NON-TARGET EFFECTS OF SUNN HEMP AND MARIGOLD COVER CROPS ON THE SOIL INVERTEBRATE COMMUNITY

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ABSTRACT

McSorley, R., D. R. Seal, W. Klassen, K.-H. Wang, and C. R. R. Hooks. 2009. Non-target effects of sunn hemp and marigold cover crops on the soil invertebrate community. Nematropica 39:235-245.

Two field experiments were carried out in south Florida to determine the effects of summer cover cropping practices on soil nematode communities and other soil invertebrates. Treatments consisted of a summer cover crop of 'Tropic Sun' sunn hemp (*Crotalaria juncea*), a cover crop of 'Single Gold' marigold (*Tagetes patula*), or bare fallow. Following termination of cover crops in early fall, all of the plots were planted with a winter vegetable crop of yellow squash (*Cucurbita pepo*). Among the plant-parasitic nematodes, *Quinisulcius acutus* was suppressed by sunn hemp, but *Helicotylenchus dihystera* increased on marigold. Bacterivorous nematodes were stimulated following the sunn hemp cover crop but treatment differences did not persist through the subsequent vegetable crop. Population levels of soil mites showed a similar trend. Omnivorous and predatory nematodes were not affected consistently by cover crop treatments. Yield of yellow squash was greater following sunn hemp than marigold or fallow. Results suggest that sunn hemp is a versatile cover crop that can differentially lower numbers of some plant-parasitic nematodes and temporarily stimulate beneficial nematodes and soil mites.

Key words: Crotalaria juncea, Cucurbita pepo, Helicotylenchus, marigold, mites, nematode community, plant-parasitic nematodes, *Quinisulcius*, squash, sunn hemp, *Tagetes patula*.

RESUMEN

McSorley, R., D. R. Seal, W. Klassen, K.-H. Wang, and C. R. R. Hooks. 2009. Efectos secundarios de crotalaria y tagetes como cultivos de cobertura sobre las comunidades de invertebrados del suelo. Nematropica 39:235-245.

Se efectuaron dos experimentos de campo para determinar los efectos de dos cultivos de cobertura de verano sobre las comunidades de nematodos y otros invertebrados del suelo. Los tratamientos fueron cultivo de cobertura con *Crotalaria juncea* 'Tropic Sun', *Tagetes patula* 'Single Gold' y barbecho desnudo. Después de los tratamientos, se sembraron todos los lotes con cultivo de calabacín (*Cucurbita pepo*) en el otoño. En cuanto a los nematodos fitoparásitos se observó supresión de *Quinisulcius acutus* con crotalaria, y aumento de *Helicotylenchus dihystera* con tagetes. La crotalaria estimuló las poblaciones de nematodos bacterívoros, pero las diferencias entre tratamientos no persistieron hasta el siguiente cultivo. El efecto sobre las poblaciones de ácaros fue similar. El efecto de los tratamientos sobre los nematodos omnívoros y depredadores no fue consistente. La producción de calabacín fue más alta después de crotalaria que después de tagetes o de barbecho. Los resultados sugieren que la crotalaria es un cultivo de cobertura versátil que puede reducir las cantidades de algunos nematodos fitoparásitos y estimular temporalmente lo nematodos benéficos y los ácaros del suelo.

Palabras clave: ácaros, calabacín, comunidad de nematodos, *Crotalaria juncea, Cucurbita pepo, Helicotylenchus*, nematodos fitoparásitos, *Quinisulcius*, *Tagetes patula*.

