Annual Report to
Almond Board of California
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Project Leader:
Frank G. Zalom
Department of Entomology
University of California
Davis, CA 95616
Tel: (530) 752-3687

Project Participants: UC Farm Advisors, Mark Freeman (UCCE Fresno Co.), Rich Coviello, Toby Glik (UC Davis) and Walter Leal (UC Davis) for Objective 1; Walt Bentley (UC Kearney Agricultural Center) for Objective 2; Mike Oliver (UC Davis), Ken Giles (UC Davis), Herb Scher (UC Davis) and Barry Wilson (UC Davis) for Objectives 3 and 4.

Objectives:

1. Purchase pheromone traps, navel orangeworm (NOW) bait traps, and lures for UC Cooperative Extension Farm Advisors as part of their ongoing monitoring and extension efforts. Determine distribution of NOW eggs on the almond tree canopy.

2. San Jose Scale (SJS) -Develop treatment thresholds for SJS by correlating damage to male abundance in pheromone traps and to scale crawlers and scales on almond spurs.

3. Peach Twig Borer (PTB) - Determine efficacy of registered and candidate insecticides for control of PTB during orchard dormancy, and examine effects of copper on residual availability of organophosphates.

4. Validation of Best Management Practices for mitigating dormant spray runoff - Conduct orchard field trials to test the impact of earlier treatment timings and vegetated filter strips as mitigation methods for runoff.

Summary of Results:

Objective 1, Monitoring supplies and navel orangeworm spatial distribution. Each year through this project, trapping supplies are purchased for use by UC Cooperative Extension Farm Advisors to help them to monitor the phenological activity of almond insect pests in their counties. The Advisors use the data gathered from these traps to update pest status for local growers and PCA's. Trapping records are solicited from the Advisors at the end of each season, and become part of a historical database. For the 2003 season, supplies purchased and distributed included 1350 wing traps and trap liners, 760 San Jose scale traps, 1485 pheromone lures, and 14 lbs of NOW bait. As in 2002, funding was provided to Mark Freeman and Rich

Coviello for trapping at multiple sites in Fresno Co. for NOW (Kerman, Selma, and 2 in northwest Fresno Co.), PTB (Parlier, Laton, Selma, Kerman, and 2 in northwest Fresno Co.), OFM (Laton, Parlier, Panoche), and SJS (Parlier, Laton, Panoche).

Determining the spatial location of nuts on which NOW prefer to oviposit is significant both in terms of where to place traps for monitoring but also to improve the potential for ovipositional disruption. To determine if there is a preferred height in an almond tree for oviposition, NOW egg traps were placed at 3 heights in two orchards about 20 miles apart in northwest Fresno Co., in an orchard near Manteca, San Joaquin Co., and in an orchard near Winters, Solano Co. Each trap location within an orchard consisted of a 20 ft length of PVC pipe placed vertically within a tree to which were attached standard Trece black navel orangeworm bait vials baited with almond press cake at 6 (low), 12 (middle) and 18 (high) ft heights. As in 2002, there was no clear pattern to navel orangeworm egg spatial distribution as results varied by orchard. Figures 1 and 2 give the average for total navel orangeworm eggs collected at the Fresno County sites. At the Fresno A site (Panoche Road), a significant difference ($F=13.852$; $df=2,7$; $p<0.0005$) was observed between trap heights, with significantly more ($p<0.05$) eggs being found at the 6 foot height than at the 12 0r 18 foot heights (Figure 1). At the Fresno B site, a significant difference ($F=22.53$; $df=2,7$; $p<0.0005$) was observed between trap heights, with significantly more ($p<0.05$) eggs being found at all 3 heights (Figure 2). Navel orangeworm densities were much lower at the Manteca and Winters sites, but egg laying pattern followed more closely that observed at the Fresno B site with the highest traps recording the most oviposition activity. These data are important to control by ovipositional disruption. If in fact most eggs are laid higher in the tree canopies, then any product applied for ovipositional disruption might benefit from application higher in the tree canopy.

Figure 1. Average number of navel orangeworm eggs per trap per season at 3 trap heights recorded at the Fresno A location.

