# Impact of Sweet Potato Whitefly Infestation On Yield and Quality of Cantaloupe

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*Abstract*

*A range of population levels of sweet potato whitefly, Bemisia tabaci Gennadius was evaluated in three field experiments allowing measurement of the effect of whitefly numbers on melon quality and yield. An increase in total numbers of immature whitefly was associated with significant declines in harvested melon weight, a decline in number of boxes harvested, a decrease in fruit size, a decrease in percent sugars, and an increase in sooty mold. Regression analysis of individual whitefly life stages with yield parameters indicated that adult number was a more precise parameter and higher $R^2$ values were obtained with increased range of whitefly population densities. Adults were sampled at the third leaf node in both locations. Nymph samples were taken at varying nodes from the base of the plant. Estimates of the mean adult whitefly density resulting in 5% and 15% dollar-yield loss were 3 and 10 adults per leaf. Estimates of the mean total nymph density resulting in 5% and 15% dollar-yield loss 0.5 and 2 (AZ) nymphs per $cm^2$ of leaf area, respectively.*

## Introduction

Quantification of damage to crops by the sweet potato whitefly, *Bemisia tabaci* Gennadius, is no simple matter because of the complexity of host plant/whitefly interactions (Van Lenteren and Noldus 1990), the interaction with plant viruses (Brown and Nelson 1986), the genetic (Bellows et al. 1994) and phenotypic (Mound 1963, Mohanty and Basu 1986) variation, and the wide range of crop species affected by whiteflies (Mound and Halsey 1978). Whitefly damage generally includes a reduction of plant vigor due to adults and nymphs feeding on the plant phloem, the development of disorders including silver leaf symptoms in squash and irregular ripening of fruit, excretion of honey-dew which promotes sooty mold, and the transmission of plant viruses (Azab et al. 1971). There are numerous references on control of *Bemisia* spp. that expound the economic benefit of treatments (Dittrich et al 1990), but most of these benefits are quantified relative to treatment effects and not directly to the whitefly itself.

The relationship of whitefly infestation level to yield has only been quantified in detail for a few crops; cotton being the most studied. Van Lenteren and Noldus (1990) and de Ponti et al. (1990) summarized literature on whitefly-plant interactions and suggested that far too little research had been done to quantify the impact of *B. tabaci* on crop quality. Damage by whitefly in agricultural systems has been mostly based on general observations or associations (Byrne et al. 1990) and not on regression analysis. Not knowing the specific relationship of whiteflies to important cash crops, such as melons, can lead to haphazard management decisions, resulting in possibly serious economic and environmental consequences. The objective of this study was to determine the relationship between crop yield quality and silverleaf whitefly infestation level for cantaloupe. Estimates for potential action threshold were also provided based on this data.

## Materials and Method

"Top Mark" melons were planted on 20 Feb, 1992 and 3 March, 1993 in four 2-m beds by 18m long plots in a randomized complete block design with four replicates. Treatments consisted of weekly insecticide applications to maintain different levels of whitefly infestations throughout the season. These insecticide treatment levels were (1) High; 6 applications of bifenthrin 0.1 kg AI/ha (Capture 2EC, FMC Corp., Philadelphia, PA) plus endosulfan 1.1 kg AI/ha (Endosulfan 3EC, Gowan Co., Yuma AZ) initiated on 17 Apr., 1992 and 22 Apr, 1993 (2) Medium; 5

applications with bifenthrin 0.1 kg AI/ha initiated on 8 May 1992, and 13 May 1993, (3) Low; 3 applications of endosulfan 1.1 kg AI/ha initiated on 8 May 1992 and 13 May 1993 (4) None (no treatments). Applications of insecticide were made with two overhead hollow-cone spray tips/bed (TX-18, Spraying Systems Co.) at 22.1 kg/cm$^2$$CO_2$ pressure resulting in ca. 560 l/ha spray volume.

Samples for whitefly nymphs and adults were taken weekly beginning 30 Mar in 1992 and 7 Apr in 1993. Eggs and nymphs were counted on four 1-cm$^2$ areas on the oldest leaf on young plants (fewer than 6-true leaves) and later on the four-fifth leaf proximal to the base of the plant (Tonhasca et al. 1994). All immature data was reported on a cm$^2$ basis. A total of ten randomly selected plants per plot were sampled per date. Large nymphs (ca. third and fourth instars), small nymphs (ca. first and second instars), eggs and empty pupal cases were counted on the leaf disks using 40x magnification. Adult sampling consisted of a visual inspection of ten plants, one leaf per plant at the third leaf node from the apical meristem.

