Field Evaluations of Peanut Germplasm for Resistance to Stem Rot Caused by *Sclerotium rolfsii*[1]

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ABSTRACT

Southern stem rot, caused by the soilborne fungus *Sclerotium rolfsii*, is a major disease of peanut (*A. hypogaea*) in the U.S. Advanced lines from the Univ. of Florida peanut breeding program were evaluated in field tests at the Marianna North Florida Res. and Educ. Center for resistance to stem rot. Breeding lines and cultivars were evaluated in irrigated field studies in 1999 to 2001. Plants were inoculated at 55 to 65 d after planting with aggressive isolates of *S. rolfsii* that were grown on grain-based (oats, corn) medium in the laboratory. Entries planted in three tests were grouped based on maturity (early, medium, late). Additional split-plot field tests were conducted to compare inoculated vs. uninoculated plants of selected lines. Late-maturing entries consistently showed the highest levels of resistance to stem rot and greatest pod yields. In general, early and medium entries had similar yields, but some medium-maturing entries had greater pod yields and better disease resistance than any of the early genotypes. The mean pod yields for the early, medium and late maturity groups were 2697, 2780, and 4301 kg/ha, respectively. The mean disease ratings on a 1-10 scale (1 ≤ 10% disease; 10 ≥ 90% of plants dead or dying) were 4.6, 4.4, and 3.4, for the early, medium, and late maturity groups, respectively. The mean yield loss to stem rot in the split-plot test was 706 kg/ha. New cultivars with resistance to stem rot were released from the Florida Agric. Exp. Sta. in 2002 and 2003 from material reported in these tests.

Key Words: Groundnut, southern blight.

Stem rot, caused by *Sclerotium rolfsii* Sacc, is a serious fungal disease of peanut (*Arachis hypogaea* L.) in many areas of the world. The pathogen usually infects stems near the crown of the plant and may kill part or all of the plant (1). Infections originate from soilborne sclerotia that germinate under warm, moist conditions. The fungus may colonize debris or other organic matter before infecting living plant tissue. Sclerotia also may germinate eruptively in the presence of volatile compounds from decaying organic matter and infect plants directly (11). In the southeastern U.S., pod yield losses from stem rot have been reported at 7 to 10% annually (10).

Differences among peanut cultivars and genotypes in their response to stem rot have been reported (3, 4, 5, 7, 8, 13, 14). Resistance of peanut to stem rot may be due to phenological, metabolic, structural, or possibly other

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factors (13). Brenneman *et al.* (5) and Shokes *et al.* (15, 16) found that field screening was an effective method to evaluate resistance in peanut, although natural antagonists and non-uniform spatial distribution of natural inoculum can be problematic (12). Amending soil with inoculum grown in the lab on sterilized grain-based media increases the pathogen population and improves the distribution of the fungus in field tests (5, 13, 16).

Several peanut cultivars have shown partial resistance to stem rot in the field. Southern Runner, Florida MDR 98, and C-99R are multiple disease resistant runner cultivars that manifest partial resistance to *S. rolfsii* (8, 14, 15). However, all of these cultivars are late maturing, which most producers do not favor. Earlier-maturing and completely or partially resistant cultivars are needed. The objective of these studies was to evaluate advanced breeding lines in the Univ. of Florida peanut breeding program for resistance to stem rot under field conditions. Genotypes included in these tests varied in maturity grouping and showed good to excellent yield potential in field trials in Florida in which plants were not inoculated with pathogens. All lines originated from crosses made in Florida and were selected in field trials at Marianna or Gainesville.

Materials and Methods

Selected advanced peanut breeding lines were grouped into separate early, medium, and late maturity tests conducted from 1999 to 2001 at the North Florida Res. and Educ. Center at Marianna, FL. Experiments were planted with a cone planter in mid-May each year under a center pivot irrigation system. The soil was a Chipola loamy sand which had been in a 3-yr rotation of 2 yr of grain sorghum and 1 yr of peanut. Plots were 6.1 m long and consisted of two rows spaced 0.9 m apart. Plots were seeded at a rate of five to six seed per 30 cm of row. Entries were arranged in a randomized complete block design with three replications in each year (Table 1). Days to maturity in the lines were previously characterized as < 125 d for the early group, 135 to 140 d for the medium group, and > 150 d for the late group. The number of entries in each group varied across years. There were 20 to 30 entries in the early group, 30 entries in the medium group, and 30 to 32 entries in the late group. Plants were inoculated at 55 to 65 d after planting (DAP) with a mixture of aggressive isolates of *S. rolfsii* that were grown in the lab on sterile grain (oats, corn). Infested grain was applied at a rate of approximately 60 cm^3 per 6.1 m row. All plots were irrigated the day before inoculation, followed by irrigation for 2 consecutive d after inoculation, if no rain occurred. A full production management program was followed in which chlorothalonil was applied for foliar disease control on a 14-d schedule.

