Components of Resistance to Late Leafspot in Peanut. I. Levels and Variability - Implications for Selection[1]

Z. A. Chiteka, D. W. Gorbet, F. M. Shokes, T. A. Kucharek and D. A. Knauft*[2]

ABSTRACT

Components of resistance to late leafspot (*Cercosporidium personatum* (Berk. & Curt.) Deighton) in peanut were evaluated for 116 genotypes in three tests during 1986. The tests were conducted in greenhouses at Gainesville and Quincy, Florida and in the field near Marianna, Florida. The components of resistance evaluated were spore incubation period, latent period, lesion number per leaf, percent leaf necrotic area, lesion size, and amount of sporulation. Significant differences were observed in at least one test for each component. The greatest variability among genotypes was observed for lesion diameter and latent period. Resistant genotypes had smaller lesions, longer latent periods, and reducded sporulation. Among the most resistant genotypes were UF81206-1, UF81206-2, 72x32B-3-2-2-2-2-1-b3-B, and US 29-b3-B (85701).

Key Words: *Arachis hypogaea*, L. groundnuts, disease resistance, genetic variability, *Cercosporidium personatum* (Berk. and Curt.) Deighton.

Early and late leafspots, caused by *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. and Curt.) Deighton, respectively, are major foliar diseases affecting peanut (*Arachis hypogaea* L.). They occur wherever peanuts are grown (10, 20). Breeding for resistance to early and late leafspots is a major objective in peanut breeding programs (13, 16). Sources of resistance to early and late leafspots have been identified in the cultivated peanut (1, 2, 8, 14, 21, 22). While further sources of resistance have been found in wild *Arachis* species (1, 3, 4), resistance in cultivated peanuts is more readily available for immediate use in peanut breeding programs (3).

Pixley (17), Watson (25), and Gorbet *et al.* (5) found partial resistance to late leafspot, and Johnson and Beute (11) found partial resistance to early leafspot. In all cases this resistance, found in cultivated peanut, reduced the severity of the disease. The resistance, which reduced the rate of development of the disease, included various components (7, 12, 23, 24) that were associated with each other, although in no instance was the association complete (15). It should be possible to select genotypes with relatively high levels of different components of rate-reducing resistance, allowing incorporation of these into desirable commercial cultivars. The value of selecting components of resistance that reinforce each other will depend on the level, the degree of genetic variability, and heritability of each component.

[1]Contribution from the Florida Agric. Expt. Sta. Journal Series No. 8733.

[2]Former Agronomy Department graduate student (now groundnut breeder, Crop Breeding Institute, Harare, Zimbabwe); Professor of Agronomy, Agricultural Research and Education Center, Marianna 32446; Associate Professor of Plant Pathology, North Florida Research and Education Center, Quincy 32351; Professor of Plant Pathology, Gainesville 32611; and Associate Professor of Agronomy, Gainesville 32611, respectively.

Evaluations of components of resistance have often been conducted in the greenhouse (7, 24), with few studies in the field. The purpose of this study was to assess components of resistance measured in the field and in the greenhouse for variability and consistency.

Materials and Methods

Experiment 1

Twenty six genotypes were evaluated for resistance to late leafspot in the greenhouse at the University of Florida in Gainesville. Table 1 provides identity for the genotypes referred to in this study. Information on any of the genotypes used in the three experiments constituting this study may be obtained from D. W. Gorbet. Florunner was included as a susceptible check and Southern Runner was included as a partially resistant check (5, 6). Seed were planted on February 13, 1986 in plastic pots 16 cm diameter by 16 cm deep using Metromix 220 (Grace Corp., Lexington, Ma.) and inoculated with *Rhizobium* spp. (Nitragin Co., Milwaukee, WI). Pots were arranged on a greenhouse bench in a randomized complete block design with four replications. The experiment was terminated when the plants were 90 days old.

Table 1. Identification of entries used in Gainesville greenhouse test with highest levels of one or more components of resistance to late leafspot in peanut.

