SILVERLEAF WHITEFLY COLONIZATION AND LEAF SHAPE AND VASCULAR BUNDLES RELATIONSHIPS IN COTTON

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Abstract

Okra-leaf cultivars and lines were colonized with fewer whitefly, *Bemisia argentifolii* Bellows and Perring, adults, eggs and nymphs compared to normal-leaf cultivars. The distance from underleaf surfaces of cotton leaves to the centers of nearest minor vascular bundles was negatively correlated with adult, egg and nymphal densities on leaves for all genotypes with exception of the Australian breeding line 89013-114. Our results suggest that okra-leaf and distance from underleaf surfaces to the center of nearest minor vascular bundles of cotton leaves are genetic traits that have potential for breeding whitefly resistant upland cotton cultivars.

Introduction

Differences in cotton plant susceptibility to colonization by silverleaf whiteflies have been reported between upland, *G. hirsutum* L., and Pima, *G. barbadense* L., cotton cultivars (Natwick et al. 1995) and between different upland cotton cultivars (Chu et al. 1998). These differences have been attributed to leaf hairiness, (Butler et al. 1991, Flint & Parks 1990, Norman & Sparks 1997), and to differences in leaf shapes, i.e., okra-leaf genotypes (Berlinger 1986). Our studies were conducted to determine the relationships between cotton leaf shape and depth of vascular bundles in leaf tissues and silverleaf densities in selected United States Deltapine (DPL) and Australian upland cotton cultivars and breeding lines.

Materials and Methods

The study was conducted at the University of California Desert Research and Extension Center at Holtville, California in 1996. The experimental design was a randomized complete block with four replicates. The cotton cultivars and breeding lines studied were United States normal-leaf cultivars, Deltapine (DPL) numbers 20, 50, 90, 5415, 5432, 5461, 9050, and 9057. The Australian entries were normal-leaf CS 50, and Australian okra-leaf cultivars and breeding lines 87031-126, 89013-114, Siokra 1-4/69, Siokra L23 and Siokra V-15. The Deltapine entries and the Australian entry CS 50 are all smooth leaf or low trichome density cultivars but are not glabrous. The other Australian entries are okra-leaf cultivars all of which are also smooth leaf with the exception of 87031-126 which is slightly closer to glabrous. Each plot was 14 m long and 8 m wide. Rows were 1 m apart. Cotton seeds were planted and irrigated for germination on 20 March 1996. No insecticides were applied during the cotton growing season. Leaves for all parameters measured were of the same age.

Whitefly adults were counted on 5th main stem node leaves on each of five separate plants in each plot from June to July for 7 sample days in 1996, using the leaf turn method (Naranjo & Flint 1995). Five 5th main node leaves were also picked from separate plants in each plot for counts of eggs and nymphs. Counts were made with the aid of a microscope on two 1.25 cm^2 leaf disks from each leaf (Naranjo & Flint 1994). Leaf trichomes were counted on 4 June from plants grown in 1997 when plants were at the 6-7 leaf stage and again on 18 August when plants were fully grown. Numbers of trichomes were counted on ten 1.25 cm^2 leaf disks, one leaf disk from each of the 5th main stem node leaves from each sampled plant.

A 5th main stem node leaf was taken from a plant in each plot of two replicates for histological examination using the procedure described earlier (Cohen et al. 1996a). The three best slide preparations were selected for measurements of leaf thickness, underleaf epidermal cell layer thickness, and distance from underleaf surface to the center of the nearest minor vascular bundle. We define the minor vascular bundles as those with 1 to 3 xylem elements (Cohen et al. 1996a).

Results and Discussion

Okra-leaf genotypes as a group had significantly lower whitefly numbers than normal-leaf genotypes. The overall seasonal mean numbers of adults per leaf, eggs and nymphs per cm^2 leaf disk were 47.3, 44.3 and 32.4, respectively, for the normal-leaf cultivars, compared with 28.7, 25.5 and 18.0, respectively, for the okra-leaf cultivars, suggesting that some okra-leaf cultivars and breeding lines were less susceptible to whitefly colonization compared with the normal-leaf cultivars (data not tabulated). For comparisons between individual entries, normal-leaf cultivars DPL 5432 and 9050 but not other normal-leaf cultivars had higher numbers of adults compared to okra-leaf entries (Table 1). DPL 5432 and 9050 had higher numbers of eggs and nymphs compared to okra-leaf 87031-126 and Siokra L23.