INTRODUCTION

Cover crops have often been used in rotation systems for suppression of plant-parasitic nematodes (Duncan, 1991; Good, 1968; McSorley, 1999; 2001; Rodriguez-Kabana *et al.*, 1988; 1998; Trivedi and Barker, 1986). In tropical and subtropical production systems, root-knot nematodes (*Meloidogyne* spp.) and the reniform nematode (*Rotylenchulus reniformis* Linford & Oliveira) are often the nematodes targeted by crop rotation systems (McSorley, 2002; McSorley *et al.*, 1994; McSorley and Parrado, 1983; Rodriguez-Kabana *et al.*, 1988; 1998). Of the wide variety of nematode-suppressive crops available, marigolds (*Tagetes* spp.) are perhaps the most well-known, but interest in sunn hemp (*Crotalaria juncea* L.) and other *Crotalaria* species has increased in recent years (Wang et al., 2002a).

The benefits of marigolds against plant-parasitic nematodes, particularly *Meloidogyne* spp. and *Pratylenchus* spp., have been recognized for many years (Ferraz and de Freitas, 2004; Khan *et al.*, 1971; Steiner, 1941; Suatmadji, 1969; Tyler, 1938). Marigolds were effective against several species of *Meloidogyne* (McSorley *et al.*, 1994; Rickard and Dupree, 1978), although responses varied with different species and populations of *Meloidogyne* spp. (Ferraz and de Freitas, 2004). Suppression of root-knot nematodes depends on the species and cultivars of marigolds used (Ploeg, 2002; Ploeg and Maris, 1999). Cultivars of French marigold (*Tagetes patula* L.) generally provide good results against *Meloidogyne* spp. but many cultivars of African marigold (*T. erecta* L.) are useful as well (Ferraz and de Freitas, 2004).

Tagetes patula cultivars are also known to be suppressive to *R. reniformis* (Caswell *et al.*, 1991; Ko and Schmitt, 1993). However, *T. erecta* was shown to be a good host for *R. reniformis* (Wang *et al.*, 2001). In Martinique, *T. erecta* caused population decline of *M. incognita* but was a good host for *R. reniformis* (Queneherve *et al.*, 1998).

A number of different plant-parasitic nematodes are suppressed by sunn hemp, *C. juncea*, and other *Crotalaria* spp. (Wang *et al.*, 2002a). Sunn hemp showed relatively high levels of resistance to several species of root-knot nematodes (Araya and Caswell-Chen, 1994; McSorley, 1999; Wang *et al.*, 2002a). Sunn hemp cover crops were suppressive to *Meloidgyne* spp. in several field tests as well (Sipes and Arakaki, 1997; Wang *et al.*, 2002a; 2008; Wang *et al.*, 2007).

In addition to root-knot nematodes, sunn hemp cover crops may be used against *R. reniformis* because the plant is suppressive in several ways (Wang *et al.*, 2001). Sunn hemp is a poor host and releases allelopathic chemicals toxic to *R. reniformis*, and soil amended with sunn hemp showed increased levels of nematode-trapping fungi (Wang *et al.*, 2001). Due to these characteristics, *R. reniformis* was targeted and managed by sunn hemp (Caswell *et al.*, 1991; Wang *et al.*, 2002b).

Sunn hemp produces a large amount of biomass that may significantly impact soil organisms once the cover crop is terminated and incorporated into soil. In a recent study in which the rotation and amendment effects of a sunn hemp cover crop were separated experimentally, sunn hemp suppressed *Meloidogyne* spp. more when used as an amendment than as a rotation crop (Wang *et al.*, 2008). The amendment increased population levels of bacterivorous nematodes in soil but their numbers were not increased when sunn hemp was grown as a cover crop and residues were removed. Sunn hemp amendments increased bacterivores and other free-living nematodes, including omnivorous *Eudorylaimus* spp., in greenhouse experiments (K.-H. Wang *et al.*, 2003).

Burial of sunn hemp residues in litter bags in an agricultural field resulted in increased levels of bacterivorous nematodes followed by increases in *Eudorylaimus* spp., establishing a succession of beneficial non-target nematodes during decomposition of this amendment (Wang *et al.*, 2004). Similar successions of bacterivorous or fungivorous nematodes followed by omnivores or predators occur with other amendments as well (McSorley and Frederick, 1999).