Entry	Identification
2	72x93-6-1-2-b2-B (PI 203396 x Florunner)
3	72x93-9-1-2-b3-B
6	72x101B-2-3-2-b2-B (439-17 x PI 306230-2-2)
7	72x101B-2-3-3-b2-B
11	72x100-17-1-1-b3-B (PI 306230-2-2 x Florunner)
12	72x100-12-1-1-b3-B
13	72x31-2-1-1-b2-B (Florigiant x PI 145681)
15	PI 203396
17	72x94-12-1-1-b2-B (PI 203396 x 427B-)
18	72x32B-10-1-1-b3-B (Florigiant x PI 259785)
19	72x31-11-1-2-b3-B
20	72x101B-2-3-2-b2-B
28	72x83A-4-1-2-B (Florunner x PI 121067)
29	72x36B-15-3-1-b (Florunner x PI 261911)
30	72x67-14-4-1-B (439-16- x PI 458681)

Inocula of *C. personatum* originated from lesions on the susceptible cultivar Early Bunch. Conidia from sporulating lesions were obtained with a cyclone spore collector attached to a test tube with 5 mL of distilled water. Conidial concentrations were determined with a hemocytometer. Suspensions were diluted to 4000 conidia mL^{-1}, and a drop of Tween 80 100 mL^{-1} of mixture was added to aid in the spread of inoculum on the leaf surface. Conidial inoculum had a germination rate of 90 to 100%.

Forty-three days after planting, six healthy, fully expanded leaves from the middle region of the plant canopy were tagged and inoculated with the conidial suspension, using a Spra - Tool (Fisher Scientific Products, Pittsburgh, PA) which delivered 1 mL inoculum $second^{-1}$. The leaf was held on a small wooden board with the top of the leaf surface facing upwards and misted for one second with the spore suspension. After drying, target leaves were shielded and the remainder of the plant was inoculated by misting for 5 seconds. Inoculated plants were placed in a mist chamber for 48 hrs (mean temperature of 25 C) and pots were then placed on a greenhouse bench (temperature range of 19.8 - 30.8 C). Plants were kept well watered to prevent moisture stress.

Data were collected on the following components of resistance: i) incubation period (IP), defined as days from inoculation to the appearance of the first lesion, ii) latent period in days from inoculation to the

first sporulating lesion (LS_1) and the second sporulating lesion (LS_2), iii) latent period defined as days from inoculation to 50% of primary lesions sporulating (LS_{50}), iv) lesion counts per leaf (LC 21) at 21 days after inoculation (DAI), v) percent necrotic area per leaf (%NA) at 50 DAI, using a standardized pictorial chart (18), vi) sporulation score (SSC) using a 1 - 5 scale, according to Subrahmanyam *et al.* (23), where,

1 = few stromata with little or no sporulation,
2 = stromata with slight sporulation,
3 = stromata over most of lesion, moderate sporulation,
4 = stromata on entire lesion, moderate to profuse sporulation,
5 = dense production of stromata with heavy sporulation.

Identification of sporulating lesions was done with the aid of a (20x) magnifying lens. Latent periods were determined by observing all target leaves on a daily basis. Sporulation score was determined at 40 and 50 DAI from nontarget leaves located in middle canopy. Leaves were excised and placed in a moist chamber (petri dish with moist filter paper) under fluorescent light for 72 hr to enhance sporulation. Sporulation was rated for 10 randomly selected mature lesions using a dissecting microscope (70x) and secondary lesions were not scored.

Experiment 2

This test was conducted in the greenhouse at North Florida Research and Education Center in Quincy Florida with 105 genotypes. Table 2 lists all genotypes and their pedigrees for entries subsequently referenced. Florunner and Southern Runner were again included as check cultivars. The planting and inoculation procedures were the same as described for experiment 1, with the exception that there were three replicates and five target leaves. High humidity was maintained with automatically controlled misting nozzles placed above the greenhouse bench by misting for thirty seconds every five minutes for 48 hrs after inoculation. Mean daily temperatures in the greenhouse ranged from 27 to 34 C. Target leaves were examined in the same manner as in experiment 1. Data were collected on IP, LS_1, LS_2, and lesion counts at 19 and 23 days (LC 19 and LC 23, respectively). Percent leaf necrotic area was determined on target leaves at 23 DAI (%NA23) and SSC was determined at 35 DAI in the same manner described for experiment 1. Lesion diameter (LD) was measured using a Finescale comparator, (Finescale Co. Orange, CA) assuming lesions to be circular. When plants were 90 days old, they were rated for disease using the Florida 1 to 10 scale as noted in Table 3.

Experiment 3

The field test was conducted at Marianna (Dozier Boys School) and included the same 105 genotypes as in experiment 2. The design was a randomized complete block with two replicates with two row plots, each 6.1 m long and 91 cm wide with seed spaced 15 cm apart and inoculated with *Rhizobium* at planting. The non-irrigated test was planted on May 22, 1986 and standard cultural practices were followed, except that no fungicide was applied for leafspot control.

