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Effect of Compost and Maize Cultivars on Plant-parasitic Nematodes[1]

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Abstract: Effects of yard waste compost and maize (*Zea mays*) cultivar on population densities of plant-parasitic nematodes were examined in four experiments in north Florida. In one experiment, eight maize cultivars were evaluated; the other three experiments involved split-plot designs with compost treatments as main plots and maize cultivars as subplots. The three compost treatments used in these experiments were: 269 mt/ha of a yard-waste compost applied to the soil surface as a mulch, 269 mt/ha of compost incorporated into the soil, and an unamended control. No interactions between compost treatment and cultivar occurred in any experiment. Effects of compost treatment on *Mesocriconema* spp., *Meloidogyne incognita,* and *Pratylenchus* spp. were inconsistent, whereas significant effects of compost on population densities of *Paratrichodorus minor* were found on four of six sampling occasions. Cultivar affected final population densities (Pf) of *M. incognita.* In two tests, Pf of *M. incognita* on a Florida subtropical experimental hybrid (Howard III) were only 36% and 23% of Pf on the standard tropical hybrid (Pioneer Brand X304C). In an integrated approach to management of nematodes in maize, the effects of compost amendment and cultivar choice acted independently. Apparently, cultivar choice is more important than amendment with yard waste compost for management of *M. incognita* population levels in a maize rotation crop.

Key words: compost, cultural practice, host plant resistance, integrated pest management, *Meloidogyne incognita,* mulch, nematode, organic amendment, *Paratrichodorus minor,* sustainable agriculture, *Zea mays.*

Various nonchemical alternatives are available for the management of plant-parasitic nematodes (McSorley and Duncan, 1995; Noling and Becker, 1994; Trivedi and Barker, 1986). However, some nonchemical methods may not be particularly effective when used alone, making integration of methods necessary to achieve optimal nematode management, particularly in sustainable systems (McSorley and Duncan, 1995; Noling and Becker, 1994; Roberts, 1993). Applications of organic amendments have been evaluated for use in nematode management (Muller and Gooch, 1982; Rodríguez-Kábana, 1986), although results have been inconsistent (McSorley and Gallaher, 1995a, 1995b; Stirling, 1991). Crop rotation has been a successful method for suppressing plant-parasitic nematodes (Johnson, 1982; McSorley and Duncan, 1995; Trivedi and Barker, 1986), and recently emphasis has been placed on the development of candidate crops for rotations in the southeastern United States (McSorley and Dickson, 1995; Rodríguez-Kábana et al., 1988, 1989). Maize (*Zea mays*) is a particularly useful rotation crop for the southeastern United States (Stanley and Gallaher, 1997; Teare, 1991), and rotation with maize has been beneficial in managing some nematode problems as well (Kinloch, 1983; Schmitt, 1991). However, some tropical maize cultivars tend to increase populations of root-knot nematodes (McSorley and Gallaher, 1991, 1992). Recently, work in Mississippi has resulted in maize germplasm with some resistance to root-knot nematodes (Windham and Williams, 1988), and two of these genotypes reduced soil population levels of *Meloidogyne incognita* below that of a tropical hybrid in a microplot test in Florida (McSorley and Dickson, 1995). Thus, it may be possible to find some level of root-knot nematode resistance in other maize germplasm and cultivars that may be adapted for tropical and subtropical growing conditions. The objective of this study was to examine the effects of integrating compost amendment and selected maize cultivars on population levels of root-knot and other plant-parasitic nematodes on maize.

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Materials and Methods

Four experiments were conducted at four sites, all located within 5 km of each other in Alachua County, Florida, near 29°40′N and 82°30′W. The soil types in these fields were Arredondo and Bonneau fine sands, consisting of 92% sand, 2–4% silt, 4–6% clay, and pH = 5.2–5.4, with <2.0% organic matter. Each of these sites contained *M. incognita, Paratrichodorus minor, Mesocriconema* spp. (*M. sphaerocephalum, M. ornatum*), and *Pratylenchus* spp. (*P. scribneri, P. brachyurus*). In each of these sites, the *M. incognita* population was confirmed to be race 1 by a differential host test (Taylor and Sasser, 1978).

Experiment 1 (Haufler silage site): This experiment was conducted in a commercial silage production site. Treatments consisted of 8 maize cultivars arranged in a randomized complete block design with 10 replications. The cultivars were Howard III, a Florida experimental subtropical hybrid; FLASTOP, a Florida experimental subtropical population; a tropical hybrid, Pioneer Brand X304C; and 5 temperate hybrids: Asgrow RX949W, DeKalb 706, ICI 8100, ICI 8105, and Pioneer Brand 3154.

