Distribution and Severity of Peanut Leafspot in Florida

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ABSTRACT

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Thirty-five peanut fields in seven Florida counties were sampled in 1979 for early and late leafspots caused by *Cercospora arachidicola* and *Cercosporidium personatum*, respectively. Late leafspot predominated in the sample, accounting for 88% of all leafspots counted and 66% of the leafspot area calculated. Some fields, however, had more early than late leafspot. Both high and low leafspot counts were made in fields where recommended control practices (repeated fungicide applications at 10-to 14-day intervals beginning 35–40 days after planting, and crop rotation) had been followed and also where they had not been followed. Analysis of the distribution patterns of leafspots within 12 of the fields revealed four types of distributions for both early and late leafspot. Three types of nonrandom distribution patterns and one completely random distribution pattern were detected. There was no apparent relationship between the leafspot distribution patterns and the average disease severities in the fields.

Peanut leafspot, a disease complex of early and late leafspot caused by *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. and Curt.) Deighton, respectively, is a severe disease problem of peanuts in Florida. Control programs in Florida are based on repeated fungicide applications (10–14 day intervals) beginning early in the growing season (about 35–40 days after seeding) and crop rotation (3,4). The effectiveness of these control measures in the context of the varying disease pressures occurring in different seasons and in different areas is unknown. Extensive field sampling to determine disease incidence and severity in areas where different control procedures have been followed can give an indication of the utility of particular control strategies.

Field sampling has applications other than the determination of disease incidence and severity. If a fungicide is used intensively in a control program, sampling can increase the chances for the early detection of strains of the pathogen that are resistant to the fungicide. Sampling also can facilitate the collection of pathogen isolates that reflect the current nature of the pathogen population. Such isolates are useful in screening plant germplasm for disease resistance.

Regardless of the reason for sampling, the sample should reflect the true nature of the sampled population if conclusions based on observations of the sample are to have validity. The degree to which a sample reflects the sampled population depends on the sampling strategy, the number of samples collected, the method (path) of collection, and the distribution of diseased plants (6).

The purposes of this study were: to determine the incidence and severity of early and late leafspots of peanuts in Florida in 1979, to relate observed levels of leafspot incidence and severity in sampled fields to control procedures, to identify the distribution patterns of early and late leafspots within sampled fields, and to obtain isolates of *C. arachidicola* and *C. personatum* representative of the sampled pathogen populations for future use in the characterization of variation in their fungicide resistance, pathogenicity, and virulence.

MATERIALS AND METHODS

Arrangements to sample peanut fields were made with county agents in seven counties in Florida. Agents located the fields and obtained information from growers regarding seeding dates, dates of the first fungicide applications, the interval between

TABLE 1. Relative prevalences and severities of early and late leafspots (lsp.) caused by *Cercospora arachidicola* and *Cercosporidium personatum*, respectively, in peanut fields sampled in Florida in 1979

	Number of leafspots[a]			Area of leafspots (mm^2)[b]		
Field	Total	Early lsp.	Late lsp.	Total	Early lsp.	Late lsp.
1	2	0	2	2	0	2
2	8	1	7	23	3	20
3	1	0	1	2	0	2
4	3	1	2	5	3	2
5	20	5	15	na[c]	na	na
6	14	5	9	na	na	na
7	972	354	618	4,695	3,603	1,092
8	4,837	2,439	2,398	21,120	15,018	6,102
9	16,133	39	16,094	25,241	466	24,775
10	83	44	39	975	700	276
11	219	92	127	2,079	1,596	483
12	187	32	155	952	465	487
13	1,439	35	1,404	5,634	299	5,337
14	3,874	155	3,719	12,211	1,667	10,544
15	3,799	214	3,585	10,953	1,830	9,123
16	273	221	52	3,628	3,209	418
17	221	58	163	1,881	729	1,152
18	12	3	9	141	59	82
19	1,022	32	990	3,097	291	2,807
20	150	26	124	484	265	219
21	131	8	123	318	101	217
22	542	81	461	2,184	735	1,448
23	7	0	7	46	0	46
24	4	1	3	45	20	26
25	5	3	2	119	94	25
26	196	34	162	1,323	590	733
27	178	76	102	1,391	1,003	388
28	69	56	13	950	852	98
29	162	9	153	516	82	434
30	527	68	459	2,296	855	1,442
31	152	47	105	1,252	651	601
32	31	5	26	333	161	172
33	136	12	124	644	362	281
34	106	8	98	851	111	740
35	22	3	19	112	26	86
Totals	35,537	4,167	31,370	105,503	35,846	69,660

[a] Number of leafspots per 200 leaflets per field from third fully expanded leaves from shoot tips.
[b] Leafspot area = number of leafspots × 3.14 × (average leafspot diameter [mm] / 2)^2.
[c] Not available.

