EFFECT OF FRESH AND DRY ORGANIC AMENDMENTS ON *MELOIDOGYNE ARENARIA* IN GREENHOUSE EXPERIMENTS†

C. H. S. P. Ritzinger[1] and R. McSorley[2]

EMBRAPA, Caixa Postal 007, CEP 44380, Cruz das Almas, BA, Brazil,[1] and Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611, U.S.A.[2]

ABSTRACT

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Organic amendments (OA) were evaluated in two greenhouse experiments for their effectiveness in suppressing *Meloidogyne arenaria* populations in naturally infested soil. Vegetative shoots from castor (*Ricinus communis*), collard (*Brassica oleracea*), sesame (*Sesamum indicum*), sorghum (*Sorghum bicolor*), velvetbean (*Mucuna deeringiana*), and zinnia (*Zinnia elegans*) were chopped into small pieces and placed on the soil surface in plastic pots. Nematode numbers and growth of 'Clemson Spineless' okra (*Hibiscus esculentus*) planted into each pot were evaluated. In a winter experiment, 4 g of the fresh OA or 4 g of the dried OA were used as separate treatments. Dried OA was more effective than fresh OA, and greatest reduction of juveniles (J2) in the root system was obtained with dry OA from zinnia, castor, velvetbean, and collard. In a summer trial, 4 g of dry OA and the fresh weight of each OA corresponding to 4 g dry weight did not differ in their ability to reduce J2. Castor and velvetbean gave best suppression of J2 in soil, while reduction of J2 in the root systems was greatest with velvetbean. For both seasons, growth of okra and nematode suppression generally were greater with castor, velvetbean, and collard, which had lower C/N ratios than sesame and sorghum.

Key words: Brassica oleracea, castor, collard, *Hibiscus esculentus, Mucuna deeringiana,* mulch, okra, *Ricinus communis,* root-knot nematode, sesame, *Sesamum indicum,* sorghum, *Sorghum bicolor,* velvetbean, zinnia, *Zinnia elegans.*

RESUMEN

Ritzinger, C. H. S. P., y R. McSorley. 1998. Efectos de cobertura orgánica en la población de *Meloidogyne arenaria* en maceteros. Nematrópica 28:173-185.

Efectividad de coberturas orgánicas para reducir poblaciones de *Meloidogyne arenaria,* en suelos naturalmente infestados, fue evaluada en dos experimentos en invernadero. Partes vegetativas de ricino (*Ricinus communis*), col (*Brassica oleracea*), ajonjolí (*Sesamum indicum*), sorgo (*Sorghum bicolor*), frijol mucuna (*Mucuna deeringiana*), y zinia (*Zinnia elegans*) fueron cortadas en pequeñas secciones y colocadas en la superficie del suelo en maceteros plásticos. Tratamientos testigos no recibieron materia orgánica (MO). El número de nemátodos y producción de plantas fueron medidos en ocra (*Hibiscus esculentus*), variedad 'Clemson Spineless,' en cada macetero. En primavera, 4 g de MO fresca o 4 g d MO seca de cada MO, fueron usados como tratamientos diferentes. El efecto principal de MO fresca vs. seca en la población de nemátodos y su interacción con el tipo de MO fue significativo (P# 0.05), siendo más efectiva la MO seca que la MO fresca. Reducción del número de juveniles (J2) en el sistema radicular fue obtenida con MO seca en tratamientos con zinia, ricino, frijol mucuna y col. El menor índice de agallamiento fue obtenido cuando ricino, frijol mucuna, sorgo y zinia fueron usados.

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No hubo diferencia entre MO para el índice de masas de huevos. En verano, 4 g de peso seco y el peso fresco correspondiente a 4 g de peso seco no difirieron en la habilidad para reducir J2. Ricino y frijol mucuna causaron lamejor reducción de J2 en suelo, seguidos por col y zinia. Reducción de J2 en el sistema radicular fue superior con el uso de frijol mucuna, seguido por col, ricino y sorgo. En ambas estaciones, el mejor crecimiento de ocra fue obtenido con MO de ricino, frijol mucuna, y col que tiveron una tasa de C/N baja. En general, ricino y frijol mucuna fueron las fuentes más efectivas de MO, mientras ajonjolí y sorgo fueron las menos efectivas.