The distance (mm) from underleaf surfaces to the center of nearest minor vascular bundles for genotypes in descending order were 94.2 (Siokra L-23), 92.5 (87031-126), 86.6 (DPL 20), 85.4 (CS 50), 77.9 (Siokra 1-4/69), 77.8 (DPL 90), 73.3 (DPL 5461), 77.1 (DPL 50), 70.3 (DPL 5432), 66.7 (DPL 5415), 66.6 (DPL 9057), 65.4 (Siokra V-15), 59.2 (DPL 9050), and 41.5 (89013-114). This leaf characteristic may be important for whitefly survival because of their underleaf habitat (Chu et al. 1995) and their restrictive feeding preference for minor vascular bundles (Cohen et al. 1996a & 1996b). When the Australian breeding line 89013-114, which had an exceptionally low underleaf surface to vascular bundle distance, was excluded from the regression analyses, statistically significant relationships for adults/leaf ($R^2 = 0.653$ and $P = 0.001$), eggs ($R^2 = 0.496$ and $P = 0.006$) and

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nymphs/cm^2 of leaf disk($R^2 = 0.372$ and $P = 0.025$) (N = 13 for all cases) occurred. Leaf thicknesses ranged from 190.0 mm (89013-114) to 283.3 mm (Siokra V-15). The distances from underleaf surfaces to the centers of nearest minor vascular bundles and leaf thickness were significantly correlated ($R^2 = 0.845$, $P < 0.001$, and N = 14).

Seed cotton yields, without whitefly insecticide control, ranged from 577 (DPL 9050) to 1509 kg/ha (DPL 50) (Table 1). The only statistically significant yield difference occurred between the DPL 50 and DPL 9050.

Seed cotton yields were negatively related to mean numbers of adults per leaf and mean numbers of eggs/cm^2 of leaf disk ($R^2 = 0.328$, $P = 0.032$ and $R^2 = 0.288$, $P = 0.048$, N = 14, respectively), but less well related to mean numbers of nymphs/cm^2 of leaf disk ($R^2 = 0.229$, $P = 0.083$, N = 14). The results suggest that cotton yields are also influenced by other environmental factors. Whitefly densities in the present study could be attributed to less than one third of the yield variability.

Our results have indicated two genetic traits that should be examined as potential means to increase whitefly resistance in cotton. Okra-leaf cultivars have been associated with resistance to a range of pests including twospotted spider mite, *Tetranychus utricae* (Koch) (Wilson 1994). Sippell et al. (1983) found that the okra- and super-okra-leaf genotypes were resistant to sweetpotato whiteflies. In the United States, nymphal (Flint & Parks 1990) or adult (Butler & Wilson 1984) densities on the okra-leaf line WC-12NL were not significantly different compared with normal-leaf DPL 61 cultivars. This may indicate that whitefly resistance in okra-leaf cotton may be influenced by other factors than leaf shape and/or other variables. Our results also suggest that the distance from the underleaf surface to the center of nearest minor vascular bundles is a genetic trait that may reduce susceptibility to whitefly colonization. This appears to be explained by the fact that successful feeding can be accomplished only when stylets are longer than the distance from the underleaf surface to a minor vascular bundle. Using the 65 mm distance as the threshold stylet length (Cohen et al. 1996b), DPL 9050 would probably be more susceptible to whiteflies compared with those where the underleaf surface to minor vascular bundle distance exceed 65 mm. Siokra V15 and 89013-114 would be more susceptible, however, the okra-leaf shape character may compensate for the disadvantage of shorter distances from underleaf surface to the minor vascular bundles. The reduced leaf area of okra-leaf surfaces probably results in reduction of protected sites for whitefly oviposition on the underleaf surfaces of leaves. It appears unlikely that silverleaf whitefies will readily adapt longer stylet lengths to feed in cottons where the distances to minor leaf vascular bundles are longer than their stylets.

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Table 1. Mean cotton lint yields and numbers of silverleaf whitefly adults per leaf-turn, and eggs and nymphs per square centimeter leaf disk on fifteen upland cotton cultivars studied at Holtville, CA in 1996.

Cultivars	Leaf shape	Lint yield (kg/ha)	No. Adults/ leaf-turn	No./cm^2 leaf disk Eggs	Nymphs
DPL 20	Normal	1540 ab[a]	32.3 c	37.3 ab	28.1 ab
DPL 50	Normal	1617 a	38.2 c	45.8 ab	32.7 ab
DPL 90	Normal	1183 ab	30.2 c	35.5 ab	29.9 ab
DPL 5415	Normal	1509 ab	52.1 bc	39.2 ab	31.5 ab
DPL 5432	Normal	760 ab	73.7 ab	57.7 a	37.8 a
DPL 50	Normal	1617 a	38.2 c	45.8 ab	32.7 ab
DPL 5461	Normal	770 ab	39.6 c	47.2 ab	30.9 ab
DPL 9050	Normal	577 b	86.1 a	58.6 a	38.3 a
DPL 9057	Normal	1091 ab	44.1 bc	43.9 ab	31.1 ab
CS 50	Normal	865 ab	29.3 c	34.7 ab	31.5 ab
87031-126	Okra	1353 ab	10.6 c	18.2 b	12.2 b
89013-114	Okra	1164 ab	39.9 c	30.3 ab	21.1 ab
Siokra 1-4/649	Okra	1424 ab	36.8 c	36.6 ab	24.4 ab
Siokra L23	Okra	1315 ab	19.4 c	16.0 b	14.4 b
Siokra V-15	Okra	1322 ab	36.7 c	26.5 ab	17.7 ab

[a] Means ± std in column with different letters differ significantly (Student-Neuman-Keul's Multiple Range Test, $P = 0.05$).