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applications, the fungicides applied, and the recent crop histories of the fields (crops grown in previous years). Fields were not selected at random; in some cases the agents selected fields in which there was either poor or excellent control of peanut leafspot. Fields in Jackson County constituted the bulk of the sampled fields since most of the peanut acreage (>50%) of Florida is in Jackson County (1). The cultivar Florunner was grown in each of the 35 fields that were sampled.

If possible, fields were sampled 90–130 days after planting since symptoms of both early and late leafspots normally are expressed at those times (7). Leaflets were collected from the third fully expanded leaves from shoot tips from randomly selected stems at each collection site. This practice was consistent from field to field, allowing comparisons of leafspot counts to be made between fields.

The sampling strategy was to collect 200 leaflet samples per field along a W-shaped path through each field. There were 10 collection sites along each of the four arms of the W. Five leaflets, one from each of five stems, were collected at each site. Collection sites were spaced at about 20-m intervals. The W-shaped path was travelled in such a way that an area of about 8 hectares was traversed in each field.

Collected leaflets were examined in the laboratory. Leafspots were identified as being caused by *C. arachidicola* or *C. personatum* according to color, shape, and pattern of sporulation occurring on the leafspots (2). Leafspots were counted and leafspot diameters were measured. Leafspot area was calculated by multiplying the number of leafspots per leaflet by the square of one half of the average leafspot diameter per leaflet by 3.14. Disease severities (number of leafspots per leaflet and leafspot area per leaflet) were determined for each field for early, late, and total (early plus late) leafspots.

For analysis of leafspot distribution patterns within fields, a square root transformation of leafspot counts was used (transformed value = $[\text{no. of leafspots} + 1]^{1/2}$) so that the assumptions of the analysis of variance would be met. A standard analysis of variance based on a nested design was performed on the transformed values to determine the type of leafspot distribution pattern (random or nonrandom) within the sampled fields. Sources of variation were arms within a field (Arm) and sites within the arms of field (Site [Arm]). F-values were calculated and levels of significance for each source of variation were determined. The mean square of Site (Arm) was used as the error term for calculating the F-value of Arm. The mean square of error, the mean square of leaflets within Site (Arm), was used for calculating the F-value of Site (Arm). If the probability of obtaining an F-value by chance that was as great, or greater, than the calculated F-value was ≤ 0.05, the leafspot distribution pattern for that source of variation was considered to be nonrandom. If this probability was >0.05, the leafspot distribution pattern for that source of variation was considered to be random.

RESULTS

Low amounts of leafspot (less than one leafspot per leaflet) were detected in 23 of the 35 sampled fields (Table 1). Among the remaining fields, however, up to 81 leafspots per leaflet (16,133 leafspots per 200 leaflets in field 9) were counted. Late leafspot

TABLE 2. Leafspot control programs and previous crop histories of peanut fields sampled in Florida for leafspot caused by *Cercospora arachidicola* and *Cercosporidium personatum* in 1979

