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IN THIS ISSUE

TRAP SUPPRESION USING FOUR HAND-APPLIED CODLING MOTH (LEPIDOPTERA: TORTRICIDAE) PHEROMONE DISPENSERS

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Keywords: *Cydia pomonella* (L.), mating disruption, pear pest management

Abstract

Four hand-applied dispensers were tested for codling moth, *Cydia pomonella* (L.), trap suppression ability: Suterra's (Consep) Checkmate CM-WS and Checkmate CM-XL1000 and Pacific BioContol's Isomate C+ and Isomate Ctt. To compare these products, we measured trap suppression in side-by-side, 10-acre plots by releasing sterile codling moth males and assessing trap catches in each plot. During the 2000 field season we had two treatments: Checkmate CM-XL1000 and Isomate Ctt, replicated in three orchards. During the 2001 field season we had three treatments: Checkmate CM-WS, Isomate C+, and Isomate Ctt, replicated in four orchards. Sterile codling moths were released at a rate of 800 moths per release at each of five release points per plot. In the 2000 and 2001 field seasons, we performed releases on four and six different dates, respectively. The release times were chosen to coincide with codling moth flights. There was a significantly greater number of moths caught in plots under Checkmate than plots under Isomate dispensers ($P<0.01$) during the four release dates in 2000 and during four of the six release dates in 2001. We measured

dispenser longevity through periodic laboratory analysis and by following weight loss for the BioControl dispensers.

Introduction

Codling moth mating disruption is being implemented on the majority of pear acreage in California. Hand-applied dispensers are commercially produced by Suterra (formerly Consep) and by Pacific BioControl. Suterra has two products: Checkmate CM-XL1000 designed to last the entire field season, and Checkmate CM-WS designed to last as long as 80 days. Pacific BioControl has two products: Isomate C+ with one release tube, and Isomate Ctt with two release chambers, doubling the amount of pheromone per dispensers which allows it to be placed at 1/2 the per-acre rate of Isomate C+.

In warm years, when we may have a third flight, it is important to know if the dispensers will last beyond harvest, thus reducing infestation of the fruit remaining on the trees. It is also important to determine the earliest date on which we can deploy the products, in order to protect the fruit through harvest and to avoid increasing populations in the fruit remaining in the trees post-harvest. Furthermore, we need to know how late in the season hangings can be made, so that we have protection until the end of September, but without wasting product in October and November when codling moth has entered diapause. We measured the longevity of these dispensers through weight loss and chemical analysis, and evaluated their efficacy by measuring codling moth trap suppression.

Materials and Methods:

Trap Suppression. To evaluate the trap suppression efficacy of the dispensers, we released sterile codling moths and evaluated how many male moths were caught in traps in each plot. The release of sterile males gives a greater population with which to measure trap shutdown than the natural population. In 2000, two treatments of 10 acres each (one with Checkmate CM-XL1000 and the other with Isomate Ctt dispensers) were replicated in three orchards. Both dispensers were applied once at the codling moth biofix at a rate of 200 dispensers/acre. Biofix was set as the first date that codling moth male moths were consistently found in pheromone traps and the sunset temperature was above 62° F. In 2001, three treatments of ten acres each were used; 1) Isomate C+ dispensers applied at 400 dispensers/acre, 2) Isomate Ctt dispensers applied at 200 dispensers/acre, and 3) Checkmate CM-WS dispensers applied at 160 dispensers/acre. Isomate C+ and Ctt were applied once during the season at codling moth biofix. Checkmate CM-WS was applied twice: at biofix and approximately 90 days later (last week of June). The three treatments were replicated in four different orchards. Sterile codling moths, obtained from Canada, were released at a rate of 800 moths at each of five release points situated in the center 5 acres of each plot. For each release site, a pair of traps was set 40 feet upwind from the moth release point. Within each pair, which was separated from each other by 80 feet, one trap was loaded with a 10-mg lure and placed at the top of the tree. The other was loaded with a 1-mg lure and placed at eye level. Traps were checked every other day for 10 days following release. In 2000, four sterile male moth releases were done at approximately 675, 1,400, 1,670 and 1,835 degree days after biofix on June 2, July 11, July 25 and August 1, respectively. In 2001, six releases were done at approximately 150, 600, 1000, 1400, 2000 and 2400 degree-days on May 1, May 23, June 20, July 11, August 8 and August 29, respectively. The 2001 release times were chosen to coincide with two peaks of the overwintering flight (A and B peak), the beginning and the B peak of the second flight, during harvest and post-harvest, respectively. Data were analyzed using ANOVA and mean separation.

Fruit damage. Fruit damage was evaluated by inspecting three thousand fruit per plot for presence of codling moth worms or evidence of tunneling with frass at harvest.

Dispenser longevity. Field-hung Isomate-C+ and Isomate Ctt dispensers were weighed weekly to determine weight loss. In addition, in 2001 Isomate C+, Isomate Ctt and Checkmate CM-WS dispensers were sent to Scenturion, Inc. for chemical analysis every two to three weeks. Checkmate CM-WS dispensers were analyzed after being in the field for 40, 68, 82 and 96 days. Isomate C+ and Ctt were analyzed after 54, 68, 82, 96, 110, 124 and 138 days in the field. Analyses of Checkmate CM-WS dispensers were stopped after 96 days, since the manufacturer considers it as an 80 to 90-day product.

Results and Discussion

Trap Suppression - 2000 Trial. Over the four release dates, in traps loaded with 10 mg lures, we recaptured an average of 7.55 ± 0.94 and 2.26 ± 0.95 sterile moths per trap on the Checkmate CM-XL1000 and Isomate-Ctt treatments, respectively. Over all dates, trap suppression was significantly greater in the Isomate Ctt plots by a factor of 3X. Data for the individual releases are presented in Figure 1. At all four release dates, trap suppression was greater in the Isomate Ctt plots by factors of 4, 3, 10, and 2X in releases 1,2,3 and 4 respectively. Traps loaded with 1-mg lures caught too few moths on for statistical analysis.

