Effects of Winter and Fall Cover Crops on Plant-Parasitic Nematode Population Development

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ABSTRACT

Combinations of winter and fall cover crops were evaluated for the management of plant-parasitic nematodes. The winter cover crops examined were rye (*Secale cereale*) and narrow-leafed lupin (*Lupinus angustifolius*) and the fall cover crops were soybean (*Glycine max*), cowpea (*Vigna unguiculata*), sorghum-sudangrass (*Sorghum* bicolor x *S. sudanense*), sun hemp (*Crotalaria juncea*), and corn (*Zea mays*). A summer crop of corn was planted in between the winter and fall cover crops. Nematode population densities were determined before and after each cropping season. Both rye and narrow-leafed lupin suppressed the population development of *Meloidogyne incognita* and *Pratylenchus* spp. during the winter crop season. However, this effect was eliminated after one cropping cycle of the summer crop, corn. During the fall cropping season, plant-parasitic nematode populations increased in general, however, plots previously in winter narrow-leafed lupin had higher population densities of *M. incognita* than plots that had winter rye ($P = 0.05$). All the fall cover crops tested had lower *M. incognita* levels than corn ($P = 0.05$). Sorghum-sudangrass and corn supported the highest population densities of *Paratrichodorus minor* and *Mesocriconemella* spp. Sun hemp suppressed all the plant-parasitic nematodes present including *Helicotylenchus dishystera* and *Pratylenchus* spp. as compared to corn ($P = 0.05$). Therefore, rye was more effective in the winter, whereas sun hemp, 'Iron Clay' cowpea, and 'Hinson Long Juvenile' soybean have good potential as fall cover crops for nematode management.

KEYWORDS

Conventional tillage, legumes. Grasses, narrow-leafed lupin, *Lupinus angustifolius* L, tropical sunhemp, *Crotalaria juncea* L

INTRODUCTION

Conservation-tillage has shown many benefits in crop management including reduced soil erosion, moderate soil temperature, conservation of soil moisture (Gallaher, 1977) and machinery energy, and some crops such as rye (*Secale cereale* L.) can even suppress weeds (Shilling et al., 1995). However, no-till practices have failed to suppress most plant-parasitic nematodes compared to cover crop rotation (McSorley and Gallaher, 1993; Cabanillas *et al*., 1999) except for *Pratylenchus* spp., which are usually higher in conventional-tillage plots than in no-tillage plots (McSorley and Gallaher, 1994). In fact, population densities of some nematodes increased in no-till compared to conventional-till plots (Fortnum and Karlen, 1985). Limitations of a one cover crop rotation cycle are the resurgence of nematode populations at the end of the subsequent cash crop cycle, making the subsequent crops prone to nematode damage (McSorley, 1999) or accumulation of plant-parasitic nematode population densities over time (McSorley *et al*., 1994). Although leaving the soil fallow could overcome the nematode problem, volunteer weeds during the fallow period might maintain or even increase some plant-parasitic nematodes. Strategies to improve cover-cropping systems for crop management are under investigation. This research proposed to incorporate winter and fall cover crops in a triple-cropping system to improve nematode management by cover crops.

Rye as a winter crop maintained population densities of *Meloidogyne arenaria* (Neal) Chitwood (McSorley, 1994). In the southeastern U.S., low temperatures in the winter may limit the nematode reproduction, thus using rye, as a winter crop would be beneficial. Although planting legumes in the winter can improve soil nitrogen, most winter legume cover crops such as crimson clover (*Trifolium incarnatum* L.), white clover (*T. repens* L.), or alyceclover (*Alysicarpus* vaginalis (L.) D.C.) are highly susceptible to *Meloidogyne* spp. and other plant-parasitic nematodes (McSorley and Gallaher, 1991; Quesenberry *et al*., 1986; Taylor *et al*., 1986). A potential winter legume that is less

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susceptible to plant-parasitic nematodes is narrow-leafed lupin (*Lupinus angustifolius* L.) (McSorley and Gallaher, 1994; Ferris *et al*., 1993).

In the fall, a number of cover crops are adapted to growing conditions in Florida and the Southeast. For example, some sorghum (*Sorghum bicolor* (L.) Moench) cultivars were effective in reducing population densities of *M. incognita* (Kofoid & White) Chitwood (McSorley and Gallaher, 1991) but were not effective against *Paratrichodorus minor* (Colbran) Siddiqi and *Belonolaimus longicaudatus* Rau (Crow *et al*., 2001; McSorley *et al*., 1994; McSorley, 1996). A summer legume cover crop such as 'Iron Clay' cowpea (*Vigna unguiculata* (L.) Walp.) suppressed *M. incognita* as compared to weed treatment at the beginning of the first cash crop, tomato (*Lycopersicon esculantum* Mill.), but this effect did not persist into a spring vegetable crop (McSorley *et al*., 1999). Sun hemp (*Crotalaria juncea* L.) is another legume cover crop that recently gained recognition for nematode management (Wang *et al*., 2002).