At 60 days after planting (DAP) three representative plants were selected from each plot and marked with a stake. Three target leaves were selected and inoculated with a *C. personatum* conidial suspension standardized to 10,000 conidia mL^{-1}. The remainder of the plot was inoculated by dusting with finely shredded diseased plant material at a rate of 20 g per plot. The test site received a total of 45.2 cm of rainfall during the growing period. Lesion counts per leaf were recorded at 15 and 19 DAI (LC 15 and LC 19, respectively), and %NA was determined at 25 DAI. Latent period was also recorded as the number of days from inoculation to the first (LS_1) and the second (LS_2) lesion sporulating. Lesion diameter and sporulation rating were determined in the same manner as for experiment 2. Plant appearance score (PAS) was rated on a 1 to 10 scale at 120 DAP and at 135 DAP on a whole plot basis, using the scale shown in Table 3.

Statistical Analysis

Analysis of variance was performed on the means of each component on a plot basis. Lesion counts per leaf and %NA were transformed using the square root transformation to normalize the data.

Components which showed statistical significance at $P \leq 0.05$ were used to calculate an index to determine the relative breeding value of genotypes with respect to the various components in the field test. Each component was adjusted for the degree of variability for that particular component. The index of merit for each genotype in each replicate was calculated according to the following formula;

$$I = C_1 + C_2 + \ldots + C_n$$

where each C value is the weighted value for each component and n is the number of components showing statistical significance at $P \leq 0.05$.

C_n = $((F-G)/(LSD_{0.05}) \times 2)$, where $LSD_{0.05}$ measures variability for the test,
F = mean for the susceptible check cultivar Florunner,
G = mean for the genotype
$LSD_{0.05}$ = least significant difference for the component at the 5% level.

The sign of the index for latent period and incubation period was reversed, giving Florunner an index of 0.0 and any genotype with an overall resistance lower than Florunner a negative index value. Genotypes were classified as either resistant, moderately resistant, or susceptible in accordance with their relative rating in comparison with the moderately resistant check cultivar, Southern Runner, and Florunner, the susceptible check. Analysis of variance was conducted on the indices.

Table 2. Identification of entries used in Quincy greenhouse test and Marianna field test with highest levels of one or more components of resistance to late leafspot in peanut.

Entry	Identification
1	73x20B-5-3-1-1-b2-B (439-16 x PI 268894)
4	72x32B-3-2-2-2-2-1-b3-B (Florigiant x PI 259785)
5	72x94-12-1-1-b2-B-3-b3-B (PI 203396 x 427B-)
6	W.C. Egret
8	US 29-b3-B
9	UF 563B (439-16- x PI 331326)
10	US 202b2
11	US 27A-b3
12	Makulu Red
14	NC 3033
30	PI 365553
33	PI 384498
34	PI 415881
35	PI 121067
38	PI 203395
39	PI 203396
40	PI 259641
44	PI 261893
51	PI 268913
58	UF 81206-1
59	UF 81206-2
61	72x94-14-1-1-1-2-1-3-B (PI 203396 x 427B-)
63	72x93-6-1-2-b2-B-FL-b3-B (PI 203396 x Florunner)
64	72x31-11-1-1-b3-B-b3-B (Florigiant x PI 145681)
65	76x5-1-2-2-1-b2-B (535B x PI 383424)
66	76x9-10-1-1-1-2-b2-B (GK19 x PI 383424)
68	UF 639B-5-1-B (519-4- x UF 81206-1)
70	76x5-3-2-3-1-1-1-b3-B
71	72x93-9-1-2-2-B-3-b2-B
72	72x93-9-1-2-3-B-2-b2-B
74	79x6B-10-3-3-b2-B [(72x38) x (72x83A)]
78	72x83A-4-1-1-1-1-1-b2-B (Florunner x PI 121067)
80	72x86A-10-1-1-3-1-1-3-b2-B (Tifspan x PI 203396)
83	76x9-10-4-1-2-b2-B (GK19 x PI 383424)
85	78x4A-6-1-2-b2-B (714021 x PI 383424)
88	77x1B-1-2-1-1-b3-B (PI 383424 x GK19)
95	PI 306230
96	72x31-2-1-1-b2-B
102	72x83A-8-1-1-B
103	72x83B-7-1-1-B

Table 3. Leafspot scoring system used for plant appearance score.