Trap Suppression - 2001 Trial. Over the six release dates, in traps loaded with 10-mg lures, we recaptured an average of 66 ± 15, 31 ± 10 and 23 ± 7 sterile moths per trap on the Checkmate CM-WS, Isomate C+ and Isomate Ctt treatments, respectively. Trap suppression was significantly greater with Isomate C+ and Isomate Ctt dispensers during 4 of the 6 release dates (Figure 2). Trap catches were greater in the Checkmate CM-WS plots than the Isomate C+ plots by factors of 0.7, 6, 2 and 3X in releases 1, 3, 5 and 6, respectively. Also, in releases 3, 5 and 6 we caught between twice and three times the number of moths in the plots with Checkmate CM-WS dispensers than in the plots with Isomate Ctt dispensers. Release number 4 occurred one week after the second application of Checkmate CM-WS was placed in the field. Isomate plots did not receive a second application. This may explain why on the 4th release date there was no significant difference among treatments. But, one month later, on the 5th and 6th release dates, we once again caught substantially more moths in the plots under Checkmate CM-WS dispensers than the other two treatments. Traps loaded with 1-mg lures caught too few moths for statistical analysis.

Fruit Damage. Fruit damage was evaluated mid-season and at harvest in both years. There was no significant difference in damage between treatments; damage was very low in all treatments in both years. We chose orchards with low codling moth populations to conduct the experiment to avoid having to put a cover spray that might have interfered with the results of the comparison of the treatments.

Dispenser longevity. Isomate C+ and Ctt dispenser weights were measured by weighing the dispenser every week in 2001 (Figure 3). Isomate Ctt is composed of two tubes of the Isomate C+ dispenser. Thus, Isomate Ctt has double the amount of pheromone as Isomate C+ and therefore is placed at 1/2 the rate of Isomate C+ dispensers/acre. The weight loss for the Isomate C+ dispenser ranged from 0.4 to 2.2 mg/day and for Ctt from 0.7 to 4.4 mg/day. The results for the 2000 and 2001 field seasons were very similar. Since Isomate Ctt is composed of two tubes, the average weight loss per day should be double the weight loss per day of Isomate C+. After day 21, the weight loss for Isomate Ctt was approximately double of Isomate C+, however during the first three weeks of spring, when temperatures were cool, Isomate Ctt released approximately 80% above the Isomate C+ release rate.

The Checkmate CM-WS dispenser was loaded with only two three codling moth pheromone components: codlemone (the main component of codling moth pheromone) and the 12-carbon alcohol. It did not contain the 14-carbon alcohol. The weights of codlemone obtained through the chemical analysis of the Isomate and Checkmate dispensers are shown in Table 1. Isomate C+ are loaded with half the amount of codlemone of both Isomate Ctt and Checkmate CM-WS, but the application rate for Isomate C+ is 400/acre, while Isomate Ctt is 200/acre and Checkmate CM-WS is 160/acre. Therefore, all three dispensers should be similar in the amount of codlemone on a per acre basis. Because the chemical analysis was done at long intervals, the average weight loss is a rough estimate of the loss per day (Table 2). Release rate per day ranged from 0.4 to 1.1 mg during the first 80 days for Isomate C+, and approximately double to triple that for Isomate Ctt (from 1.8 to 2.4 mg). The release rate increased substantially for both Isomate dispensers between days 82 and 96, then decreased after day 96. By day 138, both Isomate dispensers had approximately 10% of the original codlemone remaining. When only 10% of the codlemone is left in the tubes, the release rate is very low. Thus, both Isomate dispensers lasted approximately 135 days in the field in Mendocino County. The Checkmate CM-WS dispenser released approximately 1.4 mg per day until day 68 and then released between 4 to 5 mg per day until day 96 when the analysis was stopped.

Table 1. Weight of codlemone present in Isomate C+, Isomate Ctt and Checkmate CM-WS dispensers at 0, 66, 99 and 141 days old in 2001.

	mg of codlemone		
Day	Isomate C+	Isomate Ctt	Checkmate CmWs
0	147	290	287
41	-	-	234
54	85	194	-
68	79	167	190
82	69	134	134
96	30	80	64
110	29	72	-
124	20	46	-
138	12	39	-

Conclusions

There was a significant difference in trap suppression among treatments. The difference in trap suppression cannot be explained by analysis of the amount of codlemone remaining in the different dispensers as the season progressed. If we assume that the weight loss was due solely to pheromone release, the release rates up to day 68 were similar for all three dispensers, taking into account the number of dispensers deployed per acre for each product. After day 68, Checkmate CM-WS dispensers appeared to be releasing at very high rates, and in those plots we continued to catch the most moths.

Other explanations that may account for the differences in trap suppression among the products need to be investigated. For example, the dispenser shapes are different, thus, the spatial nature of the chemical plumes emitted may also be different. Also, Checkmate dispensers are loaded with two pheromone components, while Isomate is loaded with a blend of three components. As the pheromone is released it may polymerize and form a film on the outside of the dispensers. Thus, the chemical analyses showing a decline of the codlemone component do not necessarily mean that it is being released. The level of polymerization of the pheromone may vary between dispensers.

Both Bio-Control dispensers (Isomate C+ and Ctt) lasted approximately 135 days in the field in Mendocino County. If BioControl dispensers are placed at biofix, pheromone will be released through harvest. However, there are six weeks post-harvest where fruit remaining on trees is unprotected, and codling moth populations may build up and affect population levels the next year. According to the chemical analysis, Checkmate CM-WS lasted at least 80 days. However, we consistently caught more moths in the Checkmate CM-WS plots. Further studies are needed to determine if trap suppression is correlated with the amount of pheromone present in the orchard and with worm damage at harvest.

Table 2. Average codlemone weights loss/day for three dispensers Isomate C+, Isomate Ctt and Checkmate CM-WS through the 2001 season.

Period	Average codlemone (mg/day)		
	Isomate C+	Isomate Ctt	Checkmate CmWs
0-41			1.3
0-54	1.1	1.8	
41-68			1.5
54-68	0.4	1.9	
68-82	0.7	2.4	4.0
82-96	2.8	3.9	5.0
96-110	0.1	0.6	
110-124	0.6	1.9	
124-138	0.6	0.5	

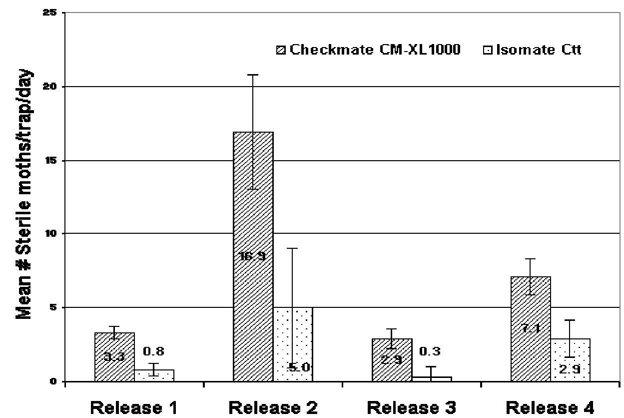

Figure1. Mean number of sterile male moths captured per trap per day in plots under Checkmate CM-XL1000 and Isomate Ctt dispensers at four release dates (June 2, July 11, July 25 and August 1, 2000).

