Peanut Breeding for Leafspot Resistance in Wide and Narrow Intrarow Spacings[1]

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ABSTRACT

Sixteen peanut (*Arachis hypogaea* L.) genotypes were grown without the use of fungicides for two years in two planting arrangements, one an intrarow spacing typically used in commercial production (5 cm between plants) and the other typically used in breeding selection plots (30 cm between plants). At 10-day intervals throughout each growing season the proportion of necrotic leaf area caused by leafspots (*Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. & Curt.) Deighton), leafspot disease rating (0-9), and stage of vegetative growth (v stage) were assessed. Leafspot disease ratings of genotypes spaced 30-cm apart were significantly correlated with the ratings of genotypes in 5-cm spacing. There was no interaction between genotypes and spacing. Percentage necrotic area in 30-cm and 5-cm plantings was significantly correlated. However, large experimental error and complex interactions among spacings, genotypes, and time of observation lessened the value of this method of disease assessment. While the correlation of v stage in the two spacings was highly significant, differences among genotypes were not consistent.

Key Words: *Arachis hypogaea* L., leafspot, v stage, selection.

Breeding and selection procedures for the development of peanut (*Arachis hypogaea* L.) cultivars are similar to those used for most self-pollinated crops (11). The selection of individual plants is a practice that is common to the procedures of the pedigree, bulk, single-seed descent, and recurrent selection breeding methods. In peanut breeding programs in the United States, seed to be grown for purposes of individual plant selection are often planted at intrarow distances of 30 cm or more (11). This planting arrangement allows the breeder to more accurately assess the characteristics of individual plants in a segregating population than would be possible with spacings used for commercial production, where intrarow distances are often less than 5 cm. The greater intrarow distances also facilitate the separation of individual plant selections. However, if genotypes respond differently to intrarow spacings, those genotypes selected for performance in breeding nurseries may not perform similarly in commercial plantings.

Studies of plant spacing and selection have been conducted in a number of crops. Baker and Briggs (1) examined five densities of barley and found a low density (40 x 40 cm) was optimal for single plant selection for yield and yield components. Hamblin *et al.* (6) found less plant-to-plant variation in barley at low plant densities as compared to high densities. However, in cassava Kawano et al. (9) found a low correlation between single-plant yields and unit-area yields. Schutz and Brim (14) and Wilcox and Schapaugh (19) reported significant genotype x spacing interactions for yield and yield components in soybean.

There are few reports in peanut on the comparison of plant performance in breeding nursery and commercial row spacings. Evaluations of the data from studies to determine most appropriate spacings for maximum yields in commercial production generally indicate that there is little spacing by genotype interaction, given similar plant types within botanical types. Interactions have occurred when different plant types or different botanical types were used (3,8,10,20).

A range of heritabilities has been reported for leafspot resistance (4,5,7,12,15,18), depending on environments, genotypes, and the type of assessment made. Even high heritabilities for leafspot resistance may not indicate good correlation of disease levels between plants in high and low densities, since plant spacing could affect the amount of disease present. It is expected that the microclimates in plots with 30-cm and 5-cm intrarow plant spacings could have different light, humidity, and temperature regimes that may differentially affect the development of leafspot on resistant and susceptible lines.

Preliminary research by Saca-kuri (13) indicated that v stage (vegetative growth stage defined by Boote (2) as the number of nodes on the mainstem) could be used as a quick, non-destructive method for separating resistant lines with high and low levels of vegetative growth. Among resistant selections, those with lower vegetative weight tended to have higher pod yields. Since v stage measurements were more repeatable than vegetative or pod weight when measured on a plant basis, Saca-kuri hypothesized that individual plant selection based on disease resistance and low v stage might be used to identify high yielding resistant lines in early generations.

This research was conducted to determine whether genotype x spacing interactions existed throughout the growing season for v stage and for two methods of rapid leafspot resistance assessment; leaf necrotic area and a leafspot disease rating.

Materials and Methods

Sixteen peanut genotypes, randomly selected from a range of both resistant and susceptible accessions, as well as from agronomically adapted and unadapted material (Table 1), were grown for each of two years. Early Bunch, Florunner, NC 7, and Sunrunner are susceptible to the leafspots, while the remaining genotypes possess varying levels of resistance, depending on the method of evaluation. The experiment was conducted at the agronomy farm near Gainesville, Florida where the soil is an Arredondo fine sand (Grossarenic Paleudult, pH 5.9). Plots were hand-planted 9 June 1986 and 4 June 1987 and replicated four times in a split-plot design with genotypes in the main plots and intrarow spacings in the subplots. Each subplot was 6.1-m long and consisted of four rows 90-cm apart. Intrarow seed distances were 30 cm for the spaced planting and 5 cm for the commercial planting. The susceptible cultivar, Early Bunch, was planted every fourth plot to serve as a source for natural inoculum in the test. No fungicides were used, but other cultural practices followed standard cooperative extension recommendations