Palabras claves: Ajonjolí, *Brassica oleracea,* col, frijol mucuna, *Hibiscus esculentus, Mucuna deeringiana,* mulch, nematodos, nematodos de las galhas, ocra, ricino, *Ricinus communis, Sesamum indicum,* sorghum, *Sorghum bicolor,* zinia, *Zinnia elegans.*

INTRODUCTION

Organic amendments have been used by farmers and researchers to manage plant-parasitic nematodes since early in this century, but they have not been fully accepted or understood as a control method because of the many interactions with environmental factors (Linford *et al.*, 1938; Mankau, 1968; Watson, 1945). The mechanism of action has been attributed to the improvement of soil structure and aggregation resulting in increased aeration and water-holding capacity, to improvement in plant nutrition, to release of by-products toxic to nematodes, or to the enhancement of the growth of organisms able to compete with or destroy nematodes (Stirling, 1991). These attributes may be important in individual cases, since the efficacy of the organic amendments has varied depending upon the nature of the organic matter, soil type, crop, and nematode species (Mian and Rodríguez-Kábana, 1982; Rodríguez-Kábana, 1986; Stirling, 1991).

A number of organic amendments have been used to manage nematodes, because they are associated with reduced infection, decreased survival, or increased numbers of microbial and animal antagonists of nematodes (Linford *et al.*, 1938; Mankau, 1968; Mankau and Minteer, 1962; Sitaramaiah and Singh, 1978; Watson, 1945). These effects may have resulted from the release of phenolic compounds, NH_3, nitrite, or Ca^{2+} ions; from changes in soil pH or soil moisture; or from the type, amount, and C/N ratio of the organic amendment used (Brown, 1987; Holtz and Vandecaveye, 1938; Mankau, 1968; Mankau and Minteer, 1962; Rodríguez-Kábana, 1986; Singh and Sitaramaiah, 1967; Walker, 1971; Watson, 1945). Nonetheless, increased yields under organic amendments may not be directly related to the dynamics of the nematode population, since the organic amendment itself may promote healthy plants, as well as improvement in soil moisture. Thus, some amended crops may better tolerate the presence of nematodes, without showing decreased yields (McSorley and Gallaher, 1995).

Castor (*Ricinus communis* L.), collard (*Brassica oleracea* L.), sesame (*Sesame indicum* L.), sorghum-sudangrass (Sorghum bicolor [L.] Moench × *Sorghum sudanense* [*Stapf*] Hitchc.), velvetbean (*Mucuna deeringiana* [Bort.] Merr.; syn. M. *pruriens* DC), and zinnia (*Zinnia elegans* L.) were chosen for greenhouse studies, because they have been previously used as organic amendments to suppress nematodes when used in crop rotation, incorporated into soil, or applied as mulch (Huang, 1984; Lear, 1959; Mankau, 1968; Mankau and Minteer, 1962; Mian and Rodríguez-Kábana, 1982; Rich *et al.*, 1989; Rodríguez-Kábana *et al.*, 1988; McSorley and Gallaher, 1993; McSorley *et al.*, 1994; Watson, 1922; Watson, 1936; Watson, 1945, Watson and Goff, 1937). The objective of these greenhouse experiments was to compare the effect of fresh and dry material of these six organic amendments on okra *(Hibiscus esculentus* L.) inoculated with *Meloidogyne arenaria* (Neal) Chitwood race 1.

MATERIALS AND METHODS

Two separate experiments were carried out during the winter and summer of 1995, in a greenhouse on the University of Florida campus in Gainesville, Florida. The following plants were grown to supply fresh or dry organic amendments for both experiments: castor, 'Georgia Southern' collard, 'Sesaco-16' sesame, 'SX-17' sorghum-sudangrass, velvetbean, and 'Scarlet' zinnia. Aboveground parts of all plants were harvested before flowering. Leaves and stems of each plant species were chopped separately, mixed, and used as fresh or dry amendment, as specified for each experiment. A sample of each type of plant was taken for mineral analysis and determination of C/N ratio (Gallaher *et al.*, 1975; Mehlich, 1953; Ritzinger, 1997; Walkley, 1947; Walkley and Black, 1934).

