2002 BELTWIDE COTTON CONFERENCES, ATLANTA, GA – JANUARY 8-12

SILVERLEAF WHITEFLY RESISTANCE IN THE COTTON RELATIVE, *GOSSYPIUM THURBERI*

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Abstract

Three cotton, *Gossypium hirsutum* L., cultivars and the cotton relative, *G. thurberi,* were evaluated in the field for resistance to the silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring, in Imperial Valley, CA. The cultivars were DP 5415, Siokra L23 and Stoneville 474. Trial entries were evaluated for colonization by silverleaf whitefly as numbers of adult, eggs, and nymphs. In the field trial,*G. thurberi* was favored by silverleaf whitefly on potted green house grown seedlings over upland cotton entries. In field trials, *G. thurberi* had very low numbers whitefly adults eggs and nymphs, followed by Siokra L23, DP 5415 and Stoneville 474. In contrast, in a greenhouse trial on potted seedlings, silverleaf whitefly had higher nymphal survival and shorter development time on *G. thurberi* compared to DP 5415. Further studies are needed to determine why *G. thurberi* is so resistant to silverleaf whitefly resistance in the field, while it is more susceptible than commercial cotton when tested as potted seedlings in the greenhouse.

Introduction

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). Whiteflies rank as one of the most important pests of cotton, especially in the arid southwest USA. The direct dollar loss to cotton producers in the Lower Rio Grande Valley of Texas was more than $80 million in 1991 and the direct dollar losses to cotton in Arizona in 1992 exceeded $100 million (Henneberry 1993). Whiteflies inflict three types of damage to cotton plants: direct feeding damage, transmission of viral diseases such as cotton leaf crumple, and sticky cotton which downgrades the value of the cotton due to problems it causes during processing. The greatest economic losses caused by whiteflies in the US are probably due to the latter problem, sticky cotton. Cotton growers in Southern California spend approximately $100 per acre for insecticidal control of whitefly annually (Mayberry et al. 2000). Host plant resistance, when available, is an economical and environmentally friendly method for pest control. Furthermore, host plant resistance is usually compatible with other components of an integrated pest management system such as pesticides or biological control, and generally host plant resistance does not interfere with control of other pests in the cropping system. Wilson et al. (1993) reported a high degree of resistance to whiteflies in the cotton relative, *Gossypium thurberi*.*G. thurberi* has been successfully crossed with commercial cotton in the past (Fryxell 1976), and therefore could serve as a source of whitefly resistance genes that could be introduced into commercial cotton. The study presented here was initiated to verify the results of Wilson (1993) and to determine the degree of resistance of G.thurberi to silverleaf whitefly.

Material and Methods

A field study was conducted in 2001at the University of California Desert Research and Extension Center in Holtville, CA. The experimental design was a randomized complete block with six replicates. Each plot was 3 m long and 2 m wide. There were two rows per plot. Seeds of the three upland cotton, *Gossypium hirsutum* L., cultivars were sown and irrigated on 21 March 2001. The cultivars were DP 5415 of Delta and Pine Seeds, Siokra L23 of Cotton Seed Distributors Ltd. of Australia, and Stoneville 474 of Stoneville Pedigree Seed Company. *G. thurberi* seedlings were transplanted into plots 18 April 2001. There were no insecticide spray treatments applied to the plots.

Whitefly adults were sampled from ten plants in each plot semi-monthly from 5 July through 18 September 2001, using the leaf turn method (Naranjo & Flint 1995). Samples of ten 5^{th} node leaves per plot were excised from plants at random on the same dates adult whitefly counts were taken. Whitefly eggs and nymphs were counted on single leaf disks of 1.65 cm^2 taken from the lower left quadrant from each of the ten leaves per plot. Seasonal mean whitefly density for adults, eggs and nymphs were analyzed using ANOVA (MSTAT-C 1989). Student-Neuman-Keul's Multiple Range Test (SNKMRT) was used for means separations.

A greenhouse study was conducted at the University of California, Riverside campus. Greenhouse grown plants were used for experiments comparing nymphal survival and development time on *G. thurberi* and DP 5415.