Sunn hemp cover crops are well adapted to south Florida and have increased growth and yield of subsequent winter vegetable crops in rotation (Abdul-Baki *et al.*, 2005; Q. Wang *et al.*, 2003). Sunn hemp and marigold were suppressive to *M. incognita* in a greenhouse test conducted in that area. There is evidence that in some instances, sunn hemp increased omnivorous Dorylaimida relative to marigold (Wang *et al.*, 2007). The objective of the current study was to examine the effects of sunn hemp and marigold cover crops in rotation with vegetables in a field environment in south Florida, emphasizing their effects on nematodes not typically targeted by these cover crops.

MATERIALS AND METHODS

Experimental site and environmental conditions

The experiment was carried out on a site at the Tropical Research and Education Center in Homestead, FL (25.46°N, 80.45°W) during 2006-07 and repeated in 2007-08. The soil was Krome very gravelly loam, a Rockdale soil with pH ca. 7.5, bulk density of 1.42 g/cm^3, porosity of 0.45, 51% coarse material, 2.8% organic matter, and texture consisting of 36% sand, 40% silt, and 24% clay. The site was maintained as weed fallow prior to initiation of the experiment in July 2006. The climate for this area is subtropical, and detailed weather data are available for this site (Anonymous, 2009). During the summer cover crop season (July-Sept.) in 2006, air temperature averaged 26.5°C, with 27.0°C soil temperature, 81.0% relative humidity (RH), and 26.3 cm rainfall per month. Over the same time period in 2007, air temperature was 27.2°C, with 26.6°C soil temperature, 78.7% RH, and 16.3 cm rainfall per month. During the winter vegetable season (Nov.-Mar.) of 2006-07, air temperature averaged 20.7°C, with 20.4°C soil temperature, 77.4% RH, and 4.4 cm rainfall per month. Conditions in 2007-08 were similar, with 21.8°C air temperature, 19.8°C soil temperature, 74.4% RH, and 4.6 cm rainfall per month.

Experimental design and crop management

Experimental treatments were three different summer management methods: 'Tropic Sun' sunn hemp cover crop; 'Single Gold' marigold (*T. patula*) cover crop; and bare fallow. The three treatments were arranged in a randomized complete block design with four replications. Individual plots were 12 m × 13 m in size and separated by a buffer of 13 m × 8 m in all directions. Each plot could then accommodate 7 planting beds with row middles spaced 1.8 m apart.

Sunn hemp seed was treated with rhizobium and broadcast with a Tye drill (AGCO Corporation, Duluth, GA) at a rate of 56 kg/ha and a setting of 2.2 cm between plants on 26 July 2006. The holes in the seed box of the Tye drill were taped so that a 45-50 cm strip in the center of each future planting bed received no seeds. This strip was then free to be planted with a vegetable crop in the fall. Marigold seedlings were grown in 128-cell Speedling trays using a Fafard® Soil, Canadian Growing

Mix (Conrad Fafard, Inc., Agawam, MA) and transplanted to the field on 21 Aug., at a spacing of 20 cm between plants in all directions. Fallow plots were maintained free of weeds by mechanically plowing with a hand-held plow.

The sunn hemp cover crop was mowed on 25 Sept. 2006 and the residue remained on the soil surface as organic mulch. Marigold was left in place to die back naturally. Strips (61 cm wide, 1.2 m between) were tilled in each plot and planted directly with 'Dixie' squash (*Cucurbita pepo* L.) at a rate of one seed every 15 cm on 10 Nov. 2006. Squash was harvested two times in spring 2007, approximately two weeks apart, by picking and counting all marketable fruit from two rows per plot. Yield data are reported as number of fruit per row.

