Soil-Borne Pests of Peanut in Growers' Fields with Different Cropping Histories in Alabama[1]

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ABSTRACT

Pest levels and yields of peanut were monitored in growers' fields in 1991 through 1993. Yields ranged from 2085 to 6440 kg/ha and averaged 3947 kg/ha over the 3 yr. Incidence of southern stem rot (SSR) (caused by *Sclerotium rolfsii*) averaged 7.6 foci (up to 30 cm in length) per 30.5 m row and ranged from 0 to 31.0 foci. Peanut yield tended to be inversely related to incidence of SSR and directly related to the number of years between peanut crops. Incidence of SSR was inversely related to number of years between peanut crops and was consistently greater in fields cropped to peanut every other year compared to other fields with less intensive peanut production. Yields obtained from irrigated fields averaged 11.4% greater than those without irrigation. Leaf spot control programs used by growers provided consistent levels of control. Peanut seed invasion by aflatoxigenic fungi and plant damage by larvae of the lesser cornstalk borer (*Elasmopalus lignosellus*) generally were low. Seed invasion by *Aspergillus flavus*-type fungi was positively correlated ($P < 0.05$) with damage due to lesser cornstalk borer in 1993. Juvenile populations of root knot nematodes (*Meloidogyne incognita*) were positively correlated ($P < 0.001$) with incidence of SSR in 1992.

Key Words: Yield losses, rotations, *Arachis hypogaea*, groundnut, white mold.

Peanut (*Arachis hypogaea* L.) is an important crop of the southeastern U.S. In Alabama alone, more than 97,000 ha of peanut are grown for a value exceeding $170 million annually. The financial return on the peanut crop, however, is somewhat suppressed due to chronic infestations of soil-borne pests, including *Sclerotium rolfsii* Sacc., the lesser cornstalk borer (LCB) [*Elasmopalus lignosellus* (Zeller)], and *Aspergillus flavus* Link and *A. parasiticus* Speare, which cause aflatoxin contamination.

Southern stem rot (SSR), caused by the fungus *S. rolfsii*, is a common and often destructive disease of peanut (2, 20). Annual yield losses to this disease in Alabama have been estimated at 5 to 10% of the state's total crop (27). Until recently, fungicides have not been highly efficacious against SSR. Crop rotation and other cultural control methods have been recommended for control of SSR, but are only partially effective (17, 28).

Lesser cornstalk borer is one of the most destructive insect pests of peanut (26). These larvae feed on root hypocotyls and on developing pods (11, 13). During hot and dry growing seasons, which occur sporadically, LCB populations can reach economically damaging levels and cause as much as 70% loss in potential yield (26). Since this insect cannot compete well in moderate environmental conditions, losses due to LCB vary from year to year. Larvae of LCB, *S. rolfsii*, and aflatoxigenic fungi also appear to interact. Damage from LCB facilitates entry of aflatoxigenic fungi into peanut seed (3, 12) and *S. rolfsii* into other plant tissue (29). Rotation is suggested as a cultural means of control but insecticides are primarily used for LCB control (26, 28).

Aspergillus flavus and *A. parasiticus* are closely related species of fungi that produce the highly carcinogenic compounds called aflatoxins (7). These two *Aspergillus* species are ubiquitous in soils and invade peanut plant parts throughout most growing seasons (8; Bowen, unpubl. data). Aflatoxigenic fungi are favored by hot, dry conditions, and aflatoxin contamination is greatest in growing seasons when drought prevails (23). No fungicides or other chemicals have been found to be effective in reducing aflatoxin contamination (16), and this suggests that no fungicides are effective against preharvest *A. flavus*-type fungal invasion of peanut seed. Rotation does not consistently reduce invasion of peanut seed (7). The only effective method for minimizing preharvest aflatoxin contamination is through irrigation, but many southeastern peanut fields remain nonirrigated.

