Yield and Market Quality of Seven Peanut Genotypes as Affected By Leafspot Disease and Harvest Date[1]

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ABSTRACT

The effects of leafspot disease (causal organisms *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. & Curt.) Deighton) on the yield and market quality of peanut (*Arachis hypogaea* L.) must be understood to more accurately assess genetic potential of breeding lines. Seven peanut genotypes were grown without fungicide application at two locations, Gainesville and Marianna FL, for three years and harvested at three biweekly dates. Consistent pod yields near 5000 kg ha^{-1} were obtained for leafspot resistant breeding line 94 at Marianna when it was harvested later than 142 days after planting (DAP). Other resistant lines also reached maximum production at late harvests, even though disease incidence increased for all resistant lines. Highest yields of susceptible lines occurred ca. 120 DAP, with the susceptible cultivar Florunner producing over 3400 kg ha^{-1} at Marianna. Although disease pressure on the susceptible lines was heavy at 120 DAP, pod yields did not decline until later harvests, indicating that a major effect of the leafspot disease was the loss of pods already produced. Increased disease pressure was poorly correlation with seed size or total sound mature kernels in either resistant or susceptible lines.

Key Words: Groundnut, maturity, disease resistance, *Arachis hypogaea* L., digging date.

Worldwide, early and late leafspot (*Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. & Curt.) Deighton, respectively) are two of the most serious diseases of peanut. The diseases can cause yield reductions of more than 50% if fungicides are not used (5,10). Although effective fungicides are available, most notably chlorothalonil, their use increases peanut production costs. The development of peanut cultivars with resistance to early and late leafspot would lower both production risks and costs. Therefore this is an important goal in many breeding programs (6).

Correlations have been reported between leafspot resistance and late maturity (2, 4, 7, 11). When leafspot resistant germplasm is used in a crossing program with agronomically acceptable lines, the maturity of segregates varies considerably. Choosing the correct harvest date for breeding lines is a difficult process, because precise methods for determining maturity require destructive sampling techniques and cannot be used on small plots (6). Also, the less resistant material in a test may become so severely affected by the leafspot organisms that yield reductions take place prior to appropriate maturity dates.

This research was conducted to accurately assess the effects of harvest dates on disease pressure, agronomic performance, and market grade quality for seven breeding lines with various levels of resistance to leafspot diseases, especially late leafspot (*C. personatum*).

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Materials and Methods

Three cultivars, Southern Runner (SR), Florunner (FR), and Dixie Runner (DR), along with four breeding lines, UF 72x94-7-1-1-*b3*-B (hereafter referred to as line 94), UF 714021 (line 71), UF 72x93-9-1-1-B (line 93), and UF 533A-5-2-1-3-B (line 53) were grown for three years (1981-1983) at two University of Florida agronomy farms, one near Gainesville and the other near Marianna. The Gainesville site was planted to peanut each year, while the Marianna site was planted to peanut in one of three years. Standard cultural practices were used, with fungicide treatments omitted. Tests were grown under irrigated conditions and were planted near May 20 each year. Plots consisted of two rows 6.1 m long and 90 cm apart. Three replications for each entry were nested within the three digging dates at each location. Digging dates in each of the three years (1981, 1982, and 1983) were spaced at two-week intervals, with the first digging date at Gainesville 106, 106, and 104 days after planting (DAP), and 122, 114, and 117 DAP for the Marianna test. The first harvest at each location was made when leafspot pressure on Florunner was perceived to be limiting further pod yield increase. Peanuts were dug with a standard tractor-mounted, peanut digger-inverter and picked with a stationary plot thresher.

Observations on leafspot disease incidence were recorded two days before harvest for each of the digging dates, using the scale listed in Table 1. The individual effects of early and late leafspot were not measured with this scale because this method was designed for rapid field assessment of germplasm. Laboratory identification of the two leafspot diseases in Florida during the time of these tests has shown a preponderance of late leafspot (3). Pod yields were calculated at 8% moisture. Standard peanut grading data were obtained. Since other grade factors showed similar trends, the only data reported are weight of 100 sound mature kernels and percentage of total sound mature kernels (TSMK), which is the sum of sound mature whole seed that ride a 0.6 x 2.54 cm screen and split seed over 6.5 cm in length.