Methods for the 2007-08 season were similar to those for 2006-07 except that all crops were grown on raised beds. Each plot contained 7 raised beds with row middles spaced 1.8 m apart. Granular 6-6-6 (N-P_2O_5-K_2O) fertilizer was applied at a rate of 56 kg/ha over the full surface of the bed and incorporated with a rototiller. Sunn hemp seeds were planted on each side of a bed on 11 July 2007 and marigold seedlings were transplanted on each side of a bed one week later following methods described for the first season. Crops were irrigated using an overhead sprinkler system. The sunn hemp was mowed on 25 Sept. and its residue remained on the surface along the bed as organic mulch. Marigold was left intact to die back naturally and served as a dying mulch. In each cover crop, a 61-cm strip was strip-tilled between the 2 rows of cover crops on each bed. One row of 'Yellow Crookneck' squash was seeded on 7 Oct. at the center of each bed between the rows of the cover crop. Thus, each of the 7 beds per plot contained 3 rows of plants, including a central row of squash plants with a row of cover crop on either side. Harvest of squash was similar to that of the previous year except that only one row was harvested per plot, and the last harvest was earlier (late March) due to the earlier planting date in 2007-08.

Soil sampling and extraction

Soil samples for nematode analysis were collected from each plot on 19 July 2006, 19 Oct. 2006, 18 Apr. 2007, 27 Nov. 2007, and 29 Mar. 2008. Each sample consisted of soil collected with a hand trowel to a depth of 15 cm from 6 locations per plot. Soil samples were shipped overnight to the University of Florida, Department of Entomology and Nematology in Gainesville, FL, for extraction of nematodes. For each sample, the rock soil was first passed through a sieve with 1-cm^2 openings to remove large pieces of rock. Nematodes were extracted from a 100-cm^3 subsample of the sieved soil by a sieving and centrifugation method (Jenkins, 1964) and identified and counted under an inverted microscope. Although other methods are typically used for the recovery of microarthropods (McSorley and Walter, 1991), enchytraeid worms (O'Connor, 1955), and tardigrades (Nelson and Higgins, 1990), some of these invertebrates were also recovered by the nematode extraction methods used here, and were counted along with the nematodes.

Data analysis

Data were subjected to analysis of variance (ANOVA) using SAS software (SAS Institute, Cary, NC). When a significant ($P \leq 0.10$) treatment effect was obtained, means were separated using the Waller-Duncan k ratio ($k = 100$) t-test. Nematode count data were log-transformed by $\log_{10}(x + 1)$ prior to ANOVA, but untransformed arithmetic means are presented for all data.

RESULTS

Effects on plant-parasitic nematodes

Plant-parasitic nematode numbers were low at the beginning of the experiment (July 2006), with the spiral nematode *Helicotylenchus dihystera* (Cobb) Sher averaging 4.8/100 cm^3 soil, the stunt nematode *Quinisulcius acutus* (Allen) Siddiqi at 1.0/100 cm^3 soil, and *R. reniformis* at 0.7/100cm^3 soil. Initial numbers of free-living nematodes averaged 37.1 bacterivores, 31.6 fungivores, 1.6 omnivores, and 0.3 predators per 100 cm^3 soil.

The stunt nematode, *Q. acutus*, was suppressed by sunn hemp relative to marigold on all sampling dates (Table 1). This suppression following the cover crop extended through the squash crop as well. Although not affected by cover crop treatments in the first season, *H. dihystera* increased on the marigold cover crop in 2007 and remained high in the squash crop as well (Table 1). *Rotylenchulus reniformis* was not detected during the crop cycles in 2006-07 but increased in all plots in the second year, reaching relatively high numbers by the end of the squash crop. *Meloidogyne* spp. were detected in low numbers only on 18 April 2007 (0.2/100 cm^3 soil in sunn hemp plots, 1.8/100 cm^3 in fallow, zero in marigold). *Mesocriconema* spp. were found only on 27 Nov. 2007, averaging 8.2/100 cm^3 soil in marigold plots, 1.2/100 cm^3 in sunn hemp, and 1.0/100 cm^3 in fallow, but numbers were variable and did not differ (P > 0.10) among treatments.