The root-knot nematode [*Meloidogyne arenaria* (Neal)

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Chitwood] is difficult to control and consistently reduces yields. Damage from root-knot nematodes also may facilitate invasion by aflatoxigenic fungi (14, 15). Rotation is a recommended means of minimizing nematode populations (18, 28). Nematicides also are used for nematode control. Peanut leaf spots [caused by *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. & Curt.) Deighton] also cause significant losses when not effectively controlled through regular fungicide applications (17, 18).

Published studies on the effects of cropping frequency or rotation have not considered the interactions among the soil-borne pests affecting peanut production. In addition, many published studies on rotation effects on pests have been conducted on experiment stations (4, 12, 13, 21, 23) where fields are likely to be optimally managed and not reflective of the reality of a grower's field. Variability among farms due to chemical and cultural practices, insect and disease infestations, soil types, etc. influence yields and pest levels in crops. We sought to characterize soil-borne pest levels, pest interactions, and possible effects on peanut yield, and to determine whether peanut cropping history affects pest levels and yields in peanut fields in eight counties in Alabama.

Materials and Methods

Characterization of Peanut Pests. In April of 1991, 1992, and 1993, tests were established in 16 to 23 growers' fields. Fields were selected according to their recent cropping history. Cropping histories were (a) excellent, peanuts cropped after at 5 or more yr of pasture, usually bahiagrass; (b) good, peanuts cropped after 2 yr of corn, cotton, or other nonleguminous agronomic crop; (c) fair, peanuts cropped in alternate years with corn, cotton, or other nonleguminous agronomic crop; and (d) poor, peanuts cropped continuously for 3 consecutive yr. Cropping patterns had been practiced by cooperating growers generally for 10 or more yr. Growers in the region are least likely to maintain excellent and poor cropping histories, and fewer fields with these two cropping histories were identified for monitoring. However, at least two fields with each cropping history were monitored in each year of the study (Table 1). In each year, several of the monitored fields were irrigated with approximately 2.54 cm water per week, as needed. Fields were

Table 1. Numbers of growers' fields on which peanut pest and yield data were collected and analyzed in southeastern Alabama from 1991 to 1993.

	1991		1992		1993	
Rotation[a]	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
	no.					
Excellent	1	1	0	6	0	3
Good	3	1	6	12	1	4
Fair	1	4	1	6	8	13
Poor	1	3	0	3	1	3

[a]Rotation classifications for individual fields were 'Excellent' = peanuts planted after 3 or more years bahiagrass; 'Good' = peanuts planted every third year; 'Fair' = peanuts planted every second year; and 'Poor' = peanuts planted continuously.

located throughout the peanut growing region of southeast Alabama in Barbour, Henry, Houston, Dale, Crenshaw, Pike, Geneva, and Bullock counties. Soil at all sites was a sandy loam with < 1% organic matter.

Field sites were conventionally tilled and planted (28) to cv. Florunner peanuts by cooperating growers. At each field site, six replicate plots were delimited. Plots were 15.2 m in length, consisting of two rows of plants. Cooperative growers applied no chemical treatments to plot areas except for six to eight semimonthly chlorothalonil (1.2 ai kg/ha) applications for peanut leaf spot control (28). In order to ascertain that leaf spot control programs had not differed among growers, defoliation was assessed over most field sites approximately 1 wk prior to inversion. Defoliation was assessed by arbitrarily selecting 10 plants across the plot area of the field and removing their central stems at the soil line. On each stem, leaflets present and leaf nodes were counted. Number of leaf nodes was used to determine total possible leaflet numbers and defoliated leaflets (defoliation) was expressed as the percentage of total possible leaflets (5). Several fields in each year of the study were not sampled for defoliation.

