Citrus Peel Miner *Marmara salictella* Monitoring Techniques and Control Measures 1996-97[1]

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Abstract

Citrus peel miner populations were monitored to evaluate various methods of trapping citrus peel miners. Observing 25 fruit per tree and 10 trees per block on the lower three feet of the tree canopy provided the best technique for determining the level of citrus peel miner infestations. The use of oleander plants, clear plates and green 3 inch diameter balls sprayed with Tangle-Trap were not effective in trapping citrus peel miner. In 1996, the first of September citrus leaf miner populations rose above the 10% infestation level. Success, Lorsban, Alert and Agri-Mek provided the highest mortality levels of citrus peel miner larvae. In citrus fruit, Success, Lorsban and Alert had the greatest efficacy of citrus peel miner larvae.

Introduction

The citrus peel miner (*Marmara salictella* Clemens) is not a new pest problem of desert citrus. It has been present in Arizona for a number of years. It is typically found at low populations, but in certain years is an economic pest of citrus. The difficulty has been the sporadic nature of the citrus peel miner. This has made research and control programs difficult to establish. The citrus peel miner was first described in 1863 by J.B. Clemens. However, it was not until 1917 that S.C. Vinal reported citrus peel miners on orange peels in Southern California. Since citrus peel miner problems have been reported in 1933 (Lockwood, 1933), 1948 (Woglum, 1948), 1955, 1971 (Atkins, 1971), 1984-85 (Reeves, 1995) and 1993 (Gibson, et. al., 1997).

Citrus peel miner appears to have a extensive host range and in addition to citrus has been found infesting oleander, willow, grape and cotton. In oleander they are considered an economically damaging pest where cuttings are used for propagation. Fresh oleander cuttings infested with peel miner will often become infected with secondary plant pathogens and fail to root properly.

In a laboratory study Atkins (1961) determined the life cycle of the citrus peel miner at 80 F, but under field conditions during late summer in Arizona, these values maybe reduced. Eggs are deposited singly on the stem or more preferably citrus peel and hatch in about 5 days. The eggs are very small, oval in shape and convex on top. They are whitish in color and the top has some indistinct sculpturing. The number of eggs produced per female moth is not certain, but some have laid 7 to 12 eggs over a 4-day period.

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The larvae exit the egg from the bottom and immediately burrow into epidermal layer of the peel. Thus they are never exposed. The larvae will extensively mine the peel of the fruit while passing through 6 instars. The 6th instar cuts out of the mine and lowers itself via a silken thread, to the ground or to a niche on the tree to pupate. The larvae complete their development cycle in 20-28 days.

The pupa is yellow in color and covers itself with a silken cocoon. The cocoon is silverish-white and covered with approximately 40 small silverish-white ball shaped objects. The pupal stage lasts 10-14 days, after which the adult emerges. The adults are about the size of a mosquito. Their forewings are dusky grayish-black with one silvery-white band across the wing about a third from the base of the wing. More silvery-white mottling can be found towards the tip of the wing. The wings are held length wise over the body when at rest. The adult will rest in the shade during the day, and beginning dispersing near dusk. The adults will generally begin laying eggs about 2 days after emerging. Citrus peel miner appear to prefer ovipositing on larger fruit, thus grapefruit is preferred to navel oranges and navel oranges are preferred to lemons.

Monitoring is the key to most pest management programs. Ideally, it would be beneficial to be able to detect adult peel miner movement into the grove. Thus would allow the grower to time insecticide applications toward the adults before any damage can occur, and/or to time for maximum egg hatch. Unfortunately there is no commercially available pheromone to monitor citrus peel miner adults, nor can they be trapped on yellow sticky cards or with black lights. Field observations have determined that the greatest fruit damage occurs on the lower 3 feet of the citrus tree canopy (Atkins, 1971 and Gibson et. al., 1997). In addition, most of the mined fruit appear to be in the internal canopy of the tree. The use of Guthion and Parathion were reported to be the most effective materials for control of the citrus peel miner (Atkins, 1971). Trees treated with Guthion on 26 September and 8 October had 15.4 and 37.5% mined fruit, respectively (Atkins, 1971). Application timing is critical to achieve maximum control of the citrus peel miner.

In this study, we investigated several alternatives for monitoring citrus peel miner adults and larvae. Additionally, we investigated several insecticides for controlling this pest.

Materials and Methods

Monitoring techniques. To evaluate monitoring techniques two groves at Cactus Lane Ranch were selected, one was a mature grove of 'Ruby Red' grapefruit and the other a young grove of 'Rio Red' grapefruit. Both groves had previous histories of citrus peel miner problems.