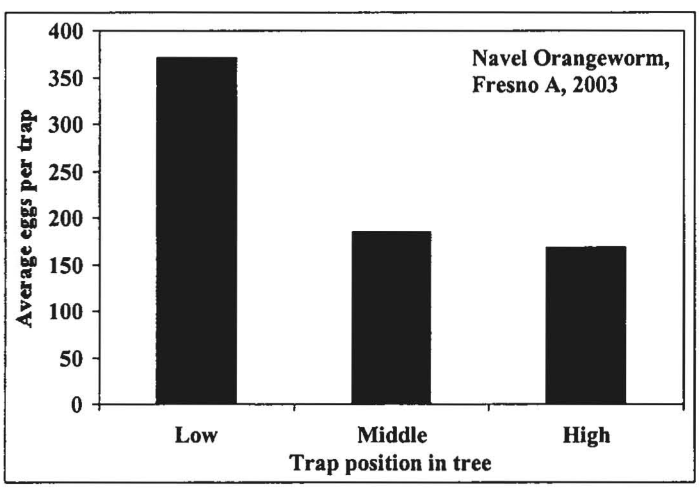


Figure 2. Average number of navel orangeworm eggs per trap per season at 3 trap heights recorded at the Fresno B location.

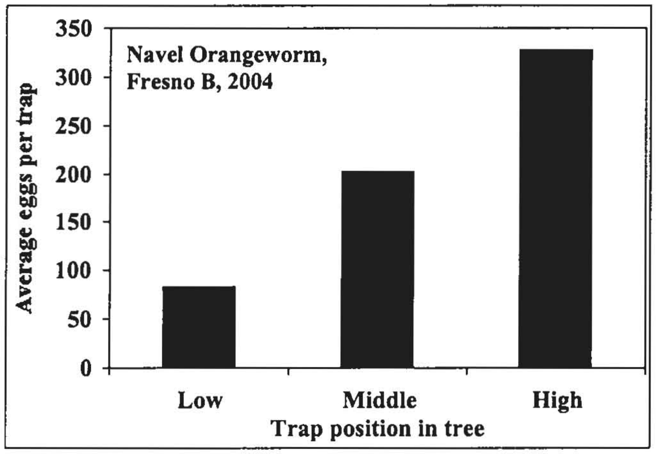


Figure 3. Average number of navel orangeworm eggs per trap per season at 3 trap heights recorded at the Manteca location.

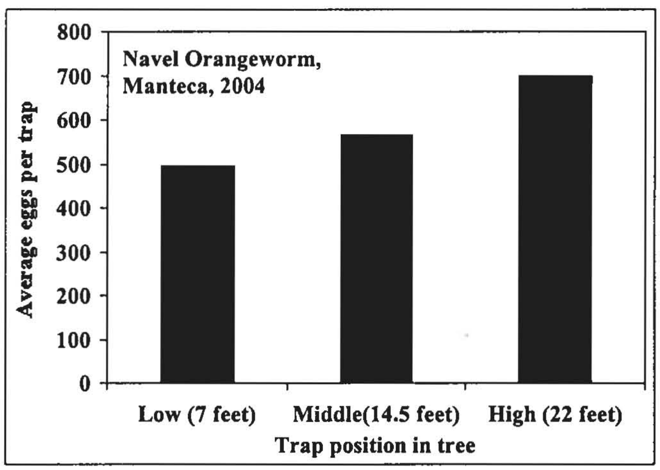
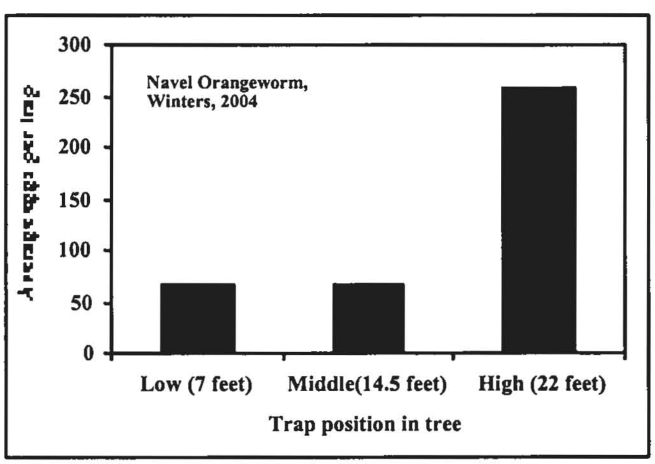


Figure 4. Average number of navel orangeworm eggs per trap per season at 3 trap heights recorded at the Winters location.



In 2003, the Zalom lab began collaboration with Drs. Walter Leal and Marshall Johnson on the ten lined June beetle. The Zalom lab monitored the field sites weekly where the Leal experiments took place near Manteca. Results of this monitoring and deployment of candidate volatiles for beetle attraction are reported in their individual projects.