Soil samples for root-knot nematode were taken from most field sites in July or August (19) and analyzed by the Plant Diagnostic Laboratory of the Alabama Cooperative Extension Service at Auburn University. Soil samples consisted of a composite of up to 20 cores from across the plot area. Juveniles of root-knot nematodes in 500 cc of soil were enumerated and data were presented as juveniles per 100 cc soil. Plants were inverted at maturity, allowed to dry for 3-5 d, then harvested. Within each plot, incidence of SSR was determined in the windrow by counting the number of affected foci (up to 30 cm in length) in two rows of the inverted crop (20), for a maximum of 31 sites per plot. Incidence of aflatoxigenic fungal invasion of seed was determined on sound mature peanut seed from plots of many field sites. Twenty seed from each plot were surface sterilized by soaking in 0.525% sodium hypochlorite solution for 1 min. Seed were placed on a paper towel moistened with 20% NaCl solution, then incubated at 30 C, 99% relative humidity for 3 d. *Aspergillus flavus*-type fungal colonies were identified based on conidial color and counted for determining percentage of seed invaded by *A. flavus* (3). Samples for determination of seed invasion from several locations were lost in each year of the study.

Data were collected at an additional 12 sites in 1992 and 1993. Relative numbers of LCB, plant damage due to LCB, root-knot nematode populations, incidence of seed infection by *A. flavus*-type fungi, and yield were determined. Ten plants were randomly selected from each plot and examined for insect damage within 24 hr of inversion. Presence of LCB larvae and silken tubes, along with holes in plant crowns or developing pods, were enumerated as LCB plant damage. Data on LCB plant damage were presented as the percentage of plants affected.

Weather data were collected from the National Weather Service monitoring station at the Wiregrass Substation of the Alabama Agricultural Experiment Station, near Headland, in Henry County. This site is considered central to Alabama's peanut production area and environmental data collected there reflect prevailing weather patterns.

Data Analysis. Data collected from each of six plots in a field were averaged for comparisons among locations. Due to differences in weather, data comparisons were not made among years. In order to ascertain that effectiveness of individual growers' leaf spot control program was similar, mean and standard deviation of percentage defoliation were calculated over all fields within each year. All data from fields with a percentage defoliation that was greater than two standard deviations from the yearly mean were omitted from analyses.

Preliminary evaluations of general trends and interrelationships among variables were determined through PCA (24). Number of years between peanut crops (rotation system), presence or absence of irrigation, plus root-knot juvenile populations, percentage defoliation, and incidence of SSR from all locations in each year were subjected to principal component analysis (PCA). Yield, pest, and disease data from each year were regressed on number of years between peanut crops and irrigation. Significance levels of the coefficients of regression from these models indicated which variable accounted for the most variation in yield and pest data (24). Correlation coefficients were calculated among variables within each year and for data combined over 3 yr (24). Significance was set at the $P < 0.10$, unless otherwise indicated. Means of yield, disease and pest levels were calculated if data analyses indicated consistent trends due to other variables.

Results

Average monthly temperatures and total precipitation for May through September were 25.6 C and 65.8 cm in 1991, 24.7 C and 49.3 cm in 1992, and 25.4 C and 37.1 cm in 1993. The 1993 growing season was hot and dry throughout the region, with rainfall for May through September totalling 23.6 cm less than 30-yr normals at the Wiregrass Substation for those months (1).

In 1991, all pest and yield data collected from one field location were not included in analyses due to severe foliar insect damage. Several samples for evaluation of seed invasion by *A. flavus*-type fungi also became lost in 1991, and these data are missing from analyses. In 1993, all data from two field locations were omitted from comparisons due to the effects of excessive drought and exceptionally low yields. Defoliation due to leaf spots from one field site in 1992 was significantly greater than all other fields, so all pest and yield data from that location were omitted from analyses. Percentage defoliation from all other fields in each of the 3 study yr were within two standard deviations of the annual mean for defoliation. Distribution of fields among rotation and irrigation categories is shown in Table 1.

Peanut yields from 82 growers' fields in southeast Alabama, over 3 yr of monitoring, averaged 3948 kg/ha. Yields ranged from 2085 kg/ha in 1993 to 6440 kg/ha in 1992 (Table 2). The lowest yielding field was rainfed with peanuts cropped every other year (fair rotation) and had 7.33 foci of SSR per 30.5 m row and 0 root-knot juveniles per 100 cc soil. The highest yielding field also was rainfed with peanuts cropped every third year (good rotation) and had 1.83 SSR foci per 30.5 m row and 12 juveniles per 100 cc soil. Incidence of SSR ranged from 0.17 to 31.00 and averaged 7.6 disease foci per 30.5 m row in 58 growers' fields over 3 yr. Populations of juvenile root-knot nematodes ranged from 0 to 5032 and averaged 135 juveniles per 100 cc soil in growers' fields. No root-knot juveniles were detected in 31 of the 60 growers' fields sampled for nematodes. Defoliation averaged 33.6% and ranged from 13.5 to 47.9% in 45 fields over 3 yr. Lesser cornstalk borer damage was identified on an average of 17% of peanut plants from 24 fields sampled in 2 yr.