The site was plowed in spring 1995, and the maize cultivars were planted on 22–23 March in two-row plots, 30 m long with 0.75 m between rows. Anhydrous ammonia was injected under the row during planting at a rate of 71 kg N/ha. On 30 March, 16 kg N/ha, 39 kg P_2O_5/ha, and 94 kg K_2O/ha were applied together with other macro- and micronutrients. Plots were side-dressed with 89 kg K_2O/ha on 22 April and 178 kg N/ha on 28 April. Cultivations on 14 April and 1 May aided in fertilizer incorporation and weed management. Plots were watered as needed from a center-pivot irrigation system. On 26 June, a plant biomass sample was collected from each plot by cutting stalks at a 6-to-7-cm height (just above prop roots) and removing all plants from a 3-m^2 area. Samples were dried at 70 °C in an oven to determine plant dry weight.

Soil samples for nematode analysis were collected on 26 April and 28 June. Each sample consisted of 6 soil cores (2.5-cm diam. × 20 cm deep) collected from each plot. The cores were composited and mixed, and a 100-cm^3 subsample was removed for nematode extraction using a modified sieving-and-centrifugation procedure (Jenkins, 1964).

Experiment 2 (Agronomy Farm): This experiment was conducted at the University of Florida Green Acres Agronomy Research Farm in Alachua County. Treatments consisted of 3 compost treatments as main plots and 4 maize cultivars as subplots. The design was a split-plot with 8 replications. The cultivars used in this test were FLASTOP, Howard III, Pioneer Brand X304C, and Howard II (Florida experimental subtropical hybrid). Compost treatments were 269 mt/ha of yard waste compost applied in early February 1996 and incorporated into the top 20 cm of soil by rototilling; 269 mt/ha of yard waste compost applied in early February and maintained on the soil surface as a mulch; and an unamended control, which was rototilled. The yard waste compost, obtained from Enviro-Comp Services of Jacksonville, Florida, consisted mainly of fragments of pine bark and wood chips <3 cm in length (Table 1).

Maize cultivars were planted on 13 March in subplots consisting of two rows, 3.5 m long and 0.75 m apart. Plots were fertilized with 233 kg N, 9 kg P, and 158 kg K/ha, and were hand-weeded and irrigated from overhead sprinklers as needed. Soil samples for nematode analysis were collected on 13

Table 1. Analysis of yard waste compost obtained from Jacksonville, Florida.

Property analyzed	Year of application	
	1995	1996
Organic matter (% of dry wt.)	37.5	52.2
Ca (% of dry wt.)	1.13	1.47
Mg (% of dry wt.)	0.07	0.17
K (% of dry wt.)	0.14	0.31
N (% of dry wt.)	0.98	0.62
P (% of dry wt.)	0.08	0.15
Cu (ppm)	18	22
Fe (ppm)	2,608	2,615
Mn (ppm)	75	97
Zn (ppm)	138	107

March and 11 July, using the methods described above.

Experiment 3 (Haufler amended site): The site for this experiment had been amended with 269 mt/ha of a yard waste compost in 1992 and was the site of other experiments involving compost amendments from 1993 to 1995 (McSorley and Gallaher, 1996). The site was plowed and disked in fall 1995 to redistribute any remaining compost over the site. Soil organic matter content averaged 3–4%, about twice as much as in the other experiments. In early 1996, a split-plot experiment with 5 replications was initiated, involving 3 compost treatments as main plots and 2 maize cultivars (Howard II, Howard III) as subplots. The compost treatments, timing of applications, and nature of the compost were identical to those of Experiment 2.

Maize was planted on 25 April 1996 in subplots consisting of two rows, 0.75 m apart and 30 m long. Plots were fertilized with 296 kg N/ha. Soil samples for nematode analysis were collected on 25 April and 24 July, using the methods described above.

Experiment 4 (Haufler unamended site):

TABLE 2. Effect of cultivar on *Meloidogyne incognita* population densities and maize silage yield. Experiment 1, Haufler silage site, Alachua County, 1995.

Cultivar	Nematodes per 100 cm³ soil: 26 April	Nematodes per 100 cm³ soil: 28 June	Top dry weight (g/plant)
Asgrow RX949W	4	132 ab	1,109 bc
DeKalb 706	2	126 ab	1,262 ab
FLASTOP	1	99 b	1,387 a
Howard III	3	75 b	865 d
ICI 8100	2	148 ab	923 d
ICI 8105	3	86 b	1,153 b
Pioneer Brand 3154	2	72 b	975 cd
Pioneer Brand X304C	2	208 a	935 d

Data are means of 10 replications. Means in columns followed by the same letter do not differ at $P \leq 0.05$ according to Duncan's multiple-range test. No letters in columns indicate no differences at $P \leq 0.10$.