Soil infested with *Meloidogyne arenaria* race 1 was used for the inoculum treatment. This soil had been infested by adding the nematode to steam-sterilized field soil, followed by growth of 'Rutgers' tomato *(Lycopersicon esculentum* Mill.). For the no-inoculum treatment, the same soil was used to grow 'Rutgers' tomato but without *M. arenaria* race 1 added. The final soil mixture was prepared by mixing ¼ infested soil and ¾ of steam sterilized field soil with sand in a ratio of 1:1 by volume. The soil mixture for the no-inoculum treatment was similarly prepared. Soil samples were taken from both batches to determine the initial population levels of second-stage juveniles (J2).

For both experiments, the nematode-susceptible 'Clemson Spineless' okra was planted in pots in the greenhouse. In the first experiment, the amendments were applied to okra grown from seeds, and in the second experiment, transplanted okra was used. Other differences between the two experiments, mainly in the amounts of amendments used and sampling dates, are described below.

In both experiments, the experimental design was a 6 × 2 × 2 factorial with six organic amendments, two forms of organic amendments (fresh and dry), and two nematode densities, replicated six times. Plants in both experiments were watered as needed and sprayed two times per week with dilute soap solution to reduce infestations of whiteflies (*Bemisia tabaci*).

At harvest, plants were removed from the soil, and shoot and taproot lengths as well as the fresh root and top weights were recorded. Root galls and egg masses were rated according to the root-knot index of Taylor and Sasser (1978), where 0 = 0 galls or egg masses per root system, 1 = 1-2, 2 = 3-10, 3 = 11-30, 4 = 31-100, and 5 = more than 100 galls or egg masses per root system. The final numbers of second-stage juveniles hatching from egg masses in the okra root system were quantified by extracting eggs in 1.05% NaOCl (Hussey and Barker, 1973), then incubating the eggs on Baermann trays (Rodríguez-Kábana and Pope, 1981) for seven days, and counting the hatched J2. Population levels of J2 in soil were quantified from 100 cm^3 of soil by the sieving and centrifugation technique (Jenkins, 1964).

Plant data from each experiment were statistically analyzed as a 6 × 2 × 2 factorial with six replications, to determine the main effects and interactions. Where appropriate, means were separated by Tukey's test (SAS Institute, Cary, NC). Nematode data were analyzed as a 6 × 2 factorial. Data on juveniles hatched from the egg masses or juveniles extracted from 100 cm^3 of soil were analyzed from only three replications.

Experiment 1 (Winter 1994-1995). Okra in this experiment was grown from seed in plastic pots filled with 380 cm^3 of soil (600 g dry weight of soil). Initial nematode numbers were 120 J2/pot in the infested soil treatment and 0 J2/pot in the non-inoculated treatment. On 17 December 1994, two okra seeds were planted one cm deep in each pot. After plant emergence, the seedlings were thinned to one, on 29 December 1994.

The mulch treatment consisted of 4 g of dry or fresh weight of each organic amendment. Fresh mulch consisted of chopping the aerial parts of each plant species into small pieces (<0.5 cm) and immediately weighing 4 g of each one. Dry mulch consisted of drying the chopped aerial parts at 60°C until constant weight was reached and then weighing 4 g of each one. The mulch was placed over the surface of the soil at the time when seeds were sown. Plant height and stem diameter were recorded 42 days after planting. Plants were harvested at 65 days after planting (20 February 1995). Minimum temperatures during the experimental period ranged from 4.2 to 8.4°C, and maximum temperatures ranged from 18.6 to 20.4°C.