Table 1. Florida leafspot disease rating scale.

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 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

An analysis of variance was made for each trait. Digging dates were considered as nested within locations, as the days from planting to digging differed at the two locations. Replications were nested within digging dates, and the seven genotypes were randomized in subplots. Digging dates and locations were considered as fixed effects. Arcsine transformed data were used for the TSMK analysis of variance and for mean separations. TSMK percentages were reconverted for data presentation. Because heterogeneity of variance was not indicated for other data, no additional transformations were necessary.

Results

Pod Yield

The genotype by year by digging data within location interaction for pod yield was significant, as were all other interactions and all main effects. Because the three-way interaction was significant, the yields for each genotype at the two locations for each year and each digging date are presented (Table 2). In Gainesville, the genotypic response to treatments can be divided into three groups. The first group, composed of Florunner and lines 53 and 71, had large yield decreases as digging date was delayed in the second and third year of the experiment. For example, in one instance the pod yield of line 53 was only 13% of the highest yield. In the second group of genotypes, Southern Runner and lines 93 and 94, yields increased as harvest was delayed. Dixie Runner produced its highest yield on the second digging date in each year. The decrease in yield from the second to the third digging date was significant the second and third years of the study. The genotypes with the highest yields at the first digging date were from the first group. A mixture of genotypes was highest yielding at the second digging date, and the second group, especially lines 93 and 94, was most productive at the last digging date.

Table 2. Pod yields for seven peanut genotypes evaluated without the use of fungicides for leafspot control at two locations for three years and with three digging dates.

Gainesville

Genotype†	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
	kg ha^{-1}								
SR	2557bc§	3482a	3550bc	2141b	2846b	2765b	1098d	2236a	2033a
94	2815ab	3291ab	4162a	2236b	3456a	3551a	1274cd	2277a	2399a
71	3019a	3386a	2693d	3022a	3537a	813d	2128a	2006ab	664c
DR	2135d	3482a	3223c	1965b	2887b	2331c	1437cd	2290a	1491b
FR	2720abc	2951bc	1632e	3185a	2710b	786d	1667bc	2426a	583c
93	2326cd	3482a	3794ab	2380b	2570b	2788b	1700abc	1496c	2108a
53	3033a	2747c	789f	2842a	2774b	395d	1958ab	1714bc	286c

Marianna

Genotype	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
	kg ha^{-1}								
SR	3964a	4216a	4087b	2951c	3284bc	3862b	3237bc	3604b	3726b
94	3903a	4440a	4821a	3203bc	3815a	4923a	3590ab	4406a	4889a
71	4107a	4066a	3244c	3815a	3862a	1870c	3890a	3468b	2020c
DR	2564b	2849b	2380d	2224d	2543d	1822c	2421d	2108d	1720c
FR	3856a	2285c	1054f	3400abc	2462d	231d	3726a	2407cd	931d
93	4230a	4325a	4461ab	3108c	3543ab	4182b	3074c	3754b	3536b
53	4155a	2951b	1775e	3645ab	3040c	564d	3747a	2768c	816d

$LSD_{.05}$ for comparisons among digging dates within years and locations = 432.

† Full genotype descriptions are in text.

§ Means for genotypes within a location, year, and digging date followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

The response of the seven genotypes to different harvest dates at the Marianna location can also be divided into three groups. The three lines with yield reductions as harvest was delayed at Gainesville (Florunner and lines 53 and 71) showed the same trend at Marianna. Both Florunner and line 53 had a significant decrease in yield from the first to the second digging date, while line 71 had no significant difference in yield until the third digging date. Lines 93 and 94, as well as Southern Runner, increased yields with delayed harvest except the first year of the study, when digging date differences for Southern Runner and line 94 were not significant. Yields for Dixie Runner peaked at the second digging date in Marianna.

