Host Preference Of Silverleaf Whitefly And Factors Associated With Feeding Site Preference

C. C. Chu, T. J. Henneberry, A. C. Cohen

USDA-ARS, Western Cotton Research Laboratory, Phoenix, AZ

Abstract

Silverleaf whitefly (SLW), Bemisia argentifolii, Bellows and Perring, preferred cantaloupe to cotton, broccoli and lettuce in field and greenhouse studies. In the absence of cantaloupe, SLW preferred cotton to broccoli and lettuce. In the field, more eggs and fewer nymphs were found on broccoli than on cotton. Differences in the relative abundance of vascular bundles per unit of leaf area between the four plant species may partly account for differences in oviposition site selection. Vascular bundle volume/unit of leaf tissue volume was 50% greater in cantaloupe than in cotton and broccoli, which in turn were significantly greater than in lettuce. Most SLW on cotton leaves are found on underside leaf surfaces. Distances from top and underside leaf surfaces to the nearest vascular bundles in cotton leaves were 131 and 60 μm, respectively, in the present studies.

Introduction

A new whitefly species commonly called the silverleaf whitefly (SLW) has an expanded host range and attacks most commercially grown crops as well as ornamentals and many weed hosts (Perring et al., 1993 and Bellows et al., 1994). This has made SLW particularly difficult to control (Butler et al., 1986). Arizona and California, sequential plantings of cole crops, curcurbits, cotton, and alfalfa offer a continuum of year-round susceptible host material and the opportunity to move within and between cropping systems to expand population development.

The objectives of our studies were to quantify SLW host preference between cantaloupe, cotton, broccoli and lettuce in the laboratory and in the field. We also investigated cotton and cantaloupe vascular leaf bundle volume per unit of leaf area and cotton leaf top and underside side vascular bundle proximity in relation to cotton leaf surfaces as possible factors in SLW host preference.

Material and Methods

Cotton, cantaloupe, broccoli and head lettuce seeds were planted in white silica sand in the greenhouse in 4 L pots. Randomized complete block designs were used with ten replicates. Space between pots was 15 cm. SLW nymphs were obtained from heavily infested field grown okra leaves. One infested okra leaf, kept turgid in a water jar, was placed in the center of each replicate of 4 pots. Infested leaves were replaced weekly for four weeks. When plants had about five expanded leaves/plant, 2.5 cm^2 leaf disks were sampled from the base of top mature leaves of plants in each pot. SLW eggs and nymphs were counted on undersides of leaf disks. A total of five leaf disk samples were taken during first sample period and five samples during the second sampling period after cataloupe plants were killed by SLW. Data were analyzed using ANOVA and means for each of the two sampling periods were separated by orthogonal comparisons (MSTAT-C 1989).

In the field, cantaloupe, cotton, broccoli and lettuce seeds planted on 15 September. Seed hills were spaced 30.5 cm apart in a row for cantaloupe, 10.2 cm apart for cotton, and 15.2 cm apart for broccoli and lettuce. Row covers were placed over the beds after planting and removed on 18 October. Five leaves were taken from each crop per plot on 25 and 29 October, and 2 November. Following the 2 November leaf samples, cantaloupe vines with leaves were excised from the roots to kill the plants. The plants were left in place on the beds to provide a source of SLW for the three remaining crops. Five leaves were taken from each cotton, broccoli or lettuce plot on 8, 12, and 16 November. In all cases, top mature leaves (position number 4 on main stems from plant terminals) were sampled. Leaf disks of 3.14 cm^2 in size were punched from the base of each sampled leaf and SLW eggs and nymphs counted on the underside surface of each leaf disk. Data were analyzed using ANOVA and means for each of the two sampling periods were separated by orthogonal comparisons (MSTAT-C 1989).

Volumes of vascular tissue per mm^3 of leaf tissue in each of experimental crops were determined as a possible factor contributing to host preference. Four leaves of approximately the same size were picked from each crop species. Leaf disks of 0.57 cm^2 were taken from the base of leaves at locations 5 mm from petiole:blade junctures and 10 mm from main veins. Leaf disks were processed in alcohol, examined under a microscope and with a video camera recording. Marked acetate sheets were placed over the video monitor. Vascular bundles were traced and measured with calibrated lengths of tygon tubing. Vascular bundle volumes were calculated from their lengths and diameters. Measurements were made at identical magnifications for each plant species. Means and standard errors were calculated.