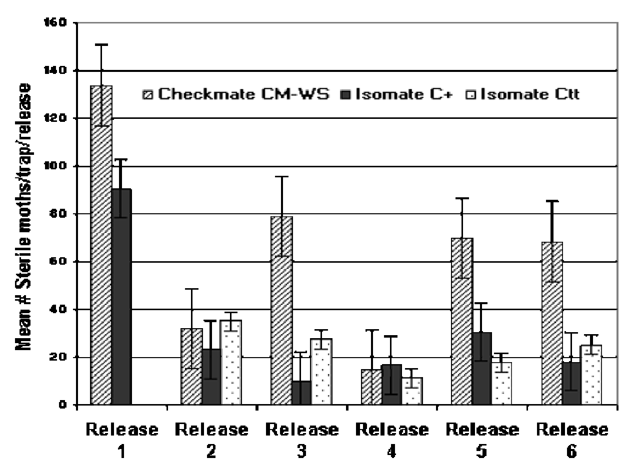

Figure 2. Mean number of sterile male moths captured per 10X trap in plots under Checkmate CM WS, Isomate C+ and Isomate Ctt at six release dates (May 1, May 23, June 20, July 11, August 1 and August 29, 2001).

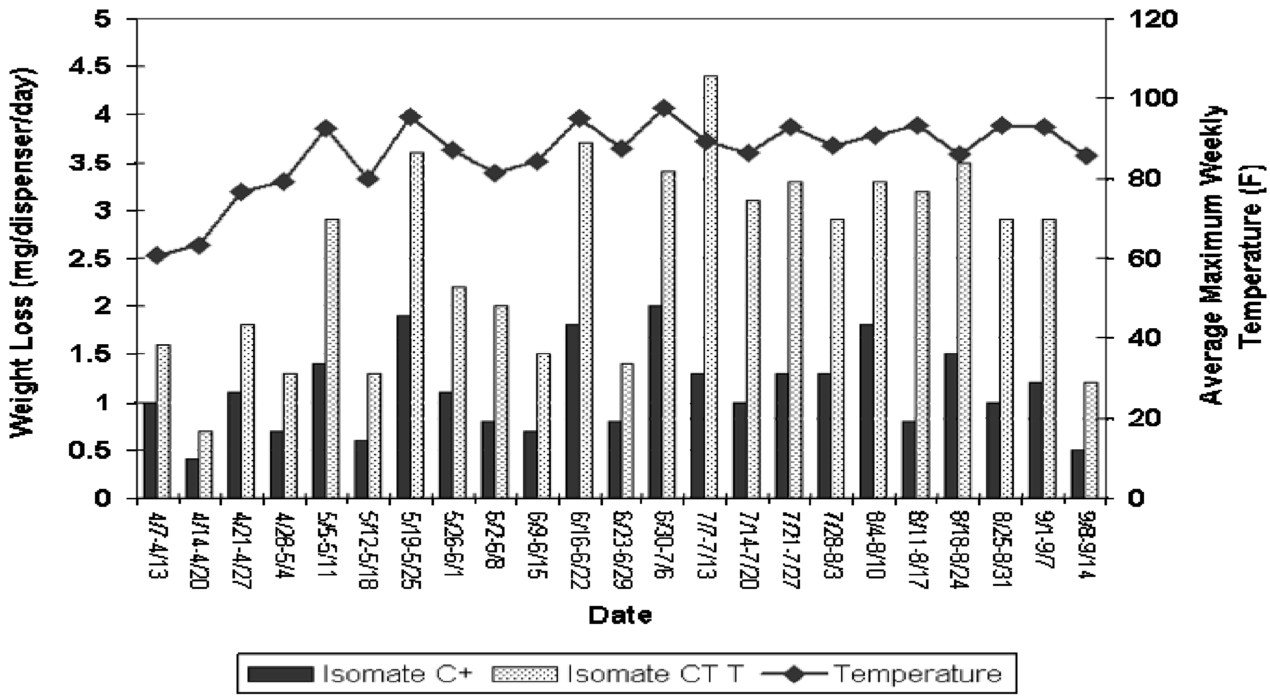

Figure 3. Isomate C+ and CTT dispenser weekly weight loss and average weekly temperature in Ukiah, CA 2001.

KATYDID MANAGEMENT IN SAN JOAQUIN VALLEY STONE FRUIT ORCHARDS

Shawn A. Steffan, Walter J. Bentley, Carlos V. Hernandez, and Susan B. Mallek, U. C. Kearney Agricultural Center

Keywords: *Scudderia furcata*, sampling, insecticides, reduced-risk pest management

Abstract

The fork-tailed bush katydid, *Scudderia furcata* Brunner (Orthoptera: Tettigoniidae), was investigated for its susceptibility to three insecticides. Trials were conducted on commercial acreage (Fresno, Kings, Tulare Cos.) and at the UC Kearney Research and Extension Center (UC KREC) in the spring of 2002. Phosmet, spinosad, azadirachtin, and a water-only check were assayed at UC KREC for their insecticidal activity on katydids caged on nectarine saplings. Treatment effects were measured as number of dead katydids at 1, 2, 4, and 7 days-after-treatment. Results from the trial indicate that nymphal (3^{rd}-4^{th} instar) fork-tailed bush katydids were readily killed by phosmet and spinosad within 48 h of treatment, while azadirachtin caused significantly less mortality after 7 days. On the commercial acreage, katydid mortality levels were measured pre- and post-treatment in ten nectarine and two peach blocks. Katydid counts were conducted between six and ten days post-treatment. Mortality levels were similar among the three insecticides, with substantial control achieved across all treated blocks. Untreated blocks had significantly higher katydid populations.

