CALIFORNIA CITRUS NURSERY BOARD

Grant Report December 2010

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Project Title: Citrus Leafminer Management Program for Nursery Citrus

Objectives:

1) Determine the best insecticides and series and timing of rotations of insecticides for suppressing citrus leafminer infestations in nursery situations.
2) Determine if pheromones could be utilized as mating disruption or attract and kill technology to reduce overall leafminer infestations in greenhouse nursery situations.

Report

Citrus leafminer, *Phyllocnistis citrell*a, is a tiny moth that arrived in California, presumably from Mexico in 2000. It was first observed in southern California and has continued to spread northward, arriving in the San Joaquin Valley in 2006 and now infesting most of California. The moth lays its eggs on new flush growth of citrus and the larval stage feeds on the leaves creating serpentine mines. Mining damage causes retardation of plant growth of young trees and nursery stock and renders the leaves unsightly reducing sales to homeowners. Studies in Florida have shown that significant stunting can occur if trees are not protected from CLM from the time of budding until they are about 4 years of age. There are several insecticides that have been determined to be effective in control of citrus leafminer, including the neonicotinoids systemic imidacloprid (Admire) and acetamiprid (Assail) and to a lesser extent oils and azadirachtin (neem). Information is needed on the length of time between rotations of insecticides to minimize their use and so avoid resistance development. In addition, a highly effective pheromone has been developed for citrus leafminer. Since leafminer needs to mate to reproduce, there is potential for a pheromone-baited trap to be used to hinder male moths in their search for females, and so prevent mating, depress egg-laying and thereby suppress populations in greenhouse nursery situations.

Pesticide screening: Two experiments were conducted during 2010 to determine the efficacy and persistence of various pesticides on citrus leafminer survival.

Greenhouse study (Table 1): In the 2010 greenhouse experiment, the plants were treated, placed in a greenhouse and leafminer moths were released every 2-3 weeks. Treatments included water, Omni 6 E oil, Agri-Mek, DPX-HGW86 (cyazypyr), SA-013041 (etofenprox), NAI 2303 (tolfenpyrad), Belt (flubendiamide) and Baythroid. The effective treatments were Agri-Mek and DPX-HGW86 providing significant control for 28 days.

Outdoor study (Table 2): In the field study at Lindcove, mature field trees were pruned to stimulate new flush on 29 September and then treated with insecticides on 18 Oct. Treatments included water, Agri-Mek, Agri-Flex, Actara, Altacor, HGW86, and Micromite followed by Agri-Mek or a second Micromite treatment after 2 weeks. All treatments had 0.25% Omni 6E oil added. Treatments of Agri-Mek, Altacor, HGW86 and Micromite followed by a second treatment of Agri-Mek or Micromite were all very effective in reducing CLM through December.

2010 Conclusions: The data suggest that, depending on how fast the flush grows, most registered insecticide treatments will last the duration of the flush, about 3-4 weeks. A few foliar insecticides, such as Agri-Mek, Altacor and HGW86 will provide longer control, probably due to translaminar movement of the pesticide into new leaves.

It is very important that nurserymen change insecticide class each time a spray is applied to reduce selection for resistance to insecticides in citrus leafminer, as resistance has developed in populations in other areas of the world. Currently available insecticide classes include: group 4 neonicotinoids (Actara, Platinum, Provado, Admire Pro, Couraze, Assail), group 5 spinosyns (Delegate), group 6 abamectin (Agri-Mek, Zoro, AgMectin), group 15 insect growth regulators (Dimilin), group 18 insect growth regulators (Intrepid), group 21 acaricides (Fujimite), group 23 (Movento), group 28 (Altacor and cyazypyr), and oils.

Table 1. Greenhouse trial to compare the insecticide efficacy of various insecticides against citrus leafminer. Treatments were applied in a 200 gallons of water per acre dilution to rough lemon seedlings using a ½ liter spray bottle on 28 Sep 2010. Moths were released the day after treatment. Six potted seedlings (Schaub rough lemon) per treatment were evaluated for live larvae and pupae each week. After every count an additional 200 leafminer moths were released

