Supplement to Journal of Nematology 23(4S):652–657. 1991.
© The Society of Nematologists 1991.

Cotton as a Rotation Crop for the Management of *Meloidogyne arenaria* and *Sclerotium rolfsii* in Peanut

R. Rodríguez-Kábana,[1] D. G. Robertson,[1] L. Wells,[2]
C. F. Weaver,[1] and P. S. King[1]

Abstract: The value of cotton (*Gossypium hirsutum* cv. Deltapine 90) in rotation with peanut (*Arachis hypogaea* cv. Florunner) for the management of root-knot nematode (*Meloidogyne arenaria*) and southern blight (*Sclerotium rolfsii*) was studied for 6 years in a field at the Wiregrass Substation in southeast Alabama. Peanut yields following either 1 or 2 years of cotton (C-P and C-C-P, respectively) were higher than those of peanut monoculture without nematicide [P(−)]. At-plant application of aldicarb to continuous peanut [P(+)] averaged 22.1% higher yields than those for P(−) over the 6 years of the study. The use of aldicarb in cotton and peanut in the C-C-P rotations increased yields of both crops over the same rotations without the nematicide. When the nematicide was applied to both crops in the C-P rotation, peanut yields were increased in only two of the possible three years when peanut was planted. Application of aldicarb to cotton only in the C-P rotation did not improve peanut yields over those obtained with the rotation without nematicide. Juvenile populations of *M. arenaria* determined at peanut-harvest time were lowest in plots with cotton. Plots with C-P or C-C-P had lower populations of the nematode than those with either P(−) or P(+). The incidence of southern blight (*Sclerotium rolfsii*) in peanut was lower in plots with the rotations than in those with peanut monoculture. Aldicarb application had no effect on the occurrence of southern blight.

Key words: chemical control, crop rotation, *Meloidogyne arenaria*, nematicide, nematode, pest management, root-knot nematode, *Sclerotium rolfsii*, southern blight.

Damage caused by the root-knot nematode *Meloidogyne arenaria* race 1 is one of the principal yield-limiting factors in peanut (*Arachis hypogaea*) in Alabama and other areas of the southeastern United States (4,7,9). The nematode is present in 40% of the peanut fields in Alabama, and approximately 12% of the fields are so heavily infested that production is not possible without management of the pest (4). There is an inverse relationship between peanut yields and the number of juveniles of *M. arenaria* in the soil (21). Traditional strategies for the management of the nematode in the southeastern United States have been based on the use of nematicides and on rotation with crops that are either nonhost or that are poorer hosts than peanut (11,14–19,23). This management approach was determined by the availability of inexpensive and effective nematicides (DBCP, EDB) and by the lack of commercial peanut cultivars resistant or tolerant to *M. arenaria*. The elimination of DBCP and EDB for use in peanut has left the producer with relatively few available nematicides (1,3,13). In addition, the current cost of nematicide application is too high (U.S.$60–80/ha) for production of peanut without governmental subsidies. Sources of resistance to *M. arenaria* are few, and there is little prospect for commercially acceptable resistant peanut cultivars in the near future (5). Management strategies based on crop rotations are at present the only viable long-term solution to nematode problems in peanut. We have studied the value of corn (*Zea mays*), sorghum (*Sorghum bicolor*), bahiagrass (*Paspalum notatum*), and other crops in rotation with peanut for suppression of *M. arenaria* (11,14–19). A preliminary study on the value of rotation of cotton (*Gossypium hirsutum*) with peanut indicated good potential for development of effective and profitable rotations useful for the management of *M. arenaria* (12) because cotton is a non-host of *M. arenaria* (22). This paper presents a more comprehensive study of the value of sev-

---

Received for publication 4 March 1991.

[1] Professor, Research Associate, Research Associate, and Research Technician, respectively, Department of Plant Pathology, Auburn University, Auburn, AL 36849.