Additionally, cotton leaf thickness and vascular bundle proximity to top and underside leaf surfaces was determined as a consideration in SLW feeding and oviposition site preference in cotton. Cotton leaf samples were taken from greenhouse grown plants. Leaf sections were fixed, dehydrated, and cleared. The samples were infiltrated with Paraplast, cut into blocks and cut into 10 μm sections, retained with Haupt's gelatin fixative, stained with safranin and fast green and destained with enthanol. Leaf thickness and the nearest vascular bundles from the top and underside leaf surfaces were measured with an ocular micrometer. Means and standard errors were calculated.

Results and Discussion

In the greenhouse, the highest numbers of eggs and nymphs occurred on cantaloupe followed by cotton, broccoli and lettuce (Table 1). Cantaloupe plants died on days 15 to 18 after initial plant sampling. During days 18 to 44, following the death of the cantaloupe plants, SLW moved to cotton in preference to broccoli and lettuce. Over 2x and 9x the number of nymphs occurred on cotton as compared to broccoli and lettuce, respectively.

In the field, after removal of row covers, the highest numbers of SLW eggs occurred on cantaloupe, followed by broccoli, cotton and lettuce (Table 2). Following death of cantaloupe plants, the highest number of eggs occurred on broccoli compared to cotton and lettuce. However, numbers of nymphs on broccoli were significantly less than those on cotton, but more than those on lettuce. Apparently, survival of immatures was less on broccoli and lettuce than on cotton. Fewer eggs were found during the 8 to 16 November sampling period than during the 25 Oct to 2 November sampling period. The 5.2°C reduction in mean daily temperatures between 25 October to 2 November (22.2°C) and 8 to 16 November (17.0°C) and declining SPWF population may explain lower oviposition rates. In previous studies without row covers, SLW induced cantaloupe leaf necrosis and plant mortality were much greater than in broccoli and lettuce. Cantaloupe plants did not survive to bear mature fruit when planted in the field in the fall (unpublished data).

Cantaloupe leaves had over a 50% greater vascular bundle tissue volume/mm^3 of leaf tissue compared with cotton (Table 3). Cotton and broccoli vascular bundle volume/mm^3 was about 2x and 1.5x greater than lettuce, respectively. Cotton leaves averaged 237 μm in thickness. The distance from underside cotton leaf surfaces to nearest vascular bundles averaged 60 μm as compared to 131 μm for the distance from top side leaf surfaces to vascular bundles.

It appears logical that accessibility and relative amounts of vascular leaf tissue would be important factors in feeding and oviposition site preference of phloem feeders. Our results show that volumes of vascular leaf tissue per unit of leaf were highest in cantaloupe followed by cotton, broccoli and lettuce. The results may provide a partial explanation for SLW host selection among these crops. Lettuce has been reported as a non-preferred host for the SPWF (Butler et al. 1989), but under laboratory conditions, SPWF can complete development from egg to adult on lettuce in 30% less time than on broccoli (Coudriet et al. 1985).

Under no choice conditions, SLW and other whitefly species may be able to adjust to a marginal host to obtain the necessary nutritional requirements for development. At least in the case of cotton, the difference in distance to nearest vascular bundle feeding sites on underside and top side leaf surfaces suggest a contributing factor in SLW underside leaf positioning. There are also other differences between anatomical lower and upper leaf structures, including more stomatal pores, spongy mesophyll instead of densely-packed palisade cells, more air space and interstitial fluid in the lower side leaf tissues that may be SLW feeding related. Our results appear to support the reasoning of Pollard (1955) that whitefly feeding habits may be related to the proximity of phloem tissue to the surface of host leaves.

References Cited

Bellows, T. S., Jr., T. M. Perring, R. J. Gill, and D. H. Headrick. 1994. Description of a species of *Bemisia* (Homoptera: Aleyrodidae). Ann. Entomol. Soc. Amer. 81:195-206.