			Fungicide program				Crop rotation	
Field	County	Crop age when sampled (days)	Crop age[a] 1st appl. (days)	Spray interval (days)	No. of appls. prior to sample	Material[b]	Previous crops	Years grown
1	Levy	113	70	5–14	4	CS, CA, MA+BN, CH	Bahia	4
2	Marion	125	60	7–14	5	CS, CH	Bahia	5
3	Marion	118	65	10–14	4	CS, CH	Bahia	10
4	Levy	136	60	14	6	CS, BN+MA	Bahia	3
5	Suwannee	107	60	10–14	5	CH, CH+S	Corn	4
6	Suwannee	100	60	14	5	CS	Corn	2
7	Jackson	105	65	10–14	5	CH, CH+S	Winter grain/Soybean	2
8	Jackson	116	60	10–14	5	CH	Pasture	2
9	Jackson	130	60	14	6	CH, CH+S, CS	Corn/Soybean	2
10	Jackson	105	60	14	4	CH+S	Corn/Soybean	2
11	Jackson	92	50	14	4	CH+S	Corn/Fallow	2
12	Jackson	92	30	14	5	CH+CO	Corn	1
13	Jackson	117	60	10–14	5	CH, CH+S, TP	Bermuda/Corn/Soybean	2
14	Jackson	119	40	12–14	8	CH, CH+S	Bahia	15
15	Jackson	121	40	12–14	8	CH, CH+S	Winter grain/Soybean	2
16	Jackson	115	45	16–17	5	CH, CH+S	Corn	2
17	Jackson	121	45	9–18	6	CH, CH+S	Winter rye/Soybean	2
18	Jackson	111	20	14	6	CH, CH+S	Soybean	2
19	Jackson	95	65	10–14	6	CH+S	Bahia/Watermelon	2
20	Jackson	123	35	14	7	CH, CH+S	Soybean	2
21	Jackson	121	30	14	7	CH, CH+S	Corn/Soybean	2
22	Jackson	112	85	10–14	3	CH+S	Bahia/Soybean	2
23	Jackson	95	35	14	5	CH+S	Soybean	2
24	Jackson	109	35	14	6	CH+S	Soybean	2
25	Jackson	109	35	14	6	CH+S	Peanut	4
26	Jackson	112	35	8–14	7	CH, CH+S	Fallow	1
27	Santa Rosa	125	40	14	7	CH+S	Peanut	1
28	Santa Rosa	115	65	14	5	CH	Soybean	1
29	Santa Rosa	125	40	14	7	CH	Soybean	1
30	Santa Rosa	127	85	14	4	CH	Soybean	1
31	Walton	na[c]	na	na	na	na	na	
32	Walton	na	na	na	na	na	na	
33	Walton	na	na	na	na	na	na	
34	Calhoun	na	na	na	na	na	na	
35	Calhoun	na	na	na	na	na	na	

[a] To the nearest 5 days.
[b] CS = copper sulfate, CA = captafol, MA = manzeb, BN = benomyl, CH = chlorothalonil, S = sulfur, CO = copper hydroxide, and TP = triphenyltin hydroxide.
[c] Not available.

occurred with greater frequency, accounting for 88% of all leafspots counted. When leafspot areas were calculated, however, late leafspot accounted for only 66% of the total leafspot area. The discrepancy in percentages reflects the generally larger size of early leafspots. The maximum average sizes (diameters) of leafspots on a leaflet ranged from 2.0–10.0 mm and from 1.5–7.0 mm for early and late leafspots, respectively (*unpublished*). Although late leafspot predominated in the sample, some fields had as much, or more, early leafspot (eg, fields 8, 10, 16, and 28).

The level of leafspot severity in fields did not always correspond to the intensity of the control effort (Table 2). Fields where fungicide applications were started no later than 35 days after planting had few leafspots on collected leaflets (less than one leafspot per leaflet), but so did eight fields where fungicide applications were not started until 60–70 days after planting. Even though most of the fields received fungicide applications at the recommended interval of 10–14 days, one field (field 16) that received applications at 16- to 17-day intervals had fewer leafspots on collected leaflets than many of the more intensely treated fields. Chlorothalonil was used as the recommended fungicide in most of the fields. In Jackson County, fields 14 and 15 had relatively high leafspot counts although eight applications of chlorothalonil and chlorothalonil plus sulfur had been made beginning about 40 days after planting. Fields 24 and 25 had relatively low counts of leafspot and had received six applications of chlorothalonil plus sulfur beginning about 35 days after planting. Field 22 had an intermediate level of leafspot although it had received only three applications of chlorothalonil plus sulfur beginning at about 85 days after planting. Crop rotation did not assure good leafspot control nor was it always required for good leafspot control. Field 25, where peanuts had been grown consecutively for 4 yr, had a low leafspot count. Field 14, where bahia had been grown for the previous 15 yr, had a relatively high leafspot count.