[2] Assistant Superintendent, Wiregrass Substation, Headland, AL 36345.

eral peanut–cotton rotations for management of *M. arenaria*.

Material and Methods

The efficacy of cotton cv. Deltapine 90 in rotation with peanut cv. Florunner for the management of *M. arenaria* was studied in an experiment at the Wiregrass Substation, near Headland, Alabama. The experiment was started in 1985 in an essentially flat field with a center pivot irrigation system. The field has been in peanut monoculture and winter fallow for at least a decade. The soil was a sandy loam with pH = 6.2, organic matter content < 1.0% (w/w), and cation exchange capacity < 10 meq/100 g soil. The field was heavily infested (> 200 juveniles/100 cm^3 soil at peanut harvest time) with the nematode. The eight treatments in the experiment consisted of peanut in monoculture and in several rotations with cotton, all with and without application of nematicide. The nematicide application was performed at planting with aldicarb in a 20-cm-wide band at a rate of 30.5 g a.i./100 m of row. The row width was 91 cm, so that this rate was equivalent to 15.3 kg a.i./ha on a broadcast basis. The nematicide granules were lightly incorporated (2–3 cm) into the soil by means of spring-activated tines attached to the planting equipment.

A plot (experimental unit) was eight rows wide and 10 m long. Eight cropping systems (treatments) were replicated eight times in a randomized complete block design.

Cultural practices and control of insects, foliar diseases, and weeds for the two crops were according to recommendations for the area (1–3). The field was irrigated as needed. Yield was obtained each year by harvesting the two center rows of each plot.

Soil samples for nematode assay were collected from each plot every year one to two weeks before peanut harvest (late August to mid September) to coincide with the period of maximal juvenile population development of *M. arenaria* (20). A sample consisted of 16 to 20 soil cores obtained in zig-zag fashion at 0.5-m intervals along the two center rows of a plot using a 2.5-cm-d probe. The cores were collected from the root zone to a depth of 20–25 cm. The cores from a plot were composited and a 100-cm^3 subsample was used to determine nematode numbers with the "salad bowl" incubation technique (8).

The incidence of southern blight caused by *Sclerotium rolfsii* in peanut was estimated on the last year of the experiment by counting the number of disease loci ("hits") in the center two rows of plots immediately after digging and inverting the peanut plants. A "hit" is defined as a length of row ≤ 30 cm with plants killed by the fungus (10).

All data were analyzed following standard procedures for analysis of variance (6), and Fisher's least significant differences (FLSD) were calculated for separation of means. Unless otherwise stated, all differences referred to in the text were significant at $P \leq 0.05$.

Results and Discussion

Juvenile populations of *M. arenaria* in soil were lowest in plots with cotton, a nonhost (Table 1). Application of aldicarb had no effect on juvenile populations in this crop. Applications of nematicide reduced numbers of juveniles in plots with continuous peanut in only one year (1986) of the study. Plots with peanut following 1 or 2 years of cotton had lower populations of the nematode than those under continuous peanut. The application of aldicarb to cotton had little effect on nematode populations in the succeeding peanut crop. In 1990 and in plots in which peanut alternated with cotton for 1 year each, treatments with aldicarb had lower juvenile populations than those with the same cropping system but without nematicide. Application of aldicarb to peanut after 2 years of cotton had no effect on *M. arenaria* juvenile populations when compared to plots with the same cropping sequence but without nematicide.

The incidence of southern blight was lower in plots with the rotations than in those with peanut monoculture (Table 2).

TABLE 1. Effect of cropping systems with peanut (P) and cotton (C) on end-of-season juvenile populations of *Meloidogyne arenaria* in a field experiment at the Wiregrass Substation, near Headland, Alabama.

