ROTATIONS OF SOYBEAN WITH TWO TROPICAL LEGUMES FOR THE MANAGEMENT OF NEMATODE PROBLEMS

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ABSTRACT

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The effects of two tropical legumes, American jointvetch (*Aeschynomene americana*) and hairy indigo (*Indigofera hirsuta*), in rotations with soybean (*Glycine max*) on populations of root-knot (*Meloidogyne arenaria*) and cyst (*Heterodera glycines*) nematodes and on soybean yields were studied in a 2-year field experiment. End-of-season juvenile soil populations of *M. arenaria* and of *H. glycines* were reduced by 95–100% where either of the tropical legumes was grown. Yields of seven soybean cultivars (Braxton, Centennial, Gordon, Kirby, LeFlore, Ransom, Stonewall) increased significantly in plots planted with jointvetch or indigo the previous year. The magnitude of the yield increment depended on the soybean cultivar; the average increases in yields for all cultivars were 46% and 55% following jointvetch and indigo, respectively. At-plant application of aldicarb (17 g a.i./100 m of row in a 20-cm-wide band) was most effective in increasing yields of soybean grown in monoculture but was generally ineffective in soybean grown in rotation. The suppressive effect of the tropical legumes on end-of-season juvenile soil populations of *M. arenaria* and of *H. glycines* was short-lived; end-of-season juvenile populations in plots with soybean planted with either jointvetch or hairy indigo the previous year were equal or greater than the populations found in plots with continuous soybean.

Key words: Aeschynomene americana, American jointvetch, cropping systems, cultural practices, cyst nematode, hairy indigo, *Heterodera glycines*, *Indigofera hirsuta*, integrated pest management, *Meloidogyne arenaria*, root-knot nematode, rotations, soybean, tropical legumes.

RESUMEN

Rodríguez-Kábana, R., D. B. Weaver, D. G. Robertson, R. W. Young y E. L. Carden. 1990. Rotaciones de soya con dos leguminosas tropicales para el manejo de problemas nematológicos. Nematrópica 20:101–110.

Se estudiaron por 2 años en un experimento de campo los efectos de dos leguminosas tropicales, la arveja americana (*Aeschynomene americana*) y el índigo (*Indigofera hirsuta*), en rotaciones con soya (*Glycine max*), sobre poblaciones del nematodo agallador (*Meloidogyne arenaria*) y las del enquistador de la soya (*Heterodera glycines*). Las poblaciones larvales en el suelo determinadas a fín de estación tanto de *M. arenaria* como de *H. glycines* fueron drásticamente reducidas en las parcelas con las leguminosas tropicales. Los rendimientos de siete cultivares de soya (Braxton, Centennial, Gordon, Kirby, LeFlore, Ransom, Stonewall) sembradas en parcelas que habían estado con la arveja americana o con índigo el año anterior fueron aumentados significativamente. La magnitud del aumento en producción dependió del cultivar de soya en particular siendo el promedio de aumento para todos los cultivares de 46% con la rotación arveja-soya y de 55% para con la del índigo. Un tratamiento con el nematicida sistémico aldicarb (17 g i.a./100 m de surco aplicado en una franja de 20 cm de ancho) efectuado durante la siembra fué más efectivo para aumentar la producción de soya en las parcelas en monocultivo siendo por lo general ineficaz en las que estaban bajo rotación. El efecto reductor de las dos leguminosas tropicales sobre las poblaciones larvales de *M. arenaria* y de *H. glycines* a fin de estación fué de corta duración ya que las poblaciones larvales de estos nematodos en el segundo año del estudio en las parcelas con las rotaciones fueron iguales o aun mayores que las observadas en las parcelas en monocultivo.

Palabras claves: Aeschynomene americana, arveja americana, *Heterodera glycines,* índigo hirsuto, *Indigofera hirsuta,* leguminosas tropicales, manejo integrado de plagas, *Meloidogyne arenaria,* nematodo agallador, nematodo del quiste, rotaciones, sistemas de producción, soya.

