#141
2005
(continue to 2006)

TITLE: Spotted Wilt Resistance Mechanisms (141)

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SUMMARY: We continued to gather evidence that field resistance in runner peanut varieties to TSWV involves plant canopy characteristics. We hypothesize that canopy traits affect vector thrips behavior. We repeated the variety vegetative plant mapping in 2005 non-prominent main stems again were related to reduced spotted wilt risk. Regression analysis to explain spotted wilt differences consistently included one of the calculated variables for ratio of main stem length and one or more secondary stem lengths (RMSSS…). We are increasing our understanding of plant types that are highly vulnerable during spotted wilt epidemics and also plant types that hold up well to TSWV. This has potential for selection even in years with little spotted wilt pressure. The traits related to spotted wilt variety ratings do not indicate a simply inherited disease resistance. Rather, these canopy traits fall in the category of 'field resistance' that is polygenically inherited. This type of 'field resistance' should be stable and additive with the low levels of 'true resistance' available in some lines.

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 has reported problems with spotted wilt since 1990 and problems still occur in Southwest Texas. Several southwest Texas growers had severe losses in 2004 and 2005. 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 and high seeding rates (resulting in high plant populations) during seasons with spotted wilt epidemics may also be due in part to altered thrips behavior related to more rapid row cover and a more uniform (dense) canopy surface.

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.

MATERIALS and METHODS: Nine peanut varieties and two breeding lines (11 entries) were mapped for vegetative stem growth for the third year. The experimental design with two-row 13-ft plots was a randomized complete block with four replications. Whole plants were destructively sampled on 29Jun, 5Aug, and 6Sep by removing a minimum of three plants in 1 row-ft from each of the two rows per plot (target was 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 19Jul, 6Sep, and 4Oct. 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: Spotted wilt was moderate-to-severe in this test, and variety rank on all three dates was about as we expected (Table 1). Tamrun88 had the most disease on all dates. C11-2-39 had (or tied for) the least on all dates. It is interesting that GeorgiaGreen and US224, the two entries with the smallest early season plant size (Table 2), ranked higher for disease early (Table1; also compare ratings to test average on that date), but not late in the season. This is probably due to the delayed lapping of middles.

Highly TSWV-susceptible varieties tended to have taller main stems throughout the season (Table 2). However, TSWV-resistant ViruGard, the only virginia bunch plant type in the test, was tall early. Greater secondary stem 1 (Table 2) and 2 (data not shown) lengths were also a common trait of TSWV-susceptibility.

Tamrun96, TamrunOL01, and TamrunOL02 generally had low total stem numbers (Table 2). This uncluttered zone at the crown may contribute to lower southern blight ratings in previous years and in other tests and may help explain why these varieties hold up better than most other runners to Sclerotinia blight . Tamrun96, TamrunOL01, and TamrunOL02 ranked lowest for total stem length on 6Sep (Table 2) even though growers in Southwest Texas perceive these varieties as large and "stemmy." The greater difficulty in digging (prone to not roll over completely) is probably due to the less prominent main stems and more prominent upper secondary stems. Reduced branching contributed to low total stem lengths, and the three Texas varieties apparently have more rigid stems at maturity. Stem strengths may help explain different variety tolerances to various environmental stresses observed in years (hot dry weather late).

Numerous correlations of stem traits with all three spotted wilt disease ratings were significant (Table 3A). Significant correlations of spotted wilt with main branch lengths, [height (main stem) and canopy width (secondary branches 1,,3,4,5,8,9)] were positive 13 of 14 times. Significant correlations of spotted wilt with higher order branches (tertiary, quaternary, quinary) were sometimes positive and sometimes negative. Data for 2003 and 2005 were more alike than those of 2004. We suspect weather x variety interactions for vegetative growth.

Thirty-eight of 42 significant correlations between spotted wilt and calculated variables (Table 3B, rows TtNoSSt through RMSTS) were positive, supporting our hypothesis of higher risk of large plants and prominent main stems compared to secondary stems.

Regression of all variety stem characteristics and several calculated variables with spotted wilt ratings on three dates explained low but significant portions of total variation in spotted wilt disease (Table 4). Two of eight significant models had positive terms for a secondary stem (S2 or S3) length and only one significant model had a negative effect for a secondary stem (S1). All nine models (eight were significant at P=0.05) had a positive term for one of the rations between main stem length and one or more secondary stem lengths.

Production practices that modify canopy shape in peanut fields also reduce spotted wilt, *i.e.*, twin vs. single rows and high plant populations. Main stems are less prominent, and bare soil is covered earlier in the season.

Vegetative plant mapping was very labor intensive and many additional statistical analyses will be done with these data. Due to the high number of zeros in the data, appropriate data transformations will be used before publication. 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 are 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. The best disease correlations with vegetative growth traits varied somewhat among the three years of plant mapping, but these is commonality. We continue to gain understanding of plant types that are highly vulnerable and this can be used in years with little spotted wilt pressure.