A split-plot study with 10 to 14 entries was also conducted each year to evaluate effects of stem rot on yield and grade of test lines. Peanuts were planted in four-row plots. Rows were 6.1 m long, and 0.9 m apart. Two rows were inoculated as described above, and two rows were left uninoculated in each plot. This test was managed in the same manner as in the tests described above.

Disease severity was rated on a 1-10 scale, with 1 ≤ 10% disease and 10 ≥ 90% of plants are dead or dying. The disease index approximated the percentage of plants in the plot with severe symptoms from *S. rolfsii* infection, with part or all of the plant wilting, dying, or dead. The ratings were made on the day of digging on inverted plots. Plants were dug according to maturity group (Table 1), partially cured in the windrow for 3 to 4 d, and picked with a plot thresher. Pod yield and grade data were collected from the dried (8% moisture) pod samples. Data from individual tests each year (i.e., early, medium, late) were subjected to analysis of variance by SAS procedures. Differences among means were determined by Fisher's Protected Least Significant Difference Procedure with P = 0.05.

Results and Discussion

The methods used in these studies provided consistent stem rot development from *S. rolfsii*. Highly significant differences ($P \leq 0.01$) were found among entries in almost all tests for disease ratings and pod yields (Table 2). Highly significant ($P \leq 0.01$) differences were found

Table 1. Planting and digging dates for studies to evaluate peanut breeding lines of different maturity groups for resistance to stem rot in field tests at Marianna, FL, 1999-2001.

Year and test	Date planted	Date inverted	Days
1999			
Early[a]	19 May	24 Sept.	128
Medium	19 May	1 Oct.	135
Late	20 May	18 Oct.	151
Split-plot[b]	20 May	1, 18 Oct.	134, 151
2000			
Early	22 May	25 Sept.	126
Medium	19 May	2 Oct.	136
Late	19 May	13 Oct.	147
Split-plot	22 May	9, 20 Oct.	140, 151
2001			
Early	17 May	21 Sept.	127
Medium	17 May	1 Oct.	137
Late	18 May	15 Oct.	150
Split-plot	18 May	1, 15 Oct.	136, 150

[a]Approximate days from planting to maturity were: early = 125 d; medium = 135-140 d; late = 150 d.

[b]Only medium and late maturity lines were included in paired row/split-plot tests. Medium maturity lines were dug on the first date listed.

Table 2. Pod yields and disease ratings in field evaluations of resistance to stem rot in early, medium, and late maturity peanut lines at Marianna, FL, 1999-2001.

Maturity/ test year	Entries	Pod yield Range	Pod yield Mean	Statistical significance[b]	Disease rating[a] Range	Disease rating[a] Mean	Statistical significance[b]
	no.	------------ kg/ha ------------		P > F			P > F
Early[c]							
1999	30	3044-1452	2201	0.01	7.3-3.3	4.8	0.01
2000	28	4696-2891	3728	0.01	7.0-3.3	5.0	0.01
2001	20	3988-1667	2826	0.01	7.5-2.7	4.2	0.01
Medium							
1999	30	4257-1207	2818	0.01	7.8-2.2	4.5	0.01
2000	30	4818-1163	2244	0.01	7.5-2.2	4.2	0.01
2001	30	4919-2309	3269	0.01	7.3-2.8	4.5	0.01
Late							
1999	30	5367-2753	4302	0.01	6.0-1.8	3.4	0.01
2000	32	5700-3647	4577	0.01	4.2-3.0	3.4	NS
2001	32	5342-3163	4001	0.01	4.2-2.5	3.3	0.05

[a]Disease severity rated at harvest on 1-10 scale, where 1 ≤ 10% disease, 10 ≥ 90% of plants dead or dying, approximating the percentage of severe symptomatic plants in the plot.

[b]Statistical significance of line effect from ANOVA of pod yield and disease ratings in each test (maturity group/year).

