

# Disease Progress of Tomato Spotted Wilt Virus in Selected Peanut Cultivars and Advanced Breeding Lines

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## ABSTRACT

Culbreath, A. K., Todd, J. W., Gorbet, D. W., Branch, W. D., Sprenkel, R. K., Shokes, F. M., and Demski, J. W. 1996. Disease progress of tomato spotted wilt virus in selected peanut cultivars and advanced breeding lines. *Plant Dis.* 80:70-73.

Epidemics of spotted wilt, caused by tomato spotted wilt tospovirus, were monitored in field plots of advanced breeding lines of peanut (*Arachis hypogaea*) GA T-2846, F 84X9B-1-1-1-b3-B, and F 84X1A-7-2-1-1-b2-B, and in runner-type peanut cultivars Georgia Browne, Southern Runner, and Florunner in one location in 1993 and in three locations in 1994. Across all tests, final incidence of spotted wilt and standardized areas under the disease progress curves were lower in the three breeding lines, Georgia Browne, and Southern Runner compared to standard runner-type cultivar Florunner. With some exceptions, numbers of tobacco thrips (*Frankliniella fusca*), western flower thrips (*F. occidentalis*), and larvae of *Frankliniella* spp. were similar for all peanut cultivars and breeding lines. There was no evidence that differences in disease progress among the six entries were due to differences in preference by thrips or to suitability for thrips reproduction. Results indicate that all three advanced breeding lines evaluated in this study represent potential tools for management of spotted wilt in peanut production areas of the southeastern United States.

Additional keywords: disease resistance, epidemiology, groundnut, TSWV

Spotted wilt, caused by tomato spotted wilt tospovirus (TSWV), has been an erratic problem in peanut (*Arachis hypogaea* L.) and other important crops in the southern United States since 1985 (2,5,12,17). The disease is common across the peanut growing areas of Georgia, Florida, and Alabama, but typically has occurred at low to moderate levels. However, fields with incidence of symptomatic plants of over 60% have occasionally been observed. There are few effective tactics for management of spotted wilt in peanut (13,14,19), and none provide consistently high levels of control.

Although TSWV is vectored only by thrips, control of thrips with insecticides typically has not resulted in corresponding reduction in incidence of spotted wilt compared to nontreated plots (18,19). The sporadic occurrence of this disease from year to year and among fields, and the lack of control measures make it very desirable

to have cultivars with resistance or tolerance to TSWV. Peanut cultivars Southern Runner and Georgia Browne have provided consistent suppression of spotted wilt epidemics compared to the standard runner-type cultivar Florunner (3,6,8).

However, because of average kernel size that is smaller than that of other runner-type peanut cultivars and shelling and blanching characteristics that require segregation for processing, these cultivars currently are not widely accepted and are grown primarily with contract arrangements for specialty use. We need a cultivar with resistance to TSWV that also has agronomic characteristics that are acceptable for general use in runner-type peanut production areas.

Recently, three advanced peanut breeding lines (GA T-2846 from the University of Georgia breeding program, and F 84X9B-1-1-1-b3-B and F 84X1A-7-2-1-1-b2-B from the University of Florida breeding program) have shown potential for release as cultivars based on pod yield, grades, pod and seed kernel qualities, and other agronomic characteristics. These lines have been identified in preliminary field screening experiments as having lower incidences of spotted wilt than those of Florunner. The objectives of this study were to determine the effects of these ad-

vanced peanut breeding lines on apparent epidemics of spotted wilt and to characterize populations of tobacco thrips, *Frankliniella fusca* (Hinds), and western flower thrips, *F. occidentalis* (Pergande), 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 cultivars Georgia Browne, Southern Runner, and the susceptible cultivar, Florunner.

## MATERIALS AND METHODS

**Field plot designs.** One test was conducted at the University of Georgia Atapulgus Research Farm, Atapulgus (Decatur Co.) in 1993 and 1994 in different fields on the same farm. Soil type in both fields was Dothan loamy sand thermic Plinthic Kandiudult (pH 5.8). Randomized complete block designs with five and six replications were used in 1993 and 1994, respectively. Two other tests were conducted at Moultrie (Colquitt Co.), Georgia, and Marianna (Jackson Co.), Florida, in 1994. Randomized complete block experimental designs with six replications were used at Marianna and Moultrie. Soil types were a Dothan mix complex (pH 5.8) at Moultrie and Orangeburg loamy sand (pH 6.0) at Marianna. Naturally occurring thrips populations and resultant infections of TSWV were utilized in all tests.