Introduction

In the San Joaquin Valley, katydids are becoming perennial pests of stone fruit, particularly nectarines. The predominant katydid species, *Scudderia furcata*, is commonly known as the fork-tailed bush katydid (FTBK). Nymphs and adults feed directly on the fruit, causing substantial yield loss. In past years, control has generally occurred incidentally as other pests in the orchard are targeted with various organophosphates and carbamates. The typical dormant-season application of chlorpyrifos (Lorsban®), for example, likely kills katydid eggs, and in-season applications of phosmet (Imidan®) are thought to have reduced nymphal and adult populations. In recent years, the use of organophosphates (OPs) has been in decline as reduced-risk insecticides have become more widely used (Epstein *et al*., 2000). The decline in the use of OPs may be attributed to insect resistance (Rice and Jones, 1997), effective alternatives and the recent Food Quality Protection Act (FQPA). FQPA regulations mandate that all OPs be re-registered by 2006, and it is anticipated that certain materials will be lost at this time. Non-OP materials (e.g., pyriproxifen, Bt, spinosad, pheromone mating disruption) have proven to be effective alternatives for certain pest species (Bentley *et al*., 2000), but since many of these materials are not broad-spectrum, pests such as katydids require extra attention. For growers and PCAs seeking reduced-risk approaches to katydid control in stone fruit orchards, efficacy information on reduced-risk materials is needed.

A primary objective of this work was to determine how well azadirachtin (AZA-Direct®), spinosad (Success®), and phosmet (Imidan 70-W®) could reduce nymphal katydid numbers. Azadirachtin and spinosad are considered to be reduced-risk materials because they are relatively short-lived and less toxic to non-target organisms. AZA-Direct, Success, and Imidan were chosen because they are registered products in California nectarines. Various growers, PCAs and farm advisors have indicated these materials are often effective on katydids, but rates per-acre and precise efficacy information are not available. Although Imidan is an OP, it was included to provide a benchmark for comparison with the other insecticides.

Methods and Materials

Single-Tree Insecticide Trials. Trials were conducted in the spring of 2002 to determine the efficacy of Success, AZA-Direct, and Imidan 70-W in controlling FTBK nymphs. In the first trial, 30 single-tree replicates (15-20 cm tall), 'Summer Red,' were established in 2 L pots. The saplings were maintained outside under natural conditions.

On 19 April 2002, over 200 2nd- and 3rd-instar FTBK nymphs were collected by sweeping lambsquarters, cheeseweed, and common vetch in the understory of a Traver (Tulare Co., CA) nectarine orchard. The nymphs were brought to the University of California Kearney Agricultural Center (Parlier, CA), caged on a peach sapling, and allowed to feed for 3 days to screen the katydids for the strongest individuals. The cage was then placed in a temperature cabinet at 12° C to arrest development. On 24 April 2002, the nymphs were carefully removed from the cage and placed in small plastic containers—five per container—and kept under refrigerated conditions (4° C) 3 h prior to the experiment.

Each insecticide was prepared at the dilution commonly used in commercial fields. Into four pints (1.89 L) of warm tap water, Triton X-100 non-ionic surfactant (100 µL) was dissolved. A pint of this solution was poured into each of the four handheld spray bottles to be used for the insecticide applications. Into one sprayer, 222 µL of Success was added, making the dilution equivalent to a 6 oz./100 gal/A application rate. Into the second sprayer, 1.18 mL of AZA-Direct was added (equivalent to 32 oz./100 gal/A). Into the third sprayer, 1.13 g Imidan 70-W was added (equivalent to 2 lbs./100 gal/A). The last sprayer was left as the water-only check.

The experimental design was a RCB with six treatments and five replications. The six treatments were as follows: 1) water applied to the sapling and katydids, 2) Success applied to the sapling only, 3) Success applied to the sapling and katydids, 4) AZA-Direct applied to the sapling only, 5) AZA-Direct applied to the sapling and katydids, 6) Imidan applied to the sapling and katydids. All saplings were sprayed to drip, requiring 4-5 squirts (10-15 mL total/sapling). Five-gallon paint strainer bags were used to cage the katydids on the potted saplings. Five katydid nymphs were inserted into each cage. For the treatments requiring katydids to be sprayed, the nymphs were carefully placed within the paint-strainer bags and sprayed immediately before sealing the bag around the treated sapling. For the treatments in which only the sapling was sprayed, the saplings were allowed to dry for 10-15 minutes before the nymphs were placed within the paint-strainer bags and the bags sealed around the saplings. All applications were made at the UC Kearney Agricultural Center on 24 April 2002. Each sapling was kept at least 3 m from other saplings during the application to protect from drift.

The saplings were kept outside under natural conditions, with afternoon shade. Katydid nymphs were counted at 1, 2, 4, and 7 days after treatment (DAT).

Katydid Monitoring and Field Trials. Spray trials on commercial fields were conducted to provide corresponding field data. The following five nectarine varieties were monitored before receiving treatments: 'Red Jim' (Hanford, Kings Co.), 'Summer Red' (Parlier, Fresno Co.), 'Summer Fire' (Sanger, Fresno Co.), 'Bright Pearl' (Farmersville, Tulare Co.), and 'Fire Pearl' (Farmersville, Tulare Co.). A peach variety ('Elegant Lady,' Parlier, Fresno Co.) was also monitored, despite having no history of katydid problems. Each variety was divided into two halves, providing 12 blocks across the six varieties. Within a given variety, a reduced-risk material was compared with a conventional material/approach.

Monitoring consisted of timed (1 min per tree) visual searches of the entire mid- to lower-canopy. The number of katydid nymphs and the number of leaves with katydid feeding was recorded. Approximately ten trees per acre were examined, and thus the sample size for a given block was a function of the block's acreage. Sample sizes ranged from 25 to 80 trees per block. Monitoring was initiated in early-April as katydid nymphs began to emerge. Each block had signs of a actively feeding katydid population.

On 15 April 2002, Success (6 oz./75 gal/A) was applied to one of the 'Red Jim' blocks, and Imidan 70-W (4 lbs./75 gal/A) was applied to the other. Both 'Red Jim' blocks were approximately ten acres. On 10 April 2002, Success (6 oz./125 gal/A) was applied to one 'Summer Red' block, and the other block was left untreated. Both 'Summer Red' blocks were four acres. On 6 May 2002, AZA-Direct (32 oz./100 gal/A) was applied to one of 'Summer Fire' blocks, and Success (6 oz./200 gal/A) was applied to the other. Both 'Summer Fire' blocks were 4.25 acres. On 8 April 2002, Success (6 oz./100 gal/A) was applied to one of the 'Bright Pearl' and one of the 'Fire Pearl' blocks. On the same date, Sevin® (4 lbs./100 gal/A) was applied to the other block in each variety. Each of the four blocks was approximately 3 acres.

