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Effect of *Meloidogyne arenaria* and Mulch Type on Okra in Microplot Experiments[1]

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Abstract: The effects of perennial peanut (*Arachis glabrata*) hay, an aged yard-waste compost (mainly woodchips), and a control treatment without amendment were determined on two population levels of root-knot (*Meloidogyne arenaria*) nematode over three consecutive years in field microplots. Okra (*Hibiscus esculentus*, susceptible to the root-knot nematode) and a rye (*Secale cereale*) cover crop (poor nematode host) were used in the summer and winter seasons, respectively. The organic amendment treatments affected plant growth parameters. In the first year, okra yields were greatest in peanut-amended plots. Yield differences with amendment treatment diminished in the second and third years. Okra plant height, total fruit weight, and fruit number were greater with the lower population level of the root-knot nematode. Residual levels of nutrients in soil were greater where root-knot nematode levels and damage were higher and plant growth was poor. Nutrient levels affected the growth of a subsequent rye cover crop.
Key words: compost, *Hibiscus esculentus, Meloidogyne arenaria,* nematode, organic amendments, pest management, root-knot nematode, sustainable agriculture.

Organic amendments have been often used in the management of plant-parasitic nematodes (Holtz and Vandecaveye, 1938; Johnson, 1959; Johnson and Shamiyeh, 1975; Lear, 1959; Linford et al., 1938; Mankau and Minteer, 1962; McSorley and Gallaher, 1995a, 1995b; Miller et al., 1968; Muller and Gooch, 1982; Rodríguez-Kábana, 1986; Singh et al., 1967; Stirling, 1991; Watson, 1945; Watson and Goff, 1937). However, amendments might be used more widely if the mechanisms involved in nematode suppression and the amount of organic amendment necessary for suppression of plant-parasitic nematodes were better known (McSorley and Gallaher, 1995b).

The plant-parasitic nematode population levels under organic amendment treatments may change for many different reasons, including changes in soil properties, nutrients released to plants, increase in predators or parasitic microorganisms, toxic metabolites released from organic amendment breakdown, or health of the host crop (Stirling, 1991). However, changes in nematode populations are still dependent on the C/N ratio of the organic amendment, nematode species, and level of amendment needed for nematode suppression or plant tolerance. The objective of this study was to verify the effects of two organic amendments (with different C/N ratios) and a control treatment (without amendment) and two population levels of *Meloidogyne arenaria* (Neal) Chitwood race 1 on a highly susceptible crop and on nematode populations. The experiment was conducted in microplots under field conditions over a period of three years, during which microplots were planted with a root-knot nematode-susceptible vegetable crop in the summer and a cover crop (poor nematode host) in the winter.

Materials and Methods

The experiment was carried out at the University of Florida Green Acres Agronomy Farm in Alachua County, Florida, during 1994, 1995, and 1996. The study was conducted in fiberglass microplots (Johnson et al., 1981), 75 cm in diameter, 50 cm deep, and open at the bottom. The soil texture was characterized as 92% sand, 6% clay, and 2% silt.

On 26 May 1994, 24 microplots were cleaned of any weeds and sampled for determining initial nematode population. The nematodes were extracted and quantified

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from five soil cores per microplot by the centrifugal flotation technique (Jenkins, 1964). The microplots were then characterized as having a low or high level of *Meloidogyne arenaria,* based on the initial count of juveniles (J2) extracted from 100 cm^3 soil. Initial population of *M. arenaria* in the 12 plots defined as low level averaged 1.58 (sd = 2.8) and in the 12 plots defined as high level averaged 303 (sd = 187) *M. arenaria* per 100 cm^3 soil.

The nematode-susceptible 'Clemson spineless' okra (*Hibiscus esculentus* L.) was used as a test plant each summer. 'Wrens Abruzzi' rye (*Secale cereale* L.) was used as a cover crop in the fall/winter season because this crop is not a good host of root-knot nematode (McSorley, 1994). Each year, okra seeds were individually sown in Speedling trays (27 cm × 42 cm, with capacity for 36 seedlings) in a growth room according to procedures described elsewhere (Ritzinger, 1997). Each microplot received seven 2-week-old okra seedlings. Transplanting and harvesting dates for okra differed for each year, but data were collected by the same procedures to avoid variability. In the first year, on 20 June 1994, each microplot was fertilized by applying 40 g of 13-4-8 (N-P_2O_5-K_2O) fertilizer before the treatments were established. In subsequent years, no fertilizer was applied. Irrigation and occasional insecticidal sprays to control grasshoppers were applied as needed. After harvest, okra residues were removed from microplots, and 14.6 g (ca. 550 seeds) of 'Wrens Abruzzi' rye were sown in each plot. The germination rate was about 64%.