Objective 2, San Jose scale. Walt Bentley has been leading the effort to develop sampling decision rules for San Jose scale which would allow growers and PCAs to predict the need for a dormant spray application. This study is being conducted in the Kern Co. Almond Pest Management Alliance Orchard in Wasco. Treatments in the orchard include 4 replicates of 'conventional' sprays and 4 replicates of 'reduced-risk; sprays with 2 of the 3 replicates in each treatment being either hard shell or soft shell varieties. In 2003, the 'conventional' plots received a dormant spray of diazinon (Diazinon 50W, 4 lb/ac) plus 6 gal of Volck Oil Supreme in 200 gallons of water per acre. The 'conventional' plots also received a hullsplit application of phosmet (Imidan 70WP) at the rate of 4 lbs per acre in 200 gal of water. The 'reduced risk' plots received a May application of tebufenozide (Confirm 2F) at the rate of 16 oz per acre.

As in the previous two years, each of the plots was again split in half creating two plots of 10 acres each. One of the ten-acre halves was treated in the dormant period as described above, while the other ten-acre half remained untreated during the dormant period but was sprayed either in May (reduced risk), or at hullsplit (conventional). A San Jose scale trap is deployed in each 10 acre plot in March and the traps are monitored through October. Male scale, *Encarsia perniciosa*, and *Aphytis* spp. are counted every week on the sticky cards. Double-sided sticky tape is wrapped around a secondary scaffold from the tree holding the trap to monitor scale crawlers during the season, as well as each tree to the north, south, east and west of the trap tree. The tapes are deployed in March and monitored through October. In late August, each of the trees with a sticky tape (five per plot) is evaluated for San Jose scale infestation and damage, and assigned a rating from 0 to 3 based on a 3 minute timed search as follows: no scale = 0; any live scale = 1; live scale in the presence of yellowing leaves or small branches that are dying = 2; live scale in the presence of dead or dying large limbs = 3. The ratings are summed for all of the five trees searched in each plot. Finally, 20 spurs (3 inch lengths) from each of the five trees in all plots are examined, and number of live scales recorded during the following winter.

Results of regression analysis indicate a relationship between spur infestation, number of live scales per spur, and severity of damage. The relationship between the average number of infested spurs and damage severity was highly significant (unadjusted R^2=0.795; Y=0.865+0.615X; P=0.0001). The relationship between number of live scales and damage severity is also highly significant (unadjusted R^2=0.694; Y=2.008+0.034 X; P=0. 0001), but less close. The relationship between number of infested spurs infested and number of live scale found on spurs is also highly significant (unadjusted R^2=0.802; P=0. 0001). There was significantly (P=0.0012; Fisher's Protected LSD) more damage to trees that were not dormant sprayed (5.5 damage rating) than to those trees which received a dormant spray (0.75). This was true for all of the different conventional and reduced-risk approaches tested. As shown in previous studies, dormant oil alone, one of the treatments in the reduced risk approach, also significantly ($P<0.05$; Fisher's Protected LSD) reduced the amount of observed tree damage (1.5 damage rating).

Figure 5. Average San Jose scale crawlers per square inch of sticky tape in conventional plots, Kern Co., 2003.

