GLASSY-WINGED SHARPSHOOTER IMPACT ON ORANGE YIELD, FRUIT SIZE, AND QUALITY

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ABSTRACT

INTRODUCTION

The California citrus growers needed to know what impact if any the glassy-winged sharpshooter *Homalodisca coagulata* (GWSS) has on fruit yield, size and quality as well as tree vigor. The goals of this project are to determine the usefulness of the management of GWSS to prevent yield loss, fruit size reduction, and degraded fruit quality. First we have to know what impact GWSS has on citrus, and second we need to know how to use currently available materials against the GWSS in IPM programs to prevent potential losses as well as minimizing negative impact to other citrus pests. This information is paramount before we can even begin to incorporate these into conventional IPM programs. Prior to the initiation of this study, we didn't know what the effects of heavy GWSS feeding has on the vigor of citrus trees or fruit yield, size, sugar/acid ratio, peel thickness etc. GWSS suppression in citrus was done to prevent the movement of GWSS into grape under areawide management programs to limit the spread of *Xylella fastidiosa* (*Xf*). Therefore, the focus of this study is to determine the impact of heavy GWSS feeding on citrus yields, fruit size, and quality.

OBJECTIVES

This research was initiated to:

1. Address the impact of GWSS on fruit yield, and distribution of fruit size when GWSS are controlled compared to untreated blocks of Valencia oranges, 'Washington' navel oranges, and grapefruit;
2. Evaluate the effects of high GWSS populations have on fruit quality (sugar/acid ratios, peel thickness, sugar/acid ratio, juice quality, peel texture and firmness, susceptibility to post-harvest disorders) in Valencia and Navel oranges;
3. Evaluate the effects of large GWSS populations have on water stress, nutrient loss (Ca etc.), metabolite loss (amino acids, xylem translocated PGRs) due to xylem feeding and fruit drop and fruit quality, and fruit drop; and 4) Determine if Admire enhances fruit size, tree health and vigor in the absence of GWSS.

RESULTS AND DISCUSSION

The data from the first three seasons of this study indicate that chronic high feeding of GWSS on orange reduces overall yield and size distribution (Hix et al. 2003, Hix et al. 2004). At the beginning of the study, two population levels were established in a 'Washington'navel orange grove. The low population level had essentially 0 GWSS/tree and the high population level trees had more than 1100 GWSS/tree during July, August, and September of 2001, 2002, and 2003. At the beginning of this study there were no differences in the mean number of cartons packed by size distributions (Hix et al. 2003). However, as the influences of GWSS feeding were moved, differences were detected (Figure 1). Navel oranges were harvested from 37 trees within the harvest rows on 8 March, 2004 and sent to the Blue Banner Packing House in Riverside for packout and evaluation 10 March, 2004. Two cartons from two sizes (88 and 113) and two grades (Choice and Export) from each replication (total of 96 cartons) were selected. Trans-Pacific shipment was simulated by storing the 96 cartons at the packinghouse for 21 days at 37 ºF after which time the fruit was sent to KAC for storage at 68 °F for 4 days followed by 55 °F for 5 days. For postharvest evaluation, initial measurements of general appearance, pitting, puff and crease, peel firmness, thickness, color, TA, TSS, and percent juice were taken from a 20 fruit sub-sample at harvest. Fruit were subsequently rated for general appearance, rind pitting, and decay following simulated shipment.

The effects of the high feeding populations of GWSS on navel orange peel nutrient status and metabolism have been consistent for the two years of the study. High GWSS feeding populations significantly reduced peel Ca and Mg concentrations both years of the study: year 1 ($P \leq 0.05$) and year 2 compared to the low GWSS population (control trees treated with Admire) ($P \leq 0.001$) (Table 1). High GWSS feeding populations significantly disrupted N metabolism causing high peel nitrate-N or total N in years 1 and 2, respectively ($P \leq 0.05$). (Note that nitrate-N concentration is lower than that of total N and easier to perturb.) High GWSS feeding populations significantly increased peel arginine and putrescine concentrations in both years of the study with the magnitude of the difference between the two treatments greater in year 2 ($P \leq 0.05$). High GWSS feeding populations resulted in a numerically higher concentration of proline in year 1 and a significantly higher proline concentration in year 2 ($P \leq 0.05$). In year 1, the yield of the 24 data trees in the high GWSS feeding population treatment has numerically lower than the yield of the 24 control trees treated with Admire (low GWSS feeding population). In year 2, the yield reduction caused by the high GWSS feeding population was approximately 50% and significant ($P \leq 0.05$). The effect of GWSS feeding appears to be cumulative over the two years of the study as the magnitude of the changes tended to increase in magnitude and significance from year 1 to year 2. Although GWSS feeding causes changes in peel Ca, Mg and N status, high levels of feeding and the induced changes occur after maximum peel thickness and, thus far, have not affected external fruit quality. The changes in metabolism induced by GWSS feeding are indicative of tree stress. The increased magnitude and statistical significance of these metabolic changes over the two years of high GWSS feeding pressure is consistent with cumulative stress to the trees.