Rank	Description
1	No disease
2	Very few lesions (none on upper canopy)
3	Few lesions (very few on upper canopy)
4	Some lesions with more on upper canopy than for rank of 3 and slight defoliation noticeable
5	Lesions noticeable even on upper canopy with noticeable defoliation
6	Lesions numerous and very evident on upper canopy with significant defoliation (50%+)
7	Lesions numerous on upper canopy with much defoliation (75%+)
8	Upper canopy covered with lesions with high defoliation (90%+)
9	Very few leaves remaining and those covered with lesions (some plants completely defoliated)
10	Plants dead

Results and Discussion

Statistical significance for each component of resistance in all three tests are shown in Table 4.

Table 4. Statistical significance for components of resistance to late leafspot and plant appearance score in the greenhouse in Gainesville (GNV) and Quincy (QCY), and in the field test at Dozier Boys School at Marianna (MNA), 1986.

Component	GNV	QCY	MNA
Incubation period	NS	NS	*[a]
Latent period (LS_1)	***	**	***
Latent period (LS_2)	ND[b]	ND	***
Latent period (LS_{50})	**	ND	***
Transformed lesion count per leaf[c]	*	NS	NS
Transformed percent leaf necrotic area[d]	NS	NS	*
Lesion diameter (LD)[e]	ND	**	***
Sporulation score on 1 to 5 scale	***	***	***
Plant Appearance Score (PAS)	ND	***	***

[a] Statistical significance indicated by NS, *, **, and *** are not significant and significant at P 0.05, 0.01, and 0.001, respectively.

[b] No data collected.

[c] Lesion count per leaf at 21, 20, and 19 days after inoculation (DAI) for each location, respectively.

[d] Percent necrotic area at 50, 23, and 25 DAI, respectively.

[e] Measured in mm at 35 DAI.

Incubation Period

Significant differences among genotypes were found only in the field test at Marianna for incubation period. Florunner had the second longest incubation period in this test, contrary to results in the greenhouse tests at Quincy and Gainesville. The range for mean incubation period in the field was low (7 to 10 days), probably because conditions in the field were favorable for the development of late leafspot. Incubation period does not appear to be a useful component for isolating resistant genotypes for *C. personatum*.

Latent Period

Latent period was measured as days from inoculation to the first (LS_1) and second (LS_2) lesion sporulating and days from inoculation to 50% of primary lesions sporulating (LS_{50}) in the Gainesville test. In the Quincy test only LS_1 could be determined due to a low infection frequency. In the field test, latent period was measured as LS_1, LS_2, and LS_{50}. On some genotypes, the target leaves defoliated before 50% sporulation could be recorded, while on other genotypes, lesions did not reach 50% sporulation as of the last date of observation. Only 46 of the 105 genotypes tested had an estimable LS_{50} value in the field trial.

There were highly significant differences ($P<0.001$) (Table 4) for latent period as measured by one or more methods in all three tests. The means for eight genotypes with the longest LS_1 in the Gainesville and Quincy tests are shown in Table 5 and Table 6, respectively, and in Table 7 for LS_1 and LS_2 measured in the field test. The Gainesville test mean for LS_1 (28.1 days) was 9 days longer than means for the Quincy and field tests. LS_1 for Florunner was 16.2 days in the Quincy test and 29.3 days in the Gainesville test. This disparity can be attributed to different environmental conditions. Mean daily temperatures were lower in Gainesville than in Quincy and may have prolonged the latent period. Genotypes UF81206-1 (entry 58), UF81206-2 (entry 59), and 72x93-6-1-2-b3-B (entry 61) ranked among the five genotypes with the longest latent period in both the greenhouse and field tests. Genotype UF81206-2 (entry 59) had a latent period significantly longer ($P<0.05$) than that of its resistant parent, PI 203396 (entry 38).

Table 5. Lesion count at 21 days after inoculation (LC 21), latent period (LS1), and sporulation score (SSC) for peanut genotypes rated in the greenhouse test at Gainesville, 1986.

Entry No.	LC 21[a]	Entry No.	LS_1[b]	Entry No.	SSC[c] 40 DAI	SSC[c] 50 DAI
30	8.6	18	37.4	19	1.6	1.0
7	10.1	13	35.0	3	1.0	1.0
6	10.8	17	34.6	12	1.0	1.0
28	10.9	19	31.0	13	1.0	1.0
19	11.7	15	29.5	17	1.1	1.1
9	12.2	29	29.5	20	1.0	1.1
S.R.[d]	12.3	Fr.	29.3	18	1.0	1.2
2	12.4	7	29.1	11	1.0	1.2
3	12.5	30	29.1	S.R.	1.8	2.6
Fr.[e]	13.0	S.R.	28.3	Fr.	2.7	2.7
Mean[f]	15.7		28.1		1.9	2.2
$LSD_{0.05}$	2.0		2.5		0.8	0.9

[a] Lesion count per leaf at 21 days after inoculation.

