SUPPRESSION OF *MYLLOCERUS UNDATUS* (COLEOPTERA: CURCULIONIDAE) IN VALENCIA ORANGE WITH CHLORPYRIFOS SPRAYS DIRECTED AT GROUND AND FOLIAGE

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Myllocerus undatus Marshall (Coleoptera: Curculionidae) has been reported in Florida on numerous ornamental species and fruit crops, in which it causes damage to the foliage and possibly root systems (Thomas 2005; NPGA 2000; O'Brien et al. 2006). However, reports of its pest status and importance on citrus have not been published. At least 1 citrus grove manager in the Immokalee area in Collier Co., FL has been battling the weevil for 2 years in response to considerable foliar damage caused by *M. undatus* adults. At his request, we visited the grove and observed cumulative damage in several blocks of 'Valencia' orange, in which some hotspots were nearly defoliated. Numerous adults were found feeding on the leaves in the canopy of affected trees, concentrated near the trunk, and in branches with dense foliage. Adults were seen at the base of the trunk where they had presumably descended to oviposit and in considerable numbers on the orchard floor feeding on leaves of broadleaf weeds, especially Spanish needles, *Bidens bipinnata* L. (PAS & HAA, personal observations). On 2 May 2008, we examined the root systems and surrounding soil of 7 or 8 trees that have been removed due to Huanglongbing symptoms. Although no obvious root damage was observed and a single pharate *M. undatus* adult was found, the foliar damage alone was cause for concern.

The grower's intent was to spray, so for the purpose of designing a management trial, a heavily infested 65-acre block of 17-year-old Valencia on Swingle oranges was selected to evaluate the effects of insecticide treatments on *M. undatus* adults. A randomized complete block design with 4 treatments replicated 3 times was used. Treatments selected were (a) insecticide application directed to the foliage (foliar-only), (b) insecticide applications directed to the ground (ground-only), (3) combined treatments (ground + foliar), and (4) an untreated control. Each treated plot covered 2.46 ha (6.1 acres), while control plots were 1.45 ha (3.6 acres) each. The orchard floor under the canopy was treated for the ground-only and the combined treatments on 6 Mar 2008 with a tractor pulled boom sprayer 30 cm above ground operating at 20 psi and 6.43 Km/h (4 MPH) miles per hour. Seven nozzles were used to apply 5.68 L/ha (0.6 gpa) of chlorpyrifos (Yuma 4 E (emulsifiable), AgriSolutions St. Paul MN) in 2861 L/ha (306 gpa). Ground and foliar applications could not be made simultaneously or on the same day due to reentry restrictions so ground applications were made first with the idea that surviving weevils would concentrate in the canopy. Foliar applications of chlorpyrifos for foliar-only and combined treatments were conducted on 10 Mar 2008 with a standard airblast sprayer operating at 4 Km/h (2.5 MPH) and 150 psi delivering spray material through 12 nozzles at 2337 L/ha (250 gpa). Control plots were left untreated. No rain was recorded and temperatures fluctuated between 10 and 2°C during and between applications dates.

Eight sets of 10 continuous trees were randomly selected from the 2 center beds in each plot. Branches from 2 separate sections of each tree were vigorously shaken up and down for 5 s and the number of *M. undatus* adults that fell into a 106-cm diameter black umbrella placed underneath the branch was recorded. On the last tree from each group, 10 randomly selected flushes were observed and the number of flushes damaged by *M. undatus* was recorded as an indicator of pest injury. The number of adults and the amount of leaf damage were estimated 3 d before the ground application and 6, 22, and 35 d after foliar application. A one-way ANOVA was used to compare treatments at each sample day supplemented with a Least Square Difference (LSD) with $\alpha = 0.05$ to separate means contingent on a significant treatment effect for each date. Dunnett's method was used to compare the results from the sample dates with the pretreatment sample, to determine the direct effect on initial populations (Dunnett 1955).

Combined application of Yuma 4E was the only treatment that significantly reduced the number of adults at d 6 and 22 when compared with the initial pre-application population ($F = 12.03$; $df = 5, 11$; $P = 0.004$) (Table 1). Foliar-only applications reduced the number of *M. undatus* at d 6 compared with pretreatment levels ($F = 5.90$; $df = 5, 11$; $P = 0.02$). Significantly lower populations than the pretreatment levels were observed on untreated trees at d 22; however the population in control plots increased again at day 35 ($F = 6.19$; $df = 5, 11$; $P = 0.02$). We suspect that this reduction in the control population was due to dispersion from control plots into adjacent treated plots. Significantly more adults were observed on trees in the ground-only treatment compared with the combined treatment at d 6 and 22. By d 35 there

TABLE 1. MEAN (±SEM) NUMBER OF *M. UNDATUS* CAPTURED WITH A SHAKE SAMPLE FOLLOWING THE PROCEDURES DESCRIBED. YUMA (CHLORPYRIFOS) 4E WAS APPLIED AT 5 PT PER ACRE EITHER TO THE FOLIAGE, THE ORCHARD FLOOR OR BOTH. OBSERVATIONS WITHIN COLUMNS FOLLOWED BY THE SAME LETTER OR NO LETTER ARE NOT SIGNIFICANTLY DIFFERENT WITH LSD ($\alpha = 0.05$). OBSERVATIONS FOLLOWED BY AN ASTERISK (*) ARE SIGNIFICANTLY DIFFERENT BASED ON DUNNETT'S MEAN SEPARATION TEST ($\alpha = 0.05$) COMPARED WITH PRE-APPLICATION MEANS (PRE) WITHIN EACH TREATMENT.