INTRODUCTION

Root-knot nematodes (*Meloidogyne* spp.) and the cyst nematode (*Heterodera glycines* Ichinohe) are important yield-limiting factors in the production of soybean (*Glycine max* (L.) Merr.) in Alabama and other states in the southeastern United States (8,19,25). Damage from these nematodes can be so severe that continued production is not possible without appropriate management of the pests (7,22,23). Traditional management of nematode problems in soybean across the region has been based primarily on development of cultivars resistant to root-knot and cyst nematodes. A number of cultivars are available with high levels of tolerance to the root-knot nematode (*M. incognita* (Kofoid & White) Chitwood) and resistant to several races of *H. glycines* (8,20,30). There also are a few cultivars tolerant to *M. arenaria* (Neal) Chitwood (18,29). Although the availability of resistant and tolerant cultivars permits adequate management of nematode problems in many fields, there are fields in Alabama where both root-knot and cyst nematodes are present (19). The number of soybean cultivars available with combined resistance to root-knot and cyst nematdes is limited (28); therefore, other management practices must be employed in fields with multiple species infestation. The recent removal of inexpensive fumigant nematicides eliminated the practical use of nematicides in soybean (9,11,29). Nematicides currently available are not as effective as were the fumigants and are generally too expensive to use in soybean (17,28). Rotations with nonhost plants or with crops that are less suitable hosts for nematodes than soybean offer another alternative for the management of root-knot and cyst nemmatodes (5,6,19,24,27). Bahiagrass (*Paspalum notatum* Flugger) and corn (*Zea mays* L.) can be used successfully in rotations with soybean to manage problems in fields infested with root-knot and cyst nematodes (21,31). There is, however, need to find cover or forage crops that can be used as rotation crops to manage nematodes in fields with multi-species infestation. Some tropical legumes and crops uncommon to A1abama have potential as aternatives for use in rotations with soybean to manage nematode problems (14,15). This paper presents results of a field study on the use of two tropical legumes in rotation with soybean to manage *M. arenaria* and *H. glycines.*

MATERIALS AND METHODS

A 2-year experiment was established to assess the value of two tropical legume cover crops, American jointvetch (*Aeschynomene americana* L.) and hairy indigo (*Indigofera hirsuta* L.) for the management of soybean nematodes. The experiment was done near Elberta, Baldwin County, Alabama. The field had been in soybean for the preceeding 10 years with either rye (*Secale cereale* L.) or ryegrass (*Lolium* sp.) as winter cover crops. The soil was a sandy loam (thermic typic Paleudult, pH = 6.2, organic matter content < 1.0%, cation exchange capacity < 10 meq./100 g of soil) infested with *M. arenaria* and *H. glycines* race 4. In 1987, the experimental area in the field was divided into six sections each 100 m long and 36 rows wide on 0.8-m centers. Two sections were planted with 'Kirby' soybean, two with jointvetch and the other two with 'Florida 101' hairy indigo. Soybeans were planted in rows and the legumes were broadcast. The field was left fallow in the winter and in 1988 each section was divided into eight 6-m-long blocks separated by 6-m-long alleys. Each block was divided into two-row plots with four border rows on each side of the block. The soybean cultivars Braxton, Centennial, Gordon, Kirby, LeFlore, Ransom, and Stonewall were planted in the plots so as to have for each block a plot treated with aldicarb and another plot without the nematicide. The aldicarb (15G formulation) treatment consisted of an at-plant application at a rate of 17 g a.i./100 m row in a 20-cm-wide band with the seed furrow in the middle. The nematicide was incorporated 3–5 cm into the soil by spring activated tines mounted ahead of the planting equipment. Border rows were planted with 'Kirby' and were not treated with aldicarb. Table 1 presents maturity groups and the relative resistance of the cultivars to *M. arenaria* and races 3 and 4 of *H. glycines.*

Cultural practices and control of insects and weeds were as recommended for the area (1,3,4). Soybean yields were obtained at maturity of the crop by harvesting the entire plot area in 1988. In 1987 soybean yields were obtained from eight areas each two-rows wide and 6 m long from the middle of each section and where the blocks were positioned in 1988. Dry matter yields for jointvetch and hairy indigo were deter-

Table 1. Relative resistance of soybean cultivars to root-knot (*Meloidogyne arenaria*) and cyst (*Heterodera glycines*) nematodes.

Cultivar	Maturity group	*M. arenaria*	*H. glycines*	
			Race 3	Race 4
Braxton	VII	R[z]	S	S
Centennial	VI	S	R	S
Gordon	VII	R	R	S
Kirby	VIII	R	R	S
LeFlore	VI	S	R	R
Ransom	VII	S	S	S
Stonewall	VII	S	R	S

[z]R = resistant, S = susceptible.

mined at blooming (30 September 1987) by harvesting eight 0.5-m^2 areas from the center of each section to coincide with the location of the blocks in 1988. The harvested green matter was dried to 6% (w/w) moisture content and weighed.

