Reaction of Select Peanut (*Arachis hypogaea L.*) Lines to Southern Stem Rot and Pythium Pod Rot Under Varied Disease Pressure

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ABSTRACT

Eight breeding lines, three parents, and the cultivar Florunner were compared under two levels of disease pressure induced by *Sclerotium rolfsii* Sacc., or *Pythium myriotylum* Drechs. at each of two locations for three years to ascertain the effectiveness of the host plant resistance to each pathogen. Varied disease pressures were created by application of fungicides and supplement of fungal inoculum.

Mean Florunner pod yields varied more than 1000 kg/ha as a result of the *S. rolfsii* treatments but the yields of the resistant TxAG-3 were not affected. Disease incidence, as measured by frequency of *S. rolfsii* infection sites and diseased pods, was much higher for Florunner than TxAG-3. Breeding lines for which TxAG-3 was a parent sustained significant yield reductions. The disease incidence in these lines was higher than the resistant parent, equal or less than Tamnut 74, their other parent, and less than Florunner. The grades of TxAG-3 and its derivatives were lower than Florunner.

Pod rot incidence differed for the *P. myriotylum* treatments but pod yields were not different. TxAG-3 and Toalson sustained less pod disease than Florunner and Tamnut 74. The percent of diseased pod tissue for one derivative of Toalson was lower than Toalson and TxAG-3, and that of one TxAG-3 derivative was equal to its best parent. The breeding lines varied in reaction to the two diseases and some lines showed considerable resistance to both organisms.

Key Words: Groundnut, breeding, disease resistance, southern blight, white mold, pod breakdown, blackhull, *Pythium myriotylum, Sclerotium rolfsii.*

Sclerotium rolfsii Sacc. and *Pythium myriotylum* Drech. are important soilborne pathogens of peanut in Texas (1, 10). Southern stem rot (southern blight or white mold) causes the more widespread damage but Pythium pod rot causes severe localized yield and grade losses (10,16). Cultural methods and fungicides effectively reduce disease losses but control is incomplete and fungicide applications increase production costs (7, 10, 16). Diseases caused by both pathogens are erratic in occurrence and the need for protective treatment is irregular in many fields (12, 16). Host plant resistance adequate to contain disease losses would be of major benefit to the peanut industry.

Early reports by McClintock (11) indicated that runner-type peanuts were more resistant to *S. rolfsii* than virginia bunch types, but subsequent reports have disagreed (3, 5, 7, 17). Valencia peanuts are highly susceptible to this fungus (2, 3, 17), and spanish-type peanuts are often more susceptible than virginia.

Resistance to Pythium pod rot was reported in spanish-type peanut by Frank and Krikun (4) and later reports of genotypic difference in Pythium pod disease reaction have been reported by several researchers (6, 8, 9, 15, 21). The mechanism(s) of resistance have been explored with the conclusion that cell compaction is more dense and lignification is more uniform in the pericarps of resistant than in susceptible genotypes (13, 14). Godoy and coworkers (9) found that structural differences between pod rot resistant and susceptible genotypes were present in pods and other plant parts.

Exploitation of the resistances of PI 341885 (4), Toalson (19), and TxAG-3, a selection of PI 365553, have been pursued in the Texas peanut breeding program (20). Evaluation and selection has been on the basis of field tests since no rapid, efficient, and effective supplementary screening method has been developed. Breeding lines were selected that sustained less pod disease and were competitive in yield with check cultivars under moderate to heavy disease pressure, but they were less suited agronomically than the commercial cultivars in the absence of disease. A lingering question during the development of these lines, and a concern in the continued hybridization and selection of superior lines has been whether or not the resistance levels of the parents, if transferred, are adequate to substantially reduce losses from these diseases.

The purpose of this research was to evaluate under field conditions the levels of disease resistance in selected semi-adapted breeding lines derived from three resistance sources. This was accomplished through the use of natural and supplemented pathogen populations, and fungicides to create divergent disease pressures within otherwise common environments.