The rind pitting is seemingly a postharvest disorder and is not caused by direct damage of the GWSS. Pitting was clearly a problem in the May 2003 harvested Newhall 'Valencias', but there were no significant differences in the treated (i.e. low population trees) and the untreated (high population trees) (F= 0.361, P=0.550). The low population trees had 34.4% pitting (± 1.23 SEM), whereas the high population trees had 36.5% pitting (± 1.2 SEM) following simulated trans-Pacific shipping as described above. Navel pitting on the Jan. 2003 harvest following simulated trans-Pacific shipment was 3.9% (±0.3 SEM) for the untreated trees (high populations) and 4.1% (±0.5 SEM) on the treated (low or 0 population trees). Prior to shipment simulation, pitting on the navels was 0.03% and 0.01%, respectively. The preliminary information suggests a postharvest physiological problem that's not the result of GWSS xylem feeding behavior. However, this xylem feeding behavior may be contributing significantly to tree (and fruit) stress as discussed below. Navel orange fruit size distribution for the harvest of 2004 was significantly reduced for the high GWSS population trees (Figure 1). Significantly more cartons of fruit sizes 72, 88, 113 and 138 were packed from the low GWSS population trees. When taking into account oranges rejected to the juice line, the overall yield by weight was also higher for the low population trees.

Consistent results were obtained for 'Valencia' and navel orange orchards in two different citrus growing areas, Newhall and Mentone, respectively, in year 1 of the study and for two consecutive years for the navel orange orchard in Mentone. The results confirm that the glassy-winged sharpshooter disrupts the normal basal carbon and nitrogen metabolism of the peel and creates mineral nutrient deficiencies in the peel compared to fruit from trees not under the feeding pressure caused by high populations of glassy-winged sharpshooter. Peel nutrient deficiencies included significantly lower concentrations of Ca, Mg, NO_3-N (analyzed in year 1 only) (Table 1). There was also a significant reduction in Zn in year 2. In all cases, peels of fruit from trees with high populations of GWSS exhibited classic symptoms of stress: high concentrations of arginine and putrescine and, to a lesser degree, praline (Table 2). Accumulation of arginine and putrescine to a greater degree than proline indicates a loss of available carbohydrate. The consistent and persistent symptoms of stress observed for trees under heavy feeding by high population densities of GWSS correlates with losses in yield and fruit size.

One half of the trees in a 'Valencia' orchard in Woodlake, Calif. were treated 27 June 2002, 13 June 2003, and 10 June 2004 with 32 oz of Admire per acre administered through the irrigation system. The treated and untreated areas were five rows wide by 79 trees long and replicated three times each. Twenty trees in each plot were analyzed for total number of fruit and fruit weight. Twenty fruit of size 56 in each plot were used to determine average length, width, and rind thickness, percent juice, sugar/acid ratio, and percent soluble solids.

Table 3 shows that there were no significant differences in fruit number or weight before treatments were applied. In May 2003, in the season after the first Admire treatment, there was still no difference in fruit number per tree, fruit weight or fruit size distribution. In May 2004, after the second Admire treatment, the number of fruit per tree was significantly reduced in the Admire treated trees in 2003 and the fruit size was significantly larger. There was a significantly higher sugar/acid ratio in the fruit from the Admire-treated fruit only during 2003. Thus, we saw no consistent effect of Admire on fruit quality. See Hix et al. 2003, Hix et al. 2004 for 2002 and 2003 results.
See Hix et al. 2003 and Hix et al. 2004 for additional 2003 results.

Table 1. Effect of GWSS population density on peel nutrient status of navel orange.