Leafspot distribution within fields was analyzed statistically only for the 12 fields that had leafspot counts of at least one leafspot per leaflet (Table 3). Four types of leafspot distribution within these fields were identified on the basis of F-values significant or nonsignificant, $P = 0.05$ for the two sources of variation, Arm and Site (Arm) (Table 4). There were three nonrandom distribution patterns and one random distribution pattern. The first nonrandom distribution pattern was represented by fields (field 8 for early leafspot; fields 7, 8, 13, 15, 19, and 30 for late leafspot) where the F-value was significant for both sources of variation. In these fields disease severity (number of leafspots per leaflet) differed across the field (arm to arm), similar to a disease gradient, and also from site to site within the arms of the field. Thus, disease foci were clustered, and the clusters were concentrated in particular portions of the field. The second nonrandom distribution pattern was represented by fields (field 30 for early leafspot; fields 16 and 22 for late leafspot) where the F-value was significant for Arm but not for Site (Arm). In these fields disease severity differed across the field, similar to a disease gradient. Within the arms of the field, however, disease was distributed randomly. The third nonrandom distribution pattern was represented by fields (fields 7, 11, 14, 16, and 17 for early leafspot; fields 9, 14, and 17 for late leafspot) where the F-value was significant for Site (Arm), but not for Arm. In these fields disease severity differed from site to site within a field, but without a noticeable gradient across the field; that is, disease foci appeared to be distributed in a random manner across the field. The completely random distribution pattern was represented by fields (fields 9, 13, 15, 19, and 22 for early leafspot; field 11 for late leafspot) where the F-value was nonsignificant for both Arm and Site (Arm). There was no difference in disease severity from site to site either within an area of the field or across the entire field.

There was no apparent relationship between the leafspot distribution patterns and the average disease severities in the fields. Early leafspot in fields 7, 15, and 16 had similar severities (1.1–1.8 leafspots per leaflet) but represented two distribution patterns (Tables 3 and 4). Likewise, fields 9, 11, 13, 14, 17, 19, 22, and 30 had similar early leafspot severities (0.2–0.8 leafspots per leaflet) but represented three distribution patterns. Late leafspot in fields 8, 14, and 15 had similar disease severities (12.0–18.6 leafspots per leaflet) but represented two distribution patterns; fields 7, 13, 19, 22, and 30 had similar disease severities (2.3–7.0 leafspots per leaflet) but represented two distribution patterns; and fields 11, 16, and 17 had similar disease severities (0.2–0.8 leafspots per leaflet) but represented three distribution patterns.

TABLE 3. Distribution of early and late leafspots (lsp.) of peanuts, caused by *Cercospora arachidicola* and *Cercosporidium personatum*, respectively, in 12 peanut fields sampled in Florida in 1979

Field	Arm[a]	Early lsp.[b]	Late lsp.[c]	Field	Arm	Early lsp.	Late lsp.	Field	Arm	Early lsp.	Late lsp.
7	A	1.5	5.1	13	A	0.2	11.8	17	A	0.2	0.9
	B	2.0	2.3		B	0.2	6.4		B	0.3	1.2
	C	1.9	4.4		C	0.2	4.4		C	0.4	0.5
	D	1.7	0.6		D	0.2	5.6		D	0.3	0.6
	$\bar{x}$[d]	1.8	3.1		$\bar{x}$	0.2	7.0		$\bar{x}$	0.3	0.8
8	A	7.9	25.3	14	A	0.5	17.0	19	A	0.1	2.8
	B	14.1	5.0		B	0.6	18.9		B	0.1	2.1
	C	12.9	6.3		C	1.0	21.9		C	0.2	8.6
	D	13.9	11.4		D	1.1	16.6		D	0.3	6.2
	$\bar{x}$	12.2	12.0		$\bar{x}$	0.8	18.6		$\bar{x}$	0.2	4.9
9	A	0.1	86.6	15	A	1.6	20.8	22	A	0.2	2.7
	B	0.2	84.0		B	1.0	21.7		B	0.5	1.1
	C	0.1	73.5		C	1.1	21.0		C	0.5	2.9
	D	0.3	77.8		D	0.6	8.2		D	0.4	2.6
	$\bar{x}$	0.2	80.5		$\bar{x}$	1.1	17.9		$\bar{x}$	0.4	2.3
11	A	0.7	0.5	16	A	1.0	0.3	30	A	0.0	3.6
	B	0.6	0.3		B	0.9	0.1		B	0.3	3.9
	C	0.3	0.7		C	1.3	0.4		C	0.5	0.7
	D	0.3	1.0		D	1.3	0.2		D	0.6	1.0
	$\bar{x}$	0.5	0.6		$\bar{x}$	1.1	0.2		$\bar{x}$	0.4	2.3