Treatment	Rate Form/acre	Mean number live stages/seedling			
		14 DAT Larvae	21 DAT Larvae + pupae	28 DAT Larvae + pupae	35 DAT Larvae + pupae
Water control		23.12 ± 8.82abc	20.50 ± 7.71ab	10.33 ± 4.05ab	11.00 ± 4.77ab
0.25% Omni 6E oil	0.25%	29.67 ± 8.92a	26.50 ± 9.91a	11.0 ± 1.04a	11.83 ± 4.30ab
Agri-Mek 0.15 EC + 0.25% Omni 6E oil	10 fl oz 0.25%	0.00 ± 0.00e	0.00 ± 0.00c	4.83 ± 3.37bcd	11.17± 2.95b
DPX-HGW86 10SE	6.75 fl oz	2.67 ± 1.86de	0.17 ± 0.17c	3.17 ± 2.20bcd	3.33 ± 2.17a
DPX-HGW86 10SE + Omni 6E oil	6.75 fl oz 0.25%	0.00 ± 0.00e	0.00 ± 0.00c	2.00 ± 2.00d	4.33 ± 2.84ab
DPX-HGW86 10SE	13.5 oz	3.00 ± 3.00 de	0.00 ± 0.00c	1.33 ± 0.80cd	2.50 ± 1.31ab
SA-013041+ Omni 6E oil	6 oz	13.50 ± 4.33abc	12.00 ± 3.47ab	6.17 ± 2.27abc	6.50 ± 2.36ab
SA-013041 + Omni 6E oil	8 oz	25.83 ± 7.52a	20.67 ± 5.72a	4.67 ± 0.95abc	3.50 ± 0.89ab
NAI 2303 15SC+ Omni 6E oil	27 fl oz + 0.25%	7.50 ± 3.53bcd	7.33 ± 3.91b	7.33± 6.39abcd	8.33± 6.77ab
Belt SC 39%	3 fl oz	21.33 ± 6.92ab	16.00 ± 6.37ab	6.12 ± 2.75abcd	7.50 ± 3.44ab
Belt SC 39%	5 fl oz	16.50 ± 5.05abc	13.00 ± 3.55ab	3.00 ± 1.03abcd	5.33 ± 3.07ab
Belt SC 39%	7.5 fl oz	15.67 ± 4.51abc	12.33 ± 3.70ab	6.67 ± 2.33abc	8.33 ± 6.19ab
Belt SC 39% + Omni 6E oil	5 fl oz 0.25%	19.83 ± 9.51	9.67 ± 3.96ab	3.00 ± 1.41abcd	8.00 ± 3.79ab
Baythroid XL 1EC	6.4 oz	9.17 ± 7.59cde	10.83 ± 5.31ab	3.50 ± 1.15abcd	8.50 ± 3.16ab

Means followed within a column by the same letter are not significantly different (LSD, P>0.05)

Table 2. 2010 field trial to compare insecticide efficacy against citrus leafminer infestation. Treatments were applied at a rate of 200 gallons per acre on ‘Washington’ navel oranges in block 24 at the Lindcove Research and Extension Center. 8 trees per treatment were evaluated for live larvae on new flush. 4 flushes per sample tree were evaluated. Sample trees were pruned on 29 September to stimulate new flush.

			Mean number live larvae/suitable leaf						
Treatment/ formulation	Rate-amt form/acre	Application dates	28 Oct	4 Nov	10 Nov	19 Nov	24 Nov	1 Dec	7 Dec
Water check	-		0.603a	1.407a	1.071a	0.778a	0.376a	0.522ab	0.405a
Agri-Mek SC + Omni 6E oil	4.25 fl oz + 0.25%	18 Oct	0.003b	0.005cd	0.075d	0.118cd	0.136bc	0.182cd	0.163c
Agri-Flex SC + Omni 6E oil	8.5 fl oz + 0.25%	18 Oct	0.059b	0.1678b	0.087d	0.345b	0.212b	0.324bc	0.272bc
Actara 25 WDG + Omni 6E oil	5.5 oz + 0.25%	18 Oct	0.019b	0.213b	0.380b	0.637a	0.433a	0.567a	0.406ab
Altacor WDG + Omni 6E oil	4 oz + 0.25%	18 Oct	0.000b	0.00d	0.020d	0.077cd	0.054c	0.116d	0.016d
DPX HGW86 10 SE + Omni 6E oil	13.5 fl oz + 0.25%	18 Oct	0.024b	0.00d	0.115d	0.027d	0.071c	0.104d	0.015d
Micromite 80 WGS + Omni 6E oil	6.25 oz + 0.25%	18 Oct	0.008b	0.151b	0.286bc	0.140cd	0.053c	0.110d	0.000d
Agri-Mek SC + Omni 6E oil	4.25 fl oz + 0.25%	10 Nov							
Micromite 80 WGS + Omni 6E oil	6.25 oz + 0.25%	18 Oct	0.004b	0.138bc	0.206c	0.172c	0.072bc	0.190cd	0.041d
Micromite 80 WGS + Omni 6E oil	6.25 oz + 0.25%	10 Nov							

Means within a column followed by the same letter are not significantly different (LSD, $P \geq 0.05$), after $\log_{10}(x+1)$ transformation of the data. Untransformed means are listed.