Data collection began 58 days after planting (DAP) in 1986 and continued at 10-day intervals until harvest at 138 DAP. Data collection in 1987 began 38 DAP and continued until harvest at 138 DAP. In both years, data collection was terminated at 138 DAP because plants of the susceptible genotypes were dead. Two representative plants from each plot were originally selected at random, tagged, and used for each subsequent assessment. At each sampling date the plants were scored for disease reaction, using a 1-9 scale developed by Subrahmanyam, *et al.* (17). The percentage of necrotic area on the fifth fully expanded leaf from the top of the mainstem of the same plants was measured with the aid of a pictorial key (16). No distinction was made between early and late leafspot,

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Table 1. Peanut genotypes grown in plots without fungicide treatments to assess association of characteristics measured on plants grown at 5- and 30-cm intrarow spacings.

Genotype	Parents of breeding lines
Dixie Runner	
Early Bunch	
Florunner	
NC 7	
NC 3033	
Sunrunner	
BL-1	PI 306230 x Florunner
BL-8	Florunner x PI 121067
BL-10	PI 121067 x Florunner
PI 109839	
PI 306222	
UF 8026-4-2-3-1-B	BL-8 x PI 306222
UF 8034-1-2-5-1-B	BL-3* x PI 109839
UF 8034-2-1-1-1-B	
UF 8034-3-2-3-2-B	
UF 8143B-2-1-3-4-B	(BL-3 x PI 196604) x (BL-10 x PI 262090)

* BL-3 is PI 203396 x Florunner

although late leafspot predominated during the period of this study. The v stage of each plant (2) was also recorded.

An overall analysis of variance was calculated for the experiment. For disease rating, necrotic area, and v stage the genotypes were considered main effects, the spacings as subplots and the sampling date as sub-subplots. Arcsine transformations of necrotic area did not change the results of the analysis. Therefore analyses of the untransformed data are reported. The same analysis of variance was calculated for pod yield on a unit area basis, excluding the sampling date factor. Because sampling dates and years were significant sources of variation in this experiment, individual analyses were calculated for each sampling date and year combination.

Correlations also were calculated for each sampling date and year combination. Homozygous lines were used in this study, allowing replication in the field to provide a better estimate of true values in data collection. In most breeding nurseries, selections are made on unique genotypes for which replication is not feasible. Correlations were determined using actual plot data, as well as means over all replications, to determined the effect of non-replication. First, means were used from the two samples gathered in each replication for each of the three parameters. The second set of correlations were calculated using the means of the four replications. Coefficients reported are from linear correlations. Quadratic and cubic correlations were also tested and found to be nonsignificant.

Results and Discussion

Disease Ratings

Sampling dates and genotypes were the largest sources of variation in disease ratings (Table 2). During the middle of the growing season in both years, average ratings were significantly higher with the 5-cm spacing of plants than in the 30-cm spacing, although the difference was never greater than 0.8 rating units (Tables 3 and 4). It is likely the higher inoculum level from the greater amount of susceptible tissue in the 5-cm plantings gave the consistently higher ratings in the early season. Late in the season, when disease pressure was high in both plantings, the disease ratings were the same in both spacings (Tables 3 and 4).

Correlations among disease ratings at the two plant spacings were highly significant in both years of the study from 78 days after planting to the end of the experiment. This occurred for both individual plot data (Table 5) and data averaged over replications (Table 6). When data were averaged over replications, r values exceeded 0.80 from 88 days after planting to the end of the experiment in both years. As expected, the data from individual plots had a lower correlation, but r values were above 0.60 from 118 days after planting in the first year of the study and were above 0.80 from 108 days after planting in the second year. Thus, the ratings from the 30-cm spacings accurately reflected disease ratings for 5-cm spaced plants, especially beyond 78 days after planting. Before this date, disease incidence was low and there were few significant differences, even among genotypes.

Table 2. Analyses of variance for leafspot rating, necrotic area, and v stage for sixteen peanut genotypes grown in plots without fungicide treatments to assess association of characteristics measured on plants grown at 5- and 30-cm intrarow spacings.