We attempted to monitor adult peel miners using three techniques. Since oleander is considered a favorite host of the peel miner, oleander plants may serve as an indicator of peel miner activity before they are attracted to the citrus fruit. Oleander plants were obtained from Desert Winds Nursery which were free of citrus peel miner and placed between citrus trees in the groves.

Since peel miner adults appear to be attracted to larger fruit, we attempted to monitor adult activity using 3-inch diameter wood balls, which were painted green to match the color of immature grapefruit. The spheres were then sprayed with Tangle-Trap and placed in the inside of the tree canopy in each of the 4 quadrants of the tree.

A passive monitoring technique was also attempted. In Florida, investigators have been attempting to monitor the movement of a similar insect species in citrus, the citrus leafminer, *Phyllocnistis citrella* Stainton. They found that very high populations of leafminer adults could be passively captured using clear Plexiglas plates sprayed with Tangle-Trap. We evaluated this technique using 3 X 5-inch plates placed in the 4 quadrants of the tree.

In addition monitoring for adults, we monitored for larval activity. Twenty-five fruit from the inside of the lower 3 feet of the tree canopy were randomly selected and evaluated for the presence or absence of citrus peel miners.

Oleander plants, spheres, plates and citrus fruit were evaluated weekly. Each grove contained of 10 replicates of the four different monitoring techniques.

Timing and insecticide efficacy. Six year old 'Rio Red' grapefruit trees at Cactus Lane Ranch (Maricopa County) were treated with insecticides for the control of citrus peel miner. The treatments were arranged in a completely randomized block with 6 replicates. Each replicate consisted of a single tree (20 x 20-ft). Treatments consisted of 5 insecticides (Dipel 2X, Lorsban 4F, Provado 1.6 F, Alert and Admire) and an untreated control and 6 applications sequentially for 6 weeks (16, 23, 30 July, 6, 13 and 20 August). All treatments were applied with X-77 non-ionic surfactant at 0.1% v/v, except the Admire, which was applied as a soil drench on only two application dates (16 July and 6 August). Applications were made with a handgun sprayer calibrated to deliver 200 gpa. Fruit were harvested and percentage of mined fruit determined.

Efficacy of citrus peel miner larvae on oleander. In a preliminary efficacy test, insecticides were evaluated for their efficacy to peel miners infesting oleander plants. Oleander plants (Nakase Nursery) infested with citrus peel miner larvae were found and the stems were cut off. The cut end of the oleander stem was then placed in a water-pick and the top was trimmed to 10 inches. The cut stem was then placed in a collective pile.

Once 120 stems with citrus peel miners were collected, the stems were arranged in a randomized complete block design for treatment. Each treatment was replicated 4 times with 5 oleander stems per replicate. Treatments consisted of untreated control, Agri-Mek (abamectin) at 10 oz/ac, Provado (imidacloprid) at 0.1 lbs-ai/ac, Alert (chlorfenapyr) at 0.3 lbs-ai/ac Success (spinosad) at 9.0 oz/ac and Lorsban (chlorpyrifos) at 3 qt/ac. All treatment except Agri-Mek included the non-ionic spreader Kinetic at 0.1% v/v. Agri-Mek included NR-415 spray oil at 1 gal/ac. Applications were made using a backpack air-blast sprayer calibrated to deliver 100 gpa. After treatment stems were allowed to air dry, they were placed in paper bags and transported to the lab. In the lab stems were placed in 3 gal buckets (1 bucket per plot) with ventilated lids. After 21 days, the numbers of emerged adult citrus peel miners were counted. Henderson - Tilton's equation [$C = 100(1 - X_c Y_t / Y_t Y_c)$; where C = percent control, X_c = precount untreated, X_t = precount in the treatment, Y_c = post count in the untreated and Y_t = post count in the treatment] was used to estimate percent control. Differences among treatments were separated using ANOVA and F protected LSD.