[b] Days from inoculation to the first lesion sporulating.

[c] Sporulation score on a 1-5 scale, where 1=few stromata with little or no sporulation and 5=stromata over most of lesion with heavy sporulation.

[d] Southern Runner

[e] Florunner

[f] Mean for all 30 entries included in the test.

Table 6. Lesion diameter (LD), latent period (LS_1), amount of sporulation at 35 days after inoculation (SSC), and plant appearance score (PAS) at 90 days after planting for Florunner, Southern Runner, and the eight most resistant genotypes in the greenhouse test at Quincy, 1986.

Entry No.	LD (mm)	Entry No.	LS_1[a]	Entry No.	SSC[b]	Entry No.	PAS
59	1.8	58	35.0	58	1.0	59	2.7
8	1.9	59	32.7	71	1.0	6	2.7
11	2.0	68	29.4	59	1.0	61	3.0
10	2.0	66	27.0	51	1.2	10	3.0
61	2.1	96	26.4	80	1.2	70	3.0
39	2.2	83	25.9	68	1.2	11	3.0
58	2.2	1	25.7	65	1.3	12	3.0
66	2.2	51	25.5	11	1.3	74	3.0
S.R.[c]	2.7	S.R.	19.0	S.R.	1.6	S.R.	3.7
Fr.[d]	2.9	Fr.	16.2	Fr.	3.7	Fr.	4.7
Mean[e]	2.6		19.9		2.5		4.0
$LSD_{0.05}$	0.6		4.6		0.8		0.8

[a] Days from inoculation to first lesion sporulating.

[b] Sporulation score on a 1-5 scale, where 1=few stromata with little or no sporulation and 5=stromata over most of lesion with heavy sporulation.

[c] Southern Runner

[d] Florunner

[e] Mean for all 105 genotypes included in the test.

Table 7. Incubation period (IP), latent period in days from inoculation to first sporulating lesion (LS_1), percent leaf necrotic area (NA), lesion diameter (LD), and amount of sporulation (SSC) for Florunner, Southern Runner, and the eight most resistant peanut genotypes in the field at Dozier Boys School at Marianna, 1986.

Entry No.	IP	Entry No.	LS_1	Entry No.	NA	Entry No.	LD	Entry No.	SSC[a]
102	10.1	59	38.0	58	1.2	59	2.3	58	1.2
Fr.[b]	9.9	58	30.7	39	1.4	58	2.4	59	1.2
103	9.9	4	30.5	30	1.4	71	2.4	4	1.4
74	9.8	66	29.3	59	1.6	72	2.5	8	1.4
5	9.8	65	29.2	34	1.6	35	2.6	63	1.4
95	9.8	70	29.2	35	2.1	39	2.6	61	1.5
6	9.7	8	28.0	72	2.1	61	2.6	38	1.5
78	9.7	85	27.9	40	2.1	44	2.7	71	1.5
14	9.6	S.R.	17.5	Fr.	3.8	S.R.	3.1	S.R.	2.2
S.R.[c]	7.8	Fr.	17.1	S.R.	5.1	Fr.	3.9	Fr.	4.5
Mean[d]	8.9		19.9		4.2		3.5		3.0
$LSD_{0.05}$	2.0		6.2		1.0		0.9		1.0

[a] Sporulation score on a 1-5 scale, where 1=few stromata with little or no sporulation and 5=stromata over most of lesion with heavy sporulation.

[b] Florunner

[c] Southern Runner

[d] Mean of all 105 genotypes in the test.

Reports on latent period of *C. personatum* in peanuts have been usually based on greenhouse tests using the detached leaf technique. Little work has been done on latent period of a wide range of genotypes in the field. However, data collected from the field should be the most meaningful when selecting for resistance. Watson (25) found a mean LS_{50} value of 24.5 days for Florunner in the greenhouse, which is similar to the LS_{50} (29.4 days) obtained for Florunner in the Gainesville test. The LS_{50} value obtained in the field, however, was much less. Because this environmental variation exists, greenhouse and field-measured latent periods may not correlate for a given genotype. However, genotype rankings in the greenhouse and field were similar in this experiment.