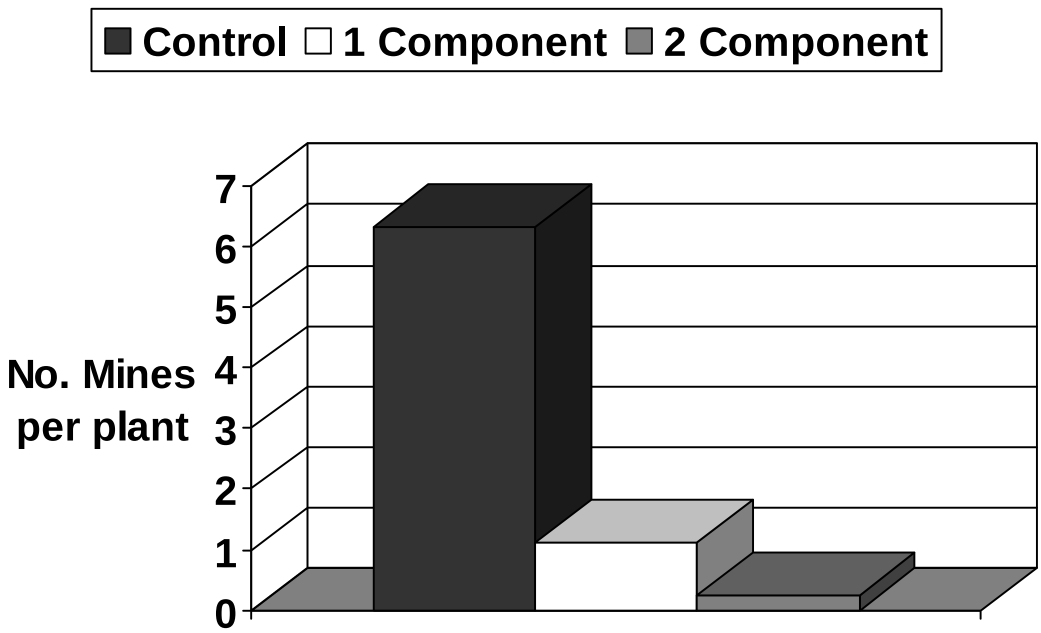
Experiments using SPLAT containing 1 or 2 components of CLM pheromone conducted in the Greenhouse at the Kearney Ag Center

Beth Grafton-Cardwell and Saida Kharrat

All experiments: 24 schaub rough lemon seedlings, 1 ft tall were placed in each room of about 12 x 18 feet. Spacing of 1.5 ft between plants and 2 feet between rows. Citrus leafminer pupae in plants were placed in the room among the seedlings and the moths were allowed to emerge naturally. One room received pheromone as SPLAT (2 component), one room received pheromone as SPLAT (1 component) and the control room was left without pheromone. The SPLAT was applied to all trees in the greenhouse rooms. The number of larvae per plant was counted approximately 15 days after the pupae were placed in the greenhouse.