Treatments in all tests consisted of advanced peanut breeding lines GA T-2846, F 84X9B-1-1-1-b3-B, and F 84X1A-7-2-1-1-b2-B and runner-type cultivars Georgia Browne, Southern Runner, and Florunner. Planting dates were 14 April 1993 and 19 April 1994 at Atapulgus, 13 May 1994 at Moultrie, and 22 April 1994 at Marianna. In 1993, seeding rate was 12.3 seeds per m of row. In 1994, all plant populations in all plots were thinned to one plant per 20 cm of row. Plant populations were lower than used for commercial peanut production to promote higher incidence of spotted wilt (11) and to facilitate observation of spotted wilt symptoms in individual plants. In 1993, plots were four rows, 3.6 m wide × 6.1 m long. In 1994, all plots were two rows, 1.8 m wide × 6.1 m long.

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In 1994, all plots at Attapulugus and Moultrie were bordered on both sides by susceptible cultivar Tamrun 88 to increase overall incidence of spotted wilt in all entries (1). Each plot at Marianna was bordered on one side by Tamrun 88. Plants in each plot were counted 19 days after planting (DAP) in 1993 and 22 DAP at Attapulugus, 18 DAP at Moultrie, and 19 DAP at Marianna in 1994.

All tests were maintained as recommended for commercial peanut production. Chlorothalonil (Bravo 720 or Evade 500) or tebuconazole (Folicur 3.6 F) was applied as a foliar spray at 7- to 14-day intervals for foliar and/or soilborne fungal disease control. All entries were dug the same date in 1993. In 1994, plants were dug and inverted at approximate optimum maturity for each cultivar based on the hull-scrape maturity index (20) or visual maturity estimates. Heavy rains after plants were inverted damaged the plants so severely at the Moultrie location that comparison of yields from that experiment was not possible. In all other tests, entire plots were harvested for yield estimates. Inverted plants were dried in the windrow for 3 to 7 days. Pods were harvested mechanically, and pod yields were determined for each plot.

**Disease incidence evaluation.** Plants in each plot were evaluated for symptoms of spotted wilt 55, 70, 83, 97, 111, 127, and 139 DAP in 1993 and 35, 43, 50, 57, 63, 70, 78, 84, 92, and 112 DAP in 1994 at Attapulugus. Plants were evaluated for symptoms of spotted wilt 38, 45, 53, 60, 67, 74, 81, 88, 95, and 109 DAP at Moultrie and 35, 51, 65, 79, 94, and 109 DAP at Marianna. On each evaluation date, all plants of each plot were examined individually for symptoms of spotted wilt.

Symptoms included concentric ring spots, "oak leaf" patterns of chlorosis, bronzing of leaves, stunting, and distortion and/or necrosis of leaves in the terminal bud. 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. Flags were placed immediately adjacent to the main stem of plants on which symptoms were found, regardless of where symptoms were found on the plant. 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.

Diagnosis was confirmed by taking one or two symptomatic leaves from one symptomatic plant from each plot for each evaluation date. Leaf samples were assayed in the laboratory for the presence of TSWV by enzyme-linked immunosorbent assay (ELISA) with commercially avail-

able antiserum to the common (L-strain) isolate of the virus (Agdia Inc., Elkhart, IN) as described by Culbreath et al. (8). Positive ELISA results were obtained from over 98% of samples assayed.

In all tests, disease progress curves were constructed for each entry by using disease incidence, which is the percentage (0 to 100) of plants in each plot with symptoms of spotted wilt. Asymptomatic infections of TSWV in peanut have been reported (7), but all discussion of incidence in this study refers only to symptomatic plants. Area under the disease progress curve (AUDPC) was calculated for each plot according to the method of Shaner and Finney (15), using time in days after planting and apparent disease incidence.