The traits related to spotted wilt variety ratings explored in this report do not fit the classical definition of disease resistance, although at least one entry (C11-2-39) does have a low level of 'true resistance.' Rather, these canopy traits we identified fall in the category of 'field resistance' (some varieties/breeding lines have less disease in the field than would be expected based solely on laboratory tests). Fortunately, this type of 'field resistance' is stable to date, 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 using somewhat different genetics than Texas breeders for spotted wilt resistance, with the former apparently relying more on both dense-low spreading-highly branched canopy and some 'true resistance' to TSWV; those canopies are apparently more prone to southern blight, Sclerotinia blight, and heat stress. The Texas program apparently uses genetics for a less branched canopy that may have advantages for field resistance to southern blight, Sclerotinia blight, and summer stress.

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.

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Table1. Spotted wilt in peanut plots of eleven varieties and breeding lines for plant mapping at Phillips Farm in Frio County, TX, 2005.

Entry	Spotted wilt, % row ft		
	19Jul	6Sep	4Oct
Tamrun88	4.4	76.6	97.6
FlavoRunner458	0.0	37.3	81.2
Florunner	2.1	28.4	70.3
GeoGreen	3.2	14.7	65.1
TamrunOL01	1.1	9.9	56.4
Virugard	0.0	7.7	46.8
US224	3.2	19.6	45.0
SouthernRunner	1.1	14.9	40.0
TamrunOL02	0.0	9.7	38.8
Tamrun96	0.0	7.1	37.5
C11-2-39	0.0	3.7	32.5
Average	**1.4**	**20.9**	**55.6**
LSD 0.05*	**N.S.**	**17.6**	**17.7**
CV, %**	**208**	**58**	**22**

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

Table 2. Selected peanut stem measurements for eleven varieties or breeding lines, Phillips Farm, Frio County, TX, 2005.

Entry	Number of main stem leaves			Main stem length, cm			Secondary stem 1 length, cm		
	29Jun	5Aug	6Sep	29Jun	5Aug	6Sep	29Jun	5Aug	6Sep
TR88	10.8	21.2	25.1	13.7	40.3	46.1	17.8	62.8	70.8
FR458	10.5	18.9	24.3	14.0	34.3	41.6	18.6	62.0	76.4
Florunne	10.3	19.3	24.0	14.7	40.2	43.5	19.2	64.5	76.2
GeoGreen	10.5	19.8	24.5	9.4	31.1	35.0	16.5	53.5	60.7
TROL01	11.1	18.8	22.0	13.0	31.8	34.3	17.8	57.3	65.5
Virugard	11.0	20.2	23.3	14.2	34.2	38.3	17.5	55.2	63.8
US224	10.2	19.0	23.2	8.3	23.7	34.2	11.2	38.5	52.2
SoRunner	11.0	19.7	25.2	12.6	35.5	45.8	18.7	59.0	70.8
TROL02	10.3	17.9	23.7	12.1	31.6	38.2	17.8	53.5	67.8
TR96	10.5	18.4	23.2	13.0	34.1	38.4	17.6	56.4	63.5
C11-2-39	10.3	19.9	25.2	11.8	28.3	36.7	18.0	59.9	72.7
Average	**10.6**	**19.4**	**24.0**	**12.4**	**33.2**	**39.3**	**17.3**	**56.6**	**67.3**
LSD0.05*	**NS**	**1.4**	**1.9**	**2.1**	**2.8**	**4.1**	**2.0**	**5.2**	**8.2**
CV, %**	**6**	**5**	**5**	**12**	**6**	**7**	**8**	**6**	**8**

continued....

Table 2 continued…

Entry	Number of stems, total			Total stem length, cm			RMSSS		
	29Jun	5Aug	6Sep	29Jun	5Aug	6Sep	29Jun	5Aug	6Sep
TR88	13.8	44.2	48.7	122	1054	1173	1.09	1.30	1.47
FR458	18.0	53.1	64.8	157	1095	1624	1.10	1.19	1.19
Florunne	16.8	51.9	57.8	148	1178	1583	1.19	1.25	1.21
GeoGreen	20.7	55.3	62.6	154	1108	1440	0.88	0.97	1.05
TROL01	12.0	23.6	27.1	130	670	840	0.98	0.99	0.95
Virugard	20.5	68.8	74.1	177	1478	1942	1.14	1.09	1.10
US224	14.5	48.2	69.0	80	667	1249	1.08	1.08	1.07
SoRunner	18.4	45.8	52.4	166	1086	1325	0.98	1.11	1.30
TROL02	15.5	39.6	43.0	134	881	1080	0.96	0.99	1.16
TR96	10.8	26.9	31.7	112	734	947	1.03	0.98	1.09
C11-2-39	15.3	62.9	62.1	127	1210	1438	1.01	0.95	1.06
Average	**16.0**	**47.3**	**53.9**	**137**	**1015**	**1331**	**1.04**	**1.08**	**1.15**
LSD0.05*	**3.3**	**11.5**	**13.6**	**32**	**245**	**341**	**0.12**	**0.12**	**0.19**
CV, %**	**14**	**17**	**17**	**16**	**17**	**18**	**8**	**8**	**11**

*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.