Seventy-two genotypes in the field and 68 genotypes in the Quincy greenhouse test had an LS_1 value of 22 days or less. Ranking of genotypes for LS_1 and LS_2 were similar, whether measured in the field or in the greenhouse, indicating that both methods were consistent in selecting resistant genotypes.

In the Quincy greenhouse test and in the Marianna field test, LS_{50} for the genotype UF81206-2 (entry 59) could not be determined, but the LS_1 value was 38 days in the field and 32.7 days in the Quincy test. Watson (25) also reported a low proportion of lesions sporulating from UF 81206.

No other reports of latent period of *C. personatum* on a large number of genotypes have been found for field experiments. The use of LS_{50} under field conditions is time consuming and impractical with large numbers of entries on a field scale where labor is a limiting resource. Days to first sporulating lesion or second sporulating lesion is a more practical approach.

Lesion Count Per Leaf

Significant differences ($P<0.05$) among genotypes for lesion counts were noted only in the greenhouse test in Gainesville. Means for eight genotypes with the lowest number of lesions per leaf in the Gainesville test and for check varieties are shown in Table 5. Large environmental variation was apparent with lesion counts and this does not appear to be a consistent component to use when selecting for resistance. This conclusion agrees with that of Subrahmanyam *et al.* (22), Walls *et al.* (24), and Watson (25). Hassan and Beute (8) reported that the ranking of some genotypes for lesion count was reversed from the greenhouse to the field for early leafspot.

Percent Necrotic Area

Genotypic differences for percent necrotic area were not significant ($P<0.05$) in the Gainesville and Quincy tests, but were significant in the Marianna field test. Means for eight genotypes with the lowest percent necrotic area and for Florunner and Southern Runner are shown in Table 6. Significant differences among genotypes for percent leaf necrotic area in greenhouse tests were reported by Subrahmanyam *et al.* (22) and in field tests by Iroume and Knauft (9). There was considerable environmental variability for percent leaf necrotic area, especially in the greenhouse tests where CVs exceeded 30%.

Lesion Size

Highly significant differences were observed among genotypes for lesion size in the Quincy and Marianna tests ($P<0.001$). These results support other reports of significant differences among genotypes for lesion size (22, 24, 25). The mean lesion diameter in the field (3.5 mm) was higher than that in the Quincy test (2.6 mm). Conditions were conducive for disease development in the field where lesions developed faster and were larger. The time of inoculation coincided with the period most favorable for late leafspot epidemics to develop in North Florida. Mean lesion diameter for the eight most resistant genotypes (smallest lesion diameter) are shown in Tables 6 and 7 for the Quincy and Marianna tests, respectively. These data show that lesion diameter is a useful component in selecting resistant genotypes. Although the ranking of genotypes in the field and greenhouse were not identical, they were similar. Genotypes UF81206-2 (entry 59), UF81206-1 (entry 58), US 29-b3-B (8701) (entry 8), 72x94-14-1-1-1-2-1-3-B (entry 61), PI 203396 (entry 39), and PI 121067 (entry 35) ranked among the most resistant genotypes in both the greenhouse and field environments.

Amount of Sporulation

Differences among genotypes were highly significant ($P<0.001$) for sporulation ratings in all tests. Means for the best eight genotypes for SSC ratings at 50 DAI in Gainesville are shown in Table 5, and in Tables 6 and 7 for Quincy and Marianna, respectively. In the Gainesville test, sporulation ratings at 40 and 50 DAI were similar for genotypes, and overall mean sporulation scores ranged from 1 to 3.7. The mean sporulation score was highest for the field test (3.0) and lowest for the greenhouse test in Gainesville (2.2). Differences in genotypes and temperature conditions between the two tests probably account for these results. Sommartya *et al.* (19) reported differences in sporulation for isolates of *C. personatum* at varying temperatures and humidity. Our results indicated that a rating scale can be used effectively for identifying genotypes with reduced sporu-

lation in field or greenhouse conditions. Subrahmanyam *et al.* (22) found the sporulation score to be a consistent component for rating genotypes and had no interaction with plant age. Significant differences among genotypes for amount of sporulation of *C. personatum* have also been noted by others (15, 22, 25).

Plant Appearance Score

Highly significant differences ($P<0.001$) were found for PAS in the field and greenhouse (Tables 8 and 6, respectively). In the field the rating for PAS at 120 DAP ranged for 2.0 to 9.0. The susceptible check cultivar Florunner (entry 105) had a rating of 9 at 120 DAP and 10 at 135 DAP. Genotypes that had small lesions generally had less spore production, longer latent period, and lower plant appearance scores. The rating scale used for plant appearance appears to be effective in identifying resistant genotypes and is recommended for preliminary screening. This scale had been used in the Florida breeding program to select many of the lines in this study.