Principal component analyses of data from each of the 3 yr indicated that years between peanut crops and incidence of SSR consistently had high positive loadings of similar value in the first component. For years between peanut crops, the values of loadings in the first principal component ranged from 0.51 to 0.59, and loadings ranged from 0.35 to 0.64 for incidence of SSR. This indicates that peanut crop frequency and incidence of SSR in a field may be combined into an artificial variable that describes most of the variation in data from each year. Irrigation consistently had a high positive loading (0.50 to 0.56) in the second component. Over each of the 3 yr of analyses, other variables had loadings ranging from < 0 through positive values for the first two principal components. These two components explained 65 to 82% of the variance in the data in each of the 3 yr.

Yields in 1991 were significantly affected by the interaction of irrigation and number of years between peanut crops (Table 3). There was no consistent trend in yield

Table 2. Peanut yields from growers' fields, grouped by rotation classification, located in southeastern Alabama from 1991 to 1993.

	1991[a]				1992				1993			
Rotation[b]	Fields	Mean	Range	S.D.[c]	Fields	Mean	Range	S.D.	Fields	Mean	Range	S.D.
	no.	---- kg/ha -----			no.	--- kg/ha ----			no.	---- kg/ha -----		
Excellent	2	4594	4251-4938	485.6	7	4814	3930-6182	761.2	3	2814	2317-3414	556.0
Good	4	4221	2860-5141	981.3	12	4466	3357-6440	768.1	4	4003	2515-4932	1065.1
Fair	5	4063	3086-4877	814.1	5	3476	2419-4635	792.8	13	3220	2085-5620	1018.1
Poor	4	3649	2971-4938	596.9	3	4186	3557-5318	982.8	3	2879	2389-3401	507.0

[a]Data presented and average calculated from both irrigated and rainfed growers' fields in 1991 and from rainfed fields only in 1992 and 1993 because a lack of representative irrigated fields.

[b]Rotation classifications for individual fields were 'Excellent' = peanuts planted after 3 or more years bahiagrass; 'Good' = peanuts planted every third year; 'Fair' = peanuts planted every second year; and 'Poor' = peanuts planted continuously.

[c]S.D. is standard deviation.

Table 3. Mean squares from regression of yield and each of the pest variables on number of years between peanut crops (rotation rating) and irrigation. Data obtained from growers' fields in southeast Alabama in 1991, 1992, and 1993.

Year and variable	Yield	Incidence of SSR	Root-knot nematodes[b]	Defoliation	Seed invasion by *A. flavus*[c]	LCB plant damage[d]
1991						
Rotation rating (RR)[e]	358,091	99.9	1,333,260***	71.7	765.8	ND
Irrigation (I)	378,026	40.9	4,701,888***	7.2	ND	ND
RR * I	974,525	7.5	4,314,984***	9.1	ND	ND
1992						
Rotation rating	1,467,441**	239.5***	15,966	89.1	33.7	2.03
Irrigation	927,664	60.8	7,118	25.9	150.7	0.37
RR * I	163,538	90.8	3,493	32.1	ND	ND
1993						
Rotation rating	1,275,638	139.1**	379**	107.3	595.7***	16.8***
Irrigation	872,178	20.3	208	45.7	41.0	0.2
RR * I	199,091	38.3	409*	21.6	ND	ND

[a]Incidence of southern stem rot.

[b]Number of juveniles per 100 cc of composited soil sample.

[c]Incomplete analysis due to the loss of several seed samples in 1991 for *A. flavus* incidence; all samples from irrigated fields in 1992 and 1993 were from fields of the same rotation rating.

