Silverleaf Whitefly and Cotton Lint Stickiness

T. J. Henneberry[1], L. Forlow Jech[1], D. L. Hendrix[1], H. H. Perkins[2], and D. E. Brushwood[2]

[1] *USDA-ARS, Western Cotton Research Laboratory, Phoenix, AZ*
[2] *USDA-ARS, Cotton Quality Research Station, Clemson, SC*

Abstract

Cotton plant densities of 10 or 40 thousand plants/acre had no effect on numbers of silverleaf whitefly, Bemisia argentifolii Bellows and Perring, adults, eggs, nymphs, extracted sugars from lint samples or thermodetector sticky cotton counts. Higher numbers of whiteflies occurred in early-season in Pima S-7 cotton than in DPL 50 or DPL 5415 cotton. Seasonal averages for sugars, percentages of total reducing sugars and thermodetector counts were higher for DPL 50 compared with Pima S-7 but not DPL 5415. Insecticide treatments reduced thermodetector counts and associated sugars extracted from lint.

Introduction

Whitefly infestations in cotton often result in localized honeydew deposits on lint of open cotton that adheres to machinery surfaces during harvest, ginning, and lint processing (Bourley et al. 1984, Khalifa and Gameel 1982, Miller et al. 1994, Carlson and Mohamed 1986). The cotton lint stickiness problem is of most concern at the textile mill (Hector and Hodkinson 1989). Numbers of silverleaf whiteflies approaching epidemic proportions have occurred in cotton in some years in CA, AZ, and TX since 1986 (USDA 1995, 1996).

Henneberry et al. (1995, 1996) found that trehalulose and melezitose produced by *Bemisia* spp., and certain other honeydew sugars (fructose and glucose) not specific to *Bemisia*, but found in cotton plants, were significantly correlated to increasing cotton stickiness. Henneberry et al. (1996) also reported that trehalulose and melezitose accumulated in cotton lint in open bolls with increasing exposure in silverleaf whitefly infested cotton fields. Rainfall reduced amounts of all sugars found in lint and cotton stickiness. Although, the possibility of developing enzymes that hydrolyze honeydew sugars on cotton lint appears promising (Hendrix et al. 1993), the sticky cotton problem remains a serious issue in the textile industry.

In 1995, we conducted studies to further define whitefly population development on long- and short-staple cotton cultivars and determine the influence of plant density and insecticides on whitefly populations and sticky cotton.

Materials and Methods

Deltapine (DPL) 5415 and DPL 50, *Gossypium hirsutum* L., and Pima S-7, *G. barbadense* L., cotton seeds were planted 11 April 1995 in a four replicate split-split plot experimental design. Cultivars were main plots, plant densities of 10 or 40 thousand per acre were split plots and insecticide-treated and untreated units were split-split plots. Individual plots were 6 rows wide, rows 40" apart and 70' long. Insecticide applications were made with a high clearance ground sprayer when the need was determined by the University of Arizona's Maricopa Agricultural Center pest control advisor. This generally occurred when adult whitefly levels were ≅ 5 to 10 per leaf using the method of Naranjo and Flint (1995). For insecticide-treated plots, imidacloprid (Pravado®, Miles Inc., Kansas City, MO) at the rate of 3.75 oz. per acre was applied on 25 July, 2 August, and 6 September, Bifenthrin (Capture®, FMC Corp., Philadelphia, PA) plus acephate (Orthene® 755, Valent Corporation, Walnut Creek, CA) at 4 oz. (AI/A) and 3/4 lb. (AI/A), respectively on 8 and 22 August. Additionally, all plots were oversprayed with Lorsban (LOCKON®, Dow Elanco, Indianapolis, IN) at 1.5 pints AI/A plus acephate (3/4 lb. AI/A) on 31 July, 22 and 29 August for lepidopterous pests. Cotton defoliant was applied to all plots on 13 September.

Adult whiteflies were sampled weekly from 27 June to 11 September using the binomial sampling method of Naranjo et al. (1994b) and Naranjo and Flint (1995). Eggs and immatures were counted on 3.88 cm^2 leaf disks from 15 leaves taken on the same dates from the fifth node from the terminal of sampled plants (Naranjo and Flint 1994a). Immature life stages are presented as numbers per cm^2 of leaf area.