Standardized areas under the disease progress curves (SAUDPC) were calculated for the four experiments by dividing the AUDPC value for each plot by the total time (days) duration during which the epidemic was monitored (9).

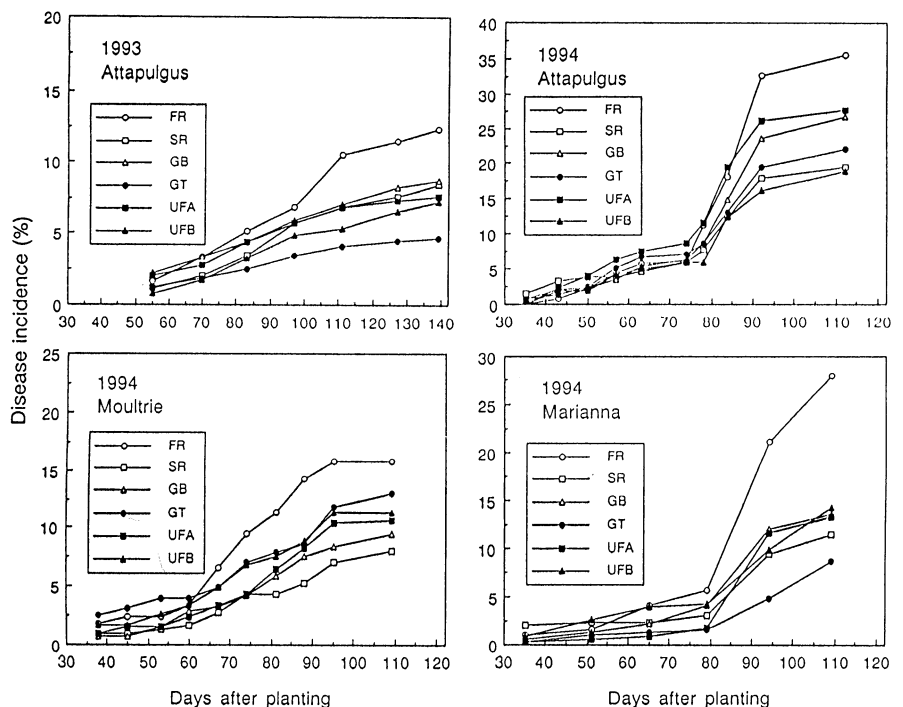
**Thrips sampling.** Samples of 10 terminal quadrifoliolate leaves per plot were collected on 27, 36, and 42 DAP in 1993 for comparison of populations of thrips among the entries. Numbers of thrips per 10 whole seedlings, 10 quadrifoliolate terminal leaves, and 10 open flowers were compared among the entries in all experiments in 1994. For evaluation of genotype effects on thrips populations, one sample of 10 whole plants was collected from each plot. Whole plant samples were collected from each plot 21 DAP at Attapulugus, 18 DAP at Moultrie, and 19 DAP at Marianna. Three subsequent samples of 10 partially unfolded quadrifoliolate terminal

leaves were collected from each plot 29, 36, and 42 DAP at Attapulugus; 25, 32, and 29 DAP at Moultrie; and 26, 33, and 39 DAP at Marianna. Ten flowers were collected from each plot 42, 49, and 56 DAP at Attapulugus; 39, 46, and 53 DAP at Moultrie; and 46, 53, and 60 DAP at Marianna. Whole plants, quadrifoliolate terminals, and flower samples were collected and processed as described by Chamberlin et al. (4). 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).

**Statistical analysis.** All data were subjected to analysis of variance across years and locations (16). Fisher's protected LSD values were calculated for comparison of genotypes (16). Differences referred to in the text are significant at  $P \leq 0.05$  unless otherwise indicated.

## RESULTS

Year and location effects were significant for final incidence of spotted wilt, and SAUDPC values. Differences among years and locations are illustrated by disease progress curves in Figure 1. There were no year or location  $\times$  genotype interaction effects ( $P > 0.10$ ) on final incidence of spotted wilt or SAUDPC values. Therefore, data from the four experiments were pooled prior to analysis, and pooled means



**Fig. 1.** Effect of peanut genotype on disease progress of spotted wilt caused by tomat spotted wilt tospovirus. FR = Florunner, SR = Southern Runner, GB = Georgia Browne, GT = GA T-2846, UFA = F 84X9B-1-1-1-b3-B, UFB = F 84X1A-7-2-1-1-1-b2-B.