The experimental design was a 2 × 3 factorial with two nematode levels and three mulch types, replicated four times. The organic amendment treatments consisted of an aged yard-waste compost (mainly woodchips) (McSorley and Gallaher, 1995a), perennial peanut (*Arachis glabrata* Benth.) hay, and a control treatment without amendment.

The amendment treatments were applied as mulches and consisted of dry volumes of 9,000 cm^3 of perennial peanut hay or woodchips per microplot, weighing 1,474 g and 850 g, respectively. These application rates were equivalent to 33.4 mt/ha and 19.2 mt/ha, and these amendments were applied only in the first year, immediately after okra seedlings were transplanted. Any additional amendment in each plot was due to the hay from the rye cover crop, which was cut, weighed, and remained on the plot. Initial samples of perennial peanut hay, woodchips, and rye hay as well as periodic samples of soil and okra leaves were taken for mineral analysis according to the methodology described previously (Gallaher et al., 1975; Mehlich, 1953; Walkley, 1947; Walkley and Black, 1934) and for determination of C/N ratio (J.R. Rich, North Florida Research and Education Center, Quincy, FL, pers. comm.). Analyses of the amendments are presented in Table 1.

Okra fruit were harvested at a minimum length of 6 cm and picked at least twice weekly to avoid great variability among treatments. Plant height and stem diameter were measured twice after transplanting. Stem diameter was measured at a height of 10 cm, and plant height was measured from plant base to apical meristem. Data on yield consisted of average pod size, number of pods, and total weight of pods per microplot. Root galling and egg masses were rated on a 0-to-5 scale, where 0 = 0 galls or egg masses per

TABLE 1. Mineral analysis and C/N ratio for each organic amendment.

		Macronutrients (percent)					Micronutrients (ppm)			
Amendment	C/N ratio	N	K	Ca	Mg	P	Mn	Zn	Cu	Fe
Peanut hay	10.7	1.35	1.38	1.77	0.32	0.33	79	88	12	277
Woodchips	14.8	0.39	0.15	2.25	0.13	0.10	180	69	25	770
Rye hay	11.3	0.20	1.10	0.21	0.08	0.17	57	22	3	90

Data are means of five replications.

root system, 1 = 1–2, 2 = 3–10, 4 = 11–30, 4 = 31–100, and 5 = more than 100 galls or egg masses per root system (Taylor and Sasser, 1978).

For each crop, five soil cores were taken per microplot to estimate the initial and final nematode population on okra each year. Nematode count data were log-transformed ($\log_{10}$ [x + 1]) before data analysis, but only untransformed arithmetic means are presented in tables.

Data were statistically analyzed as a 2 × 3 factorial to determine the main effects and the interaction between mulch and nematode level. When the main effect and interaction were significant, separate analyses of variance were carried out, followed by separation of the means by Tukey's test (SAS Institute, Cary, NC).

First year - 1994: Okra seedlings were transplanted on 23 June. Immediately after transplanting, a layer of 2 cm of the appropriate organic amendment was distributed on each microplot, totalling 9,000 cm^3. Harvest of okra pods was initiated on 30 July and completed on 14 September, totalling 18 pickings. Data on stem diameter and plant height were recorded at 58 and 75 days, respectively, after transplanting.

On 15 September, the remaining plants in each microplot were removed and rated for root galling (in subsequent seasons, both galls and egg masses were rated). On the same day, a soil sample was collected from each plot for extraction of nematodes from soil. Microplots were then cleaned of the okra residues, but any of the original organic amendment remaining was left in each microplot. On 16 October, another soil sample was taken for soil mineral analysis and, after that, rye was sown. No additional irrigation or fertilizer was applied.

Second year - 1995: On 17 May, rye hay was cut and the stems were chopped into lengths of about 20 cm and left on each microplot. Okra was transplanted on 1 June. On 10 June, the average depth of the rye layer was recorded based on five random measurements in the microplot. Stem diameter and plant height of okra were recorded 36 and 72 days after transplanting. Harvesting began on 21 July and finished on 14 August, totalling 10 pickings. On 15 August, the experiment was terminated by the same procedure described in 1994, and samples for nematode analysis were collected. However, okra tops were left in the microplots. On 4 November, plots were cleaned of the okra residues and another soil sample was taken to represent the initial nematode population for the rye cover crop. An additional 100 cm^3 of soil was removed from each microplot, dried, and used for the mineral and organic matter analyses.

