Disease Progress of Spotted Wilt in Peanut Cultivars Florunner and Southern Runner

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ABSTRACT

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Early season abundance of tobacco thrips (*Frankliniella fusca*) and incidence and disease progress of spotted wilt, caused by tomato spotted wilt virus (TSWV), were compared in Florunner and Southern Runner peanut (*Arachis hypogaea*) cultivars in field studies in 1989–1991. In replicated plot experiments and large field quadrat studies, populations of tobacco thrips adults and thrips larvae were similar for the two cultivars. In 1989 and 1991, cultivar, time, and cultivar × time interaction effects on incidence of spotted wilt were significant in all replicated plot studies except one. In all experiments, incidence of spotted wilt progressed linearly in both cultivars. Linear regression of disease incidence over time indicated disease incidence increased more rapidly in Florunner than in Southern Runner. Final incidence of spotted wilt was lower in Southern Runner than in Florunner in all but one experiment. Final apparent incidence of spotted wilt in Florunner was approximately twice as high as that in Southern Runner in tests in which average final incidence in Florunner ranged from 0.034 to 0.268.

Spotted wilt disease, caused by tomato spotted wilt virus (TSWV), is cosmopolitan in distribution (2) and causes major losses in yield in many vegetable, ornamental, and field crops, including peanut (*Arachis hypogaea* L.) (2–4,8,12,15,19). Recently, spotted wilt has become a problem in peanut-producing areas of the United States (3,4,13,14,22). Spotted wilt was first observed on peanut in Texas in 1972 (14). In 1985, 1986, and 1990, severe epidemics occurred in several peanut-producing counties there. In Georgia, prevalence and incidence of spotted wilt have increased greatly in peanut and other crops since 1986 (9–11). In 1989, plants showing symptoms of TSWV were found in almost every peanut field surveyed in Georgia (24).

The virus is vectored by seven species of thrips (25). The tobacco thrips, *Frankliniella fusca* (Hinds), and the western flower thrips, *Frankliniella occidentalis* (Pergande), are found in peanut in Georgia (1,18). Conventional insecticide applications for control of thrips in replicated small-plot experiments have been ineffective for control of spotted wilt in peanut in Georgia (J. W. Todd, *unpublished data*).

During the epidemics in Texas in 1985 and 1986, incidence of spotted wilt was lower in cultivar Southern Runner than in Florunner (5), which is the standard runner-type cultivar grown in most of the southeastern United States. Detailed quantitative descriptions of spotted wilt epidemics, however, have not been reported for either cultivar. Accurate data on virus epidemics in peanut are difficult to collect because of dense populations of plants within rows and the plant growth habit that promotes intertwining of branches of adjacent plants. The purposes of this study were to characterize temporal aspects of spotted wilt epidemics in Florunner and Southern Runner in the field and to determine the relative effects of these cultivars on apparent disease progress of spotted wilt.

MATERIALS AND METHODS

Replicated plot studies were conducted in 1989 and 1991 at The University of Georgia, Attapulgus Research Farm, Attapulgus, GA, in fields of Dothan loamy sand. In 1989, cultivar and insecticide effects on spotted wilt epidemics were evaluated. A split-plot experimental design with four replications was used. Whole plots were 15.2 m long and consisted of 24 rows of the cultivar Florunner or Southern Runner. Both cultivars were planted 13 April at a seeding rate of 112 kg/ha in rows 0.91 m apart. Subplots consisted of six rows treated with one of the following: application of aldicarb (Temik 15G, Rhone Poulenc Inc., Monmouth Junction, NJ), 1.12 kg a.i./ha in-furrow at planting; application of three sprays of acephate (Orthene 75 WP, Valent USA, Memphis, TN), 0.8 kg a.i./ha per application; aldicarb and acephate applications as described for individual treatments; and untreated control. Acephate sprays were applied with a tractor-mounted sprayer equipped with one TX8 hollow-cone nozzle per 0.5 m of boom on 0.9-m row spacing. Applications of acephate were made on 11 May, 29 May, and 13 June.

For evaluation of cultivar effects on thrips populations, five partially unfolded quadrifoliate terminals were collected from the center two rows of each subplot on 18 May and 29 May, and five blooms were collected from each subplot on 29 May. Leaf and bloom samples were collected and processed as described by Chamberlin et al (6). Immediately after removal from the plant, terminal leaf or bloom samples were placed in vials of 70% ethyl alcohol and refrigerated until thrips could be removed and counted in the lab. Adult thrips in each sample were sorted according to species and sex and were counted. Thrips larvae were counted without regard for species.

Numbers of plants showing symptoms of TSWV were determined at 14-day intervals after observation of first symptoms. Evaluation dates were 11 June, 25 June, 1 July, 15 July, and 1 August. Plants with symptoms on one leaf or more were designated symptomatic. To aid in subsequent evaluations, we marked the location of each symptomatic plant with a colored surveyors' flag. Flags were placed immediately adjacent to the main stem of plants on which symptoms were found, regardless of where symptoms occurred 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. Numbers and locations of symptomatic plants were recorded for each subplot. Stand counts were made on 24 August. Average number of plants per subplot was 1,110 for Florunner and 1,260 for Southern Runner.

In 1991, three randomized complete block experiments were conducted in another area of the same farm. All portions of the field used had been planted to corn (*Zea mays* L.) the previous 2 yr. In all three experiments, treatments consisted of Florunner and Southern Runner cultivars and were replicated four times. The experiments differed only in planting dates, which were 13 April, 14 May, and 5 June for the three tests. Seeding rate in all cases was 112 kg/ha for both cultivars. Plots were 15.2 m long and consisted of six rows at 0.91 m spacing. No insecticides were applied for thrips control. Stand counts were made for the center two rows of each plot on 8 May, 30 May, and 25 June in the respective tests, and average number of plants in the center two rows of each plot was 380, 418, and 352 for Florunner and 382, 380, and 318 for Southern Runner for the respective planting dates. Quadrifoliate terminal leaves and blooms were collected from the center two rows of each plot for thrips counts. Terminals were collected on 6 May and 13 May, 11 June and 18 June, and 2 July and 9 July in the tests planted in April, May, and June, respectively. Bloom samples were collected on 13 May, 18 June, and 9 July in the respective tests. Collection and counting of thrips were done as described previously.

The center two rows of each plot were used for incidence determination. Symptomatic plants were marked and counted as described previously. Evaluation dates were 28 May, 4 June, 26 June, 2 July, 6 August, and 13 August for the April planting date test; 2 July, 16 July, 1 August, 6 August, 28 August, and 3 September for the May planting date test; and 23 July, 1 August, 13 August, 20 August, 3 September, and 10 September for the June planting date test.

In 1989 and 1991 tests, disease incidence was calculated as the proportion (0–1.0) of the plant population showing symptoms of TSWV. Disease progress was plotted over time. Analysis of variance (23) was used for analysis of initial and final incidences of spotted wilt and numbers of thrips. Fisher's protected least significant differences were calculated for comparisons of treatment means of those variables. Repeated measures analysis of variance (17,23) was used to examine the effects of cultivar × time interactions on disease incidence.

Large field quadrat studies were conducted in three areas of the Attapulgus Research Farm in 1989 and 1990. Soil type in all three fields was Dothan loamy sand. In 1989, one of two contiguous areas 43.9 m wide and 152.4 m long was planted to Florunner and the other was planted to Southern Runner on 13 April at the same seeding rate as described previously. Each of these areas was divided into 240 contiguous quadrats (1.8 m wide × 7.6 m long) representing 20 tiers of 12 quadrats. No insecticide for thrips control was applied to plants or soil in either of these areas. Both areas had similar cropping histories, and neither had been planted to peanut in recent years. Stand counts were made in 10 3.1-m sample areas of each cultivar on 24 August. Average number of plants per quadrat was 185 for Florunner and 210 for Southern Runner.

In 1990, large area quadrat studies were repeated in two areas of the same farm with Florunner and Southern Runner. The same plot design and cultivars were used as in 1989. Planting date was 13 April for both fields. One field received no insecticide applications for thrips control, whereas the other received aldicarb (1.12 kg a.i./ha in-furrow at planting) and five foliar sprays of acephate (0.8 kg a.i./ha per application). Foliar applications were made at weekly intervals after initial application on 21 April. For each cultivar in each field, 25 quadrats were chosen at random and were demarcated as permanent sample areas (1.7 m wide × 7.6 m long). Stand counts were made in each of the sample areas on 9 May. Average numbers of plants per quadrat were 105 for Florunner and 69 for Southern Runner in the untreated field, and 116 for Florunner and 92 for Southern Runner in the field treated with insecticides. Five terminals were collected from each sample area on 15 May and 22 May, and five blooms were collected from each sample area on 22 May for comparison of thrips populations. Samples were collected, processed, and counted as described previously.

In 1989 and 1990, symptomatic plants were marked with colored surveyors' flags as described previously. Disease incidence was determined in all quadrats of both cultivars in the untreated fields in both years and in the 25 sample areas of each cultivar in the field treated with insecticides in 1990. Numbers and locations of symptomatic plants were recorded, and incidence was calculated as previously described. Incidence was evaluated in both cultivars on 11 June, 25 June, 1 July, 15 July, and 1 August in 1989. In 1990, evaluation dates in untreated and treated fields were 30 May, 12 June, 26 June, 10 July, and 25 July.

In the large field quadrat tests, effects of cultivar on adult tobacco thrips and immature thrips populations and initial and final incidence of spotted wilt were evaluated by use of Student's t test for comparison of two means from independent populations with unequal variances (7). For these comparisons, each quadrat represented an experimental unit in untreated fields in both years. In the insecticide-treated field, 24 quadrats per cultivar were used for the comparisons.

Except for insecticide treatments, plants in all experiments were maintained as recommended for peanut production in Georgia (16). Chlorothalonil was applied eight times at 14-day intervals for control of foliar fungal diseases. In all experiments, first application was made approximately 30 days after planting. Calcium sulfate was applied as gypsum (560 kg/ha) on a broadcast basis approximately 60 days after planting in all experiments.

In all experiments, linear regression of disease incidence on time in days after planting was used to describe disease progress in each cultivar. Rate parameters for the two cultivars were compared; F tests were used for comparison of the combined within cultivar mean squares vs. the pooled mean squares across cultivars (20).

In each test, symptomatic leaf tissue (one symptomatic quadrifoliate leaf) was taken from symptomatic plants and assayed for the presence of TSWV by use of enzyme-linked immunosorbent assay (ELISA) with polyclonal antiserum, prepared by Sreenivasilou et al, to an isolate of the common or "L" strain

TABLE 1. Effect of Florunner and Southern Runner peanut cultivars on thrips populations and incidence of spotted wilt in Attapulgus, GA, 1989

	Number of thrips[a]						Disease incidence[b]	
	Terminals (A)		Terminals (B)		Blooms			
	Adults[c]	Larvae[d]	Adults	Larvae	Adults	Larvae	11 June	1 August
Florunner	3.5	15	3.0	5.8	14.3	3.3	0.003	0.036
Southern Runner	4.3	22	5.8	7.5	14.3	2.3	0.002	0.019
LSD ($P \leq 0.05$)	NS[e]	NS	NS	NS	NS	NS	NS	0.008

[a] Comparisons of numbers of thrips were made only for untreated plots. Sample dates were 11 May for terminals (A) and 29 May for terminals (B) and bloom samples.
[b] Cultivar comparisons were made across insecticide treatments.
[c] Mean number of adult *Frankliniella fusca* per five terminals or blooms per plot.
[d] Mean number of thrips larvae per five terminals or blooms per plot.
[e] Indicates that cultivar effects were not significant ($P > 0.05$) according to analysis of variance.

of TSWV from peanut (21), which had been shown to react with isolates of TSWV typically encountered in peanut in Georgia. Assays were made with double antibody sandwich ELISA techniques. In both experiments conducted in 1989, all symptomatic plants were assayed for TSWV. Only plants for which diagnosis was confirmed by ELISA were used for calculation of disease incidence. In 1990 and 1991, symptomatic leaf tissue was taken from every tenth symptomatic plant within a row, beginning at a randomly chosen number of symptomatic plants from the end of each row.

RESULTS

First symptoms of TSWV typically were observed 30–45 days after planting in all tests and years. In all years, more than 95% of plants identified as symptomatic by visual diagnosis gave positive results in tests for TSWV with ELISA.

In the insecticide experiment in 1989, there were significant insecticide effects on thrips populations. For the purpose of cultivar comparison, however, only numbers of thrips from untreated plots are reported in Table 1. Numbers of adult tobacco thrips and thrips larvae were not affected by cultivar (Table 1). Adult western flower thrips were observed in both cultivars but at levels too low for comparison. There were no significant insecticide or cultivar × insecticide effects on early or final incidence of spotted wilt; therefore, cultivar evaluations were made across all insecticide treatments. Final cumulative incidence of spotted wilt ranged from 0.015 to 0.044 among plots of Florunner and from 0.004 to 0.029 among plots of Southern Runner. Final incidence was higher ($P \leq 0.05$) in Florunner than in Southern Runner (Table 1). Average final incidence in Southern Runner was approximately half that in Florunner. Incidence of spotted wilt increased linearly in both cultivars (Fig. 1). Rate of disease progress was higher in Florunner than in Southern Runner ($F = 29$, df 1,156; $P \leq 0.01$) (Fig. 1).

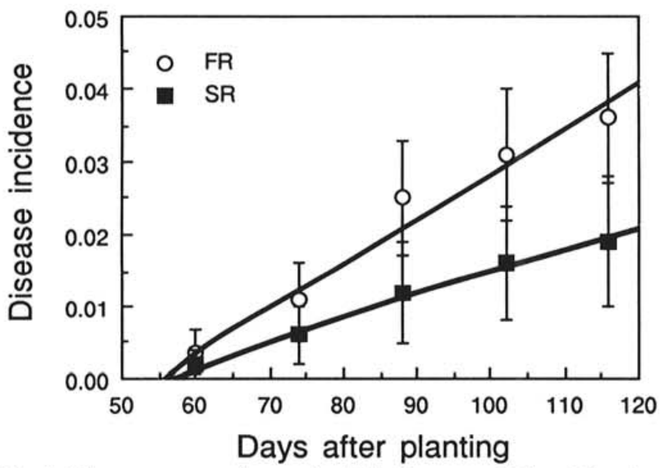

Fig. 1. Disease progress of spotted wilt in Florunner (FR) and Southern Runner (SR) peanut cultivars in replicated plot studies in 1989. Each value is the mean of four replications. Error bars give the standard deviations of the means. Increase in disease incidence (Y) over time in days (t) after planting was described by the linear equations: $Y = 0.0417 + 0.0061t$, $R^2 = 0.73$ in Florunner; and $Y = -0.0181 + 0.0031t$, $R^2 = 0.47$ in Southern Runner.

In 1991, there were no consistent significant cultivar effects on thrips populations (Table 2). In the earliest planted test, numbers of thrips larvae in the second terminal sample were higher for Southern Runner than for Florunner. Numbers of adult *F. fusca* in the blooms were higher for Florunner than for Southern Runner. In the latest planted test, numbers of thrips larvae were higher for Southern Runner in the first terminal samples. Numbers of adult *F. fusca* in the second terminal sample were higher in Florunner. For all other cases, numbers of adult tobacco thrips and thrips larvae were similar on the two cultivars (Table 2). Adult western flower thrips were observed on both cultivars but at levels too low for comparison.

Cultivar × time interaction effects on incidence of spotted wilt and cultivar effects on final incidence were significant in the two later planted tests. Final incidence of spotted wilt was higher in Florunner than in Southern Runner in the tests planted in May and June (Table 2). In the earliest planted test, final incidence followed a similar trend, although the difference was not significant. Incidence of spotted wilt increased linearly in all three experiments (Fig. 2). Rate of disease progress was greater in Florunner than in Southern Runner in all cases (April planting date, $F = 15.2$, df 1,44; May planting date, $F = 14.1$, df 1,44; and June planting date, $F = 12.6$, df 1,44, $P \leq 0.01$) (Fig. 2).

In both large field quadrat experiments in 1990, numbers of adult tobacco thrips and thrips larvae were similar for the two cultivars (Table 3). Adult western flower thrips were observed on both cultivars but in very low numbers. In all cases, final incidence of spotted wilt was lower in Southern Runner than in Florunner (Table 3). Differences between the two cultivars were evident throughout much of the epidemic (Fig. 3). In 1989, final incidence ranged from 0 to 0.200 in plots of Florunner compared to 0 to 0.078 in plots of Southern Runner. Disease incidence in both cultivars increased linearly with time (Fig. 3). Increase in disease incidence was more rapid in Florunner than in Southern Runner ($F = 164$, df 1,2298; $P \leq 0.01$) (Fig. 3).

TABLE 2. Effects of peanut cultivar on thrips populations incidence of spotted wilt in Attapulgus, GA, 1991

	Number of thrips[a]							
	Terminals (A)		Terminals (B)		Blooms		Initial disease incidence[b]	Final disease incidence[c]
Planting	Adults	Immatures	Adults	Immatures	Adults	Immatures		
Field A[d]								
Florunner	4.3	31	4.5	10	43	9	0.019	0.079
Southern Runner	6.5	57	4.0	21	26	17	0.007	0.041
LSD ($P \leq 0.05$)	NS[e]	NS	NS	7	4	NS	NS	NS
Field B								
Florunner	1.0	2.5	1.3	8.8	65	1.8	0.006	0.041
Southern Runner	3.3	4.8	2.5	7.0	67	2.5	0.004	0.020
LSD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS	NS	0.018
Field C								
Florunner	1.5	10	13	15	15	3.3	0.014	0.101
Southern Runner	3.0	29	8	18	18	3.0	0.007	0.050
LSD ($P \leq 0.05$)	NS	11	2	NS	NS	NS	NS	0.042

[a] Sample dates were 6 May for terminals (A) and 13 May for terminals (B) and blooms in field A; 11 June for terminals (A) and 18 June for terminals (B) and blooms in field B; and 2 July for terminals (A) and 9 July for terminals (B) and blooms in field C.
[b] Evaluation dates were field A, 28 May; field B, 2 July; and field C, 23 July.
[c] Cumulative incidence as of final evaluation dates of field A, 13 August; field B, 3 Sept.; and field C, 10 Sept.
[d] Planting dates were field A, 13 April; field B, 14 May; and field C, 5 June.
[e] Indicates that cultivar effects were not significant ($P > 0.05$) according to analysis of variance.

In 1990, incidence of spotted wilt was much higher in the respective cultivars than incidence in 1989 (Fig. 3). Average final incidence in Florunner was greater than 0.250 and ranged from 0.047 to 0.510 compared to a range of 0–0.246 among quadrats of Southern Runner. Differences in final incidence between cultivars were greater numerically in 1990 than in 1989, but differences were similar proportionally for the 2 yr. Final incidence in Florunner was higher than that of Southern Runner in untreated and insecticide-treated fields (Table 3). Disease progressed linearly in all cases, and disease incidence increased more slowly in Southern Runner than in Florunner in both fields (untreated field: $F = 110$, df 1,2298; treated field: $F = 32$, df 1,246; $P \leq 0.01$) (Fig. 3).

DISCUSSION

Experiments conducted with replicated plot designs or large adjacent areas of contiguous plots of the two cultivars indicate that epidemics of TSWV progressed linearly in Florunner and Southern Runner. Apparent incidence of TSWV increased more slowly and to a lower final incidence in Southern Runner. Also, maximum incidence observed in the two cultivars provides another indication that epidemics of TSWV are suppressed in Southern Runner in comparison to their development in Florunner. This study corroborates earlier observations by Black (5) that indicated lower final incidence of spotted wilt in Southern Runner than in Florunner. Our results indicate that this difference is apparent throughout much of the season. Differences in disease progress in Florunner and Southern Runner also were apparent in 3 yr of light and moderate infestations. Use of large fields of contiguous quadrats helped to ensure that epidemics observed in one cultivar were not affected by those in the other. Our results indicate, however, that relative effects of the two cultivars were similar in both replicated plot studies and large area studies in which entire plant populations were monitored.

Differences in incidence of spotted wilt do not appear to be attributable to differential preference of thrips vectors for one

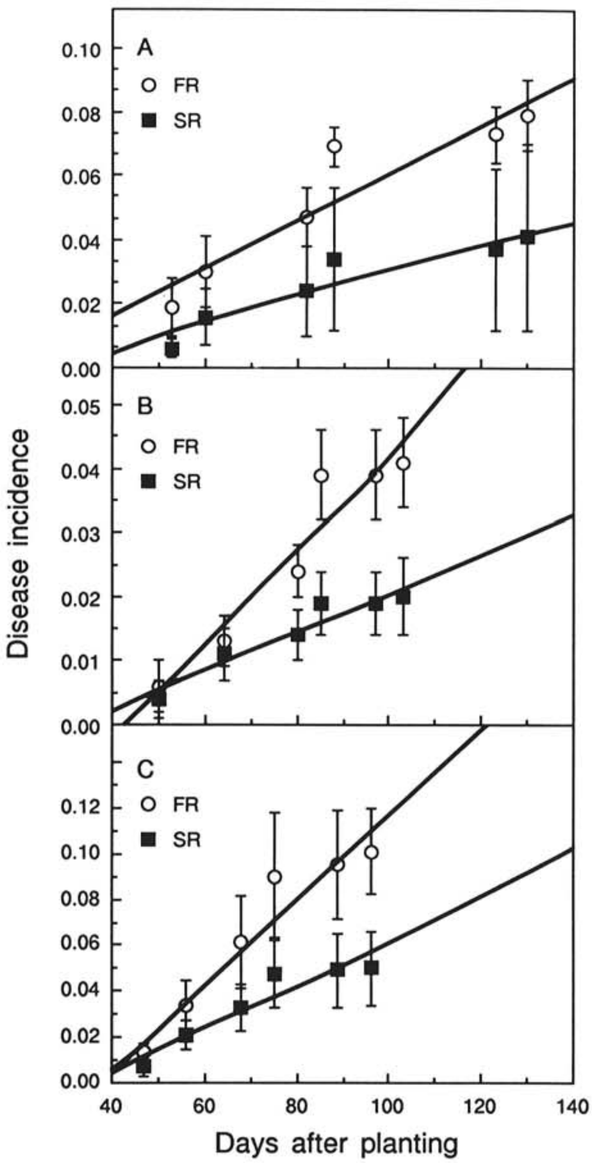

Fig. 2. Disease progress of spotted wilt in Florunner (FR) and Southern Runner (SR) peanut cultivars in replicated plot studies in 1991. Each value represents the mean of four replications. Error bars give the standard deviations of the means. Increase in disease incidence (Y) over time in days (t) after planting was described by the linear equations: **A,** $Y = -0.0121 + 0.0007t$, $R^2 = 0.77$ for Florunner and $Y = -0.0091 + 0.0004t$, $R^2 = 0.31$ for Southern Runner (planting date = 13 April); **B,** $Y = -0.0299 + 0.0007t$, $R^2 = 0.81$ for Florunner and $Y = -0.0010 + 0.0003t$, $R^2 = 0.65$ for Southern Runner (planting date = 14 May); **C,** $Y = -0.0649 + 0.0018t$, $R^2 = 0.74$ for Florunner and $Y = -0.0284 + 0.0009t$, $R^2 = 0.62$ for Southern Runner (planting date = 5 June).

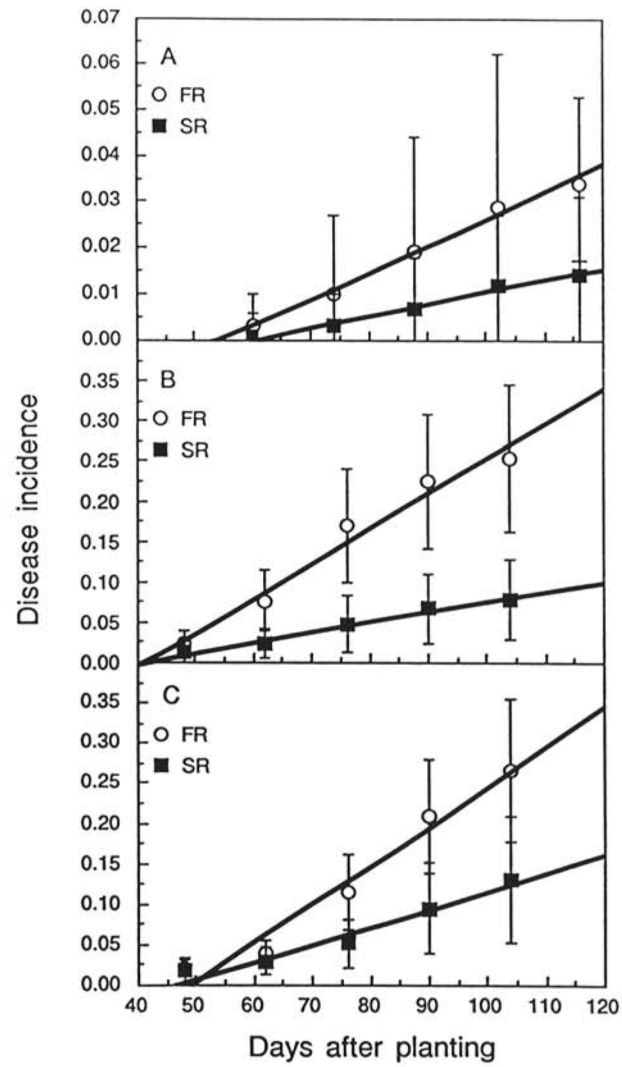

Fig. 3. Disease progress of spotted wilt in Florunner (FR) and Southern Runner (SR) peanut cultivars in large field quadrat studies in 1989 and 1990. Each value is the mean of 240 quadrats in **A,** untreated field, 1989, and **B,** untreated field, 1990, and 25 quadrats in **C,** insecticide-treated field, 1990. Error bars give the standard deviations of the means. Increase in disease incidence (Y) over time in days (t) after planting was described by the linear equations: A, $Y = -0.0311 + 0.0006t$, $R^2 = 0.16$ for Florunner and $Y = -0.0142 + 0.0002t$, $R^2 = 0.14$ for Southern Runner; B, $Y = -0.1792 + 0.0043t$, $R^2 = 0.61$ for Florunner and $Y = -0.0480 + 0.0012t$, $R^2 = 0.33$ for Southern Runner; C, $Y = -0.2295 + 0.0047t$, $R^2 = 0.72$ for Florunner and $Y = -0.0937 + 0.0021t$, $R^2 = 0.43$ for Southern Runner.

cultivar over another or to cultivar effects on thrips reproduction, as indicated by similar numbers of tobacco thrips adults and thrips larvae, respectively, in the two cultivars. Southern Runner is as suitable and apparently as attractive for feeding and reproduction by *F. fusca* and *F. occidentalis* as Florunner (J. W. Todd, *unpublished data*), but physical or physiological factors in Southern Runner may affect inoculation frequency and infection processes of the virus in the plant populations.

Mechanisms for lower rates of apparent disease progress of TSWV in Southern Runner than in Florunner were not addressed in this study. Comparative effects of these cultivars on the infection process and reproduction of the virus are not known. The apparent resistance in Southern Runner, evidenced by lower rates of apparent disease progress and final incidence, is not complete, as indicated by incidence of almost 0.25 in some quadrats of Southern Runner in 1990.

Because of the complex nature of host, virus, and vector relationships, conclusions about the biology of the system are difficult to make based on disease progress curves. For this study, the use of the linear model was for the description of the epidemics and estimation of quantitative parameters of the epidemics in the comparison of the cultivars. We did not draw biological conclusions from the use of this model, because we did not know if disease increase was attributable to secondary spread after initial infections or to a continual influx of primary inoculum from a source or sources, such as weeds or other crops from within or outside a given field. Increase in apparent disease incidence could have been attributable to infections from secondary inoculum or to variation in incubation and latent periods of the hosts after transmission of the virus by thrips. In India, incidence of spotted wilt in peanut is correlated with populations of thrips early in the cropping season (19). Studies to determine the relationship between thrips population dynamics and disease incidence dynamics in Florunner and Southern Runner and to investigate several potential sources of primary inoculum are in progress. Also, the role, if any, of secondary inoculum in TSWV epidemics has not been elucidated. Preliminary analysis of spatial patterns of TSWV incidence in the large field studies indicates a nonrandom or clustered dispersal pattern (10,11). Further analysis of the effect of the two cultivars on spatial patterns is in progress and should help to elucidate the mechanisms of increase in disease incidence over time.

Regardless of the mechanisms responsible for differences in apparent incidence, spotted wilt progressed more slowly and to a lower final apparent incidence in Southern Runner than in Florunner. The relative effects of Southern Runner on disease progress were consistent across 3 yr, in which a range of final incidences of spotted wilt was observed in both cultivars. Lower incidence of spotted wilt and slower disease progression in Southern Runner than in Florunner may be of great practical importance in peanut production areas of the United States, if spotted wilt epidemics become more intense and widespread. Because no other consistent and effective controls of spotted wilt in peanut are known, use of resistance in Southern Runner may have the most potential for limiting development of spotted wilt epidemics. Also, differences in the effects of these cultivars on spotted wilt epidemics illustrate that genetic variation in reaction to TSWV exists among available peanut lines and suggest that a source of resistance may exist in the parental lines of Southern Runner.

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TABLE 3. Effect of peanut cultivar on thrips population and early and final incidence of spotted wilt in large area quadrat studies in Attapulgus, GA, 1989 and 1990

	Number of thrips[a]							
	Terminals (A)		Terminals (B)		Blooms		Early disease incidence[b]	Final disease incidence[c]
Cultivar	Adults	Immatures	Adults	Immatures	Adults	Immatures		
1989								
Florunner	...	...	...	...	...	...	0.004(±0.008)	0.034(±0.036)
Southern Runner	...	...	...	...	...	...	0.002(±0.005)	0.015(±0.017)
Student's *t* test							3.5*[d]	7.5**
1990 Untreated field								
Florunner	6.5(±2.9)	76(±28)	2.2(±2.0)	51(±23)	32(±11)	5.9(±2.5)	0.024(±0.016)	0.253(±0.092)
Southern Runner	6.5(±3.3)	69(±41)	2.2(±1.8)	53(±27)	41(±11)	7.3(±3.8)	0.013(±0.013)	0.078(±0.049)
Student's *t* test	NS	NS	NS	NS	NS	NS	8.7**	26.0**
1990 Insecticide-treated field								
Florunner	2.9(±3.1)	1.0(±1.5)	1.9(±1.3)	2.4(±1.4)	10(±4.2)	5.2(±3.5)	0.021(±0.010)	0.268(±0.090)
Southern Runner	6.6(±3.7)	1.4(±1.4)	2.0(±1.0)	1.5(±1.4)	12(±4.2)	4.2(±2.9)	0.018(±0.016)	0.132(±0.080)
Student's *t* test	NS	NS	NS	NS	NS	NS	NS	5.63**

[a] Means (± standard deviation) of 25 sample plots for each cultivar. Sample dates were 15 May 1990 for terminals (A) and 22 May 1990 for terminals (B) and blooms.

[b] Incidence of spotted wilt was determined 11 June 1989 and 30 May 1990. Numbers are the means (± standard deviation) of 240 plots in 1989 and the untreated field in 1990, and the means of 25 plots in the insecticide-treated field in 1990.

[c] Final cumulative incidence determined 1 August 1989 and 25 July 1990.

[d] *, ** Indicate that means for the two cultivars are significantly different for $P \leq 0.05$ and $P \leq 0.01$, respectively, according to Student's *t* test. NS indicates difference was not significant ($P > 0.05$).

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