Field Performance of Advanced Runner- and Virginia-Type Peanut Breeding Lines During Epidemics of TSWV

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ABSTRACT

Spotted wilt, caused by tomato spotted wilt tospovirus (TSWV), has become a major problem in peanut- (*Arachis hypogaea* L.) producing areas of the southern U.S. Development of cultivars with resistance to TSWV appears to be among the most promising methods for managing this disease. As part of efforts toward characterizing breeding lines with potential for release as cultivars, epidemics of spotted wilt were monitored in field plots of runner-type peanut cultivars Southern Runner and Florunner and advanced breeding lines: 79/4-6-2-1-1-Z16-b2-B (virginia-type), F 84/23-11-1-1-1-b2-B (runner-type), and F 84/28-5-5-2-2-1-b2-B (runner-type), F 84/28-5-4-2-2-b3-B (runner-type). The tests were conducted near Attapulgus, GA and Marianna, FL in 1995 and 1996. In 1996, the tests also included the runner-type cultivar AT-108. Epidemics of spotted wilt were suppressed in F 79/4-6-2-1-1-Z16-b2-B, F 84/23-11-1-1-1-b2-B, F 84/28-5-5-2-2-1-b2-B, and Southern Runner in comparison to those in Florunner. Final disease incidence and/or final disease intensity ratings in F 79/4-6-2-1-1-Z16-b2-B and F 84/23-11-1-1-1-b2-B were similar to those of Southern Runner. In 1996, final spotted wilt intensity ratings in F 84/28-5-4-2-2-b3-B and AT-108 did not differ from those of Florunner. Yields of F 79/4-6-2-1-1-Z16-b2-B and F 84/23-11-1-1-1-b2-B were superior to those of Florunner in three of the four tests. No differences were found among the genotypes in numbers of adults of tobacco thrips (*Frankliniella fusca*) or western flower thrips (*F. occidentalis*), and differences in numbers of larvae of *Frankliniella* spp. were few and not consistent. There was no evidence that differences in final disease incidence or disease intensity ratings were due to differential preference by thrips or to suitability for thrips reproduction. F 79/4-6-2-1-1-Z16-b2-B and F 84/23-11-1-1-1-b2-B represent potential tools for management of spotted wilt in peanut production areas of the southeastern U.S.

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Spotted wilt, caused by tomato spotted wilt tospovirus (TSWV), has been increasing in importance as a problem in peanut (*Arachis hypogaea* L.) and other important crops in the southern U.S. since 1985 (2,4,8,12). The disease is common across the peanut-growing areas of Georgia, Florida, and Alabama and has become the most important disease problem for many peanut growers. There are few effective tactics for management of spotted wilt in peanut (4,13,14,17), and none provide consistently high levels of control.

Development and deployment of resistant cultivars appear to have the most potential for minimizing the risks of losses to spotted wilt. In several experiments, the peanut cultivars Southern Runner (6,7,8,9), Georgia Browne (6), and Georgia Green (8) have provided consistent suppression of spotted wilt epidemics when compared to the standard runner-type cultivar Florunner. In addition, the runner-type breeding line UF 91108, which was recently approved for release by the Univ. of Florida, has effects on spotted wilt epidemics similar to those of Southern Runner (9). Factors responsible for the impedance of spotted wilt epidemics by these cultivars have not been elucidated, but in this paper we will refer to genotype characteristics of reduced levels of disease as resistance. Resistance does not imply immunity, and the level of resistance may vary from partial to complete. Epidemic development in Southern Runner, Georgia Green, Georgia Browne, and UF 91108 would suggest that all of these cultivars have a moderate level of partial resistance. Our use of the terms resistant or partially resistant does not imply that the mechanisms for or genetic factors responsible for the reduced level of disease have been determined.

In many areas of the southeastern U.S., it will be essential that all peanut cultivars grown have some level of resistance to TSWV if epidemics in those areas continue to increase in intensity. Resistant cultivars will become even more important for production efficiency as U.S. peanut production moves toward pricing structures based on the world market.