Cropping sequence and year†						Juveniles per 100 cm³ soil					
1985	1986	1987	1988	1989	1990	1985	1986	1987	1988	1989	1990
P(−)	P(−)	P(−)	P(−)	P(−)	P(−)	579	72	144	97	155	283
P(+)	P(+)	P(+)	P(+)	P(+)	P(+)	539	15	281	84	151	226
C(−)	P(−)	C(−)	P(−)	C(−)	P(−)	5	41	1	59	2	128
C(+)	P(−)	C(+)	P(−)	C(+)	P(−)	10	23	5	17	6	128
C(−)	P(+)	C(−)	P(+)	C(−)	P(+)	24	15	2	69	7	68
C(+)	P(+)	C(+)	P(+)	C(+)	P(+)	6	10	7	47	5	59
C(−)	C(−)	P(−)	C(−)	C(−)	P(−)	15	16	24	8	6	88
C(+)	C(+)	P(+)	C(+)	C(+)	P(+)	14	12	65	11	4	50
				FLSD ($P = 0.05$):		153	26	116	43	47	114

† (−) = without nematicide; (+) = with at-plant application of aldicarb at 30.5 g a.i./100 m row in a 20-cm-wide band.

Aldicarb had no effect on the occurrence of southern blight, and there were no differences in the incidence of this disease between plots that had been with cotton for 1 or 2 years before.

Peanut yields in 1985 in plots with aldicarb were 3,689 kg/ha, 16.2% higher than the yields from the untreated control (Table 3). Seed cotton yields the same year in untreated plots averaged 2,830 kg/ha, and in plots with aldicarb, the average was 3,391 kg/ha (a 19.8% yield increase). Except for one year (1986), peanut yield response to aldicarb treatment in monocultured plots was positive. The increase varied from 16.2% to 35.0%, averaging 22.1% over the 6 years of the study. Peanut yields following 2 years of cotton (C-C-P) were higher than the yields obtained with the monocultured peanut. When cotton and peanut were treated with aldicarb in these rotations [C(+)-C(+)-P(+)], peanut yields were higher than in plots with the same rotation but without the nematicide. Cotton yields in the C-C-P rotations were generally improved by aldicarb application; C(+)-C(+)-P(+) plots yielded 26% more cotton than those with C(−)-C(−)-P(−).

TABLE 2. Effect of various cropping systems with peanut (P) and cotton (C) on the incidence of *Sclerotium rolfsii* in peanut at the end of a 6-year experiment in a field at the Wiregrass Substation, near Headland, Alabama.

Cropping sequence and year†						Loci per 100 m row‡
1985	1986	1987	1988	1989	1990	
P(−)	P(−)	P(−)	P(−)	P(−)	P(−)	137
P(+)	P(+)	P(+)	P(+)	P(+)	P(+)	145
C(−)	P(−)	C(−)	P(−)	C(−)	P(−)	110
C(+)	P(−)	C(+)	P(−)	C(+)	P(−)	89
C(−)	P(+)	C(−)	P(+)	C(−)	P(+)	96
C(+)	P(+)	C(+)	P(+)	C(+)	P(+)	100
C(−)	C(−)	P(−)	C(−)	C(−)	P(−)	90
C(+)	C(+)	P(+)	C(+)	C(+)	P(+)	84
			FLSD ($P = 0.05$):			25

† (+) = with at-plant application of aldicarb at 30.5 g a.i./100 m row in a 20-cm-wide band.

‡ Number of disease loci ("hits") of ≤ 30 cm per 100 m of row.

Except for one year (1988), peanut yields following 1 year of cotton (C-P) were higher than those for monoculture without nematicide. Application of aldicarb to cotton in the C-P rotation did not improve peanut yields over the yields obtained with the C(−)-P(−) rotation. When the nematicide was applied to peanut in these rotations, [C(−)-P(+) and C(+)-P(+)], only the C(+)-P(+) rotation resulted in increased peanut yields over the C(−)-P(−) rotation (and only for 1988).