Efficacy of citrus peel miner larvae on grapefruit. Ten year old 'Rio Red' grapefruit trees in Maricopa County, AZ (Gila River Farms) were treated with insecticides to control citrus leaf miner larvae. The treatments were arranged in a randomized complete block design with four replicates. Each plot (20 x 60 ft) consisting of three trees in a row 20 ft apart. Applications were initiated as soon as visible mines were detected. Applications were made using a backpack air-blast sprayer calibrated to deliver 100 gpa. Prior to application, 10 to 15 fruit with active mines were tagged in each plot. Treatments included Agri-Mek (abamectin) at 10 oz/ac, Provado (imidacloprid) at 0.1 lbs-ai/ac, Alert (chlorfenapyr) at 0.3 lbs-ai/ac Success (spinosad) at 9.0 oz/ac, Dimethoate 267 (dimethoate) at 2 qt/ac and Lorsban (chlorpyrifos) at 3 qt/ac. All treatment except Agri-Mek included the non-ionic spreader Kinetic at 0.1% v/v. Agri-Mek included NR-415 spray oil at 1 gal/ac. Treatments were applied on 18 September. The following day, the fruits were picked and the numbers of mines on each fruit were counted. They were than placed in 3 gal buckets with ventilated lids, and transported to the laboratory for storage. The numbers of emerged adult citrus peel miners were counted on 11 October. Statistical analysis was used as previously described. Fruit were harvested and percentage of mined fruit determined. Henderson - Tilton's equation [$C = 100(1 - X_c Y_t / Y_t Y_c)$; where C = percent control, X_c = precount untreated, X_t = precount in the treatment, Y_c = post count in the untreated and Y_t = post count in the treatment] was used to estimate percent control. Differences among treatments were separated using ANOVA and F protected LSD.

Results and Discussion

Monitoring techniques. The use of oleander plants for monitoring citrus peel miners was ineffective as citrus peel miner larvae were detected in citrus fruit prior to detection in oleander plants. Although, the citrus peel miner is known to infest oleander plants (Gibson *et al.*, 1997) in the grove, oleander plants were not a preferred host of the citrus peel miner. Citrus peel miners infested the oleander concurrently with the citrus fruit. The use of sticky plates and spheres were likewise ineffective as monitoring techniques as no citrus peel minor were found on any of the traps. The only effective means of monitoring the citrus peel miner was by randomly selecting 25 fruit per tree from the lower 3 ft of canopy focusing on the inside of the canopy. Citrus peel miner populations began to increase by the middle of August 1996 (Fig. 1 and 2), which is similar to the findings of Gibson *et al.* 1997.

The best monitoring technique is looking for citrus peel miner mines in the fruit itself. It appears that by randomly selecting 25 fruit from the inner, lower 3 ft of tree canopy is the best way to determine citrus peel miner levels. A minimum of 10 trees should be selected for monitoring, concentrating on areas in the grove known to previously have citrus peel miner problems. Previous observations in a 40-acre block of grapefruit indicate that citrus peel miner populations seem to be ubiquitous throughout the grove (Maurer, unpublished data).

Timing and insecticide efficacy. There was no significant difference in any of the treatments in this experiment. The percentage of mined fruit averaged 5.5, 4.6, 7.4, 5.0, 5.0 and 5.1 for all the Dipel, Alert, Provado, Lorsban, Admire and the untreated control treatments, respectively. The low level of citrus peel miner in this grove was likely the reason no differences between treatments was observed. The previous year (1995), this same grove averaged 25 to 30% mined fruit (Maurer, unpublished data). It appears that parasites or the sporadic nature of the citrus peel miner have resulted in populations which were not of economic significance in 1997.

Efficacy of citrus peel miner larvae on oleander. Agri-Mek, Alert, Success and Lorsban had significantly higher mortality rates of citrus peel miner larvae than Provado (Table 1). Although, the Agri-Mek was not significantly different from Alert, Success and Lorsban the percent mortality was 80%, which was lower than the other compounds. The result of this experiment indicate that pesticides are available for the control of citrus peel miner larvae.

Efficacy of citrus peel miner larvae on grapefruit. Alert, Success and Lorsban provided the best control with over 95% mortality of citrus peel miner larvae (Table 2). Agri-Mek provided moderate control, while Provado and Dimethoate provided the poorest mortality (Table 2). The percentage of mined fruit at harvest was not significantly different for any of the treatments (Table 2). This may be attributed to the fact that most of the fruit had been mined prior to treatment when live citrus peel miner larvae were sprayed. Although, the controls average 29.1% mined fruit in 1996 the level of mined fruit in this grove averaged less than 5% in 1997.