For various reasons, Southern Runner and Georgia Browne currently are not acceptable for production on a large acreage (8). Georgia Green has become available since its release in 1995 and is rapidly gaining acceptance by growers. All three of these cultivars have average seed size that is smaller than most of the runner-type cultivars planted in the southeastern U.S. Because of its small seed size, Georgia Browne is now classified as a spanish market type. UF 91108 is not yet available to growers, and its acceptance remains uncertain. This cultivar is a large-seeded runner type, and its suppressive effects on spotted wilt epidemics indicate that traits of moderate levels of resistance to TSWV can be combined with larger seed size than in cultivars previously reported. Similar levels of resistance have not been reported in virginia-type cultivars or breeding lines. In fields with moderate epidemics of spotted wilt, the virginia-type cultivar NC-V11 was similar to Southern Runner and UF 91108 in its effects on spotted wilt epidemics (9). However, in tests with more severe epidemics, NC-V11 was similar to susceptible Florunner in field response to TSWV (9).

None of the cultivars released to date have a high level of resistance and may suffer significant damage during extremely intense epidemics. Cultivars with higher levels of resistance than is currently available would be of great benefit across all of the U.S. peanut-growing areas. This work represents portions of ongoing efforts to develop runner- and virginia-type peanut cultivars with improved performance during tomato spotted wilt epidemics.

TSWV is vectored only by thrips. Two species that are confirmed vectors of TSWV—tobacco thrips, *Frankliniella fusca* Hinds, and western flower thrips, *F. occidentalis* Pergande—occur on peanut in Georgia. There has been no indication in previous studies that reduced incidence and severity of spotted wilt in advanced breeding lines or cultivars have been due to lack of preference by thrips or reduced suitability for thrips reproduction (6,7,8,9). Nonetheless, screening for resistance to the thrips vectors continues to be a substantial part of our genotype characterization efforts in an attempt to find lines with resistance to thrips as well as to TSWV.

Recently, advanced peanut breeding lines F 79/4-6-2-1-1-Z16-b2-B, F 84/23-11-1-1-1-b2-B, F 84/28-5-5-2-2-1-b2-B, and F 84/28-5-4-2-2-b3-B from the Univ. of Florida breeding program have shown potential for release as cultivars based on pod yield, market grades, pod and seed qualities, and resistance to fungal pathogens. These breeding lines have been identified in preliminary field screening experiments as having lower incidences of spotted wilt than the susceptible cultivar Florunner. AT-108 is a new runner-type cultivar that was first available to growers in 1995. During that season, questions arose regarding possible resistance to TSWV. However, quantitative characterization of the effects of this cultivar on spotted wilt epidemics has not been reported. The objectives of this study were to determine the effects of these advanced peanut breeding lines and AT-108 on epidemics of spotted wilt, and to characterize populations of tobacco thrips, *F. fusca*, and western flower thrips, *F. occidentalis*, naturally occurring on these genotypes. Of particular interest was the comparison of spotted wilt epidemics and thrips populations in these new genotypes to those in Southern Runner and the susceptible cultivar Florunner.

Materials and Methods

Field Plot Designs. Tests were conducted at the Univ. of Georgia Attapulgus Research Farm, Attapulgus, (Decatur Co.) GA and at the North Florida Res. and Educ. Center, Marianna (Jackson Co.), FL in 1995 and 1996. Soil type was Dothan loamy sand (pH 5.8) for fields at Attapulgus, and Orangeburg loamy sand (pH 6.0) for fields in FL. Randomized complete block designs with six replications were used in both years and both locations. Thrips and TSWV were endemic at both locations, and neither virus nor vector was introduced into plots.

Planting dates were 4 Apr. 1995 and 12 Apr. 1996 in Georgia, and 11 Apr. 1995 and 19 Apr. 1996 in Florida. Plant populations in all plots were thinned to one plant/20 cm of row. Plant populations were lower than recommended for commercial production to promote higher incidence of spotted wilt (4,10) and to facilitate observation of spotted wilt symptoms in individual plants. Plots were two rows, 6.1 m long with row spacings of 0.9 m. All plots in Georgia were bordered on both sides by susceptible cultivar Tamrun 88 to increase overall incidence of spotted wilt in all entries (1). Each plot in Florida was bordered on one side by Tamrun 88. Plants in each plot were counted 20 d after planting (DAP) in 1995, 18 DAP in 1996 in Georgia, and 48 DAP in 1995 and 25 DAP in 1996 in FL to determine initial plant populations.