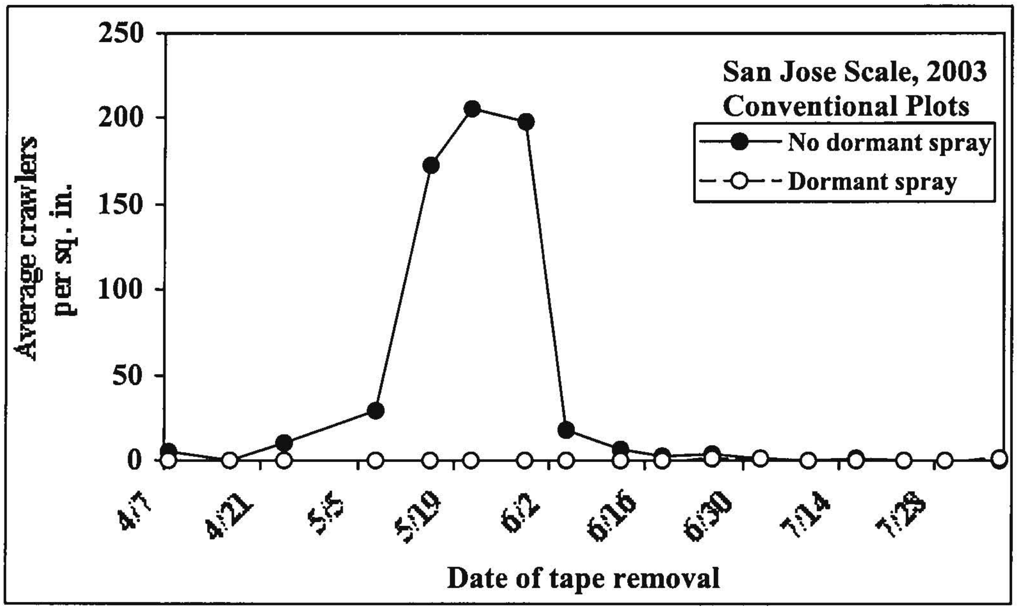
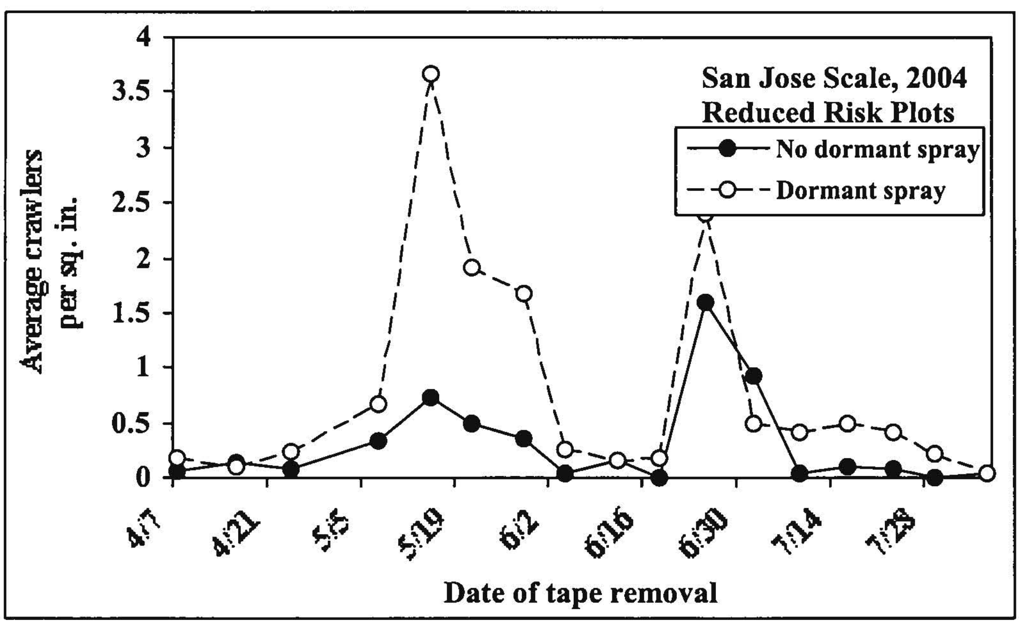


Figure 6. Average San Jose scale crawlers per square inch of sticky tape in reduced risk plots, Kern Co., 2003.



Results of season long San Jose scale monitoring showed significant effects of the conventional versus reduced risk management practices in terms of scale densities, with much greater scale densities being recorded in the conventional plots (Figures 5 and 6).

Objective 3, Peach Twig Borer. Copper ions are known to catalyze the hydrolytic decomposition of organophosphate insecticides, and may result in accelerated decomposition of the organophosphate on the tree surface requiring higher rates to achieve control. Lat year we reported results of laboratory experiments using diazinon and chlorpyrifos in combination with copper hydroxide which suggested that the presence of copper hydroxide accelerates organophosphate decomposition, and that the microencapsulation of organophosphates somewhat mitigated the catalytic decomposition. Two sets of laboratory studies are being conducted at this time to separate the effects of pH and copper, and preliminary results are confirming previous results. A field experiment was conducted during winter, 2003, to determine if there are biological implications from the accelerated decomposition. Treatments evaluated included encapsulated and non-encapsulated Diazinon and Lorsban, applied at full and half label rates, with and without copper (Nu-Cop 3L, 5.33 pts/ac). All treatments also included Volck Oil Supreme at 1.5 gal (v/v). Each treatment replicate was a single tree, and all treatments were replicated 12 times in a completely randomized design. At least 4 trees remained untreated as buffers at the ends of each row. Efficacy of the treatments was determined by counting shoot strikes per tree in a 3 minute timed search conducted the last week of April. Results of 1-way ANOV indicated a significant difference (F=6.893, df=16,187, P<0.001) between treatments. All treatments significantly reduced PTB shoot strikes relative to the treated control. Multi-factor ANOV indicated no differences between Diazinon treatments (P>0.05 for all factors), but a significant difference was indicated for Lorsban with and without copper (P=0.0101), with more shoot strikes counted in treatments with copper than without copper.