Yield data were collected from four individual harvests over 9-14 days. Harvested melons were culled, sorted and assessed for size and quality based on USDA standards that included measurements of total number of mature cantaloupe fruit per 10-m section of row, mean circumference (cm) of each harvested cantaloupe fruit, percentage soluble sugars (Atago® refractometer, Kew Gardens, NY), and the occurrence of sooty mold on fruit. Dollar values per box of melon by the following size categories (#=number of melons per box: #30=$5.10, #23=$5.25, #18=$6.05, #15=$7.20, #12=$8.15, #9=$8.10) were used to determine crop value. An economic analysis was used to evaluate action threshold levels using crop budgets for commercial melon production. Numbers of individual and combined stages of whitefly by infestation level were regressed (SAS Institute 1987, PROC GLM) onto fruit production, and fruit quality to establish whitefly nymph-plant damage relationships in 1992 and 1993. The slopes estimated from yield vs. whitefly regressions were compared between years with analysis of covariance.

## Results and Discussion

Sweet potato whitefly numbers in 1992 and 1993 (Table 1) were associated with reductions in melon size, number of boxes, and percent sugars (Table 2). Yield differences between 1993 and 1992 were associated with smaller plot size, and cooler weather conditions in 1992. The greater range in infestation level in 1993 than in 1992 (Table 1) resulted in better correlations with number of boxes percent sugars and sooty mold, but correlations with melon size did not seem affected (Table 3). Higher correlations of various harvest parameters with adult samples were noted for both years.

The relationship of whitefly to yield was best described by a linear regression and to percent sugars and melon size by quadratic regressions or log regressions. Estimates for potential action thresholds for whitefly adults per leaf and total nymphs per cm$^2$ based on the seasonal average which resulted in 5% and 15% yield losses were estimated from regression analysis (Table 4). Results of analysis of covariance indicated that slopes for dollar value did not differ between years (Value=Adult, F=2.0; df=3,28,P<0.10;Value=large nymph,F=0.4,df=3,28,P<0.53) and therefore combined values for the two years were used. Regression models based on both years (n=32) for dollar value per 12 m$^2$ (Y) for adults ($X_1$) and nymphs ($X_2$) were $Y=0.45\ X_1 + 30.3$ ($R^2$=0.33,P,0.03), $Y = -2.00\ X_2 + 29.8$ ($R^2$=0.41, P,0.02), respectively. The nymph numbers (rounded to the nearest 0.1) resulting in dollar losses of approximately 5% and 15% were 0.5 and 2 nymphs per cm$^2$, respectively. The adult numbers (rounded to the nearest whole number) resulting dollar losses of approximately 5% and 15% were 3 and 10 adults per leaf.

In all tests sufficient ranges in whitefly infestation levels were established to measure the relationship of whitefly numbers and effects on melon yield. An increase in total numbers of whiteflies was clearly associated with declines in harvested melon crop quality and value. The type of relationship between whiteflies and certain harvest quality measurements are clearer from the results of these tests. For example, yield in terms of boxes or dollar value can best be described with a linear relation to whitefly numbers. The relationship of whitefly to other factors, such as sooty mold, melon size, and percent sugars, is best described with log or quadratic regressions.

The relationship of different stages of whitefly with yield parameters in these tests indicated that certain life stages of whitefly provided a better indicator of whitefly effects on yield. Adult numbers on leaves was a more precise indicator for effects on yield. In both years, the mean numbers of whitefly adults or nymphs that resulted in 5% (moderately acceptable) to 15% (unacceptable) yield loss are suggested for testing as potential action threshold levels. The 5% and 15% yield-loss values of 3 and 10 adults per leaf should be tested as potential adult-based thresholds.

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Table 1. Average number of whiteflies by lifestage and insecticide treatment level in "Topmark" cantaloupes at Yuma, AZ, spring 1992 and 1993.

| Treatment Level | Adults | Eggs | Small nymphs | Large nymphs | Pupal cases |
|---|---|---|---|---|---|
| **1992** | | | | | |
| None | 8.4 a | 39.8 a | 1.6 a | 1.7 a | 0.8 a |
| Low | 4.7 b | 21.1 b | 1.0 b | 0.9 b | 0.7 a |
| Medium | 2.1 c | 7.5 bc | 0.7 b | 0.3 b | 0.1 b |
| High | 1.1 c | 3.7 c | 0.6 b | 0.1 a | 0.1 b |
| **1993** | | | | | |
| None | 20.0 a | 26.5 a | 8.0 a | 4.3 a | 0.5 a |
| Low | 10.7 b | 13.6 b | 5.1 b | 2.2 ab | 0.3 a |
| Medium | 3.0 c | 5.4 bc | 2.2 c | 0.1 b | 0.0 b |
| High | 1.9 c | 1.3 c | 0.4 c | 0.2 b | 0.0 b |

Means followed by the same letter are not significantly different, LSD tests ($P<0.05$), $n = 16$

Table 2. Melon yields and quality per 24.4 $m^2$ in response to sweetpotato whitefly treatments at Yuma, AZ, spring 1992 and 1993.

