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Potential of Crops Uncommon to Alabama for Management of Root-knot and Soybean Cyst Nematodes

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Abstract: *Vigna unguiculata*, *Cassia fasiculata*, and *Sesamum indicum* did not support *Meloidogyne arenaria*, *M. incognita*, or *Heterodera glycines* race 4 in greenhouse studies with soils from peanut and soybean fields. *Fagopyron esculentum*, *Cyamopsis tetragonoloba*, and *Cucurbita pepo* were hosts to the two *Meloidogyne* spp. but were nonhosts to *H. glycines*. *Meloidogyne arenaria* and *M. incognita* galled but reproduced poorly in the roots of three types of *Amaranthus cruentus*, and low densities of these two *Meloidogyne* spp. (< 10 second-stage juveniles/100 cm^3 soil) occurred in soil cultivated with this crop. In a field study no juveniles of *M. arenaria* determined at peanut harvest were recovered from plots with *Ricinus communis*, *Gossypium hirsutum*, *Aeschynomene americana*, *C. fasiculata*, or *S. indicum*. Peanut plots averaged 120 juveniles/100 cm^3 soil. Application of aldicarb (12 kg a.i./ha broadcast) in peanut resulted in an average of 27 juveniles/100 cm^3 soil. Several crops were as effective as aldicarb treatment for reducing soil juvenile population densities of *M. arenaria*.
Key words: *Amaranthus cruentus*, *Arachis hypogaea*, *Cassia fasiculata*, cropping system, *Cucurbita pepo*, cultural practice, *Cyamopsis tetragonoloba*, *Fagopyron esculentum*, *Glycine max*, *Heterodera glycines*, *Meloidogyne arenaria*, *Meloidogyne incognita*, peanut, pest management, population dynamics, root-knot nematode, rotation, *Sesamum indicum*, soybean cyst nematode, *Vigna unguiculata*.

Damage from plant-parasitic nematodes is one of the principal yield-limiting factors in the production of most legume crops in the southeastern United States (5,20,21, 24). Losses caused by *Meloidogyne* spp. can be so severe in peanut (*Arachis hypogaea* L.) or soybean (*Glycine max* Merr.) that their continued production is not possible without appropriate management of the pests (4,8,18,19). Nematode management strategies are based on development and use of resistant cultivars (6,26), rotation to nonhost or less susceptible crops (5,10,24), and use of nematicides (6,8,12,15). Nematicide use is limited to high-value crops, such as peanut, and to situations where there are no alternative control methods. Crop rotations can be effective for preventing nematode problems and to reduce nematode population densities to manageable levels in heavily infested fields (5,24). Crops such as corn (*Zea mays* L.) or sorghum (*Sorghum bicolor* Moench), available for rotations with peanut or soybean (10,16), are typically of low value, so that rotations are often unattractive economically. Yields of corn in Alabama are low (< 4,000 kg/ha) because the crop is grown mostly in unirrigated land typical of peanut and soybean fields in the state. *Meloidogyne arenaria* (Neal) Chitwood can be managed in peanut by rotating with cotton (*Gossypium hirsutum* L.) (11). The majority of peanut producers in Alabama, however, do not have the specialized equipment needed to produce cotton. A similar situation exists for soybean. Crops suited to Alabama that can be used to manage nematodes and that also have the economic and agricultural prerequisites for adoption by producers in the region are needed. Our objectives were to evaluate several crops not common to Alabama for their potential as rotation crops in the management of nematode problems in peanut and soybean.

Materials and Methods

Greenhouse study: Soil was collected from a soybean field in Baldwin County, Alabama. The field had been in continuous soybean production for 8 years with rye (*Secale cereale* L.) or ryegrass (*Lolium multiflorum* Lam.) as a winter cover crop each year. The soil was a Ruston fine sandy loam (60% sand, 22% silt, 18% clay, < 1.0% organic matter; pH = 6.2) with a cation exchange capacity < 10 meq/100 g soil. It was infested with a mixture of *M. incognita* (Kofoid and White) Chitwood and *H. gly-*