Genotypes Evaluated. In 1995, genotypes evaluated included advanced breeding lines F 79/4-6-2-1-1-z-16-b2-B (henceforth referred to as F 79/4), F 84/23-11-1-1-1-b2-B (F 84/23), and F 84/28-5-5-2-2-1-b2-B (F 84/28-5), and runner-type cultivars Southern Runner and Florunner. In 1996, F 84/28-5-4-2-2-b3-B (F 84/28-4) was substituted for F 84/28-5, and treatments also included the runner-type cultivar AT-108 (Agratech Seed, Ashburn, GA). F 79/4 is a virginia type with average seed weights of *ca.* 95 g/100 seed and ≥ 50% extra large kernels (D. W. Gorbet, unpub. data). It was developed from a cross of NC Fla 14//F 72/93-9-1-1-B. F 72/93-9-1-1-B is a sister line of Southern Runner. The other three lines are runner types. F 84/23 was developed from the cross UF 81206-1//GP-NC 343/NC Ac 15729. UF 81206 is from a cross between PI 203396 and Univ. of Florida breeding line F 427B. F 84/28-5 and F 84/28-4 are from a selection from UF 91108 and originated as F_3 selections from the same F_2 plant. UF 91108 originated from the cross Southern Runner//Andru 94/UF 81206. All four of the breeding lines examined in this study are relatively late maturing, generally requiring *ca.* 150 d to mature in north Florida and south Georgia. This is similar to time to maturity for Southern Runner, and typically 10-14 d later than Florunner.

Thrips Sampling. Multiple samples were taken from each plot for comparison of thrips populations among the entries. Ten partially unfolded quadrifoliolate terminal leaves were collected from each plot 27, 34, and 42 DAP in Georgia and 27, 36, and 43 DAP in Florida in 1995; and 26, 32, 39, and 46 DAP in Georgia and 26, 32, 40, and 46 DAP in Florida in 1996.

Terminal leaves were collected and processed as described by Chamberlin *et al.* (5). Immediately after collection, samples were placed in vials of 70% ethyl alcohol and refrigerated until thrips could be removed and counted in the lab. Thrips were sorted and counted according to species, sex, and life stage. Due to extreme difficulty in differentiating larvae, thrips larvae in the genus *Frankliniella* were counted without regard for species. Previous studies indicate that these larvae are almost exclusively *F. fusca* (18).

Disease Evaluation. In 1995, incidence of spotted wilt virus was monitored in each plot. Plants were evaluated for symptoms of spotted wilt on *ca.* 14-d intervals during the growing season. On each evaluation date, all plants of each plot were examined individually for symptoms of spotted wilt. Symptoms included concentric ringspots, "oak-leaf" patterns of chlorosis, bronzing of leaves, stunting, and distortion and/or necrosis of leaves in the terminal bud, general chlorosis, wilting, and death. Symptoms of spotted wilt on peanut are highly variable, but there were no noticeable differences in types of symptoms observed among entries in this study. Plants with symptoms on one leaflet or more were designated as symptomatic. To aid in subsequent evaluations, the location of each symptomatic plant was marked with a color-coded surveyor flag. All plants exhibiting symptoms on a given date were marked with flags of the same color; a different color was used for each subsequent evaluation date. Disease progress curves were constructed for each entry by using disease incidence, the percentage of symptomatic plants in each plot. Plots also were evaluated using a disease intensity rating that represents a combination of incidence and severity. The number of 0.31-m portions of row containing severely stunted, chlorotic, wilted, or dead plants was counted for each plot immediately prior to digging. This method was adapted from a similar method for assessing incidence of southern stem rot, reported by Rodriguez-Kabana *et al.* (15). In contrast to evaluations for incidence, portions of row with plants showing foliar symptoms on a limited portion of the plant were not counted in this evaluation. The number of 0.31-m portions of linear row severely affected by spotted wilt was converted to a percentage of row length severely affected for comparison of genotypes.

In 1996, plots were not evaluated for incidence of spotted wilt. Studies completed in 1995 indicated that final disease incidence of spotted wilt and final disease intensity ratings among genotypes were highly correlated, and that disease intensity ratings were more closely correlated with yield. Therefore, only the intensity ratings were used in 1996. All plots were evaluated using the intensity ratings on *ca.* 14-d intervals. Disease progress curves were constructed using spotted wilt intensity ratings instead of disease incidence.

