HORSEBEAN (*CANAVALIA ENSIFORMIS*) AND CORTALARIA (*CROTALARIA SPECTABILIS*) FOR THE MANAGEMENT OF *MELOIDOGYNE* SPP.

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ABSTRACT

Rodríguez-Kábana, R., J. Pinochet, D. G. Robertson, C. F. Weaver, and P. S. King. 1992. Horsebean (*Canavalia ensiformis*) and crotalaria (*Crotalaria spectabilis*) for the management of *Meloidogyne spp.* Nematropica 22:29–35.

In a greenhouse experiment at Cabrils, Spain, horsebean (*Canavalia ensiformis*) roots in pots inoculated with an isolate of *Meloidogyne incognita* race 1 from Spain became severely galled 7 weeks after inoculation; roots from pots inoculated with Spanish isolates of *M. arenaria* race 2 or *M. javanica* had few or no galls. In another greenhouse experiment at Auburn, Alabama, U.S.A., with field soil infested with *Heterodera glycines* race 4 and *M. arenaria* race 2, roots of horsebean and showy crotalaria (*Crotalaria spectabilis*) developed no galls although severe galling occurred in roots of 'Davis' soybean (*Glycine max*) and 'Summer Crookneck' squash (*Cucurbita pepo*); increases in *H. glycines* populations were associated only with soybean. In microplots filled with naturally infested soil at Auburn, crotalaria suppressed populations of *M. arenaria*; horsebean, soybean, and squash did not. When 'Purple Hull' cowpea (*Vigna unguiculata*) was planted following a crotalaria crop, final juvenile populations of *M. arenaria* in soil were lower than in microplots with cowpea following horsebean, squash, or soybean.

Key words: antagonistic plants, *Canavalia ensiformis*, crop rotation, *Crotalaria spectabilis*, *Meloidogyne arenaria*, *M. incognita*, *M. javanica*, nematode, nematode control, vegetables.

RESUMEN

Rodríguez-Kábana, R., J. Pinochet, D. G. Robertson, C. F. Weaver y P. S. King. 1992. El frijol macho (*Canavalia ensiformis*) y la crotalaria (*Crotalaria spectabilis*) para el manejo de *Meloidogyne* spp. Nematrópica 22:29–35.

En un experimento de invernadero realizado en Cabrils, España, las raíces de plantas de frijol macho (*Canavalia ensiformis*) de macetas inoculadas con una población española de *M. incognita* raza 1 estaban severamente agalladas 7 semanas después de inoculación, no siendo así las raíces de plantas en macetas inoculadas con *M. arenaria* raza 2 o con *M. javanica*. En otro experimento de invernadero en Auburn, Alabama, EE.UU., con suelo naturalmente infestado con *Heterodera glycines* raza 4 y con otra población de *M. arenaria* raza 2, tanto las raíces de frijol macho como las de crotalaria (*Crotalaria spectabilis*) no mostraron agallamientos aunque sí se observaron numerosos en las raíces de soya (*Glycine max*) 'Davis' y de calabacín (*Cucurbita pepo*) 'Summer Crookneck'. En este experimento sólo se encontraron incrementos de poblaciones de *H. glycines* en las macetas con soya. En otros experimentos con microparcelas con suelo naturalmente infestado en Auburn, crotalaria en contraste con calabacín, frijol macho y soya ejerció un efecto supresor sobre las poblaciones juveniles de *M. arenaria*. Cuando se plantó chícharo (*Vigna unguiculata*) 'Purple Hull' después de crotalaria las poblaciones finales de juveniles de *M. arenaria* en el suelo fueron inferiores a las de microparcelas con chícharo después de calabacín, frijol macho o soya.

Palabras clave: cambios de cultivos, *Canavalia ensiformis*, control de nematodos, *Crotalaria spectabilis*, hortalizas, *Meloidogyne arenaria*, *M. incognita*, *M. javanica*, nematodo, nematodos agalladores.