Source of variation	df	MS rating	MS nec. area	MS node no.
Year (Y)	1	223.13**	44.78**	301.75**
Rep within Y	6	2.23**	5.98	40.17*
Genotype (G)	15	75.68**	153.19**	316.95**
Y x G	15	1.07*	5.92*	17.01
Error a	90	0.56	2.77	15.66
Spacing (S)	1	68.75**	3.86	83.34*
S x Y	1	0.21	0.30	211.58**
S x G	15	0.85	3.44	40.02**
Y x S x G	15	1.18*	3.98	11.80
Error b	96	0.63	2.38	16.24
Sampling date (D)	8	1107.25**	1796.36**	11284.59**
Y x D	8	48.26**	95.01**	100.43**
D x G	120	3.18**	21.87**	19.69**
G x Y x D	120	1.35**	3.72**	2.00
D x S	8	2.40**	5.44**	32.78**
Y x D x S	8	2.25**	3.84	9.12**
S x G x D	120	0.29	2.63*	2.30
Y x S x G x D	120	0.40*	2.26	2.03
Error c	1536	0.31	2.04	2.03

* and ** denote significance at the 5% and 1% levels, respectively.

Table 3. Disease rating (1-9 scale, where 1 = no disease and 9= heavily infected), percentage necrotic area, and V stage for sixteen peanut genotypes grown in plots without fungicide treatments to assess association of characteristics measured on plants grown at 5- and 30-cm intrarow spacings, 1986.

Trait	Intrarow Spacing	Sample date in days after planting 58	68	78	88	98	108	118	128	138
Rating	5	2.0	2.4	3.0	4.0*	4.8*	5.3*	6.0*	6.3	6.4
	30	2.2	2.2	2.8	3.3	4.0	4.8	5.6	6.3	6.3
Necrotic area	5	0.0	0.6	0.8*	0.8*	1.4	2.2	5.1	5.1*	5.3*
	30	0.0	0.3	0.4	0.5	1.3	2.5	4.8	4.4	5.9
V stage	5	12.2	14.5	17.0*	21.1	23.0	25.7	28.0	30.0	31.6
	30	11.6	14.2	15.8	21.1	22.7	26.0	27.8	30.5	31.9

* Means of the two intrarow spacings at the given sampling date are statistically different at the 5% level.

Table 4. Disease rating (1-9 scale, where 1 = no disease and 9= heavily infested), percentage necrotic area, and V stage for sixteen peanut genotypes grown in plots without fungicide treatments to assess association of characteristics measured on plants grown at 5- and 30-cm intrarow spacings, 1987.

Trait	Intrarow Spacing	Sample date in days after planting 58	68	78	88	98	108	118	128	138
Rating	5	2.0	2.3	2.7	4.1*	5.5*	6.3*	7.2	7.6	8.4
	30	1.3	1.8	2.5	3.6	5.0	5.9	6.9	7.6	8.3
Necrotic area	5	0.0	0.0	0.1	0.2	1.2*	3.0*	4.5	5.8	8.4*
	30	0.0	0.0	0.0	0.2	0.7	2.5	4.5	6.1	8.9
V stage	5	12.3	15.0	17.2	19.9	21.8	25.9*	28.8*	29.5*	29.9*
	30	12.3	14.8	17.4	19.4	21.6	23.7	26.7	27.5	28.1

* Means of the two intrarow spacings at the given sampling date are statistically different at the 5% level.

No interaction existed between spacing and genotype (Table 2), indicating that the differences in rating obtained in the two spacings tended to be the same for each genotype. For each of the last three sampling dates in the two years of the study, the four genotypes with the lowest average ratings were the same in both 5-cm and 30-cm plantings, with one exception. Both the lack of interaction between genotype and spacing and the relatively high r values for correlations between spacings justify the use of this rating system in breeding programs.

Necrotic area

A majority of the variation in proportion of necrotic area for this experiment was attributed to sampling date (Table

Table 5. Correlation coefficients for disease rating (1-9 scale, where 1 = no disease and 9= heavily infested), percentage necrotic area, and v stage between sixteen peanut genotypes grown in plots without fungicide treatments to assess association of characteristics measured on plants grown at 5- and 30-cm intrarow spacings, 1986 and 1987.

Sample date (days after planting)	1986			1987		
	Rating	Necrotic Area	V stage	Rating	Necrotic Area	V stage
58	0.05*	0.00	0.32	0.20	0.00	0.24
68	0.18	0.00	0.29	0.12	0.20	0.21
78	0.33	0.12	0.32	0.41	0.32	0.36
88	0.44	0.36	0.37	0.50	0.26	0.48
98	0.56	0.26	0.37	0.76	0.26	0.47
108	0.57	0.32	0.49	0.83	0.52	0.44
118	0.66	0.35	0.45	0.86	0.65	0.52
128	0.72	0.49	0.44	0.82	0.79	0.54
138	0.77	0.58	0.58	0.87	0.68	0.66

* Correlation coefficients above 0.17 and above 0.23 are significant at the 5% and 1% levels, respectively.