Any organic amendments remaining at the end of the summer crop were temporarily removed for sowing of rye seed and then replaced. No fertilizer or supplemental irrigation was applied during the rye cover crop.

Third year - 1996: On 8 May, rye hay was cut, chopped, and left on each microplot according to the same procedure described for 1995. However, rye seed heads and stems were weighed individually for each microplot. Soil samples for estimating the nematode population and nutrient levels were collected on the same day.

Okra seedlings were transplanted on 30 May, and depth of the rye hay layer was measured again. Stem diameter and plant height were recorded at 33 and 69 days after okra transplanting. Okra leaf blades and petioles were sampled for mineral analyses at 26 days after transplanting. Harvesting began on 11 July and was terminated on 7 August, totalling 10 pickings. The experiment was terminated on 7 August, and soil samples were collected for evaluating the final nematode populations.

Results

Okra plant growth: In the first year of the experiment (1994), there were interactions ($P \leq 0.05$) between nematode population level and amendment treatment for plant height at harvest and total fruit weight. For these variables, the highest values were recorded under the low level of nematode and mostly with the peanut hay treatment (Table 2). Nematode level affected all okra param-

TABLE 2. Effect of *Meloidogyne arenaria* population level and organic amendment on plant parameters of 'Clemson Spineless' okra in microplot experiments.

	Plant height (cm)											
	First measurement			Second measurement			Total number of fruit			Total fruit weight (g)		
Amendment	Low level	High level	Mean	Low level	High level	Mean	Low level	High level	Mean	Low level	High level	Mean
	1 July 1994			15 August 1994					1994 harvest[c]			
Control	34[a]	20	27 b	41 Ab	21 Bb	31	22	2	12 b	284 Ab	11 Ba	147
Peanut hay	57	40	49 a	76 Aa	42 Ba	59	39	11	25 a	642 Aa	139 Ba	391
Woodchips	39	25	32 b	47 Ab	28 Bb	38	21	2	12 b	239 Ab	15 Ba	127
Mean	43 A	28 B	36	55	30	46	27 A	5 B	16	388	55	222
	6 July 1995			11 August 1995					1995 harvest			
Control	19	18	19 a	33	28	30 b	13	8	10	165	76	120
Peanut hay	20	19	19 a	35	34	34 a	13	9	11	187	102	145
Woodchips	17	17	17 b	25	25	28 b	9	3	6	115	22	70
Mean	18	18	18	33 A	29 B	31	12	7	9	156 A	68 B	112
	2 July 1996			7 August 1996					1996 harvest			
Control	21 Aa[b]	20 Ab[b]	20	36 Aa	28 Bb	32	12	4	8	159	39	99
Peanut hay	20 Ba[b]	22 Aa[b]	21	29 Bb	37 Aa	33	9	14	12	101	157	129
Woodchips	20 Aa[b]	20 Ab[b]	20	32 Aab	32 Aab	32	6	10	8	67	97	82
Mean	20	21	21	32	32	33	9	9	9	109	98	103

[a] Data are means of four replications. Means followed by the same small letters in columns are not significantly different ($P \leq 0.05$), according to Tukey's test. Capital letters stand for comparisons between means in rows. Comparisons shown for main effects if interaction was not significant at $P \leq 0.10$.
[b] Significant at $0.05 \leq P \leq 0.10$.
[c] Total of 18 pickings in 1994 and 10 pickings each in 1995 and 1996.

eters ($P \leq 0.05$). Measurements in plots with the low nematode level were always greater than the corresponding values at the high nematode level. However, most differences with nematode level did not persist into the second and third seasons.

Amendment effect: The organic amendment used affected ($P \leq 0.05$) stem diameter at midseason and harvest in every season (data not shown), and affected ($P \leq 0.01$) plant height on both sampling dates in the first two seasons. The highest values generally were recorded under the peanut hay amendment (Table 2). Okra yields (number and weight of fruit) also were greatest in peanut-amended plots, but only in the first season. In the third season, significant ($P \leq 0.05$) interactions between nematode level and organic amendment resulted from a greater response to peanut amendment in the plots with the high level of *M. arenaria.*

Since no fertilizer was applied except in the first year, the organic amendments were of particular importance as potential sources of nutrients. Peanut hay was the richest source of N (Table 1) and probably provided a fertility source responsible for the improved plant growth.

