Influence of Crop Rotation and Minimum Tillage on the Population of *Aspergillus flavus* Group in Peanut Field Soil

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ABSTRACT

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The influence of various sequences of corn, soybean, peanut, green manuring with sorghum sudangrass, fallow, and minimum-tillage soybean cropping on *Aspergillus flavus* group populations was investigated in field plots from 1975 to 1979. Planting corn in 1975 and peanut in 1976 were associated with significant ($P = 0.05$) increases in the population of *A. flavus* group in soil the following years, compared with the fallow treatment. Populations increased primarily in the lower half of the plow layer following corn planting. Other crop sequences did not significantly affect *A. flavus* group populations.

Additional key words: aflatoxin, inoculum potential

The fungi *Aspergillus flavus* Link ex Fries and *A. parasiticus* Speare are capable of invading peanut (*Arachis hypogaea* L.) and corn (*Zea mays* L.) kernels in the field before harvest (3,4,9,10,12,14). In Virginia, these fungi have been shown to colonize deep-plowed, green rye manure and peanut fruit debris left in the soil (7). Their presence in peanut fruit debris may increase the inoculum potential for *A. flavus* colonization of peanut and corn and thus the probability of aflatoxin contamination. Because this group of parasitic fungi is relatively unspecialized, with a wide saprophytic capability on crop debris left in the soil, certain crop sequences could lead to a buildup of inoculum that would favor *A. flavus* colonization of peanut kernels. Corn may be especially likely to produce a buildup of inoculum because the plant parts can be colonized before harvest, and corn and peanut are commonly rotated in the Virginia peanut-growing region.

We undertook this investigation to determine the influence of certain crop sequences, minimum tillage, and green manuring with sorghum sudangrass on the population of *A. flavus* group (*A. flavus* and *A. parasiticus*) in soil. We also determined populations of the *A. niger* group (13) because these fungi are antagonists of *A. flavus* (1,8).

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MATERIALS AND METHODS

Field plots. Two field plots were established in 1975 on a farm in Southampton County, VA, with a transit for precise relocation of the plots each year. One plot (crop rotation) was used to investigate the influence of corn, soybean, and peanut rotations on *A. flavus* and *A. niger* group populations; the other plot (minimum tillage and green manuring) was used to investigate the influence of soybean rotation with and without minimum tillage and green manuring with sorghum sudangrass. Both plots incorporated a completely randomized block design of five treatments (crop sequences) and four replicates, which were composed of five four-row subplots measuring 9.1 × 19.7 m. Three alleyways 6.1 m wide separated the four replicates.

Crop sequences from 1975 to 1977 in the crop rotation plot were Coker 16 corn, Florigiant peanut, and Essex soybean; continuous corn; soybean, corn, and peanut; continuous peanut; and continuous fallow. Crop sequences for both 1976 and 1977 in the minimum tillage and green manuring plot were Arthur winter wheat followed by minimum tillage soybeans; winter wheat followed by fallow; winter fallow followed by conventionally tilled soybeans; winter fallow followed by FFR-66 sorghum sudangrass; and fallow. Paraquat dichloride was used to treat winter wheat, minimum tillage subplots at planting time. In 1978, peanuts were planted in both plots areas. In 1974, before this research, peanuts were also grown in both plots.

Pesticides (alachlor, chlorothalonil, carbaryl, and Spreader-Sticker 268) were used at recommended commercial rates in both plots to control weeds, Cercospora leaf spot of peanut, insects, and animal pests. Herbicides were also used, as well as hand cultivation, to manage late-season grasses. Animal damage required the hand replanting of peanut, corn, and soybean seeds until mid-June in 1975 and late May in 1976. Other chemicals (calcium nitrate for corn and calcium sulfate for peanut) were applied to the appropriate treatments at recommended commercial rates.

Plant residues in the crop rotation plot were disked into the soil in November before a cover crop of Western rye grass was planted. The sorghum sudangrass was disked into the soil in September. Both the crop rotation and selected subplots of the minimum tillage and green manuring plots were deep-plowed in April with a moldboard plow and disked twice before planting.

Soil sampling and fungal assay. Soil samples were taken each year in June or early July from each of the middle two rows of the four-row subplots with a standard soil probe (2 cm diam). In the crop rotation plot, a soil sample divided into two portions (2 cm × 0–12.7 cm deep and 2 cm × 12.7–25.4 cm deep) was taken every 30.5 cm of row. A similar procedure was used for the minimum tillage and green manuring plot, except that the soil core was not divided into two portions. Soil samples from each row were combined and hand mixed in a plastic bag for 5 min before being transported to the laboratory in an insulated container. Air holes in plastic bags allowed air exchange during transport and storage.

A. flavus and *A. niger* group populations were determined by the method of Griffin and Garren using a selective medium (5–7). Soil pH ranged from 5.3 to 5.9; calcium, magnesium, phosphorus, and potassium ranged from 60–110 kg/ha, 9–13 kg/ha, >50 kg/ha, and 10–17 kg/ha, respectively, for both plots. Soil texture ranged from sandy loam to loamy sand-sand, and the soil types present were Emporia, Goldsboro, and Kenansville.

RESULTS

In 1975, populations of *A. flavus* group, primarily of *A. flavus*, were generally low (Table 1). However, in 1976 and 1977, high mean *A. flavus* group populations were present in all four soils that had been cropped to corn the previous year. In soils cropped to peanut, high *A. flavus* group populations were observed in 1977. In the fallow sequence, an anomalously high *A. flavus* group population was observed in 1978. Statistical analysis of the results (Duncan's multiple range test, $P = 0.05$) indicated no significant associations, except for the high *A. flavus* group population in 1976 following corn in the continuous corn sequence (Table 1).