Table 8. Plant appearance scores at 120 and 135 days after planting (PAS 120 and PAS 135, respectively, based on system in Table 3) and field resistance index at Dozier Boys School, Marianna 1986, for Florunner, Southern Runner and the eight most resistant genotypes.

Entry No.	PAS 120	Entry No.	PAS 135	Entry No.	Index[a]
59	2.0	10	4.0	59	18.7
58	2.5	12	4.5	58	16.9
8	3.0	6	4.5	4	14.6
39	3.0	38	5.0	8	13.4
38	3.0	9	5.0	63	13.2
64	3.0	35	5.0	61	13.1
88	3.5	1	5.5	71	12.5
6	3.5	33	5.5	44	12.4
S.R.[b]	3.5	S.R.	7.0	S.R.	8.1
Fr. [c]	9.0	Fr.	10.0	Fr.	0.0
Mean[d]	4.8		6.9		6.0
$LSD_{0.05}$	2.8		1.4		4.8

[a] Index is the sum of weighted values for each statistically significant component of resistance. Weighting procedure is described in text.

[b] Southern Runner

[c] Florunner

[d] Mean for all 105 genotypes in the test.

Field Resistance Index

Index values for the eight most resistant genotypes in the field test are shown in Table 8. LS_1 was not included in the calculation of the index because it had a very similar ranking with LS_2. Components of resistance included in the index were transformed %NA, LS_2, LS_{50}, lesion diameter, SSC, PAS 120, and PAS 135. Index values ranged from -2.4 to 18.7, with a mean of 6.0. There were highly significant differences among genotypes for index value ($P<0.001$). The most resistant genotypes was UF81206-2 (entry 59), while NC3033 (entry 14) was the most susceptible. Resistance among genotypes was classified as good, fair, or poor by comparing the index with Southern Runner, the partially resistant check, and Florunner, the susceptible check cultivar. Twenty-six genotypes had a resistance index greater than ten and were classified as having good resistance. Twenty-nine genotypes with a resistance index value between five and ten were classified as fairly resistant, and the remainder were described as susceptible.

Conclusions

Statistical significance was noted for each component of resistance in at least one test indicating that variability existed for all the components evaluated in these genotypes. Variability among these genotypes was greatest for lesion diameter, latent period, and amount of sporulation, based on the range and levels of statistical significance. Data indicated that these components of resistance showed the most consistency when used for rating in different environments and could be useful tools in evaluating genotypes for disease resistance. Other components of resistance would be less useful. Variability among genotypes for incubation period was low, while lesion count and percent leaf necrotic area had high coefficients of variation.

Plant appearance scores were significantly different among genotypes, were consistent in different environments and had the advantage of rapid measurement when compared to the other components of resistance in this test. While PAS may be useful for rapid screening of segregating genotypes, it does not allow identification of specific components of resistance and may not be useful for development of genotypes with high levels of resistance for several components. The field resistance index was used to identify such genotypes, and UF 81206-1, UF 81206-2, and 72x32B- combined the highest levels of all components included in the index.

Literature Cited

1. Abdou, Y. A. M., W. C. Gregory, and W. E. Cooper. 1974. Sources of resistance to *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. and Curt.) Deighton in *Arachis* species. Peanut Sci. 1:6-11.
2. Chalal, A. S., and R. S. Sandhu. 1972. Reaction of groundnut varieties against *Cercospora personata* and *Cercospora arachidicola*. Plant Dis. Rpt. 56:601-603.
3. Foster, D. J., H. T. Stalker, J. C. Wynne, and M. K. Beute. 1981. Resistance of *Arachis hypogaea* and wild relatives to *Cercospora arachidicola* Hori. Oleagineux 36:139-143.
4. Gibbons, R. W., and B. E. Bailey. 1967. Resistance to *Cercospora arachidicola* in some species of *Arachis*. Rhod. Zamb and Mal. J. Agric. Res. 5:57-59.
5. Gorbet, D. W., A. J. Norden, F. M. Shokes, and D. A. Knauft. 1986. Southern Runner - A new leafspot-resistant peanut variety. Circular No. S-324. Florida Agricultural Experiment Station. IFAS, University of Florida, Gainesville. 13 p.
6. Gorbet, D. W., A. J. Norden, F. M. Shokes, and D. A. Knauft. 1987. Registration of 'Southern Runner' Peanut. Crop Sci. 27:817.
7. Green, C. C., and J. C. Wynne. 1986. Field and greenhouse evaluation of components of partial resistance to early leafspot in peanut. Euphytica 35:561-563.
8. Hassan, H. N., and M. K. Beute. 1977. Evaluation of resistance to *Cercospora* leafspsot in peanut germplasm potentially useful in a breeding program. Peanut Sci. 4:78-83.
9. Iroume, R. N., and D. A. Knauft. 1987. Heritabilities and correlations for pod yield and leafspot resistance in peanut (*Arachis hypogaea* L.):Implications for early generation selection. Peanut Sci. 14:46-50.
10. Jackson, L. F., and D. K. Bell. 1969. Diseases of peanut (groundnut) caused by fungi. Georgia Experiment Station Bulletin No. 56. University of Georgia. pp. 5-15.
11. Johnson, C. S., and M. K. Beute. 1986. The role of partial resistance in the management of *Cercospora* leafspot in North

