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Effect of Sorghum-Sudangrass and Velvetbean Cover Crops on Plant-Parasitic Nematodes Associated with Potato Production in Florida[1]

W. T. Crow,[2] D. P. Weingartner,[3] D. W. Dickson,[2] and R. McSorley[2]

Abstract: In a 3-year field study, population densities of *Belonolaimus longicaudatus* and other plant-parasitic nematodes and crop yields were compared between potato (*Solanum tuberosum*) cropping systems where either sorghum-sudangrass (*Sorghum bicolor* × *S. arundinaceum*) or velvetbean (*Mucuna pruriens*) was grown as a summer cover crop. Population densities of *B. longicaudatus, Paratrichodorus minor, Tylenchorhynchus* sp., and *Mesocriconema* sp. increased on sorghum-sudangrass. Population densities of *P. minor* and *Mesocriconema* sp. increased on velvetbean. Sorghum-sudangrass increased population densities of *B. longicaudatus* and *Mesocriconema* sp. on a subsequent potato crop compared to velvetbean. Potato yields following velvetbean were not greater than following sorghum-sudangrass despite reductions in population densities of *B. longicaudatus*.

Key words: Belonolaimus longicaudatus, cover crop, cropping sequence, *Dolichodorus heterocephalus, Hemicycliophora* sp., management, *Meloidogyne incognita, Mesocriconema* sp., modeling, *Mucuna pruriens,* nematode, *Paratrichodorus minor,* population dynamics, potato, root-knot nematode, *Solanum tuberosum, Sorghum bicolor* × *S. arundinaceum,* sorghum-sudangrass, sting nematode, stubby root nematode, *Tylenchorhynchus* sp., velvetbean.

Potato (*Solanum tuberosum* L.) is grown during the winter-spring months in northeast Florida and is usually followed by a cover crop during the summer months. The cover crop most commonly grown in this area during the past 20 years has been a sorghum-sudangrass hybrid (*Sorghum bicolor* (L.) Moench × *S. arundinaceum* (Desv.) Stapf var. *sudanense* (Stapf) Hitchc.) (Weingartner et al., 1993). The cover crop, valued primarily for its biomass, is incorporated with the soil after maturity. Cover crop residues help maintain the integrity of the potato rows by providing protection from soil erosion until the potato canopy covers the rows (Myhre, 1957). In addition, cover crops restrict weed growth during the summer that may increase weed management problems in the subsequent potato crop, or that may serve as alternate hosts for soilborne pathogens such as *Ralstonia solanacearum* (syn. *Pseudomonas solanacearum*) and *Meloidogyne incognita* (Weingartner, unpubl. data).

Sudangrass as a green manure crop has been shown to suppress *Verticillium dahliae* (Davis et al., 1996) and *M. chitwoodi* (Mojtahedi et al., 1993) on potato, but neither of these pathogens is common in Florida potato production. Sorghum-sudangrass as a cover crop suppresses *M. incognita,* a plant-parasitic nematode that can negatively affect potato in Florida, but may increase population densities of other important plant-parasitic nematodes such as *Belonolaimus longicaudatus* and *Paratrichodorus minor* (Rhoades, 1983; Weingartner et al., 1993). *Belonolaimus longicaudatus* is the major nematode associated with yield reductions of potato in northeast Florida, whereas *P. minor* is important in the region primarily as a vector for tobacco rattle virus on potato (Crow et al., 2000; Weingartner et al., 1993). Many other species of plant-parasitic nematodes have been associated with potato in northeast Florida (Nguyen and Smart, 1975), but their pathogenicity on potato has not been determined.

Nearly all of the commercial potato fields in northeast Florida are treated each year with chemical nematicides, primarily to manage *B. longicaudatus* and *P. minor* (Weingartner and Shumaker, 1983, 1990). Because nematicide applications are a major expense, an alternative cover crop that generates equivalent biomass and weed suppression, and yet is a non-host for important plant-parasitic nematodes, would benefit potato growers.

Velvetbean (*Mucuna pruriens* (Wallich ex Wight) Baker ex Burck, syn. *M. deeringiana*) is a nitrogen-fixing tropical legume. From 1890 to 1930 it was commonly grown in Florida as a cover crop to add nitrogen to soil, and for animal feed (Clute, 1896; Miller, 1902). However, common use of velvetbean in Florida stopped before the 1930s (Newell, 1930). Recently, this crop has received renewed interest in the southeastern United States for suppression of plant-parasitic nematodes and other soilborne pathogens (McSorley et al., 1994a,b; Reddy et al., 1986; Rodríguez-Kábana et al., 1992; Weaver et al., 1993).