Table 6. Correlation coefficients for disease rating (1-9 scale, where 1 = no disease and 9= heavily infested), percentage necrotic area, and v stage between sixteen peanut genotypes grown in plots without fungicide treatments to assess association of characteristics measured on plants grown at 5- and 30-cm intrarow spacings, averaged over replication, 1986 and 1987.

Sample date (days after planting)	1986			1987		
	Rating	Necrotic Area	V stage	Rating	Necrotic Area	V stage
58	0.62*	0.00	0.37	0.01	0.00	0.72
68	0.54	0.24	0.33	0.28	0.00	0.59
78	0.60	0.30	0.24	0.53	0.24	0.72
88	0.87	0.42	0.71	0.84	0.57	0.67
98	0.83	0.68	0.71	0.96	0.93	0.67
108	0.82	0.74	0.85	0.97	0.91	0.79
118	0.84	0.59	0.88	0.96	0.87	0.75
128	0.92	0.73	0.87	0.97	0.89	0.84
138	0.95	0.78	0.86	0.92	0.88	0.88

* Correlation coefficients above 0.35 and above 0.45 are significant at the 5% and 1% levels, respectively.

2). The next largest amounts of variation were attributable to genotype and the genotype by sampling date interaction. Although there was no significant effect of spacing, the spacing by sampling date interaction was significant. Necrotic area proportion was significantly greater in the 5-cm spacings on several sample dates, although the dates were inconsistent from year to year (Tables 3 and 4). In both years of the study, the final sampling had higher percentage necrotic area in the 30-cm plantings.

The percentage necrotic area was significantly correlated in 30-cm and 5-cm plantings from 88 DAP through the final sampling date (Tables 5 and 6), regardless of the method of calculation. However, significant differences among genotypes did not exist until 108 DAP in both years of the study. After that date, the percentage of necrotic area may be of some use in selecting leafspot resistant genotypes. However, correlations tended to be greater in the second year of the study when disease severity was greater (Tables 3 and 4). Individual plot data the first year of the study showed only one correlation with $r > 0.50$ at 138 days after planting.

As with the disease ratings, there was no interaction between spacings and genotypes. At each of the last three sampling dates, three of the four genotypes with the lowest percentage necrotic area in 30-cm plantings were lowest in 5-cm plantings as well.

In this study the overall CV for percentage necrotic area was 59%, and only the variation from sampling date exceeded experimental error variation (Table 2). Other researchers have found the variability of the trait to be higher than other leafspot assessment procedures, which may limit the use of necrotic area as a selection tool (4,7,18). In comparison, the CV in this study for disease rating was 12%.

V stage

As would be expected, the primary source of variation in v stage was sampling date (Table 2). The first year of the study, v stages were similar for the two spacings, while the second year there was a tendency for the plants in 5-cm spacings to have a higher v stage later in the growing season (Tables 3 and 4).

Measurements of v stage in 30-cm and 5-cm planted peanuts had a highly significant correlation coefficient throughout the growing season, whether measured on a plot basis or averaged over replications (Tables 5 and 6). However, when individual plot evaluations were used, r was less than 0.50 until the sampling at 138 DAP. Thus, while the 30-cm plants with high v stages would tend to have high v stages in 5-cm spacings, this association is not a strong one, especially when measurements must be made on individual, unreplicated plants.

There also was a highly significant interaction between genotypes and spacings, indicating that the differences in v stage observed among the genotypes of this study would not be expected to be the same at different spacings. This interaction was obvious when the averages for individual genotypes at each spacing were examined. The genotypes with the highest or lowest v stages in 30-cm plantings rarely had the same corresponding rank in 5-cm plantings. However, the plants with the highest v stage in 30-cm plantings were invariably in the top half of the genotypes in 5-cm plantings, and the same trend held for plants with the lowest v stage at each of the sampling dates.

Conclusions

In this study, the leafspot disease rating system used on plants with 30-cm intrarow spacings was correlated with ratings of plants at 5-cm intrarow spacings. The correlations were significant throughout the portion of the growing season when leafspot severity was adequate to distinguish genotypic differences. Differences in disease severity among genotypes in the two intrarow spacings were also similar. Thus, the use of a subjective disease rating appears to be a feasible method to select plants in breeding progams for disease reaction in commercial plantings.

Percentage necrotic area was a less desirable measurement of disease resistance. Although there were significant correlations between plants at 30-cm and 5-cm intrarow spacings, large experimental error and complex interactions among spacings, genotypes, and time of observation lessened the value of this method of disease assessment.

V stage may not be consistent enough to use in assessing vegetative growth. Its correlation in 5-cm and 30-cm plantings was relatively low, and the differences among genotypes were not consistent in the two spacings.

Correlations of all traits were higher when means over replications were used. However, the accuracy gained by such replication is not practical in breeding nurseries where individual genotypes cannot be replicated.

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