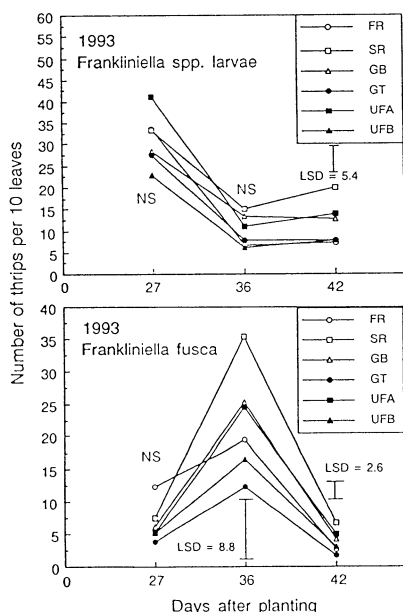
**Table 1.** Effect of peanut genotype on final incidence (FI) and standardized areas under the disease progress curves (SAUDPCs) of spotted wilt epidemics, and pod yields in experiments in Attapulgus (AT) and Moultrie (MO), Georgia, and Marianna (MA), Florida

Genotype	FI (% symptomatic plants)					SAUDPC <sup>a</sup>					Yield (kg/ha)		
	1993	1994	1994	1994	Avg. <sup>b</sup>	1993	1994	1994	1994	Avg. <sup>b</sup>	1993 <sup>c</sup>	1994 <sup>c</sup>	1994 <sup>c</sup>
	AT	AT	MO	MA		AT	AT	MO	MA		AT	AT	MA
Florunner	12.3	35.5	15.8	28.0	22.9	7.3	10.5	8.8	7.4	8.5	3,208	3,754	4,454
Southern Runner	8.4	19.5	8.0	11.4	11.8	5.0	7.2	3.8	3.9	5.0	4,582	3,198	5,069
Georgia Browne	8.7	26.7	9.5	13.6	14.5	5.3	8.5	4.7	4.3	5.8	4,181	2,575	4,289
GA T-2846	4.6	22.0	13.0	8.7	12.1	3.2	7.8	6.9	2.1	5.0	3,941	3,280	5,291
F 84X1A-7-2-1-1-1-b2-B	7.6	27.7	10.7	13.4	14.9	5.3	10.3	5.3	3.1	6.0	4,208	2,873	5,480
F 84X9B-1-1-1-b3-B	7.2	19.0	11.4	14.3	13.0	4.2	6.6	6.3	4.9	5.5	4,788	3,449	5,293
LSD ( $P = 0.05$ )					4.9					2.1	915	435	506

<sup>a</sup> Area under the disease progress curve (AUDPC) values were calculated using seven evaluations at Attapulgus in 1993, and 10 evaluations at Attapulgus, 11 evaluations at Moultrie, and eight evaluations at Marianna in 1994. For analysis across locations and years, AUDPC values were standardized by dividing AUDPC by the total time in days of the evaluation period. These times were 84 days at Attapulgus in 1993, and 77 days at Attapulgus, 71 days at Moultrie, and 74 days at Marianna in 1994.

<sup>b</sup> There were no significant ( $P > 0.05$ ) test  $\times$  genotype interaction effects on FI or SAUDPC. Therefore, avg. means were used for genotype comparisons.

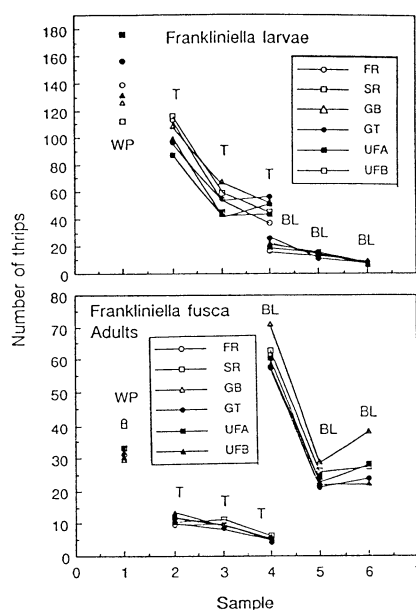
<sup>c</sup> There were significant ( $P \leq 0.05$ ) test  $\times$  genotype interaction effects on yield. Therefore, comparisons of genotypes were made for each test.