Materials and Methods

Eight breeding lines and four cultivars were compared for pod disease reaction, yield, and grade factors for three years at two locations with normally heavy natural infestations of soilborne pathogens. The tests were in South Central Texas: one near Yoakum on the Texas A&M University Plant Disease Research Station, and the other on a

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peanut producer's farm near Poth.

The Yoakum tests were on Tremona loamy fine sandy loam soil (pH 7.7) that was naturally infested with *S. rolfsii*. Stubble from the previous barley crop was conserved as surface residue to enhance fungal growth. Two disease pressures were provided each year. For the high disease pressure treatment, steam sterilized oat seed colonized with a field isolate of *S. rolfsii* were air dried, sifted through a 6.4 mm mesh screen, and applied over the row at the rate of 2 g per row meter in 30 cm bands at pegging. Disease development was suppressed for the other treatment by the addition of pentachloronitrobenzene (PCNB) in split applications at pegging and during mid-pod fill at a rate of 4.5 kg ha^{-1} a.i. per application.

The tests at Poth were on Pythium infested soil of the Miguel fine sandy loam series. The soil was naturally basic, pH 7.8, a condition which was aggravated by the addition of irrigation water containing sodium salts. No inoculum was applied for the high disease pressure treatment, but Metalaxyl (N-(2,6-Dimethylphenyl)-N-(methoxyacetyl)-alanine methyl ester) was added at the rate of 0.28 kg ha^{-1} a.i. to lower the disease pressure for the second treatment.

The breeding lines were $F_{4,7}$ (F_7 generation line derived from an F_4 plant) and later generation derivatives of the crosses Tamnut 74//Tamnut 74/PI 341885 (Tx776711 and Tx765585), PI 365553/Tamnut 74 (TX798184, Tx798396, Tx798411, and Tx798165), and Toalson/UF 73-4022 (TX798736 and Tx798716). Tamnut 74 and Toalson (spanish), and Florunner and TxAG-3 (runner) were included as checks. The entries were selected on the basis of soilborne pathogen reactions and agronomic performance in previous tests to provide a range in disease responses among agronomically adapted lines. TxAG-3 was selected from PI 365553 on the basis of pod rot reaction. All breeding lines produced spanish-type pods but main stem flowering was absent or irregular on the PI 365553 derivates.

The entries and treatments were arranged in a randomized split block design with entries as main plots and treatments as sub-plots, except for one test at Yoakum which was erroneously planted in a randomized complete block design. Each test included four replications. An average 21 seed per row meter were planted for entries producing spanish-type pods and 14 m^{-1} for the runner. Each plot consisted of two rows 5.04 m in length spaced 97 and 92 cm apart for Yoakum and Poth, respectively.

The tests at Yoakum were planted July 17 in 1981 and June 4 and 8 in 1982 and 1983, respectively. All plantings at Poth were in mid-to-late June and followed harvest of wheat. Cultural management was in accord with that recommended for irrigated peanut production. Leafspot was controlled by regular applications of Chlorothalonil. *S. rolfsii* infection sites were not recorded in 1981 but were counted immediately prior to digging in 1982 and 1983. Infection sites were denoted by dead or wilted plant branches with visual confirmation of the organism by mycelia or sclerotia. Distinction between adjacent infection sites were based on the presence of healthy appearing intervening stems. The plots were dug on an entry basis: early maturing entries were dug simultaneously with the spanish checks and later maturing entries were dug with Florunner. Vines with pods intact were bagged in burlap and dried at 35 C to approximately 10% moisture. The pods were subsequently detached by means of a stationary picker, partially cleaned of pegs and stems with a mechanical stemmer, and hand picked for removal of inert matter. Random, 300 g pod samples were collected with a riffle divider and visually rated for pod discoloration caused by pod disease. Ratings were made on a 0 to 10 basis; the scores if multiplied by a factor of 10 provide a visual estimate of the percentage of diseased pod tissue. All samples were rated by two or three experienced raters; however, the data of only the most experienced rater is reported.

Grades were determined on 250 g pod samples of each plot using procedures described by the Federal-State Inspection Service. The damaged kernel percentages included only the visually damaged seed.