	Mean number of *M. undatus* per 10 trees			
Treatment	PRE	Day 6	Day 22	35 DDA
Control	10.25 ± 2.72	6.88 ± 3.00 ab	3.45 ± 1.41 ab*	6.50 ± 2.20
Foliar	10.00 ± 4.57	2.41 ± 1.17 ab *	4.71 ± 2.46 ab	5.16 ± 1.69
Ground	9.75 ± 2.13	9.12 ± 3.85 a	10.33 ± 2.86 a	14.50 ± 5.91
Combined	8.46 ± 2.42	0.75 ± 0.25 b *	1.54 ± 0.15 b*	6.08 ± 2.17
	($F = 0.54$; $df = 5, 11$; $P = 0.74$)	($F = 2.10$; $df = 5, 11$; $P = 0.20$)	($F = 2.75$; $df = 5, 11$; $P = 0.08$)	($F = 0.93$; $df = 5, 11$; $P = 0.52$)

TABLE 2. MEAN (±SEM) OF SHOOTS OUT OF TEN SHOWING INJURY INFLICTED BY *M. UNDATUS* ON VALENCIA ORANGE TREES. YUMA (CHLORPYRIFOS) 4E WAS APPLIED AT 5 PT PER ACRE EITHER TO THE FOLIAGE, THE ORCHARD FLOOR, OR BOTH. OBSERVATIONS WITHIN COLUMNS FOLLOWED BY THE SAME LETTER OR NO LETTER ARE NOT SIGNIFICANTLY DIFFERENT (LSD, $\alpha = 0.05$). OBSERVATIONS FOLLOWED BY AN ASTERISK (*) ARE SIGNIFICANTLY DIFFERENT FROM PRE-APPLICATION MEANS (PRE) WITHIN EACH TREATMENT USING DUNNETT'S MEAN SEPARATION TEST ($\alpha = 0.05$).

	Mean No. Of damaged flush per tree out of ten observed			
Treatment	PRE	Day 6	Day 22	Day 35
Control	1.33 ± 0.22	1.29 ± 0.15	2.37 ± 0.26 a	2.41 ± 0.48
Foliar	0.81 ± 0.43	1.17 ± 0.44	2.62 ± 0.37 a*	2.16 ± 0.15 *
Ground	1.17 ± 0.27	0.95 ± 0.15	2.16 ± 0.54 a*	2.83 ± 0.29*
Combined	0.88 ± 0.12	1.12 ± 0.63	1.33 ± 0.22 b	2.54 ± 0.39*
	($F = 3.84$; $df = 5, 10$; $P = 0.083$)	($F = 3.03$; $df = 5, 11$; $P = 0.104$)	($F = 6.35$; $df = 5, 11$; $P = 0.021$)	($F = 0.43$; $df = 5, 11$; $P = 0.813$)

were no differences among treatments and all had returned to pre-treatment levels, suggesting that the residual effect of the treatments had ended (Table 1).

Significant treatment effects on foliar damage caused by feeding of adult *M. undatus* were observed only at d 22. On this day significantly less damage was observed on leaves from trees receiving the combined treatment when compared with all other treatments (Table 2). At d 22, both the foliar-only (F = 15.99; df = 5, 11; P = 0.002) and ground-only (F = 12.93; df = 5, 11; P = 0.003) treatments had significantly more damage compared with the pre-treatment levels as did all treatments on d 35.

The shake sample used here appeared to be an effective method to evaluate relative population levels and the effectiveness of treatments. Our results showed that the best treatment regime to reduce the number of adults in the grove was the combined application. Trees that only received the ground treatment appeared to have higher numbers of *M. undatus* in the foliage, possibly due to a repellent effect of the insecticide on the ground. However, the ground application tended to increase the effect of the foliar application, possibly by denying the weevils a safe-haven when the foliage was sprayed. Effectiveness of the treatments seemed to end on or before d 35 indicating a relatively short residual effect for these treatments. To date, no natural enemies or other control techniques have been explored in citrus groves. More research is needed to determine life cycles, biology, and economic thresholds to improve the management of this emerging pest in citrus.

Summary

Myllocerus undatus is a potentially destructive pest for citrus in Florida. Adults feed on leaves potentially reducing the quality and quantity of the fruit production by reducing photosynthetic area of the plant. Oviposition occurs in the soil and the presence of immature stages in the root area of the citrus trees indicates the potential for root damage although none was observed. Application of insecticide to both ground and foliage provided better control than applications directed only to the canopy or only to the ground.

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