Table3. 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 and breeding lines at Phillips Farm in Frio County, TX, 2005.

	Spotted wilt, % row ft								
Disease rating date	**19Jul**			**6Sep**			**4Oct**		
Plant sample date	**29Jun**	**5Aug**	**6Sep**	**29Jun**	**5Aug**	**6Sep**	**29Jun**	**5Aug**	**6Sep**
A. Stem length[z]									
MS (main stem)					+.45**	+.45**		+.46**	+.31*
S1	-.33*							+.34*	
S1T1Q1					-.33*				
S1T1Q2					-.30*				
S1T1Q3					-.32*				
S1T2Q1					-.31*				
S1T3					+.32*			+.30*	
S1T4Q5					+.40**				
S1T4Q6					+.54**			+.32*	
S1T5Q3		+.39**			+.35*				
S1T5Q4		+.39**			+.35*				
S1T6					+.39**				
S1T7					+.33*				
S1T8					+.38*				
S1T9		+.35*							
S1T10		+.34*							
S1T11		+.39**			+.35*				
S2T1	-.31*								

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Table 3 continued….

Disease rating date	22Jul			17Aug			6Oct		
	Spotted wilt, % row ft								
Plant sample date	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**	**29Jun**	**28Jul**	**7Sep**
S2T2						+.30*			
S2T3Q1V1			+.41**			+.36*			
S2T5					+.29*				+.31*
S2T6									+.36*
S2T6Q2			+.51**						+.34*
S3						+.30*			+.31*
S3T1	-.31*					-.35*			-.46**
S3T2Q1	+.39**								
S3T5	+.61**								
S4					+.31*			+.41**	
S5					+.31*			+.35*	
S5T3	+.45**								
S6T1Q2			+.52**						
S6T2	+.61**								
S7T2									-.31*
S8								+.32*	
S9									+.31*
B. Calculated variables									
TtNoSSt						+.32*		+.33*	+.34*
TtSStemL								+.31*	
TStemL	-.31*			-.29*					
S12L	-.31*							+.32*	
S34L								+.36*	+.30*
S1234L	-.30*							+.35*	
SmMSS1_4	-.29*							+.38*	+.29*
MSxxS1_4					+.41**	+.38*		+.47**	+.33*
MSnodeL					+.32*	+.34*		+.34*	+.30*
MSLvs					+.30*	+.31*		+.31*	
RMSSS1					+.36*				
RMSSS2					+.32*	+.37*			
RMSSS1_2					+.36*	+.32*			
RMSSS1_4					+.38*				
RMSSS					+.59**			+.56**	
MSSS						+.48***			+.34*
RMSTS				+.49**	+.32*	+.30*	+.31*		
RSSTS	+.33*			+.45**				-.30*	

[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, SS and SSt=secondary stem; T= and TS=tertiary stem; Q= quaternary stem; V=quinary stem; Tt=total; R=ratio (of stems described); 1_2=1 and 2; 1_4=1, 2, 3, and 4; no number indicated an average of all SS. on that date.

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

Table 4. Regression analysis of plant mapping data (three dates, destructive sampling) for 11 varieties or breeding lines and spotted wilt disease ratings at Phillips Farm in Frio County, TX, 2005.

Sample date	Disease rating date	Best regression equation[z]	Model P > F	R^2
29Jun	19Jul	SW = 2.12 – 0.25S1 + 1.66RSSTS	0.02	0.17
	6Sep	SW = -24.45 + 19.49RMSTS	<0.001	0.24
	4Oct	SW = -15.92 + 2.19S3 + 17.64RMSTS	0.02	0.17
5Aug	19Jul	SW = -5.92 + 12.05RMSS1	N.S.	0.08
	6Sep	SW = -69.86 + 80.72RMSSS	<0.001	0.35
	4Oct	SW = -77.47 + 0.68S2 + 85.99RMSSS	<0.001	0.37
6Sep	19Jul	SW = -14.94 + 0.42MSLvs + 10.32RMSSS12	0.04	0.15
	6Sep	SW = -44.28 + 53.69RMSSS	0.001	0.23
	4Oct	SW = 4.10 + 42.89RMSSS	0.03	0.11

[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.