain other nonhosts for suppressive effects. Plant species were selected based on evidence of unsuitability for nematode reproduction (15,17) and potential for use as orchard cover in South Carolina peach orchards. Marigold was included because it is not a host for *C. xenoplax* (Zehr, unpubl.) and it has activity against other nematodes (2,6).

MATERIALS AND METHODS

Test site: Microplots, 1-m-d and 0.75 m deep, were established at the Clemson University Sandhill Research and Education Center in Lakeland sand (89% sand, 6% silt, 5% clay) and planted with 'Nemaguard' peach seedlings, which had been inoculated with *C. xenoplax* in the greenhouse prior to planting. The seedlings

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were allowed to grow for 3 years before the experiment began.

Plot design: Initial nematode populations in microplots ranged from 144 to 706 (mean of 474) *C. xenoplax* per 100 cm^3 of soil. Treatments were arranged in an augmented randomized complete block design using seven single-tree replicates in seven blocks with one smaller block consisting of five trees. The first seven treatments consisted of peach interplanted with centipedegrass (*Eremochloa ophiuroides* (Munro.) Hack.), goosegrass (*Eleusine indica* (L.) Gaertn.), marigold (*T. patula* 'Janie Flame'), marigold (*T. erecta* L. 'Pumpkin Crush'), sicklepod (*Cassia obtusifolia* L.), and buckhorn plantain (*Plantago lanceolata* L.). Peach trees in hand-weeded bare soil served as the control. In a smaller block consisting of five microplots, treatments were peach interplanted with perennial ryegrass (*Lolium perenne* L.), goosegrass, and three plantings of showy crotalaria. In May 1985 and 1986, all microplots were seeded directly, seeds were lightly raked into the soil, and plots were watered well. Seeds of sicklepod and showy crotalaria were mechanically scarified to increase the germination prior to planting. Microplots with poor stand establishment were reseeded or greenhouse-grown test plants were transplanted into the microplot to enhance plant stands. Plots were hand weeded biweekly to remove competing vegetation. Supplemental water was provided with drip irrigation using one emitter per microplot.

After approximately 7 weeks for establishment of test plants, *C. xenoplax* populations in microplots were sampled monthly for the duration of the experiment. Four subsamples per plot were collected with a sampling cone (3-cm-d) to a depth of 20 cm and combined to form a single composite sample. The soil was placed in plastic bags, mixed well, placed in an ice chest, and stored at room temperature until assayed. Nematodes were extracted from 500 cm^3 of soil by a semiautomatic elutriator followed by centrifugal flotation (3). Adult and juvenile nematodes were counted at 34× magnification.

Greenhouse experiments: One-month-old Nemaguard peach seedlings grown in vermiculite were transplanted into 20-cm plastic azalea pots filled with 3 liters steamed (57–62 C for at least 1 hour) Lakeland sand. A few days after transplanting, seeds of common bahiagrass (*Paspalum notatum* Fugge), centipedegrass, perennial ryegrass, annual ryegrass(*Lolium multiflorum* Lam.), goosegrass, orchardgrass (*Dactylis glomerata* L.), sicklepod, Janie Flame marigold, Pumpkin Crush marigold, or buckhorn plantain were sown into the pots. Seeds of sicklepod were mechanically scarified prior to planting. One month after planting, 500 *C. xenoplax* juveniles and adults were added to each container in four 1- × 10-cm holes made with a glass rod. Each interplanted combination was replicated six times, and the experiment was repeated twice. Controls consisted of fallow soil infested with *C. xenoplax,* peach seedlings interplanted with herbaceous plants without *C. xenoplax,* and peach seedlings alone in nematode-infested soil.

Fertilizer was added at 2-week intervals in the first experiment and weekly in the two repetitions alternately as 45 g $Ca(NO3)_2$ + 15 g $MgSO_4$, or as 45 g 15-0-14 (N-P-K), 12 g 0-46-0, + 2 ml Stoller's Super Crop Mix (Stoller Chemicals, Houston, TX) diluted in 19 L tap water. Lighting was supplemented with fluorescent lights as needed to provide 14 hours of light. Greenhouse temperatures ranged from 21 to 35 C.

The experiments were terminated 12 to 15 weeks after inoculation with *C. xenoplax.* Peach shoots were cut 5 cm above the soil line, dried for 1 week at 66 or 93 C, and weighed. Soil and roots were placed in a large plastic bag, and the soil was removed by shaking from the roots or washing with tap water. Peach roots were dried for 1 week and weighed. Nematodes were extracted from the soil as described for the field experiments. If the soil appeared to be dry it was moistened with tap water 2 days before extraction to enhance nematode recovery (4).

Statistical comparison: Because large fluctuations in *C. xenoplax* populations were

observed during the sampling period, and uneven sample numbers occurred at some sampling dates, mean nematode population levels from field data were analyzed using analysis of variance (ANOVA) followed by Fisher's protected least significance difference test (12). ANOVA with Duncan's multiple-range test was used to compare differences in nematode populations, dry root weight, and dry shoot weight among the treatments in the greenhouse studies.

