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**TITLE: Peanut Spotted Wilt Resistance Mechanisms and Abiotic Stress Reactions**

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**SUMMARY:**

**Four peanut varieties pruned to modify the canopy shape.** The short canopy pruning treatment had significantly less spotted wilt on 6Oct than the check or tall treatments. The short treatment also reduced southern blight on 6 Oct compared to the check, but was not different from the tall treatment. These data support our hypothesis that canopy shape contributes to variety reaction to spotted wilt. Our data also agree with conclusions from plant mapping that reduced air circulation and light penetration in a zone at the crown is associated with southern blight vulnerability. Both pruning treatments decreased yield and seed size as expected, but did not effect grade.

Highly susceptible Tamrun88 had more than double the thrips as GeorgiaGreen in three categories early in the season, in agreement with spotted wilt disease ratings. There were more thrips in main stem terminals than in side stem terminals in three categories early in the season, but 2 weeks later the opposite occurred. The early season data is consistent with our hypothesis that characteristics of the main stem early in the season are involved with spotted wilt disease.

We now have evidence that peanut variety reactions to TSWV involve at least two mechanisms: a) reactions on the cellular or systemic level in the plant (2002 results with mechanical inoculation) and b) thrips behavior related to plant canopy characteristics.

**Variety vegetative plant mapping.** Highly TSWV-susceptible varieties had tall main stems early and late in the season. TSWV-resistant ViruGard, the only bunch plant type in the test, was also tall early. TSWV-resistant SouthernRunner, the most indeterminate runner in the test, was also tall late. Similar trends of highly TSWV-susceptible varieties were true for secondary stem 2 lengths. At harvest time, large-plant susceptible varieties apparently have more flaccid stems than somewhat smaller but more rigid resistant Texas varieties. Tamrun96, TamrunOL01, and TamrunOL02 has lowest total stem numbers, followed by SouthernRunner (Table 4). All four varieties usually have ranked low for southern blight in various variety tests, and this zone at the crown with less branching may be involved.

**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. State and federal supported breeding programs in Texas, Georgia, Florida, North Carolina and one private company have developed and released cultivars that perform differently under TSWV pressure. Cultivars that hold up well have been rapidly accepted in high risk growing areas and breeding work continues to improve this resistance. The partial resistance appears to be stable but the 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, 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 a certain canopy shape may be an easy-to-use trait for breeders to use when selecting early generation breeding lines for reactions to spotted wilt and southern blight diseases. Thrips behavior may be related to plant canopy shape or other canopy characteristics. The benefits of twin-rows during spotted wilt epidemics may be due in part to wide and short canopy characteristics with less prominent main stems.

Advantages of traditional plant breeding with field evaluation include increased probability of stable resistance and opportunities to select for resistance to multiple diseases and environmental stress. Disadvantages of field evaluations for all breeding lines and the release of new varieties are the slow pace (8-10 years), uncertainty of disease occurring in plots every 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 objectives were to 1) identify peanut resistance/tolerance mechanisms to thrips-vectored TSWV that will predict field performance of varieties and breeding lines; and 2) identify traits common to breeding lines and varieties with different stress reactions.

**MATERIALS and METHODS:**

**Four peanut varieties pruned to modify the canopy shape.** This split-plot experiment with three replications was planted 29May03 at Phillips Farm in Frio County, TX. Two-row plots were shortened to a standard length on 20June. Main plot effect was canopy shape (check, tall, short); sub-plot effect was variety (Tamrun88, Tamrun96, ViruGard, GeorgiaGreen). Due to constraints unrelated to this experiment, there were extra sub-plots, resulting in an unbalanced design for data collected from all plots. Non-check plots were pruned 26June, 15July, 5Aug, and 19Aug based on ratio of main stem height to half the canopy width (before middles lapped) in check treatments, by variety, on each pruning date. Pruned canopy width by variety for the tall treatment was check ratio + 0.2. Pruned canopy height by variety for the short treatment was check ratio - 0.2. Spotted wilt and southern blight diseases were evaluated on all plots.