Cotton lint stickiness data was obtained weekly from 20 boll (29 August to 20 September) samples of seed cotton hand-picked from all plots. All cotton samples were ginned and lint and seed weighed. Lint samples were analyzed for percentages of total reducing sugars by the method of Perkins (1993) and lint stickiness by the thermodetector method of Brushwood and Perkins (1993). All determinations were done at the USDA-ARS Cotton Quality Research Station, Clemson, SC. Thermodetector analysis is accomplished by spreading 2.5 g lint samples between aluminum foil sheets followed by heating under pressure. Aluminum foil sheets are separated and the number of sticky spots counted. Less than 5 sticky spots indicates nonsticky cotton, 5 to 14, light stickiness, 15-24, moderate stickiness and above 24, heavy stickiness (Perkins and Brushwood 1995). The individual sugars and amounts of trehalulose, melezitose, fructose and glucose were determined by the High Performance Liquid Chromatography methods of Hendrix and Wei (1992).

Results

General - plant density. Densities of 10 or 40 thousand plants per acre had no statistically significant effects on silverleaf whitefly adults, eggs, or nymphs. Similarly, there were no effects of plant density on percentages of total reducing sugars, trehalulose, melezitose, fructose, glucose, or thermodetector counts. There also were no significant interactions for plant density and cultivars or insecticide-treated and untreated cottons. Thus for these tabulated data, plant densities were averaged with cultivar and insecticide-treated and untreated plot data.

Whitefly adults and nymphs. Populations in untreated plots of all cultivars increased slowly through mid-August and rapidly thereafter to mid-September (Figures 1 and 2). Populations in all insecticide-treated plots were significantly reduced compared with untreated plots.

Cotton lint sugars and stickiness - weekly 20 boll cotton samples. Over all sampling date percentages of total reducing sugars and thermodetector counts were higher for DPL 50 than for Pima S-7 and DPL 5415 cotton lint (Table 2). Amounts of trehalulose, melezitose, glucose and fructose from DPL 50 cotton lint were also significantly higher than from Pima S-7 cotton, but not DPL 5415 cotton except for fructose. Percentages of total reducing sugars, trehalulose, melezitose, and fructose but not glucose and thermodetector ratings were significantly higher for lint samples from untreated cotton plots compared with insecticide-treated plots. There was no significant interaction between cultivars and insecticide-treated-untreated cotton. Trehalulose increased with each sampling date from 29 August to 20 September. Results for 29 August compared to 5 September were not statistically different. For melezitose, there were no significant differences between 29 August, 5 or 13 September lint samples but, in each case, amounts were significantly lower compared with 20 September lint samples. The highest amount of glucose occurred on 5 September which was significantly different compared with 29 August and 13 September but not 20 September. The highest amount of fructose occurred on 29 August. Percentages of total reducing sugars increased from 29 August to 20 September.

Amounts for 5 and 13 September samples were not significantly different. Thermodetector counts increased significantly from 29 August to 5 September, but were not significantly different thereafter.

Discussion

Adult silverleaf whitefly populations were higher on Pima S-7 cotton through 7 August compared with DPL 50 and DPL 5415. Results became variable thereafter and reversed in some instances. Results were similar for silverleaf whitefly eggs and nymphs up to 10 July. Natwick et al. (1995) also reported higher whitefly populations on Pima vs. upland cotton in three of four experiments. Although these results have generally suggested that higher whitefly populations occur on Pima vs. upland cottons, other investigations have reported higher populations on upland vs. *G. barbadense* cultivars (Khalifa and Gameel 1982). The differences in results remain unexplained but may be related to whitefly population densities, variations in susceptible or resistant characteristics within species, or different environmental or crop production methods. The variation in susceptibility within and between cottons does however suggest the possibility of plant breeding and/or molecular biology approaches to develop cotton cultivars less susceptible to whitefly attack.

The results of the present study agree with those previously reported (Henneberry et al. 1995) regarding the lack of effect of plant density on whitefly populations and lint stickiness associated with honeydew sugars. Also in these studies cotton lint stickiness was reduced following insecticide applications. Cotton stickiness levels were below those of concern for textile mill processing. These results are consistent with our previous report for Arizona (Henneberry et al. 1995) but in contrast to the results in Imperial Valley, Southern California (Chu et al. 1994) where insecticide applications failed to reduce cotton stickiness below threshold levels. The different results appear related to differences in whitefly population densities.