Results and Discussion

Single-Tree Insecticide Trials. One day after treatment (1 DAT), there were significantly different levels of survival among the six treatments ($F = 50.49$; $df = 1, 5$; $P < 0.001$; Table 1). Mean survival in the cages in which katydids were directly sprayed was much lower than that of controls and the cages in which only the tree was sprayed (Table 1). Imidan and Success, when applied to the leaf and katydid, provided significant control, with respective mortality percentages of 100 and 80% by the end of the first day ($P < 0.001$; Fig. 1). AZA-Direct (applied to plant surfaces and katydids) produced a substantial degree of contact-kill activity, as evidenced by the 46% mortality rate (Fig. 1) compared to the 0% mortality in the control cages ($P < 0.001$).

By the end of the second day (2 DAT), the Success and Imidan treatments involving direct spraying of the katydids were statistically indistinguishable ($P = 0.669$), which suggests that Success is an effective material for katydids, but it simply takes an extra day to have the same effect as Imidan. The leaf-only treatment of Success produced significant mortality by 2 DAT with only 1.4 nymphs per tree remaining, compared to 4.8 nymphs per tree in the controls ($P < 0.001$; Table 1). The delay may be attributable to the time required for the nymphs to feed on treated surfaces after the agitation of being handled and caged. Both treatments of AZA-Direct had not improved much following the initial contact-kill, though they were still better than the controls (Fig. 2).

At 4 DAT, Success applied to leaves-only had a survival rate essentially equal to that of the Imidan treatment ($P = 0.653$; Table 1), indicating that Success works well as a stomach-poison within 96 hours of an application. AZA-Direct, applied to leaves and katydids, had achieved over 50% mortality (Fig. 3), yet the same material applied only to leaf surfaces was indistinguishable from the control ($P = 0.583$). After a week, the leaf-only AZA-Direct application still was not statistically different from the control ($P = 0.166$), which suggests that the material functions mostly as a contact-kill agent.

Application to both plant surface and katydid effectively simulates field conditions provided katydids are present at the time of application. The leaf-only cages provided insights into the modes of action. In the case of Success, the two coverage types converged, in terms of live nymphs remaining, after 96 hours. It appears that Success residues will readily kill katydid nymphs, but it takes more time than Imidan. AZA-Direct was somewhat effective as a contact insecticide, but the residues alone did not seem to cause mortality within a one-week period. The fact that a small number of nymphs died in the control cages by 7 DAT (Fig. 4) indicates that the caging system may have imposed a degree of hardship on the nymphs. Nymphs were often observed crawling about on the mesh rather than feeding or seeking shade.

Overall, the reduced-risk materials, Success and AZA-Direct, provided substantial levels of control compared to the water treatments, but the durations required to achieve these levels were longer than that of Imidan (Figs. 1-4). Most importantly, Success and Imidan stood out as highly effective materials for control of nymphal katydids.

Katydid Monitoring and Field Trials. Each spring, FTBK nymphs emerge from eggs laid within leaves from the previous year. The nymphs generally crawl out from leaf litter on the orchard understory, and as they search for food, some climb up into the tree canopy. The injury to fruit and leaves caused by their feeding at this time is visible in the lower and middle canopy.

In late-March and early-April of 2002, katydid populations and feeding activity were assessed in the 12 blocks being monitored. The pre-spray counts were fairly low (Table 2), although there were significant differences among the blocks ($F = 7.35$; $df = 1, 4$; $P < 0.001$). As mentioned previously, there are no established treatment thresholds, so the presence of katydids, or signs of any leaf or fruit damage, is often justification for a treatment.

All post-treatment counts were significantly lower than the corresponding pre-treatment counts, except for the following blocks: 'Elegant Lady'/untreated, 'Summer Red'/untreated, 'Red Jim'/Imidan, and 'Fire Pearl'/Success (Table 2). Regarding the 'Red Jim' block sprayed with Imidan, the post-spray count was not lower because this block started out with zero katydids in the pre-spray counts. The block was still sprayed, though, because feeding damage on the leaves had been observed. The 'Fire Pearl' block treated with Success was similar to the Imidan block in that the pre-spray count was very low. After the Success application, the count in the 'Fire Pearl' was lower than the pre-spray count, but since the initial count was so low, the post-spray mean was not statistically different.

Comparing the efficacy of the various insecticides, it is clear that they all suppressed katydid populations (Table 2). Overall, the populations of katydids were significantly reduced in fields sprayed with an insecticide ($P < 0.0001$). Across the six blocks that were treated with Success, the pre-spray mean was 0.59 ± 0.07 ($\pm$ SEM); after the respective Success treatments, the mean post-spray count was 0.03 ± 0.01. The blocks receiving Sevin had an overall pre-spray mean of 0.70 ± 0.15, and after the treatments, the mean katydids/tree was 0.00 ± 0.00. The 'Summer Fire' block sprayed with AZA-Direct had a pre-spray mean of 0.56 ± 0.16, and after the treatment, 0.02 ± 0.02 katydids/tree remained. All post-spray counts were done at least six days after the application.

The reduced-risk materials, Success and AZA-Direct, suppressed katydid populations almost as well as the organophosphate (Imidan) and carbamate (Sevin). When the counts from blocks sprayed with the reduced-risk materials were averaged, the overall katydid/tree mean was 0.027 ± 0.011; in the blocks sprayed with the conventional materials, no katydids were found. Despite a slightly higher mean in the reduced-risk blocks, the degree of katydid suppression was quite good, and in terms of acceptable efficacy for growers, the reduced-risk materials appear to be viable alternatives.

These findings correspond to the single-tree data derived from the experiments at UC KREC. Success ultimately worked as well as Imidan, though it required an extra day to do so. AZA-Direct appeared to be more effective in the field setting than in the single-tree trial, which may be attributable to many factors. AZA-Direct is thought to function as an IGR, an anti-feedant, and as a sterilant for females. It should be emphasized that the single-tree experiment and the field trials were conducted in the spring when katydids were 3rd and 4th instars. As they grow, it appears they become more resilient and may not be as effectively suppressed with a given material. Treatments for katydids in the spring are critical because as the nymphs develop, they appear to become more difficult to suppress. As long as the application is not delayed too long, the timing does not appear to be as critical as it is for Oriental fruit moth (OFM) or peach twig borer (PTB) applications. If the katydid population is exceptionally large in the spring, leaf damage will be very evident. In this scenario, a spray should probably be applied at the soonest spray window for OFM or PTB. The very young nymphs feed almost entirely on leaves, so there should be a "grace period" allowing a grower to wait to effectively target both katydids and moths.