All tests were maintained as recommended for commercial production. Chlorothalonil (Bravo 720) or tebuconazole (Folicur 3.6 F) was applied as a foliar spray at 7- to 14-d intervals for control of foliar and/or soilborne fungal diseases. Plants were dug and inverted at approximate optimum maturity for each cultivar based on the hull-scrape maturity index (19) and/or visual maturity estimates. Entire plots were harvested for yield estimates. Inverted plants were dried in wind rows for 3-7 d. Pods were harvested mechanically, and pod yields were determined for each plot.

Statistical Analysis. All data were subjected to analysis of variance. Data were analyzed across locations within years (16). Fisher's protected LSD values were calculated for comparison of genotypes. Differences described below are significant at $P \leq 0.05$ unless otherwise indicated.

Results

In 1995, location effects were significant for final incidence and final intensity ratings. Epidemics were more severe in Florida than in Georgia (Fig. 1). However, there were no significant location × genotype interaction effects for final incidence or intensity ratings. Therefore, data from the two locations were pooled for genotype comparisons. All three advanced lines and Southern Runner had final incidence and final intensity ratings that were lower than those of Florunner (Table 1). Final incidence for F 84/23 was lower than for the other two breeding lines, but not Southern Runner. There were no differences in intensity ratings among Southern Runner and the three breeding lines.

Location and location × genotype interaction effects were significant for yield in 1995. Therefore, analysis was done for each location. There were no significant genotype effects on yield in Georgia. In Florida, Southern Runner and all three breeding lines produced yields

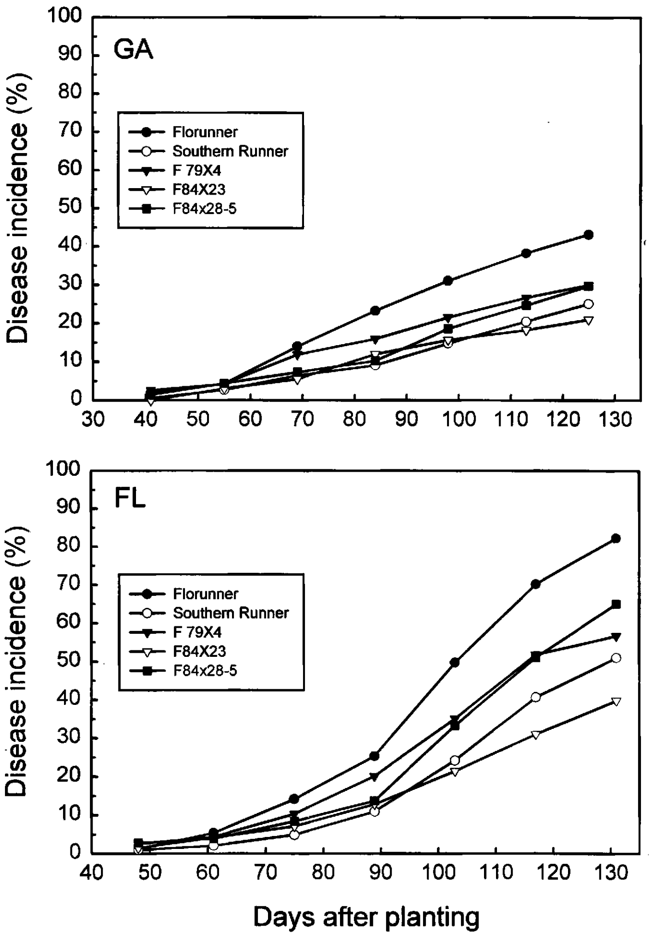

Fig. 1. Effect of peanut genotype on progress of incidence (percentage of plants with symptoms) of spotted wilt caused by tomato spotted wilt tospovirus in Georgia and Florida in 1995.

Table 1. Disease and yield responses of peanut genotypes to tomato spotted wilt tospovirus at Attapulgus, Georgia (GA) and Marianna, Florida (FL) in 1995 and 1996.