Acknowledgment

The authors are extremely grateful for the assistance of Ed Holguin, Maria Gamez, Maria Panter and Regan Walker for assistance in data collecting.

References

Bourley, J., J. Gutknech, and J. Fournier. 1984. Etude chemique du collage des fibres de coton. lre, partie: Role des sucres et des miellats dans la processus du collage. Coton et fibres tropicales 39: 47-53.

Brushwood, D. E., and H. H. Perkins. 1993. Cotton stickiness potential as determined by minicard, thermodetector, and chemical methods, pp. 1132-1135. *In* D. J. Herber and D. Richter [eds.], Proc. Beltwide Cotton Prod. Res. Conf., National Cotton Council Am., Memphis, TN.

Carlson, G. A., and A. Mohamed. 1986. Economic analyses of cotton insect control in the Sudan Gezira. Crop Protection 5: 348-354.

Chu, C. C., T. J. Henneberry, D. H. Akey, and N. Prabhaker. 1994. A study on control action thresholds for *Bemisia tabaci* (Gennadius) on cotton, pp. 1239-1241. *In* D. J. Herber and D. A. Richter [eds.], Proc. Beltwide Cotton Prod. Res. Conf, National Cotton Council Am., Memphis, TN.

Hector, D. J., and I. D. Hodkinson. 1989. Stickiness in cotton. CAB. International, Oxon, UK, 43 pp.

Hendrix, D. L., B. Blackledge, and H. H. Perkins, Jr. 1993. Development of methods for the detection and elimination of insect honeydews on cotton fiber, pp. 1600-1602. *In* D. J. Herber, and D. A. Richter [eds.], Proc. Beltwide Cotton Res. Conf., National Cotton Council Am, Memphis, TN.

Hendrix, D. L., and Y. Wei. 1992. Detection and elimination of honeydew excreted by the sweetpotato whitefly feeding upon cotton, pp. 671-673. *In* D. J. Herber, and D. A. Richter [eds.], Proc. Beltwide Cotton Res. Conf., National Cotton Council Am, Memphis, TN.

Henneberry, T. J., D. L. Hendrix, H. H. Perkins, L. Forlow Jech, and R. A. Burke. 1996. *Bemisia argentifolii* (Homoptera: Aleyrodidae) honeydew sugars and relationships to sticky cotton. Environ. Entomol. 25: 551-558.

Henneberry, T. J., D. L. Hendrix, H. H. Perkins, S. E. Naranjo, H. M. Flint, D. H. Akey, L. Forlow Jech, and R. A. Burke. 1995. *Bemisia argentifolii* (Homoptera: Aleyrodidae) populations and relationships to sticky cotton and cotton yields. Southwestern Entomol. 20: 255-271.

Khalifa, H., and O. I. Gameel. 1982. Control of cotton stickiness through breeding cultivars resistant to whitefly, *Bemisia tabaci* (Genn.) infestation. Improvement of oil seed industrial crops by induced mutations, IAEA, Vienna, pp. 181-186.

Miller, W. B., M. E. Peralta, D. R. Ellis, and H. H. Perkins, Jr. 1994. Stickiness potential of individual insect honeydew carbohydrates on cotton lint. Test. Res. J. 64: 344-350.

Naranjo, S. E., and H. M. Flint. 1994a. Spatial distribution of preimaginal *Bemisia tabaci* (Homoptera: Aleyrodidae) in cotton and development of fixed-precision sequential sampling plans. Environ. Entomol. 23: 254-266.

Naranjo, S. E., and H. M. Flint, and T. J. Henneberry. 1994b. Progress in the development of sampling plans for *Bemisia tabaci:* Evaluation of binomial sampling methods, pp. 975-877. *In* D. J. Herber, and D. A. Richter [eds.], Proc. Beltwide Cotton Res. Conf., National Cotton Council, Memphis, TN.

Naranjo, S. E., and H. M. Flint. 1995. Spatial distribution of adult *Bemisia tabaci* (Homoptera: Aleyrodidae) in cotton and development and validation of fixed-precision sampling plans for estimating population density. Environ. Entomol. 24: 261-270.