The objective of this research was to study the effects of sorghum-sudangrass and velvetbean cover crops on population densities of plant-parasitic nematodes and potato yields in the northeast Florida potato production system.

Materials and Methods

A 3-year field experiment was conducted at the University of Florida Agricultural Research and Education Center, Yelvington Farm near Hastings, Florida. This site was naturally infested with *B. longicaudatus, P. minor, M. incognita* race 1, *Pratylenchus brachyurus, P. zeae, Tylenchorhynchus* sp., *Dolichodorus heterocephalus, Mesocriconema* sp., and *Hemicycliophora* sp. Soil at the research site is an Ellzey fine sand (sandy, silicaceous, hyperther-

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[1] Florida Agricultural Experiment Station Journal Series no. R-07012. A portion of the PhD dissertation by the first author.
[2] Assistant Professor and Professors, Entomology and Nematology Department, P.O. Box 110620, University of Florida, Gainesville, FL 32611.
[3] Center Director, University of Florida Agricultural Research and Education Center, Hastings, FL 32145.
E-mail: wtcr@ufl.edu
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mic Arenic Ochraqualf) consisting of 95% sand, 2% silt, 3% clay; < 1% organic matter; pH 6.5 to 7.0. Bed construction and irrigation were consistent with those reported for potato grown in the area (Campbell et al., 1978; Rogers et al., 1975).

The experimental design was a split-plot, with whole-plots being cropping treatments and the subplots being nematicide treatments. Cropping treatments were 'Atlantic' potato grown in the spring followed by summer cover crops of either 'DeKalb SX17' sorghum-sudangrass or an unspecified cultivar of velvetbean. Planting and harvest dates for potato and cover crops are listed in Table 1. Clean fallow was maintained during the time interval between the cover crops and potato crops.

Nematicide treatments applied to potato were aldicarb or 1,3-dichloropropene (1,3-D). Untreated plots served as controls. Aldicarb (15G) was banded directly over potato seed pieces at time of potato planting in a 25-cm-wide band at the rate of 3.4 kg a.i./ha (34 g/100 m of row) and incorporated lightly as the beds were closed. 1,3-Dichloropropene was injected at 56 liters/ha (570 ml/100 m of row) with a single chisel per row 25 to 30 cm deep into soil 3 weeks before planting potato.

Plot dimensions were 9 m long and four rows wide with a row spacing of 102 cm. Three meters of clean fallow were maintained between plots in the same rows. Two clean fallow rows were maintained between adjacent plots. Yield and nematode data were collected from the two inner rows of each plot, and the two outer rows were border rows.

Potato crops were fertilized at planting with 1,120 kg/ha of 14-2-12 (N-P_2O_5-K_2O). Nutrient rates were 157 kg/ha N, 10 kg/ha P, 112 kg/ha K, 23 kg/ha Mg, 45 kg/ha S, and trace amounts of other micronutrients. Cover crops were fertilized at planting with the same mixture and rate as used for potato. The sorghum-sudangrass was side-dressed with an additional 56 kg/ha N 1 month after planting.

Nematode samples were collected at planting (Pi) and at harvest (Pf). Because cover crops were planted immediately following potato harvest, the potato Pf samples also served as the cover crop Pi samples. The soil also was sampled in January of each year before applying 1,3-D. Each sample was a composite of 12 cores 2.5-cm diam. × 20 cm deep. Nematodes were extracted from a 130-cm^3 subsample using the centrifugal-flotation method (Jenkins, 1964) modified by doubling the sugar concentration. Following extraction, all plant-parasitic nematodes were counted with the aid of an inverted light microscope at a magnification of ×32. Potato tubers were harvested with a single-row mechanical harvester and mechanically sized into grade categories: "A" (>4.76-cm diam.) and "B" (3.81 ≤ 4.76-cm diam.). Tuber weight per plot was recorded for each grade category.

To determine host status, Pi and Pf for nematode population densities in soil were transformed with ln (x + 1) before analysis and the ratio of Pf/Pi was determined. A crop was considered a host if Pf/Pi >1.00. A single data set composed of the nematode count data for all 3 years was used to determine host status. Only plots with a Pi density ≥1 nematode/130 cm^3 of soil were included in analysis for host status.

