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Bahiagrass, Corn, Cotton Rotations, and Pesticides for Managing Nematodes, Diseases, and Insects on Peanut[1]

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Abstract: Florunner peanut was grown after 1 and 2 years of Tifton 9 bahiagrass, corn, cotton, and continuous peanut as whole-plots. Pesticide treatments aldicarb (3.4 kg a.i./ha), flutolanil (1.7 kg a.i./ha), aldicarb + flutolanil, and untreated (control) were sub-plots. Numbers of *Meloidogyne arenaria* second-stage juveniles in the soil and root-gall indices of peanut at harvest were consistently lower in plots treated with aldicarb and aldicarb + flutolanil than in flutolanil-treated and untreated plots. Percentages of peanut leaflets damaged by thrips and leafhoppers were consistently greater in flutolanil-treated and untreated plots than in plots treated with aldicarb or aldicarb + flutolanil but not affected by cropping sequences. Incidence of southern stem rot was moderate to high for all chemical treatments except those that included flutolanil. Stem rot loci were low in peanut following 2 years of bahiagrass, intermediate following 2 years of corn or cotton, and highest in continuous peanut. *Rhizoctonia* limb rot was more severe in the peanut monoculture than in peanut following 2 years of bahiagrass, corn, or cotton. Flutolanil alone or combined with aldicarb suppressed limb rot compared with aldicarb-treated and untreated plots. Peanut pod yields were 4,186 kg/ha from aldicarb + flutolanil-treated plots, 3,627 kg/ha from aldicarb-treated plots, 3,426 kg/ha from flutolanil-treated plots, and 3,056 kg/ha from untreated plots. Yields of peanut following 2 years of bahiagrass, corn, and cotton were 29% to 33% higher than yield of monocultured peanut.

Key words: *Arachis hypogaea,* bahiagrass, corn, cotton, *Criconemella ornata,* crop rotation, *Frankliniella* spp., fungicide, *Gossypium hirsutum,* management, *Meloidogyne arenaria,* monocrop, nematicide, nematode, *Paspalum notatum,* peanut, population dynamics, *Rhizoctonia solani,* ring nematode, root-knot nematode, *Sclerotium rolfsii,* thrips, *Zea mays.*

Peanut (Arachis *hypogeae* L.) is damaged by many nematode species (Dickson, 1998; Minton, 1984; Minton and Baujard, 1990). *Meloidogyne arenaria* (Neal) Chitwood race 1 is recognized as the most important nematode pathogen of peanut in the southeastern United States (Rodríguez-Kábana, 1982; Rodríguez-Kábana et al., 1988; Sasser, 1979; Sturgeon, 1986). In fields heavily infested with *M. arenaria,* large areas of plants often die. In Alabama, Georgia, Florida, and Texas, as many as 40% of the peanut fields are infested with this pathogen (Sturgeon, 1986). Losses in heavily infested fields may exceed 50%; however, infestations in most fields are unevenly distributed and average yield losses are usually less than 50% (Minton, 1984).

In addition to crop damage directly attributable to nematode pathogenesis, *M. arenaria* is frequently involved in disease complexes with *Sclerotium rolfsii* Sacc., the causal agent of southern stem rot, and *Rhizoctonia solani* Kühn Ag-4, the causal agent of limb rot (Brenneman et al., 1995; Porter et al., 1984; Rodríguez-Kábana et al., 1975; Starr et al., 1996). The single most damaging soilborne fungal pathogen to peanut in the southeastern United States is *S. rolfsii.* All commercially grown peanut cultivars are susceptible to this pathogen. Until recently, available fungicides were expensive and only partially effective in controlling *S. rolfsii.* The new fungicides tebuconazole, flutolanil, and azoxystrobin are effective against stem rot (Brenneman et al., 1995), but significant yield losses still sometimes occur. *Sclerotium rolfsii* is not readily controlled by crop rotation alone due to its extremely wide host range and ability to survive saprophytically in soil (Aycock, 1966; Umaerus, 1992), and short rotations can result in higher disease incidence (Brenneman et al., 1995).