[d]Percentage of plants with damage by larvae of the lesser cornstalk borer. ND = data not collected in 1991.

[e]Rotation rating reflects number of years between peanut crops.

*, **, ***Significant at P <0.10, <0.05, and <0.01, respectively.

due to irrigation among rotation systems (Fig. 1). However, over all cropping histories, average peanut yield in 1991 from irrigated fields was 4355 and was 3874 kg/ha from nonirrigated fields, a 12.4% increase due to irrigation. Yields, averaged over both irrigation systems in 1991, decreased as frequency of peanut cropping increased (Table 2). Root-knot nematode populations were significantly affected by irrigation, cropping history, and the two-way interaction in 1991 (Table 3). Nematodes were detected only in rainfed fields and generally increased in populations with fewer years between peanut crops (Fig. 1).

Incidence of SSR during in 1991 ranged from 0.2 to 25.2 disease foci per 30.5 m row, and mean incidence was greatest in fields with fair cropping history compared to other rotation systems (Table 4). Data on defoliation and seed infection by *A. flavus* were missing from fields with excellent cropping histories in 1991. Peanuts cropped continuously appeared to have highest defoliation compared to good and fair cropping histories (Table 4).

Yield and incidence of SSR were significantly affected by cropping history in 1992 (Table 3). Yields were lowest in fields cropped every other year to peanuts (fair rotation system) than in other rotation systems (Table 2). Yields from irrigated fields were 4800 and 4342 kg/ha from rainfed fields, but this difference was not significant. Incidence of SSR generally decreased with increasing years between peanut crop, from an average of 14.2 foci over the combination of fair and poor rotations to 0.2 foci in excellent rotations (Table 5). Incidence of SSR averaged 3.75 foci in irrigated fields and 6.42 foci in rainfed fields (data not shown).

Juvenile populations of root-knot nematodes appeared to be greatest in peanuts cropped every other year, but the variability in populations was high (Table 5). No discernible trends among cropping histories were noted for seed invasion by *A. flavus*, LCB damage, or defoliation in 1992 (data not shown). Defoliation due to leaf spot diseases averaged 30.8% over all fields and ranged from 13.5 to 47.9% in 1993. Plant damage due to LCB ranged from no damage to 31.7% and averaged 12.8% plants with damage. The percentage of seed invaded by *A. flavus*-type fungi averaged 12.2 and ranged from 0 to 52.5% invasion of seed from a location. Populations of root-knot nematode juveniles were found to be correlated to incidence of SSR ($r = 0.69$, $P < 0.01$, $n = 21$) in 1992.

Yields averaged 3390 kg/ha in 1993 over all field sites. Yields from rainfed fields averaged 3259 kg/ha, and 3682 kg/ha from irrigated fields, although this difference was not significant. No differences in yields were detected due to rotation system (Table 3); however, average yields were lower from fields with excellent and poor rotations than from fields with peanuts planted every second or third year (Table 2). Two of the three field sites that had excellent cropping systems in 1993 were in close proximity. These two sites were severely affected by drought and 75% of plants in one field had LCB damage (compared to less than 45% LCB damage in other fields monitored in 1993). Seed from these two locations also had the highest level of seed invasion by *A. flavus*-type fungi (45%) compared to less than 30% seed colonization from all other fields (Table 6). Plant damage by LCB and seed invasion by *A. flavus* were significantly affected by number of years between peanut crops. Since nine of 12 fields sampled for LCB were in the fair rotation system, effect of rotation cannot be discerned from these data. Seed invasion was positively correlated with plant damage due to LCB (r = 0.68, P < 0.05, and n = 11) and with numbers of years between peanut crops (r = 0.77, P < 0.001, n = 22).