**Fig. 2.** Effect of peanut genotype on numbers of adults of *Frankliniella fusca* and larvae of *Frankliniella* spp. per 10 partially unfolded quadrifoliate leaves, Attapulgus, Georgia, 1993. NS indicates no significant ( $P > 0.05$ ) genotype effect according to analysis of variance. FR = Florunner, SR = Southern Runner, GB = Georgia Browne, GT = GA T-2846, UFA = F 84X9B-1-1-1-b3-B, UFB = F 84X1A-7-2-1-1-b2-B.

were used for genotype comparisons (Table 1). Across four experiments, final incidence of spotted wilt and SAUDPC values were higher in Florunner than in all other entries. Final incidence of spotted wilt and SAUDPC values were similar among the three breeding lines, Georgia Browne, and Southern Runner.

Cultivar effects on yield were not consistent across the three tests in which yields were evaluated (Table 1). Because of significant year and location  $\times$  genotype effects on yield, the experiments were analyzed independently. In 1993, all entries had yields higher than those of Florunner except GA T-2846, which also had yields



**Fig. 3.** Effect of peanut genotype on numbers of adults of *Frankliniella fusca* and larvae of *Frankliniella* spp. per 10 whole plant samples (WP), 10 partially unfolded quadrifoliate leaves (T) or 10 blooms (BL) in 1994. Each point represents the mean of three locations. There were no significant ( $P > 0.05$ ) genotype effects across or within locations for any sample according to analysis of variance. FR = Florunner, SR = Southern Runner, GB = Georgia Browne, GT = GA T-2846, UFA = F 84X9B-1-1-1-b3-B, UFB = F 84X1A-7-2-1-1-b2-B.

that did not differ significantly from the other advanced lines, Georgia Browne, or Southern Runner. At Attapulgus in 1994, yields of Florunner were higher than those of all other entries except F 84X9B-1-1-1-b3-B (Table 1). At Marianna, yields of all entries except Georgia Browne were higher than those of Florunner (Table 1). Pod yields did not differ among Southern Runner and the three advanced breeding lines.

Since sample number for thrips estimates differed for the 2 years, results from 1993 and 1994 were analyzed independ-

ently. In 1993, there were no significant genotype effects on numbers of adults of *F. fusca* for the 27-DAP sample dates, and no effects on larvae of *Frankliniella* spp. at the 27- or 36-DAP sample dates (Fig. 2). At 36 DAP, numbers of adults of *F. fusca* were higher in Southern Runner than in any other genotype (Fig. 2), but no other entry differed from Florunner. At 42 DAP, numbers of adults of *F. fusca* were higher on Southern Runner than on any entry except F 84X9B-1-1-1-b3-B (Fig. 2). No other entry differed from Florunner.

In 1993, numbers of larvae of *Frankliniella* spp. were higher on Southern Runner and F 84X9B-1-1-1-b3-B than on Florunner at 42 DAP (Fig. 2). Numbers of larvae on all other entries were similar to those on Florunner. Less than two adults of *F. occidentalis* per 10 leaves were found on all entries for the 27- and 42-DAP samples. Numbers of *F. occidentalis* ranged from 3.3 adults per 10 leaves on GA T-2846 to 6.1 adults per 10 leaves on Southern Runner at 36 DAP. There were no significant genotype effects on numbers of adults of *F. occidentalis* for any sample date.

In 1994, thrips population samples were compared across three locations. There were no location  $\times$  genotype interaction effects on numbers of adults of *F. fusca* or larvae of *Frankliniella* spp. Therefore, numbers of thrips presented in Figure 3 represent the average across three experiments. There were no significant ( $P > 0.05$ ) genotype effects on adults of *F. fusca* or larvae of *Frankliniella* spp. for any sample. *Frankliniella occidentalis* was found in all tests, but numbers of this species were very low (fewer than two adults per 10 leaves) and did not differ among genotypes (data not shown).