Nymphal survival studies were initiated with cohorts of eggs oviposited over a one day period. To obtain the cohorts of eggs, a new, partially expanded leaf from each plant (5 DP 5415 plants and 6 *G. thurberi* plants) was caged, and approximately ten pairs (male & female) of whiteflies were introduced into each cage. After one day, the adult whiteflies and cages were removed and the numbers of eggs counted. When the eggs were close to hatching (approximately 5-6 days later), the infested leaves were then examined every 2-3 days. As eggs hatched and first instar nymphs settled, the leaves were mapped to record the position of every first instar nymph. Each individual nymph received a unique identification number on the map, and its fate was followed at 2-3 day intervals through death or adult emergence. This allowed us to determine stage-specific mortality for each nymphal instar. This technique has been successfully used to construct life tables of silverleaf whitefly on poinsettia (Hoddle & Van Driesche 1996, Hoddle et al. 1996). A t-test for unequal variances was used for comparisons of silverleaf whitefly development time on *G. hirsutum* L. (DP 5415) versus *G. thurberi*.

Results and Discussion

The field experiment results suggest a high degree of whitefly resistance in *G. thurberi* (Table 1). The seasonal mean adult densities were 97-fold higher on Stoneville 474, 56-fold higher on DP 5415, and 37-fold higher on Siokra L23 than on *G. thurberi*. Seasonal mean densities for whitefly eggs were 750-fold higher on Stoneville 474, 198-fold higher on DP 5415, and 95-fold higher on Siokra L23 than on *G. thurberi*. Whitefly nymph seasonal mean densities were 284-fold higher on Stoneville 474, 66-fold higher on DP 5415, and 33-fold higher on Siokra L23 than on *G. thurberi*.

The green house results starkly contrast the field results. Silverleaf whitefly survivorship from first instar through adult was greater on *G. thurberi* 243/265 (92%) as compared to DP5415181/235 (77%) in the green house study, Fig. 1. Also, whitefly development time from egg to adult stage was shorter on *G. thurberi* as compared to DP 5415, Table 2. The contrasting greenhouse and field study results are believed to be due to the use of greenhouse grown seedling plants that had not hardened off. In the field study, *G. thurberi* plants were not attractive to whitefly adults; therefore difference between greenhouse results and field results may be due to antixenosis in the field grown *G. thurberi* plants.

Gossypium thurberi has an okra leaf shape whereas DP 5415 and Stoneville 474 have a normal leaf shape. The effect of okra leaf shape in cotton on susceptibility to whiteflies has been a topic in several studies, and results are mixed. In some studies, cotton cultivars with small sized leaves and/or deeply lobed "okra-type" leaves have been correlated with lower densities of *B. tabaci* and *Trialeurodes abutilonea*. (Haldeman) than occur on cultivars with larger, more typical cotton-shaped leaves (Berlinger 1986, Jones et al. 1974, Butler et al. 1988, 1991, dePonti et al. 1990, van Lenteren & Noldus 1990, Chu et al. 1999), while in other studies, slight effect, no effect, or even the opposite effect occurred (Butler & Wilson 1984, Butler et al. 1986, Sippell et al. 1987, Flint & Parks 1990, Natwick et al. 1995, Chu et al. 2000). It is possible that the difference in whitefly densities between *G. thurberi* and DP 5415 may be influenced by the difference in leaf shape between the two cottons. However, Siokra L23 also is an okra leaf cotton that was used for comparison to *G. thurberi*. While okra leaf shape may contribute to the whitefly resistance of *G. thurberi* comparisons with Siokra L23 clearly shows *G. thurberi* has very strong resistance factors in addition to okra leaf shape.

A well-established plant trait associated with variability in susceptibility to whiteflies is leaf pubescence. Smooth-leaf cotton varieties are less susceptible to attack by *Bemisia* than pubescent-leaf varieties (Pollard & Saunders 1956, Mound 1965, Butler & Muramoto 1967, Butler & Henneberry 1984, Butler & Wilson 1984, Bindra 1985, Ozgur and Sekeroglu 1986, Butler et al. 1986, 1988, 1991, Flint & Parks 1990, Wilson et al. 1993, Flint et al. 1994, Watson et al. 1994, Norman et al. 1995, Norman & Sparks 1996, 1997). Although lower whitefly densities on smooth leaf cotton than on hairy leaf cotton have been well established, the difference in susceptibility is relative, and even the smooth leaf cultivars are not very resistant. *G. thurberi* is indeed a smooth leaf cotton, but so is DP 5415. Therefore, while lack of leaf pubescence may contribute to the whitefly resistance of *G. thurberi*, comparisons with other smooth leaf cottons, DP 5415 and Siokra L23 clearly shows *G. thurberi* has very strong resistance factors in addition to smooth leaf.