In 1993, number of years between peanut crops had a significant effect on incidence of SSR which was greatest in fields with fair cropping histories than in other fields (Table 6). Numbers of years between peanut crops and the two-way interaction of cropping history and irrigation significantly affected nematode populations (Table 3). In the fair rotation system, no root-knot nematode juveniles were found in rainfed fields and an average of 0.67 juveniles per 100 cc soil were found in irrigated fields. Too few samples were taken to discern additional effects of irrigation or rotation system on root-knot nematodes in 1993. No trends in data were observed for defoliation, which averaged 36.3% over all fields, and ranged from 24.0 to 45.2% in 1993 (data not shown).

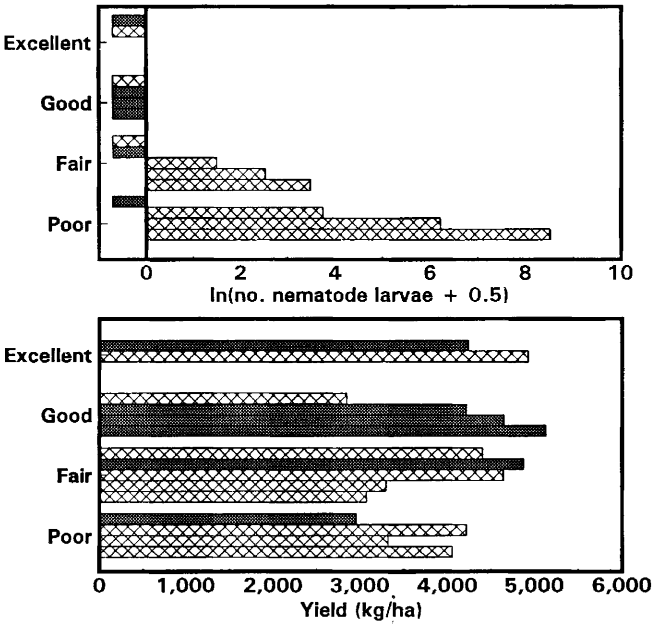

Fig. 1. Juvenile populations of root-knot nematodes (*Meloidogyne arenaria*) and peanut yields (kg/ha) from 15 growers' fields in southeast Alabama in 1991. Data are grouped by cropping history: 'Excellent', peanuts cropped after at least 3 yr of pasture; 'Good', peanuts planted once every third year; 'Fair', peanuts planted every other year; and 'Poor', peanuts planted continuously. Solid bars represent data from irrigated fields; hatched bars represent rainfed fields. Nematode juveniles were not detected in samples from nine fields (values < 0).

Correlation coefficients indicate relationships among variables over all 3 yr (Table 7). Yields were negatively correlated with incidence of SSR and LCB damage, and were positively correlated with years between peanut crops. Incidence of SSR and populations of root-knot nematodes were negatively correlated with years between peanut crops (Table 7). Correlations calculated from the combined 3 yr indicate that there were no interactions between pests and diseases (Table 7).

Discussion

Among all monitored fields, no single pest or disease defined the productivity of a location. These observations were not surprising given the variability among growers' practices, soil types and fertility, geographic differences of field sites, and erratic rainfall patterns throughout the region. However, over 3 study years, SSR and LCB had a negative relationship with yield, and increased numbers of years between peanut crops had a positive effect on yield. We did not observe sufficient variation in the level of control of leaf spot diseases to determine effects on yield. As expected, irrigation generally increased yield.

In each of 3 study years, yields were greatest in fields planted to peanuts no more than once in 3 yr (good or excellent rotation system). Brenneman *et al.* (4) indicated that new fungicides for control of SSR may shorten

Table 4. Relative occurrence of pests in both rainfed and irrigated growers' fields from four rotation classifications in the peanut-growing region of Alabama, 1991.

	Southern stem rot[a]				Defoliation due to leaf spot diseases				*A. flavus*[b]			
Rotation[c]	Fields	Mean	Range	S.D.[d]	Fields[e]	Mean	Range	S.D.	Fields	Mean	Range	S.D.
	no.	----no. foci----			no.	-----%-----			no.	-----%-----		
Excellent	2	0.5	0.2- 0.8	0.5	1	40.2	ND	ND	1	0.0	ND	ND
Good	4	5.6	2.0-11.8	4.3	3	29.5	25.6-35.4	5.2	1	56.0	ND	ND
Fair	5	13.4	6.8-25.2	7.9	4	35.0	28.5-41.6	5.3	2	54.2	41.0-67.5	18.7
Poor	4	5.9	2.8- 9.7	3.0	2	42.0	39.2-44.9	4.0	2	46.6	37.0-56.2	13.6

[a]Based on number of disease foci (≤30 cm) per 30.5-m row.