Results, confirming those of our earlier study (12), showed that cotton can be used as a rotation crop with peanut to suppress *M. arenaria*. Cotton is a non-host for *M. arenaria* (22), a fact that was evident in all the rotation systems of this study in the years when cotton was planted; final populations of *M. arenaria* juveniles in plots

TABLE 3. Relation between yields of peanut (P) and of cotton (C) and the cropping sequence followed in an experiment at the Wiregrass Substation, near Headland, Alabama, in a field infested with *Meloidogyne arenaria*.

Cropping sequence and year†						Yield (kg/ha)‡					
1985	1986	1987	1988	1989	1990	1985	1986	1987	1988	1989	1990
P(−)	P(−)	P(−)	P(−)	P(−)	P(−)	3,173	2,929	1,383	1,899	2,061	1,546
P(+)	P(+)	P(+)	P(+)	P(+)	P(+)	3,689	3,200	1,817	2,495	2,577	2,088
C(−)	P(−)	C(−)	P(−)	C(−)	P(−)	[2,794]	3,499	[1,654]	1,573	[1,437]	2,235
C(+)	P(−)	C(+)	P(−)	C(+)	P(−)	[3,689]	3,499	[2,061]	1,736	[2,414]	2,685
C(−)	P(+)	C(−)	P(+)	C(−)	P(+)	[2,821]	3,363	[1,790]	2,088	[1,465]	2,659
C(+)	P(+)	C(+)	P(+)	C(+)	P(+)	[3,038]	3,689	[2,088]	2,360	[2,197]	2,712
C(−)	C(−)	P(−)	C(−)	C(−)	P(−)	[2,875]	[1,844]	2,088	[1,329]	[1,220]	2,820
C(+)	C(+)	P(+)	C(+)	C(+)	P(+)	[3,445]	[1,899]	2,495	[1,844]	[1,980]	3,417
					FLSD ($P = 0.05$):	489 [320]	409 [377]	336 [342]	404 [478]	469 [561]	507

† (−) = without nematicide; (+) = with at-plant application of aldicarb at 30.5 g a.i./100 m row in a 20-cm-wide band.

‡ Yield and FLSD values in brackets are for cotton; values without brackets are for peanut.

with cotton were never significantly different from zero. The value of the suppressive effect of cotton on *M. arenaria* is best assessed by considering the effect of the crop on final juvenile populations of the nematode in the peanut crop following cotton. Populations of *M. arenaria* juveniles in peanut following cotton were lower than in plots with peanut monoculture. It is important to note that the application of aldicarb to peanut in the monoculture system reduced final juvenile populations in only 1 of the 6 years of the study. This contrasts with the suppressive effect of cotton on *M. arenaria* and suggests that reliance on nematicide application as the sole means for management of the nematode is not the best way to solve the root-knot problem in peanut. Peanut yields may be increased by aldicarb application in the monoculture system, but *M. arenaria* populations are not suppressed.

Our results also indicate that the value of a rotation system with cotton extends beyond the suppressive effect of cotton on *M. arenaria*. The incidence of southern blight in plots with cotton–peanut rotations was lower than in those with peanut monoculture. The monoculture system can be expected to lead to increased pathogen inoculum and decline in yields. This is probably true not only for *S. rolfsii* but also for other peanut pathogens. Thus, peanut yields (Y) in the monoculture system declined as the number of years in peanut monoculture (X) increased. For the P(−) system, this decline was predictable ($r^2 = 0.65$; $P \leq 0.05$; df = 46) by:

$$Y = 3{,}152 - 900(\ln [X])$$

and for the P(+) system ($r^2 = 0.64$; $P \leq 0.01$; d.f. = 46) by:

$$Y = 3{,}561 - 836(\ln [X])$$

indicating that (Fig. 1) the application of nematicide was ineffective in stopping the downward trend in yields for the monoculture system.