Thrips population was estimated from terminal samples (main stem/top of canopy, secondary stem/side of canopy) collected at approximately the same times in the morning on 5Aug (before pruning), 12Aug, 19Aug (before pruning), and 26Aug from two varieties (Georgia Green, Tamrun88) with extra plots omitted. Five terminals from top and five from side were

immediately placed in large vials of 70% ethanol. Thrips were decanted after agitation and concentrated with partial vacuum onto grided filter paper for counts.

Plots were inverted 16Oct and threshed 21Oct (extra plots omitted) for yield, grade and seed size estimates.

**Variety vegetative plant mapping.** Nine peanut varieties and two breeding lines were selected for a plant mapping field experiment on based a wide range of reactions to TSWV and putative heat and water deficit stress. The experimental design with two-row plots was an 11-entry randomized complete block with three replications. Planting, row-shortening, and harvest dates were the same as described above for the canopy pruning experiment. Whole plants were destructively sampled on 30June, 29July, and 23Sep by removing all plants in 1-ft for each of the two rows. The gap was measured after each sampling date to estimate stand. All branch lengths were recorded. Spotted wilt and southern blight were rated late in the season.

**RESULTS AND DISCUSSION:**

**Four peanut varieties pruned to modify the canopy shape.** There were no significant interactions, so only main plot and sub-plot averages are presented (Table 1A). Spotted wilt was low-to-moderate and southern blight was low. There were significant differences among variety and canopy effects for both diseases on at least one date. As has been observed before, Tamrun96 had significantly greater spotted wilt rating than GeorgiaGreen on 18Set, but differences were not significant later in the season on 6Oct. Tamrun88, the susceptible check, had significantly more spotted wilt and southern blight as expected.

The short canopy treatment had significantly less spotted wilt on 6Oct than the check or tall treatments. The short treatment also reduced southern blight on 6 Oct compared to the check, but was not different from the tall treatment (Table 1A). These data support our hypothesis that canopy shape contributes to variety reaction to spotted wilt.

Effects of pruning on southern blight may be related to increased light intensity and air movement within the canopy. This agrees with observations and plant vegetative mapping data where Tamrun 96, with consistently low southern blight ratings, has fewer branches and after mid-season has a more open zone at the crown largely devoid of leaves.

Both pruning treatments decreased yield and seed size, but did not effect grade (Table 1B). This was expected. There were significant differences among varieties for yield, grade, and seed size.

There were few significant interactions, and those are not presented. There were significant differences among sub-plot treatments for two of the four terminal sampling dates (Table 2). There were never differences among canopy pruning treatments. On 5Aug, highly susceptible Tamrun88 had more than double the thrips as GeorgiaGreen in three categories (Table 2A), in agreement with disease ratings. On 5Aug, there were more thrips in main stem terminals than in side stem terminals in three categories. This is consistent with our hypothesis that characteristics of the main stem early in the season are involved with spotted wilt disease. On 19Aug, when canopies were large and middles well-lapped, there were more thrips in the

side stem terminals than in main stem terminals (Table 2B). Variety was not significant. Thrips numbers were never high on the dates of sampling.

**Variety vegetative plant mapping.** Spotted wilt was moderate and southern blight was low in this test, so we did not get good separation among varieties (Table 3). Vegetative plant mapping was very labor intensive and there are many additional statistical analyses could be done on our data.

Highly TSWV-susceptible varieties tended to have taller main stems early in the season (Table 4). However, TSWV-resistant ViruGard, the only virginia bunch plant type in the test, was tall early. Highly TSWV-susceptible varieties also had tall main stems late in the season. However, TSWV-resistant SouthernRunner, the most indeterminate runner plant type in the test, was also tall late. Similar trends were true for secondary stem 2.

Tamrun96, TamrunOL01, and TamrunOL02 has lowest total stem numbers, followed by SouthernRunner (Table 4). All four varieties usually rank low for southern blight in variety tests, and this uncluttered zone at the crown may contribute.

Tamrun96, TamrunOL01, and TamrunOL02 ranked lowest for total stem length on 23Sep, even though growers in Southwest TX perceive these varieties as large, "stemmy," and tough to combine (Table 4). Reduced branching contributed to low total stem lengths. The three Texas varieties ranked lower than Florunner on 23Sep for main stem and secondary stem 2 lengths, so Florunner stems must be considerably more flexible at digging. We need to estimate stem strengths in a future experiment, because this feature could help explain variety tolerance to various environmental stresses.