Our objective is to examine the nematode population development in a triple-cropping system involving winter crops, a summer crop of corn (*Zea mays* L.) as a cash crop, followed by fall cover crops. Our goal is to improve the nematode suppressive effect of cover crops in a conservation-tillage system.

MATERIALS AND METHODS

A triple-crop system under a combination of conventional and conservation-tillage practice was set up at the University of Florida Plant Science Research Center, Marion County, FL. A field experiment was conducted in a 2.75 acres site previously planted to pasture. The soil is Arredondo fine sand, consisted of 91.3% sand, 3.5% silt, and 5.2 % clay, with an organic matter content of 1.3%, and a pH of 5.8. A mixture of *Helicotylenchus* spp., *Meloidogyne incognita*, *Mesocriconemella* spp., *Paratrichodorus minor*, and *Pratylenchus* spp. were present at this site.

The summer cash crop, corn, was in rotation with winter and fall cover crops. Two winter cover crops tested were 'Wrens 96' rye (*Secale cereale* L.) planted into a conventional tillage seedbed at 60 lbs acre^{-1}, and 'Tift Blue' narrow-leafed lupin planted at 30 lbs acre^{-1}. The winter cover crops were planted in late November 2000. Individual plots were 2800 ft^2. The experimental design was a randomized complete block with 6 replications. March 21, 2001, the above ground biomass of winter crops was harvested, leaving roots and a stubble height of about 2 inches. The field was prepared for the summer corn crop by which the weeds and crop residues were killed with 0.82 lbs glyphosate a.i. acre^{-1}. 'Florida IRR' experimental corn was no-till planted in rows 10 inches apart (50,000 seeds acre^{-1}). Corn was harvested on June 28, 2001, and the field was prepared for fall crops in which the weeds were sprayed with glyphosate (0.82 lbs a.i. acre^{-1}) then no-tilled with a Tye drill seed planter. Five fall cover crops—soybean (*Glycine max* (L.) Merr. 'Hinson Long Juvenile', 420,000 seeds acre^{-1}), cowpea ('Iron Clay', 420,000 seeds acre^{-1}), sorghum-sudangrass (*Sorghum bicolor* x *S. sudanense* (Piper) Stapf 'Cow Chow', 420,000 seeds acre^{-1}), sun hemp ('Tropic Sun', 260,000 seeds acre^{-1}), and corn ('Florida IRR', 50,000 seeds acre^{-1}) were planted as subplots in each of the winter crop treated plot. Each subplot was 560 ft^2 in size. Thus the experiment became a 2x5 (winter crop x fall crop) split-plot experiment. The biomass of these fall cover crops was then harvested on 3 October 2001.

Rye and narrow-leafed lupin were fertilized with 122 lbs N, 28.5 lbs P_2O_5, 89 lbs K_2O, 7 lbs Mg, 14 lbs S per acre at planting. Prior to corn planting, field plots were sprayed with pre-emergence herbicide, atrazine, at 2.2 lbs a.i. acre^{-1}, and carbofuran was applied at 0.44 lbs a.i. acre^{-1} to control lesser cornstalk borer (*Elasmopalpus lignosellus* Zeller). Summer corn and the subsequent fall crops received a total of 211 lbs N, 52 lbs P_2O_5, 193 lbs K_2O, 12 lbs Mg, 25 lbs S per acre applied at 3 intervals for each crop. Foliar insecticide, methomyl, was applied several times during summer corn and cover crops seasons at 0.26 lbs a.i. acre^{-1} and the field was irrigated with overhead irrigation as needed.

Soil was sampled from each plot at the beginning and end of each crop to estimate initial and final population densities of nematodes. Six soil cores of 1" diam. to 8" depth from each plot were composited to form a sample. Nematodes were extracted from a subsample of 0.2 pt. by the centrifugal-floatation method (Jenkins, 1964). At harvest of each crop, above ground plant biomass was removed, dried, and expressed as dry matter yield per acre.

Nematode counts were log-transformed ($\log_{10}$ [x+1]) before the analysis of variance (ANOVA) using Statistical Analysis System (SAS Institute, Cary, NC), but untransformed means are presented in tables. Data collected after winter crop and summer corn were subjected to one-way ANOVA whereas data collected after fall crop were subjected to split-plot (2 x 5) ANOVA where the winter cover crop treatment was the main plot, and the fall cover crop treatment was the subplot. Means were separated by Waller-Duncan *k*-ratio (*k*=50) where appropriate.