Butler, G. D., Jr., and T. J. Henneberry. 1986. *Bemisia tabaci* (Gennadius), a pest of cotton in the Southwestern United States. U.S. Dept. Agric. Tech. Bull. 1701. 19 pp.

Butler, G.D., Jr., D.L. Coudriet, and T.J. Henneberry. 1989. Host plant preference and repellent effect of plant-derived oils on cotton, squash, lettuce and cantaloupe. Southwestern Entomol. 14:9-16.

Coudriet, D.L., N. Prabhaker, A.N. Kishaba, and D.E. Meyerdirk. 1985. Variation in developmental rate on different hosts and overwintering of the sweetpotato whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae).

MSTAT-C. 1989. A microcomputer program for the design, management, and analysis of agronomic research experiments, ver. 1.2, Michigan State University, East Lansing, MI 48824.

Perring, T. M., A. D. Cooper, R. J. Rodriguez, C. A. Farrar, T. S. Bellow, Jr. 1993. Identification of a whitefly species by genomic and behavioral studies. Science 259: 74-77.

Pollard, D.G. 1955. Feeding habits of the cotton whitefly, *Bemisia tabaci* Genn. (Homoptera Aleyrodidae). Ann. Appl. Biol. 43:664-671.

Table 1. Mean[1] Numbers of Silverleaf Whitefly eggs and nymphs on leaf disks from cantaloupe, cotton, broccoli, and lettuce in greenhouse choice tests at Brawley, CA in 1992-93

Crop	No. immatures/cm^2 (underside surface)			
	Sample Period 1		Sample Period 2[2]	
	Eggs	Nymphs	Eggs	Nymphs
Cantaloupe	72 ± 9 a	23 ± 3 a	-	-
Cotton	6 ± 1 b	1 ± 0 b	61 ± 9 a	9 ± 1 a
Broccoli	6 ± 1 b	1 ± 0 b	36 ± 4 b	4 ± 1 b
Lettuce	1 ± 0 c	0 ± 0 c	2 ± 0 c	<1 ± 0 b

[1] Means ± SEM of 10 replicates in a column with different letters differ significantly (orthogonal comparison $P \leq 0.05$).
[2] Cantaloupe plants killed by SLW infestations.

Table 2. Mean[1/] numbers of silverleaf whitefly eggs and nymphs on leaf disks from cantaloupe, cotton, broccoli, and lettuce leaves under field condition at Brawley, CA, 1993

Sampling dates	Crops	No. immatures/cm^2 (underside surface)	
		Eggs	Nymphs
25 Oct to 2 Nov.	Cantaloupe	101 ± 9 a	4 ± 2 a
	Cotton	20 ± 2 c	1 ± 0 b
	Broccoli	36 ± 7 b	1 ± 0 b
	Lettuce	8 ± 1 d	0 ± 0 b
8 to 16 Nov.	Cotton	13 ± 2 b	10 ± 1 a
	Broccoli	17 ± 2 a	2 ± 1 b
	Lettuce	2 ± 0 c	0 ± 0 c

[1/] Means ± SEM of 10 replicates in column in a period with different letters differ significantly (orthogonal comparison, $P \leq 0.05$). Infestation began from 18 October.

Table 3. Means of vascular bundle volumes (μm^3) per mm^3 of leaf tissue from field grown cantaloupe, cotton, broccoli, and lettuce leaves, and distance of vascular bundles from top side and underside leaf surfaces of greenhouse grown cotton leaves

Crop	Total vascular bundle volume[1/] $\mu m^3/mm^3$ leaf	Leaf thickness and distance from cotton leaf surfaces to nearest vascular bundles μm		
		thickness[2/]	Top side	Underside
Cantaloupe	0.965 ± 0.169	-	-	-
Cotton	0.584 ± 0.022	237 ± 16	131 ± 6	60 ± 8
Broccoli	0.370 ± 0.008	-	-	-
Lettuce	0.282 ± 0.030	-	-	-

1/ Mean of 4 leaves ± standard error.
2/ Mean of 17 leaves ± standard error.