Experiment 2 (Summer 1995). For this experiment, okra seeds were individually sown in trays (27 cm x 52 cm, with capacity for 36 seedlings) in a growth room. These trays were filled with steam-sterilized sandy soil (92% sand, 4% silt, 4% clay), kept at 24 ± 1°C, and watered daily. After two weeks, on 27 May 1995, these seedlings were individually transplanted into pots filled with 560 cm^3 of soil (1.2 kg dry weight). On 27 May, it was determined that the infested pot treatments had only 28 J2 per pot, therefore these pots were inoculated with an additional 140 J2 per pot, totaling 168 J2 per infested pot; non-infested pots had 0 J2 per pot. The dry mulch treatment, prepared in the days just before application, consisted of 4 g of each organic amendment previously dried to constant weight, according to the same procedure used in experiment 1. However, the fresh weight treatment was the corresponding amount needed to get 4 g dry weight. These amounts were 32.1 g, 13.6 g, 26.2 g, 27.6 g, 31.3 g, and 17.6 g for sesame, sorghum, collard, castor, zinnia, and velvetbean, respectively.

Data on plant height and stem diameter were taken on 23 June, 30 days after transplanting. On 9 July, 42 days after transplanting, plants were harvested and appropriate data collected. Daily minimum temperatures during the experimental period ranged from 18.0 to 21.6°C, and maximum temperatures ranged from 31.7 to 33.5°C.

RESULTS AND DISCUSSION

Preliminary experiments had verified the beneficial effects of amendment application in the growth of 'Clemson Spineless' okra under the conditions of these tests (Ritzinger, 1997). In those experiments, plants receiving amendments were compared to unamended controls. The current studies were intended to compare the relative performance of the six amendments against one another. A comparison of the six amendments used in the current studies revealed ranges in macro- and micronutrient contents and particularly in the C/N ratios (Table 1).

Experiment 1. There was a significant interaction ($P \leq 0.01$) between mulch type and mulch form (fresh or dry organic

Table 1. Mineral analysis and C/N ratio for each organic amendment used in the experiments.

Organic amendment	C/N ratio	Macronutrients					Micronutrients			
		N	P	K	Ca	Mg	Mn	Zn	Cu	Fe
		%					ppm			
Castor	7.91	2.26[z]	0.34	3.20	1.64	0.53	280	105	34.2	61.5
Collard	7.78	3.11	0.47	4.15	2.08	0.67	242	247	12.2	68.5
Sesame	10.23	3.04	0.35	2.05	1.74	0.79	660	170	15.0	77.5
Sorghum	11.17	1.45	0.26	2.55	0.38	0.38	175	110	9.5	56.8
Velvetbean	8.68	2.20	0.23	1.39	1.40	0.39	460	1070	12.0	60.8
Zinnia	10.19	2.30	0.29	3.21	1.43	0.94	710	125	8.8	53.0

[z]Nutrient data are means of five replications from the aerial plant parts harvested before the reproductive stage.

amendment) for all plant parameters except taproot length (Table 2). For stem diameter, plant height, root weight, and top weight, the higher value was generally recorded when the organic amendment was in the dry form (Table 3). Using dry velvetbean, castor, collard, and zinnia generally resulted in greater plant responses than sesame or sorghum. However, under fresh organic amendment, there was no specific trend for mulch type.

Inoculum level affected ($P \leq 0.01$) all plant parameters (Table 2). The higher values generally were reached at 0 J2/pot, except for taproot length, and root weight (data not shown). The higher values in nematode-infected roots were due to swollen roots and galls. There was no triple interaction ($P \leq 0.05$) for any of the plant parameters assessed (Table 2).

In Experiment 1, there was a significant interaction ($P \leq 0.01$) between mulch form and mulch type for juveniles hatched from egg masses (Table 4). Similar numbers of juveniles hatched from egg masses when dry sesame or sorghum amendments were used, but not when fresh amendments were used (Table 5). However, none of the factors affected ($P \leq 0.05$) juveniles extracted from soil (Table 4). Probably, the greenhouse temperature during this winter experiment was not favorable for the development of large numbers of this second generation of *M. arenaria.* This hypothesis is in accordance with related studies (Ritzinger, 1997) and with findings of Davide and Triantaphyllou (1967), who showed that the generation time of *M. incognita* increased as temperature decreased. Generally, with dry organic amendments, the lowest number of J2 hatched from egg masses were recorded under castor, collard, velvetbean, and zinnia, which have low C/N ratios. The highest numbers were recorded under sesame and sorghum, which have higher C/N ratios (Table 5).