Line 94 was consistently among the high yielding entries at Marianna across digging dates and years. At early harvests, Florunner and lines 71 and 53 also produced high yields.

Total Sound Mature Kernels

The three-way interaction among years, genotypes, and digging dates within locations was also significant for TSMK. Means for each level of these treatment combinations are presented in Table 3.

Table 3. Percentages of total sound mature kernels (TSMK) for seven peanut genotypes evaluated without the use of fungicides for leafspot control at two locations for three years and with three digging dates.

Gainesville

Genotype†	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
	%								
SR	70.4ab§	76.3ab	77.4a	67.3bc	75.8ab	78.7ab	41.4c	77.6a	72.1a
94	60.8cd	66.0c	69.5bc	60.3c	67.3cd	74.3ab	46.4c	75.6ab	61.1b
71	68.6ab	70.3abc	71.0abc	69.7b	71.2bcd	74.1ab	67.0a	73.6ab	70.1a
DR	46.2e	65.8c	67.3c	51.9d	66.1d	73.8ab	54.2b	68.0bc	60.2b
FR	75.3a	78.0a	76.1ab	78.7a	80.3a	80.3a	70.8a	80.3a	77.1a
93	58.0d	68.8bc	71.9abc	65.4bc	65.7d	72.2b	64,0a	73.8ab	55.0b
53	66.0bc	71.1abc	68.7bc	71.7ab	74.2abc	71.2b	65.0a	65.4c	70.1a

Marianna

Genotype	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
	%								
SR	78.4a	78.0a	80.4a	79.7a	78.8a	74.4ab	77.9a	79.0a	80.3a
94	71.3ab	73.7a	75.4ab	74.8a	75.7a	71.9abc	73.1a	76.8a	76.4a
71	70.0b	71.1a	70.9b	74.2a	74.5a	67.6bc	72.8a	72.4a	74.1a
DR	68.8b	74.2a	76.6ab	75.4a	74.6a	66.2cd	71.2a	71.8a	75.1a
FR	78.4a	79.0a	81.3a	81.5a	77.1a	76.0a	78.6a	78.1a	79.7a
93	73.6ab	74.0a	76.3ab	76.6a	76.6a	60.1d	74.3a	76.4a	77.1a
53	74.5ab	75.2a	76.3ab	73.9a	74.4a	69.5abc	71.7a	72.1a	75.2a

$LSD_{.05}$ for differences among digging dates within years and locations = 6.8.

† Full genotype descriptions are in text.

§ Means for genotypes within a location, year, and digging date followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

At Gainesville, Florunner consistently produced the highest proportion of TSMK. Southern Runner also produced high proportions of TSMK, except at the first digging dates in the last two years of the study. Dixie Runner tended to produce the lowest proportion of TSMK, regardless of the digging date. Dixie Runner also showed significant increases in TSMK if digging dates were delayed. Southern Runner and lines 93 and 94 produced higher percentages of TSMK at later harvests for each year of the study.

Few differences existed in the amount of TSMK produced by the different treatment combinations at Marianna, although there was an overall trend toward higher percentages of TSMK with delayed harvest the first and third years of the study. The second year of the study, Dixie Runner and lines 71 and 94 had significant decreases in TSMK percentages from the second to the third digging date.

Weight of 100 Sound Mature Kernels

The weights of 100 sound mature kernels are presented in Table 4 for the same group of treatment combinations as shown in Tables 2 and 3. The largest seeded line, 71, and the smallest seeded line, Dixie Runner, consistently maintained those ranks at both locations throughout the range of years and digging dates of this study. When significant differences existed among digging dates at either location for a genotype in a given year, the trend was for seed weight to increase as days from planting to harvest increased. Line 94 and Southern Runner showed this significant trend all three years in both Gainesville and Marianna. Line 71 showed this trend all three years in Gainesville and two years in Marianna, while the other genotypes were less consistent.

Table 4. Weights of 100 sound mature kernels for seven peanut genotypes evaluated without the use of fungicides for leafspot control at two locations for three years and with three digging dates.