Table 1. Efficacy of full and half rates of non-encapsulated (standard Lorsban 4EC) and microencapsulated chlorpyrifos against peach twig borer with and without copper hydroxide as a dormant spray mixture.

Encapsulation?	Rate	Copper	Mean $\pm$ SE shoot strikes
Yes	Full	Yes	0.583 $\pm$ 0.193 **
Yes	Full	No	0.083 $\pm$ 0.083 **
No	Full	Yes	0.250 $\pm$ 0.131 **
No	Full	No	0.083 $\pm$ 0.083 **
Yes	Half	Yes	0.417 $\pm$ 0.260 **
Yes	Half	No	0.083 $\pm$ 0.083 **
No	Half	Yes	0.417 $\pm$ 0.193
No	Half	No	0.250 $\pm$ 0.131

** peach twig borer shoot strikes are significantly different from that of the corresponding treatment with copper by pairwise t-tests at p<0.05, n=12 replicates.

per acre, and (9) Warrior at 3.8 oz formulated product per acre. Each treatment replicate was a single tree, and all treatments were replicated 12 times in a completely randomized design. The treatments were applied following the annual pruning by the grower at the equivalent volume of 100 gal/acre. All treatments also included Volck Oil Supreme at 1.5% v/v and no copper. PTB shoot strikes were counted on April 28, 2003, to evaluate treatment efficacy. Data were analyzed by 1-way ANOV followed by pairwise mean separation by Student t-test. Data were log (x+1) transformed before analysis. Results (Table 2) indicated significant differences between treatments (F=11.253; df=8,99; P<0.0001) relative to the untreated control, with all treatments having lower shoot strike counts than the untreated control.

A second experiment was conducted to determine the efficacy of several insecticides applied for PTB control during orchard dormancy. Treatments consisted of (1) an untreated control (water), (2) Drexel Diazinon (48.2%) at 4 pints formulated product per acre, (3) Drexel Diazinon (48.2%) at 2 pints formulated product per acre, (4) Lorsban 4E at 2 pints formulated product per acre, (5) Lorsban 4E at 1 pint formulated product per acre, (6) Asana at 19.2 oz formulated product per acre, (7) Success at 9.0 oz formulated product per acre, (8) Warrior at 3.0 oz formulated product
Table 1. Mean + SD peach twig borer shoot strikes per tree in experiment to test effects of copper and encapsulation on efficacy of chlorpyrifos.

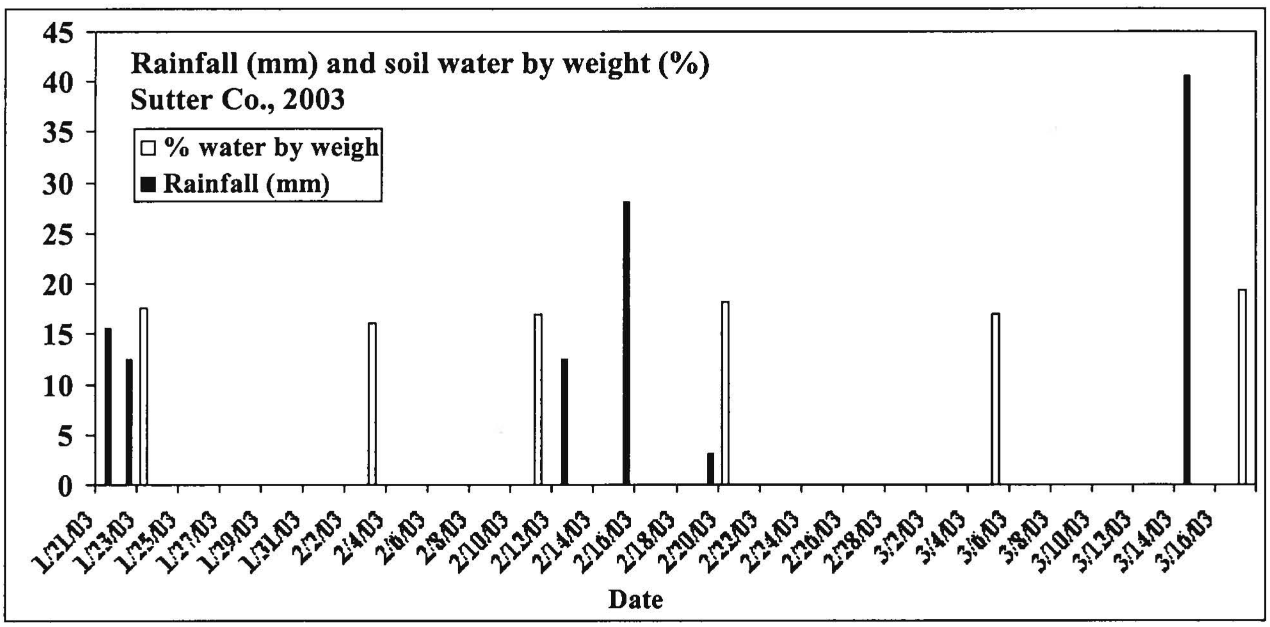
Table 2. Mean (± SD) peach twig borer shoot strikes per tree, 2003.