The data were analyzed separately for each location using the SAS ANOVA procedure (18) for a split plot design. Grade factors were analyzed statistically as g/250 g of pods, but are reported as percentages. Simple linear regression coefficients were computed on both the *S. rolfsii* and pod disease data to ascertain the effect of varied disease pressures on disease scores for individual entries. The test mean of individual entries was used as the dependent variable and the test means of all entries, a quantitative measure of disease pressure as measured by all entries in the test, as the independent variable.

Results

Sclerotium rolfsii

The additions of inoculum and fungicide altered the disease pressures within test years. Treatment effects were significant (P = .05) for pod yield, and for total, sound mature, and damaged kernel percentages (Table 1). Year effects were large for pod yield and total kernel percentage, and entry, year x entry, and year x treatment effects were significant.

S. rolfsii infection occurred for all entries in both treatments but the frequency of infection sites was greater for the inoculated than for the fungicide treatment (Table 2). Averaged over years the number of sites for the inoculated treatment ranged among entries from 3.0 to 19.4 per 10m of row compared to 2.9 to 10.8 where PCNB was applied. Entry reactions were varied as illustrated by the 1.9 infection sites per m for Florunner compared to 0.3 per m for TxAG-3. The number of infection sites in Florunner with the fungicide protectant was three times greater than that of TxAG-3 in both treatments.

Both yield and grade were affected adversely by the

Table 1. Mean squares for yield and grade factors of entries grown in *Sclerotium rolfsii* infested soil at Yoakum, 1981-1983.*

Variable	Pod Yield (kg ha^{-1}) x 1000	Total Kernels %	Sound Mature Kernels % Ω	Damaged Kernels %
	----------g/250g----------			
Year (Y)	12,730	885	n.s.	n.s.
Entry (E)	2,323	1,389	1,850	341
YXE	386	110	220	161
Error (a)	129	17	54	34
Treatment (T)	15,559	124	3,787	2,226
YXT	7,855	99	92	437
EXT	453	n.s.	n.s.	53
YXEXT	153	n.s.	n.s.	n.s.
Error (b)	86	10	38	38

* All values statistically significant at p=.05. n.s. = Non-significant
Ω Sound mature kernels + sound split kernels

Table 2. Yield, grade, and disease values for 12 entries grown at two levels of *S. rolfsii* induced disease pressure, 1981-1983.

Cultivar/ Selection	Yield Kg ha^{-1} Inoc.♦	Yield Kg ha^{-1} PCNB♂	Sound Mature Kernels % Inoc.+PCNB	Damaged Kernels % Inoc.	Damaged Kernels % PCNB	SrISa No./10m Inoc.	SrISa No./10m PCNB
Tx765585	2029 hi*	2405 e-g	70.5 ab	3.3 d-f	1.5 gh	12.3 b-d	7.3 e-i
Tx776711	1951 i	2443 d-g	71.1 a	2.7 e-g	1.8 f-h	15.4 b	10.8 c-e
Tx798396	2673 c-e	3024 b	64.6 ef	3.5 de	2.5 e-h	8.7 d-h	4.5 h-i
Tx798411	2471 d-g	2768 c	65.3 de	5.8 b	2.7 e-g	6.0 g-k	2.2 j-k
Tx798184	2007 hi	2321 fg	63.0 f	6.3 b	2.7 e-g	10.2 c-f	3.7 i-k
Tx798165	1552 j	2035 hi	59.1 g	5.2 bc	2.6 e-g	12.1 b-d	6.7 f-i
Tx798716	2402 e-g	2782 c	68.6 c	5.1 bc	2.2 e-h	11.0 c-e	5.1 hk
Tx798736	1781 ij	2582 c-f	64.8 def	4.4 cd	2.2 cd	19.0 a	9.3 c-g
Florunner	2260 gh	3298 a	69.4 abc	7.7 a	3.5 de	19.4 a	8.7 d-h
TxAG-3	2599 c-f	2576 c-f	64.5 ef	3.2 d-f	1.4 gh	3.0 jk	2.9 k
Toalson	2349 fg	2710 cd	66.6 d	2.3 e-h	1.1 h	10.5 c-f	4.7 i-k
Tamnut 74	1852 i	2562 c-f	69.2 bc	3.3 d-f	2.0 eh	12.7 bc	5.2 h-k
Mean	2160	2625	66.4	4.4	2.2	11.7	6.0