Nematode and yield data were subjected to analysis of variance using the general linear model procedure for split-plot design (Ott, 1993). The block × whole-plot interaction was used as the error term for the whole-plots (cropping treatments). Means were compared by Duncan's multiple-range test (Ott, 1993). The contrast procedure (Ott, 1993) was used to compare potato yields between the two cover crop treatments receiving the same nematicide treatment. Analyses were performed using the SAS software program (SAS Institute, Cary, NC).

Table 1. Planting and harvest dates for the crops grown in a cover crop field study performed at the Yelvington Farm near Hastings, Florida, during 1996 to 1998.

Year	Potato		Cover crop	
	Planting	Harvest	Planting	Harvest
1996	3 March	10 June	13 June	22 October
1997	10 February	14 May	22 May	7 October
1998	27 February	8 June	30 June	26 October

Results

Nematodes: Sorghum-sudangrass supported population increases for *B. longicaudatus, P. minor, Tylenchorhynchus* sp., and *Mesocriconema* sp. (Table 2). The average Pf density following sorghum-sudangrass was 168 nematodes/130 cm^3 of soil (SD = 96) for *B. longicaudatus* and 38 nematodes/130 cm^3 of soil (SD = 27) for *P. minor.* Velvetbean was a non-host for *B. longicaudatus* but was a host for *P. minor* and *Mesocriconema* sp. (Table 2). The average Pf following velvetbean was 7 nematodes/130 cm^3 of soil (SD = 8) and 34 nematodes/130

Table 2. Host status of sorghum-sudangrass and velvetbean for selected plant-parasitic nematodes present in a potato field site.

Nematode	Cover crop	
	Sorghum-sudangrass	Velvetbean
Belonolaimus longicaudatus	1.8	0.7*
Paratrichodorus minor	2.0	1.9
Meloidogyne incognita	0.7	1.0
Tylenchorhynchus sp.	1.5	0.9*
Mesocriconema sp.	1.9	1.3*

Numbers represent the mean of the ln (Pf + 1)/ln (Pi + 1) of each nematode from 1996 to 1998. Numbers >1 indicate a host. Numbers <1 indicate non-host. A value near 1 indicates that the population was maintained on the crop.

Asterisks indicate differences in population means between columns according to the contrast procedure ($P < 0.05$).

cm^3 of soil (SD = 33) for *B. longicaudatus* and *P. minor*, respectively. Following the initial cover crop season, population densities of *B. longicaudatus* remained lower ($P < 0.05$) in velvetbean plots than in sorghum-sudangrass plots throughout the study (Fig. 1).

Soil samples collected at the beginning of the potato season in January were used to evaluate the effects of cover crop treatments on nematodes in the following potato crop (Table 3). Population densities of *B. longicaudatus* were greater following a cover crop of sorghum-sudangrass than following velvetbean each year. Population densities of *Mesocriconema* sp. were greater following sorghum-sudangrass 2 of 3 years. Population densities of *P. minor* and *Tylenchorhynchus* sp. were greater following sorghum sudangrass in 1 of 3 years. Densities of *M. incognita* juveniles were greater following a cover crop of velvetbean in 1997. The cover crop grown the preceding summer had a greater effect on *B. longicaudatus* density in January than did nematicide application to the preceding potato crop. Differences ($P < 0.05$) among nematicide treatments within the same cover cropping treatment generally did not occur and are not reported.

Pratylenchus brachyurus and *P. zeae* occurred in mixed populations at the field site but were not separated in the data. Because these two nematodes may react differently to the cropping treatments, data on *Pratylenchus* spp. were unreliable and not reported.

Potato Yield: No differences ($P < 0.05$) in total potato yield were observed between the two cover crop treatments (Table 4). Tuber size differences were observed only in 1998, when plots with cover crops of sorghum-sudangrass yielded a greater weight of size B tubers and less weight of size A tubers than did plots with velvetbean cover crops. Means of potato yield between the two cover crop treatments receiving the same nematicide treatment were not different ($P < 0.05$) for any nematicide in either year.

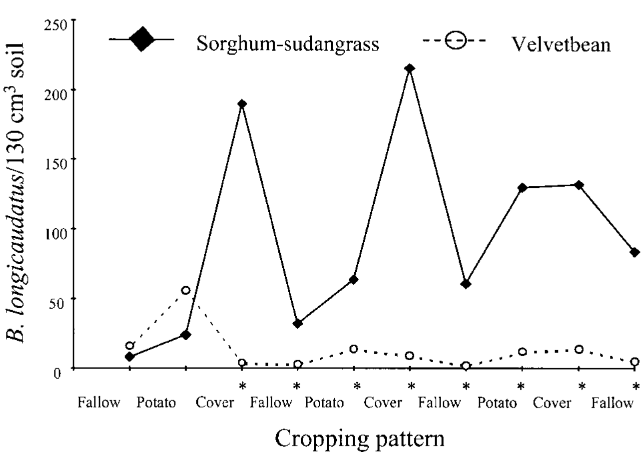

FIG. 1. Effects of cover crops on population changes of *Belonolaimus longicaudatus* in potato production over 3 years without nematicide application. Data points are means of five replications. Asterisks indicate significant differences ($P < 0.05$) between the treatments at each sampling date.