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Crop rotation is one of the oldest and most important approaches for management of *M. arenaria* in peanut (Rodríguez-Kábana et al., 1987). Because effective chemical control methods are relatively expensive and subject to environmental constraints, and resistant peanut cultivars are not commercially available, crop rotation is widely recommended. Approximately 70% of Georgia peanuts are grown after 2 years or less of another crop (Brenneman et al., 1995). In an optimum rotation, the preceding crop suppresses population densities of the target pest and prevents damage to the next crop (Johnson, 1982). A lack of other profitable rotation crops disrupts crop rotations with peanut. Generally, the degree of control is based on the level of susceptibility and resistance of the crops involved and the sequences of cropping (Johnson, 1982; Trivedi and Barker, 1986). Choice of rotation crops is restricted because of the wide host range of *M. arenaria* and limited selections of profitable alternative crops when the target is *M. arenaria* (Taylor and Sasser, 1978).

Peanut should follow crops such as bahiagrass (*Paspalum notatum* Flüggé), Coastal bermudagrass (*Cynodon dactylon* (L.) Pers.), cotton (*Gossypium hirsutum* L.), or other crops that are poor or nonhosts for root-knot nematodes (Dickson and Hewlett, 1989; Johnson et al., 1998; Rodríguez-Kábana and Canullo, 1992; Rodríguez-Kábana et al., 1988, 1994). Pensacola bahiagrass is an improved perennial that is widely grown in the southeastern United States (Burton, 1989). Rotations of bahiagrass are effective in reducing damage to peanut by *M. arenaria* (Dickson and Hewlett, 1989; Norden et al., 1980; Rodríguez-Kábana et al., 1988, 1994), *S. rolfsii* (White et al., 1962; Rodríguez-Kábana et al., 1994), and *R. solani* AG-4 (Bell and Sumner, 1993). Field corn is marginally effective for managing root-knot nematode population densities but is better than continuous peanut or other good hosts of the nematode. Different cultivars of corn have different reactions to root-knot nematode infection (Windham and Williams, 1994). Cotton fits well in rotation with peanut in fields infested with *M. arenaria* race 1 and *M. incognita* race 3, since peanut is a nonhost of *M. incognita* and cotton is a nonhost of *M. arenaria* (Johnson et al., 1998; Rodríguez-Kábana et al., 1994).

Rotations usually enhance yield and quality of subsequent crops by several mechanisms, including reduction of nematode, disease, and other pest population densities (Curl, 1963; Nusbaum and Ferris, 1973). Crop rotation is also an important practice for general soil and resource conservation programs, particularly sod-based rotations (White et al., 1962).

The objective of this experiment was to determine the effects of cropping systems and selected pesticides on nematodes, soilborne fungal diseases, insects, and yield of peanut. This study was part of a large field experiment designed to determine the effects of cropping systems and chemical treatments on the management of plant-parasitic nematodes, soilborne fungal diseases, and insects and on the yields of peanut, cotton, corn, and bahiagrass. Only data related to peanut are reported.

Materials and Methods

The study was conducted from 1991 through 1996 on the Gibbs Farm at the Coastal Plain Experiment Station, Tifton, Georgia. The experimental area was planted to okra (*Hibiscus esculentus* L.) cultivar Clemson Spineless with no treatments applied in spring 1990 and hairy vetch (*Vicia villosa* Roth) in fall 1990. The soil was a Tifton loamy sand (fine-loamy, siliceous, thermic Plinthic Kandiudult; pH 6.1 to 6.3) naturally infested primarily with *M. arenaria* race 1, *M. incognita* race 3, *S. rolfsii,* and *R. solani* AG-4. The soil was turned 20 to 25 cm deep with a moldboard plow 1 week before planting peanut, cotton (*Gossypium hirsutum* L.), corn (*Zea mays* L.), and Pensacola bahiagrass. Seed beds were shaped 1.8 m wide and 10 to 15 cm high. Whole plots (11.0 m wide × 7.6 m long) consisted of six beds (four treated and two untreated borders) with two rows per bed. Fallow alleys (9.1 m) separated blocks of plots. All data were collected and recorded from the treated beds.