[a] An "arm" consisted of a 200-m transect through a field along which five leaflets from third fully expanded leaves from shoot tips were collected at each of 10 sites, 20 m apart; four arms (A, B, C, and D) formed a W-shaped sampling pattern in each field.
[b] Mean number of early leafspots per leaflet counted on 50 leaflets per arm.
[c] Mean number of late leafspots per leaflet counted on 50 leaflets per arm.
[d] Field means ($\bar{x}$) for number of early and late leafspots per leaflet.

DISCUSSION

Counts of leafspots on leaflet samples from 35 peanut fields in Florida in 1979, revealed that late leafspot was the predominant leafspot of peanuts that year. Although 1979 was the first year that extensive sampling was undertaken, the high frequency of late leafspot relative to early leafspot may be of recent occurrence. Less extensive sampling the prior 2 yr (sampling restricted to two University of Florida research facilities, Green Acres Agronomy Farm and Marianna Agricultural Research Center) had shown that, with the exception of 1977 samples from Marianna, early leafspot occurred in as great, or greater frequencies than late leafspot (*unpublished* and [7]). Despite the fact that late leafspot predominated in the overall sample, early leafspot, for unknown reasons, occurred in greater frequencies in some fields.

Leafspot counts represent a low estimate of disease severity in sampled fields. Had leaflets lower in the plant canopy been selected, much higher counts would have been recorded. In fields with severe disease, however, defoliation would have precluded the collection of such leaflets and comparisons between fields in which disease severity differed could not have been made. Leaflets were not collected from younger leaves than those used because it was likely that even if they were infected, they would not have shown symptoms. In inoculations of peanut plants conducted in the greenhouse with over 300 single-spore isolates of *C. arachidicola* and *C. personatum* collected in Florida in 1977 and 1978, the time from inoculation to the appearance of symptoms ranged from 4 to 15 days for *C. arachidicola* and from 5 to 22 days for *C. personatum* (*unpublished*).

The sampling time of about 90–130 days after planting permitted an accurate assessment of the relative prevalences of early and late leafspots. The sampling interval bracketed the times when peak numbers of early and late leafspots probably occurred. Monasterios (7) made weekly leafspot counts in two widely separated peanut production areas of Florida in 1978 and 1979, and found that early leafspot reached a maximum level between 107 and 120 days after planting while late leafspot reached a maximum level between 114 and 127 days after planting.

Fields where recommended leafspot control procedures were followed generally had little leafspot. However, several fields where such control procedures were followed had severe leafspot, and several fields where recommendations were not followed had little leafspot. The amount of leafspot that occurs in a field is the result of interactions among many variables, which differ from field to field. Some factors, such as field location (environment) and inoculum sources and production, are unique for each field and probably are at least partially responsible for similar leafspot control procedures providing variable leafspot control.

The fact that different leafspot distribution patterns were detected in the sampled fields emphasizes the importance of the sampling method for the correct interpretation of population characteristics based on a sample. For example, interpretations of disease progress within a field, efficacy of disease control procedures, and the degree that collected isolates reflect the nature of the pathogen population, all are based on observations of samples from the host or pathogen population, not on observations of the populations themselves. Peanut growers are advised to apply fungicides for the control of leafspot, or to assess the success of their ongoing control programs, by observing the number of leafspots in the plant canopy in various areas of the field (5) or in a representative portion of the field (3). If a particular field has one of the three types of nonrandom leafspot distribution patterns described herein, the grower may not be able to make a correct interpretation of the leafspot counts since counts from a few areas may not be representative of leafspot severity in the whole field. Since leafspot severity in a field bore no relationship to leafspot distribution pattern in the same field, systematic sampling probably is required regardless of the level of leafspot severity if correct management decisions are to be made.