Formation of egg masses by *M. arenaria* was affected ($P \leq 0.01$) by the organic amendment form (fresh or dry) and by the organic amendment type (Table 5). Root gall indices were greater ($P \leq 0.01$) under fresh organic amendments (mean index = 4.97) than under dry amendments (mean index = 4.64) (data not shown). Gall and egg mass indices were higher under the fresh amendments because at equivalent weights more active amendment (less water) was applied in the dry amendment treatment, presumably resulting in more nematode suppression.

In general, the highest values for plant parameters and most effective suppression of nematodes resulted under castor, collard, velvetbean, or zinnia amendments in the dry form. These amendments tended to have the lowest C/N ratios (Table 1). There were no similar trends among mulch types with fresh organic amendments (Table 3).

Experiment 2. The effects of mulch type were significant ($P \leq 0.01$) for almost all plant parameters, except taproot length (Table 2). The highest values of most plant parameters were generally obtained from velvetbean, castor, collard, or zinnia treatments, and the lowest values from sesame or sorghum (Table 6). These results are in accordance with findings reported in the first experiment.

The effects of mulch form were significant ($P \leq 0.05$) only for plant height at harvest and top fresh weight (Table 2). The general lack of effect of mulch form in this experiment suggests that the equivalent weight of fresh or dry amendment had a similar effect on plant parameters and nematode suppression (Table 4). Inoculum level significantly affected ($P \leq 0.01$) all plant parameters (Table 2), and there were significant interactions ($P \leq 0.05$) between inoculum level and mulch type for stem diameter, top fresh weight, and root fresh

Table 2. Effect of inoculum level, mulch form (fresh or dry), and mulch type on plant parameters of 'Clemson Spineless' okra in greenhouse experiments. Data shown are F-values from the analysis of variance.

Treatment effect	Stem diameter	Plant height		Taproot Length	Root fresh weight	Top fresh weight
		Early[y]	Harvest			
	Experiment 1 – Winter 1995					
Inoculum level (A)	41.79**[z]	17.12**	19.09**	9.90**	152.41**	9.74**
Mulch form (B)	1.44 ns	10.49**	29.30**	0.05 ns	15.11**	73.12**
Mulch type (C)	13.03**	5.29**	8.13**	1.60 ns	39.05**	27.24**
Interaction (AB)	1.41 ns	0.33 ns	2.13 ns	0.72 ns	0.24 ns	0.24 ns
Interaction (AC)	2.11 ns	2.22 ns	1.85 ns	2.24 ns	0.86 ns	1.29 ns
Interaction (BC)	5.88**	3.75**	6.17**	1.89 ns	18.33**	16.60**
Interaction (ABC)	0.48 ns	1.54 ns	1.06 ns	0.48 ns	0.95 ns	0.72 ns
	Experiment 2 – Summer 1995					
Inoculum level (A)	81.53**	125.74**	174.83**	12.96*	422.66**	138.50**
Mulch form (B)	0.35 ns	1.23 ns	4.82*	0.01 ns	3.58 ns	5.86*
Mulch type (C)	18.81**	3.26**	5.05**	1.73 ns	21.93**	27.69**
Interaction (AB)	3.50 ns	2.50 ns	3.74 ns	1.52 ns	0.21 ns	1.58 ns
Interaction (AC)	3.49**	1.25 ns	2.01 ns	0.54 ns	3.92*	2.80*
Interaction (BC)	1.58 ns	0.53 ns	0.55 ns	1.38 ns	2.18 ns	1.84 ns
Interaction (ABC)	2.05 ns	0.93 ns	1.74 ns	1.93 ns	1.28 ns	1.66 ns

[y]Measured at 42 days in Experiment 1 and at 30 days in Experiment 2.
[z]*,** indicate significant main effect or interaction at $P \leq 0.05$ and $P \leq 0.01$, respectively; ns = effect not significant at $P \leq 0.05$.

Table 3. Effect of mulch type and mulch form (fresh or dry) on plant growth, Experiment 1 (Winter 1995).