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cines race 4 Ichinohe. Soil from the field was sieved (< 1 mm) to remove crop debris and large particles, and mixed 50:50 (v:v) with builder's fine (< 0.5 mm) sand. This mixture will be referred to henceforth as soil. The soil was apportioned in 1-kg amounts and placed in 1-liter capacity 10-cm-d cylindrical PVC pots. Plant species tested were buckwheat (*Fagopyrum esculentum* Moench), catjang cowpea (*Vigna unguiculata* (L.) Walp.), guar or cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.), partridge pea (*Cassia fasiculata* Michx.), and three types of grain amaranth (*Amaranthus cruentus* L.) differing in seed color: white, dark purple, and mixed color. Four sesame (*Sesamum indicum* L.) cultivars—Baco, Oro, Oro Benne, and Paloma—were also included. All sesame cultivars were of the shattering type except for Baco, which is a nonshattering type. Summer 'Crookneck' squash (*Cucurbita pepo* L.) was also included as a standard susceptible crop to *Meloidogyne* spp. Previous studies indicated several of these crops could be grown successfully in Alabama (9,23). Pots with soil were planted so that there would be 10–15 plants each of amaranth, partridge pea, and sesame, and five plants each of buckwheat, catjang pea, and squash. There were eight replicate pots of each cultivar or plant species arranged in a randomized complete block design on a greenhouse bench.

After 8 weeks plant roots were weighed and then examined for root-knot nematode galls and for cysts and females of *H. glycines.* The entire root systems were then placed in water for 72 hours to determine nematode numbers (14). Susceptibility to *M. incognita* was assessed by a root-gall index based on a scale of 0–10, where 0 = few or no galls and 10 = maximum galling (27). Nematode population densities were determined for each pot using 100-cm^3 soil samples (14).

A second greenhouse experiment of identical design was conducted with the same plant species and cultivars but with soil from a peanut field infested with *M. arenaria* race 1. The field was at the Wiregrass substation near Headland, Alabama, and had been in peanut for 15 years with hairy vetch (*Vicia villosa* Roth) planted as a winter cover crop every year. The soil was a sandy loam of similar composition and properties as that used for the first experiment. All other details, techniques, and evaluations were as described for the first experiment.

Field study: The effects of Baco sesame and partridge pea on population densities of *M. arenaria* were evaluated in the field where the soil for the second greenhouse experiment was collected. The level field was irrigated by center pivot. Other crop species included castor bean (*Ricinus communis* L.), American jointvetch (*Aeschynomene americana* L.), 'Deltapine 90' cotton, and 'Florunner' peanut. Castor bean and American jointvetch were included because previous greenhouse studies indicated they were suppressive to *M. arenaria* (Rodríguez-Kábana, unpubl.). Cotton and peanut were controls representing a nonhost crop (cotton) and a host crop for *M. arenaria* (20). Plots contained eight rows with each row 0.9 m wide × 10 m long. Each plant species was planted in eight replicates except peanut which was planted in 16 replicates. Eight peanut plots were treated with aldicarb and the other eight plots were left untreated. Aldicarb was applied at-plant with a Gandy applicator (Gandy Co., Owatonna, MN) at 3.4 kg a.i./ha (12 kg a.i./ha broadcast) in a 25-cm-wide band with the seed furrow in the middle. The experimental design was a randomized complete block. The field was irrigated as needed to maintain good growing conditions for peanut and cotton. Cultural practices and control of weeds, insects, and foliar diseases for peanut and cotton were as recommended for the area (1,2). Weed control in the other crops was by hand. Fertilization for jointvetch and partridge pea was as recommended for peanut; plots with sesame and castor bean were fertilized as recommended for cotton. Seeding rates for castor bean, partridge pea, jointvetch, and sesame were 90, 22, 28, and 5 (kg/ha), respectively. Castor bean, cotton, and peanut were planted in rows, but the other

TABLE 1. Nematode infection and indices of crops grown for 8 weeks in soil infested with *Meloidogyne incognita* and *Heterodera glycines* race 4 under greenhouse conditions.

Host	Galls/g fresh root	Root-gall index†	*M. incognita* juveniles/g fresh root‡
Squash	60	8	608
Buckwheat	51	8	841
Catjang pea	36	7	115
Guar	73	5	22
Partridge pea	0	0	1
White amaranth	58	1	73
Purple amaranth	79	1	57
Mixed amaranth	44	1	116
Baco sesame	1	0	4
Oro sesame	2	0	1
Oro Benne sesame	2	0	3
Paloma sesame	2	0	1
LSD ($P = 0.05$)	23	0.8	288

† Based on a scale where 0 = few or no galls and 10 = maximum galling (27).
‡ Numbers/100 cm^3 soil.

