# SILVERLEAF WHITEFLY AND COTTON LEAF CRUMPLE VIRUS RESISTANCE SCREENING IN UPLAND COTTON

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## Abstract

A study was conducted to evaluate a cotton cultivar and five cotton seed-lines for resistance to silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring, and resistance to cotton leaf crumple disease caused by cotton leaf crumple geminivirus. Texas 121 is a cotton cultivar accepted for commercial production in the Rio Grande Valley, Texas. Texas 121 has resistance through phenological asynchronization to silverleaf whitefly through early maturity. Five breeding-lines from USDA-ARS being selected for various desirable agronomic characteristics were also included for whitefly and virus disease resistance screening. Results showed that there were differences in whitefly infestation levels and virus disease symptoms among the cotton entries in this study. The cotton cultivar, Texas 121, had a lower seed cotton yield than other entries in the study.

## Introduction

Sweetpotato whiteflies, *Bemisia tabaci* Gennaduis, were sporadic pests of cotton in southern California and Arizona (Gerling 1967) until 1981 when severe economic losses to cotton occurred (Johnson et al. 1982). Whitefly-induced economic losses to cotton occur as a result of reduced cotton yield (Mound 1965) and contamination of lint with honeydew and sooty molds (Davidson et al. 1994). The whitefly-transmitted cotton leaf crumple disease, caused by cotton leaf crumple geminivirus (CLCV), can also cause extensive reduction in yield (Dickson et al. 1954, Duffus and Flock 1982). In the Imperial Valley, California, high sweetpotato whitefly densities in 1981 resulted in an estimated $4 million loss to the cotton crop (Natwick 1983). The newly described species, silverleaf whitefly, *B. argentifolii* Bellows and Perring, (Bellows et al. 1994) caused severe economic losses to cotton and other crops in the United States in 1991 with conservative estimates of direct dollar losses exceeding $200 million. The 1991 direct dollar loss to cotton producers in the Rio Grande Valley of Texas was more than $80 million (Henneberry 1993). The Imperial Valley, CA direct dollar losses to all crops, including cotton, exceeded $120 million (Perring et al. 1991).

Chemical controls are providing temporary control of this pest (e.g. Chu et al. 1993 and Natwick 1993), however, a long term solution that offers economical and environmental advantages is needed. With the concept of integrated pest management, breeding and selection to develop insect-resistant cultivars is a goal that warrants increased attention (Painter, 1951, Khalifa and Gameel 1983). The objectives of this study was to evaluate cotton lines for resistance to silverleaf whitefly and for resistance to CLCV.

## Material and Methods

The study was conducted in 1997 at the University of California Desert Research and Extension Center in Holtville, CA. The experimental design was a randomized complete block with six replicates. Each plots was 14 m long and 1 m wide. Rows were 1 m apart. Seeds of six cotton genotypes were sown and irrigated on 27 March 1997. The cultivar and seed-lines were Texas 121, C118-2-93, C95-2103, C95-383, C95-3109, and C95-483. There were no insecticide spray treatments applied to the plots.

Whitefly adults were sampled from five plants in each plot on each sampling date using the leaf turn method (Naranjo & Flint 1995). Leaf samples were taken weekly from 16 June through 11 August 1997. Whitefly eggs and nymphs were counted on single leaf disks of 1.54 $cm^2$ from each of ten $5^{th}$ node leaves per plot. Trichomes were also counted from single leaf disks on 16 June, 1997.

Disease symptom ratings for CLCV (1= no symptoms, 2= mild leaf crumpling, 3= moderate leaf crumpling, and 4= severe leaf crumpling) were taken on 7 and 18 August. Leaf and petiole samples from each plot were sent to the Plant Pathology Department at UC Davis to confirm the presence of CLCV by squash and dot blot hybridization with a general DNA probe, which detects the presence of whitefly transmitted geminiviruses (Gilbertson et al. 1991).