## DISCUSSION

The three advanced breeding lines and peanut cultivars Southern Runner and Georgia Browne had comparable effects on development of spotted wilt epidemics. In all of these entries, disease progress of

spotted wilt was suppressed compared to Florunner, the standard runner-type cultivar grown in the southeastern United States. These results corroborate previous reports on the relative effects of Southern Runner (3,6,8), Georgia Browne (6), and Florunner on epidemics of spotted wilt.

Results indicate that each of the three advanced lines evaluated in this study represents a potential tool for management of spotted wilt in peanut production areas of the southeastern United States. Also, results from this and previous studies (6) indicate that variation in effects on spotted wilt epidemics exists among advanced lines in current peanut breeding programs in Florida and Georgia.

GA T-2846 and Georgia Browne were developed from crosses between cultivars Southern Runner and Sunbelt Runner. Southern Runner consists of three sister lines derived by pedigree selection from crosses of PI 203396 and Florunner (10). F 84X9B-1-1-1-b3-B was developed from a cross between UF 81206-1 and F 72X32B-13-1-3-b2-B. F 84X1A-7-2-1-1-b2-B was developed from a cross between F 72X76-11-1-1-B and UF 81206-1. UF 81206-1 was developed from a cross of PI 203396 and F427B-3-1-7-4. With the exception of Florunner, all of the breeding lines or cultivars used in this study have PI 203396 in their respective pedigrees. This provides circumstantial evidence that PI 203396 may be a source of the genetic factors affecting the incidence of spotted wilt in Southern Runner, Georgia Browne, and these three advanced breeding lines.

The genotype, PI 203396, and progeny developed from crosses with it have been used extensively in peanut breeding programs in Georgia and Florida since well before the appearance of spotted wilt as a problem in peanut in the southeastern United States. This may be one explanation for the apparently serendipitous variation in field response to TSWV among current peanut cultivars and advanced breeding lines in these breeding programs. At this time, however, such an explanation is speculative. Regardless of the source of the variation, results from these tests offer further encouragement that there is potential for improved management of spotted wilt with cultivars released in the future. Furthermore, these results should prompt characterization of the susceptibility to TSWV of any potential peanut cultivar prior to its release.

Epidemic development in Georgia Browne, Southern Runner, and the three advanced lines indicates that none of these lines are highly resistant to infection. The mechanisms responsible for differences in incidence of spotted wilt among the peanut cultivars and breeding lines have not been characterized. Similarly, the incidence of asymptomatic infections with TSWV (7) in these breeding lines has not been evaluated.

Results from this study corroborate previous reports that differences among cultivars in incidence of spotted wilt could not be attributed to differences in attractiveness to thrips or suitability for thrips reproduction, as indicated by numbers of adult thrips and larvae, respectively (6,8). Similarly, population data on *F. fusca* and *F. occidentalis* provide no indication that lower incidences of spotted wilt in the breeding lines examined in this study compared with Florunner were due to differences in the component species of vectors present or to differences in populations of the two vectors among the entries.

In two of the three experiments in which yields were evaluated, lower incidence of spotted wilt in most of the breeding lines and cultivars coincided with higher yields in those entries than in Florunner. This is in contrast with results from the 1994 experiment at Attapulugus where yields of Florunner were higher than all other entries. Results from the test at Attapulugus in 1994 also contrast with previous reports in which yields of Southern Runner and Georgia Browne were higher than those of Florunner (6). With many genetic, cultural, and environmental interactions involved, the effects of spotted wilt on yield are difficult to evaluate. Likewise, the portion of any differences in yield among the entries that is due to differences in incidence of spotted wilt is virtually impossible to ascertain at this time.

Breeding line GA T-2846 has now been released as a new TSWV-resistant cultivar, Georgia Green. Several additional experiments indicate that its agronomic characteristics and yield potential should make it much more acceptable than either Southern Runner or Georgia Browne for wide-scale use in the runner-type peanut production regions of the United States. The availability of such a cultivar should be very important as a means to maintain sustainable peanut productivity as well as to reduce the risks to peanut production from severe epidemics of spotted wilt. This is particularly important since so few other options for management of this disease are available.

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