Methods for Managing Nematodes in Sustainable Agriculture

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ABSTRACT

The efficacy of tillage, yard-waste compost amedment, and crop rotation for management of plant-parasitic nematodes were examined in a number of field tests in north-central Florida. Tillage practices affected (P<0.10) nematode population densities in only a few cases. Yard-waste compost had little effect on nematode numbers in the first season following application, but there was evidence of long-term effects on some nematodes. Crop rotation was effective in reducing nematode population densities in many tests. Rotation with velvetbean *(Mucuna deeringiana)* was effective in reducing numbers of *Meloidogyne incognita* (in 7 of 7 tests), *Criconemella* spp. (5 of 7 tests), and Pratylenchus spp. (4 of 7 tests). Velvetbean and certain cultivars of cowpea *(Vigna unguiculata)* and sorghum *(Sorghum bicolor)* were particularly effective against *M.* incognita, the key nematode pest in many cropping systems in the region.

INTRODUCTION

A number of non-chemical methods are available for managing plant-parasitic nematodes and reducing their population levels in sustainable agricultural systems (McSorley, 1994; 1996; Trivedi and Barker, 1986). These include use of resistant cultivars, crop rotation and cover crops, fallow, flooding, tillage, soil solarization, organic amendments, destruction of weeds and group residues, and other practices (McSorley, 1996; Trivedi and Barker, 1986). The design of cropping systems and crop rotation schemes using nematode-resistant crops and cultivars has been particularly important in nematode management (McSorley, 1996; McSorley and Gallaher, 1992b; Trivedi and Barker, 1986).

In north-central Florida, a number of experiments have been conducted to examine the effects of tillage (McSorley and Gallaher, 1993a; 1994a,b), organic amendments (McSorley and Gallaher, 1995a; 1996a), and crop rotation (McSorley and Gallaher, 1991; 1992a; 1993b) on plant-parasitic nematodes. The purpose of this paper is to review the results from a large number of tests to assess the relative utility of tillage, organic amendments, and crop rotations for nematode management.

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MATERIALS AND METHODS

From 1990 to 1995, a variety of tests were conducted evaluating effects of tillage, organic amendments, or crop rotation on population densities of plant-parasitic nematodes in soil. All tests were conducted in Alachua and Marion counties in north-central Florida, on sandy soils consisting of 90 to 94% sand, 2 to 5% silt, and 2 to 6% clay. Treatments were imposed on small plots replicated in split-plot or randomized complete block designs. A variety of crops were examined in spring or summer experiments. Soil samples for nematode analysis were collected at the time of planting and harvest of each crop. Nematodes were extracted from soil using a sieving and centrifugation technique (Jenkins, 1964) and counted under a microscope. Nematode count data were subjected to analysis of variance followed by Duncan's multiple range test to determine whether significant (at P<0.05 or P<0. 10) treatment effects had occurred.

Tillage effects were evaluated in tests comparing conventional and no-till treatments in the management of tropical corn *(Zea mays)* cultivars during the summer. A total of eight different tests were conducted. Of these, five tests involved corn at different sites following various cover crops or N regimes (McSorley and Gallaher, 1994a). Three other tests were conducted in another site, but in three different years (McSorley and Gallaher, 1993a; 1994b).

Organic amendment effects were evaluated in tests involving treatments with 269 mt/ha of yard waste composts with C:N ratios of 35:1 to 46:1. The three treatments involved in each test were: compost applied to the soil surface as a mulch, compost incorporated into the soil by rototilling, and an unamended control. Ten tests involved evaluation of nematode numbers in the first season after compost application on field corn at two sites (McSorley and Gallaher, 1996a), and on four different vegetable crops (sweet corn, cowpea *[Vigna unguiculata]*, squash *[Cucurbita pepo]*, okra *[Hibiscus esculentus])* at two sites each (McSorley and Gallaher, 1995a). In two other tests, nematode population densities on field cornwere evaluated at two sites in the third year following compost amendment in each of the previous years (McSorley and Gallaher, 1996a).

Rotation effects were evaluated at seven different sites in whichnematode numbers following four different summer rotation crops were compared with nematode numbers following tropical corn cv. Pioneer 3098 (McSorley and Gallaher, 1992a). The four rotation crops evaluated in each test were: soybean *(Glycine max* cv. Howard), velvetbean *(Mucuna deeringiana)*, cowpea cv. California Blackeye #S, and sorghum *(Sorghum bicolor* cv. Asgrow Chaparral). Nine addition comparisons were made between nematode numbers following a summer cover crop of tropical corn cv. Pionem X304C and sorghum cultivars DeKalb FS2SE or DeKalb BR64 or sorghum-sudangrass *(S. bicolor* x *S. sudanense)* cv. DeKalb SX-17 (McSorley and Gallaher, 1991; 1993b).

RESULTS AND DISCUSSION

Plant-parasitic nematodes commonly found in the study sites included ring nematodes *(Criconemella* spp. = *Criconemoides* spp., primarily *C. ornata)*, the root-knot nematode *(Meloidogyne incognita)*, the stubby-root nematode *(Paratrichodorus minor)*, and lesion nematodes *(Pratylenchus* spp., primarily *P. scribneri)*. *Meloidogyne incognita* is considered the key nematode pest in this system (McSorley and Gallaher, 1992b).