The experiment was a split-plot arrangement of a randomized complete-block design with four replicates. Rotation crops were Pensacola bahiagrass (B), peanut (P), corn (C), and cotton (Ct). Whole-plot treatments were cropping sequences as follows: B-B-P-B-B-P, B-P-B-B-P-B, P-B-B-P-B-B, C-C-P-C-C-P, C-P-C-C-P-C, P-C-C-P-C-C, Ct-Ct-P-Ct-Ct-P, Ct-P-Ct-Ct-P-Ct, P-Ct-Ct-P-Ct-Ct, P-P-P-P-P-P, C-C-C-C-C-C, and Ct-Ct-Ct-Ct-Ct-Ct. Cropping sequences were initiated so that a crop of bahiagrass, peanut, corn, and cotton was produced each year. Only data for peanut following two crops of bahiagrass, corn, cotton, and monocrop peanut (1993–1996) are included in this study. Subplots were crop-specific pesticide treatments as follows: peanut with aldicarb 15G at 3.4 kg a.i./ha, or flutolanil 50 WP at 1.7 kg a.i./ha, or aldicarb + flutolanil, or untreated (control); cotton with aldicarb 15G at 1.7 kg a.i./ha, or mepiquat-chloride at 0.03 kg a.i./ha or, aldicarb + mepiquat-chloride, or untreated (control); corn with ethoprop 10G at 2.5 kg a.i./ha, or terbufos 15G at 1.1 kg a.i./ha, or ethoprop + terbufos, or untreated (control). Bahiagrass received no treatment. Aldicarb was applied ahead of the planter in a 30-cm band for peanut and a 15-cm band for cotton. Flutolanil was applied to peanut in 124 liters of water/ha in split applications of 0.8 kg/ha each. The first application was 60 days after planting in a 30-cm band, and the second was broadcast 90 days after planting. Mepiquat-chloride was applied as a spray (574 ml in 3 liters of water/ha) at first bloom of cotton. Ethoprop was applied to corn in a 30-cm band ahead of the planter, and terbufos was applied in the corn seed furrow.

Florunner peanut (100 to 112 kg/ha), Georgia King cotton (11 to 12 kg/ha), and Asgrow RX 945 corn (18 to 19 kg/ha) were seeded in rows 0.91 m apart each year. Plots of Tifton 9 bahiagrass were seeded at 22.4 kg/ha during late winter or early spring. The herbicide 2,4-D amine was applied broadcast to bahiagrass plots at 2.2 kg a.i./ha to control broadleaf weeds. Cultural practices and weed control on peanut, cotton, and corn were according to recommendations for the area (Delaplane, 1991). Irrigation from a traveling gun was applied to all crops as needed.

Nematodes were sampled by taking 10 soil cores (2.5-cm diam. × 15 cm deep) from all plots at planting, midseason, and harvest each year. Soil samples from each plot were mixed thoroughly, and a 150-cm^3 subsample was processed by a centrifugal flotation method (Jenkins, 1964). The remaining samples were then air-dried and analyzed for pH, P, K, Ca, and Mg (Balaguravaiah et al., 1996). Fertilizers were applied to all crops according to the recommendations of the University of Georgia Cooperative Extension Service (Plank, 1989).