Gainesville

Genotype†	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
	g								
SR	55.5c§	58.2d	59.3cd	45.9d	50.6d	54.2c	41.1d	47.4e	49.0c
94	55.9c	63.3c	70.8ab	56.0c	59.1c	66.3b	52.8c	55.4c	64.6b
71	76.5a	82.6a	68.3b	80.0a	85.3a	80.2a	73.0a	80.7a	80.1a
DR	43.6d	43.7e	43.4e	38.4e	38.4e	41.9d	39.9d	42.3f	39.5d
FR	53.5c	55.2d	56.0d	53.8c	54.2d	53.7c	48.9c	53.7cd	49.8c
93	53.6c	57.0d	61.1c	47.8d	52.0d	53.4c	48.6c	50.3de	48.9c
53	65.6b	74.2b	73.5a	65.2b	64.7b	62.2b	61.0b	68.6b	67.3b

Marianna

Genotype	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
	g								
SR	55.1d	56.0e	64.1d	53.8d	51.8d	56.0c	52.2d	55.3d	56.4d
94	65.8c	74.3c	74.6c	64.0c	66.7c	73.5b	68.3c	70.9b	72.9b
71	84.1a	92.8a	94.0a	92.3a	93.8a	92.7a	88.2a	93.0a	89.2a
DR	41.8e	48.8f	49.1e	45.6e	45.7e	47.4d	42.8e	43.8e	46.0e
FR	59.1d	64.1d	64.4d	64.6c	64.9c	61.8c	56.7d	60.8c	61.3c
93	54.7d	61.1d	64.6d	56.4d	65.4c	58.9c	55.9d	58.9cd	61.6c
53	79.4b	82.0b	82.4b	75.5b	74.5b	74.5b	74.7b	74.2b	75.9b

$LSD_{.05}$ for comparisons among digging dates within years and locations = 4.2

† Full genotype descriptions are in text.

§ Means for genotypes within a location, year, and digging date followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Disease Rating

Disease ratings are shown in Table 5, again reflecting the significant three-way interaction. The lines with the highest disease ratings, Florunner and lines 53 and 71, were considered to be susceptible to the leafspot disease pathogens. Their disease ratings were consistently among the highest ratings for all combinations of location, year, and digging date. At Gainesville, line 93 consistently had the lowest disease rating, with Southern Runner, Dixie Runner, and line 94 ranking between it and the suscrptible lines. At Marianna, all four lines had lower disease ratings than lines 53 and 71 and Florunner. Line 94 had the lowest disease level at eight of the nine ratings at Marianna.

Table 5. Leafspot disease ratings (1-10) for seven peanut genotypes evaluated without the use of fungicides for leafspot control at two locations for three years and with three digging dates.

Gainesville

Genotype†	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
SR	6.5 a§	5.5 bc	7.5 b	4.0 c	5.5 b	8.0 d	3.5 b	6.5 b	7.0 b
94	5.0 b	4.5 c	7.0 b	3.5 c	4.0 c	7.0 c	3.5 b	6.0 b	6.0 b
71	6.5 a	6.0 b	7.0 b	5.5 b	6.5 a	9.5 a	6.8 a	8.0 a	9.0 a
DR	4.0 b	5.5 bc	6.5 b	2.5 d	4.5 bc	7.0 bc	3.5 b	6.5 b	7.0 b
FR	7.0 a	8.5 a	9.0 a	7.0 a	7.5 a	10.0 a	7.8 a	8.5 a	10.0 a
93	4.5 b	4.5 c	7.0 b	4.0 c	4.5 c	5.0 d	3.8 b	4.0 c	3.5 c
53	7.0 a	8.0 a	8.5 a	6.5 a	7.5 a	10.0 a	7.8 a	8.5 a	10.0 a