INTRODUCTION

Damage caused by nematodes is a serious constraint to vegetable production world-wide. For many vegetables the management of nematode pests has been based on the use of nematicides. However, the nematicides available for use in vegetable production today are limited

and may not be available in the future due to environmental or toxicological risks (8). Crop rotation is an alternative for managing nematodes (5,9,21). For example, American jointvech (*Aeschynomene americana*), bahiagrass (*Paspalum notatum*), castrobean (*Ricinus comunis*), corn (*Zea mays*), cotton (*Gossypium hirsutum*), hairy indigo (*Indogofora hirsuta*), sesame (*Sesamum indicum*), sorghum (*Sorghum bicolor*), and velvetbean (*Mucuna deeringiana*) are non-hosts or are poor hosts for root-knot nematodes (*Meloidogyne* spp.) and have been used in rotations with peanut (*Arachis hypogaea*), soybean (*Glycine max*), and vegetable crops to manage nematode problems (4,13,14,15,16, 17,19). Vegetable production requirements vary greatly with locality so that some rotation crops, while suitable for some areas, cannot be considered in rotation schemes for other regions. Because of the diversity of production systems in vegetables and other crops there is need to identify crops with potential for the development of new rotation schemes to permit producers to select cropping systems that best fit their individual requirements. Horsebean (*Canavalia ensiformis*) and showy crotalaria (*Crotalaria spectabilis*) are legumes with nematicidal properties (2,4). Crotalaria was used as a cover crop to suppress root-knot nematodes in peach orchards (12). Horsebean was included in rotation studies with corn (*Zea mays*) in southern Mexico to improve soil fertility and suppress nematodes and other soilborne pathogens (4). The value of these legumes as rotation crops to manage root-knot nematodes in vegetables has received little attention. This paper presents results of a study comparing horsebean (*Canavalia ensiformis*) and showy crotalaria (*Crotalaria spectabilis*) for the management of root-knot nematodes.

MATERIALS AND METHODS

Inoculation experiment: The response of horsebean to three *Meloidogyne* spp. was compared to the responses of five other plant species in a greenhouse experiment at the Institut de Recerca i Tecnologia Agroalimentàries (IRTA), Cabrils, Barcelona, Spain. Nematode cultures were derived from single egg masses originally isolated from infected plants in Barcelona province and were maintained in 'Garrigues' almond (*Prunus amygdalus*). Cultures included: *M. arenaria* (Neal) Chitwood race 2 from tomato (*Lycopersicon esculentum*) in Cabrera de Mar; *M. incognita* race 1 (Kofoid & White) Chitwood from kiwi (*Actinidia deliciosa*) in Tordera; and *M. javanica* (Treub) Chitwood from fig (*Ficus carica*) in Cabrils. Eggs and juveniles were extracted from almond roots after maceration in NaOCl solution (7) and an aqueous suspension of inoculum was prepared to deliver 2 500 second-stage juveniles (J2) and eggs in 5 ml of suspension. Seeds of horsebean, 'Clemson Spineless' okra (*Hibiscus esculentum*), 'Stoneville' cotton (*G. hirsutum*), 'Davis' soybean (*Glycine max*), and 'Summer Crookneck' squash (*Cucurbita pepo*) were planted in pots (5 seeds/pot) containing 500 g of fine ($\leq$1 mm particle size) sterilized loamy sand with pH = 8.3, organic matter content < 1.0% (w/w) and cation exchange capacity < 10 meq/100 g soil. Plants were allowed to grow for 2 weeks before inoculation. Inoculum was applied to each pot through five holes 4–5 cm deep placed equidistantly in a circle midway from the pot wall and its center. There were five pots per combination of plant and nematode species in the experiment. Inoculated pots were maintained in a greenhouse at 20–27 C. Five weeks after inoculation, the plants were removed from the pots, the roots

were carefully washed to remove sand, root galls were counted, and fresh root weights were recorded.

Field soil experiment: The reactions of horsebean and showy crotalaria to nematode parasites of soybean were studied in a greenhouse experiment with soil from a field in Alabama infested with race 2 of *M. arenaria* and race 4 of *Heterodera glycines*. The soil was a loamy sand with pH = 6.2, organic matter content < 1%, and cation exchange capacity < 10 meq/100 g soil. The soil was mixed 50:50 (v:v) with fine (< 1 mm particle size) river sand and the moist mixture (60% field capacity), referred to henceforth as soil, was placed in 1-L capacity 10-cm-diam plastic pots (1 kg/pot). The pots were planted with 5 seeds per pot of Summer Crookneck squash, Davis soybean, or horsebean, or with 10 seeds per pot of crotalaria. Eight pots were included for each plant species and were arranged in a completely randomized design in a greenhouse. After 8 weeks, the plants were separated from the soil, the roots were weighed, and the galls induced by *M. arenaria* in each root system were counted. The general degree of galling was assessed using a gall index from 0 for no galling to 10 for maximal galling (22). Second-stage juveniles were extracted from roots with the salad bowl incubation technique (18) and counted. The salad bowl method was also used for assaying numbers of nematodes in 100 cm^3 soil from each pot.