In conclusion, we were unable to detect a reliable technique for monitoring citrus peel miner adults. Thus sampling for larvae is the only effective monitoring tool currently available. Under normal circumstances, the peel miner is kept in check by parasitic wasps. We know that citrus peel miners commonly infest cotton. It is our belief that in 1994-95, numerous insecticide applications targeting whiteflies in cotton, destroyed the citrus peel miner's parasitoid complex. Thus, citrus peel miners were able to build-up high densities in the cotton, and move to citrus in August with few parasitoids to follow. Thus, growers and pest control advisors should start by sampling oleander and cotton, (particularly if its not BT-cotton) in July and early-August. If heavy mining is detected, nearby groves should be watched closely. In citrus, sample primarily from the middle and lower portions of the tree canopy beginning in late July and continuing through November, or until temperatures begin to cool considerably. Treatments should be applied as soon as 5-10% of fruit is infested with mines of ½ inch or in length. Lorsban and Success have both been shown to be effective towards citrus peel miner larvae, however Lorsban should be avoided because of its harshness towards parasitoids and other beneficial insects.

Since 1995, citrus peel miner has been a significant pest in Maricopa County. Again, this probably relates to the insecticide use patterns in cotton. Beginning in 1996, cotton growers received Section 18's registrations for Applaud and Knack for control of whiteflies in cotton. These products are highly specific to whiteflies and probably had little impact on the citrus peel miner or its parasitoids. Thus, restoring ecological balance to the citrus peel miner / parasitoid ecosystem. If heavy insecticide use once again occurs in Arizona cotton, citrus growers should pay close attention to the citrus peel miner populations. Another factor that may influence the abundance of citrus peel miners is the amount of cotton acreage planted to BT-cotton. Since peel miners are Lepidopterous pests, they may be susceptible to B.T., and may not be able to develop in BT-cotton. However, this relationship has not yet been determined.

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Table 1. Efficacy of insecticides on citrus peel miner larvae on oleander stems, Nakase Nursery, 1996.

Treatments	Rate	Mortality[z]
	(lbs a.i./acre)	(%)
Agri-Mek	0.08	81.7 a
Provado	0.1	38.3 b
Alert	0.3	100.0 a
Success	0.14	100.0 a
Lorsban 4E	3.0	95.0 a
Untreated	0.0	0.0 c

Means in a column followed by the same letter are not significantly different (F protected LSD $P < 0.05$).
All treatments were applied with Kinetic non-ionic surfactant at 0.1% v/v, except Agri-Mek, which included NR - 415 petroleum oil at 1.0 gal/acre.
[z] Percent control estimated using Henderson - Tilton's equation.

Table 2. Efficacy of insecticides on citrus peel miner larvae and percentage of mined 'Rio Red' grapefruit, Gila River Farms, 1996.

Treatments	Rate	Mortality[z]	Mined fruit
	(lbs a.i./acre)	(%)	(%)
Agri-Mek	0.08	61.1 b	34.6 a
Provado	0.1	29.1 c	24.1 a
Alert	0.3	91.8 a	24.2 a
Success	0.14	94.7 a	25.9 a
Lorsban 4E	3.0	94.0 a	24.4 a
Dimethoate E267	1.34	32.9 c	32.9 a
Untreated	0.0	0.0 d	29.1 a

Means in a column followed by the same letter are not significantly different (F protected LSD $P < 0.05$)
All treatments were applied with Kinetic non-ionic surfactant at 0.1% v/v, except Agri-Mek which included NR - 415 petroleum oil at 1.0 gal/acre.
[z] Percent control estimated using Henderson - Tilton's equation.