Effects on free-living nematodes

Bacterivores were generally greatest following the sunn hemp cover crop, espe-

Table 1. Effect of summer cover crops on plant-parasitic nematodes during two seasons.

	Nematodes per 100 cm^3 soil			
Cover crop	19 Oct. 2006[y]	18 Apr. 2007	27 Nov. 2007	29 Mar. 2008
	Helicotylenchus dihystera			
Marigold	37.0[z]	29.8	167.5 a	158.0 a
Sunn hemp	28.8	19.2	78.2 b	58.2 b
Fallow	44.8	44.8	69.0 b	48.2 b
	Quinisulcius acutus			
Marigold	32.5 a	134.5 a	25.5 a	30.2 a
Sunn hemp	1.5 b	16.0 b	2.0 b	3.0 b
Fallow	34.5 a	197.5 a	17.5 ab	15.5 ab
	Rotylenchulus reniformis			
Marigold	0	0	46.0	246.5
Sunn hemp	0	0	21.8	188.2
Fallow	0	0	37.7	225.5

[y]Sampling dates correspond to end of cover crop (Oct., Nov.) and end of subsequent squash crop (Apr., Mar.).
[z]Data are arithmetic means of 4 replications. For each nematode, means in columns followed by the same letter do not differ ($P \leq 0.05$) according to the Waller-Duncan test performed on log_{10}-transformed data. No letters indicate no differences ($P \leq 0.10$) among cover crops.

cially in 2007-08, but differences did not persist through the squash crop (Table 2). Fungivores followed a similar pattern to the bacterivores in 2007-08 but not in 2006-07. Effects of cover crop treatments on omnivores + predators were inconsistent (Table 2). Although maximum levels occurred following the sunn hemp cover crop in 2006, this trend did not continue through the squash crop where maximum levels occurred following the marigold treatment. The omnivore *Eudorylaimus* spp. comprised 70.8% of the nematodes recovered in this group. Other omnivore genera found included *Enchodelus, Tobrilus, Tripyla,* and *Tylencholaimus.* Predators made up only 23.9% of the omnivore + predator total, with predominately *Ironus* spp. and some *Mononchus* spp.

Effects on mites and other soil invertebrates

In addition to nematodes, a variety of other soil invertebrates were recovered from the samples. Mites were most abundant following sunn hemp cover crops in both seasons but differences did not persist through the subsequent squash crops (Table 3). Enchytraeid worms showed a similar pattern in 2007-08 but not in 2006-07. A few tardigrades and Collembola were also recovered, but numbers were low ($\leq$1.2/100cm^3 soil) and unaffected by treatment (Table 3).

Effects on crop yield

Yield of yellow squash following sunn hemp was greater ($P \leq 0.05$) than yield following fallow on all harvest dates (Table 4).

Table 2. Effect of summer cover crops on free-living nematodes during two seasons.

	Nematodes per 100 cm^3 soil			
Cover crop	19 Oct. 2006[x]	18 Apr. 2007	27 Nov. 2007	29 Mar. 2008
		Bacterivores		
Marigold	18.8 b[y]	266.2	166.2 b	299.8
Sunn hemp	59.8 a	329.5	858.5 a	266.0
Fallow	43.8 ab	191.8	117.5 b	211.2
		Fungivores		
Marigold	20.2	106.2	169.2 b[z]	176.5
Sunn hemp	39.8	256.0	539.0 a	275.0
Fallow	102.0	113.5	212.5 b	181.0
		Omnivores + Predators		
Marigold	0.5 b[z]	11.0 a[z]	2.0	1.8
Sunn hemp	2.2 a	3.5 b	2.0	0.5
Fallow	0.5 b	1.8 b	1.8	0.8

[x]Sampling dates correspond to end of cover crop (Oct., Nov.) and end of subsequent squash crop (Apr., Mar.).
[y]Data are arithmetic means of 4 replications. For each nematode, means in columns followed by the same letter do not differ ($P \leq 0.05$) according to the Waller-Duncan test performed on $\log_{10}$-transformed data. No letters indicate no differences ($P \leq 0.10$) among cover crops.
[z]Differences significant at $P \leq 0.10$.

