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Soybean–Peanut Rotations for the Management of *Meloidogyne arenaria*

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Abstract: Rotating soybean (*Glycine max* cv. Kirby) with peanut (*Arachis hypogaea* cv. Florunner) for managing *Meloidogyne arenaria* race 1 was studied for 3 years (1985–87) in a field near Headland, Alabama. Each year soybean plots had lower soil numbers of *M. arenaria* second-stage juveniles (J2) at peanut harvest than did plots in peanut monoculture. Peanut following either 1 or 2 years of soybean resulted in approximately 50% reduction in J2 soil population densities and a 14% (1-year soybean) or 20% (2-year soybean) increase in yields compared with continuous peanut. The soybean–peanut rotation increased peanut yield equal to or higher than the yield obtained with continuous peanut treated with aldicarb at 0.34 g a.i./m^2.
Key words: Arachis hypogaea, cultural practice, *Glycine max,* integrated pest management, *Meloidogyne arenaria,* nematode control, peanut, plant breeding, population dynamics, root-knot nematode, soybean.

Meloidogyne arenaria (Neal) Chitwood is one of the principal yield-limiting pests of peanut (*Arachis hypogaea* L.) in the southeastern United States (5,6,8,9,17). Its management is based on the use of nematicides (12) and rotation with corn (*Zea mays* L.), a less suitable host than peanut (10,18,23). This strategy emerged from the lack of commercially available peanut cultivars with adequate tolerance to *M. arenaria* race 1 (7) and the relatively high cash value of peanut, a government-subsidized crop in the United States. Nematicides suitable for peanut are limited (12) and may be limited further in the future. Rotation with corn for managing *M. arenaria* is not successful in severely infested fields (14), but it is useful in peanut fields when 1 year of peanut is followed by 2 years of corn (10) and there is a low population density of *M. arenaria.* This peanut–corn–corn rotation maintains *M. arenaria* at low levels in soil but is unacceptable economically in fields without irrigation systems because corn yields in unirrigated fields are typically low (< 4,000 kg/ha).

Cotton (*Gossypium hirsutum* L.) can be used successfully to manage *M. arenaria* when in rotation with peanut (11); however, this rotation is attractive economically only for peanut producers possessing specialized cotton production equipment. Recently, soybean (*Glycine max* (L.) Merr.) cultivars that are highly tolerant of *M. incognita* (Kofoid & White) Chitwood and moderately resistant to some populations of *M. arenaria* were developed (22). Their use in rotation with peanut to manage *M. arenaria* race 1 has not been explored. Our objective was to determine the value of 'Kirby' soybean in rotations with 'Florunner' peanut for managing *M. arenaria* race 1.

Materials and Methods

The 3-year study (1985–87) was conducted in an irrigated field at the Wiregrass substation, near Headland, Alabama. The field had been in peanut production for the preceding 10 years with hairy vetch (*Vicia villosa* Roth) being planted every year as a winter cover crop. The soil was a sandy loam (75% sand, 15% silt, 10% clay, organic matter < 1.0% (w/w), pH = 6.2, cation exchange capacity < 10 meq/100 g soil). Kirby, a maturity group VIII soybean, is highly resistant to *M. incognita,* moderately resistant to *M. arenaria,* and resistant to *Heterodera glycines* race 3 Ichinohe (15,21).

Cropping sequences were continuous peanut, 1 year of soybean followed by 1

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TABLE 1. Effect of several rotations with 'Kirby' soybean and 'Florunner' peanut on population densities of *M. arenaria* race 1 and crop yields at the Wiregrass substation, near Headland, Alabama, 1985–87.

1985			1986			1987		
Crop and treatment†	Yield (kg/ha)	J2 per 100 cm^3 soil	Crop and treatment	Yield (kg/ha)	J2 per 100 cm^3 soil	Crop and treatment	Yield (kg/ha)	J2 per 100 cm^3 soil
Peanut (−)	2,821	386	Peanut (−)	2,522	288	Peanut (−)	1,926	198
Peanut (+)	3,390	326	Peanut (+)	2,983	110	Peanut (+)	2,224	210
Soybean (−)	2,851	0	Peanut (−)	2,875	149	Soybean (−)	1,714	4
Soybean (+)	3,067	0	Peanut (−)	2,847	128	Soybean (+)	2,093	9
Soybean (−)	2,869	0	Peanut (+)	3,228	61	Soybean (−)	1,804	11
Soybean (+)	2,869	0	Peanut (+)	3,038	48	Soybean (+)	2,075	10
Soybean (−)	2,779	0	Soybean (−)	1,537	124	Peanut (−)	2,305	87
Soybean (+)	2,833	0	Soybean (+)	1,736	23	Peanut (+)	2,983	97
LSD (P = 0.05) (peanut)	498	145		359	115		230	71
LSD (P = 0.05) (soybean)	N.S.	145		N.S.	115		217	71