Results

Field experiment: All plants became established and grew in association with peach trees in the microplots. Marigolds, however, did not always grow well in the shade of the peach trees. All others produced a canopy sufficient to cover the soil surface.

Populations of *C. xenoplax* associated with peach in the control plots generally remained near the mean initial population level of 492 per 100 cm^3 of soil, with small fluctuations above and below the mean through summer 1986 (Fig. 1). Large population increases were observed in centipedegrass and showy crotalaria plots in fall and winter, 1985–86, but nematode numbers did not differ significantly ($P \leq 0.05$) from those in control plots (data not shown). A similar pattern did not appear in the fall and winter, 1986–87. Nematode numbers in plots interplanted with goosegrass, sicklepod, perennial ryegrass, and both marigold species were similar to the control during the entire test period, except for a large population in November 1985 in plots interplanted with marigold (*T. erecta*). Nematode numbers in plots with *T. erecta* did not differ significantly from those of the control on any sampling date (Fig. 1).

Nematode numbers in plots interplanted with buckhorn plantain were similar to those in control plots in 1985 (data not shown), but declined relative to the control plots thereafter (Fig. 1). Numbers of nematodes were fewer ($P \leq 0.05$) than in control plots in November and December 1986 and January 1987. As in the control plots, nematode numbers increased during fall and winter 1986–87, but the increase was much smaller than in control plots.

During the sampling period, a total of 20 trees were affected by cold injury associated with the peach-tree-short-life syndrome, including eight that died in 1986. Occurrence of short-life appeared to be random and not associated with any of the treatments studied.

Greenhouse experiment: Populations of *C. xenoplax* increased on peach regardless of interplantings with any of the test plants. Lower nematode numbers resulted when bahiagrass, centipedegrass, perennial ryegrass, annual ryegrass, goosegrass, or buckhorn plantain were interplanted with peach in one experiment (Table 1) but not

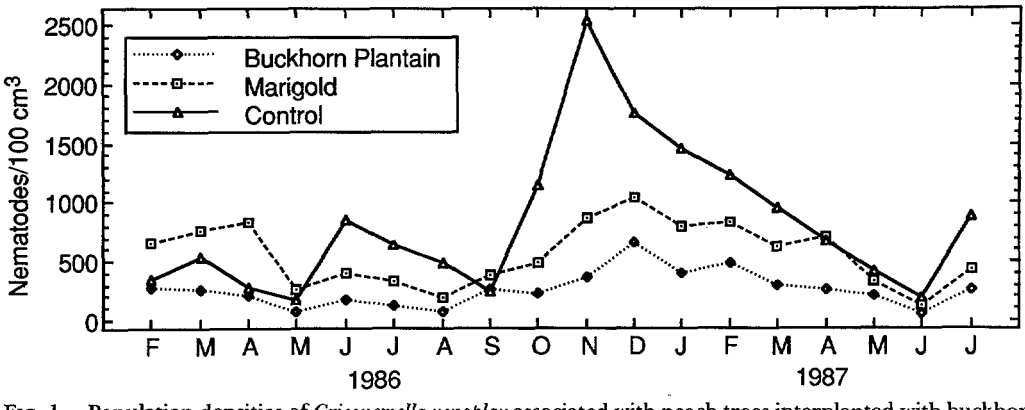

FIG. 1. Population densities of *Criconemella xenoplax* associated with peach trees interplanted with buckhorn plantain, marigold, or bare ground control between February 1986 and July 1987. Nematode numbers in the control and buckhorn plantain plots are significantly different ($P \leq 0.05$) on the November and December 1986 and January 1987 sampling dates.

TABLE 1. Mean population densities of *Criconemella xenoplax* 12–15 weeks after certain herbaceous plants were interplanted with Nemaguard peach seedlings in the greenhouse.

Treatment	*C. xenoplax*/100 cm³ soil		
	Test 1	Test 2	Test 3
Bahiagrass	621 bc	138 a	459 ab
Centipedegrass	795 bc	199 a	440 ab
Perennial ryegrass	343 c	85 a	623 a
Annual ryegrass	621 bc	106 a	452 ab
Goosegrass	542 c	103 a	427 ab
Orchardgrass	2,445 a	128 a	437 ab
Sicklepod	1,457 abc	37 a	434 ab
Pumpkin Crush marigold	1,665 ab	87 a	441 ab
Janie Flame marigold	1,985 a	127 a	455 ab
Buckhorn plantain	529 c	134 a	419 b
Control (peach only)	1,985 a	198 a	447 ab

Data are means of 6 replicates (12 for the control). Tests 1, 2, and 3 are separate repetitions of the experiment. Initial population of *C. xenoplax* was 17/100 cm³ of soil. Means followed by the same number are not different ($P \leq 0.05$) by Duncan's multiple-range test.

in two subsequent repetitions of the experiment. Marigold did not reduce nematode numbers in any of the experiments.