TABLE 2. Nematode population densities in soil from a greenhouse experiment with several crops planted in soybean field soil infested with *Meloidogyne incognita* and *Heterodera glycines* race 4.

Host	*M. incognita* juveniles	*H. glycines* juveniles†
Squash	309	17
Buckwheat	73	11
Catjang pea	542	31
Guar	0	8
Partridge pea	31	18
White amaranth	6	5
Purple amaranth	3	9
Mixed amaranth	6	2
Baco sesame	6	2
Oro sesame	4	5
Oro Benne sesame	0	2
Paloma sesame	3	2
LSD ($P = 0.05$)	77	13

† Numbers/100 cm^3 soil.

crops were broadcast. Soil samples for nematode analysis were collected 2 weeks before peanut harvest to coincide with the period of maximum population density of *M. arenaria* in this crop (17). A soil sample consisted of 16–20 equally spaced soil cores (2.5 cm d × 25 cm deep) taken from the root zone in the two center rows of each plot. Cores from plots with jointvetch, partridge pea, or sesame were taken from the center 1-m-wide band along the length of the plot. The cores from a plot were composited, and a 100-cm^3 subsample was used to determine nematode numbers (14).

Yields of cotton and peanut were determined at crop maturity by harvesting the two center rows of each plot. Sesame yields were also determined at maturity by harvesting the center 1 m^2 of each plot. Jointvetch and partridge pea forage yields were taken from the center 2 m^2 of each plot 1 week after peanut harvest; the harvested forage matter was dried at 50 C to constant weight.

Statistical analysis: All data were subjected to analysis of variance and means were compared by Fisher's least-significant differences (22). Unless otherwise stated, differences between means referred to in the text were significant at $P \leq 0.05$.

RESULTS

Greenhouse study: Partridge pea and all sesame cultivars had the lowest root-gall indices and their roots had either none or few galls caused by *M. incognita* (Table 1). These low values corresponded with the lowest numbers of *M. incognita* juveniles in the roots or in the soil (Tables 1, 2) with those plants. All other plant species sustained development of *M. incognita* as evidenced by high root-gall indices, large numbers of galls, or large numbers of juveniles in the roots. There were no cysts or females of *H. glycines* observed in roots of any plant species, and no juveniles (J2) of this nematode were extracted from the roots. Numbers of *H. glycines* J2 in soil were low (< 20/100 cm^3 soil) for all crops except catjang pea (Table 2). *Meloidogyne incognita* J2 population densities in soil were highest in pots with catjang pea and squash (Table 2). Soil population densities of this nematode were low (< 10 J2/100 cm^3 soil) for guar and the three amaranths, even though these plants were galled and had greater numbers of J2 in their roots.

In the second greenhouse experiment, lowest root-gall indices were found for catjang pea, partridge pea, the amaranths, and all sesame cultivars (Table 3). Amaranth and sesame roots had small galls, but these produced few or no *M. arenaria* J2.

TABLE 3. Nematode population densities and gall development in roots of several crops grown 8 weeks in soil infested with *Meloidogyne arenaria* under greenhouse conditions.

Host	Root-gall index†	Galls/g fresh root	Nematodes/g fresh root: *M. arenaria* juveniles	Nematodes/g fresh root: *Pratylenchus brachyurus*
Squash	6	87	602	103
Buckwheat	7	53	457	53
Catjang pea	0	0	8	64
Guar	5	77	79	156
Partridge pea	0	0	11	63
White amaranth	1	66	0	11
Purple amaranth	1	59	1	0
Mixed amaranth	0.5	23	0	2
Baco sesame	1	14	1	30
Oro sesame	1	16	13	6
Oro Benne sesame	1	8	25	4
Paloma sesame	1	12	9	10
LSD (P = 0.05)	0.9	23	207	43

† Based on a scale where 0 = few or no galls and 10 = maximum galling (27).