	Stem diameter (cm)			Plant height (cm) 42 days			Plant height (cm) 65 days			Root fresh weight (g)			Top fresh weight (g)		
Mulch type	Fresh	Dry	Mean	Fresh	Dry	Mean	Fresh	Dry	Mean	Fresh	Dry	Mean	Fresh	Dry	Mean
Castor	3.4 a[z]	3.4 a	3.4	15.7 a	18.3	17.0	14.4 a	18.2 ab	16.3	1.7 a	2.1 b	1.9	2.4 a	3.5 b	2.9
Collard	3.1 a	3.7 a	3.4	15.6 a	18.1 ab	16.8	14.8 a	16.4 bc	15.6	1.6 a	2.1 b	1.8	2.1 a	3.7 b	2.9
Sesame	3.1 a	2.6 b	2.8	15.7 a	16.1 bc	15.9	14.4 a	15.8 bc	15.1	1.5 a	1.2 c	1.3	2.0 a	2.2 cd	2.1
Sorghum	2.9 a	2.6 b	2.7	15.1 a	13.9 c	14.5	14.3 a	14.1 c	14.2	1.4 a	1.1 c	1.2	1.9 a	1.5 d	1.7
Velvetbean	3.3 a	3.6 a	3.4	15.9 a	19.8 a	17.8	15.0 a	21.1 a	18.2	1.8 a	3.1 a	2.4	2.3 a	5.0 a	3.7
Zinnia	2.9 a	3.3 a	3.1	16.3 a	16.3 abc	16.3	15.0 a	15.9 bc	15.4	1.5 a	1.4 bc	1.4	2.0 a	3.0 bc	2.5
Mean	3.1	3.2	3.1	15.7	17.1	16.3	14.6	16.9	15.7	1.6	1.8	1.7	2.1	3.2	2.6

[z]Data are means of six replications. Means followed by the same letter in columns are not significantly different ($P \leq 0.05$), according to Tukey's test.

Table 4. Effect of mulch form (fresh or dry) and mulch type on *Meloidogyne arenaria* infecting 'Clemson Spineless' okra. Data shown are F-values from the analysis of variance.

	Juveniles			
Treatment effect	(J2)/g root[w]	(J2)/100 cm^3 soil[x]	Gall index[y]	Egg mass index[y]
	Experiment 1 – Winter 1995			
Mulch form (A)	0.96 ns[z]	0.02 ns	15.72**	14.30**
Mulch type (B)	78.09**	0.38 ns	2.36 ns	3.73**
Interaction (AB)	57.76**	1.24 ns	0.95 ns	0.69 ns
	Experiment 2 – Summer 1995			
Mulch form (A)	3.15 ns	3.57 ns	0.00 ns	3.00 ns
Mulch type (B)	3.78*	3.73*	2.00 ns	10.00**
Interaction (AB)	0.27 ns	0.65 ns	0.00 ns	0.55 ns

[w]Data are based on three replications.
[x]Data are average of three replications for Experiment 1 and six replications for Experiment 2.
[y]Data are based on six replications.
[z],*,**Indicate significant main effect or interaction at $P \leq 0.05$ and $P \leq 0.01$, respectively; ns = effect not significant at $P \leq 0.05$.

Table 5. Effect of mulch type and mulch form (fresh or dry) on numbers of second-stage juveniles (J2) of *Meloidogyne arenaria* and on egg mass indices, Experiment 1 (Winter 1995).

	J2/g root			Egg mass index[y]		
Mulch type	Fresh	Dry	Mean	Fresh	Dry	Mean
Castor	198 bc[z]	98 b	148	2.67	3.00	3.3 b
Collard	174 c	104 b	139	4.00	3.60	3.8 ab
Sesame	145 c	478 a	312	4.50	4.00	4.2 a
Sorghum	375 a	439 a	407	4.17	4.00	4.1 a
Velvetbean	197 bc	124 b	160	4.00	3.67	3.8 ab
Zinnia	277 b	64 b	171	4.33	3.33	3.8 ab
Mean	228	218	225	4.11 A	3.60 B	3.8

[y]Egg masses rated on 0 to 5 scale, where 0 = no egg mass, 1 = 1 to 2, 2 = 3 to 10, 3 = 11 to 30, 4 = 31 to 100, and 5 = more that 100 egg masses per root system.
[z]Data are means of six replications. Means followed by the same letter in columns (small letters) or rows (capital letters) are not significantly different ($P \leq 0.05$), according to Tukey's test. Comparisons shown for significant main effects if interaction was not significant at $P \leq 0.05$.