Nematodes numbers did not differ much between conventional and no-till treatments (Table I). At $P<0.05$, only five significant differences were observed, while at $P<0.10$, eight such differences occurred In some of these instances, nematode numbers were greater under no-till treatment, while in other cases, numbers were greater following conventional tillage (McSorley and Gallaher, 1993a). There is some evidence that higher soil populations of *Pratylenchus scribneri* result from conventional tillage (McSorley and Gallaher, 1993a; 1995b).

In the first season following application, yard-waste compost was rather ineffective in reducing numbers of plant-parasitic nematodes (Table 2). Although in one test numbers of *M. incognita* were reduced by mulch, in one other case *M. incognita* numbers were greater in mulched plots than in unamended control plots, and in another test *M. incognita* numbers were greater in plots with incorporated compost than in unamended plots (McSorley and Gallaher, 199Sa). There was evidence that compost was more effective against nematodes after a longer period of time, as shown in tests which had received compost treatments for three years (Table 3). However, even after this length of time, there were no significant effects of compost on *M incognita*, the most serious nematode pest present in these sites.

Several rotation crops were effective in lowering nematode numbers compared to levels found on tropical corn (Table 4). Several different crops were effective against *M. incognita* and *Criconemellu* spp., and velvetbean was an effective rotation crop against the widest range of nematodes. Velvetbean and the cowpea cultivar used here reduced levels of *M. incognita* in all seven tests. Compared to population levels on corn, reductions ranged fiom 37.4% to 98.6% following cowpea and from 70.6% to 99.9% following velvetbean. The average (± standard deviation) reduction following velvetbean was 91.0% (±12.8).

In the nine comparisons of tropical corn and various sorghum cultivars, numbers of *M. incognita* following sorghum were reduced fiom those following corn in 9/9 cases (data not shown). Reductions ranged from 96.7% to 100%, with a mean (± standard deviation) of 98.4% (±1.06). Note that the sorghum cultivars used in these tests (McSorley and Gallaher, 1991; 1993b) are different from the rather ineffective cultivar used in the seven tests presented in Table 4 (McSorley and Gallaher, 1992a).

In the cropping systems of north-central Florida, it is evident that crop rotation is much more effective than tillage or yard-waste compost amendment for management of plant-parasitic nematodes, especially *M. incognita*. For yard-waste compost application, the principal benefit against nematodes may not be any reduction of numbers, but the improvement of crop tolerance to nematodes (McSorley and Gallaher, 1996b). A number of summer and winter rotation crops can be effective in reducing nematode numbers in this region (McSorley, 1994; 1996; McSorley and Gallaher, 1991; 1992a,b; 1993a,b). However, with these crops, cultivar choice can be critical, particularly with sorghum (McSorley and Gallaher, 1991; 1992a; 1993b) and cowpea (Gallaher and McSorley, 1993). Future research is needed to identify candidate crops and cultivars effective in rotations in Florida and other regions.

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Table 1. Number of tests in which significant (at P<0.05 or P<0.10) differences between conventional and no-till treatments were observed in nematode numbers measured at planting or harvest of corn.

	Number of tests			
	Differences at P≤0 05		Differences at P≤0.10	
	Planting	Harvest	Planting	Harvest
Cnconemelia spp.	0/7†	018	on	018
Meioidogyne incognita	on	018	on	018
Paratrichodorus minor	2/7	018	2 n	1/8
Pratyienchus spp.	1/7	218	2/7	318

†No. of tests with differences/Total no. of tests observed.

Table 2 Number of tests in which a significant (at P≤0.10) reduction in nematode numbers measured at planting or harvest of corn and vegetable crops was obtained by a yard-waste compost (incorporated or mulch) treatment in the first season after compost application.

	Numbers of tests			
	Incomorated		Mulch	
Nematode	Planting	Harvest	Planting	Harvest
Criconemelia spp.	0/10†	1/10	0110	1/10
Meloidogyne incognita	0/10	0110	0110	1/10
Paratrichodorus minor	0/10	1/10	0110	0110
Pratylenchus spp	0110	0110	0/10	0/10

†No. of tests with significant reductions compared to control/Total no. of tests observed

Table 3. Number of tests in which a significant (at $P \leq 0.10$) reduction in nematode numbers measured at planting and harvest of corn was obtained by a yard-waste compost (incorporated or mulch) treatment, in plots which had received compost treatments for three years.

	Number of tests			
	Incorporated		Mulch	
Nematode	Planting	Harvest	Planting	Harvest
Criconemeiia spp.	**1/27**	***212***	1/2	2/2
Meloidogyne incognita	0/2	0/2	0/2	*012*
Paratrichodorus minor	**1/2**	1/2	**1/2**	1/2
Pratylenchus spp.	***212***	***012***	2/2	0/2

†No. of tests with significant reductions compared to control/Total no. of tests observed

Table 4. Number of tests in wbicb nematode numbers following a summer cover crop were significantly lower (at $P \leq 0.05$) than numbers following tropical corn.

	Number of tests bv cover crop			
Nematode	Soybean	Velvetbean	Cowpea	Sorghum
***Criconemelia* spp.**	4/7	5/7	*2n*	0/7
Meloidogyne incognita	4/7	*7n*	7/7	2/7
Paratrichodorus minor	1/7	in	*in*	0/7
Pratylenchus spp.	0/7	4/7	in	*on*

†No. of tests with significantreductions compared to corn/Total no. of tests observed.