The highest numbers of J2 were in squash and buckwheat roots. All plant species except amaranth and sesame supported reproduction of *Pratylenchus brachyurus* (Godfrey) Goodey. Lowest numbers of *M. arenaria* in soil were in pots with partridge pea or the amaranths (Table 4). Soil population densities of *P. brachyurus* were low or nonexistent in all soils.

Field study: Soil from plots with castor bean, cotton, jointvetch, or partridge pea had few *M. arenaria* J2, whereas peanut had large population densities of the nematode (Table 5). Application of aldicarb reduced *M. arenaria* J2 population densities in soil and increased peanut yield. Dry forage yields for jointvetch or partridge pea were about 7 t/ha. Castor beans were not harvested because of frost damage. Low sesame yields were obtained because of inadequacies in harvesting equipment and knowledge of the crop.

DISCUSSION

American jointvetch, castor bean, partridge pea, and sesame have potential for use in the management of *M. arenaria.* Jointvetch and partridge pea are used as forage (3); the protein content of green forage from these crops is comparable to that of other forage legumes. There is also the possibility of using these legumes for grazing purposes. Jointvetch and partridge pea produce high tonnage of organic matter and would be suitable as green manures. Castor bean was grown experimentally in Alabama (23). The nematicidal properties of the oil cake from this crop were demonstrated in India (13). In Alabama, however, there are currently few possibilities for development of the crop because demand for the oil is low and the oil meal (or cake) is toxic to cattle.

TABLE 4. Nematode population densities per 100 cm^3 soil from a greenhouse experiment with several crops planted in peanut field soil infested with *Meloidogyne arenaria.*

Host	*M. arenaria* juveniles	*Pratylenchus brachyurus*
Squash	95	8
Buckwheat	24	1
Catjang pea	19	20
Guar	24	13
Partridge pea	0	0
White amaranth	0	0
Purple amaranth	0	0
Mixed amaranth	0	0
Baco sesame	2	0
Oro sesame	4	0
Oro Benne sesame	10	0
Paloma sesame	2	0
LSD (P = 0.05)	17	N.S.

TABLE 5. Yields of peanut and other crops and their effects on *Meloidogyne arenaria* in a field experiment at Wiregrass substation, near Headland, Alabama.

	Juveniles/100 cm^3 soil	Yield (kg/ha)
Peanut (−)†	120	2,333‡
Peanut (+)†	28	2,522
Castor bean	1	
Jointvetch	1	6,949
Partridge pea	0	7,173
Sesame	2	263
Cotton	0	1,694
LSD (P = 0.05)	78	

† (+) = aldicarb (3.4 kg a.i./ha, 25-cm band) at plant. (−) = no treatment.
‡ Differences for peanut yields were significant (P = 0.05).

Sesame grew well and did not support *M. arenaria* development in the field. Similar observations were made in Venezuela (7) where sesame fields contained low numbers of *Meloidogyne* spp. All the sesame cultivars tested in the greenhouse were nonhosts for *M. arenaria.* Some damage caused by pod-feeding insects was observed in the field, but it was minor and could be controlled easily with insecticide applications. Market possibilities for sesame in the United States are good at present because it is mostly imported (25). Although most sesame cultivars are of the shattering type, which makes mechanical harvesting difficult, there are a few nonshattering sesame cultivars and breeding lines that can be harvested mechanically.

Literature Cited

1. Alabama Cooperative Extension Service. 1988. Alabama pesticide handbook. Circular ANR-500, Auburn University, Auburn, AL.

2. Everest, J. W., A. K. Hagan, and J. C. French. 1986. Peanut pest management. Circular ANR-360, Alabama Cooperative Extension Service, Auburn University, Auburn, AL.

3. Heath, M. E., D. S. Metcalfe, and R. F. Barnes. 1973. Forages. Ames: Iowa State University Press.

4. Kinloch, R. A. 1982. The relationship between soil populations of *Meloidogyne incognita* and yield reduction of soybean in the Coastal Plain. Journal of Nematology 14:162–167.

5. Kinloch, R. A. 1980. Control of nematodes injurious to soybean. Nematropica 10:141–153.

6. Kinloch, R. A. 1974. Response of soybean cultivars to nematicide treatments of soil infested with *Meloidogyne incognita.* Journal of Nematology 6:7–11.

