CITRUS RESEARCH BOARD

Citrograph

MAGAZINE

WINTER 2022

EVALUATING IPM TOOLS

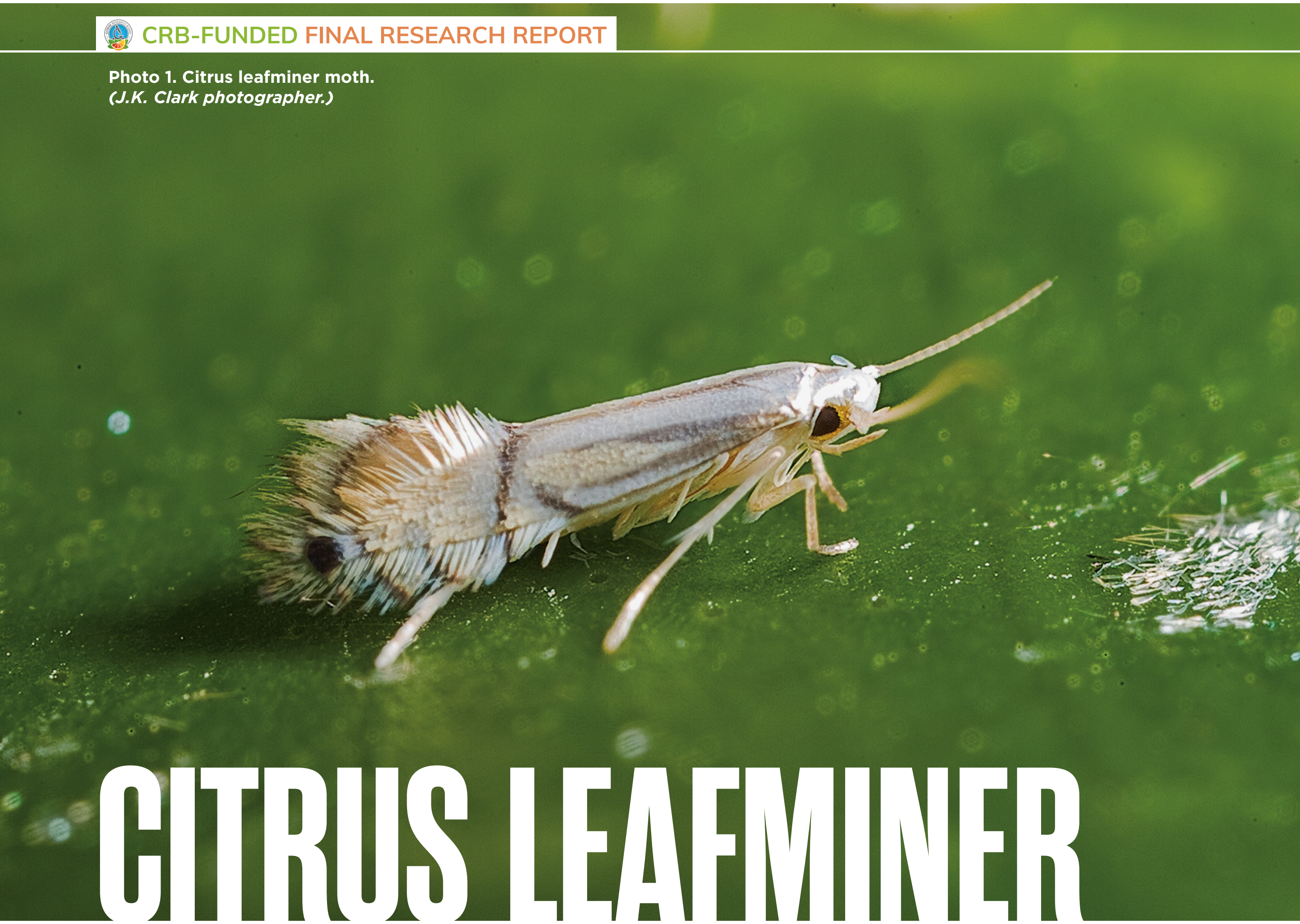

Photo 1. Citrus leafminer moth.
(J.K. Clark photographer.)