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Acknowledgments

The authors thank the California Tree Fruit Agreement for their generous support of this project. We also wish to thank Rod Kepner of Gowan, Inc. for his assistance and support.

Table 1. Mean numbers of live nymphs surviving under each treatment regimen. Counts were made at 1, 2, 4, and 7 days-after-treatment (DAT).

		Live Nymphs/Cage			
Treatment/ Coverage	**Rate**	**1 DAT**	**2 DAT**	**4 DAT**	**7 DAT**
AZA-Direct/ leaf-surfaces only	32 oz/ac	4.2 d	3.8 d	3.8 c	3.4 c
AZA-Direct/ leaf-surfaces and nymphs	32 oz/ac	2.8 c	2.4 c	2.2 b	1.8 b
Success/ leaf-surfaces only	6 oz/ac	3.6 d	1.4 b	0.2 a	0.0 a
Success/ leaf-surfaces and nymphs	6 oz/ac	1.0 b	0.2 a	0.0 a	0.0 a
Imidan 70W/ leaf-surfaces and nymphs	2 lbs/ac	0.0 a	0.0 a	0.0 a	0.0 a
Water/ leaf-surfaces and nymphs	---	5.0 e	4.8 e	4.6 c	4.2 c

Means in a column followed by the same letter are not significantly different (*P* = 0.05, Fisher's PLSD)

Table 2. Mean number of fork-tailed bush katydid (FTBK) nymphs found in the canopies of various stone fruit varieties. Sampling conducted in the San Joaquin Valley in April, 2002.

		Mean No. FTBK nymphs/100 trees			
***Variety*/Material**	**Rate/A**	**Pre-Spray ± SEM**	**Post-Spray ± SEM**	**F[1]**	***P***
Bright Pearl/Success	6 oz./100 gal	1.12 ± 0.27	0.08 ± 0.05	13.96	0.0005
Bright Pearl/Sevin	4 lbs./100 gal	0.72 ± 0.23	0.0 ± 0.0	9.41	0.0035
Fire Pearl/Success	6 oz./100 gal	0.36 ± 0.14	0.08 ± 0.05	3.46	0.069
Fire Pearl/Sevin	4 lbs./100 gal	0.68 ± 0.19	0.0 ± 0.0	12.94	0.0008
Red Jim/Success	6 oz./75 gal	0.65 ± 0.14	0.02 ± 0.02	18.99	0.0001
Red Jim/Imidan	4 lbs./75 gal	0.0 ± 0.0	0.0 ± 0.0	0	
Summer Red/Success	6 oz./125 gal	0.28 ± 0.12	0.0 ± 0.0	5.21	0.027
Summer Red/Untreated		0.0 ± 0.0	0.04 ± 0.04	0	
Elegant Lady/Success	6 oz./125 gal	0.56 ± 0.16	0.0 ± 0.0	11.64	0.0013
Elegant Lady/Untreated		0.08 ± 0.05	0.28 ± 0.11	2.71	0.1067
Summer Fire/Success	6 oz./100 gal	0.56 ± 0.16	0.0 ± 0.0	10.77	0.0015
Summer Fire/AZA-Direct	32 oz./100 gal	0.56 ± 0.16	0.02 ± 0.02	9.66	0.0026

[1]df = 1 for each pre- vs. post-spray comparison. All analyses Fisher's PLSD.

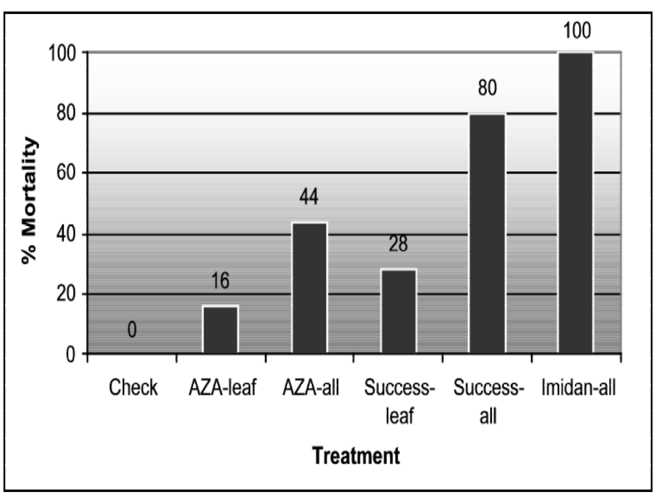

Figure 1. Percent mortality 24 hours after application (leaf = leaf sprayed; all = leaf + nymphs sprayed).

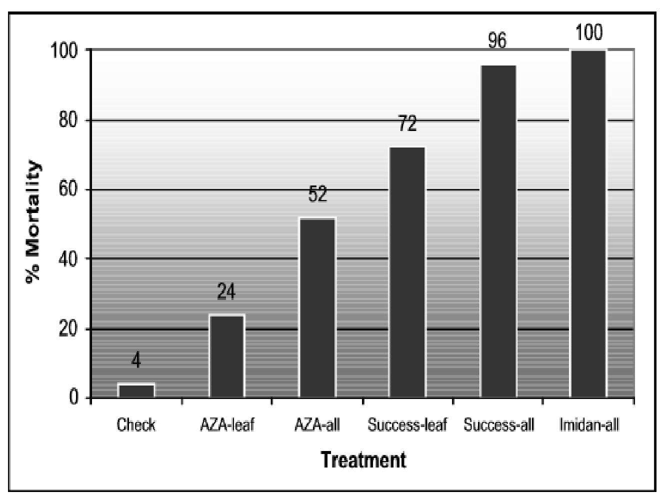

Figure 2. Percent mortality 48 hours after application (leaf = leaf sprayed; all = leaf + nymphs sprayed).

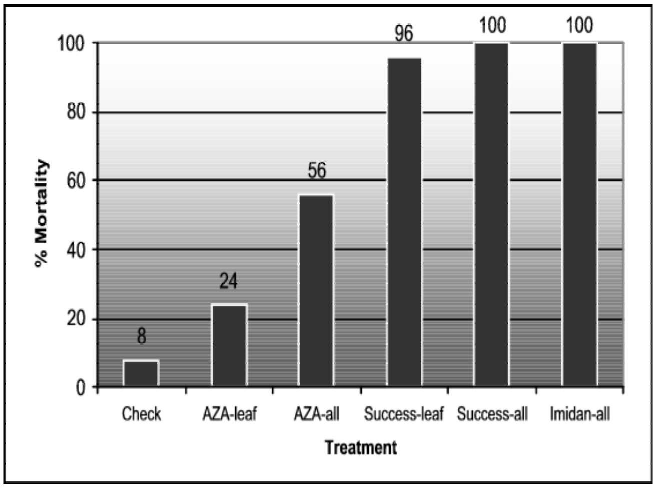

Figure 3. Percent mortality 96 hours after application (leaf = leaf sprayed; all = leaf + nymphs sprayed).