TABLE 3. Nematode population densities/130 cm^3 of soil in January, following summer cover crops.

Nematode	1997		1998		1999	
	S[a]	V	S	V	S	V
Belonolaimus longicaudatus	30	2*	61	1*	77	5*
Paratrichodorus minor	7	6	13	11	30	9*
Meloidogyne incognita	2	40*	25	31	70	39
Tylenchorhynchus sp.	15	11	3	6	15	4*
Mesocriconema sp.	52	11*	34	35	85	16*
Dolichodorus heterocephalus	1	0	2	1	5	0
Hemicycliophora sp.	3	0	1	1	0	0

Asterisks indicate differences in treatment means between columns within the same year according to the contrast procedure ($P < 0.05$).
[a] S = Sorghum-sudangrass; V = Velvetbean.

DISCUSSION

Belonolaimus longicaudatus is the plant-parasitic nematode most strongly associated with yield reductions of potato in northeast Florida (Crow et al., 2000; Weingartner et al., 1977). The Pi for *B. longicaudatus* on potato following a cover crop of sorghum-sudangrass was 30 to 77 nematodes/130 cm^3 of soil (Table 3), well above the economic threshold of 3 *B. longicaudatus*/130 cm^3 of soil for nematicide application (Crow et al., 2000). Consequently, the use of sorghum-sudangrass as a summer cover crop for potato in northeast Florida may be a factor contributing to the need for annual nematicide applications. When velvetbean was substituted as a cover crop, population densities of *B. longicaudatus* were substantially reduced in comparison with sorghum-sudangrass as a cover crop.

Population densities of *M. incognita* were maintained in both sorghum-sudangrass and velvetbean plots. Sorghum-sudangrass is reported as a non-host for *M. incognita* (Johnson et al., 1977; McSorley et al., 1994a,b; McSorley and Dickson, 1995; McSorley and Gallaher, 1991), as is velvetbean (McSorley et al., 1994a,b; McSorley and Dickson, 1995; Rodŕiguez-Kábana et al., 1992). The populations of *M. incognita* may have been maintained on weeds rather than the cover crops. A poor stand of velvetbean following potato often occurred because of seedling diseases. In addition, velvet-

TABLE 4. Effects of cover crop treatments on potato yield (kg/ha) by tuber grade. A: tubers > 4.76-cm diam. B: tubers 3.81 ≤ 4.76-cm diam. Total yield includes tubers culled for quality defects.

Year	Size grade	Summer cover crop treatment	
		Sorghum-sudangrass	Velvetbean
1997	U.S. size A	25,139	26,369
	U.S. size B	1,331	1,466
	Total yield	27,001	28,612
1998	U.S. size A	28,955	30,051*
	U.S. size B	1,745	1,200*
	Total yield	35,051	34,300

Asterisks indicate differences in treatment means between columns according to the contrast procedure ($P < 0.05$).

bean was vulnerable to severe damage from lepidopteran pests that caused defoliation later in the season. Both factors contributed to weed development in the velvetbean plots. Weeds found in these plots showing extensive galling from *M. incognita* were redweed (*Melochia corchorifolia*), pigweed (*Amaranthus hybridus*), and common purslane (*Portulaca oleracea*).

Sorghum-sudangrass was negatively affected by high population densities of *B. longicaudatus.* Sorghum-sudangrass in plots with high Pi densities of *B. longicaudatus* exhibited poor stands and plant stunting, particularly early in the season. Poor growth of sorghum-sudangrass allowed weeds to increase in these plots, which may explain why the *M. incognita* populations were maintained in sorghum-sudangrass.

Nematode management is only one factor influencing the profitability of potato production in northeast Florida. Despite reductions in *B. longicaudatus* on potato following velvetbean, yields were not increased. The effects of these cover crops on additional components of this production system, including their effects on other pests and pathogens, fertility, soil management, and erosion control, have never been quantified. For growers to make educated decisions regarding the use of cover crops, research on these factors is needed.

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