* Values in columns within variables bordered by the same letter are not statistically different: DNMR (P=.05)
a Sclerotium rolfsii infection sites: number per 10 m of row. Means for 1982 and 1983 only
♦ S. rolfsii inoculum added
♂ Pentachloronitrobenzene treated @ 22 kg ha^{-1} a.i.

increased disease pressure in the most susceptible entries. Florunner, the highest yielding entry in the test under low disease pressure, yielded 1000 kg ha^{-1} less and was 5 percent lower in SMK in the high than in the low disease pressure treatments. No effect of differential disease pressure was apparent on TXAG-3 for yield or number of infection sites; however, the SMK percentage was reduced with increased disease pressure.

Among the breeding lines, the Tamnut 74/PI 341885 backcross (Tx765585 and Tx776711) and Toalson/UF 73-4022 (Tx798716 and Tx798736) breeding lines sustained severe yield reductions and heavy disease incidence like the susceptible checks. The PI 365553 derived lines showed varied disease reactions, but all four yielded more in the fungicide-treated than in the inoculated plots. Two of the lines, Tx798396 and Tx798411, were intermediate between their parents for number of infection sites in the inoculated plots but the other two lines were not better than Tamnut 74. Lower percentages of sound mature kernels were recorded for all four lines.

There were more damaged kernels in the inoculated than in the fungicide treated plots; a two-fold difference in the amount of damage occurred in several entries. The damaged kernel percentages of TxAG-3 and Toalson were low but both sustained more damage in the inoculated than in the fungicide protected plots.

The fungicide treatment did not control disease development in total, and the varied disease pressures in three years provided six comparisons of the twelve entries. Although the year x entry interaction was significant, *a priori* prediction of year effects and disease development in soils infested with *S. rolfsii* is impossible. Thus, the average relative performance is the best predictor of future response. Averaged over the six comparisons, breeding line Tx798396 produced the highest yield and was intermediate between its parents, TxAG-3 and Tamnut 74, in total kernel percentage (Table 3). The yields of most of the breeding lines were equal or better than the commercially grown spanish variety, Tamnut 74. None of the four PI 365553 derivatives graded better than TxAG-3 and all were inferior to Tamnut 74. The shelling percentages of the Toalson and PI 341885 derived lines were comparable with Tamnut 74, but the yields were not better than their respective adapted spanish parents. Tx798736 had the highest percentage of damaged kernels in the test.

Average disease scores, or counts of infection sites, fail to portray differences in disease resistance clearly, as low disease scores for susceptible entries under low disease pressure prevents full expression of the character. The importance and usefulness of resistance increases as the disease pressure increases. No attempt was made to estimate the disease pressure in terms of pathogen propagule density, viability or other means. However, the average disease scores of all entries was considered to be an indicator of the relative disease pressure for the different tests and treatments. Individual entry disease scores were regressed as the dependent variable, on the average of all entry scores as the independent variable, to aid understanding of the disease reaction of individual entries in relation to disease pressure as measured by all entries. An entry with a regression coefficient of 1.0 would show an average increase in disease symptoms as the disease pressure increased. A desirable disease response would be low mean disease score, and a coefficient of regression near zero.

Both the means and slopes for number of *S. rolfsii* infection sites and pod disease rating varied among entries (Table 4). The average number of infection sites and the rate of increase with increased disease pressure was lowest for TxAG-3 whereas Florunner and Tx798736 were the highest. Tx798411 was the only breeding line with fewer *S. rolfsii* infection sites (P=.05) than Tamnut 74, but the pod disease incidence was high for that entry. The only breeding lines with less diseased pod tissue than Tamnut 74 were Tx798396 and Tx798716. Both the means and coefficients of regression for pod disease were low for Toalson and TxAG-3.