| Treatment Level | Number of boxes | Mean size of melons | Percent sugars | Sooty mold | Dollar value |
|---|---|---|---|---|---|
| **1992** | | | | | |
| None | 1.2 c | 17.5 a | 10.4 a | 38.1 a | 10.9 c |
| Low | 1.6 bc | 17.3 a | 9.9 a | 15.0 b | 13.5 bc |
| Medium | 1.9 ab | 17.1 a | 11.2 a | 0.0 c | 15.7 ab |
| High | 2.2 a | 16.3 a | 11.8 a | 0.0 c | 18.0 a |
| **1993** | | | | | |
| None | 3.5 c | 16.5 a | 11.5 b | 50.0 a | 26.8 c |
| Low | 4.5 bc | 16.6 a | 11.7 b | 12.5 b | 33.8 bc |
| Medium | 5.9 ab | 16.4 a | 13.8 a | 0.0 c | 45.5 ab |
| High | 7.4 a | 15.7 b | 13.4 a | 0.0 c | 55.8 a |

Means followed by the same letter are not significantly different, LSD tests ($P<0.05$), $n = 16$

Table 3. Pearson's correlation coefficients between whitefly numbers and melon yield data, Yuma, AZ spring 1992 and 1993.

| Whitefly sample | No. boxes | Size category | Percent sugar | Sooty mold |
|---|---|---|---|---|
| **1992** | | | | |
| Adults | -0.71** | 0.52* | $-0.46^{NS}$ | 0.80** |
| Eggs | -0.72** | $0.25^{NS}$ | $-0.44^{NS}$ | 0.83** |
| Small nymphs | -0.64** | 0.57* | $-0.27^{NS}$ | 0.51* |
| Large nymphs | -0.62** | 0.54* | $-0.28^{NS}$ | 0.65** |
| **1993** | | | | |
| Adults | -0.89** | $0.47^{NS}$ | -0.68** | 0.85** |
| Eggs | -0.84** | $0.40^{NS}$ | -0.63** | 0.89** |
| Small nymphs | -0.87** | $0.48^{NS}$ | -0.61** | 0.84** |
| Large nymphs | -0.76** | $0.32^{NS}$ | -0.65** | 0.83** |

NS = not significantly different; * = $P<0.05$, ** = $P<0.01$, $n=16$

Table 4. Linear regression analysis of various yield parameters to whitefly adults and nymphs on field data from Yuma, AZ, spring 1992 and 1993 (n=16).

| Regression models (melon=whitefly) | Slope (SEM) | Intercept (SEM) | MSE | $P$ | $R^2$ |
|---|---|---|---|---|---|
| **1992** | | | | | |
| Size=adult | 0.13 (0.06) | 16.5 (0.31) | 0.59 | 0.04 | 0.22 |
| Sugar=adult | -0.16 (0.07) | 11.5 (0.47) | 0.99 | 0.06 | 0.16 |
| Sooty mold=adult | 2.29 (0.450 | -5.27 (2.44) | 34.3 | 0.0002 | 0.61 |
| $ value=adult | -0.71 (0.18) | 17.41 (0.93) | 5.3 | 0.001 | 0.47 |
| Boxes=adult | -0.08 (0.02) | 2.07 (0.11) | 0.08 | 0.0001 | 0.48 |
| Size=nymph | 0.42 (0.16) | 16.3 (0.34) | 0.55 | 0.02 | 0.27 |
| Sugar=nymph | -0.26 (0.24) | 13.1 (0.49) | 1.2 | 0.29 | 0.08 |
| Sooty mold=nymph | 4.96 (1.7) | -4.52 (3.5) | 59.4 | 0.01 | 0.33 |
| $ value=nymph | -1.81 (0.56) | 17.6 (1.22) | 6.4 | 0.006 | 0.38 |
| Boxes=nymph | -0.21 (0.6) | 2.11 (0.13) | 0.09 | 0.006 | 0.39 |
| **1993** | | | | | |
| Size=adult | 0.03 (0.01) | 15.7 (0.25) | 0.21 | 0.06 | 0.17 |
| Sugar=adult | -0.11 (0.03) | 13.6 (0.36) | 0.93 | 0.003 | 0.43 |
| Sooty mold=adult | 2.54 (0.21) | -3.23 (2.50) | 43.9 | 0.0001 | 0.90 |
| $ value=adult | -1.50 (0.22) | 53.60 (2.53) | 44.3 | 0.0001 | 0.76 |
| Boxes=adult | -0.20 (0.03) | 8.09 (0.32) | 0.71 | 0.0001 | 0.77 |
| Size=nymph | 0.04 (0.02) | 16.1 (0.16) | 0.22 | 0.09 | 0.12 |
| Sugar=nymph | -0.14 (0.05) | 13.4 (0.36) | 1.04 | 0.008 | 0.36 |
| Sooty mold=nymph | 3.23 (0.5) | 1.69 (4.1) | 130.8 | 0.0001 | 0.72 |
| $ value=nymph | -2.02 (0.34) | 51.5 (2.72) | 58.3 | 0.0001 | 0.69 |
| Boxes=nymph | -0.27 (0.04) | 6.82 (0.13) | 0.97 | 0.0001 | 0.70 |