CITRUS LEAFMINER

Affects Growth and Yield of Young Tangos

Beth Grafton-Cardwell and Matt Daugherty

Project Summary

A three-year study was conducted at the Lindcove Research and Extension Center (LREC) to determine the impact of citrus leafminer larvae per leaf on newly planted Tango mandarins. Tender leaves, suitable for egg-laying by citrus leafminer, were available in spring, summer and fall; however, populations of citrus leafminer were not significant until summer and fall. Reductions in citrus leafminer densities were achieved with systemic imidacloprid and 2-5 foliar insecticide treatments. Yield was higher in the second and third year of treatments when the foliar insecticides were applied in addition to systemic imidacloprid. Individual insecticide applications generally provided only two to three weeks of leafminer suppression. The amount of tender leaf flush[1] and larval densities declined over the three years of the study. These data support the use of insecticides to control citrus leafminer on young Tango mandarins, and demonstrate that applications are needed at frequent intervals in the early years to limit damage.

Photo 2. Citrus leafminer larva mining a grapefruit leaf. *(E. E. Grafton-Cardwell photographer)*

Photo 3. Citrus leafminer damage on leaves of a young Tango citrus tree showing the top and bottom mining, distortion and curling of the leaves. *(E. E. Grafton-Cardwell photographer)*

Background Information

The citrus leafminer, *Phyllocnistis citrella*, is a tiny moth (**Photo 1**) that invaded the United States in 1990, arrived in California in 2000 and spread into the Central Valley in 2006 (Heppner 1993; Grafton-Cardwell et al. 2008). Eggs are laid in developing leaves, and the larval stage tunnels under the outer layer of leaf tissue (**Photo 2**), reducing photosynthetic capability and causing leaves to curl and look unsightly (**Photo 3**). California was one of the last citrus-growing regions to experience this pest; and by then, it was well-known that while leaf damage looks bad, mature trees can tolerate the damage without any effect on yield or tree growth. However, there were indications in limes and oranges that growth and yield of young citrus plantings were significantly affected by citrus leafminer damage (Peña et al. 2000; Powell et al. 2009). During the first three to four years after planting, trees are particularly susceptible to citrus leafminer damage because they produce new leaf flush more frequently than mature trees.

In California, citrus growers apply systemic and foliar insecticides multiple times per year, for up to four years, to reduce citrus leafminer damage of new flush during summer and fall (Grafton-Cardwell et al. 2020). Many insecticides, such as neonicotinoids, pyrethroids, diamides (Exirel® and Altacor®), abamectin, spinetoram (Delegate®), diflubenzuron (Micromite®) and others, are effective against citrus leafminer (Grafton-Cardwell et al. 2016; 2017; 2020); however, the effect generally lasts one generation (a few weeks) at most. Insecticides taken up by plants (either translaminar or systemic compounds) have a somewhat longer residual effect because young leaf flush cannot outgrow treatments as easily.

California mandarin acreage has increased dramatically from four percent of planted acreage in 2002 to 24 percent in 2020 (CDFA 2002; 2020). The W. Murcott Afourer mandarin and its irradiated selection, Tango, comprise approximately 42 percent of the mandarin acreage. Fruit of mandarins and their hybrids in the *Citrus reticulata* group are resistant to early season pest damage by forktailed bush katydid and citrus thrips (Mueller et al. 2019; Cass et al. 2020). It was not known if pesticide treatments for citrus leafminer applied during the first four years after planting were needed for these mandarin types.

What We Did

In 2011-13, we evaluated three insecticide treatment regimens to reduce citrus leafminer densities compared to untreated trees to determine if growth and development of Tango mandarin trees were affected during the first four years after planting. On May 25, 2010, 912 Tango mandarin trees on Carrizo rootstock were planted in a 9 x18- foot spacing at the LREC in Exeter, California. The orchard was divided into 12 groups of three-row plots each, and treatments were applied in each of the three subsequent years (2011-13):

Table 1. Insecticides applied to Tango mandarins one to three years after planting May 2010.