The occurrence of four leafspot distribution patterns for both early and late leafspots is indicative of the complex nature of both diseases. Leafspot cannot be assumed to occur randomly within fields, nor can patterns of nonrandomness be considered equivalent from field to field. The type of distribution that occurs, be it random or one of the nonrandom types, is the end result of the interactions that have occurred among many variables that influence disease onset and spread.

TABLE 4. Analysis of variance for leafspot distribution within 12 peanut fields sampled in Florida in 1979

			(Number of early leafspots + 1)$^{1/2}$				(Number of late leafspots + 1)$^{1/2}$			
Field	Source	D. F.	ANOVA S. S.	F[a]	PR>F	C. V.	ANOVA S. S.	F	PR>F	C. V.
7	Arm[b]	3	0.77	0.44	0.73	36.0	18.79	2.99	0.04	67.7
	Site (Arm)	36	21.32	1.89	<0.01		75.36	1.73	0.01	
	Error	160	50.09				194.14			
8	Arm	3	23.05	7.53	<0.01	21.9	203.30	0.13	<0.01	30.6
	Site (Arm)	36	36.72	1.69	0.01		121.20	3.40	<0.01	
	Error	160	96.44				158.19			
9	Arm	3	0.18	1.49	0.23	18.4	14.57	1.32	0.28	13.9
	Site (Arm)	36	1.42	1.01	0.46		132.31	2.39	<0.01	
	Error	160	6.26				246.54			
11	Arm	3	0.74	1.82	0.16	25.9	0.93	1.54	0.22	43.6
	Site (Arm)	36	4.88	1.48	0.05		7.20	0.76	0.83	
	Error	160	14.61				42.11			
13	Arm	3	0.01	0.12	0.95	16.1	37.68	12.59	<0.01	25.8
	Site (Arm)	36	1.15	1.08	0.36		35.93	2.06	<0.01	
	Error	159	4.72				77.19			
14	Arm	3	1.13	1.58	0.21	26.8	10.36	1.29	0.29	19.3
	Site (Arm)	36	8.63	2.04	<0.01		96.33	3.88	<0.01	
	Error	160	18.83				110.36			
15	Arm	3	1.70	1.72	0.18	35.3	111.70	4.19	0.01	27.7
	Site (Arm)	36	11.81	1.44	0.06		320.03	7.30	<0.01	
	Error	160	36.32				194.76			
16	Arm	3	0.71	1.45	0.25	22.3	0.44	3.57	0.02	18.9
	Site (Arm)	36	5.90	1.65	0.02		1.48	0.95	0.56	
	Error	159	15.77				6.91			
17	Arm	3	0.03	0.08	0.97	25.2	1.54	1.87	0.15	26.3
	Site (Arm)	36	4.74	1.72	0.01		9.88	2.39	<0.01	
	Error	160	12.27				18.38			
19	Arm	3	0.14	0.74	0.53	20.7	38.08	6.13	<0.01	49.2
	Site (Arm)	36	2.20	1.29	0.15		74.51	1.90	<0.01	
	Error	160	7.59				174.50			
22	Arm	3	0.52	1.59	0.21	26.7	6.84	3.63	0.02	39.4
	Site (Arm)	36	3.97	1.18	0.24		22.60	1.44	0.07	
	Error	160	14.96				69.82			
30	Arm	3	1.03	3.22	0.03	26.1	19.85	5.30	<0.01	42.9
	Site (Arm)	36	3.83	1.25	0.18		44.99	2.63	<0.01	
	Error	160	13.63				76.15			

[a] F-value for Arm is calculated by using the mean square of Site (Arm) as error; F-value for Site (Arm) is calculated by using the mean square of error (= leaflets within Site [Arm]).

[b] An "arm" consisted of a 200-m transect through a field along which five leaflets from third fully expanded leaves from shoot tips were collected at each of 10 sites, 20 m apart; four arms (A, B, C, and D) formed a W-shaped sampling pattern in each field.

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