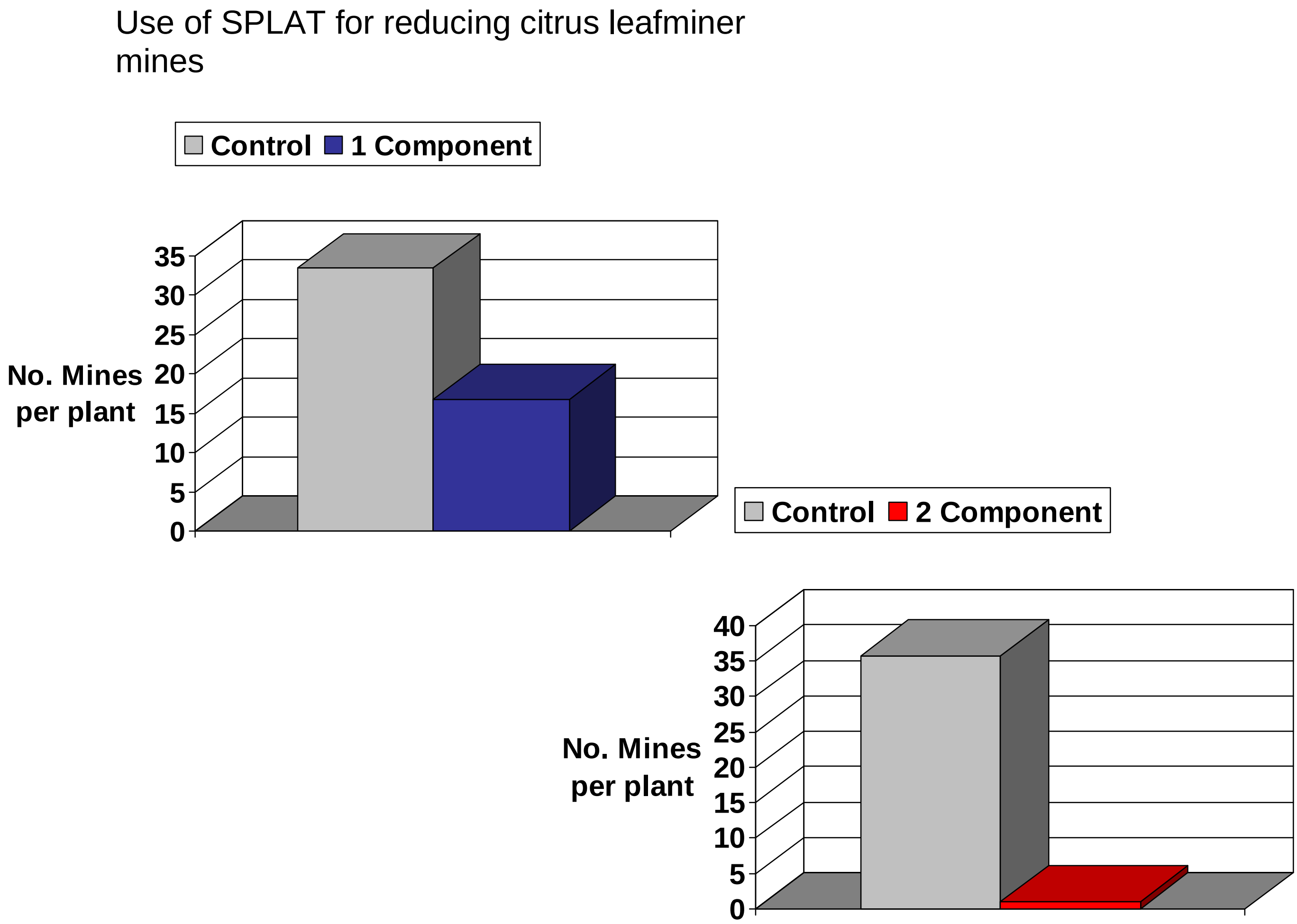
Results: In 2009, we worked demonstrated that as few as 4 lures of the 2 component pheromone could be used to reduce mining by about 50%. In 2010, we demonstrated that the 2 component SPLAT was somewhat more effective in reducing mining compared to the 1 component SPLAT (Fig. 1.) Every tree was treated in each room. In Figure 2, where the pressure of leafminer was much greater (up to 35 mines per plant), the 2 component pheromone was much more effective in reducing CLM.

Figure 1: Greenhouse experiment to compare the effectiveness of 1 or 2 component SPLAT in reducing citrus leafminer mines.



Kris' contribution to Citrus Nursery Report

Figure 2: Greenhouse experiment to compare the effectiveness of 1 or 2 component SPLAT in reducing citrus leafminer mines.



Four Winds Nursery Testing of CLM Pheromone in Standard Lures

Kris Godfrey

To determine if mating disruption could be used to minimize damage in a certified organic block of citrus nursery stock, a study was initiated at Four Winds Nursery in Winters. This nursery has a small certified organic production block (Figure 3) located near conventional citrus nursery production and a conventionally-managed demonstration citrus orchard (Figure 4). The certified organic production block is approximately 25 meters from a loosely-screened enclosure with citrus mother plants (conventionally managed) and about 50 meters from the demonstration orchard. The demonstration orchard contains examples of all the varieties of citrus that this nursery produces, and there are approximately 40 – 50 trees within the orchard. Commercially available pheromone lures were used to attempt mating disruption because the lures are compliant with the National Organic Program. Other methods of mating disruption for citrus leafminer were not yet registered for use under the National Organic Program.