Natwick, E. T. C. C. Chu, H. H. Perkins, T. J. Henneberry, and A. C. Cohen. 1995. Pima and upland cotton susceptibility to *Bemisia argentifolii* under desert conditions. Southwestern Entomol. 20: 429-438.

Perkins, H. H. Jr. 1993. A survey of sugars and sticky cotton test methods, pp. 1136-1141. *In* D. J. Herber, and D. A. Richter [eds.], Proc. Beltwide Cotton Res. Conf., National Cotton Council, Memphis, TN.

Perkins, H. H., Jr., and D. E. Brushwood. 1995. Interlaboratory evaluation of the thermodetector cotton stickiness test method pp. 1189-1191. *In* D. A. Richter and J. Armoor [eds.] Proc. Beltwide Cotton Prod. Conf., National Cotton Council, Memphis, TN.

USDA. 1995. Silverleaf Whitefly 1995 Supplement to the 5-Year National Research and Action Plan, T. J. Henneberry, N. C. Toscano, R. M. Faust, and J. R. Coppedge, [Eds.], USDA-ARS, U.S. Govt. Printing Office, Washington, D.C. 229 pp.

USDA. 1996. Silverleaf Whitefly 1996 Supplement to the 5-Year National Research and Action Plan for Development of Management and Control Methodology for Silverleaf Whitefly. T. J. Henneberry, N. C. Toscano, R. M. Faust, and J. R. Coppedge, [Eds.], USDA-ARS, U.S. Govt. Printing Office, Washington, D.C., 1996-01, 242 pp.

Table 1. Concentrations (mg/g of cotton lint) of sugars, percentages of total reducing sugars and thermodetector counts for 20 boll weekly cotton lint samples from insecticide-treated and untreated cotton plots.

Date/ Trtmt[a]	Trehalulose	Melezitose	Glucose	Fructose	% Total Reducing Sugars	Thermodetector Counts
Aug 29						
U	0.90 d	0.36 cd	0.30 b	0.65 ab	0.35 c	8.7 b
T	0.23 e	0.21 ef	0.36 ab	0.76 a	0.27 d	3.1 c
Sept 5						
U	1.34 c	0.43 bc	0.40 ab	0.47 bc	0.52 b	12.7 a
T	0.22 e	0.13 f	0.42 a	0.24 d	0.28 d	2.8 c
Sept 13						
U	1.83 b	0.47 b	0.32 ab	0.56 a-c	0.49 b	13.0 a
T	0.23 e	0.16 ef	0.29 b	0.24 d	0.23 d	2.4 c
Sept 20						
U	2.28 a	0.59 a	0.37 ab	0.63 ab	0.59 a	13.2 a
T	0.46 e	0.26 de	0.41 a	0.36 cd	0.34 c	3.8 c
Mean - dates						
Aug 29	0.56 c	0.29 b	0.32 bc	0.70 a	0.31 c	5.9 b
Sept 5	0.78 c	0.28 b	0.41 a	0.35 b	0.40 b	7.8 a
13	1.03 b	0.32 b	0.31 c	0.39 b	0.36 b	7.7 a
20	1.37 a	0.43 a	0.39 ab	0.50 b	0.47 a	8.5 a
Mean - insecticides						
U	1.59 a	0.47 a	0.35 a	0.58 a	0.49 a	11.9 a
T	0.28 b	0.19 b	0.37 a	0.40 b	0.28 b	3.0 b
Mean - cultivars						
Pima S-7	0.74 b	0.24 b	0.28 b	0.21 c	0.34 b	7.4 b
DPL50	1.09 a	0.38 a	0.42 a	0.81 a	0.44 a	8.6 a
DPL5415	0.98 a	0.37 a	0.38 a	0.44 b	0.38 b	6.4 b

[a] U = untreated, T= insecticide treated, means of 4 replications, 6 observations/replication for individual treatment dates, 4/replications for mean dates, 12 observations, 4/replications, 12 observations for insecticides and cultivars. Means within a group not followed by the same letter are significantly different $P \leq 0.05$. Method of least significant differences.