In an orthogonal comparison using the *t*-test, the mean 1976 *A. flavus* group population of the two combined sequences planted with corn the previous year was significantly greater than the population in the fallow control ($P = 0.05$). The 1976 *A. flavus* group population was significantly higher than the 1975 population in the continuous corn sequence. Orthogonal comparison also indicated that the mean 1977 *A. flavus* group population of the two combined sequences planted with peanut the previous year was significantly greater than in the fallow ($P = 0.05$).

Variance to mean ratios of *A. flavus* group populations for the 1976 and 1977 soils planted to corn the previous year were much greater than one (97 and 248 for 1976, 2,003 and 430 for 1977). Variance to mean ratios greater than one indicate a clumped or clustered inoculum pattern in the soil, whereas a random inoculum pattern in soil should have a variance to mean ratio equal to one (11; D. A. Roth and G. J. Griffin, *unpublished*). Variance to mean ratios of *A. flavus* group populations for the two 1977 soils planted to peanut the previous year were lower than for corn (13 and 80).

A. flavus group populations in 1976 and 1977 in soils planted to corn the previous year were generally associated with soil at the lower rather than the upper depth (Table 2). In 1976, only the *A. flavus* group population in the continuous corn sequence at the lower soil depth was significantly different from populations found in the sequences without corn, according to Duncan's multiple range test ($P = 0.05$).

Initial populations of *A. flavus* group in the minimum tillage and green manuring plot were also low. Populations ranging from 0.3 to 14.5 propagules per gram of soil were not significantly different ($P = 0.05$) for any of the treatments (1976–1978).

A. niger group populations were generally high for the crop rotation plot; initial populations ranged from 87.9 propagules per gram of soil for the continuous peanut crop sequence to 1,381 propagules per gram of soil for the continuous corn (1975–1977) sequence. Populations remained high through 1979. No consistent trends based on crop sequence were noted. In the minimum tillage and green manuring plot, *A. niger* group populations were lower than in the crop rotation plot. The initial range was 19.2–53.2 propagules per gram of soil, and the overall range was 6.4–285.2 propagules per gram of soil.

Table 1. Influence of peanut, corn, and soybean rotations on populations of *Aspergillus flavus* group in field soil from 1975 to 1979

	A. flavus group propagules per gram of soil				
Crop sequence[y]	1975	1976	1977	1978	1979
P-C-P-S-P	10.1 a[z]	34.6 ab	14.5 a	8.2 a	4.8 a
P-C-C-C-P	4.8 a	91.1 b	178.3 a	12.2 a	14.1 a
P-S-C-P-P	0.9 a	5.3 a	128.6 a	3.7 a	6.6 a
P-P-P-P-P	2.9 a	1.7 a	37.4 a	6.1 a	9.9 a
P-F-F-F-P	1.3 a	1.7 a	3.6 a	41.9 a	9.1 a

[y] C = corn, P = peanut, S = soybean, and F = fallow. Sequence indicates crops grown from 1974 through 1978.
[z] Populations followed by the same letter within columns are not significantly different according to Duncan's multiple range test ($P = 0.05$).

Table 2. Populations of *Aspergillus flavus* group at two soil depths in the crop rotation field plot in 1976 and 1977

	A. flavus group propagules per gram of soil			
	0–12.7 cm deep		12.7–25.4 cm deep	
Crop sequence[y]	1976	1977	1976	1977
P-C-P	32.9 a[z]	15.6 a	36.3 ab	13.4 a
P-C-C	27.6 a	51.6 a	154.5 b	305.0 a
P-S-C	2.7 a	90.2 a	7.9 a	166.9 a
P-P-P	1.4 a	41.2 a	1.9 a	33.6 a
P-F-F	1.1 a	3.9 a	2.3 a	3.2 a

[y] C = corn, P = peanut, S = soybean, and F = fallow. Sequence indicates crops grown from 1974 through 1976.
[z] Populations followed by the same letter within columns are not significantly different according to Duncan's multiple range test ($P = 0.05$).

DISCUSSION

The populations of *A. flavus* group found in this study are typical of those found in Virginia peanut field soils (6) where appreciable *A. flavus* colonization of peanuts at harvest has been observed (3,4,12). The results suggest that cropping with corn or peanut in Virginia may present a hazard of *A. flavus* group population buildup in some years. The hazard may be reduced if most of the *A. flavus* group inoculum following corn cropping is located in the lower portion of the plow layer, away from peanut pods.

A. flavus group growth is favored by low water potential (2,5), and periods of drought and high temperature have been associated with *A. flavus* colonization of corn (14). Both August 1975 and August 1976 were dry (1.85 cm and 5.84 cm of rainfall, respectively, versus a 40-yr mean of 15.75 cm) in the peanut-growing region at Holland, VA (D. L. Hallock, *personal communication*). Both years were followed by high mean *A. flavus* populations in soil of corn subplots. August 1977 was dry and hot, but high mean *A. flavus* group populations were not found in 1978 in subplots planted to corn in 1977.

It is not clear why *A. flavus* group population had no consistent, statistically significant relationship with the continuous planting of corn or other crop sequences. The high mean populations in 1977 were partly caused by exceptionally high populations in certain rows of the field plot, which may in turn have been caused by the frequent occurrence of inoculum in clumps or patches, rather than randomly, throughout the corn subplots. This hypothesis is supported by the very high variance to mean ratios, indicative of a clumped inoculum pattern (11; D. A. Roth and G. J. Griffin, *unpublished*), that were obtained for *A. flavus* group populations in soils planted to corn the previous year.

A. niger group fungi are antagonists of the *A. flavus* group fungi (1,8). Cultural practices that increase *A. niger* group populations may eventually reduce *A. flavus* group colonization of peanut or corn. However, no evidence for such an effect by crop rotation was found.

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