		Rate formulated /acre	% 415 oil	Date of application
2011 TREATMENTS				
1	Untreated			
2	Admire Pro	7 fl oz		1 June
3	Admire Pro	7 fl oz		1 June
	Altacor WG	4 oz	0.25%	27 June
	Delegate WG	6 oz	0.5%	15 August
	Agri-Mek SC	2.125 fl oz	0.5%	30 September
4	Admire Pro	7 fl oz		1 June
	Altacor WG	4 oz	0.25%	27 June
	Actara WG	5.5 oz	0.25%	19 July
	Delegate WG	6 oz	0.5%	15 August
	Agri-Mek SC	2.125 fl oz	0.5%	30 September
	Micromite 80 WGS	6.25 oz	0.5%	28 October
2012 TREATMENTS				
1	Untreated			
2	Admire Pro	7 fl oz		6 June
3	Admire Pro	7 fl oz		6 June
	Delegate WG	6 oz	0.25%	13 August
	Agri-Mek SC	2.125 fl oz	0.25%	25 September
4	Admire Pro	7 fl oz		6 June
	Altacor WG	4 oz	0.25%	13 July
	Delegate WG	6 oz	0.25%	13 August
	Actara WG	5.5 oz	0.25%	11 September
	Agri-Mek SC	2.125 fl oz	0.25%	25 September
	Micromite WGS	6.25 oz	0.5%	25 October
2013 TREATMENTS				
1	Untreated			
2	Admire Pro	7 fl oz		24 May
3	Admire Pro	7 fl oz		24 May
	Delegate WG	6 oz	0.25%	6 June
	Actara WG	5.5 oz	0.25%	3 September
4	Admire Pro	7 fl oz		24 May
	Delegate WG	6 oz	0.25%	6 June
	Altacor WG	4 oz	0.25%	18 June
	Actara WG	5.5 oz	0.25%	3 September

1. untreated,
2. systemic imidacloprid applied through the irrigation system,
3. systemic imidacloprid plus two to three applications of foliar insecticides timed for major increases in citrus leafminer activity and
4. systemic imidacloprid plus three to five applications of foliar insecticides applied three to five times to more continuously suppress citrus leafminer activity compared to treatment 3 (**Table 1**). Citrus leafminer larvae densities were evaluated on two shoots per tree on a weekly basis. At the end of the year, trees were individually harvested to measure fruit yield, weight and size using the LREC fruit grading system.

What We Found

The number of leaves that were suitable for oviposition by citrus leafminer fluctuated during each year, with the lowest numbers occurring during the summer heat. However, suitable leaves were available on all sample dates in all three years (**Figure 1A**). Suitable leaf availability (soft flush for egg laying) per sampled shoot declined as the trees aged during the three years of the experiment (**Figure 1A**). Individual insecticide applications reduced leafminer density for two to three weeks, including the systemic Admire Pro® applied at seven fluid ounces per acre; but all the insecticide treatment programs, especially those that included foliar applications, significantly reduced leafminer density compared to untreated control trees through much of the season. The maximum larvae per leaf in untreated control trees was 1.1 in 2011 (**Figure 1B**), 0.70 in 2012 (**Figure 1C**) and 0.4 in 2013 (**Figure 1D**), indicating a decline in citrus leafminer infestation over the three years of the experiment.