[b]Proportion of harvested seed from which aflatoxigenic fungi were cultured. Data are missing because samples from several field sites were lost in transit.

[c]Rotation classifications for individual fields were 'Excellent' = peanuts planted after 3 or more years bahiagrass; 'Good' = peanuts planted every third year; 'Fair' = peanuts planted every second year; and 'Poor' = peanuts planted continuously.

[d]Symbols used in table: S.D. = standard deviation, ND = insufficient data collected.

[e]Several field sites were harvested by cooperating growers before defoliation data could be collected.

Table 5. Relative occurrence of pests in growers' fields from four rotation classifications in the peanut-growing region of Alabama, 1992.

Rotation[d]	Southern stem rot[a]				Root-knot nematodes[b]				*A. flavus*[c]			
	Fields	Mean	Range	S.D.[e]	Fields	Mean	Range	S.D.	Fields	Mean	Range	S.D.
	no.	--- no. foci ----			no.	---- no. ----			no.	-----%-----		
Excellent	4	0.2	0.2-0.2	0.0	7	6.3	1-30	11.7	5	14.3	4.0-36.7	13.4
Good	13	5.0	0.2-22.7	6.0	17	69.1	0-450	151.6	16	13.0	0.0-52.5	16.1
Fair	2	22.6	ND	ND	6	108.4	2-500	219.0	4	10.2	4.2-20.0	6.9
Poor	3	8.5	3.2-14.7	5.8	3	82.7	0-248	5.8	3	7.2	2.7-15.0	6.8

[a]Based on number of disease foci (<30 cm) per 30.5-m row. Incidence not determined at 12 field sites monitored for lesser cornstalk borer.
[b]Number of juveniles per 100 cc of composited soil sample.
[c]Proportion of harvested seed from which aflatoxigenic fungi were cultured. Sample sizes do not agree with text because of unaccounted loss.
[d]Rotation classifications for individual fields were 'Excellent' = peanuts planted after 3 or more years bahiagrass; 'Good' = peanuts planted every third year; 'Fair' = peanuts planted every second year; and 'Poor' = peanuts planted continuously.
[e]Symbols used in table: S.D.= standard deviation; ND = insufficient data collected.

Table 6. Relative occurrence of pests in growers fields from four rotation classifications in the peanut-growing region of Alabama, 1993.

Rotation[c]	Southern stem rot[a]				*A. flavus*[b]			
	Fields	Mean	Range	S.D.[d]	Fields	Mean	Range	S.D.
	no.	-- no. foci --			no.	----%----		
Excellent	2	0.0	0.0-0.0	0.0	2	45.0	45.0-45.0	0.0
Good	5	2.3	1.5-4.0	1.2	1	25.8	ND	ND
Fair	12	12.4	0.3-26.3	8.9	16	16.5	5.0-28.3	7.8
Poor	3	8.1	7.0-9.2	1.5	3	11.0	1.7-16.2	8.1

[a]Based on number of disease foci (<30 cm) per 30.5-m row. Incidence not determined at 12 field sites monitored for lesser cornstalk borer.
[b]Proportion of harvested seed from which aflatoxigenic fungi could be cultured. Sample sizes do not agree with text because of unaccounted loss.
[c]Rotation classifications for individual field, were 'Excellent' = peanuts planted after 3 or more years bahiagrass; 'Good' = peanuts planted every third year; 'Fair' = peanuts planted every second year; and 'Poor' = peanuts planted continuously.
[d]Symbols used in table: S.D.= standard deviation; ND = insufficient data collected.