Carolina. Phytopathology 76:468-472.
12. Johnson, C. S., M. K. Beute, and M. D. Ricker. 1986. Relationship between components of resistance and disease progress of early leafspot on Virginia-type peanut. Phytopathology 76:495-499.
13. Knauft, D. A., A. J. Norden, and D. W. Gorbet. 1987. Peanut. Chap. 10, pp 346-384. *in*: W. R. Fehr (ed). Principles of Crop Cultivar Development Volume 2. Crop Species. Macmillan Publishing Company, New York. 768 p.
14. Monasterios de la Torre, T. 1980. Genetic resistance to *Cercospora* leafspot diseases in peanut (*Arachis hypogaea* L.). Ph. D. Dissertation, University of Florida, Gainesville. 102 p. (Diss. Abstr. 0419-4217).
15. Nevill, D. J. 1981. Components of resistance to *Cercospora arachidicola* and *Cercosporidium personatum* in groundnuts. Ann. Appl. Biol. 99:77-86.
16. Norden, A. J., O. D. Smith, and D. W. Gorbet. 1982. Breeding the cultivated peanut. Chap. 4, pp 95-122. *in*: H. E. Pattee and C. T. Young (Eds.). Peanut Science and Technology. Amer. Peanut Res. and Educ. Soc. Inc., Yoakum, TX. 825 p.
17. Pixley, K. V. 1985. Physiological and epidemiological characteristics of leafspot resistance in four peanut genotypes. MS. Thesis. University of Florida, Gainesville. 138 p.
18. Shokes, F. M., R. D. Berger, D. H. Smith, and J. M. Rasp. 1987. Reliability of disease assessment procedures: a case study with late leafspot of peanut. Oleagineux 42:245-252.
19. Sommartya, T., B. B. Shew, and M. K. Beute. 1986. Evaluation of physiological and morphological variation in isolates of *Cercosporidium personatum* from the USA and Thailand. Proc. Amer. Peanut Res. and Educ. Soc. 18:54.
20. Smith, D. H. 1984. Foliar diseases. pp 5-7 *in*: D. M. Porter, D. H. Smith and R. Rodriguez-Kabana (Eds.). Compendium of Peanut Diseases. American Phytopath. Soc., St. Paul, MN. 73 p.
21. Sowell, G. Jr., D. H. Smith, and R. O. Hammons. 1976. Resistance of peanut plant introductions to *Cercospora arachidicola*. Plant Dis. Rpt. 60:33.
22. Subrahmanyam, P., D. McDonald, R. W. Gibbons, S. N. Nigam, and D. J. Nevill. 1982. Resistance to rust and late leafspot diseases in some genotypes of *Arachis hypogaea*. Peanut Sci. 9:6-10.
23. Subrahmanyam, P., J. P. Moss, D. McDonald, and P. V. Rao. 1985. Resistance to late leafspot caused by *Cercosporidium personatum* in wild *Arachis* species. Plant Dis. 69:951-954.
24. Walls, S. B., J. C. Wynne, and M. K. Beute. 1985. Resistance to late leafspot of peanut progenies selected for resistance to early leafspot. Peanut Sci. 12:17-22.
25. Watson, R. G. 1987. Levels and components of resistance to late leafspot caused by *Cercosporidium personatum* (Berk. and Curt.) Deighton in the peanut (*Arachis hypogaea* L.) genotypes Florunner, Southern Runner, and UF81206. Ph.D. Dissertation, University of Florida, Gainesville 1987. 183 p.

Accepted June 7, 1988