Ginstar® EC was applied at 8 oz/acre on 19 August to defoliate the plots. Seed cotton was hand picked from 4-m sections of row in each plot on 3 September 1997. Weights of seed cotton sample were recorded and the samples were ginned. Weights of lint samples were recorded, percentages of lint turnout were calculated, and lint samples are being analyzed for percent reducing sugars (Perkins 1993) and lint stickiness using the thermodetector technique (Perkins and Brushwood 1995).

Seasonal whitefly density, CLCV ratings, percent reducing sugar and lint stickiness were analyzed using ANOVA (MSTAT-C 1989). Percentage of parasitism was transformed using the arcsine transformation for percent

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data. Student-Neuman-Keul's Multiple Range Test (SNKMRT) was employed for means separations.

## Results and Discussion

Silverleaf whitefly nymphs were being parasitized by *Eretmocerus* spp. by mid-July, Table 1. There were no differences among the cotton lines for percentage of parasitism on any of the sampling dates except 28 July when C95-2103 had a parasitism percentage of 52.8 which was greater than C95-483 with a parasitism percentage of 26.6, $P \leq 0.05$.

There were no differences among the cotton lines for seasonal adult means and only C95-3109 (22.3 eggs/cm$^2$) differed from C95-483 (14.5 eggs/cm$^2$) for density of whitefly eggs, $P \leq 0.05$ (Table 2). The cotton line C95-483 had fewer whitefly nymphs than C95-3109 and C118-2-93, and C95-2103 had fewer nymphs than C118-2-93, $P \leq 0.05$.

The cotton line C95-483 had the highest density of trichomes, significantly more than C95-2103. The cultivar, Texas 121, and cotton lines in this study were all smooth, normal-leaf genotypes. Trichome densities were not correlated to densities of whitefly adults and nymphs, but there was a significant correlation of trichome density to egg density (r= 0.349, P= 0.037), Table 3.

Texas 121 had a seed cotton yield of 2621.5 pounds per acre, which was lower than all other entries in the study, $P \leq 0.05$, Table 4. There were also differences in percentages of lint turnout after the seed cotton was ginned. C95-383 had a percentage of lint of 41.2 which was greater than all other entries, $P \leq 0.05$. C118-2-93 and C95-2103 each had lint turnout percentages of 37.5 which were significantly lower than all other entries.

Squash and dot blot analysis of leaf and petiole samples, collected in August, verified that cotton plants in the plots were infected with a whitefly-transmitted geminivirus (DNA sequencing of a polymerase chain reaction amplified fragment from an infected plant confirmed that the geminivirus was CLCV). The cotton line C118-2-93 had more severe CLCV symptoms than all other entries and Texas 121 CLCV symptoms were more severe than C95-3109, C95-2103 and C95-383 on 7 August ($P \leq 0.05$), Table 5. C118-2-93 had more severe CLCV symptoms than C95-3109, C95-2103 and C95-383 on 18 August and for the means of the two sampling dates. The cotton lines C95-2103 and C95-383 expressed the least severe CLCV symptoms with significantly lower ratings than C118-2-93, Texas 121 and C95-483 for the means of the two sampling dates.

Differences in cotton cultivar susceptibility to whitefly colonization have been reported for different cotton species (Natwick et al. 1995), differences in leaf pubescence (Norman and Sparks 1997), and leaf shape (Butler and Wilson 1984). The cotton lines in this study were all smooth leaf and therefore, it is not surprising to find few differences in whitefly densities related to leaf pubescence, even though the cotton line with the greatest trichome density also had the lowest density of whitefly stages. Butler et al. (1991) suggested that glabrous, small leaf area and open canopy cottons, and gossypol content were important traits that should be investigated for developing whitefly resistant cottons. The lines C95-2103 and C95-383 may have some heritable traits for CLCV resistance that should be investigated for developing CLCV-resistant cotton varieties.