† (−) = no nematicide treatment; (+) = treated with aldicarb at plant at 3.3 kg a.i./ha.

year of peanut, and 2 years of soybean followed by 1 year of peanut. Each cropping sequence was represented by 16 plots; 8 plots received aldicarb (at-plant) each year and the other 8 were untreated. Aldicarb was included to assess its relative value in increasing yields and quality for each cropping sequence. Aldicarb (0.34 g a.i./m^2 [12 kg a.i./ha broadcast]) was applied at-plant in a 25-cm-wide band centered over the seed furrow and incorporated 2–4 cm deep. The eight treatments were replicated eight times each in a randomized complete block design. Plots were 10 m long and eight rows wide with a 0.91-m row spacing. Cultural practices and control of foliar diseases, insects, and weeds were as recommended for the area for the two crops (2,3).

Soil samples for nematode analysis were collected 2–3 weeks before peanut digging to coincide with maximal *M. arenaria* juvenile population densities in the crop (16). Each sample was a composite of 18–20 soil cores (2.5 cm d × 20–25 cm deep) taken from the root zone of the center two rows of each plot. A 100-cm^3 subsample was used to determine nematode numbers with the "salad bowl" incubation technique (13). Peanut and soybean yields were obtained by machine harvesting the two center rows of each plot at crop maturity.

The net value of each rotation was calculated using production costs for each crop in the area determined by the Department of Agricultural Economics, Auburn University. The costs were $1,358 for peanut and $358 for soybean (U.S. $/ha). The cost of aldicarb treatment was $123.50/ha (current local price). Peanut crop values used in our calculations were for good quality peanut and were $0.672/kg (government subsidized) and $0.264/kg (world market). The crop value of soybean was $0.220/kg (prevailing market price).

Data were subjected to analysis of variance (20) and Fisher's least significant differences were calculated. Differences between means referred to in the text were significant at $P \leq 0.05$.

RESULTS

The aldicarb treatment resulted in increased peanut yield in 1985 but did not affect soybean yield; however, the treatment failed to reduce *M. arenaria* J2 population densities in peanut (Table 1). Juvenile populations in soybean were not detected in 1985.

Aldicarb did not improve soybean yields in 1986. Factorial analysis of the 1986 peanut yield data indicated no aldicarb × rotation interaction. Use of aldicarb resulted in a 12.3% increase in peanut yield when the effect of the nematicide on yield was

TABLE 2. Three-year net returns per hectare of several peanut production systems in a field infested with *M. arenaria* at the Wiregrass substation, near Headland, Alabama.

Crop and treatment†			3-year net return/ha	
1985	1986	1987	Government subsidized	World market price
Peanut (−)	Peanut (−)	Peanut (−)	$809	$318
Peanut (+)	Peanut (+)	Peanut (+)	1,331	523
Soybean (−)	Peanut (−)	Soybean (−)	862	399
Soybean (+)	Peanut (−)	Soybean (+)	727	286
Soybean (−)	Peanut (+)	Soybean (−)	1,000	393
Soybean (+)	Peanut (+)	Soybean (+)	685	269
Soybean (−)	Soybean (−)	Peanut (−)	424	166
Soybean (+)	Soybean (+)	Peanut (+)	566	222

All figures in U.S. dollars.

Peanut prices = 0.672/kg (government subsidized) and 0.264/kg (world market price). Soybean price = 0.2202/kg($6/bushel).

Soybean production cost = 358.15/ha ($145/acre). Peanut production cost = 1,358.5/ha ($550/acre). Aldicarb cost = 123.5/ha ($2.50/lb) for a rate of 3.3 kg a.i./ha.