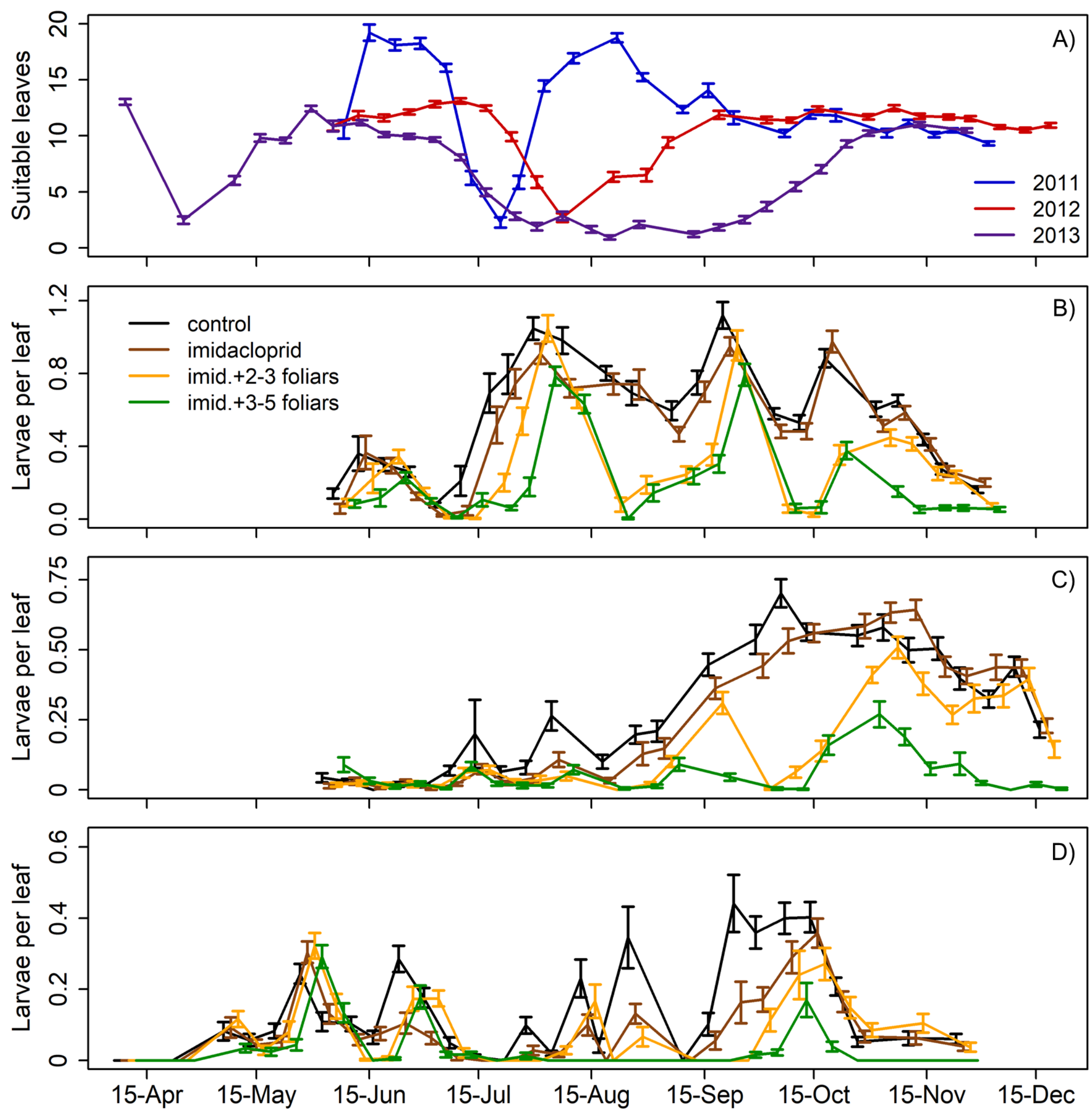

Figure 1. Mean (±Standard Error [SE]) number of suitable leaves per two sampled shoots per tree through time (A), and mean (±SE) citrus leafminer larvae per suitable leaf among sample dates for the four treatment regimens using an untreated control or imidacloprid (imid) plus zero, two to three or three to five foliar insecticides in (B) 2011, (C) 2012 and (D) 2013.

Photo 4. Tree canopy volumes were measured in 2013 by photographing each tree using a background of known size and using computer software to estimate the size of the canopy. LREC Agricultural Technicians Jose Hernandez (left) and Angel Sanchez assisting. *(J. Ruvalcaba photographer)*

Tree trunk circumference doubled during the course of the study and tended to be larger for insecticide-treated trees than untreated control trees; however, this was not statistically significant between treatments. Tree canopy volume was measured in April 2013 (**Photo 4**) after two seasons of treatments and was highest in the imidacloprid plus three to five foliar insecticide sprays treatment (**Figure 2**). Most importantly, the reduction in leafminer densities by the imidacloprid plus two to three foliar insecticide treatments and the imidacloprid plus three to five foliar insecticide treatments increased yield two- to three-fold at 32 months (2013 harvest) and 1.2-1.8-fold at 45 months (2014 harvest) after planting, respectively (**Figure 3A**). Mean fruit weights were similar among the treatment groups in 2013, whereas the imidacloprid plus three to five foliar treatments showed slightly to significantly lower fruit weight the following year (**Figure 3B**). This trade-off between yield and fruit size is well-known for citrus and is regulated by growers via pruning, fertilization and irrigation. Small, medium and undersize fruit were the most common size classes during the 2014 harvest; and in each of these classes, there were more total fruit when trees were treated with insecticides (**Figure 4**).