Thrips (*Frankliniella* spp.) and potato leafhopper (*Empoasca fabae* Harris) damage to peanut was visually estimated on 40 leaflets per plot in June of each year. Leaf spot was evaluated using the Florida 1-to-10 rating scale based on both disease incidence and defoliation, in which 1 = no disease and 10 = all plants killed by leaf spot (Chiteka et al., 1988). The peanut pods were dug, based on an optimum maturity index, and inverted. Stem rot incidence (number per 15.2 m of row where a disease locus represents one or more infected plants in 30 cm of row) and limb rot severity (visual estimate of the percentage of vines colonized by *Rhizoctonia solani* in six 0.6-m sections of linear row per plot) were rated immediately after digging. Roots, pods, and pegs of 10 randomly selected plants from each plot were examined and rated immediately after digging for percentage galled by *M. arenaria* on a 1-to-5 scale: 1 = no galling, 2 = 1% to 25%, 3 = 26% to 50%, 4 = 51% to 75%, and 5 = 76% to 100% (Barker et al., 1986). When the moisture content declined to ca. 14%, the pods were harvested with a combine, dried to ca. 8% moisture, and weighed. A 500-g pod sample was collected from each plot, cleaned to remove foreign material, shelled, and graded according to official Federal-State Inspection Service methods (U.S. Department of Agriculture, 1974). The percentages of total sound mature kernels (TSMK), immature kernels, and damaged kernels were calculated by weight.

TABLE 1. Effects of cropping sequences and chemical treatments on *Meloidogyne arenaria* second-stage juveniles (J2) in peanut at harvest during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	J2/150 cm^3 soil				
	Chemical treatment[a]				
Rotation[b]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	143	243	167	223	194 a
P-C-C-P	9	122	39	225	99 b
P-Ct-Ct-P	31	35	15	80	40 b
P-P-P-P	58	196	114	165	133 a
Treatment mean	60 B	149 A	84 B	173 A	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[b] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

Data collected each year were subjected to analysis of variance using the general linear model procedure (SAS Institute, Cary, NC). Means were separated using Duncan's multiple range test. Only significant ($P = 0.05$) differences are discussed unless stated otherwise.

RESULTS

Numbers of *M. arenaria* J2 in peanut plots at harvest were consistently lower in plots treated with aldicarb and aldicarb + flutolanil than in other plots (Table 1). Rotations with 2 years of corn and cotton followed by peanut were effective in suppressing *M. arenaria* population densities in the peanut crop.

Root-gall indices of peanut were lower following two crops of corn or cotton than bahiagrass or continuous peanut (Table 2). Aldicarb alone or combined with flutolanil consistently suppressed root-gall indices. Root-gall indices in untreated, monocropped peanut increased from 1.30 in 1994 to 2.30 in 1995 and 3.20 in 1996.

Percentages of peanut leaflets damaged by thrips and leafhoppers were not affected by cropping sequences but were consistently greater in flutolanil-treated and untreated

TABLE 2. Effects of cropping sequences and chemical treatments on *Meloidogyne arenaria* root-gall indices of peanut at harvest during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Root-gall index[a]				
	Chemical treatment[b]				
Rotation[c]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	1.75	2.20	1.78	2.28	2.00 a
P-C-C-P	1.25	1.53	1.23	1.73	1.44 b
P-Ct-Ct-P	1.18	1.28	1.13	1.58	1.29 b
P-P-P-P	1.60	1.88	1.40	2.53	1.85 a
Treatment mean	1.45 B	1.72 A	1.39 B	2.03 A	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] 1-to-5 scale: 1 = no galls, 2 = 1% to 25%, 3 = 26% to 50%, 4 = 51% to 75%, and 5 = 76% to 100% of pods and roots galled.

[b] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[c] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

TABLE 3. Thrips damage on peanut as affected by cropping sequences and chemical treatments during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Damaged leaflets (%)				
	Chemical treatment[a]				
Rotation[b]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	47	73	45	78	61 a
P-C-C-P	42	75	43	76	59 a
P-Ct-Ct-P	39	86	32	76	58 a
P-P-P-P	43	75	46	73	59 a
Treatment mean	43 B	77 A	42 B	76 A	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[b] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

plots than in plots treated with aldicarb or aldicarb + flutolanil (Tables 3,4).

Soilborne fungal diseases of peanut were affected by cropping sequences and chemical treatments. Incidence of southern stem rot was moderate to high for all chemical treatments except those that included flutolanil (Table 5). Stem rot loci were low in peanut following 2 years of bahiagrass, intermediate following 2 years of corn or cotton, and highest in the peanut monoculture.