Table 3. Effect of summer cover crops on selected soil invertebrates during two seasons.

Cover crop	Numbers per 100 cm^3 soil			
	19 Oct. 2006[y]	18 Apr. 2007	27 Nov. 2007	29 Mar. 2008
		Collembola		
Marigold	0.5	0.8	0.5	0
Sunn hemp	1.2	1.0	1.0	0
Fallow	0	0.5	0	0
		Mites		
Marigold	7.0 b[z]	4.5	3.5 b	3.0
Sunn hemp	17.5 a	2.2	13.0 a	4.2
Fallow	6.5 b	3.5	1.0 b	2.0
		Enchytraeids		
Marigold	0	1.0	0 b	0
Sunn hemp	0	3.0	5.5 a	0
Fallow	0	1.8	1.5 ab	0
		Tardigrades		
Marigold	0	0.2	0.8	0
Sunn hemp	0	1.2	1.0	0
Fallow	0	0	0.2	0

[y]Sampling dates correspond to end of cover crop (Oct., Nov.) and end of subsequent squash crop (Apr., Mar.).
[z]Data are arithmetic means of 4 replications. For each organism, means in columns followed by the same letter do not differ ($P \leq 0.05$) according to the Waller-Duncan test performed on $\log_{10}$-transformed data. No letters indicate no differences ($P \leq 0.10$) among cover crops.

With the exception of the first harvest in 2007-08, yield following sunn hemp was also superior to yield following marigold.

DISCUSSION

Among the treatments evaluated, population levels of *Q. acutus* were lowest following the sunn hemp cover crop, with the effects extending through the subsequent squash crop as well. This nematode can be added to the growing list of plant parasites suppressed by sunn hemp (Wang *et al.*, 2002a). It is interesting and somewhat unexpected that *R. reniformis* was not affected because suppression of this nematode by sunn hemp is well documented (Caswell *et al.*, 1991; Wang *et al.*, 2001; 2002a,b). However, *R. reniformis* was rare until the second year of this study, when it built up quickly on squash, which is an excellent host (McSorley and Waddill, 1982). Marigold was not suppressive to the plant-parasitic nematodes present in the current study. Instead, *H. dihystera* increased on marigold in the second year, as previously observed by Wang *et al.* (2007) with *T. patula.*

Although squash yields were greater following sunn hemp than after marigold or fallow, it is not clear that the yield increases resulted from nematode management.

Table 4. Effect of summer cover crop treatments on yield of yellow squash (number of marketable fruit per row) in 2006-07 and 2007-08 seasons.

	Number of fruit per row	
Cover crop	1st Harvest[y]	2nd Harvest
	2006-07	
Marigold	27.62 b[z]	22.50 b
Sunn hemp	42.50 a	30.88 a
Fallow	32.75 b	20.25 b
	2007-08	
Marigold	32.50 b	23.00 b
Sunn hemp	36.50 a	30.50 a
Fallow	25.50 b	17.00 c

[z]Data are arithmetic means of 4 replications. For each season, means in columns followed by the same letter do not differ ($P \leq 0.05$) according to the Waller-Duncan test.

Additional nitrogen released from residues of leguminous cover crops may provide benefits over a long period of time during crop growth (Powers and McSorley, 2000). In a recent study (Abdul-Baki *et al.*, 2005), nematode numbers were low and were not affected by sunn hemp, by several other cover crop treatments, or by soil fumigation. However, the yield of tomato (*Lycopersicon esculentum* Mill.) was greatest following sunn hemp, compared to several other cover crops evaluated. Yield of tomato following sunn hemp was also greater than yield following fumigation in one test and was equivalent to fumigation in another test. Therefore sunn hemp may stimulate crop yield on its own, possibly because of nitrogen released from decomposing residues that remain on or in the soil.