The increase in peanut yields obtained in response to cotton rotation cannot be attributed solely to suppression of *M. arenaria*. We interpret increases in yield as the integration of the suppressive effects of the rotation systems on several major and minor peanut pathogens. This is supported by our data on southern blight. The number of "hits"/100 m of row (H; Table 2) was inversely related ($r^2 = 0.81$; $P \leq 0.01$; df = 62) to peanut yield (Y) in 1990 (Table 3) by:

$$Y = 4{,}787 - 21.3H$$

or a yield loss of 21.3 kg/hit on a per ha basis. The data for 1990 also illustrate the close interactive effect between *M. arenaria* and *S. rolfsii* on peanut yields. Thus, al-

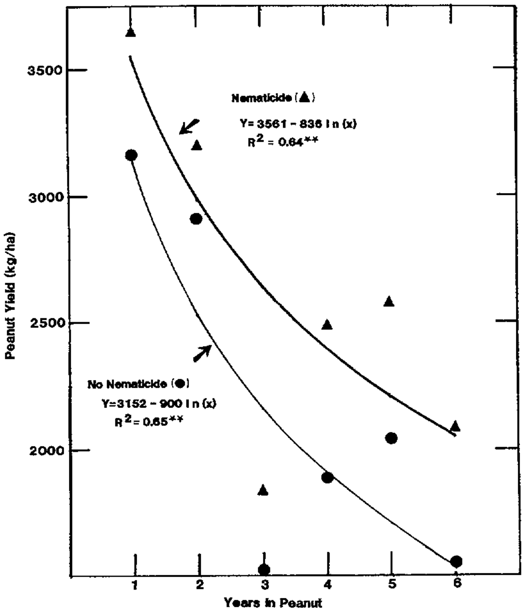

FIG. 1. Effect of monoculture with and without nematicide (aldicarb) treatment on peanut yields in a field infested with *Meloidogyne arenaria* at the Wiregrass Substation in southeast Alabama. Only mean values are shown for each year, but data for eight replications each season were included in calculations of equations and r^2 values (df = 46).

though the relation between peanut yields and numbers of *M. arenaria* juveniles (J) could be described ($r^2 = 0.81$; $P \leq 0.01$; df = 62, Tables 1, 3) by:

$$Y = 3{,}289 - 6.0J,$$

there was also a strong ($r^2 = 0.79$; $P \leq 0.01$; df = 62) association between numbers of *M. arenaria* juveniles in the soil and the numbers of southern blight hits described (Tables 2, 3) by:

$$H = 75.3 + 0.2J,$$

indicating that the number of hits increased as *M. arenaria* populations increased. This association suggests a possible interactive role of *M. arenaria* in determining the degree of damage caused by other pathogens (7,9).

Application of aldicarb to cotton resulted in increased yields. Because *M. arenaria* is not a cotton pathogen, increased yields must be the result of insect control or other effects of this systemic nematicide–insecticide on the crop (1).

An important aspect in the evaluation of rotation systems for the management of phytonematodes is the dollar value or economic return of each system compared with peanut monoculture. The effect of the different cropping systems of the study on net returns is shown (Table 4) for the peanut crop of 1990, the year when all plots were with peanut. Calculations were based on current prices of U.S.$701/ton for quota (subsidized) peanut and $358/ton for world market price (additionals). The cost of production for peanut without nematicide treatment was set at $1,307.32/ha and at $1,391.30/ha with aldicarb application. These calculations show a clear economic advantage for the use of rotations over the monoculture systems. Production of pea-

TABLE 4. Effect of several production systems with cotton (C) and peanut (P) on the net economic return from the 1990 peanut crop based on current prices for subsidized and world market price for peanut.