Figure 3. The certified organic citrus block with citrus leafminer pheromone traps at Four Winds Nursery in Winters in 2010.

Figure 4. The demonstration citrus orchard at Four Winds Nursery in Winters in 2010.

Saturation of an area with citrus leafminer pheromone was achieved using various trap and lure densities through time. Trapping around the certified organic block consisted of placing 10 traps (5 traps placed on the north edge and 5 traps on the south edge) spaced approximately 5 meters apart. The demonstration citrus orchard was trapped with two citrus leafminer pheromone traps, one at the south end (farthest from the certified organic block) and one at the north end (farthest from the certified organic block), and served as a "treated control" (i.e., populations of citrus leafminer would increase in this orchard and then would be treated with an insecticide). Trapping began on February 23, 2010, with the placement of traps each containing one citrus leafminer pheromone lure (1.33 mg of pheromone per lure). The traps were replaced at approximately monthly intervals. From May 18 through October 28, 2010, two lures were placed in each trap on each sampling date.

To manage citrus leafminer in the demonstration orchard and in the rest of the conventionally managed nursery, the citrus was treated with spirotetramat (Movento) on May 15 and July 6, and with acetamiprid (Assail) on August 14, 2010. Each time the traps were serviced, an estimate was made of the percentage of new foliage that contained citrus leafminer in both the demonstration orchard and the certified organic block.

The density of citrus leafminer males in pheromones traps was lower in the traps placed in the certified organic block than the traps placed in the demonstration orchard throughout most of the trapping season (Figure 5). Declines in the density of citrus leafminer in the demonstration orchard occurred after application of insecticides. Damage to the new foliage within both the demonstration orchard and the certified organic block was extremely low. In late April and early May, and again in late October, approximately 5% of the leaves examined in the demonstration orchard showed some mining from citrus leafminer. In the organic block, new leaves were present on each sampling date. However, mines were found only in late October and only about 2% of the plants examined had mines. The saturation of the certified organic block with pheromone appeared to reduce the density of citrus leafminer within the block as compared to the conventionally managed demonstration block.

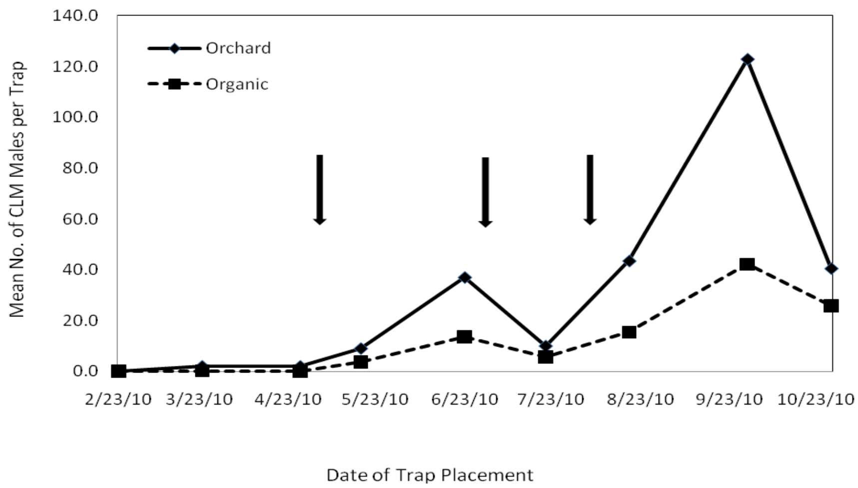


Figure 5. The mean number of citrus leafminer male moths in pheromone traps placed in the citrus demonstration orchard and around the certified organic block at Four Winds Nursery in Winters in 2010. The arrows indicate the timing of an insecticide application in the demonstration orchard.

Field studies of 1 component SPLAT at Cal Poly

Dave Headrick and Ryan Perry

Three trials were conducted with 1 component splat in lemon orchards and potted plants at Cal Poly San Luis Obispo. While reduction in male densities in traps could be demonstrated in these trials, it was difficult to demonstrate any reduction in citrus leaf infestation.

Pheromone Summary:

For the past 3 years this research group has experimented with lures and Splat as carriers of 1 or 2 component CLM pheromone. While all methods demonstrate a disruption of male moths as evidenced by a reduction in male trap catches, not all methods reduced leafminer damage. We have a sense that the 2 component pheromone is more effective in preventing egglaying and leaf damage, but additional research is needed. Greenhouse experiments have yielded better results than field experiments.   In addition, trials are needed to determine the best number and spacing of lures.