Genotype	Final incidence[a]			Intensity rating[b]			Yield	
	GA	FL	Mean	GA	FL	Mean	GA	FL
	%			kg/ha			kg/ha	
1995								
Florunner	43.1	82.3	62.8	37.5	65.0	51.3	3125	2830
Southern Runner	25.1	51.1	38.2	9.2	33.8	21.5	3769	4449
F 79/4-6-2-1-1-b3-B-Z16-b2-B	30.0	56.8	43.5	12.1	22.5	17.3	3816	4748
F 84/23-11-1-1-1-b2-B	21.1	40.0	30.5	10.0	14.2	12.1	3200	5030
F 84/28-5-5-2-2-1-b2-B	29.7	65.0	47.4	14.2	23.8	19.0	3586	4369
LSD ($P \leq 0.05$)	-	-	10.5	-	-	9.8	745	756
1996								
Florunner				25.8	29.5	27.7	3776	4572
Southern Runner[c]				9.2	18.3	13.8	3546	4557
F 79/4-6-2-1-1-b3-B-Z16-b2-B				7.1	17.5	12.3	6094	5496
F 84/23-11-1-1-1-b2-B				9.2	14.2	11.7	5477	5337
F 84/28-5-4-2-2-b3-B				17.5	26.3	21.9	5747	4853
AT-108				19.6	27.5	23.5	4047	3773
LSD ($P \leq 0.05$)				-	-	8.0	762	600

[a]Percentage of the total plant population with symptoms of spotted wilt.
[b]Percentage of the total row length with plants severely affected by spotted wilt (see text).
[c]Sparse stands in 1996.

that were greater than that of Florunner. Yields in all three advanced lines did not differ from that of Southern Runner.

In 1996, spotted wilt epidemics at both locations were less severe than in 1995. Location effects were significant for final intensity ratings, but there were no significant location × genotype interaction effects. Differences in epidemic development between the locations were not as large as in 1995 (Fig. 2). Across locations, final intensity ratings for F 84/28-4 and AT-108 did not differ from those for Florunner (Table 1). Final intensity ratings were similar for Southern Runner, F 79/4, and F 84/23; and ratings for all three of these genotypes were lower than for any other entry.

There were significant location × genotype interaction effects for yield in 1996. In Georgia, yields of F 79/4, F 84/23, and F 84/28-4 were higher than those for any of the other genotypes. In Florida, yields of F 79/4 and F 84/23 were similar and higher than for Florunner, Southern Runner, or AT-108.

In 1995, there were no significant genotype or location × genotype interaction effects on numbers of adults of *F. fusca* or on numbers of larvae of *Frankliniella* spp. for any sample date. Across both locations, there were no significant differences in numbers of thrips (data not shown). In 1996, there were no significant location × genotype interaction effects on numbers of adults of *F. fusca* or on numbers of larvae for any sample date. Data were pooled from the two locations for analysis. Across both locations, there were no genotype effects on numbers of adults of *F. fusca* for any sample date (data not shown). Genotype effects on numbers of larvae of *Frankliniella* spp. were significant only for the third and fourth sample dates. On neither sample date, however, did any genotype have fewer thrips than Florunner (data not shown). Adults of *F. occidentalis* were found in all tests. However, numbers were consistently low on all genotypes, and no differences among genotypes occurred.

Discussion

Epidemics of spotted wilt were suppressed in advanced breeding lines F 79/4 and F 84/23, and peanut cultivar Southern Runner when compared to Florunner, a standard susceptible runner type. These results corroborate previous reports on the partial resistance of Southern Runner (3,6,7,8,9) compared to Florunner. Differences in disease incidence and intensity ratings for F 79/4 and F 84/23 relative to Florunner were consistent in tests in which moderate to heavy epidemics developed. In three of the four tests, F 79/4 and F 84/23 also had pod yields greater than those of Florunner. Because of possible inherent differences in yield among genotypes, it was not possible to discern in this study what portion of the differences in yield was due to differences in levels of spotted wilt incidence or intensity. Currently, the yield potential of these breeding lines compared to Florunner in the absence of spotted wilt is not known. These results do indicate, however, that use of either of these two breeding lines would reduce the risk of losses in yield to spotted wilt as compared to Florunner. The effects of these two breeding lines on yield relative to that of Southern Runner may have been confounded by