The sunn hemp cover crop stimulated free-living bacterivores in both seasons and fungivores in the second season. For these nematodes, it is likely that the amendment effects from the sunn hemp residues are more important than any rotation effects from the growing cover crop (Wang *et al.*, 2008). Nematode sampling in the fall of each year took place after the cover crop was mowed and left as a surface mulch. During this time, evidently enough organic material and/or associated bacteria and fungi had entered the upper soil layers to stimulate these nematode groups. However, the effects were short-lived and did not persist through the squash crop. The level of stimulation of bacterivores observed here was similar to other studies in which sunn hemp residues were left on the surface in a reduced-tillage system (Wang *et al.*, 2008). Stronger and more persistent responses were obtained only in the close vicinity of concentrations of sunn hemp residues buried in litter bags (Wang *et al.*, 2004). In the current study, bacterivores and fungivores were not stimulated by the marigold cover crop. Likewise in Hawaii, sunn hemp enhanced bacterivores more than *T. erecta* (Wang *et al.*, 2001).

Residues of cover crops such as sunn hemp are known to indirectly affect population levels of omnivorous and predatory nematodes that may feed on other nematodes in the soil ecosystem (Wang *et al.*, 2004). In the current study, effects of cover crops on omnivorous and predatory nematodes were inconsistent and short-lived. In contrast, sunn hemp residues buried in litter bags greatly stimulated population levels of omnivores, especially *Eudorylaimus* spp. and *Mesodorylaimus* spp. (Wang *et al.*, 2004). However, there were two key differences between that study and the current work. First, omnivore and predator numbers in the current study were relatively low and inconsistent. Second, sunn hemp residues on the surface could be expected to provide nutrients and organic matter to soil through a gradual process rather than as a large pulse of organic matter in a buried litter bag. Therefore, the impact of added organic matter is not as concentrated in the current study. A large pulse of sunn hemp residue supplied in a litter bag greatly stimulated bacterivore and fungivore populations which was followed by great increases in omnivore populations (Wang *et al.*, 2004).

Mites were among the other invertebrates that were extracted from the nematode samples and their numbers were highest in plots with sunn hemp. Since they were not identified to family, the mites recovered may have consisted of both predators and fungivores, either of which may be stimulated by increased organic matter (Coleman and Crossley, 1996; Hyvonen and Persson, 1996; Walter and Ikonen, 1989). Effects of sunn hemp on mite numbers did not persist into the following squash crop. This probably occurred because residual organic matter typically breaks down quickly in warm subtropical soils (Powers and McSorley, 2000), such as those found in south Florida. The stimulation of enchytraeid worms by sunn hemp is likely a result of the organic matter addition, which was shown to stimulate these fungivores in another study in Florida (Wang *et al.*, 2004).

Overall, some stimulation of various components of the soil food web (such as bacterivores, fungivores, and mites) by sunn hemp was evident but was short-lived and did not persist through the next crop. Sunn hemp reduced numbers of *Q. acutus*, probably because sunn hemp is a non-host, although allelopathic effects cannot be ruled out since sunn hemp suppresses nematodes via both mechanisms (Wang *et al.*, 2001) and numbers of *Q. acutus* were lower following sunn hemp than fallow on several sampling dates. Indirect suppression of *Q. acutus* populations through stimulation of the predators evaluated is unlikely because consistent effects on these omnivores and predators were not noted. Results of this study suggest that sunn hemp is a versatile resource that can simultaneously lower numbers of some plant-parasitic nematodes and increase beneficial bacterivorous and fungivorous nematodes and other invertebrates in soil food webs.

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