Soil samples for nematode analysis were collected 2 weeks before soybean harvest to be within the period of maximal population development of root-knot nematode in a 'Kirby'-type soybean (20). The samples consisted each of 16–20 soil cores each 2.5-cm diam which were collected from the root zone of the plants to a depth of 20–25 cm. In 1987 soil cores were taken from the areas where the yields for soybean and the other legumes were obtained. In 1988, soil cores for each plot were collected at evenly spaced intervals every .25 to .33 m along the center of the plot. The cores were composited and a 100-cm^3 subsample was used to determine nematode numbers with the "salad bowl" incubation technique (16).

All data were analyzed statistically according to standard procedures for analysis of variance for split-plot design (10,26); Fisher's least significant differences were calculated and are included in the tables of results (10). Unless otherwise stated all differences referred to in the text were significant at the 5% or lower level of probability.

RESULTS

In 1987, juvenile populations of *M. arenaria* and *H. glycines* in sections with either jointvetch or hairy indigo were very low ($< 10/100$ cm^3 soil) in contrast with the populations found in sections with 'Kirby' soybean (Table 2). Dry matter yields of jointvetch and hairy indigo exceeded 10 t/ha and average soybean yields were 1 923 kg/ha (Table 2).

Analysis of the 1988 yield data revealed significant interactions for previous crop × cultivar. The analysis also revealed significant interactions between the effects of nematicide and previous crops, and

Table 2. Yield of soybean, American jointvetch (*Aeschynomene americana*), hairy indigo (*Indigofera hirsuta*), and end-of-season populations of *Meloidogyne arenaria* and *Heterodera glycines* in 1987.

		Numbers/100 cm^3 of soil	
Crop species	Yield (kg/ha)	*M. arenaria* juveniles	*H. glycines* juveniles
'Kirby' soybean	1 923	194	89
Jointvetch	11 450	5	2
Hairy Indigo	13 348	6	0
FLSD (0.05)	—	52	26

nematicide and cultivars. Thus, aldicarb increased yields of 'Kirby' in the continuous soybean system (Table 3), and yields of 'Centennial', 'Gordon', and 'LeFlore' also were increased by the treatment, but yield increments were significant only at $P = 0.10$. Aldicarb, however, did not increase yields of the other cultivars in the monoculture system. The nematicide had no effect on yield of any cultivar in the indigo-soybean rotation and with one exception (cv. Braxton) it was equally ineffective in the jointvetch-soybean system.

There was a general increase in yield of all cultivars in response to the rotations. The degree of yield response depended on the cultivar and the rotation system. Thus, for the jointvetch-soybean rotation, yield increases relative to the yield obtained in monoculture varied from 13% for 'LeFlore' to 105% for 'Stonewall' (Table 4). The average response for all cultivars was 46%. Yield response to the indigo-soybean rotation varied from 17% for 'LeFlore' to 210% for 'Braxton' (Table 4) with an overall average response for all cultivars of 55%.

Analysis of the data for root-knot nematode revealed significant interactions for nematicide × previous crop and nematicide × cultivar. Aldicarb was generally ineffective in reducing juvenile populations of *M. arenaria* in any of the cultivars in the two rotation systems but was effective for 'LeFlore' in the monoculture system. The highest populations of *M. arenaria* juveniles were associated with 'LeFlore'. The interaction of cultivars × previous crop for *M. arenaria* was not significant. *Meloidogyne arenaria* juvenile populations were higher in the indigo-soybean rotation than in the continuous soybean system; however, there were no differences in juvenile populations among the jointvetch-soybean and the monoculture systems.

Numbers of *H. glycines* juveniles in soil were lower than those for *M. arenaria* juveniles. Aldicarb had no effect on *H. glycines* juvenile populations. There was no significant interaction for cultivar × previous crop. The jointvetch rotation had the highest overall numbers of *H. glycines* juveniles and there were no differences in the sizes of populations found in the monoculture and the indiqo-soybean rotation.

Table 3. Effects of American jointvetch (*Aeschynomene americana*) and hairy indigo (*Indigofera hirsuta*) in rotation with soybean on yield of selected soybean cultivars and on end-of-season juvenile populations of *Meloidogyne arenaria* and *Heterodera glycines* race 4 in soil in a 2-year experiment near Elberta, Baldwin County, Alabama, in a field planted to soybeans in 1987.