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Table 1. Percentage of parasitism of silverleaf whitefly by *Eretmocerus* spp. on cotton varieties not treated with insecticides at Holtville, CA, 1997.

| Variety | 14 Jul | 21 Jul | 28 Jul | 4 Aug | 11 Aug |
|---|---|---|---|---|---|
| Texas 121 | 17.6 a | 32.7 a | 46.2 | 29.4 a | 26.9 a |
| C118-2-93 | 11.5 a | 30.0 a | 38.4 | 29.3 a | 21.8 a |
| C95-2103 | 15.5 a | 24.9 a | 52.8 a | 21.8 a | 17.3 a |
| C95-383 | 20.8 a | 34.1 a | 42.6 | 24.1 a | 25.8 a |
| C95-3109 | 7.1 a | 29.8 a | 34.9 | 21.6 a | 20.8 a |
| C95-483 | 15.7 a | 22.5 a | 26.6 b | 17.1 a | 24.6 a |

Mean separations within columns by Student-Newman-Keul's Multiple Range Test, $P \leq 0.05$.

Table 2. Silverleaf whitefly seasonal means as adults per leaf and as eggs and nymphs per $cm^2$, and trichomes per $cm^2$ of leaf for cotton varieties, Holtville, CA, 1997.

| Variety | Adults[a] | Eggs[a] | Nymphs | Trichomes/$cm^2$ |
|---|---|---|---|---|
| C95-3109 | 4.9 a | 22.3 a | 14.5 ab | 1.38 ab |
| C118-2-93 | 4.0 a | 19.9 ab | 16.6 a | 1.20 ab |
| Texas 121 | 3.8 a | 19.3 ab | 14.0 abc | 0.77 ab |
| C95-383 | 3.7 a | 17.9 ab | 13.9 abc | 0.90 ab |
| C95-2103 | 3.2 a | 19.4 ab | 12.8 bc | 0.48 b |
| C95-483 | 3.0 a | 14.5 b | 11.0 c | 1.68 a |

[a] Square root transformed data used for analysis; reverse transformed means reported. Mean separations within columns by Student-Newman-Keul's Multiple Range Test, $P \leq 0.05$.

Table 3. Correlation coefficients among whitefly adults, eggs, and nymphs, and density of trichomes of six cotton varieties in Holtville, CA in 1997.

| Whitefly stage | Trichomes per $cm^2$ |
|---|---|
| Adults | 0.248 |
| Eggs | 0.349 * |
| Nymphs | 0.279 |

* denotes significant at $P \leq 0.05$.

Table 4. Seed cotton as kilograms per hectare and pounds per acre, lint as pounds per acre, and percentages of lint turnout, Holtville, CA, 1997.

| Variety | Kg seed cotton/hectare | Lb seed cotton/acre | Lb lint/ acre | Lint % Turnout |
|---|---|---|---|---|
| C118-2-93 | 4241.5 a | 3784.2 | 1419.1 | 37.5 c |
| C95-383 | 3799.4 a | 3389.8 | 1395.6 | 41.2 a |
| C95-3109 | 3792.3 a | 3383.5 | 1325.3 | 39.2 b |
| C95-483 | 3765.1 a | 3359.2 | 1332.6 | 39.7 b |
| C95-2103 | 3425.1 a | 3055.8 | 1145.9 | 37.5 c |
| Texas 121 | 2621.5 b | 2338.9 | 923.9 | 39.5 b |

Mean separations within columns by Student-Newman-Keul's Multiple Range Test, $P \leq 0.05$.

Table 5. Cotton Leaf Crumple Virus Ratings, Holtville, CA, 1996.

| Variety | 7 August | 18 August | Mean |
|---|---|---|---|
| C118-2-93 | 1.92 a | 2.83 a | 2.38 a |
| Texas 121 | 1.58 ab | 2.17 ab | 1.88 ab |
| C95-483 | 1.42 bc | 2.25 ab | 1.83 ab |
| C95-3109 | 1.08 c | 1.83 b | 1.46 bc |
| C95-2103 | 1.00 c | 1.33 b | 1.17 c |
| C95-383 | 1.00 c | 1.25 b | 1.13 c |

Mean separations within columns by Student-Newman-Keul's Multiple Range Test, $P \leq 0.05$.