TABLE 3. Effect of yard waste compost and four maize cultivars on nematode population densities during the 1996 maize crop. Experiment 2, University of Florida agronomy farm, Alachua County.

Compost treatment	Compost amount (mt/ha)	13 March	11 July: FLASTOP	11 July: Howard II	11 July: Howard III	11 July: X304C	11 July: Mean
			Mesocriconema spp.				
Incorporated	269	30 b	73	63	18	96	62
Mulch	269	17 b	98	13	57	28	49
Control	0	161 a	42	36	40	63	45
Mean	—	70	71	37	38	62	52
			Meloidogyne incognita				
Incorporated	269	8 b	322	234	72	444	268
Mulch	269	4 b	269	341	61	577	312
Control	0	18 a	443	192	194	390	305
Mean	—	10	345 AB	256 BC	109 C	470 A	295
			Paratrichodorus minor				
Incorporated	269	2 b	2	4	1	2	2 b
Mulch	269	1 b	3	3	1	4	3 b
Control	0	6 a	8	4	9	9	8 a
Mean	—	3	4	4	4	5	4
			Pratylenchus spp.				
Incorporated	269	8 b	97	118	106	118	110
Mulch	269	7 b	76	118	67	136	100
Control	0	16 a	73	112	89	86	90
Mean	—	10	82	116	88	113	100

Data are means of eight replications. For each nematode, main-effect means in columns (a,b) or in rows (A,B,C) followed by the same letter do not differ at $P \leq 0.01$ according to Duncan's multiple-range test. No letters in a column or row indicate no differences at $P \leq 0.10$. No interactions were significant at $P \leq 0.10$.

This experiment was adjacent to Experiment 3, in a site that had not been amended with compost in 1992 (McSorley and Gallaher, 1996). Organic matter content in winter 1995 averaged 2.5%. All other features of this experiment (treatments, timing, sampling, etc.) were identical to Experiment 3.

Data analysis: Data from each experiment were examined by analysis of variance for the appropriate experimental design using MSTAT-C software (Michigan State University, East Lansing, MI). Nematode count data were transformed by $\log_{10}(x + 1)$ prior to analysis, but only untransformed arithmetic means are presented. When a significant ($P \leq 0.10$) effect (compost, cultivar) was detected, main-effect means were separated with Duncan's multiple-range test.

Results

Experiment 1: Population densities of *Mesocriconema* spp., *Paratrichodorus minor,* and *Pratylenchus* spp. were not affected ($P > 0.10$) by the maize cultivars grown, but final levels of *Meloidogyne incognita* in soil were lower ($P < 0.05$) on four cultivars than on Pioneer Brand X304C, a commonly grown tropical hybrid (Table 2). One of the subtropical-tropical entries, FLASTOP, had a high biomass yield, but Howard III and Pioneer Brand X304C did not perform as well (Table 2). These cultivars typically are better adapted to summer rather than spring growing conditions.

Experiment 2: At planting, numbers of all plant-parasitic nematodes were lower ($P < 0.01$) in compost-amended plots than in unamended control plots (Table 3). However, this effect did not persist through the growing season, except with *Paratrichodorus minor.* As in Experiment 1, only *M. incognita* was affected by maize cultivar, with final population densities highest on Pioneer Brand X304C and lowest on Howard III

TABLE 4. Effect of yard waste compost and maize cultivars Howard II and Howard III on nematode population densities during the 1996 maize crop in a site amended with 269 mt/ha of compost in 1992. Experiment 3, Haufler amended site, Alachua County.

Compost treatment	Compost amount (mt/ha)	Nematodes per 100 cm³ soil			
			24 July		
		25 April	Howard II	Howard III	Mean
		Mesocriconema spp.			
Incorporated	269	2 b	9	1	5
Mulch	269	1 b	2	6	4
Control	0	61 a	10	25	18
Mean	—	21	7	11	9
		Meloidogyne incognita			
Incorporated	269	7 b	124	46	85
Mulch	269	19 a	87	42	65
Control	0	10 ab	150	60	105
Mean	—	12	121	50*	85
		Paratrichodorus minor			
Incorporated	269	12	2	2	2 b
Mulch	269	10	1	3	2 b
Control	0	30	9	6	7 a
Mean	—	18	4	4	4
		Pratylenchus spp.			
Incorporated	269	15 b	73	16	44
Mulch	269	10 b	30	37	34
Control	0	50 a	76	45	60
Mean	—	25	60	32(*)	46

Data are means of five replications. For each nematode, main-effect means in columns followed by the same letter do not differ at $P \leq 0.05$ according to Duncan's multiple-range test. No letters in a column indicate no differences at $P \leq 0.10$.