A very relevant question is "what is the likelihood of introducing whitefly resistance genes from *G. thurberi* into commercial cotton?" Although both upland and Pima cottons are tetraploid and *G. thurberi* is diploid (Fryxell 1979), breeding programs in the past have successfully introduced genes from *G. thurberi* into upland cotton (Fryxell 1976). New advances in genetic engineering should only increase the likelihood of introducing more *G. thurberi* genes into commercial cotton in the future. To facilitate this transfer of genes, either through classical plant breeding or genetic engineering, we must elucidate the mechanisms of whitefly resistance in *G. thurberi*.

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Table 1. Silverleaf whitefly seasonal means for adults per leaf and whitefly eggs and nymphs per cm^2 of leaf for cotton varieties, Holtville, CA, 2001.

Variety	Adults	Eggs	Nymphs[z]
Stoneville 474	9.7 a	150.1 a	85.1 a
DP 5415	5.6 b	39.6 b	19.9 b
Siokra L23	3.7 c	19.1 c	9.8 c
G. thurberi	0.1 d	0.2 d	0.3 d

[z] Log 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 2. Silverleaf whitefly development time as the number of days from egg to adult.[z].

Entry	mean (days)	standard deviation	standard error	n	median (days)
DP5415	27.7	12.9	0.96	182	22
G. thurberi	19.5	2.6	0.17	244	18

[z] t-test (unequal variances)T=8.43; P < 0.0001.

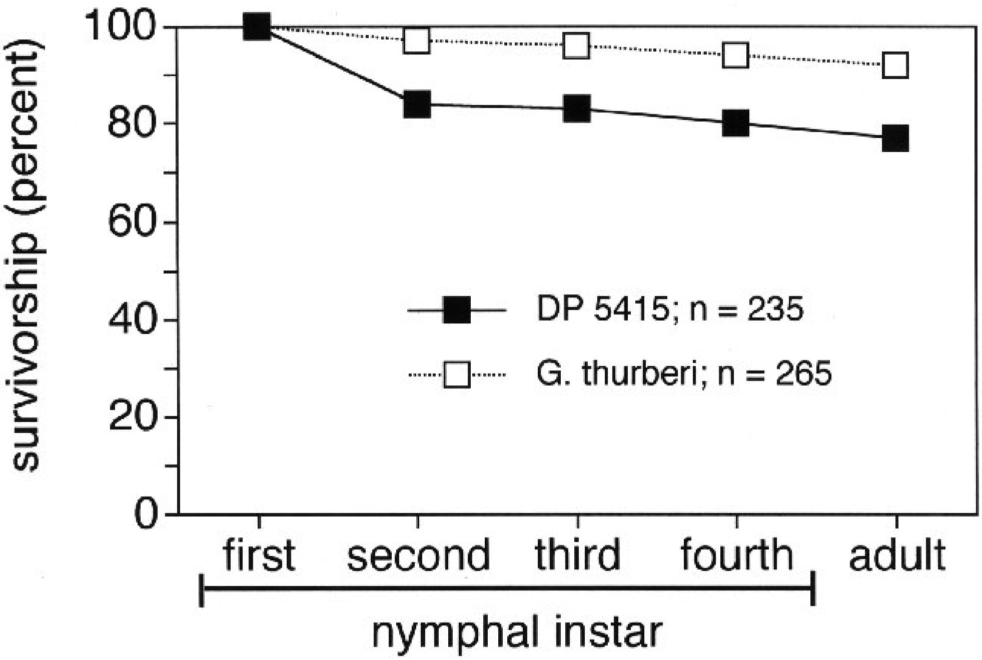

Figure 1. Silverleaf whitefly stage-specific survival on DP 5415 cotton and on *G. thurberi*.