Microplot experiments: Two microplot experiments were conducted on the Old Agronomy Farm on the Auburn University campus. A microplot consisted of a 930-cm^2 area delimited by a square terra cotta chimney liner with walls 2.5 cm thick. The liners were 60 cm long and had been placed into holes in the soil so as to have 8 cm of wall above the soil surface. A sandy loam (pH = 6.2, organic matter < 1.0%, cation exchange capacity < 10 meq/100 g soil) from a soybean field infested with *M. arenaria* race 2 was used to fill the volume enclosed by the liners. One experiment included horsebean and the other included crotalaria. Treatments in each experiment consisted of planting Summer Crookneck squash, Davis soybean, and horsebean or crotalaria all in separate microplots. There were eight replicate microplots each for squash and soybean, and 16 each for horsebean and crotalaria. Microplots were planted on 10 May 1990 (crotalaria experiment) and on 28 May 1990 (horsebean experiment) at a rate of 5 seeds/microplot for all plant species except crotalaria, which was planted at 25–30 seeds/microplot. The resulting plants were allowed to grow for 3 months, when the tops of all plants were removed and the soil in each microplot was loosened and mixed. Soil samples for nematode analysis then were collected by taking from each microplot two 2.5-cm-diam soil cores to a depth of 25 cm with a standard probe. The cores from a plot were composited and a 100-cm^3 subsample was used to assess nematode numbers with the salad bowl method (18). The shoots from each of eight microplots with crotalaria (or horsebean in the horsebean experiment) were incorporated into the soil and those from the remaining eight microplots were removed. Two weeks after incorporation of the shoots all microplots were planted with 'Purple Hull' cowpea (*Vigna unguiculata*). The resulting cowpea plants were grown for 2 months when they were removed and their roots were separated from the soil by washing. The fresh weights of shoots and roots were recorded and the degree of galling of the root system was assessed using Zeck's

scale of 0–10 (22). *Meloidogyne arenaria* J2 were extracted from roots and soil as described previously.

All microplots were fertilized and maintained according to recommended practices for the plants in the area (1). Weeds were removed by hand and microplots were watered as needed with a drip irrigation system.

Statistical analyses: Data were analysed by the appropriate analysis of variance (10,20) and Fisher's least significant differences were calculated when F values were significant ($P = 0.05$). Unless otherwise stated all differences referred to in the text were significant at the 5% or lower level of probability.

Table 1. Root galls on horsebean (*Canavalia ensiformis*) and selected crop plants 5 weeks after being inoculated with three root-knot nematodes (*Meloidogyne* spp.) in a greenhouse experiment at Cabrils, Barcelona, Spain.

	Galls per root system		
	M. arenaria race 2	*M. incognita* race 1	*M. javanica*
Horsebean	0	43	15
Cotton	0	0	0
Okra	58	65	221
Peanut	0	0	0
Soybean	160	18	0
Squash	81	91	93
FLSD ($P=0.05$)	25	17	24

Data are means of five replications.

RESULTS AND DISCUSSION

Inoculation experiment: Horsebean roots had significant numbers of galls in pots inoculated with *M. incognita* (Table 1). Soybean roots were galled only in pots inoculated with *M. arenaria* or *M. incognita*. All three *Meloidogyne* spp. induced galls on squash and okra. No galls were observed in cotton or peanut roots in any pot.

Field soil experiment: The only roots with appreciable numbers of galls caused by *M. arenaria* were those of soybean and squash, which had the highest gall indices and the largest populations of *M. arenaria* J2 (Table 2). Calculations based on numbers per gram fresh root resulted in identical patterns of response as on a root system basis; hence all nematode data were expressed in terms of nematodes per root system. *Heterodera glycines* J2 populations increased only in pots containing soybean.

Microplot study: In contrast with squash and soybean, planting crotalaria suppressed *M. arenaria* J2 populations in soil to low levels (Table 3). Low population levels were maintained in crotalaria plots when the succeeding cowpea plants were harvested. Juvenile populations in soil from plots that had squash or soybean were lower after growing cowpea than when it was planted. This was probably due to a decline in juvenile populations following an earlier peak since cowpea roots in plots that previously had soybean or squash had the highest gall indices. Cowpea roots in crotalaria plots had the lowest gall indices. Incorporation of crotalaria shoots into the soil had no effect on the gall index values or on the number of *M. arenaria* J2 in soil. Plots that had crotalaria produced the largest amounts of cowpea shoots. Incorporation of crotalaria shoots into the soil resulted in a 27% increase in cowpea shoot production.