Rhizoctonia limb rot severity was low to moderate each year. Mean data across years indicate that *Rhizoctonia* limb rot was more severe in the peanut monoculture than when peanut followed 2 years of bahiagrass, corn, or cotton (Table 6). Flutolanil alone or combined with aldicarb suppressed limb rot compared with aldicarb-treated and untreated plots. Plots treated with aldicarb had higher limb rot severity than untreated plots.

Although all plots of peanuts were sprayed with chlorothalonil (1.3 kg/ha) approximately every 14 days, low to moderate levels of leaf spot developed each year. The primary pathogen was *Cercospora arachidicola,* but *Cercosporidium personatum* was present near the end of the season. Leaf spot was more severe in peanut monoculture than in other cropping sequences but was not affected by chemical treatments (Table 7).

TABLE 4. Leafhopper damage on peanut as affected by cropping sequences and chemical treatments during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Leafhopper damage index[a]				
	Chemical treatment[b]				
Rotation[c]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	1.7	3.9	1.8	4.0	2.9 a
P-C-C-P	2.0	3.7	1.8	3.7	2.8 a
P-Ct-Ct-P	1.9	4.0	1.8	4.0	2.9 a
P-P-P-P	1.8	3.9	2.0	4.0	2.9 a
Treatment mean	1.8 B	3.9 A	1.8 B	3.9 A	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] 1-to-5 scale: 1 = no damage, 2 = 1% to 25%, 3 = 26% to 50%, 4 = 51% to 75%, and 5 = 76% to 100% leaf damage (discolored).

[b] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[c] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

TABLE 5. Effects of cropping sequences and chemical treatments on the incidence of southern stem rot of peanut, caused by *Sclerotium rolfsii* during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Stem rot loci[a]				
	Chemical treatment[b]				
Rotation[c]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	7.7	2.0	2.1	5.6	4.3 c
P-C-C-P	15.0	2.7	4.6	11.8	8.5 b
P-Ct-Ct-P	17.3	4.3	6.2	11.5	9.8 b
P-P-P-P	25.3	6.1	9.6	22.7	15.9 a
Treatment mean	16.3 A	3.8 B	5.6 B	12.9 A	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] Number of southern stem rot loci per 15.2 m of row, where a disease locus represents one or more infected plants in 30 cm of row.

[b] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[c] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

Yields of peanut varied each year, but the influence of cropping sequences and chemical treatments was similar among years. Peanut yields were consistently highest in the aldicarb + flutolanil-treated plots, intermediate in the aldicarb- and flutolanil-treated plots, and lowest in the untreated plots (Table 8). The yield increases over the untreated control were 19%, 12%, and 36%, respectively, for aldicarb, flutolanil, and aldicarb + flutolanil treatments. Yields of peanut following 2 years of bahiagrass, corn, and cotton were 29% to 33% higher than yield of monocultured peanut.

Immature kernels, TSMK, and damaged kernels are components of peanut quality. The percentages of immature kernels ranged from 10 to 12 and sound mature kernels from 66 to 69 among cropping sequences and chemical treatments. Neither percentage of immature kernels nor percentage of TSMK was affected by chemical treatments or cropping sequences (data not included). Percentage damaged kernels was less than 2% in all plots each year. Even though kernel damage was low, more occurred in the peanut monoculture than in other cropping sequences (Table 9). Also,

TABLE 6. Effects of cropping sequences and chemical treatments on *Rhizoctonia* limb rot of peanut during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Rhizoctonia limb rot[a]				
	Chemical treatment[b]				
Rotation[c]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	7.1	4.0	4.5	4.8	5.1 b
P-C-C-P	8.0	4.3	5.4	6.2	6.0 b
P-Ct-Ct-P	8.4	3.1	5.4	5.0	5.5 b
P-P-P-P	10.2	5.5	6.5	8.1	7.6 a
Treatment mean	8.4 A	4.2 C	5.5 C	6.0 B	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] Percentage of vines colonized by *Rhizoctonia solani* in 15.2 m of row.