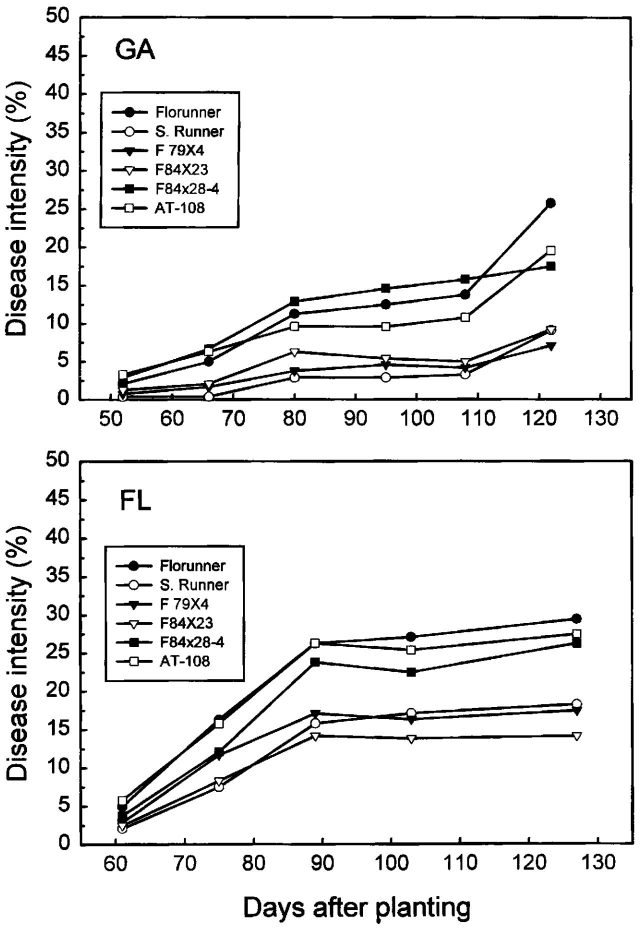

Fig. 2. Effect of peanut genotype on progress of intensity (percentage row length severely affected) of spotted wilt caused by tomato spotted wilt tospovirus in Georgia and Florida in 1996.

poor plant stands in Southern Runner plots in 1996. Effects of the two F 84/28 lines on final disease intensity ratings were not consistent relative to the other genotypes. Results from 1996 indicated that AT-108 did not differ in disease reaction from Florunner.

Based on these findings, a moderate level of partial resistance to TSWV is available in a virginia-type breeding line. In addition, field performance of F 79/4 provides circumstantial evidence that partial resistance to TSWV is not restricted to small-seeded genotypes.

Neither F 79/4 nor F 84/23 is highly resistant to infection by TSWV, as indicated by disease development in both for all four tests. This is similar to previous findings with Southern Runner and other cultivars and breeding lines from the breeding programs in Georgia and Florida (6,7,8,9). The mechanisms responsible for differences in disease incidence or disease intensity ratings among the peanut cultivars and breeding lines have not been characterized. As with previous reports, differences in disease incidence or intensity ratings among cultivars and breeding lines in this study could not be attributed to differences in numbers of adult thrips or larvae (6,7,8,9).

Our results indicate that F 79/4 and F 84/23 represent potential tools for management of spotted wilt in production areas of the southeastern U.S. In these tests, efforts were taken to maximize potential for development of spotted wilt epidemics. In addition, F 84/28-5 also may have potential for management of spotted wilt, but this study provided results from only one year on this line. F 84/28-4 did not have suppressive effects on spotted wilt epidemics that were observed with F 84/28-5.

The effects of these breeding lines on spotted wilt epidemics may be of even greater practical importance when integrated with management factors (4) that may help suppress epidemics of spotted wilt. If agronomic characteristics are acceptable, F 79/4 could be especially important for those who grow virginia-type peanuts in areas at risk for spotted wilt . Epidemics of spotted wilt have been reported elsewhere to be suppressed in virginia-type cultivar NC-V11 in comparison to Florunner in two of four tests (9). However, the effects of F 79/4 relative to Florunner were more consistent than those of NC-V11, particularly in tests in which spotted wilt epidemics were severe. Time to maturity for F 79/4 may limit its use to the more southern portions of the U.S. production area.

Both F 79/4, and F 84/23 may provide moderate levels of partial resistance to important fungal pathogens of peanut as well (11; F.M. Shokes and D.W. Gorbet, unpub. data, 1997). Multiple pathogen resistance in a cultivar would be very beneficial, possibly reducing the cost of production associated with fungicide usage and minimizing the risk of yield losses to spotted wilt. Minimized disease losses and increased economic efficiency of disease control inputs may be essential if peanut producers in the U.S. are to remain competitive as suppliers for domestic peanut consumption and become more competitive in export markets.