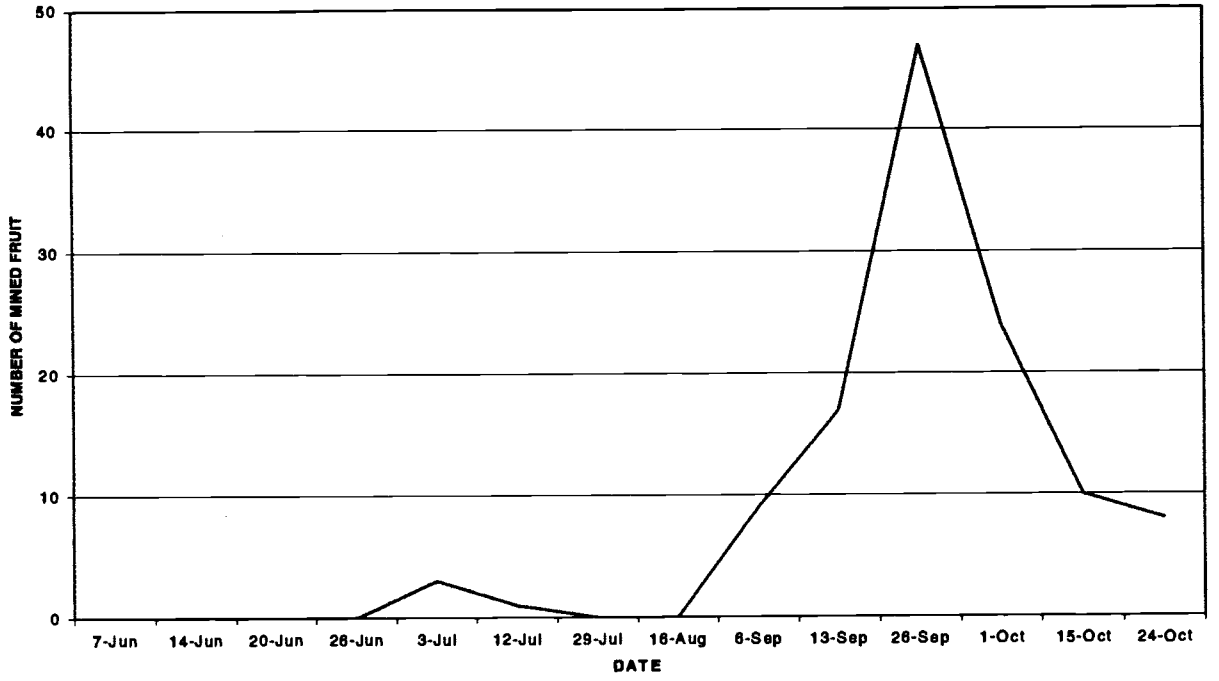

Figure 1. Citrus peel miner activity on 10 'Rio Red' grapefruit trees during 1996. Number of mined fruit by randomly selecting 25 fruit per tree.

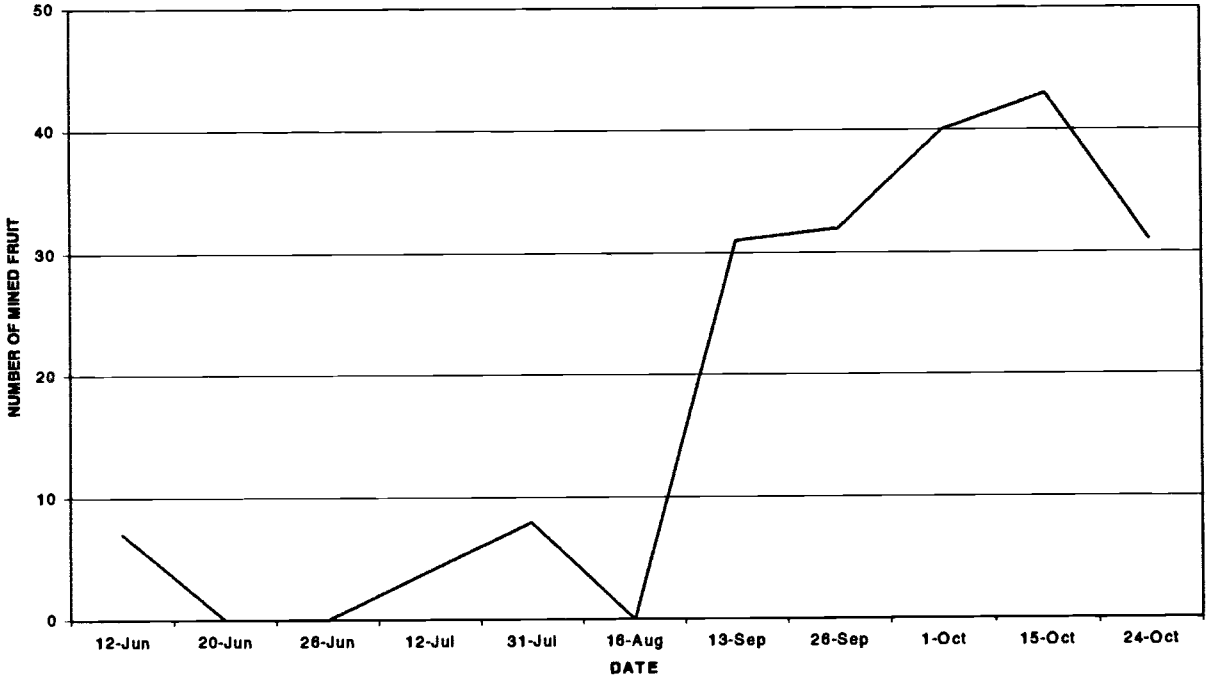

Figure 2. Citrus peel miner activity on 10 'Ruby Red' grapefruit trees during 1996. Number of mined fruit by randomly selecting 25 fruit per tree.