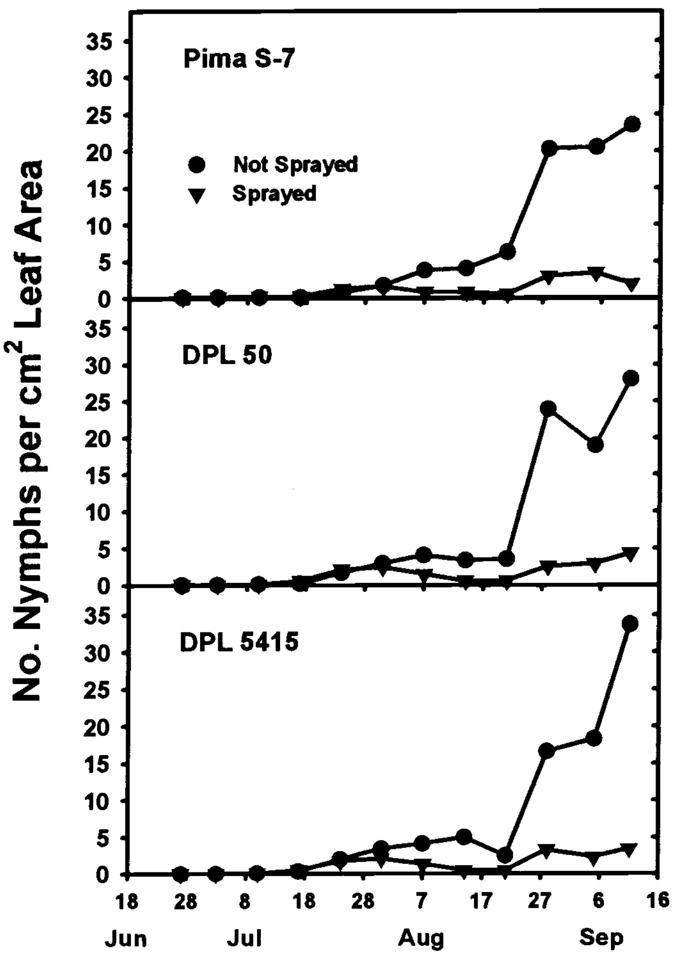

Figure 1. Number of adult whiteflies per leaf turn in 3 cultivars of cotton in Arizona in 1995.

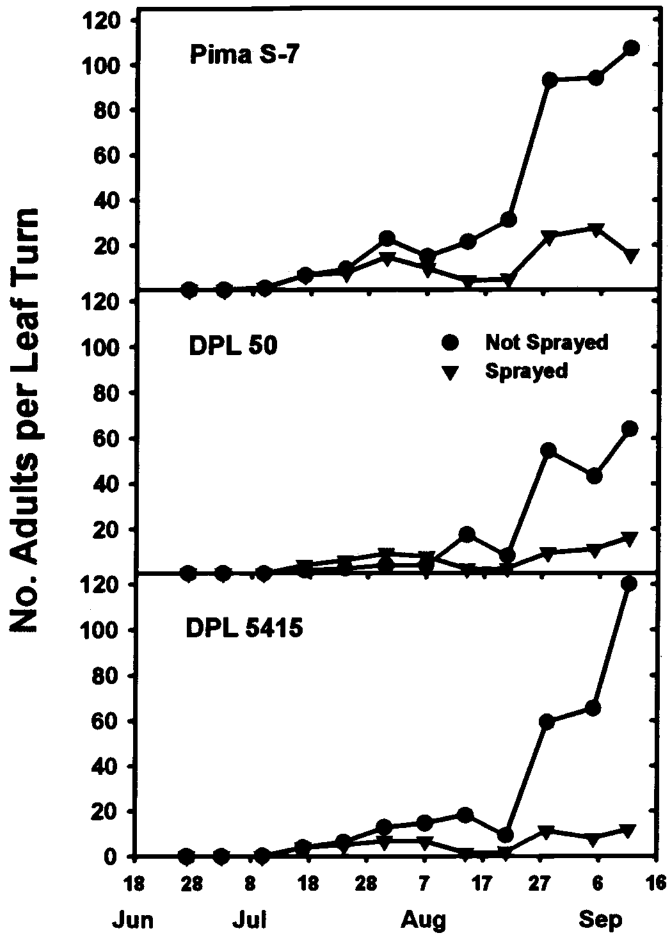

Figure 2. Number of whitefly nymphs per cm^2 leaf area in 3 cultivars of cotton in Arizona in 1995.