Both stem diameter and plant height had a tendency to decrease each year. The average plant height at harvest varied from 45.9 cm in 1994 to 32.8 cm in 1996, and stem diameter varied from 9.2 mm to 6.4 mm. Also, the total number of fruit and total fruit weight decreased from the first year to the second. These declines in plant growth over time probably resulted from N depletion.

Nematodes: In the first year, gall index and initial and final root-knot nematode populations were affected ($P \leq 0.01$) by nematode level (Tables 3 and 4). This would be expected since the original treatment separated plots into high and low levels of root-knot nematodes. However, amendment treatment had no effect on nematode population or gall index during the first year ($P > 0.05$).

Differences in numbers of root-knot nematodes and in galling and egg mass indices between plots with high vs. low nema-

TABLE 3. Effect of *Meloidogyne arenaria* population level and organic amendment on numbers of root-knot (*Meloidogyne arenaria*) and stubby-root (*Paratrichodus minor*) nematodes per 100 cm^3 soil in microplot experiments with 'Clemson Spineless' okra.

	Root-knot nematodes/100 cm^3 soil						Stubby-root nematodes/100 cm^3 soil					
Amendment	Low level	High level	Mean	Low level	High level	Mean	Low level	High level	Mean	Low level	High level	Mean
	23 May 1994			23 September 1994			23 May 1994			23 September 1994		
Control	1[a]	284	143	14	127	71	12	0	6	19	4	11
Peanut hay	0	242	121	66	169	118	6	0	3	10	5	7
Woodchips	4	382	193	72	247	160	12	1	6	14	5	8
Mean	2 B	303 A	152	51 B	181 A	116	10 A	0 B	5	14 A	4 B	9
	1 June 1995			15 August 1995			1 June 1995			15 August 1995		
Control	5	20	13 b	25 Bb[b]	197 Aa[b]	111	13	7	10	5	5	5
Peanut hay	16	101	57 ab	258 Aa[b]	180 Aa[b]	219	19	17	18	19	4	11
Woodchips	76	104	90 a	48 Ab[b]	259 Aa[b]	154	11	7	9	10	15	13
Mean	33 B	75 A	54	110	212	161	14	10	12	11	8	10
	8 May 1996			7 August 1996			8 May 1996			7 August 1996		
Control	3	24	14	49 Bb[b]	212 Aab[b]	131	11	6	8	12	10	11
Peanut hay	15	15	15	337 Aa[b]	125 Bb[b]	231	10	4	7	9	15	12
Woodchips	10	13	12	206 Aa[b]	273 Aa[b]	239	3	5	4	15	9	12
Mean	9 B	18 A	14	198	203	200	8	5	6	12	12	12

[a] Data are means of four replications. Means followed by the same small letters in columns are not significantly different ($P \leq 0.05$), according to Tukey's test. Capital letters stand for comparisons between means in rows. Comparisons shown for main effect(s) if interaction was not significant at $P \leq 0.10$.
[b] Significant at $0.05 \leq P \leq 0.10$.

tode levels generally were maintained in the second and third years of the experiment (Tables 3 and 4). However, in these years, amendment treatment affected ($P \leq 0.01$) gall and egg mass indices, and significant interactions between nematode level and amendment were evident for these parameters as well. These interactions resulted be-

TABLE 4. Effect of *Meloidogyne arenaria* population level organic and amendment on gall and egg mass indices on 'Clemson Spineless' okra in microplot experiments.

	Gall index[a]			Egg mass index[a]		
Amendent	Low level	High level	Mean	Low level	High level	Mean
			1994			
Control	1.8[b]	4.3	2.7	—	—	—
Peanut hay	1.5	4.9	3.2	—	—	—
Woodchips	2.1	4.8	3.4	—	—	—
Mean	1.6 B	4.7 A	2.8	—	—	—
			1995			
Control	1.1 Bb	5.0 Aa	3.1	0.6 Bb	3.8 Aa	2.2
Peanut hay	3.9 Aa	4.9 Aa	4.4	2.6 Aa	3.3 Aa	2.9
Woodchips	2.8 Ba	5.0 Aa	3.9	2.2 Aa	3.3 Aa	2.7
Mean	2.6	5.0	3.7	1.8	3.4	2.5
			1996			
Control	2.7 Bb	4.3 Aa	3.5	1.7 Bb	2.8 Aa	2.3
Peanut hay	4.0 Aa	4.1 Aa	4.1	3.4 Aa	3.2 Aa	3.3
Woodchips	3.9 Aa	4.5 Aa	4.2	2.8 Aa	3.2 Aa	3.0
Mean	3.6	4.3	3.9	2.6	3.1	2.8