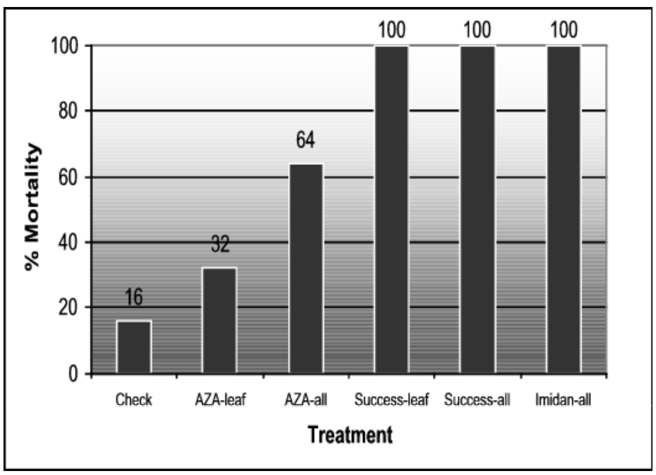

Figure 4. Percent mortality 1 week after application (leaf = leaf sprayed; all = leaf + nymphs sprayed).

ABSTRACTS

PACIFIC BRANCH ENTOMOLOGICAL SOCIETY OF AMERICA, June, 2002, Lake Tahoe, CA

Managing Insecticide Resistance in California Red Scale

Elizabeth E. Grafton-Cardwell and Yuling Ouyang, U.C. Kearney Agricultural Center, Department of Entomology, Riverside.

During 1990-1996 our laboratory documented resistance to the organophosphate insecticides chlorpyrifos and methidathion and the carbamate carbaryl in California red scale (*Aonidiella aurantii*). Two methods were of testing for resistant scale were used. The first was a fruit-dip bioassay in which citrus fruit infested with 1st instar scale were dipped in discriminating concentrations of insecticides and survival was determined after 10 days. The second method used a colorimetric test to determined the esterase activity of 3rd instar nongravid female scales. Using these methods over 300 populations of scale were screened and the majority were found to have at least low levels of resistance to the organophosphate and carbamate insecticides. During the early 1990s, growers were experiencing field efficacy problems due to resistance and had increased the number of insecticide treatments for California red scale from one every two years to several sprays per. A number of growers shifted to releasing *Aphytis melinus* parasitoids to combat resistance. During 1998, two insect growth regulators (IGRs) obtained section 18 registration for California red scale control, buprofezin and pyriproxifen. Use of these insecticides greatly reduced organophosphate and carbamate treatments in citrus and alleviated many of the red scale problems. Three years after discontinuing use of organophosphates and carbamates, only 1/3 of sites tested showed a reduction in esterase activity of resistant scale. Thus, reversion to susceptibility is slow and incomplete. OP-resistant and susceptible laboratory California red scale colonies were tested for their response to the IGRs and a 7-fold cross-resistance to Applaud was detected in the OP-resistant population. The insect growth regulators will need very careful management to retain their usefulness for California red scale management.

Investigating The Relationship Between San Jose Scale Life Stages And Wood Infestation In Almonds

Walt Bentley, Brian Ribeiro, Frank Zalom and Mario Viveros, U.C. Kearney Agricultural Center, Statewide IPM Program, Dept. of Entomology, U.C. Davis, and UCCE Kern County.

Five almond orchards having San Jose scale (SJS) infestation were monitored in winter 2001. Male SJS were monitored using standard pheromone caps and traps manufactured by Trece®. Traps were placed in orchards on February 19 and monitored through November. Sticky traps were changed weekly. Pheromone caps were changed monthly. Three of the orchards (over 60 acres in size) were monitored with four SJS traps, evenly distributed throughout the orchard. The remaining two orchards were less than 20 acres and only three SJS traps utilized. All five orchards grew the nonpareil cultivar in 2/3 of the planting. The five orchards had been in full production for 10 years.

Crawlers were monitored on four trees around each of the pheromone traps. A single tree at each of the four compass points around the tree that held the pheromone trap was selected and a single double-sided sticky tape was placed on one of the scaffolds. Tapes were placed prior to crawler emergence in the spring (April 1) and were changed after each crawler generation (a total of five changes made at approximately 6-week intervals). The tapes were counted and the number of crawlers per tape was totaled for the season. During December 25 live spurs were collected from each of the trees where sticky tapes were used. Counting of SJS was done from the base to a distance of 3 inches on the spur.

A simple regression analysis was performed (Stat View 5.1) using the number of crawlers per tape per season as the independent variable and the number of infested spurs as the dependent variable. The number of male SJS was also used as the independent variable and a regression performed with the number of infested spurs. The 18 data points from the five orchards were pooled for the analyses. When the number of crawlers per tape per season at each trapping location was regressed with the number of infested spurs per 100, a highly significant (P< 0001) relationship was found. The R square was .788 using the no intercept model (Stat View 5.1). The Regression equation was Y=0+. 029*X. Similarly, the number of male scale per trap per season was regressed with the number of infested spurs out of 100 collected. The R square was .718 and was highly significant (P<. 001 Stat View5.1, no intercept model). The Regression equation is Y=0+. 01*X.

The information gained will be used in developing an insecticide treatment threshold for San Jose Scale.

The Influence of Trap Placement in Monitoring San Jose Scale (Hom.: Diaspididae) and Its Natural Enemies

Kent Daane, Brian N. Hogg, Glenn Y. Yokota and Walter J. Bentley, U.C. Kearney Agricultural Center, Division of Insect Biology, Berkeley and UC Statewide IPM Program.