Table 6. Effect of mulch type and *Meloidogyne arenaria* inoculum level (J2/pot) on plant parameters, Experiment 2 (Summer 1995).

	Root fresh weight (g)			Stem diameter (cm)			Top fresh weight (g)		
Mulch type	0 J2/pot	168 J2/pot[y]	Mean	0 J2/pot	168 J2/pot	Mean	0 J2/pot	168 J2/pot	Mean
Castor	7.20 ab[z]	11.72 b	9.46	5.55 bc	5.28 ab	5.40	25.3 ab	20.0 ab	22.7
Collard	7.83 a	13.45 a	10.64	5.79 ab	5.61 a	5.70	26.5 ab	23.2 a	24.8
Sesame	5.42 c	9.97 cd	7.69	5.32 c	5.05 bc	5.20	21.0 c	16.9 bc	19.0
Sorghum	5.75 bc	9.10 d	7.42	5.35 c	4.75 c	5.00	20.6 c	14.0 c	17.3
Velvetbean	7.02 abc	9.85 cd	8.43	6.02 a	5.30 ab	5.60	28.8 a	20.2 ab	24.5
Zinnia	6.37 abc	11.04 bc	8.70	5.69 abc	5.13 bc	5.40	24.2 b	19.2 b	21.7
Mean	6.60	10.85	8.72	5.62	5.19	5.30	24.4	18.9	21.6

[y]Number of juveniles (J2) hatched from the egg masses and used as inoculum.

[z]Data are means of six replications. Means followed by the same letter in columns are not significantly different ($P \leq 0.05$), according to Tukey's test.

Table 7. Effect of mulch type on numbers of *Meloidogyne arenaria* juveniles (J2) in soil and roots and on egg mass indices, Experiment 2 (Summer 1995).

Mulch type	J2/g root	J2/100 cm^3 soil	Egg mass index[y]
Castor	121 ab[z]	25 b	3.83 b
Collard	85 ab	75 ab	4.08 b
Sesame	172 a	133 ab	4.67 a
Sorghum	138 ab	174 a	4.75 a
Velvetbean	45 b	12 b	4.00 b
Zinnia	94 ab	82 ab	4.17 b

[y]Egg masses and galls rated on 0 to 5 scale, where 0 = no egg mass, 1 = 1 to 2, 2 = 3 to 10, 3 = 11 to 30, 4 = 30 to 100, and 5 = more that 100 egg masses per root system.
[z]Data are means of six replications. Means followed by the same letter in columns are not significantly different ($P \leq 0.05$), according to Tukey's test.

weight (Table 2). The highest values for stem diameter and top weight were obtained with no inoculum under castor, collard, velvetbean, or zinnia amendments (Table 6). Greater taproot lengths (data not shown) and root weights (Table 6) were obtained in the presence of *M. arenaria*, which caused swollen roots and galls.

Mulch type affected J2/g root, egg masses, and J2/100 cm^3 soil (Table 4). Generally, sesame and sorghum amendments resulted in the highest values for these variables and castor, collard, velvetbean, or zinnia the least (Table 7). When comparing the various amendments, those with the lowest C/N ratios generally resulted in the highest values for plant parameters and the lowest numbers of nematodes. These results were in accordance with those obtained from the first experiment.

The significant effect of fresh or dry organic amendment in the first experiment was probably due to the fact that the 4 g of fresh weight did not represent the corresponding amount of dry weight for all amendments. In the second experiment, where fresh and dry weights used had proportional values for each amendment, there were no significant differences between effects of fresh or dry organic amendment for most plant variables and for all nematode responses. Thus, it can be concluded that there is no significant difference in the ability of the organic amendment form (fresh vs. dry) to reduce J2 in the root system or in the soil. In general, for both experiments, castor and velvetbean suppressed the nematode population best, followed by zinnia and collard. Plant growth responses were better under castor, velvetbean, collard, or zinnia amendments, which had the lowest C/N ratios. Sesame or sorghum amendments, which had the highest C/N ratios, had much less effect on plant growth and on suppression of nematodes.

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