[a] Egg masses and galls rated on 0-to-5 scale, where 0 = no galls or egg masses per root system; 1 = 1 to 2; 2 = 3 to 10; 3 = 11 to 30; 4 = 31 to 100; and 5 = more than 100 galls or egg masses per root system.
[b] Data are means of four replications. Means followed by the same small letters in columns are not significantly different ($P \leq 0.05$), according to Tukey's test. Capital letters stand for comparisons between means in rows. Comparisons shown for significant main effect means for 1994 because interaction was not signficant at $P \leq 0.10$.

cause galling and egg mass indices were lower with the control treatment at the low nematode level but were not affected by organic amendment treatment at the high nematode level (Table 4).

Paratrichodorus minor (Colbran) Siddiqi, the stubby-root nematode, colonized these microplots. In the first year of the study, stubby-root nematodes built up more quickly in plots with low levels of *M. arenaria* than in plots with high levels of *M. arenaria* (Table 3). In the following years, stubby-root nematodes reached similar levels in all treatments.

Rye cover crop: The depth of straw from the rye hay residues was affected by the amendment ($P \leq 0.01$) only after the first year, with a depth of 5.2 cm following the peanut amendment but only 3.0 cm and 3.7 cm following the control and woodchip treatments, respectively. However, on all dates of measurement, the greatest depth of straw ($P \leq 0.10$) was recorded under the high root-knot nematode level (June 1995: 3.37 cm low level, 4.60 cm high level; November 1995: 0.71 cm low level, 1.04 cm high level; June 1996: 1.46 cm low level, 2.46 cm high level). The greatest weights of rye heads and stems were recorded under the high nematode level (data not shown).

Soil properties and nutrients: Soil organic matter ranged from 0.65% to 1.33%, and soil pH ranged from 6.35 to 7.32 over the course of the experiment. Organic amendment affected organic matter in soil only in November 1995 and May 1996 ($P \leq 0.05$). The highest percentage of organic matter was registered under the peanut hay amendment in May 1996 (data not shown). There was a significant ($P \leq 0.01$) interaction between amendment and nematode level for pH in August 1995. The interaction possibly was due to dryness during this period since, according to the remaining data, amendment did not affect soil pH.

Among macronutrients, N, K, and Ca were the most affected by amendment; P and Mg were affected the least. On all sampling dates, N was higher under peanut hay and woodchip amendments (Table 5). For K, there was no significant difference between amendment and control treatment in the first year. However, on the second collection date, soil K content from the peanut hay amendment treatment was almost double that of the control treatment (Table 5). In general, levels of N and K tended to be higher in soil of plots with the high root-knot nematode levels. There were no interactions between amendment and nematode level for Ca and Mg except in August 1995. There was not much variability in soil P (data not shown). The average level of P in soil from September 1994 to May 1996 was 64.6 ppm (sd = 3.6).

Discussion

Okra growth was affected by the nematode (*Meloidogyne arenaria*) level. These effects were expected since plots were set up initially as having low or high nematode levels. The highest plant-growth responses were recorded under peanut hay amendment, especially in the first year. One reason is that fertilizer was applied only in the first year. In addition, analysis of the peanut hay revealed high levels of mineral nutrients that might be released faster from peanut hay than from woodchips or rye hay because peanut hay had the lowest C/N ratio.

According to Norton (1978), damage caused by nematodes can be overcome to various degrees by application of fertilizer, although fertilizer application affects nematode population levels in different ways. Moderate fertilization resulted in increase of *Pratylenchus* spp., but no N-P-K application in corn resulted in higher levels of *Helicotylenchus pseudorobustus* (Norton, 1978). In another study, NH_4^+ and Mg^{2+} required for plant growth were reported to increase infection of *M. incognita* in lima bean and cucumber (Huber, 1980). In our study, nutrient levels were highest in the first year and affected plant growth, but nematode population density was not associated with nutrient level.

In our experiment, supplementary fertilizer was applied only in the first year; thus, most soil nutrients were added through the decomposition of amendments. However,

TABLE 5. Effect of *Meloidogyne arenaria* population level and organic amendment on soil macronutrients in microplot experiment.