Cropping sequence and year†						Net return/ha in U.S. $‡	
1985	1986	1987	1988	1989	1990	World price	Subsidized
P(−)	P(−)	P(−)	P(−)	P(−)	P(−)	−136.72	−90.50
P(+)	P(+)	P(+)	P(+)	P(+)	P(+)	14.97	29.32
C(−)	P(−)	C(−)	P(−)	C(−)	P(−)	53.65	105.05
C(+)	P(−)	C(+)	P(−)	C(+)	P(−)	118.87	232.76
C(−)	P(+)	C(−)	P(+)	C(−)	P(+)	97.74	191.38
C(+)	P(+)	C(+)	P(+)	C(+)	P(+)	105.42	206.43
C(−)	C(−)	P(−)	C(−)	C(−)	P(−)	138.43	271.07
C(+)	C(+)	P(+)	C(+)	C(+)	P(+)	207.60	406.51

† (−) = without nematicide; (+) = with at-plant application at aldicarb at 30.5 g a.i./100 m row in a 20-cm-wide band.
‡ Calculations based on a production cost of U.S.$1,307/ha without aldicarb and U.S.$1,391/ha with aldicarb, and prices of $701/ton and $358/ton for subsidized and world market peanut, respectively.

nut using the monoculture system is not competitive but it is profitable with any of the rotation systems.

LITERATURE CITED

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

2. Cope, J. T., C. E. Evans, and H. C. Williams. 1981. Soil test fertilizer recommendations for Alabama soils. Circular 252, Agricultural Experiment Station, Auburn University, Auburn, Alabama.

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

4. Ingram, E. G., and R. Rodríguez-Kábana. 1980. Nematodes parasitic of peanuts in Alabama and evaluation of methods for detection and study of population dynamics. Nematrópica 10:21–30.

5. Minton, N. A., and R. O. Hammons. 1975. Evaluation of peanut for resistance to the peanut root-knot nematode, *Meloidogyne arenaria.* Plant Disease Reporter 59:944–945.

6. Little, T. M., and F. H. Hills. 1978. Agricultural experimentation. New York: John Wiley and Sons.

7. Porter, M. D., D. H. Smith, and R. Rodríguez-Kábana, eds. 1984. Compendium of peanut diseases. The Disease Series of the American Phytopathological Society. St. Paul, MN: APS Press.

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

9. Rodríguez-Kábana, R. 1982. Diseases caused by nematodes. Pp. 378–410 *in* H. E. Pattee and C. T. Young, eds. Peanut diseases. Yoakum, TX: American Peanut Research and Education Society.

10. Rodríguez-Kábana, R., P. A. Backman, and J. C. Williams. 1975. Determination of yield losses to *Sclerotium rolfsii* in peanut fields. Plant Disease Reporter 59:855–858.

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

12. 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.

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

14. Rodríguez-Kábana, R., P. S. King, D. G. Robertson, and C. F. Weaver. 1988. Potential of crops uncommon to Alabama for management of root-knot and soybean cyst nematodes. Supplement to the Journal of Nematology 20:116–120.

15. Rodríguez-Kábana, R., D. G. Robertson, P. A. Backman, and H. Ivey. 1988. Soybean–peanut rotations for the management of *Meloidogyne arenaria.* Supplement to the Journal of Nematology 20:81–85.

16. Rodríguez-Kábana, R., D. G. Robertson, L. Wells, P. S. King, and C. F. Weaver. 1989. Crops uncommon to Alabama for the management of *Meloidogyne arenaria* in peanut. Supplement to the Journal of Nematology 21:712–716.

17. Rodríguez-Kábana, R., D. G. Robertson, L. Wells, and R. W. Young. 1988. Hairy indigo for the management of *Meloidogyne arenaria* in peanut. Nematrópica 18:137–142.

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

19. Rodríguez-Kábana, R., C. R. Weaver, D. G. Robertson, and H. Ivey. 1988. Bahiagrass for the management of *Meloidogyne arenaria* in peanut. Supplement to the Journal of Nematology 20:110–114.

20. 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. Nematrópica 16:185–196.

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

22. Sasser, J. N. 1979. Pathogenicity, host ranges and variability of *Meloidogyne.* Pp. 256–268 *in* F. Lamberti and C. E. Taylor, eds. Root-knot nematodes (*Meloidogyne* species): Systematics, biology and control. New York: Academic Press.

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