	Nutrient				
	Year 1 (20 Aug.)			Year 2 (15 Sept.)	
Population density	Ca	Mg	NO_3-N	Ca	Mg
	------------ *%* ------------		--- *ppm* ---	---------- *ppm* ----------	
High	0.84 b	0.12 b	1292.6	7409 b	1068 b
Low	1.09 a	0.15 a	1536.6	10280 a	1497 a
Significance	*	*	*	***	***

Table 2. Effect of GWSS population density on the metabolism of 'Valencia' and navel orange trees in Newhall and Mentone, respectively, on the accumulation of stress metabolites in peel tissue.

Population density	'Valencia' Year 1 (15 Aug.)	Navel Year 1 (20 Aug.)	Navel Year 2 (15 Sept.)
	nmol arginine/g fresh wt peel		
High	1319[z]	2429	1092
Low	1210	2271	983
Significance	**	*	*
	nmol putrescine/g fresh wt peel		
High	444	716	517
Low	407	397	272
Significance	*	*	*
	nmol spermidine/g fresh wt peel		
High	43	74	18
Low	40	122	13
Significance	*	*	NS
	nmol proline/g fresh wt peel		
High	8826	8100	8312
Low	9281	8200	7400
Significance	NS	NS	*

[z] Means within a vertical column within a section of the table were separated by Duncan's multiple range test at $P = 0.05$.

[NS, *, **] Not significant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 3. Fruit number, weight and size of 'Cutter' Valencia oranges harvested from Paramount-Rayo (block 49) and processed at Lindcove Research and Extension Center (treated with Admire on 27 June 2002, 13 June 2003 and 10 June 2004).

Treatment	Avg # fruit	Avg fruit weight (lb)	Size 88	72	56
March 2002					
Untreated	473.3a	0.51a	24.7a	30.9a	23.9b
Admire 2F	470.5a	0.48a	21.0b	31.2a	33.7a
May 2003					
Untreated	623.1a	0.50a	18.6a	28.3a	38.0a
Admire 2F	659.0a	0.47a	20.2a	29.0a	32.2a
May 2004					
Untreated	480.1a	0.43b	22.0a	24.2a	19.5a
Admire 2F	404.1b	0.46a	21.0a	24.9a	26.4a

Means within a column followed by the same letter are not significantly different (LSD, $p = 0.05$).

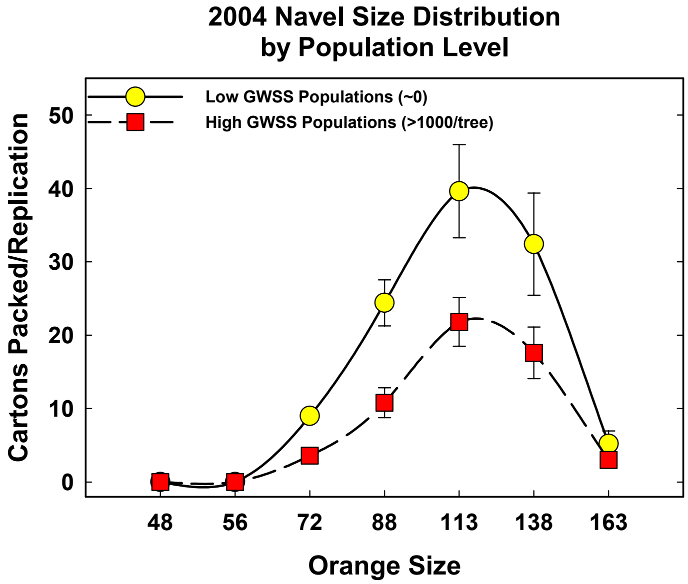

Figure 1. Mean number (±SEM) of cartons packed fresh for market on 10 March 2004. N=5 reps. 1 rep = 37 trees. 902 total cartons packed fresh with 751 cartons were packed from the "low" GWSS trees and 151 were packed from the "high" GWSS trees.

REFERENCES

Hix, R. L., M. L. Arpaia, C. Lovatt, E. Grafton-Cardwell, and P. A. Phillips. 2004. Glassy-winged sharpshooter impact on orange yield, fruit size, and quality. Citrus Research Board 2003 Annual Report.

Hix, R. L., Mary Lu Arpaia, B. Grafton Cardwell, and P.A. Philips. 2003. Glassy-winged sharpshooter impact on yield, size, and quality. Proceedings of the Pierce's Disease Research Symposium, Dec 15-18, 2003, San Diego, CA.

Hix, R. L., N. C. Toscano and C. Gispert. 2003. Area-wide management of the glassy-winged sharpshooter in the Temecula and Coachella valleys. Proceedings of the Pierce's Disease Research Symposium, 8-11 Dec, 2003, San Diego, CA.

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