Horsebean did not suppress *M. arenaria* J2 populations in soil (Table 4). When cowpea was planted in horsebean plots, juvenile populations at harvest were equal to or higher than those in plots that had squash or soybean as the

Table 2. Final *Meloidogyne arenaria* race 2 populations and root galling on showy crotalaria (*Crotalaria spectabilis*), horsebean (*Canavalia ensiformis*), 'Summer Crookneck' squash (*Cucurbita pepo*), and 'Davis' soybean (*Glycine max*) after 8 weeks in greenhouse pots filled with a mixture of sand and soil from an Alabama field infested with *M. arenaria* race 2 and *Heterodera glycines* race 4.[y]

			M. arenaria juveniles	
	Galls per root system	Gall index[z]	Per root system	Per 100 cm³ soil
Horsebean	0	0.0	43	3
Crotalaria	0	0.0	0	0
Soybean	36	5.1	341	100
Squash	28	5.7	273	99
FLSD ($P = 0.05$)	5	0.5	123	43

Data are means of eight replications.
[y]Data for *H. glycines* not presented.
[z]Based on a scale of 0 = no galls to 10 = maximal galling (22).

previous crop. Horsebean had no effect on the gall index of cowpea. Incorporation of horsebean shoots into the soil prior to planting cowpea had no effect on the *M. arenaria* J2 population or on the gall index of cowpea. Fresh shoot production by cowpea was lowest in plots where horsebean shoots were not incorporated into the soil prior to planting cowpea; differences in cowpea shoot production among the other treatments of the experiment were not significant.

Results from this study confirm those of McBeth (12) and others (2,6) who found that *C. spectabilis* and other *Crotalaria* spp. suppressed populations of *Meloidogyne* spp. and other phytonematodes. *Crotalaria spectabilis* suppresses nematode populations by producing root exudates containing monocrotaline and

Table 3. Effects of previously growing showy crotalaria (*Crotalaria spectabilis*), squash (*Cucurbita pepo*), and soybean (*Glycine max*), on growth of a subsequent crop of 'Purple Hull' cowpea (*Vigna unguiculata*) and on populations of *Meloidogyne arenaria* in soil and roots of cowpea in microplots containing naturally infested soil.

	Juveniles/100 cm³ soil			
Previous crop	At plant	At harvest	Root-knot index[y]	Fresh shoot weight (g)
Squash	179	13	5.4	446
Soybean	136	70	5.5	350
Crotalaria	11	32	2.9	631
Crotalaria[z]	2	6	3.8	804
FLSD ($P = 0.05$)	46	33	1.0	270

Data are means of eight replications.
[y]Index based on a scale ranging from 0 for no galls to 10 for maximal galling (22).
[z]Shoots incorporated into the soil prior to planting cowpea.

Table 4. Effects of previously growing horsebean (*Canavalia ensiformis*), squash (*Cucurbita pepo*), and soybean (*Glycine max*), on growth of a subsequent crop of 'Purple Hull' cowpea (*Vigna unguiculata*) and on populations of *Meloidogyne arenaria* in soil and roots of cowpea in microplots containing naturally infested soil.

Previous crop	Juveniles/100 cm³ soil		Root-knot index[y]	Fresh shoot weight (g)
	At plant	At harvest		
Squash	354	205	5.0	376
Soybean	280	277	5.1	266
Horsebean	447	387	5.5	189
Horsebean[z]	328	322	4.8	358
FLSD ($P = 0.05$)	106	89	NS	113

Data are means of eight replications.
[y]Index based on a scale ranging from 0 for no galls to 10 for maximal galling (22).
[z]Shoots incorporated into the soil prior to planting cowpea.

other nematicidal compounds (3). In our microplot experiments, the suppressive effect of *C. spectabilis* on *M. arenaria* lasted through the following cowpea crop. Thus, planting Crotalaria as a summer cover crop may be a practical way to deal with root-knot problems in fall vegetable production.

Marbán et al. (11) found that the lectins produced by *C. ensiformis* (horsebean) suppressed infection of tomato by *M. incognita* in microplots as well as under greenhouse conditions. Our contrasting results for horsebean inoculated with *M. arenaria* race 2 populations from Spain and Alabama, however, suggest that the reaction of horsebean to *Meloidogyne* spp. may depend on populations within a species. This could limit the use of horsebean as a rotation crop from management of root-knot nematodes. Further research is needed.

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Received: *8.XI.1991*
Recibido:

Accepted for publication: *9.III.1992*
Aceptado para publicar: