Spotted Wilt, Thrips vector efficiency & stress as related to runner peanut #118 Final 2004

Plant Pathology
NPB 04 Report, February 15, 2005

TITLE: Spotted Wilt Related to Runner Peanut Canopy Characteristics

PERSONNEL: : Mark C. Black, Noel N. Troxclair, Michael R. Baring, Texas Cooperative Extension, Uvalde and Texas Agricultural Experiment Station, College Station, Texas A&M University.

SUMMARY: We continued to gather evidence that peanut variety reactions to TSWV involve at least two mechanisms: a) reactions on the cellular or systemic level in the plant (2002 mechanical inoculation) and b) thrips behavior related to plant canopy characteristics (2003, 2004 canopy modification, vegetative plant mapping).

Four peanut varieties pruned to modify the canopy shape. Spotted wilt was moderate-to-severe in this 2004 test. Our working hypotheses were 1) 'tall' canopy would have more thrips (TSWV vectors) and more spotted wilt than 'check', and that 'short' would have fewest thrips and the least spotted wilt; 2) main terminals would have more thrips than side terminals; and 3) Tamrun 88 would have more thrips than other varieties. Data in 2004 supported in part hypotheses 2) and 3). Hypothesis #1 was supported in part by thrips data, but not disease data. These treatments would probably have had more pronounced effects if initiated 2-3 wk after planting instead of at 7 wk.

Variety vegetative plant mapping. Large plant size [height (main stem); width (secondary branches 1,2,3,4)] was always positively correlated with increased spotted wilt. All significant correlations of disease with tertiary branch lengths for S3, S4, and S5 were negative. Significant correlations were all negative between disease and length of branches that fill in the canopy between main stem and near-horizontal secondary branches (secondary branches 6 to 11). More growth in this 'middle' part of the canopy would result in less exposed main stems, supporting our hypothesis that non-prominent main stems reduce spotted wilt risk. Thirty-nine of 44 significant correlations between spotted wilt and calculated variables were positive, also supporting our hypothesis of large plants and prominent main stems compared to secondary stems 1 to 4 contributing to TSWV field susceptibility.

Regression analysis of stem with three spotted wilt ratings explained significant portions of total variation in spotted wilt disease. Six of nine significant models had positive terms for secondary stems (range: 1 to 4) lengths, and only one significant model had a negative effect for these secondary stems. For the last sampling date, models for all three disease ratings included a negative term for secondary stem 6 length.

We are gaining an understanding of plant types that are highly vulnerable during spotted wilt epidemics and this can be used to some extent in years with little spotted wilt pressure. However, we have not yet identified one or two easily measured traits in the seedling stage that breeders could use for early screening in the greenhouse or winter nursery. The traits related to spotted wilt variety ratings explored in this report do not fit the classical definition of disease resistance, although some entries do have partial true 'resistance' (2002 report). Rather, these canopy traits fall in the category of 'field resistance.' This type of 'field resistance' should be stable and additive with 'true resistance.'

INTRODUCTION:

Tomato spotted wilt virus (TSWV) suddenly became the biggest threat to peanut production in Southwest Texas in the early 1980s. A few years later this also happened in Central Texas, Alabama, Georgia and Florida. Every peanut producing state reported problems with spotted wilt by 1990 and problems still occur in Southwest Texas. Several growers had severe losses in late planted 2004 fields. State and USDA breeding programs in Texas, Georgia, Florida, North Carolina and one private company have developed and released cultivars that perform better than old standard varieties under TSWV pressure. Some cultivars that hold up well have been rapidly accepted in high risk growing areas and breeding work seeks to improve this resistance. The partial resistance appears to be stable but resistance mechanisms are not well understood. Some varieties have premature vine death following heat and drought with symptoms somewhat similar to late-season spotted wilt symptoms. New varieties for Texas should have both virus and stress resistance/tolerance. Variety development proceeds slowly with labor-intensive field selection for disease and stress resistance.

In our 2002 work, some level of 'true' resistance to *Tomato spotted wilt virus* (TSWV) was confirmed in growth chamber tests, in agreement with work done in Georgia. Inoculations of peanut seedlings with TSWV usually identified the most susceptible and most resistant entries, but usually did not rank intermediate varieties consistent with rankings from field data. Field observations and greenhouse work suggested that plant canopy shape may contribute to variety reaction during spotted wilt epidemics. Selecting breeding lines with certain canopy characteristics may be a useful trait for breeders to use when selecting early generation breeding lines for use in regions with spotted wilt and southern blight disease problems. Thrips behavior may be affected by plant canopy shape or other canopy characteristics. The benefits of twin-rows during spotted wilt epidemics may also be due in part to altered thrips behavior related to wider row canopy and less difference in canopy surface between main stems and row-middles.

Advantages of traditional plant breeding with field evaluation include increased probability of selecting stable multiple-component resistance and opportunities to select for resistance to multiple diseases, environmental stress, pod traits, and yield. Disadvantages of field evaluations for almost all breeding lines generations and the release of new varieties are the slow pace (8-10+ years), uncertainty of disease occurring in plots a given year, and the expense of multiple year field tests for large numbers of lines. Discovery of peanut plant traits in the seedling stage related to spotted wilt resistance would help us discard many susceptible lines earlier and save time and expenses in the field. Knowledge of TSWV resistance mechanisms will also provide a knowledge base for long term stable use of resistance mechanisms.

The objective was to identify peanut resistance/tolerance mechanisms to thrips-vectored TSWV that will predict field performance of varieties and breeding lines. Partial funding did not permit us to explore thrips vector efficiency or stress reactions in 2004.

MATERIALS and METHODS:

Four peanut varieties pruned to modify the canopy shape. This split-plot experiment with four replications was planted 20May04 at Phillips Farm in Frio County, TX. Main plot effect was canopy shape (check, tall, short); sub-plot effect was variety (Tamrun88, Tamrun96, ViruGard, GeorgiaGreen). Non-check plots were pruned 9Jul, 28Jul, and 27Aug based on ratio of average main stem height to half the average canopy width in check treatments, by variety, on each pruning date. Pruned canopy width by variety for the tall treatment was check ratio plus 0.2. Pruned canopy height by variety for the short treatment was check ratio minus 0.2. Spotted wilt disease was evaluated on 22Jul, 17Aug, 15Sep and 6Oct.

Thrips populations were estimated from terminal samples (main stem/top of canopy, secondary stem/side of canopy) collected at approximately the same times in the morning on 9Jul (before pruning) from all four varieties, and on 28Jul, 27Aug from only two varieties (Georgia Green, Tamrun88). Five terminals from the canopy peak (top) and five from the canopy side (widest point) were immediately placed in large vials of 70% ethanol. Thrips were decanted after agitation and concentrated with partial vacuum filtration onto grided filter paper for counting.

Variety vegetative plant mapping. Nine peanut varieties and two breeding lines (11 entries) were mapped for vegetative stem growth. The experimental design with two-row 15 ft plots was a randomized complete block with four replications. Plots were inverted 7Oct and threshed 13Oct (three of four replications) for yield and value estimates. Whole plants were destructively sampled on 29Jun, 28Jul, and 7Sep by removing a minimum of three plants in 1 row-ft from each of the two rows per plot (minimum six plants per plot). The resulting gaps were measured after each sampling date to estimate stand (plants per row ft). Total number plants sampled and all branch lengths on the six largest plants were recorded (primary, secondary, tertiary, quaternary, quinary). Spotted wilt was rated 22Jul, 17Aug, and 6Oct. Plot averages (six plants) for each stem and several other variables were calculated. Data were compared using analysis of variance (PC-SAS Proc ANOVA), Pearson correlation (Proc CORR), and stepwise regression (Proc REG; model selection also based on minimum C(p) statistic).

RESULTS AND DISCUSSION:

Four peanut varieties pruned to modify the canopy shape. Disease. Spotted wilt was moderate-to-high in this test in 2004. Only main plot and sub-plot averages are presented (Table 1) because interactions were not significant. Tamrun88, the susceptible check, had significantly more spotted wilt than other entries on all rating dates, as expected. Canopy treatment was similar on the first three dates and 'short' and 'check' treatments had significantly more spotted wilt than 'tall' treatment on the last date.

Thrips. Only main plot, sub-plot, and sample site averages are presented (Table 1) because only one significant interaction (not presented). There were significant differences among (first date) or between (second, third date) varieties for two of the three terminal sampling dates, among canopy treatments for two of three dates, and between terminal sample locations on two of three dates (Table 2). On 9Jul Virugard had significantly more male tobacco thrips than Georgia Green, Tamrun 88, and Tamrun 96. On 9Jul side terminals had significantly more male tobacco thrips and total tobacco thrips than main terminals. This terminal location effect early in the season (middles not completely lapped) may result from the putative preference of migrating insects for peanut terminals contrasted against bare soil.

On 28Jul 'tall' canopy treatment had significantly more male tobacco thrips and total thrips than 'short' or 'check' canopies. Prominent exposed main stems may have more thrips due to attraction or passive impact. On 27Aug Tamrun 88 had significantly more second stage larvae, all immature stages, and total thrips than did Georgia Green, consistent with final disease ratings (Table 1); 'check' and 'tall' canopies had significantly more second stage larvae than the 'short' treatment; and main terminals had significantly more total immatures and total thrips than side terminals (Table 2). Taller plants and upper terminals may have attracted or were impacted more often by thrips migrating late in the season.

The numbers of thrips collected by our technique were never high on the dates of sampling. Some of these data are consistent with our hypothesis of main stem (canopy) characteristics affecting spotted wilt disease. This is probably due to thrips behavior responses to developing canopy.

The test site was inaccessible during June04 due to farm road construction and several weeks of rain, delaying our imposing of canopy treatments compared to the 2003 test. These treatments would probably have had more pronounced effects if initiated 2-3 wk rather than 7 wk after planting.

Variety vegetative plant mapping. Spotted wilt was moderate-to-severe in this test, and variety rank on all three dates was about as we expected (Table 3). Yield and value/A estimates were high (Table 4) proably due to overcorrection for row length based on gaps after plant sampling, and because of compensation for light and moisture near gaps. A new measurement in '04 was plant size expressed as row-ft (distance down the row) covered by single plants (Table 3). The standout was Tamrun 88, which covered an average of 2.76 ft per plant. Once a viruliferous thrips inoculated a terminal anywhere on the plant and the infection quickly progressed to systemic, first stage larvae feeding on terminals up to 2.76 ft away would be acquiring TSWV. With several potential cycles of these events per season compared to other varieties, this may partly explain why Tamrun88 is highly susceptible.

Highly TSWV-susceptible varieties tended to have taller main stems early in the season (Table 5). However, TSWV-resistant ViruGard, the only virginia bunch plant type in the test, was also tall early. TSWV-susceptible varieties also had tall main stems at mid and late season. Similar trends were true for secondary stem 1 (Table 5) and secondary stem 2 (not shown).

Tamrun96, TamrunOL01, and TamrunOL02 generally had low total stem numbers (Table 5). This uncluttered zone at the crown may contribute to lower southern blight ratings in previous years and in other tests. Tamrun96, TamrunOL01, and TamrunOL02 ranked lowest for total stem length on 7Sep (Table 5) even though growers in Southwest Texas perceive these varieties as large, "stemmy," and tough to combine. Reduced branching contributed to low total stem lengths. The three Texas varieties ranked lower than Florunner on 7Sep for main stem and secondary stem 1 lengths, so Florunner stems must be considerably more flexible at digging. Stem strengths may help explain variety tolerance to various environmental stresses observed in previous years.

Numerous correlations of stem traits with all three spotted wilt disease ratings were significant (Table 6). The main branch lengths, [height (main stem) and width (secondary branches 1,2,3,4)] were always positively correlated with increased spotted wilt. Significant correlations of spotted wilt with higher order branches (tertiary, quaternary) were sometimes positive and sometimes negative. However, twenty-one significant correlations of disease with tertiary branch lengths for S3, S4, and S5 were all negative.

Significant correlations between disease and lengths of six adjacent secondary branches of the middle-canopy that fill in the canopy between main stem and near-horizontal secondary branches (Table 6, S6–S11) were all negative. More growth in this part of the canopy would result in less exposed main stems, supporting our hypothesis that non-prominent main stems reduce spotted wilt risk.

Thirty-nine of 44 significant correlations between spotted wilt and calculated variables (Table 6, rows TtStemL through RMSTS) were positive, supporting our hypothesis of higher risk of large plants and prominent main stems compared to secondary stems 1 to 4. Plant population (stand) correlations were significant only for the 22Jul disease ratings, indicating that vegetative compensation for slight differences in stand were more important early in the season (Table 6) before compensation occurred.

Regression of all variety stem characteristics and several calculated variables with spotted wilt ratings on three dates explained significant portions of total variation in spotted wilt disease (Table 7). Six of nine significant models had positive terms for secondary stem lengths 1 to 4, and only one significant model had a negative effect (last row). For the last sampling date, models for all three disease ratings included a negative term for secondary stem 6 length.

An unrelated production practice that modifies canopy shape in peanut fields also reduces spotted wilt, *i.e.*, twin vs. single rows. Main stems are less prominent, and bare soil is covered earlier in the season with twin rows. Fungicides with potential for plant growth regulating (PGR) effects should perhaps be tested for similar responses.

Vegetative plant mapping was very labor intensive and many additional statistical analyses could be done with these data. The 11 entries chosen for this test represent very diverse genetic backgrounds, and more consistent variables in regression equations would be expected for plant mapping of breeding lines from similar backgrounds.

Significant differences for spotted wilt reactions occur in almost all collections of peanut breeding lines. The exception has been with field tests of closely related sister lines (e.g. lines generated by repeated backcrosses to Tamrun 96).

There is apparently not one or two easily measured traits related to spotted wilt reaction in the seedling stage that breeders could use for early screening in the greenhouse or winter nursery. However, we are gaining an understanding of plant types that are highly vulnerable and this can be used in years with little spotted wilt pressure. Other possibilities we hope to explore in 2005 are non-destructive objective and subjective canopy shape/contour descriptors for use in the field, canopy density at junction with bare-soil (bare soil visible within the canopy perimeter), and leaf/canopy color.

The traits related to spotted wilt variety ratings explored in this report do not fit the classical definition of disease resistance, although some entries do have partial 'true resistance.' Rather, these canopy traits fall in the category of 'field resistance' (some varieties/breeding lines have less disease in the field than expected based on laboratory tests). Fortunately, this type of 'field resistance' should be stable, and even when epidemics occur, there should always be a similar rank of known susceptible and known resistant entries. The Georgia and Florida university breeding programs are clearly using different genetics in breeding for spotted wilt resistance, apparently relying more on 'true resistance' than the Texas program and a dense canopy. Genetics developed by Texas breeders appears to have other advantages including potential for tolerance/resistance to southern blight, Sclerotinia blight, and summer stress.

Therefore, field testing and screening breeding lines at locations with risk of spotted wilt should continue. Work will continue on defining traits for use in field selections when disease intensity if low or absent.

ACKNOWLEDGMENTS: Texas Peanut Producers Board provided partial funding through National Peanut Board funds. We thank Alfred Sanchez, James 'Bud' Davis, and Sindy Ortiz for technical assistance; Maggie Gunn for secretarial service; and Murray Phillips, Brad Easterling, and Jaime Lopez for support and help with the field plots.

Table 1. Spotted wilt in peanut plots pruned three times to modify the canopy shape at Phillips Farm, Frio County, TX, 2004.

	Spotted wilt, % row ft.			
Entry	**22Jul**	**17Aug**	**15Sep**	**6Oct**
Tamrun88	10.1 a[z]	35.3 a	51.8 a	78.9 a
Tamrun96	5.3 b	9.2 b	10.8 b	17.2 b
Ga.Green	2.0 b	6.0 b	11.8 b	21.1 b
ViruGard	4.7 b	7.5 b	12.3 b	15.1 b
Canopy				
Tall	4.7	12.5	19.6	27.2 b
Short	7.3	16.6	20.8	35.2 a
Check	4.5	14.3	24.7	36.8 a
Test average	**5.6**	**14.1**	**20.8**	**32.0**
C.V., %[y]	**93**	**46**	**27**	**22**

[z]Mean separation at *P*=0.05 with least squares means because of missing plots due to planting errors in three plots.
[y]Low C.V. (Coefficient of Variation) indicates more consistent data.

Table 3. Spotted wilt and plant size down the row in peanut plots of eleven varieties and breeding lines for destructive sampling and plant mapping at Phillips Farm in Frio County, TX, 2004.

	Spotted wilt, % row ft				Plant size (row-ft)
Entry	**22Jul**	**17Aug**	**6Oct**	**Entry**	**7Sep**
Tamrun 88	12.9	30.7	89.7	Tamrun 88	2.76
FlavorRunner458	9.2	26.4	73.3	Tamrun96	2.37
Florunner	10.1	21.5	63.4	C11-2-39	2.34
TamrunOL01	12.1	21.5	63.4	Florunner	2.32
US 224	6.5	18.0	44.4	TamrunOL02	2.27
Southern Runner	8.2	18.4	44.2	Virugard	2.24
Ga. Green	5.5	8.1	39.0	Southern Runner	2.18
TamrunOL02	3.8	9.6	35.1	TamrunOL01	2.17
Tamrun96	4.6	8.1	23.5	FlavorRunner458	2.16
Virugard	4.6	6.0	19.6	Ga. Green	2.07
C11-2-39	0.0	3.1	5.8	US 224	2.02
Average	**7.0**	**15.6**	**45.6**	**Average**	**2.26**
LSD 0.05*	**5.8**	**11.4**	**22.7**	**LSD 0.05***	**0.26**
CV, %**	**57**	**51**	**34**	**CV, %****	**8**

* Least significant difference at *P*=0.05
**Low C.V. (Coefficient of Variation) indicates more consistent data.

Table 4. Yield and value estimates in peanut plots of eleven varieties and breeding lines for destructive sampling and plant mapping at Phillips Farm in Frio County, TX, 2004.

Entry	**Yield, lb/A**	**Value, $/A**
Ga. Green	8110	1454
Tamrun 96	8126	1448
C11-2-39	7700	1415
Virugard	7933	1345
So Runner	7266	1257
Tamrun OL 02	6864	1181
Florunner	6088	1072
Tamrun 88	5955	1021
Tamrun OL 01	6042	1019
Flavor 458	4940	858
US 224	3189	494
Average	**6565**	**1142**
LSD 0.05*	**1336**	**250**
CV, %**	**12**	**13**

*Least significant difference among any two averages at *P*=0.05.
**Low C.V. (Coefficient of Variation) indicates more consistent data.

Table 5. Selected peanut stem measurements for eleven varieties or breeding lines, Phillips Farm, Frio County, TX, 2004.

	Number of main stem leaves			**Main stem length, cm**			**Secondary stem 1 length, cm**		
Entry	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**
Tamrun88	12.9	18.7	24.5	27.3	49.4	57.5	35.7	68.0	80.0
FlvRn458	12.0	18.4	21.5	24.8	43.2	51.5	30.5	62.1	70.3
Florunne	11.6	18.3	21.9	25.1	46.2	55.8	30.3	62.1	71.9
TmrnOL01	12.2	17.0	20.3	22.8	37.1	38.8	32.4	57.2	65.7
US___224	11.3	17.5	21.3	15.2	25.9	30.5	18.7	38.6	49.2
SoRunner	11.8	18.2	22.0	23.5	37.3	41.3	28.7	59.4	67.1
GeoGreen	11.9	18.8	21.6	20.2	35.5	38.1	27.3	50.3	57.5
TmrnOL02	11.7	17.9	21.3	22.9	35.0	35.8	26.9	53.7	58.7
Tamrun96	11.8	17.4	20.5	24.0	40.8	42.2	29.7	59.2	63.4
Virugard	12.8	18.5	21.5	26.9	46.8	49.8	30.5	55.8	65.2
C11239	12.1	18.3	22.5	21.1	33.5	38.2	27.3	52.8	67.3
Average	**12.0**	**18.1**	**21.7**	**23.1**	**39.1**	**43.6**	**28.9**	**56.3**	**65.1**
LSD 0.05*	**0.5**	**NS**	**1.5**	**2.3**	**4.8**	**6.7**	**2.1**	**5.8**	**7.1**
CV, %**	**3**	**5**	**5**	**7**	**9**	**11**	**5**	**7**	**8**

Table 5 continued…

	Number of stems, total			**Total stem length, cm**			**Secondary stem 9 length, cm**		
Entry	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**
Tamrun88	18.8	36.4	43.5	267	776	1017	0.3	9.0	13.1
FlvRn458	23.3	44.8	41.0	278	941	980	0.7	17.7	12.0
Florunne	18.2	43.4	37.8	240	938	957	0.4	11.5	12.2
TmrnOL01	14.3	21.0	24.3	249	561	670	0.0	5.7	9.9
US___224	15.8	51.9	81.2	140	575	1143	0.3	6.3	15.3
SoRunner	15.2	37.9	42.8	218	758	1000	0.6	11.1	16.8
GeoGreen	21.3	45.4	41.8	261	842	910	1.0	12.1	12.1
TmrnOL02	14.6	39.6	40.1	176	760	883	0.3	12.0	13.4
Tamrun96	15.4	24.8	32.3	227	587	762	0.3	5.2	8.3
Virugard	25.0	44.7	47.8	330	923	1145	2.4	13.0	16.7
C11239	19.3	40.6	46.3	210	803	1184	1.8	21.5	25.9
Average	**18.3**	**39.1**	**43.5**	**236**	**769**	**968**	**0.7**	**11.4**	**14.1**
LSD 0.05	**2.9**	**8.1**	**11.3**	**34**	**138**	**223**	**0.7**	**5.6**	**6.1**
CV, %	**11**	**14**	**18**	**10**	**12**	**16**	**64**	**34**	**30**

*Averages followed by the same letter are not significantly different at *P*=0.05 by Least Significant Difference (LSD). Differences were not significant if averages have no letters.

**Low C.V. (Coefficient of Variation) indicates more consistent data.

Table 6. Significant (*P*≤0.05) Pearson correlation coefficients (N=44) for three spotted wilt disease ratings with selected peanut stem characteristics from three sampling dates for eleven varieties or breeding lines at Phillips Farm in Frio County, TX, 2004.

	Spotted wilt, % row ft								
Disease rating date	**22Jul**			**17Aug**			**6Oct**		
Plant sample date	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**
A. Stem length[z]									
MS (main stem)						+.35*[y]		+.32*	+.40**[y]
S1	+.41**			+.31*			+.42**	+.38*	+.37*
S1T1Q1									-.35*
S1T2	+.33*					-.31*			-.30*
S1T2Q1									-.35*
S1T2Q2			-.33*						-.36*
S1T9Q2									+.33*
S1T10									+.32*
S1T11						+.35*			+.38*
S1T12									+.37*
S1T13									+.34*
S2	+.37*	+.35*			+.32*		+.33*	+.44**	
S2T1			-.36*						
S2T2	+.32*								
S2T1Q1						-.35*			-.30*
S2T1Q2									-.35*
S2T1Q3									-.30*
S2T2Q1			-.30*			-.39**			-.45**
S2T5Q1		+.32*			+.35*				
S2T5Q2		+.33*			+.36*			+.30*	
S2T5Q4									+.32*
S2T6							+.35*		
S2T6Q2									+.30*
S2T6Q3									+.37*
S2T6Q4									+.34*
S2T7							+.32*		
S2T8							+.34*		
S2T12									+.35*
S3	+.39**						+.32*	+.39**	+.37*
S3T1			-.40**			-.40**			-.30*
S3T2			-.42**			-.45**			-.42**
S3T3			-.31*			-.32*			-.31*
S3T4						-.30*			-.32*
S4	+.41**	+.32*		+.30*	+.32*		+.39**	+.40**	
S4T1		-.32*							
S4T2			-.40**			-.42**			-.37*
S4T3			-.35*			-.39**			
S5	+.33*								
S5T1			-.31*	-.34*			-.31*		-.33*
S6			-.43**			-.58***[y]			-.53***
S7			-.32*			-.33*			
S8						-.33*	-.34*		
S8T2								+.34*	

Table 6 is continued on next page

Table 6, continued….

	Spotted wilt, % row ft								
Disease rating date	**22Jul**			**17Aug**			**6Oct**		
Plant sample date	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**
S9			-.38*	-.32*		-.42**	-.38*		-.36*
S10			-.39**			-.36*			-.37*
S11			-.47**			-.42**			-.39**
S13T1						+.30*			
S17					+.47**			+.38*	
B. Calculated variables----------									
TtStemL			-.30*						
TtSStemL	+.38*								
TtTStemL			-.34*						
StemL	+.39**								
SStemL	+.44**						+.33*		
TStemL	+.31*								
S12L	+.39**						+.38*	+.42**	+.32*
S34L	+.41**						+.36*	+.40**	+.32*
S1234L	+.42**						+.38*	+.42**	+.32*
SmMSS1_4	+.39**						+.36*	+.41**	+.35*
MSxxS1_4	+.37*					+.35*	+.34*	+.42**	+.42**
MSnodeL						+.33*			+.34*
RMSSS1							-.30*		
RMSSS2						+.33*			+.34*
RMSSS1_2						+.31*			
RMSSS1_4	-.33*					+.33*			+.30*
RMSSS	-.30*								
MSSS			+.45**			+.39**			+.49***
RMSTS			+.41**			+.51***			+.49***
Plant population 7Sep	+.39**	+.39**	+.39**						

[z]Stem length was an average of six plants per plot. Calculated variables were based on averages of previous variables for each plot. There were four replications, N=44. MS=main stem; S= and SS=secondary stem; T= and TS=tertiary stem; Q= quaternary stem; Tt=total; R=ratio (of stems described); 1_2=1 and 2; 1_4=1, 2, 3, and 4. Plant population 7Sep was estimated from number of plants actually sampled and resulting skips on that date.

[y]Asterisks (one, two, or three) indicate significance at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively.

Table 7. Regression analysis of plant mapping data (three dates, destructive sampling) for 11 varieties/breeding lines and spotted wilt disease ratings at Phillips Farm in Frio County, TX, 2004.

Sample date	Disease rating date	Best regression equation[z]	Model P > F	R^2
29Jun	22Jul	SW = –6.27 + 0.76SStmL	0.003	0.19
	17Aug	SW = –9.53 + 0.92S1 – 1.36TtQStmL	0.022	0.17
	6Oct	SW = 19.91 + 4.15S1 + 6.58S4 – 2.03TtSStmL – 4.61TtQStmL + 0.37TtTStmL	<0.001	0.43
28Jul	22Jul	SW = –7.95 – 0.71MS + 0.70S2 + 0.80S4 + 0.33TtNoTSt - 0.13TtSStmL	<0.001	0.47
	17Aug	SW = 53.41 + 2.11S4 + 0.41TtNoStm – 0.28TtSStmL – 94.71RMSSS12	<0.001	0.41
	6Oct	SW = 333.72 + 2.15TtNoTSt – 0.62TtSStmL – 374.24RMSSS1_4 + 0.07MSxxS1_4	<0.001	0.57
7Sep	22Jul	SW = 5.20 – 0.27S6 + 8.14MSSS	<0.001	0.31
	17Aug	SW = 27.78 + 0.61S3 – 0.85S6 – 0.86TStmL	<0.001	0.49
	6Oct	SW = 94.15 – 1.34S2 + 3.03S3 – 2.37S6 – 1.83SStmL	<0.001	0.59

[z]Equations were estimated by PC-SAS Proc Regression using Stepwise option and minimum C(p) statistic. Six whole plants were collected from each plot on each date. Stem descriptions are

SW = spotted wilt (% row ft with noteworthy symptoms)
MS = average length of main (primary) stem 1 (cm)
S1 = average length of secondary stem 1 (cm)
S2 = average length of secondary stem 2 (cm)
S3 = average length of secondary stem 3 (cm)
S4 = average length of secondary stem 4 (cm)
S6 = average length of secondary stem 6 (cm)
SStmL = average total/plant secondary [arising from main(primary)] stem length (cm)
TStmL = average total/plant tertiary stem length
TtSStmL = average total/plant secondary stem lengths (cm)
TtTStmL = average total/plant tertiary (from secondary stems) stem lengths (cm)
TtQStmL = average total/plant quaternary (from tertiary stems) stem lengths (cm)
TtNoStm = average total number all stems/plant (cm)
TtNoTSt = average total number tertiary stems/plant (cm)
RMSSS12 = average ratio of main stem length to average of secondary stems 1 and 2
RMSSS1 = average ratio of main stem length to secondary stem 1 length
MSxxS1_4 = product of main stem length and the average length of secondary stems 1-4
MSSS = ratio of average main stem length/plot to average secondary stem length /plot.

Table 2. Thrips counts (composite of five terminals) in peanut plots pruned three times to modify the canopy shape at Phillips Farm in Frio County, TX, 2004.

-----**A. 9July samples**-----

	Male*		Female		Immature			All			
Entry	**TT****	**WFT****	**TT**	**WFT**	**1Lar**	**2Lar**	**3Lar**	**TT**	**WFT**	**Imm**	**Thrips**
GeoGreen	0.21 b	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tamrun88	0.21 b										
Virugard	0.64 a										
Tamrun96	0.21 b										
Canopy											
Check	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tall											
Short											
Terminal											
Main	0.49 b	NS	NS	NS	NS	NS	NS	0.78 b	NS	NS	NS
Side	0.91 a							1.75 a			

-----**B. 28Jul samples**-----

	Male		Female		Immature			All			
Entry	**TT**	**WFT**	**TT**	**WFT**	**1Lar**	**2Lar**	**3Lar**	**TT**	**WFT**	**Imm**	**Thrips**
GeoGreen	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tamrun88											
Canopy											
Check	0.21 b	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.74 b
Tall	0.43 a										5.77 a
Short	0.16 b										3.81 b
Terminal											
Main	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Side											

Table 2 is continued on next page

Table 2, continued…

-----C. 27August samples-----

	Male		Female		Immature			All			
Entry	**TT**	**WFT**	**TT**	**WFT**	**1Lar**	**2Lar**	**3Lar**	**TT**	**WFT**	**Imm**	**Thrips**
GeoGreen	NS	NS	NS	NS	NS	1.81 b	NS	NS	NS	3.32 b	3.71 b
Tamrun88						2.58 a				4.59 a	5.10 a
Canopy											
Check	NS	NS	NS	NS	NS	1.44 a	NS	NS	NS	NS	NS
Tall						1.42 a					
Short						0.78 b					
Terminal											
Main	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.56 a	5.81 a
Side										3.29 b	4.23 b

*Averages (de-transformed means) followed by the same letter are not significantly different at P=0.05 by LSD (least significant difference). NS indicates was not significant. Data were transformed using $(y+0.5)^{-2}$ to improve normality before statistical analysis. Averages (means) reported in this table were de-transformed by (transformed mean)^2 - 0.5 + unconverted error mean square.

**TT=tobacco thrips; WFT=western flower thrips.