San Jose scale (SJS), *Quadraspidiotus perniciosus* Comstock, a major pest of stone fruit in California, is commonly monitored with sex pheromone traps. The density of SJS parasitoids captured on Sticky traps has been used to assess the natural; regulation of SJS. In this study, trap placement, both by cardinal direction and by height within the tree canopy, was studied for its influence on trap efficacy. Experiments were conducted both with and without SJS sex pheromone lures. Without pheromone lures, results show little difference in capture rates between sticky traps placed at the four cardinal directions. Although *Aphytis* spp. showed no clear preference for traps at any height, traps placed in the lower sections of the tree canopy, captured greater numbers of *Encarsia perniciosi*, while the number of SJS was greatest in the upper canopy. This indicates that trap placement has important implications for monitoring SJS and its natural enemies – traps placed low in the canopy yield an inaccurately high estimate of the *Encarsia*:SJS ratio, while traps placed high in the canopy give a high low estimate of the *Encarsia*:SJS ratio. When lures were added, this pattern was still evident and number of both *Encarsia* and SJS increased – but the density of *Aphytis* spp. trapped did not respond accordingly. As a result, the density of *Aphytis* spp., in relationship to *Encarsia* and SJS, is underestimated by the sex pheromone baited traps.

Life-History and Ecology of Vine Mealybug (Homoptera: Pseudococcidae) In Central California

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The vine mealybug, *Planococcus ficus,* is a serious vineyard pest in southern and central California. We conducted population dynamic studies in the San Joaquin Valley to determine its life history and levels of natural controls. Results show all stages of mealybugs (except adult males) feed throughout the vine on the roots, trunk (under the bark), canes, leaves and berry clusters. There are 5-6 generations of mealybugs per year, as suggested by patterns of crawler emergence and male flight (recorded with pheromone traps). The key biotic mortality factor is a resident parasitoid – *Anagyrus pseudococci* (Hym.: Encyrtidae). Parasitoid densities were low during the winter (<2%). As the temperature and vine shoot growth increased, mealybugs moved from underneath bark to exposed surfaces such as new canes, leaves and fruits. After which, mortality from *A. pseudococci* increased to 70% up to 90% of the exposed mealybugs in August and September samples. The parasitoid is currently being tested in augmentative release trials to reduce the early-season spread of mealybugs to leaves and fruit.

Parasitoids of the Obliquebanded Leafroller in California Pistachio: Development of An Augmentation Program With *Macrocentrus iridescens*

Rodrigo Krugner, Kent M. Daane and Glenn Y. Yokota, U.C. Kearney Agricultural Center, Division of Insect Biology, Berkeley.

The obliquebanded leafroller (OBLR), *Choristoneura rosaceana*, has become an increasing important pest of pistachio in California's Central Valley. We studied OBLR and natural enemy population dynamics to determine levels of damage and potential for improved biological controls. As a part of that study, parasitoids were reared from OBLR collected in six commercial pistachio blocks from 1999-2001. Here, we report on levels of OBLR parasitism and the development of an augmentation program with a braconid wasp, *Macrocentrus iridescens*. Results from commercial blocks showed a steady rise in OBLR densities from late April to July, when >75% of the damaged leaves contained an OBLR larva. After mid-August, there was a considerable reduction in OBLR presence, with most "strikes" empty of live OBLR. Collected data and observations suggest a combination of parasitoids and lowered leaf quality were the cause for lowered OBLR densities. Overwintered OBLR, collected in April, had parasitism levels ranging from 0-15%, depending on orchard block. Parasitism steadily increased to 40-60% in July and August and then to 80-100% from late August to October. Parasitoids collected included *Trichogramma* nr. sp. *pretiosum*, which parasitized 60-80% of the egg clusters in August and September collections. And the larval parasitoids including *Macrocentrus iridescens, Spilochalcis sp., Goniozus* sp., and at least one parasitic fly (a tachinid, tentatively identified as *Actia* sp.). Cage studies of OBLR feeding were conducted throughout the season and suggest that OBLR feeds preferentially on leaves; however, larvae can, at any time, cause damage to the nut. *M. iridescens* was the most common parasitoid. We successfully developed colonies of *M. iridescens* and we will begin tests of field release this spring.

Winter Sanitation Practices for Navel Orangeworm in California Pistachio May Not Be Complete

Kent M. Daane, Glenn Y. Yokota, Rodrigo Krugner, and Walter J. Bentley, U. C. Kearney Agricultural Center, Division of Insect Biology, Berkeley, and Statewide IPM Program, R. Beede, UCCE, Kings County.

Navel orangeworm (NOW), *Amyelois transitella*, is a moth pest of almond and pistachio nuts. The larvae directly damage nuts, which is the only portion of the tree attacked. NOW populations can be suppressed through an orchard sanitation practice of removing nuts or "mummies" left on the tree after harvest; thereby removing NOW host sites from winter until nut-split the following season. Still, pistachio growers using sanitation practicing often report high NOW damage. We studied NOW survival in overwintered mummies knocked to the ground and left on the orchard floor middles and berms from winter through harvest the following summer/fall. Results show overwintered pistachio nuts the berm can host NOW throughout the season. Nut infestation levels were 8.5, 6.7, 1.7, 0.2, 1.1 and 0.3% in January, February, March, April, June and August respectively. The spring and summer infestations represent new NOW generations – and indicate that adult NOW oviposited on the fallen nuts. Based on the number of infested nuts per m^2, we estimated a live NOW every 3 m of berm in summer, a significant contribution to damage at harvest. Ongoing studies indicate that sanitation practices can be improved by blowing nuts off the berms and into the middles during the winter. Also, disking the middles significantly reduces NOW survival in nuts.

FOURTH INTERNATIONAL CONGRESS OF NEMATOLOGY, June, 2002, Tenerise, Spain

Effect of Oxycom on Growth of Tomato and Reproduction of *Meloidogyne incognita*

Safdar Anwar and M. V. McKenry, U.C. Kearney Agricultural Center, Dept of Nematology, Riverside.

Single or multiple applications of Oxycom, peroxyacetic acid plus various biocontrol agents, were compared on 15-day-old susceptible tomato inoculated with 1500 second stage juvenile (J2) *M. incognita*. Forty pots were dipped into 2500 ppm (v/v) Oxycom, and 20 in water. Twenty of the 40 pots received four additional Oxycom applications at 10-day intervals. Plants were harvested at 60 days after inoculation to assess the effect of treatments on plant growth, nematode development and reproduction. A single treatment of Oxycom just prior to nematode inoculation significantly increased tomato top weight but not other growth parameters. Associated with plant benefit was a significant increase in the number of root-knot females. Multiple treatments of Oxycom significantly reduced leaf area, top weight and root weight while significantly increasing the number of galls, females and J2 per plant or per g root. This study demonstrates that Oxycom stimulates plant growth and earlier fruiting while hastening nematode development. Proper timing and frequency of applications is important. No treatment reduced nematode population levels in this 60-day trial.