Regression of all variety stem characteristics with spotted wilt on two dates and southern blight on one date did not explain a large percent of total variation in diseases. Disease levels were too low to get a good spread. Additional analysis is needed using a composite ranking of these eleven varieties from previous disease evaluations. We ran correlations of all stem traits with diseases (Table 5). Few characteristics were significantly correlated with the first spotted wilt rating, but numerous characteristics were significantly correlated with spotted wilt on 15Oct and southern blight on 9Sep. All significant correlations were positive. Larger actual plant size (not perceived plant size), both height and width, were associated with both diseases.

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**Table 1. Spotted wilt and southern blight in peanut plots pruned three times to modify the canopy shape, Phillips Farm, Frio County, TX, 2003**

----------A. Disease----------

| Entry | Spotted wilt, % row ft. | | | Southern blight, % row ft. | | |
|---|---|---|---|---|---|---|
| | 19Aug | 18Sep | 6Oct | 19Aug | 18Sep | 6Oct |
| GeoGreen | 0.9 a* | 3.5 a | 11.9 a | 0.3 a | 1.9 a | 2.4 a |
| ViruGard | 0.9 a | 4.3 a | 9.9 a | 0.0 a | 2.4 a | 4.4 a |
| Tamrun96 | 1.9 ab | 9.1 b | 15.2 a | 0.0 a | 0.1 a | 0.1 a |
| Tamrun88 | 4.7 b | 15.8 c | 34.0 b | 1.4 b | 11.5 b | 13.7 b |
| **Canopy** | | | | | | |
| Check | 2.2** | 9.1 | 19.5 a | 0.9 | 6.2 | 8.1 a |
| Short | 2.7 | 6.2 | 13.9 b | 0.1 | 2.4 | 3.0 b |
| Tall | 1.4 | 9.2 | 19.8 a | 0.3 | 3.4 | 4.4 ab |
| **Test average** | 2.6 | 9.4 | 20.4 | 0.6 | 5.2 | 6.5 |

----------B. Yield, grade, and seed size----------

| Entry | Yield, lb/A | TSMK+SS, % | Seg2, % | OK, % | 100 sd-wt, g |
|---|---|---|---|---|---|
| GeoGreen | 6873 a | 73.4 a | 0.4 b | 3.2 c | 57.8 c |
| ViruGard | 4963 d | 72.1 a | 1.3 a | 3.9 bc | 69.6 a |
| Tamrun96 | 6248 b | 70.0 b | 0.7 ab | 4.3 ab | 62.9 b |
| Tamrun88 | 5662 c | 72.4 a | 1.1 a | 5.2 a | 55.7 d |
| **Canopy** | | | | | |
| Check | 6291 a | 72.4 | 1.0 | 4.0 | 63.7 a |
| Short | 5538 b | 71.8 | 0.7 | 4.0 | 59.7 b |
| Tall | 5981 a | 71.6 | 0.9 | 4.6 | 61.1 b |
| **Average** | 5937 | 72.0 | 0.9 | 4.2 | 61.5 |

*Averages (least squares means) followed by the same letter are not significantly different at $P$=0.05 by T test.

**Differences were not significant at $P$=0.05 if averages have no letters.

**Table 2. Thrips counts in peanut plots pruned three times to modify the canopy shape, Phillips Farm, Frio County, TX, 2003.** Counts were for a composite of five terminals.