Root and shoot growth of peach interplanted with the test plants were reduced in two of three experiments (Tables 2 and 3). Annual ryegrass was especially suppressive of peach seedling growth, whereas marigolds and centipedegrass tended to be less suppressive of growth. The presence of *C. xenoplax* did not measurably affect the growth of peach seedlings, whether interplanted with other plants or not (data not shown). Buckhorn plantain, which tended to reduce nematode populations in the field test, suppressed peach seedling growth almost as much as did annual ryegrass.

TABLE 2. Mean dry root weight of Nemaguard peach seedlings 3 months after infestation with *Criconemella xenoplax* and interplanting with certain herbaceous plants.

Treatment	Root weight (g)		
	Test 1	Test 2	Test 3
Bahiagrass	8.9 cd	4.7 cd	5.7 a
Centipedegrass	14.1 ab	9.6 bc	5.4 a
Perennial ryegrass	5.4 de	7.5 bcd	5.7 a
Annual ryegrass	3.7 e	4.5 cd	3.9 a
Goosegrass	7.3 cd	3.4 d	5.8 a
Orchardgrass	17.4 a	6.1 bcd	4.4 a
Sicklepod	10.9 bc	4.7 cd	4.7 a
Pumpkin Crush marigold	10.6 c	11.2 b	5.5 a
Janie Flame marigold	8.2 cd	9.4 bc	4.3 a
Buckhorn plantain	6.1 de	7.6 bcd	4.5 a
Control (peach only)	16.9 a	17.8 a	6.4 a

Data are means of 6 replicates (12 for the control). Means followed by the same number are not different ($P \leq 0.05$) by Duncan's multiple range test.

TABLE 3. Mean dry shoot weight of Nemaguard peach seedlings 3 months after infestation with *Criconemella xenoplax* and interplanting with certain herbaceous plants.

Treatments	Shoot weight (g)		
	Test 1	Test 2	Test 3
Bahiagrass	7.4 de	8.7 bcd	15.0 abc
Centipedegrass	13.1 bc	11.1 b	17.1 a
Perennial ryegrass	5.2 e	9.0 bcd	13.6 abcd
Annual ryegrass	2.9 e	5.3 d	10.6 cd
Goosegrass	6.1 de	6.7 d	13.9 abcd
Orchardgrass	14.6 bc	9.3 bcd	11.8 bcd
Sicklepod	10.4 cd	8.3 bcd	13.8 abcd
Pumpkin Crush marigold	13.7 bc	10.1 bc	13.2 abcd
Janie Flame marigold	15.2 b	10.1 bc	12.9 abcd
Buckhorn plantain	3.0 e	7.0 bcd	9.7 d
Control (peach only)	22.0 a	19.0 a	16.3 ab

Data are means of 6 replicates (12 for the control). Means followed by the same number are not significantly different ($P \leq 0.05$) by Duncan's multiple range test.

DISCUSSION

The plants used in this study were chosen because previous experiments (15,17) had shown that they were not suitable hosts for *C. xenoplax*. Marigold also is not a host for the nematode (Zehr, unpubl.). Our results indicate that none of the plants tested had large allelopathic effects on reproduction of *C. xenoplax*, although buckhorn plantain reduced nematode numbers in the field test. Buckhorn plantain was very competitive with peach seedlings in the greenhouse, and the reduced nematode population in the field might have resulted, at least in part, from reduction of the peach root system as a result of competition.

Buckhorn plantain did not suppress the nematode to levels below the economic threshold of 50 individuals per 100 cm^3 of soil, which is commonly used in South Carolina for peaches. Ritchie (11) found that the injury threshold in peach for *C. xenoplax* was between 38 and 83 nematodes per 100 cm^3 of soil, and the frequency of peach tree mortality increased as numbers increased from 9 to more than 300 nematodes per 100 cm^3. Nematode numbers in the field microplots containing plantain sometimes exceeded 300 nematodes per 100 cm^3 (Fig. 1); thus, the appearance of short life in all plots is not surprising.

Buckhorn plantain is common in natural vegetation in all peach-growing sections of South Carolina, but it rarely if ever occurs in pure stands. In additional field tests (Zehr, unpubl.), it was difficult to establish in vigorous stands under peach trees, and plantain did not compete well with other vegetation. These characteristics and the relatively low level of nematode suppression are not encouraging for the use of buckhorn plantain as a ground cover in peach orchards. Nimblewill (*Muhlenbergia schreberi* J. F. Gmel) has more attractive traits that include nematode suppression (7), and it may be a better prospect for use in peach orchards.

Marigold has been reported to suppress certain nematodes (2,5,6), and its use in gardens for nematode control has been encouraged in many newspaper and magazine articles. Marigold did not suppress *C. xenoplax* when grown in association with peach trees. Furthermore, its growth in shade was unsatisfactory; therefore, its use for suppression of *C. xenoplax* or other nematodes in peach orchards probably is of little value.

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