RESULTS AND DISCUSSION

The initial population densities of plant-parasitic nematodes in this site were very low. Both rye and narrow-leafed lupin maintained the low population densities of root-knot (*Meloidogyne incognita*), and lesion (*Pratylenchus* spp.)

Table 1. Effects of winter cover crops on plant-parasitic nematode population densities (0.2 pt soil) in a triple crop system. Data are means of 6 replications

Winter crop	Nematodes per 0.2 pt soil				
	Meloidogyne incognita	*Helicotylenchus dihystera*	*Paratrichodorus minor*	*Mesocricone-mella* spp.	*Pratylenchus* spp.
		---------------------- March, 2001 ----------------------			
Rye	0[z]	2	6	16	0
Lupin	0	13 *	2 *	13	0
		---------------------- July, 2001 ----------------------			
Rye	24	71	36	58	1
Lupin	22	50	41	97	1
		---------------------- October, 2001 ----------------------			
Rye	18	36	15	36	3
Lupin	48 *	33	22	36	2

* indicated that values for rye and lupin on that date are significantly different at $P = 0.05$ according to the analysis of variance.

nematodes at undetectable levels 4 months after the winter crop planting (Table 1). However, narrow-leafed lupin had higher numbeof spiral nematodes (*Helicotylenchus dihystera* [Cobb] Sher) than the rye, whereas rye had higher number of stubby-root nematodes (*Paratrichodorus minor*) than narrow-leafed lupin($P = 0.05$). At 4 months after summer corn planting (July, 2001), these phenomena were eliminated. During the fall cropping season, plant-parasitic nematode populations increased in general. Plots planted to narrow-leafed lupin during the previous winter had higher population densities of *M. incognita* than plots with rye ($P = 0.05$) regardless of the fall crop treatments (Table 1). This is due to the fact that plant-parasitic nematode reproductive rates increased in the summer. Some of the fall crops were hosts of the plant-parasitic nematodes present in the field. Rye might have a better suppressive effect on *M. incognita* and *P. minor* than the narrow-leafed lupin during the winter, but this effect was not observed until the nematode population was magnified over the summer on the corn crop.

During the fall, the cultivars of sorghum-sudangrass, sun hemp, soybean, and cowpea tested suppressed *M. incognita* as compared to corn ($P = 0.05$, Table 2). These results were consistent with previous research (McSorley and Gallaher, 1991; McSorley, 1999; Wang *et al*., 2002). The result from soybean, the ‘ Hinson Long Juvenile’ is a poor host to *M. incognita* and *P. minor* is a new information and should be explored due to its cash crop value. Although soybean ‘Hinson Long Juvenile’ is very susceptible to *H. dihystera*, this nematode is not very damaging to most crops, including corn and soybean. Sun hemp was the most effective cover crop tested here, resulting in statistically lowest

Table 2. Effects of fall cover crops on plant-parasitic nematode population densities (0.2 pt soil). Data are means of 6 replications.

Fall crop	Nematodes per 0.2 pt soil				
	Meloidogyne incognita	*Helicotylenchus dihystera*	*Paratricho-dorus minor*	*Mesocricone-mella* spp.	*Pratylenchus* spp.
Soybean	13 b[†]	95 a	9 b	11 b	2 bc
Cowpea	3 b	13 bc	7 b	8 b	4 a
Sorghum-sudangrass	20 b	26 bc	32 a	93 a	2 bc
Sunn hemp	6 b	10 c	3 b	18 b	0 c
Corn	124 a	30 ab	42 a	50 a	6 ab

[†]Values followed by the same letters are not different according to Waller-Duncan *k*-ratio (k=100) *t*-test.

populations of all plant-parasitic nematodes in this field including *H. dihystera* and *Pratylenchus* spp. This is contradictory to the results from Kenya where another species of *Crotalaria* was found to be a good host for these two nematode genera (Desaeger and Rao, 2000). This could be because of a difference in the nematode susceptibility among *Crotalaria* species. Although sorghum-sudangrass suppressed *M. incognita* effectively, it is a good host to *P. minor* and *Mesocriconemella* spp. (Table 2) similar to previous reports (McSorley, *et al*., 1994; McSorley and Dickson, 1995). Continuous planting of corn resulted in the highest population densities of all the plant-parasitic nematodes in this field (Table 2), indicating that double cropping of corn will create future nematode problems that might not be manageable by winter cover crop alone.

CONCLUSION

A triple cropping system offered more opportunity for nematode management than the more common double-cropping systems practiced in the subtropical climate of Florida. Planting rye in the winter maintained low plant-parasitic nematode population densities. Sun hemp, 'Iron Clay' cowpea and 'Hinson Long Juvenile' soybean have good potential as fall cover crops for nematode management in addition to their nitrogen improvement properties.

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