[c]Approximate days from planting to maturity were: early = 125 d; medium = 135-140 d, late = 150 d.

among lines within groups, except for disease ratings in the late maturity test in 2000 which were nonsignificant. As a group, late-maturing lines clearly had greater resistance, as noted by lower mean disease ratings and greater pod yields compared to the other groups. The mean pod yields for the late lines averaged 4293 kg/ha across all 3 yr, whereas mean pod yields for the early lines averaged 2918 kg/ha and medium lines averaged 2777 kg/ha (Table 2). However, some individual early and medium lines produced pod yields exceeding 4000 kg/ha. These results support those obtained in Florida tests in which the late-maturing cultivars Southern Runner, Florida MDR98, and C-99R have shown some resistance to *S. rolfsii* (8, 14, 15).

Genotypes that mature in ca. 125 DAP in Florida (early-maturing) generally had lower levels of resistance than the other maturity groups. Data for early-maturing genotypes that were included across all 3 yr of testing, along with the partially-resistant cv. Georgia Green (medium) and susceptible cv. Andru 93 (early) are given in Table 3. High levels of resistance to *S. rolfsii* were not found in the early maturity group. Cultivar Andru II showed better resistance to stem rot than Andru 93 and Georgia Green and also had a significantly higher pod yield than Georgia Green (3481 vs. 2783 kg/ha). Andru II and GP-1 were released as commercial cultivars in 2002 (7). GP-1 had greater pod yields than Georgia Green even with a higher disease rating (5.2 vs. 4.2).

Among medium-maturity lines (135 to 140 DAP), disease was most severe on cv. SunOleic 97, the susceptible check (Table 4). Pod yield and disease severity data for the medium-maturity genotypes that were included across all 3 yr of testing indicated that some of the lines had good levels of resistance (Table 4). AP-3 (UF98116) had the lowest disease rating and greatest pod yield (4352 kg/ha). Cultivar Carver is a sisterline of AP-3, as is 90x7-3-2-1. All three lines have NC 3033 in their pedigrees, which has some resistance to stem rot (2). Carver was released by the Florida Agric. Exp. Sta. (FAES) in 2002 and AP-3 was released in 2003 as multiple disease resistant cultivars with partial resistance to stem rot (7).

Table 3. Pod yields and disease ratings from field evaluation of early maturity peanut lines inoculated with *Sclerotium rolfsii* at Marianna, FL, 1999-2001.

Entry[a]	Pod yield	Disease[b]
	kg/ha	
Andru II	3481	3.3
90xOL41-6	3433	4.2
90xOL41-15	3348	3.8
90xOL41-9	3348	3.5
GP-1	3296	5.2
92xOL100	3175	4.0
89xOL16B	3082	3.9
89xOL41-2	2860	4.2
Georgia Green	2783	4.2
90xOL41-8	2586	4.2
Andru 93	2227	6.1
$LSD^{c}_{(0.05)}$	403	0.6

[a]Early-maturity lines that were included in all 3 yr of testing.

[b]Disease severity rated at a harvest on a 1-10 scale (1 ≤ 10% disease, 10 ≥ 90% of plants dead or dying).

[c]LSD based on combined analysis across years for these genotypes only.

Table 4. Pod yields and disease ratings from field evaluation of medium maturity peanut lines inoculated with *Sclerotium rolfsii* at Marianna, FL, 1999-2001.

Entry[a]	Pod yield	Disease[b]
	kg/ha	
AP-3	4352	2.4
90x7-3-2-1	4004	2.6
88x49	3447	3.4
86x1B	3228	4.3
Carver	3111	3.3
88x48	3023	4.3
Sunr. BC5-42	2913	4.7
92xOL19	2757	4.1
Sunr. BC5-29	2720	4.8
ANorden	2576	3.6
Georgia Green	2340	4.3
SunOleic 97R	1841	7.3
$LSD^c_{(0.05)}$	538	0.7

[a]Medium-maturity lines that were included in all 3 yr of testing.
[b]Disease rated at harvest on a 1-10 scale (1 ≤ 10% disease, 10 ≥ 90% all plants dead or dying).
[c]LSD based on combined analysis across years for these genotypes only.

Other studies indicate that both of these cultivars also have good resistance to tomato spotted wilt virus (Tospovirus) (7, 17). Cultivar ANorden was released in 2002 as a new high oleic cultivar and had resistance to stem rot similar to Georgia Green in these tests (7).