**A. 5August**

| Entry | Male* | | Female | | Immature | | | All | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | TT | WFT | TT | WFT | 1Larv | 2Larv | 3Larv | TT | WFT | Immature | Thrips |
| GeoGreen | 0.11 b | 0.33 b | | | | | | 0.28 b | | | |
| Tamrun88 | 0.41 a | 0.89 a | | | | | | 0.95 a | | | |
| **Terminal** | | | | | | | | | | | |
| Main | | | | 1.41 a | | | | | 2.39 a | | 8.67 a |
| Side | | | | 0.78 b | | | | | 1.15 b | | 5.19 b |

**B. 19August**

| Entry | Male | | Female | | Immature | | | All | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | TT | WFT | TT | WFT | 1Larv | 2Larv | 3Larv | TT | WFT | Immature | Thrips |
| **Terminal** | | | | | | | | | | | |
| Main | | | | | 1.25 b | 0.38 b | | 0.23 b | | 1.71 b | 2.04 b |
| Side | | | | | 2.53 a | 0.98 a | | 0.65 a | | 3.59 a | 4.45 a |

*Averages (de-transformed means) followed by the same letter are not significantly different at $P$=0.05 by LSD (least significant difference). The effect was not significant if averages have no letters. Data were transformed using $(y+0.5)^{-2}$ to improve normality before statistical analysis.

| Entry | Stand, pts/ft. | Spotted wilt, % row ft. 9Sep | Spotted wilt, % row ft. 10Oct | Southern blight, % row ft., 9Sep |
|---|---|---|---|---|
| Tamrun88 | 2.0 | 7.3 | 55.2 | 4.2 |
| FlvRn458 | 3.1 | 1.0 | 19.8 | 1.0 |
| Florunnr | 2.9 | 1.0 | 17.7 | 5.2 |
| TROL01 | 3.6 | 4.2 | 14.6 | 0.0 |
| TROL02 | 2.9 | 1.0 | 13.5 | 0.0 |
| GeoGreen | 3.0 | 1.0 | 11.5 | 1.0 |
| Tamrun96 | 3.4 | 4.2 | 9.4 | 0.0 |
| ViruGard | 2.9 | 1.0 | 7.3 | 0.0 |
| C11-2-39 | 3.2 | 2.1 | 6.3 | 0.0 |
| US224 | 2.8 | 2.1 | 6.3 | 0.0 |
| SoRunner | 3.1 | 0.0 | 3.1 | 0.0 |
| LSD.05* | 0.8 | N.S. | 9.7 | 2.5 |
| Test average | 3.0 | 2.3 | 15.0 | 1.0 |
| C.V.** | 15% | 150% | 38% | 138% |

*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 4. Selected peanut stem measurements for eleven varieties and breeding lines, Phillips Farm, Frio County, TX, 2003**

| | Main stem nodes | | | Main stem length, cm | | | Secondary stem 2, cm | | | Total number stems | | | Total stem length, cm | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Entry | 30Jun | 29Jul | 23Sep | 30Jun | 29Jul | 23Sep | 30Jun | 29Jul | 23Sep | 30Jun | 29Jul | 23Sep | 30Jun | 29Jul | 23Sep |
| Tamrun88 | 9.8 | 20 | 29 | 13 | 44 | 60 | 18 | 62 | 89 | 14 | 40 | 58 | 132 | 1221 | 2023 |
| FlvRn458 | 8.6 | 17 | 26 | 14 | 46 | 62 | 18 | 62 | 87 | 13 | 24 | 33 | 131 | 852 | 1181 |
| Florunnr | 10.1 | 18 | 26 | 14 | 44 | 63 | 18 | 63 | 86 | 13 | 25 | 40 | 129 | 868 | 1233 |
| TROL01 | 8.8 | 17 | 23 | 14 | 43 | 48 | 18 | 62 | 70 | 10 | 17 | 16 | 103 | 634 | 710 |
| TROL02 | 8.7 | 18 | 24 | 10 | 42 | 50 | 14 | 56 | 78 | 10 | 26 | 27 | 82 | 750 | 934 |
| GeoGreen | 8.8 | 18 | 25 | 10 | 38 | 49 | 14 | 53 | 68 | 13 | 32 | 35 | 107 | 851 | 1084 |
| Tamrun96 | 8.9 | 17 | 24 | 13 | 42 | 52 | 17 | 56 | 76 | 9 | 19 | 26 | 91 | 647 | 929 |
| ViruGard | 9.6 | 18 | 24 | 16 | 48 | 53 | 17 | 60 | 68 | 13 | 25 | 38 | 125 | 841 | 1290 |
| C11-2-39 | 9.4 | 18 | 27 | 9 | 32 | 48 | 14 | 50 | 78 | 12 | 28 | 48 | 83 | 748 | 1385 |
| US224 | 8.6 | 16 | 27 | 9 | 27 | 49 | 12 | 36 | 68 | 10 | 23 | 54 | 58 | 485 | 1204 |
| SoRunner | 8.9 | 18 | 27 | 12 | 43 | 61 | 17 | 61 | 86 | 12 | 26 | 31 | 117 | 806 | 1181 |
| LSD.05* | 1.0 | 2 | 2 | 2 | 6 | 9 | 3 | 8 | 10 | 2 | 6 | 12 | 25 | 179 | 341 |
| Test average | 9.1 | 18 | 26 | 12 | 41 | 54 | 16 | 57 | 78 | 12 | 26 | 37 | 105 | 791 | 1196 |
| C.V.** | 6% | 6% | 4% | 9% | 8% | 10% | 10% | 8% | 8% | 12% | 13% | 18% | 14% | 13% | 17% |