† (−) = no nematicide treatment; (+) = treated with aldicarb at plant at 3.3 kg a.i./ha.

considered independently of the rotation system. When the effect of the rotation scheme on peanut yield was considered independently of the effect of aldicarb on the variable, the analysis revealed that yields from plots that had soybean in 1985 were 9.5% higher than those from plots in continuous peanut. Peanut yield in plots with soybean in 1985 but without aldicarb treatment in either 1985 or 1986 were similar to those in continuous peanut with aldicarb treatment. Treatment of soybean with the nematicide in 1985 had no effect on peanut yield in 1986 in the soybean–peanut rotations.

The aldicarb × rotation interaction on *M. arenaria* J2 population densities in 1986 was not significant. When the effect of the nematicide was considered independently of rotation system, it was found that aldicarb resulted in a 61.4% reduction in juvenile numbers in soil. When the effect of rotation systems was considered independently of the effect of aldicarb on the variable, the *M. arenaria* J2 population densities were lower in peanut plots that had been in soybean the previous year. The use of aldicarb in soybean in 1985 had no effect on J2 population densities in 1986. Also, the J2 population densities in plots with peanut in 1986 and soybean in 1985 were as low as those with continuous peanut treated with aldicarb in 1985 and 1986.

In 1987, as in the previous 2 years, there was no aldicarb × rotation interaction on peanut yield. Aldicarb resulted in a 23.4% increase in yield when its effect was considered independently of rotation systems. Conversely, plots with peanut in 1987 and soybean in the previous 2 years yielded 27.6% higher than those with continuous peanut. The highest peanut yields in 1987 were in plots with 2 years of soybean followed by peanut and receiving aldicarb each year. This production system resulted in a 34.1% increase in yield over the yield for continuous peanut with aldicarb. There was no aldicarb × rotation interaction for soybean yield in 1987. Rotation systems had no effect on soybean yield; however, the use of aldicarb resulted in a 19.3% overall increase in yield.

In 1987 the highest numbers of *M. arenaria* J2 were in plots with continuous peanut and the lowest numbers were in those with 2 years of soybean. There was no aldicarb × rotation interaction on *M. arenaria* J2 population densities. The effect of aldicarb on the populations was not significant when considered independently of the effects of rotation system on the variable.

Calculated net returns for each of the production systems show the most profitable system was the monoculture of peanut with aldicarb treatment (Table 2). This system, however, was followed closely in profit by the rotation of soybean–peanut–soybean, one year each, with aldicarb treatment for peanut only.

Discussion

Kirby soybean can be used to manage *M. arenaria* race 1. The success of this strategy is predicated on an accurate identification of the reaction of individual populations of *M. arenaria* to the soybean cultivar. There is evidence that *M. arenaria* varies considerably in its reaction to soybean and peanut. According to one description of this variability (19), there are two races of the nematode: one capable of parasitizing peanut (race 1) and one that is not (race 2). There is also evidence for variation in reaction to soybean even within these races (1,4). In Alabama, we have found field populations of *M. arenaria* capable of attacking Kirby soybean (and other cultivars of similar ancestry) with substantial reductions in yield (21,22). Therefore, implementation of the strategy suggested by our findings will require not only accurate identification of *Meloidogyne* spp., but also quantitative description of the reaction of individual field populations of *M. arenaria* to soybean cultivars. To our knowledge this type of service is not routinely available anywhere.

Two years of Kirby soybean after peanut do not appear to offer any particular economic advantage over a rotation in which the two crops alternate. Calculation of the net return accrued for each of the rotation systems of the study (Table 2) suggested that the least profitable systems were those in which soybean was used for 2 years following peanut. These calculations also indicated that the most profitable system was continuous peanut treated every year with aldicarb. Net returns based on world market price for peanut also supported the use of an efficacious nematicide with peanut, but not with soybean in the rotation where the crops alternated.

Not considered in this study, but currently the subject of examination by our group, are the effects of rotation on soilborne diseases other than those caused by nematodes. These diseases almost certainly are being affected by rotation, as were the nematodes. Yields and crop values, therefore, reflect the sum total of these effects and not just the nematodes examined in the present study.

Although the findings support the monoculture of peanut with nematicide applications, we do not view this practice as the most rational of the systems studied. The peanut–soybean rotation with aldicarb treatment in the peanut year differed little in net return or in degree of nematode control from peanut monoculture with nematicide. A change in crop species may be advantageous in managing diseases such as peanut pod-rot (8) that affect one crop but not the other. These additional considerations may determine the use of peanut–soybean rotations over continuous peanut.

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