* (*) indicates significant differences from Howard II at $P \leq 0.05$ and $P \leq 0.10$, respectively. No interactions were significant at $P \leq 0.10$.

(Table 3). No compost × cultivar interactions were observed in this or in any of the other split-plot experiments.

Experiment 3: Although several nematodes were affected initially by compost treatment, only *P. minor* had lower numbers in compost-amended plots at the end of the maize crop (Table 4). Final population densities of *M. incognita* and *Pratylenchus* spp. (mostly *P. scribneri* and some *P. brachyurus*) were lower ($P \leq 0.10$) on Howard III than on Howard II.

Experiment 4: Although *P. minor* and *Pratylenchus* spp. numbers at planting were reduced ($P < 0.05$) by compost treatments, these differences persisted to the end of the season only with *Pratylenchus* spp. (Table 5). None of the nematodes present were affected by cultivar in this test.

Discussion

Experiments indicated that the performance of yard waste compost against plant-parasitic nematodes was inconsistent, as in previous tests with this amendment (McSorley and Gallaher, 1995a, 1995b). Some inconsistency was expected since the composition of yard waste compost varied somewhat from year to year. However, amendment with yard waste compost apparently benefits crop performance more by increasing soil organic matter and waterholding capacity of soil, rather than by lowering nematode numbers (McSorley and Gallaher, 1995a). More consistent effects on nematode levels were observed where this compost had been applied for several years (McSorley and Gallaher, 1996). However, the current experiments confirmed previous observations (McSorley and Gallaher, 1996) of a more rapid response of *Paratrichodorus minor* to amendment with yard waste compost. It is not clear whether reduction of *P. minor* population levels with compost amendment is a result of habitat modification or other factors (McSorley and Gallaher, 1996).

No interaction between compost amendment and cultivar was observed on population density of any nematode in these experiments. Thus, in integrating use of yard waste compost amendment and cultivar choice in nematode management, the effects of each method must be considered independently in this maize system.

Population levels of *M. incognita* race 1

TABLE 5. Effect of yard waste compost and maize cultivars Howard II and Howard III on nematode population densities during the 1996 maize crop in a site not amended with compost in 1992. Experiment 4, Haufler unamended site, Alachua County.

Compost treatment	Compost amount (mt/ha)	Nematodes per 100 cm^3 soil: 25 April	24 July: Howard II	24 July: Howard III	24 July: Mean
		Meloidogyne incognita			
Incorporated	269	11	168	198	183
Mulch	269	13	298	154	226
Control	0	13	223	204	214
Mean	—	12	230	185	208
		Paratrichodorus minor			
Incorporated	269	6 b	4	3	4
Mulch	269	8 b	4	2	3
Control	0	20 a	5	6	6
Mean	—	11	4	4	4
		Pratylenchus spp.			
Incorporated	269	6 b	39	41	40 b
Mulch	269	16 ab	115	122	118 b
Control	0	34 a	203	242	223 a
Mean	—	19	119	135	127

Data are means of five replications. For each nematode, main-effect means in columns followed by the same letter do not differ at $P \leq 0.05$ according to Duncan's multiple-range test. No letters in a column indicate no differences at $P \leq 0.10$. No cultivar effects or interactions were significant at $P \leq 0.10$.

were lower on the new Florida subtropical hybrids than on the widely grown tropical hybrid, Pioneer Brand X304C. In the two tests in which the cultivars were compared directly, final population densities (Pf) of *M. incognita* on Howard III were only 36% and 23% of the Pf on Pioneer Brand X304C. In one test, Pf of *M. incognita* following Howard II was 54% of the Pf on Pioneer Brand X304C.

An important concern with maize as a rotation crop is the buildup of root-knot nematodes (McSorley and Gallaher, 1991, 1992). It is not clear if the *M. incognita* population levels after Howard III are low enough to result in reduced damage to susceptible crops following this maize cultivar in rotation. However, it is encouraging that some resistance to *M. incognita* has been found in maize germplasm developed independently in Mississippi (Windham and Williams, 1988) and in Florida. Perhaps future work with these and (or) other germplasm sources will improve the utility of maize as a rotation crop in tropical and subtropical cropping systems.

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