*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.

**lines, Phillips Farm, Frio County, TX, 2003. Branching was mapped on plants sampled on three dates.**

| | Spotted wilt 9Sep | | Spotted wilt 15Oct | | | Southern blight 9Sep | | |
|---|---|---|---|---|---|---|---|---|
| Stem characteristic | 29Jul | 23Sep | 30Jun | 29Jul | 23Sep | 30Jun | 29Jul | 23Sep |
| No. main stem nodes | | | | 0.45** | 0.44* | 0.41* | | |
| Main stem, cm | | | | | 0.38* | | | 0.45** |
| Secondary stem 1, cm | | | 0.37* | 0.44* | 0.35* | | 0.43* | |
| Secondary stem 2, cm | | | | | 0.40* | | | 0.41* |
| Secondary stem 3, cm | | | 0.42* | 0.35* | 0.44* | | 0.39* | 0.39* |
| Secondary stem 4, cm | | | 0.39* | 0.42* | 0.48** | 0.35* | 0.36* | 0.51** |
| Secondary stem 5, cm | | | | | 0.50** | | | 0.48** |
| Secondary stem 6, cm | | | | | 0.37* | | | |
| No. secondary stems | | | | 0.47** | 0.38* | | 0.45** | 0.36* |
| No. tertiary stems | | | 0.37* | 0.47** | | | 0.43* | |
| No. quaternary stems | 0.39* | 0.52** | | 0.51** | 0.37* | | | 0.38* |
| No. quinternary stems | | 0.74**** | | | 0.62**** | | | 0.44** |
| Total no. stems | | | 0.36* | 0.52** | 0.37* | | 0.45** | |
| Total stem length, cm | | | 0.42* | 0.65**** | 0.58*** | 0.35* | 0.54** | 0.43* |
| Tot. sec. stem lgth., cm | | | 0.38* | 0.60*** | 0.56*** | | 0.49** | 0.41* |
| Tot. tert. stem lgth., cm | | | 0.41* | 0.64**** | 0.57*** | | 0.56*** | 0.42* |
| Tot quart. stem lgth., cm | | | | 0.35* | 0.38* | | | |
| Ave. tert. stem lgth., cm | | 0.39* | | 0.37* | 0.38* | | | |
| Ratio main stem:ave. all sec. stems | | | | | | | | 0.45** |
| Ratio ave. all sec. stm. :ave. all tert. stems | | | | 0.35* | | | 0.36* | |
| Ave. sec. stems 1 and 2, cm | | | 0.35* | 0.36* | 0.40* | | 0.37* | 0.37* |
| Ave. sec. stems 3 and 4, cm | | | 0.41* | 0.39* | 0.48** | | 0.39* | 0.47** |
| Ave. sec. stems 1-4, cm | | | 0.39* | 0.38* | 0.45** | | 0.38* | 0.44* |
| Sum of main stem, sec. stems 1-4, cm | | | 0.37* | 0.36* | 0.46** | | 0.36* | 0.46** |
| Product of main stem, sec. stems 1-4 | | | | | 0.46** | | | 0.49** |

Asterisks (one, two, three, or four) indicate significance at $P \leq 0.05$, 0.01, 0.001, or 0.0001, respectively.