		Continuous soybean (1987–1988)			Jointvetch (1987)—soybean (1988)			Indigo (1987)—soybean (1988)		
			Juveniles/100 cm^3 of soil			Juveniles/100 cm^3 of soil			Juveniles/100 cm^3 of soil	
Cultivar	Aldicarb application	Yield (kg/ha)	*M. arenaria*	*H. glycines*	Yield (kg/ha)	*M. arenaria*	*H. glycines*	Yield (kg/ha)	*M. arenaria*	*H. glycines*
Braxton	–[z]	610	35	6	908	34	34	2 148	57	28
Braxton	+	781	26	8	1 611	21	25	2 148	66	22
Centennial	–	1 245	85	8	1 831	134	13	1 831	122	12
Centennial	+	1 587	87	3	1 953	73	10	1 831	129	7
Gordon	–	1 196	22	7	1 953	40	27	2 197	69	7
Gordon	+	1 513	26	5	2 002	34	18	2 148	63	9
Kirby	–	1 513	39	12	2 002	51	26	2 099	97	7
Kirby	+	1 904	53	9	2 148	58	36	2 197	101	11
LeFlore	–	1 831	130	4	2 221	104	4	2 221	185	1
LeFlore	+	2 172	190	4	2 295	146	2	2 319	209	2
Ransom	–	757	49	6	1 269	39	11	1 343	79	15
Ransom	+	879	50	9	1 562	58	25	1 294	78	28
Stonewall	–	806	29	9	1 684	74	16	1 782	99	6
Stonewall	+	928	74	5	1 879	75	18	1 928	117	5

FLSD (0.05) values for comparing any two means are 361, 54, and 13 for yield, *M. arenaria* populations, and *H. glycines* populations, respectively.
[z]– = no aldicarb treatment; + = treated with aldicarb at-plant at the rate of 17 g a.i./100 m of row in a 20-cm-wide band.

Table 4. Percentage increase in yield of selected soybean cultivars in response to two rotations with American jointvetch (*Aeschynomene americana*), and hairy indigo (*Indigofera hirsuta*) compared with continuous soybean in a field infested with root-knot (*Meloidogyne arenaria*) and cyst (*Heterodera glycines*, race 4) nematodes near Elberta, Baldwin County, Alabama.

	Rotation system (% yield increase)	
Cultivars	Jointvetch—soybean	Indigo—soybean
Braxton	82	210
Centennial	33	30
Gordon	47	61
Kirby	21	22
LeFlore	13	17
Ransom	73	62
Stonewall	105	114

DISCUSSION

Our results showed conclusively that American jointvetch and hairy indio can be used in rotations to increase soybean yield in fields infested with *M. arenaria* and *H. glycines*. These tropical legumes have been used as summer cover crops in Florida to suppress populations of *Meloidogyne* spp. and other nematodes and to increase yields of subsequent winter vegetable crops (12,13). Hairy indigo can be used as a forage crop and its protein content is equivalent to that of alfalfa (2). Dry matter yields for hairy indigo and jointvetch obtained in our study attest to the high potential these crops have to be used as green manures. We chose not to incorporate green matter produced by the legumes into the soil. The shoots and leaves were left on the ground without incorporation. Incorporation of such high amounts of leguminous organic matter could have a suppressive effect on nematode populations.

While populations of root-knot nematode were reduced by jointvetch and hairy indigo in 1987, our study indicates that this effect is short-lived since juvenile populations of the nematodes in 1988 in the plots with rotations either were not different (jointvetch) from or were higher (indigo) than the populations found in plots with monoculture. This is to be expected given the exponential nature of population development of root-knot nematodes in soybean (20). It is possible that the suppressive effect of jointvetch and indigo on *M. arenaria* carried through the early part of the 1988 season and was sufficient to account for the observed positive effect on soybean yields.

Juvenile populations of both *H. glycines* and *M. arenaria* in soil in 1988 were five to seven times lower than expected compared to the previous year. The samples in 1988 were taken after a month-long dry period which resulted in reduced numbers of juveniles. Juvenile populations of *M. arenaria* were higher than those of *H. glycines*. In both years of the study, soybeans were planted the first week of June when soil temperatures 15 cm deep are typically > 27C. These soil temperatures are maintained through the growing season and in contrast to *M. arenaria* are not favorable for development of soybean cyst nematode (23,25).

This study showed that aldicarb was ineffective in plots with the rotations. Only in the monoculture system was there some yield response to the nematicide and then only for some cultivars; the magnitude of the yield increments obtained with these cultivars does not provide economic justification for the use of the chemical.

Yield differences among cultivars were most pronounced in the monoculture system compared with the rotations. This has been observed before for other rotations of soybean with bahiagrass (21) or with corn (31) in the same location and in studies of similar design to the present one. This suggests that the choice of soybean cultivar to use in fields with rotation systems that are effective for nematode management, is less critical than for fields in soybean monoculture. Also, the yield potential of cultivars used in rotation may be a more important criterion to consider for selecting soybean cultivars than their relative resistance or susceptibility to nematodes.

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