Treatment effect	N (ppm)			K (ppm)			Ca (ppm)			Mg (ppm)		
	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean
						September 1994						
Control	207[a]	200	204 b	104	132	118	453	530	492 b	41	33	37
Peanut hay	252	230	241 a	127	174	151	502	477	490 b	44	35	39
Woodchips	245	215	230 a	113	160	137	605	647	626 a	40	44	42
Mean	215 B	235 A	225	115 B	155 A	135	520	551	536	41	37	39
						May 1995						
Control	185	215	199 b	108	144	126 b	414	520	467	42	44	43
Peanut hay	237	287	262 a	229	309	269 a	482	486	484	58	45	52
Woodchips	217	262	240 a	139	190	165 b	462	511	487	54	46	40
Mean	215 B	255 A	234	159 B	214 A	186	453	506	479	52	45	48
						August 1995						
Control	167 Aa	182 Ab	175	92 Bc	120 Ac	106	359 Bb	448 Aab	403	35	34	35
Peanut hay	185 Ba	252 Aa	219	274 Ba	351 Aa	313	451 Aa	408 Ab	430	48	34	41
Woodchips	162 Aa	185 Ab	174	132 Bb	185 Ab	159	390 Bb	498 Aa	444	38	43	40
Mean	172	207	189	166	218	192	400	451	426	40	37	39
						November 1995						
Control	177	205	191 b	87	91	89 b	540	577	558 b	34	36	35
Peanut hay	215	262	239 a	107	131	119 a	607	631	619 ab	44	41	42
Woodchips	222	220	221 ab	104	119	111 a	716	709	712 a	46	53	50
Mean	205	217	217	99 B	114 A	106	621	639	630	42	43	42
						May 1996						
Control	172	177	175 b	98	97	98 b	536	621	578	34	35	34
Peanut hay	217	255	236 a	159	167	163 a	621	642	632	43	36	39
Woodchips	190	200	195 ab	128	136	132 ab	600	742	671	40	52	36
Mean	193	211	211	128	133	131	586	668	627	39	41	40

[a] Data are means of four replications. Means followed by the same small letters in columns are not significantly different ($P \leq 0.05$), according to Tukey's test. Capital letters stand for comparisons between means in rows. Comparisons shown for significant main effects if interaction was not signficant at $P \leq 0.10$.

levels of N varied consistently with the soil amendment; in the non-amended control treatment, N level was lowest and tended to decrease over time (average of 204 to 175 ppm). In the other amendment treatments, the N level was higher compared to the non-amended control (average of 235 to 215 ppm over time). In addition, among peanut hay, woodchips, and rye hay, the peanut hay amendment had the lowest C/N ratio and woodchips the highest. Thus, higher levels of mineral elements were generally detected after amendment with peanut hay because this amendment decomposed faster than woodchips or rye hay.

Rye yields as well as amount of rye hay were greater in plots with high root-knot nematode levels where consistently higher levels of soil nutrients were available. Plant damage and root-galling of okra were greater in these plots and so it is likely that okra roots damaged by the root-knot nematodes were impaired in their ability to uptake nutrients. This hypothesis also is supported by the fact that N and K in soil were higher in plots with high root-knot nematode levels; thus, rye, a relatively poor host of root-knot nematodes (McSorley, 1994), had more nutrients available in these plots. Rye growth was best in plots with the peanut amendment where available K was particularly high.

On all sample dates in the first year, *Paratrichodorus minor* counts were greater in plots with low root-knot nematode levels, possibly because there was competition from root-knot nematodes. Since *Paratrichodorus* spp. feed on root tips (Christie, 1959), there were probably fewer feeding sites for *P. minor* due to the presence of more galls on the root system in plots with high root-knot nematode levels. Since nematode infection in plots with low levels of root-knot nematode had a tendency to increase over time, the levels of *P. minor* tended to stabilize.

Okra yields showed decreasing trends in the second and third years of the experiment. One reason might be the fact that microplots were cultivated in the same area and did not receive supplemental fertilizer to compensate for nutrients that were no longer available for plant uptake. Although the current study provides information on the availability of crop nutrients over time, it would be necessary to reapply an amendment (e.g., peanut hay) each year to sustain optimal organic production. The peanut hay amendment, which was rich in available N, improved okra growth and yield, but no amendments consistently affected nematode population levels. Under the conditions of this experiment, organic amendments did not provide an effective means for reducing nematode levels, and some other management method would be needed for this purpose.

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