7. Meredith, J. A., and G. Perez N. 1975. Generos de nematodos fitoparasitos asociados al cultivo de ajonjoli (*Sesamum indicum* L.) en Venezuela. Nematropica 5:44–46.

8. Minton, N. A., M. B. Parker, O. L. Brooks, and C. E. Perry. 1976. Evaluation of nematicides for control of nematodes in soybeans. Research Bulletin No. 189, University of Georgia Agricultural Experiment Station, Athens.

9. Pearson, A. M. 1950. Food crops for game birds on farm lands. Circular No. 90, Alabama Agricultural Experiment Station, Auburn University, Auburn, AL.

10. Rodríguez-Kábana, R., and H. Ivey. 1986. Crop rotation systems for the management of *Meloidogyne arenaria* in peanut. Nematropica 16:53–63.

11. Rodríguez-Kábana, R., H. Ivey, and P. A. Backman. 1987. Peanut-cotton rotations for the management of *Meloidogyne arenaria.* Journal of Nematology 19:484–486.

12. Rodríguez-Kábana, and P. S. King. 1985. Evaluations of selected nematicides for control of *Meloidogyne arenaria* in peanut: A multi-year study. Nematropica 15:155–164.

13. Rodríguez-Kábana, R., G. Morgan-Jones, and I. Chet. 1987. Biological control of nematodes: Soil amendments and microbial antagonists. Plant and Soil 100:237–247.

14. Rodríguez-Kábana, R., and M. H. Pope. 1981. A simple incubation method for the extraction of nematodes from soil. Nematropica 11:175–186.

15. Rodríguez-Kábana, R., D. G. Robertson, P. S. King, and C. F. Weaver. 1987. Evaluation of nematicides for control of root-knot and cyst nematodes on a tolerant soybean cultivar. Nematropica 17:61–70.

16. Rodríguez-Kábana, R., and J. T. Touchton. 1984. Corn and sorghum as rotational crops for management of *Meloidogyne arenaria* in peanut. Nematropica 14:26–36.

17. Rodríguez-Kábana, R., C. F. Weaver, D. G. Robertson, and E. L. Snoddy. 1986. Population dynamics of *Meloidogyne arenaria* juveniles in a field with Florunner peanut. Nematropica 16:185–196.

18. Rodríguez-Kábana, R., and J. C. Williams. 1981. Soybean yield losses caused by *Meloidogyne arenaria* and *Heterodera glycines* in a field infested with the two parasites. Nematropica 11:93–104.

19. Rodríguez-Kábana, R., J. C. Williams, and R. A. Shelby. 1982. Assessment of peanut yield losses caused by *Meloidogyne arenaria.* Nematropica 12:278–287.

20. Sasser, J. N., and C. C. Carter. 1982. Root-knot nematodes (*Meloidogyne* spp.): Identification, morphological and physiological variation, host range, ecology, and control. Pp. 21–32 *in* R. D. Riggs, ed. Nematology in the southern region of the United States. Southern Cooperative Series Bulletin 276, Arkansas Agricultural Experiment Station, Fayetteville.

21. Schmitt, D. P. 1985. Plant-parasitic nematodes associated with soybeans. Pp. 541–546 *in* R. M. Shibles, ed. World soybean research conference III proceedings. Boulder, CO: Westview Press.

22. Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. New York: McGraw-Hill.

23. Sturkie, D. G. 1950. Experiments with oil crops. Bulletin No. 277, Alabama Agricultural Experiment Station, Auburn University, Auburn, AL.

24. Trivedi, P. C., and K. R. Barker. 1986. Management of nematodes by cultural practices. Nematropica 16:213–236.

25. United States Department of Agriculture. 1987. Foreign agriculture trade of the United States (FATUS). January–February Issue, Economic Research Service. Washington, DC: Government Printing Office.

26. Weaver, D. G., R. Rodríguez-Kábana, and E. L. Carden. 1988. Multiple-species nematode resistance in soybean: Effect of genotype and fumigation on yield and nematode numbers. Crop Science 28: 293–298.

27. Zeck, W. M. 1971. A rating scheme for field evaluation of root-knot nematode infestations. Pflanzenschutz-Nachrichten 24:141–144.