Table 3. Mean yield and grade values for breeding lines and checks in *S. rolfsii* infested soil at Yoakum, 1981-1983.*

Entry	Yield kg ha^{-1}	Total Kernels	Total Sound Mature Kernels	Damaged Kernels
		----------%----------		
Tx765585	2217 d*	76.2 b	70.5 ab	2.4 fg
Tx776711	2197 d	76.6 b	71.1 a	2.2 fg
Tx798396	2849 a	72.1 d	64.6 ef	3.0 e-g
Tx798411	2619 bc	74.4 c	65.3 de	5.2 a-c
Tx798184	2164 d	72.4 d	63.0 f	4.5 b-d
Tx798165	1794 e	68.1 f	59.1 g	3.9 c-e
Tx798716	2592 bc	75.6 b	68.6 c	3.6 d-f
Tx798736	2181 d	75.7 b	64.8 d-f	6.3 a
Florunner	2779 ab	78.2 a	69.4 a-c	5.6 ab
TxAG-3	2588 bc	69.7 e	64.5 ef	2.3 fg
Toalson	2530 c	72.1 d	66.6 d	1.7 g
Tamnut 74	2207 d	75.8 b	69.2 bc	2.6 e-g

* Values within columns bordered by same letter are not statistically different: DNMR (P=.05)

Table 4. Mean disease values and coefficients of regression of individual entry vs mean of all entries grown in *S. rolfsii* infested soil at Yoakum, 1981-1983.

Entry	SrIS α No./10m	b	Pod disease ¥ %	b
Tx765585	9.9 b*	0.42±.180	20.7 ab	1.14±.051
Tx776711	13.1 a	0.84±.020	21.5 ab	1.24±.020
Tx798396	6.6 cd	0.79±.133	11.2 cd	0.87±.157
Tx798411	4.6 de	0.51±.002	25.4 a	1.12±.002
Tx798184	7.0 b-d	1.13±.026	21.4 ab	1.38±.808
Tx798165	9.4 bc	1.38±.155	24.7 a	1.86±.155
Tx798716	8.1 bc	0.93±.005	12.1 cd	0.02±.005
Tx798736	14.2 a	1.81±.002	16.2 bc	0.58±.002
Florunner	14.1 a	2.02±.053	22.5 a	2.22±.040
TxAG-3	2.9 e	0.16±.007	12.0 cd	0.64±.058
Toalson	7.6 b-d	0.94±.011	10.6 d	0.25±.099
Tamnut 74	9.0 bc	1.01±.029	20.4 ab	0.66±.032

* Values within columns bordered by the same letter are not statistically different: DNMR (P=.05)
α Number of S. rolfsii infection site per 10 m of row.
± Means of 1982 and 1983 only
¥ Visual estimates of visibly diseased pod tissue

Pythium myriotylum

Year, entry, and treatment effects accounted for most of the variation in pod disease at Poth (Table 5). Yield data for the 1982 Poth test was excluded from the analysis because erosion from heavy rain damaged plots extensively. Year effects were not significant for pod yield but accounted for the largest source of variation for total kernels, sound mature kernels, damaged kernels, and pod disease. Treatment effects were not significant for pod yield, but the fungicide increased the total and sound mature kernel percentages, and decreased pod disease. Year x treatment effects were significant as a result of magnitude of difference rather than from reversal in response. Data are presented as means over treatments and years.

Table 5. Mean square values for yield, grade, and pod disease for entries grown in Pythium infested soil at Poth, 1981-1983.*

	Pod Yield ($kg\ ha^{-1}$) x 1000	Total Kernels %	Sound Mature Kernels %	Damaged Kernels %	Pod Disease %
		----------g/250g----------			
Year (Y)	n.s.	13,490*	38,763	2,057	8,616
Entry (E)	3,682	403	438	84	1,842
YxE	1,021	178	373	36	262
Error (a)	233	35	95	10	132
Treatment (T)	n.s.	165	193	n.s.	2,334
YxT	687	152	201	n.s.	878
ExT	n.s.	n.s.	n.s.	n.s.	n.s.
YxExT	n.s.	n.s.	n.s.	n.s.	n.s.
Error (b)	117	17	41	5	55