Marianna

Genotype	1981			1982			1983		
	Digging Date								
	1	2	3	1	2	3	1	2	3
SR	2.5 de	5.3 c	5.3 c	5.8 c	5.5 cd	5.5 cd	3.5 b	3.8 c	5.5 c
94	2.0 e	4.0 d	5.8 c	4.5 d	4.5 d	4.5 d	3.5 b	3.3 c	4.0 d
71	3.8 c	6.5 b	7.0 b	6.8 b	8.0 b	8.3 b	6.8 a	6.8 b	8.0 b
DR	3.3 cd	4.8 cd	7.0 b	4.8 cd	5.3 cd	5.5 cd	3.5 b	4.0 c	5.5 c
FR	7.3 a	8.5 a	9.5 a	8.5 a	9.8 a	9.8 a	7.8 a	8.3 a	9.8 a
93	3.5 cd	5.5 c	5.8 c	5.5 cd	6.0 c	6.0 c	3.8 b	4.0 c	6.0 c
53	5.3 b	7.0 b	9.0 a	8.0 a	9.0 a	9.3 a	7.8 a	7.5 ab	8.8 b

$LSD_{.05}$ for comparisons among digging dates within years and locations = 1.0

† Full genotype descriptions are in text.

§ Means on a 1-10 scale, as noted in table 1, for genotypes within a location, year, and digging date followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Correlations Between Disease Rating and Other Traits

Table 6 gives correlation coefficients between disease ratings and pod yield, 100 kernel weight, and TSMK for each of the seven genotypes of this study. The disease ratings were negatively correlated with yields for the leafspot susceptible lines (FR, line 71, and line 53), but showed little correlation with yield for the other lines used in this study. Only line 93 showed a high correlation between disease rating and seed weight ($r=0.713$, $P < 0.01$), and this line had the highest correlation between disease rating and TSMK ($r=0.591$, $P < 0.01$). Lower, but significant, correlations existed between disease ratings and TSMK percentage for line 71 and DR.

Table 6. Correlations of disease ratings with pod yield, 100 kernel weight, and total sound mature kernels (TSMK) for each of seven genotypes evaluated without the use of fungicides for leafspot control for three years at two locations with three digging dates.

Genotype	Correlation of disease rating with: Pod yield	100 kernel weight	TSMK
	r		
SR	−0.104	0.186	0.207
94	−0.036	0.037	0.043
71	−0.713	0.049	0.358
DR	0.091	0.293	0.402
FR	−0.734	0.331	0.261
93	0.303	0.713	0.591
53	−0.755	0.011	0.075

Absolute r values above 0.354 are significant at the 1% level.

Discussion

The highest yields in this study were obtained when line 94 was allowed to mature until the third digging date (Table 2). In every year and location combination, this line continued to increase in yield at each subsequent digging date, giving no indication that maturity had been reached. However, the third harvest at

Marianna was made as late as 153 days after planting. Later harvest may not be feasible in many peanut producing areas of the United States, as cooler fall temperatures would prevent such late lines from reaching maturity. The three leafspot susceptible genotypes, Florunner and lines 53 and 71, produced yields of over 3000 kg ha^{-1} at Gainesville and near 4000 kg ha^{-1} at Marianna, even though no fungicides were used (Table 2). Disease ratings indicated that heavy disease pressure was present, even at the first harvest date in Gainesville, which was either 104 or 106 DAP (Table 5). The non-rotated field conditions at Gainesville probably contributed to higher disease levels earlier in the growing season.

The leafspot fungi contribute to a loss of photosynthetic area by destruction of leaf tissue and leaf defoliation, as well as a destruction of plant parts through deterioration of stems and pegs (9). Since high yields were recovered from leafspot susceptible lines at early harvests but not at later ones, it is probable that yield depression of leafspot susceptible lines was associated with loss of harvestable yield through deterioration of pegs and other plant tissue. By harvesting approximately two weeks earlier than the average 135 days after planting used for Florunner, the yield produced by the susceptible lines was harvested before leafspot pressure reduced the yield by deterioration of plant parts. Since fungicide-sprayed plots were not included in these tests, the direct association between leafspot incidence and pod yield loss at each harvest date can not be made. Pod losses of Florunner in other tests were minimal when diseases were controlled.