Table 7. Correlation coefficients calculated among yield, incidence of southern stem rot, root-knot nematode populations, percentage peanut seed invaded by aflatoxigenic fungi, percentage defoliation by peanut leaf spot diseases, plant damage due to lesser cornstalk borer (LCB), and peanut cropping frequency. Data obtained from growers' fields (number in parentheses) in southeast Alabama in 1991, 1992, and 1993.

Variable	Southern stem rot	Leaf spot defoliation	Root-knot nematodes	LCB damage	Yr between peanut crops
Yield	-0.41***	-0.15	-0.19	-0.46**	0.37***
	(58)	(45)	(60)	(20)	(82)
Southern	-	-0.13	0.03	ND[a]	-0.46***
stem rot	-	(44)	(48)	-	(58)
Root-knot	-	0.13	-0.02	-0.26**	-
nematodes	-	(39)	-	(9)	(60)
A. flavus	0.04	-0.17	0.06	0.34	-0.02
	(33)	(29)	(39)	(20)	(56)

[a]ND, insufficient data collected.
*,**,***Significant at P <0.10, < 0.05, and <0.01, respectively.

rotations, but nematodes also need to be controlled. In 2 yr of this study (1991 and 1992), populations of root-knot nematode juveniles tended to be higher in fields with peanuts cropped more than once in 2 yr than in other fields. This observation was expected given previously published data (21) suggesting that root-knot nematodes limit yields in continuously cropped peanuts. Our results confirm the need for longer rotations, which are already recommended when levels of SSR or population densities of root-knot nematodes are high (6, 17, 28).

Yield averages were consistently greater from irrigated than rainfed fields, but irrigation was not a significant effect on yield in any year. Irrigation is an important requirement for peanut production in the southeastern U.S. (10). Kernel damage and peanut grade were not quantified in this study, but previous studies have shown improved grade and control of seed invasion by *A. flavus* with irrigation (23).

Interactions among pests were limited. We were able to measure a significant relationship between LCB and invasion of peanut seed by *A. flavus* only in 1993 when the environment was conducive to both organisms. This confirms observations made from studies conducted in the laboratory and at experiment stations on the relationship between *A. flavus*-type fungi and LCB (3, 12). A significant relationship also was found between root-knot nematode populations and incidence of SSR in 1 of 3 yr. This relationship may have been calculated because of the similar relationship root-knot nematodes and SSR had with years between peanut crops.

In all 3 yr of this study, fields in which peanuts were cropped every other year had the highest incidence of SSR. These results indicate that a 1-yr rotation [as suggested in Porter (17)] is not adequate for control of SSR. Our results also differ from more recent work where a 1-yr rotation to bahiagrass controlled SSR and allowed peanut yields as high as longer rotations (4). Bahiagrass has been shown to reduce incidence of SSR and numbers of root-knot nematode juveniles (22), and was not used as a rotation crop for a single year in fair rotations in fields monitored for this study. The lower incidence of SSR in fields that were continuously cropped to peanuts, compared to SSR in peanuts planted every other year, may be due to the build-up of soil suppressiveness, as has been shown for Cylindrocladium black rot of peanut (25). Sidebottom and Beute (25) also observed that, while one disease may be suppressed in a continuous cropping system, other pests or diseases may increase. The increase in other pests may overcome yield gains made by the suppression of one. In 2 yr of this study (1991 and 1993), peanut yields were lower in fields cropped continuously to peanut than in other fields despite a lower incidence of SSR in continuously cropped fields.

Effective management of SSR has relied upon the selection of an appropriate rotation system and other cultural methods (17). However, new fungicides (tebuconazole and flutolanil) should provide good control of southern stem rot (4, 9). Improved control of *S. rolfsii* may increase the frequency of peanut cropping in individual fields, which may lead to an increase in yield losses attributable to other pests such as the peanut root-knot nematode. Incidence of SSR was positively correlated ($P < 0.001$) with root-knot nematode populations in 1 of 3 yr. Root-knot nematode populations may have contributed to incidence of SSR just as insect and root-knot nematode damage contribute to aflatoxigenic fungal invasion of seed tissue (e.g., 3, 14). These interactions indicate that further research is necessary to fully understand the ecological relationships among diseases and pests of peanut.

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