* All values statistically significant at p=0.5.
n.s. = non significant

The least Pythium pod disease occurred on the derivatives of Toalson, and Tx798736 was scored superior to both Toalson and TxAG-3 (Table 6). The Toalson derivatives showed good yield potential under the conditions of these tests, and the SMK percentage of Tx798736 was better than Florunner and the spanish checks. TxAG-3 and Toalson had significantly less pod disease than Florunner and Tamnut 74. The PI 365553/ Tamnut 74 progenies varied considerably in performance; Tx798396 ranked second among the entries and equal to Florunner in yield and grade, while Tx798165 was inferior in both yield and TK percentage. Florunner and two of the PI 365553 progenies comprised the statistical group with the most damaged kernels. None of the lines derived from PI 365553 differed from TxAG-3 in percent of diseased pods, although there was a slight difference among the lines.

Table 6. Mean yield and grade (1981 & 1983) and pod disease (1981-1983) values for breeding lines and checks in *P. myriotylum* infested soil at Poth.

Entry	Yield $hg\ ha^{-1}$	Total Kernels	Total Sound Mature Kernels	Damaged Kernels	Pod Disease Mean	Pod Disease b
	----------%----------					
Tx765585	3499 de*	70 b	62 b-d	2.6 bc	25 cd	1.57±.051
Tx776711	3645 cd	70 b	63 b-d	2.2 cd	29 bc	1.09±.020
Tx798396	4168 b	70 b	64 bc	1.9 cd	15 e-g	0.78±.020
Tx798411	3205 ef	70 b	63 b-d	3.4 ab	25 cd	0.91±.029
Tx798184	3134 f	69 b	61 cd	3.9 a	23 cd	1.24±.023
Tx798165	3043 f	67 c	61 cd	1.7 cd	24 cd	1.28±.273
Tx798716	3971 bc	71 b	65 b	9.9 cd	13 fg	0.91±.003
Tx798736	4519 a	73 a	68 a	1.7 cd	9 g	0.13±.055
Florunner	4077 b	73 a	64 bc	4.0 a	42 a	0.89±.038
TxAG-3	3084 f	66 c	60 d	1.5 d	22 c-e	1.01±.126
Toalson	3861 b-d	69 b	64 bc	1.5 d	19 d-f	0.79±.038
Tamnut 74	3685 cd	69 b	62 b-d	2.2 cd	34 b	1.39±.094

* Values within columns bordered by the same letter are not statistically different: DNMR (P=.05).

Both the mean pod disease percentages and b values varied markedly among the entries. The Toalson derivatives comprised the lowest statistical group for diseased pod tissue, but the b values differed among these entries. Both the mean disease and b value for Tx798736 were low. The PI 341885 derivatives (Tx765585 and Tx776711) were similar in performance and both were similar to Tamnut 74 for yield and grade factors, although they were somewhat less diseased. The grade and yield of TxAG-3 were low, probably a result of premature digging and thick shells. This germplasm line was the longest duration entry in the test and could have benefitted from some delay in digging.

Discussion

The intent of the study was to create divergent levels of disease pressure within locations, ideally no disease and heavy disease, in order to evaluate the usefulness of the resistance as expressed in selected semi-adapted breeding lines to two important soilborne pathogens. The breeding lines were products of our efforts to develop cultivars with pod rot, principally Pythium and Rhizoctonia, resistance superior to the prevalent commercial cultivars, Florunner and Tamnut 74. Data collected during the development of the lines indicated the presence of genetic variation in reaction to *S. rolfsii* as well. Pythium pod rot and southern stem rot disease pressures in these tests were sufficient to allow expression of distinct genotypic differences.

The test sites were chosen because of the predominance of the pathogens of interest in previous years. Disease symptoms and random platings during the test period confirmed that the principal pathogens were those specified. No assurance can be given that other pathogens were not present at low frequencies as few, if any, Texas peanut fields contain only one peanut pathogen. However, we found no indication that secondary pathogens were important factors in interpretation of the results.