Once heavy disease pressure existed, yield reduction of the susceptible lines was rapid, while yields of the resistant lines continued to increase. The average yields of line 94 at Marianna for the late harvest were close to 5000 kg ha^{-1} with no leafspot control. This was over 1000 kg ha^{-1} more than the maximum yield Florunner obtained without leafspot control, although line 94 required 28 additional days to produce the additional pod yield. The yields of the susceptible lines are probably greater than would occur in grower fields, since these lines were surrounded by resistant lines that had a lower disease incidence. Conversely, the resistant lines, which have been shown in other studies (3) to respond to fungicide application, would probably be more productive when grown in large plots with lower disease levels associated with reduce inoculum production.

Susceptible genotypes in this study showed a strong negative correlation between disease ratings and yield ($r = -0.70$, $P < 0.01$, Table 6), suggesting that the yield reductions were due to increased leafspot disease. Gorbet *et al.* (3) and Pixley (8) reported that control of leafspot can increase yields of several of the resistant lines evaluated in the present study. However, increased disease pressure, as noted from first to last harvest, was not associated with decreased yield of the resistant lines in this study. Possibly the magnitude of the relationship between disease pressure and yield in the resistant lines was small enough to prevent detection with this rating system. The resistant lines showed yield increases at the same time they were becoming more mature and the disease pressure was building. Maturity may have affected yield more than disease pressure.

Approximately 95% of the variation in 100 kernel weight was associated with differences in genotypes and in locations. The significant differences within genotypes and locations generally showed an increase in seed weight with delayed harvest. With time, plants not only became more mature but also became more infested with leafspot. Since 100 kernel weight was not reduced with delayed digging, the disease pressure did not appear to cause a reduction in seed weight. This conclusion is also supported by the nonsignificant correlation between disease rating and 100 kernel weight for all genotypes in the study except line 93 (Table 6). This line was extremely late and the high correlation was expected, since both maturity and disease increased together. For the other lines in this study, seed reached its final size before disease pressure became severe. Even as pod yield was decreasing, seed size increased in some instances.

Leafspot diseases would be expected to decrease TSMK percentages. The trend in this study was for TSMK percentages to increase as digging date was delayed, even though disease ratings increased with delayed harvest and pod yields changed. At Gainesville, large increases in TSMK occurred with delayed harvest for all but the most susceptible genotypes. As the first harvest date was near 106 DAP, these differences indicate that the resistant lines were much less mature at that date. Although correlations between TSMK and disease ratings for several of the genotypes were significant (Table 6), they were not high. Only the correlation for line 93 was higher than 0.5, and this correlation was probably associated with late maturity.

Southern Runner, Dixie Runner, and lines 93 and 94 consistently had lower leafspot disease ratings than the other genotypes in this study. However, it is questionable whether Dixie Runner contains useful resistance. It is a relatively low yielding cultivar, partitioning less than half its photosynthate to pods (1). During rapid pod fill it still partitions approximately 65% of its photosynthate to new vegetation. The disease ratings used in this study were heavily weighted to measure defoliation. Therefore it is possible that the "resistance" seen in this study is associated with continued production of new leaves. Both Southern Runner and line 94 have slower disease development at both the leaflet and canopy level and a longer time to leaf abscission than Florunner (8).

Summary and Conclusions

Although previous reports indicated a relationship between leafspot resistance and low yield, as well as between resistance and late maturity (2, 4, 7, 11), the resistant breeding lines in this study have shown consistently high yields, although they were realized only at harvest dates of 140 DAP or later. Susceptible genotypes (Florunner and lines 53 and 71) produced high yields, even under heavy leafspot pressure, if harvested approximately 120 DAP. Recoverable yield decreased after that date. High yields were also obtained at Gainesville before 120 DAP, although some lines were immature at that time. The productive leafspot resistant lines (Southern Runner and lines 93 and 94) were generally lower yielding than the susceptible lines at 120 DAP, but the resistant lines maintained or improved yield and quality when harvest was delayed.

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Accepted March 19, 1988