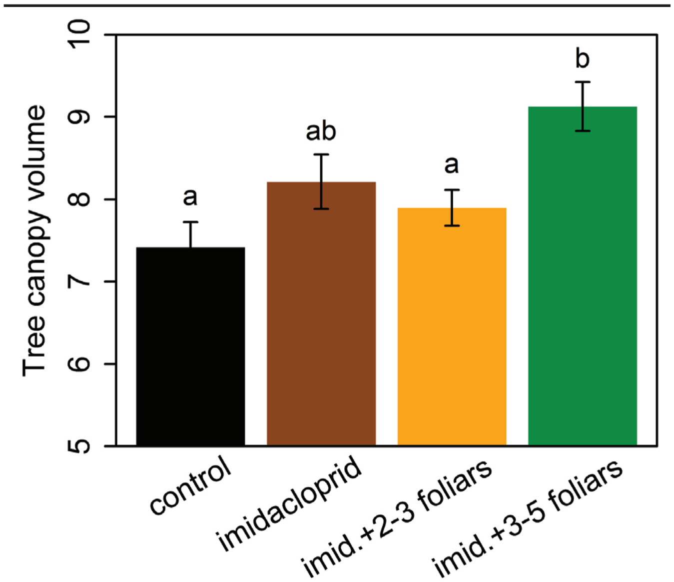

Figure 2. Mean (±SE) tree canopy volume (m^3) in 2013 among the four treatment regimens.

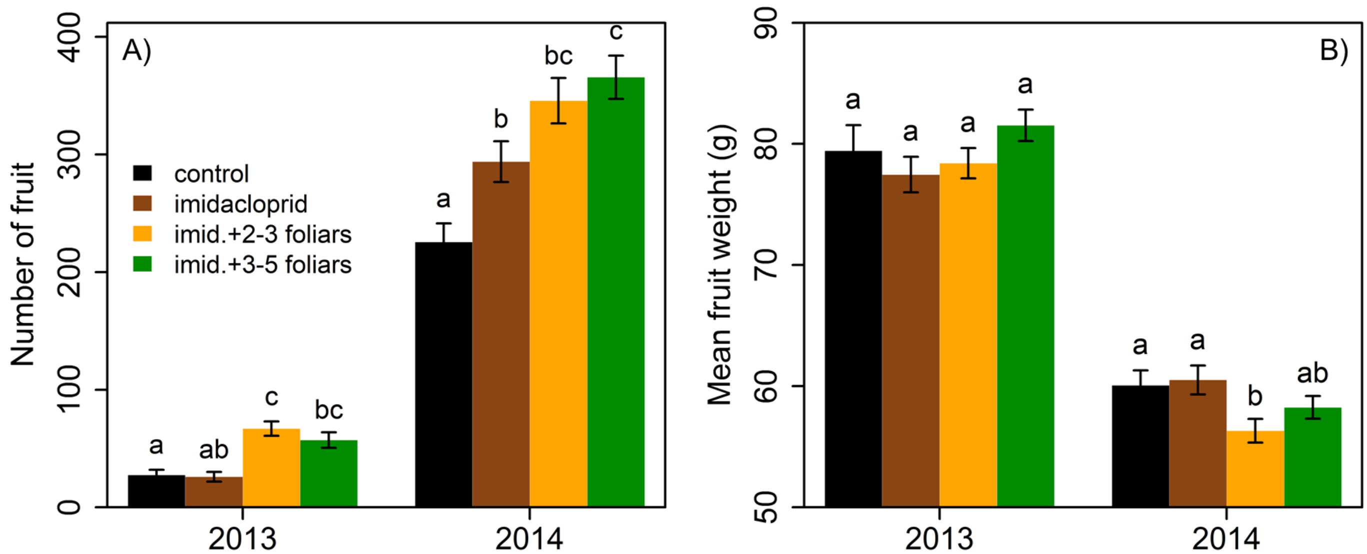

Figure 3. Mean (±SE) A) number of fruit per tree and B) mean weight of fruit in 2013 and 2014 among the four treatment regimens.

Conclusions

Similar to other regions of the world, citrus leafminer densities were low in the spring, presumably due to overwintering mortality, and gradually increased through the summer and fall (June through October), highlighting the time of year when protection against citrus leafminer is needed. Both the amount of tender leaf flush per shoot and the citrus leafminer populations per leaf declined during the three years of the study, reducing the number of applications of insecticides needed as trees matured. Systemic imidacloprid combined with multiple foliar insecticides significantly improved the yield of trees in years three and four when they first came into bearing. This is the first demonstration of tree growth and yield impacts on young Tango mandarins due to uncontrolled citrus leafminer. This research demonstrates that protection of young Tango trees during the first three to four years after planting is warranted. However, monitoring for larval mining activity should be conducted to determine the timing and frequency of treatments because activity of citrus leafminer varies during the season and tends to decline with tree age.