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Literature Cited

1. Black, M. C., T. D. Andrews, and O.D. Smith. 1993. Interplot interference in field experiments with spotted wilt disease of peanut. Proc. Amer. Peanut Res. Educ. Soc. 25:65 (abstr.).
2. Black, M. C., P. F. Lummus, D. H. Smith, and J. W. Demski. 1986. An epidemic of spotted wilt disease in south Texas peanuts in 1985. Proc. Amer. Peanut Res. Educ. Soc. 18:66 (abstr.).
3. Black, M. C., and D. H. Smith. 1987. Spotted wilt and rust reactions in south Texas among selected peanut genotypes. Proc. Amer. Peanut Res. Educ. Soc. 19:31 (abstr.).
4. Brown, S. L., J. W. Todd, and A. K. Culbreath. 1996. Effect of selected cultural practices on tomato spotted wilt virus and populations of thrips vectors in peanuts. Acta Hort. 431:491-498.
5. Chamberlin, J. R., J. W. Todd, R. J. Beshear, A. K. Culbreath, A. K., and J. W. Demski. 1992. Overwintering hosts and wingform of thrips, *Frankliniella* spp., in Georgia (Thysanoptera: Thripidae): Implications for management of spotted wilt disease. Environ. Ent. 21:121-128.
6. Culbreath, A. K., J. W. Todd, W. D. Branch, S. L. Brown, J. W.

Demski, and J. Beasley. 1994. Effect of new peanut cultivar Georgia Browne on epidemics of spotted wilt. Plant Dis. 78:1185-1189.
7. Culbreath, A. K., J. W. Todd, J. W. Demski, and J. R. Chamberlin. 1992. Disease progress of spotted wilt in peanut cultivars Florunner and Southern Runner. Phytopathology 82:766-771.
8. Culbreath, A. K., J. W. Todd, D. W. Gorbet, W. D. Branch, R. K. Sprenkel, M. Shokes, and J. W. Demski. 1996. Disease progress of tomato spotted wilt virus in selected peanut cultivars and advanced breeding lines. Plant Dis. 80:70-73.
9. Culbreath, A. K., J. W. Todd, D. W. Gorbet, F. M. Shokes, and H. R. Pappu. 1997. Field response of new peanut cultivar UF 91108 to tomato spotted wilt virus. Plant Dis. 81:1410-1415.
10. Gorbet, D. W., and F. M. Shokes. 1994. Plant spacing and tomato spotted wilt virus. Proc. Amer. Peanut Res. Educ. Soc. 26:50 (abstr.).
11. Gorbet, D. W., and F. M. Shokes. 1995. Evaluation of groundnut with multiple pest resistance. Europ. J. Plant Path. XIII Int. Plant Protec. Congr. 8:1013 (abstr.).
12. Hagan, A. K., J. R. Weeks, J. C. French, R. T. Gudauskas, J. M. Mullen, W. S. Gazaway, and R. Shelby. 1990. Tomato spotted wilt virus in peanut in Alabama. Plant Dis. 74:615.
13. Hagan, A. K., J. R. Weeks, R. T. Gudauskas, and J. C. French. 1991. Development of control recommendations for TSWV in peanut in Alabama. Proc. Amer. Peanut Res. Educ. Soc. 23:52 (abstr.).
14. Mitchell, F. L., J. W. Smith, Jr., C. R. Crumley, and J. W. Stewart, 1991. Management of tomato spotted wilt virus in South Texas peanut fields. Proc. Amer. Peanut Res. Educ. Soc. 23:76 (abstr.).
15. Rodriguez-Kabana, R., P. A. Backman, and J. C. Williams. 1975. Determination of yield losses to *Sclerotium rolfsii* in peanut fields. Plant Dis. Rep. 59:855-858.
16. Steel, R. G. D., and J. D. Torrie. 1960. Principles of Statistics. McGraw-Hill Book Co., New York.
17. Todd, J. W., A. K. Culbreath, and S. L. Brown. 1996. Dynamics of vector populations and progress of spotted wilt disease relative to insecticide use in peanuts. Acta Hort. 431:483-490.
18. Todd, J. W., A. K. Culbreath, J. R. Chamberlin, R. J. Beshear, and B. G. Mullinix. 1995. Colonization and population dynamics of thrips in peanuts in the southern United States, pp. 453-460. *In* B. L. Parker, M. Skinner, and T. Lewis (eds) Thrips Biology and Management. Plenum Press, New York.
19. Williams, E. J., and S. Drexler. 1981. A non-destructive method of determining peanut pod maturity. Peanut Sci. 8:134-141.

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