Most of the lines in the late maturity groups mature in about 150 DAP in Florida and are good sources of resistance to several peanut diseases, including stem rot. Pod yields were clearly higher and disease ratings lower in the late-maturing group, when compared to the early- and medium-maturity groups, even with longer exposure to the disease in the field. Pod yields for the late-maturing genotypes exceeded 4000 kg/ha (Table 5). Five lines produced significantly greater pod yields than Florida MDR 98. C-99R had disease ratings similar to MDR98 (8). Cultivar DP-1 and 89xOL28-HO1-7-1-1 had the lowest disease ratings (2.7 and 2.6, respectively), although they did not differ significantly from several other lines. C-99R was released in 1999 (8) and cv. Hull and DP-1 were released in 2002 (7). All of these cultivars have multiple pest resistance, including resistance to late leafspot caused by *Cercosporidium personatum* (Berk. et Curt.) and tomato spotted wilt. In addition, Hull has high oleic chemistry (7).

Medium- and late-maturity genotypes were compared in inoculated vs. uninoculated split plot tests (Table 6). Each line was harvested at its appropriate optimal maturity based on prior tests and plant development (Table 1). Pod yields and disease ratings for genotypes included for the 3-yr testing period were compared for inoculated and uninoculated paired plots (Table 6).

Table 5. Pod yields and disease ratings from field evaluation of late maturity peanut lines inoculated with *Sclerotium rolfsii* at Marianna, FL, 1999-2001.

Entry[a]	Pod yield	Disease[b]
	kg/ha	
89xOL28-HO1-7-1-1	5123	2.6
86x43-5	4760	3.1
86x43-1-2-1-1	4756	3.0
86x43-1-2-1-2	4729	3.3
87x8-2-1-1	4651	3.7
Hull	4537	3.7
88x25-6-2-2	4451	3.4
DP-1	4439	2.7
84x9B-4-2-1-1-1	4370	3.3
84x9B-4-2-1-1-3	4304	2.9
Fla. MDR 98	4220	3.0
89xOL28-HO1-7-4	4159	3.7
84x9B-4-2-1-1-4	4123	3.4
86x43-1-1-1-2	4122	3.1
C-99R	4097	3.2
84x23-11-2-1	3965	3.7
$LSD^c_{(0.05)}$	396	0.5

[a]Late-maturity lines that were included in all 3 yr of testing.
[b]Disease rated at harvest on a 1-10 scale (1 ≤ 10% disease, 10 ≥ 90% all plants dead or dying).
[c]LSD based on combined analysis for these genotypes only.

Table 6. Pod yields and disease ratings from field evaluation for the paired-row/split plot tests inoculated with *Sclerotium rolfsii* at Marianna, FL, 1999-2001.

Entry	Maturity	Pod yield		Disease[a]	
		Inoc.	Uninoc.	Inoc.	Uninoc.
		------ kg/ha ------			
Florunner	medium	2175	3102	7.1	5.8
Ga Green	medium	3780	4651	4.3	3.2
C-99R	late	4311	4675	3.0	2.5
Hull	late	4854	5480	3.2	2.5
DP-1	late	4777	5352	2.6	1.8
88x25-6	late	4903	5304	2.5	2.1
$LSD_{(0.05)}$		515	475	0.4	0.3

[a]Disease rated at harvest on 1-10 scale (1 ≤ 10% disease, 10 ≥ 90% all plants dead or dying).

Cultivar Florunner, the susceptible check, had the lowest pod yield (2175 and 3102 kg/ha, respectively) and highest disease ratings (7.1 and 5.8, respectively). Hull, DP-1, and 88x25 had the highest pod yields and generally the lowest disease ratings. C-99R had the least yield difference (364 kg/ha) between inoculated and uninoculated treatments.

Symptoms of tomato spotted wilt were present in these studies but ratings were not taken. The mid-May planting date and high seeding rates were used to help reduce tomato spotted wilt pressure based on the Univ. of Georgia TSWV index (6). Probably the greatest tomato spotted wilt incidence occurred in 1999. Some genotypes with high partial resistance to *S. rolfsii* also appeared to have resistance to tomato spotted wilt based on ratings from other studies (17).

Conclusion

Results clearly show that good levels of partial resistance to *S. rolfsii* are present among the lines and cultivars evaluated in these studies, especially in the late-maturity genotypes. Some of the medium-maturity lines also showed relatively strong resistance. Much of the germplasm with good resistance to *S. rolfsii* also manifests moderate to strong resistance to tomato spotted wilt virus. Some of the resistant lines evaluated in these studies have recently been released as commercial cultivars, which should help growers combat this important disease on peanut (7).

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