[b] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[c] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

TABLE 7. Leaf spot ratings on peanut as affected by cropping sequences and chemical treatments during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Leaf spot index[a]				
	Chemical treatment[b]				
Rotation[c]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	2.8	3.1	2.7	3.0	2.9 a
P-C-C-P	2.7	2.9	2.9	2.9	2.9 a
P-Ct-Ct-P	2.7	3.1	2.8	2.8	2.8 a
P-P-P-P	4.1	4.2	4.1	4.3	4.2 b
Treatment mean	3.1 A	3.3 A	3.1 A	3.3 A	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] Florida 1-to-10 scale: 1 = no disease and 10 = plant death (Chiteka et al., 1988).

[b] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha. All plots were sprayed with chlorothalonil (1.3 kg a.i./ha) approximately every 14 days.

[c] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

less kernel damage occurred in plots treated with flutolanil and aldicarb + flutolanil than in aldicarb-treated and control plots.

Discussion

This study was conducted in a field in which initial population densities of *M. arenaria* and root-gall indices of peanut were low, probably explaining why root-gall indices in untreated, monocropped peanut increased during the experiment. The efficacy of aldicarb against *M. arenaria* J2 population densities in peanut plots at harvest was greater than that reported by Rodríguez-Kábana et al. (1987, 1988, 1991a, 1994). Culbreath et al. (1992) reported variable effects of aldicarb on *M. arenaria* J2 populations based on time of sampling. Nematicides often suppress nematode population densities 4 to 6 weeks after planting and result in increased yields but do not affect *M. arenaria* J2 population densities in the soil at harvest (Rodríguez-Kábana and King, 1985). Our results with aldicarb on *M. arenaria* agree with those reported by Minton et al. (1991).

Recently, *Pasteuria penetrans* Sayre & Starr, a bacterial parasite of nematodes, was ob-

TABLE 8. Effects of cropping sequences and chemical treatments on yield of peanut during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Peanut yield (kg/ha)				
	Chemical treatment[a]				
Rotation[b]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	4,025	3,584	4,462	3,387	3,865 a
P-C-C-P	3,759	3,554	4,307	3,336	3,739 a
P-Ct-Ct-P	3,899	3,584	4,306	3,352	3,785 a
P-P-P-P	2,824	2,980	3,667	2,157	2,907 b
Treatment mean	3,627 B	3,426 B	4,186 A	3,058 C	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[b] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

TABLE 9. Effects of cropping sequences and chemical treatments on percentage damaged kernels of peanut during a 6-year rotation experiment at Tifton, Georgia, 1991–1996.

	Damaged kernels (%)				
	Chemical treatment[a]				
Rotation[b]	Aldicarb	Flutolanil	Aldicarb + flutolanil	Untreated	Rotation mean
P-B-B-P	1.4	1.1	1.0	1.4	1.2 b
P-C-C-P	1.3	1.2	1.0	1.2	1.2 b
P-Ct-Ct-P	1.0	0.9	1.0	1.0	1.0 c
P-P-P-P	1.5	1.1	1.3	1.3	1.3 a
Treatment mean	1.3 A	1.1 B	1.1 B	1.2 A	

Data are means of four replications. Rotation means and treatment means followed by the same letter are not different ($P \leq 0.05$).

[a] Treatments were aldicarb 15G at 3.4 kg a.i./ha, flutolanil 50 WP at 0.8 kg a.i./ha, aldicarb + flutolanil, and untreated (control). Aldicarb was applied in a 31-cm-wide band at planting and incorporated 3 to 5 cm deep. Flutolanil was applied at 0.4 kg a.i./ha to peanut 70 days after planting in a 31-cm-wide band and 3 weeks later in 124 liters of water/ha.