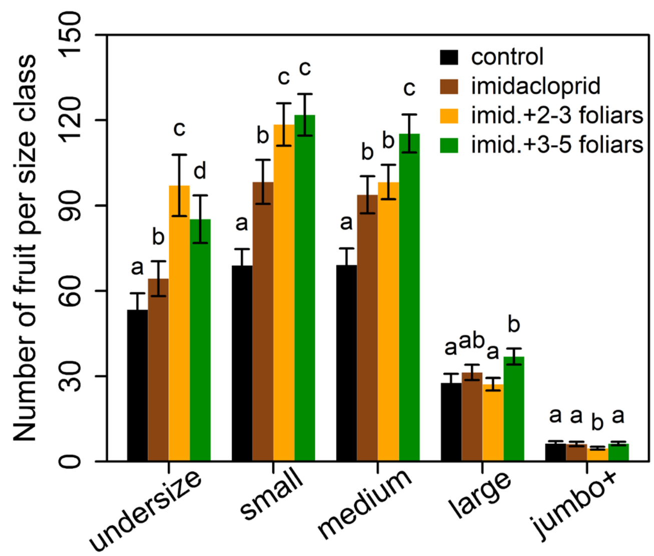

Figure 4. Mean (±SE) number of fruit in each of five size categories in 2014 among the four treatment regimens.

Glossary

[1]**Tender leaf flush:** New leaf flush that is tender enough for the newly hatched citrus leafminer larvae to mine.

References

Cass, B.; Grafton-Cardwell, E.; Rosenheim, J. 2020. Resistance of 'Tango' mandarins to fork-tailed bush katydids. *Citrograph* 11(1):58-61.

California Department of Food and Agriculture (CDFA), California Agricultural Statistics Service. 2002. California Citrus Acreage Report. Sacramento, California.

California Department of Food and Agriculture (CDFA), California Agricultural Statistics Service. 2020. California Citrus Acreage Report. Sacramento, California.

Grafton-Cardwell, E.E.; Godfrey, K.E.; Headrick, D.H.; et al. 2008. Citrus leafminer and citrus peelminer, Public. 8321. University of California Division of Agriculture and Natural Resources, Oakland, California.

Grafton-Cardwell, E.E.; Nemecek, J.N.; Scott, S.J. 2016. Insecticides for citrus leafminer control, 2015. Arthropod Management Tests. Doi:10.1093/amt/tsw008.

Grafton-Cardwell, E.E.; Reger, J.E ; Doria, S. 2017. Insecticidal control of citrus leafminer, 2017. Arthropod Management Tests. Doi:10.1093/amt/tsy021.

Grafton-Cardwell, E.E.; Morse, J.G.; Haviland, D.R.; et al. 2020. Citrus leafminer. UC IPM Pest Management Guidelines: Citrus, public. 3441. University of California Division of Agriculture and Natural Resources, Oakland, California.

Heppner, J.B. 1993. Citrus leafminer (CLM), *Phyllocnistis citrella* Stainton in Florida (Leipdoptera: Gacillariidae: Phyllocnistinae). Tropical. *Lepidoptera*. 4:49-64.

Mueller, T.G.; Kahl, H.M.; Cass, B.N.; et al. 2019. Differential impacts of citrus thrips across sweet orange and mandarin species. *Journal of Economic Entomology* 112:2767-2773.

Peña, J.E.; Hunsberger, A.; Schaffer, B. 2000. Citrus leafminer (Lepidoptera: Gracillariidae) density: Effect on yield of 'Tahiti' lime. *Journal of Economic Entomology* 93:374-379.

Powell, C.A.; Ritenour, M.A.; Bullock, R.C. 2009. Growth and yield of young 'Valencia' sweet orange trees treated with insecticides. *Hortscience* 44:686-687.

Acknowledgements

We thank Monty Lo, Jamie Nemecek, Jennifer Ruvalcaba and Sara Scott for technical assistance and Bayer CropScience, FMC Corporation, Corteva Agriscience, Syngenta Crop Protection and UPL NA Inc., for providing products.

CRB Research Project #5500-501

***Beth Grafton-Cardwell, Ph.D., is an emeritus entomology specialist and Matt Daugherty, Ph.D., is an entomology specialist, both at the University of California, Riverside. For additional information, contact* eegraftoncardwell@ucanr.edu**