Pod disease evaluations were made on threshed and cleaned pods as previous results (unpublished) have shown a close association of ratings made on threshed versus hand picked pod samples. Although some skeletized pods are lost in threshing, the frequency of retained damaged pods in susceptible entries were adequate to allow differentiation from resistant lines. The effect of the loss of heavily diseased pods in this study would be to underestimate the extent of disease damage, particularly in susceptible entries under high disease pressure. Thus, the differences in disease scores between susceptible and resistant entries should provide a conservative estimate of their relative disease susceptibility. Even so, the genotype and treatment ef-

fects provided clear evidence of differences in disease level and disease reactions.

The reaction of Tx798736 to *S. rolfsii,* relative to Florunner and Tamnut 74, was markedly different from that to Pythium. The defense mechanism of that line in regards to Pythium was not effective against southern blight. Tx798716, the other line of that cross, was equal or superior to Tamnut 74 in all respects at both locations.

Fewer *S. rolfsii* infection sites were recorded for Toalson than for Florunner. This concurs with the results of Branch and Csinos (2) in which Toalson was reported partially resistant to *s. rolfsii.* However, the resistance of TxAG-3 was considerably better than Toalson in terms of infection sites, and it was superior to all other entries in this test except for the TxAG-3 derivative Tx798411.

Variation between TxAG-3 and the PI 365553 derivatives, and among the derivatives occurred within and among locations in yield, grade, and disease scores. The resistance level of TxAG-3 to both pathogens was adequate to justify its use in breeding for multiple disease resistance. Other research has shown this breeding line to resist lesion nematodes (20). The line Tx798396 equalled Florunner in yield at both locations, and was superior in percent damaged kernels and disease scores. The combination of resistance to both pathogens with good yield is noteworthy for breeding. The yield of Tx798411 was good at Yoakum, relative to the commercial checks, but was poor at Poth. The damaged kernel percentage of that line averaged higher than both parents at both locations. Lines Tx798184 and Tx798165 yielded poorly at both locations. They were equal to Tamnut 74 in pod disease and *S. rolfsii* infection sites at Yoakum, inferior to both parents in percentage of damaged kernels at Yoakum, and superior to both parents in damaged kernel percentage at Poth. The SMK percentage of Tx798165, in particular, was low at both locations.

In general, total kernel and sound mature kernel percentages (grades) were low in both tests. Plots were dug when it appeared that the maximum percentage of harvestable pods could be retrieved. Deterioration by disease of mature pods, disease interference with pod development, and immature late set pods following the detachment of diseased pods, are presumed to be factors. The TK percentage was highest for Florunner in both series of tests. Toalson derivatives were higher than Toalson and equal to Tamnut 74 in shelling percentage at Yoakum and equal or higher than the spanish check varieties at Poth. The combination of high TK percentage and good pod rot resistance, relative to the spanish checks, provides some indication that a heavy shell might not be required for pod rot resistance. However, some increase in shell weight could be expected even if the shell thickness of pod rot resistant lines equalled those of current cultivars since the density and cellular arrangement of liquified tissue in shells appears to be a major factor in resistance (9,14). The persistent association of low grades in parental and breeding lines with resistance to pod rot is cause for concern in breeding.

Resistance of TxAG-3 and Toalson to two important soilborne pathogens provides a basis for considering if there is a common defense mechanism for both pathogens. Shell morphology and composition have been examined and some similarity in shell attributes have been apparent in the two resistant parents (9, 13, 14). However, the results of this study indicate that the mechanisms of resistance to the two pathogens are not the same. In fact, the good resistance of Tx798736 to Pythium but susceptibility to *S. rolfsii,* partial resistance of Tx798716 to both pathogens, and resistance of TxAG-3 and Tx798396 to both organisms suggest that the mechanisms differ and might be independent. Fortunately, the resistances are heritable and provide opportunity for increasing the disease resistance of current cultivars. However, careful attention must be given to grade when breeding for resistance to avoid simultaneous selection for disease resistance and thick shells.

The failure to recover the full resistance to *S. rolfsii* of TxAG-3 in these breeding lines might to coincidental or an item of concern. With fungicide two of the four TxAG-3 derivatives were equal to TxAG-3 in frequency of *S. rolfsii* infection sites. A combination of resistance and fungicide might be required for effective control of this disease.

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