[b] P = peanut, B = bahiagrass, C = corn, and Ct = cotton.

served on *M. arenaria* J2 in this study. This bacterium has been recognized as a suppressive agent for *M. arenaria* race 1 in peanut fields in Florida and Georgia (Dickson and Chen, 1996; Dickson et al., 1994; Minton and Sayre, 1989; Minton et al., 1991) and may account for the low nematode population densities and root-gall indices of peanut.

The efficacy of aldicarb on peanut leaflets damaged by leafhoppers and thrips agrees with results reported by Johnson et al. (1998) and Minton et al. (1991).

Frequently, both *S. rolfsii* and *M. arenaria* are found together in peanut fields. Incidence of southern stem rot varies each year based on inoculum levels, cropping sequences, and environmental conditions (Culbreath et al., 1992; Rodríguez-Kábana et al., 1991b, 1994). When *M. arenaria* population densities are reduced by nematicide applications or crop rotations, the incidence of southern blight also may be reduced (Rodríguez-Kábana et al., 1982, 1994). These field observations and other studies suggested that infection of peanut by M. arenaria increases the incidence of southern blight. However, Starr et al. (1996) were unable to demonstrate an interaction between *S. rolfsii* and *M. arenaria* in microplot experiments.

Culbreath et al. (1992) reported that aldicarb may have had a limited suppressive effect on southern stem rot. However, fungicidal effects of aldicarb on *S. rolfsii* have not been reported, and aldicarb had no effect on growth of *S. rolfsii* in vitro (Csinos, pers. comm.). Our results agree with earlier reports in which aldicarb did not suppress damage caused by *S. rolfsii* in peanut (Rodríguez-Kábana et al., 1991b, 1994). Disease severity of *Rhizoctonia* limb rot was increased by treatment with aldicarb, possibly as a result of the increased vegetative growth associated with reduced thrips and nematode damage.

Our data indicate that flutolanil applied to soil alone or in combination with aldicarb suppressed damage in peanut pods and roots caused by *S. rolfsii* and *R. solani.* Other studies have demonstrated the efficacy of flutolanil against *S. rolfsii* and *R. solani* (Culbreath et al., 1992; Brenneman et al., 1995).

Bahiagrass, cotton, and other crops have been used in rotation to suppress soilborne diseases in peanut (Brenneman et al., 1995; Rodríguez-Kábana et al., 1991a, 1991b, 1994). The largest yield increase and least damage may occur in peanut after 1 year in bahiagrass (Norden et al., 1980) or cotton (Rodríguez-Kábana et al., 1991b) but more frequently after 2 or more years in the rotated crop (Brenneman et al, 1995; Rodríguez-Kábana et al., 1994) compared with continuous peanut.

Leaf spot disease ratings remained low during the study period and were not affected by flutolanil treatments. These results support those reported by Brenneman et al. (1995) and Culbreath et al. (1992). Leaf spot was more severe in continuous peanut than in other cropping sequences. Brenneman et al. (1995) reported leaf spot severity was directly related to the number of years in peanut production.

Yield increases in peanut resulting from soil chemical treatments of aldicarb, flutolanil, and aldicarb + flutolanil and cropping sequences with peanut following 2 years of bahiagrass and cotton agree with those previously reported (Brenneman et al., 1995; Culbreath et al., 1992; Rodríguez-Kábana et al., 1987, 1988, 1991a, 1994) in fields infested with *M. arenaria, S. rolfsii,* and *R. solani*. Based on yield and other parameters, our data indicate that a C-C-P cropping sequence was as effective as B-B-P or Ct-Ct-P sequence. The increases in peanut yield and kernel quality obtained in response to the cropping sequences and chemical treatments were due to suppression of *M. arenaria,* thrips, leafhoppers, *S. rolfsii,* and *R. solani* population densities. Our data demonstrate the sustainable benefits and improved yield and quality from using two widely grown agronomic crops (corn or cotton) or a pasture crop (bahiagrass) in rotations with peanut combined with chemical treatments to manage root-knot nematodes and other pathogens and pests.

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