Pesticide	Rate (product/ac)	Mean (± SE) shoot strikes
Untreated	-	2.33 ± 1.50
Diazinon	4 pt	0.33 ± 0.65 **
Diazinon	2 pt	0.42 ± 0.67 **
Lorsban	2 pt	0.08 ± 0.29 **
Lorsban	1 pt	0.25 ± 0.45 **
Asana	19.2 oz	0.25 ± 0.45 **
Success	9 oz	0.42 ± 1.17 **
Warrior	3 oz	0.00 ± 0.00 **
Warrior	3.8 oz	0.00 ± 0.00 **

Application date: February 11, shoot strikes counted April 28.
** Peach twig borer shoot strikes are significantly different from the untreated control by pairwise t-tests at P<0.05, n=12 replicates.

Objective 4, BMPs for Mitigating Dormant Spray Runoff. We continue to examine Best Management Practices to mitigate impacts of dormant season pesticide applications that are both effective and economically viable for growers to use. Much of the funding for this work is coming from a Department of Pesticide Regulation contract for this purpose, and from collaborative work we have with the Prune Board and others who have contracts for related work. In the winter of 2002-03, we conducted 2 studies. One was the second year of a study to determine if applying treatments earlier in the dormant season can reduce overall pesticide load in stormwater runoff. The premise is that it rainfall events which produce runoff are more likely to occur later in the winter dormant season when soils tend to become saturated by cumulative rainfall, and that insecticide that falls to the ground during spraying is more likely to infiltrate into non-saturated soils with earlier season rainfall events where the insecticides would be subject to decomposition. Data from 2001-02 reported last year suggest that this is the case, but rainfall was also quite low until later in the season. Runoff volume for this season was collected in our autosampler units from rainfall events occurring on January 22-24, February 13-18, and March 15, 2003. Diazinon was applied at 3 treatment timings, January 17, February 4, and February 24, 2003, and an untreated control was also established. The treatment timings were replicated 3 times. Applications were applied to the soil surface using an Echo Mister/Duster Backpack Air Assist Sprayer to insure uniform coverage of each 50 m plot. The 50 m plots were defined by an earthen dam on the upslope end to preclude water entering the plot, and at the downslope end where an autosampler was located to record volume of runoff. Approximately 1% of the total runoff was collected in a Nalgene container and sent to Dr. Barry Wilson's lab for chemincal analysis. Unlike, 2001-02, rainfall events sufficient to cause surface water runoff occurred several times during the winter. Ironically, the first major event began only 4 days after the first treatment timing (Figure 7)m the second rainfall event occurred 7 days and 17 days after the second application. The last rainfall event occurred 20 days after the third application.

Figure 7. Rainfall (mm) and percent soil water by weight at Sutter County treatment timing site, 2003.



As was expected, volume of runoff was not significantly different among the treatment timing and untreated control (Figure 8). Diazinon mass followed the relationship of highest amounts occurring closest to the date of the diazinon application (Figure 9).

Figure 8. Volume of stormwater runoff from plots treated at different timings during orchard dormancy or untreated, Sutter, County, 2003.

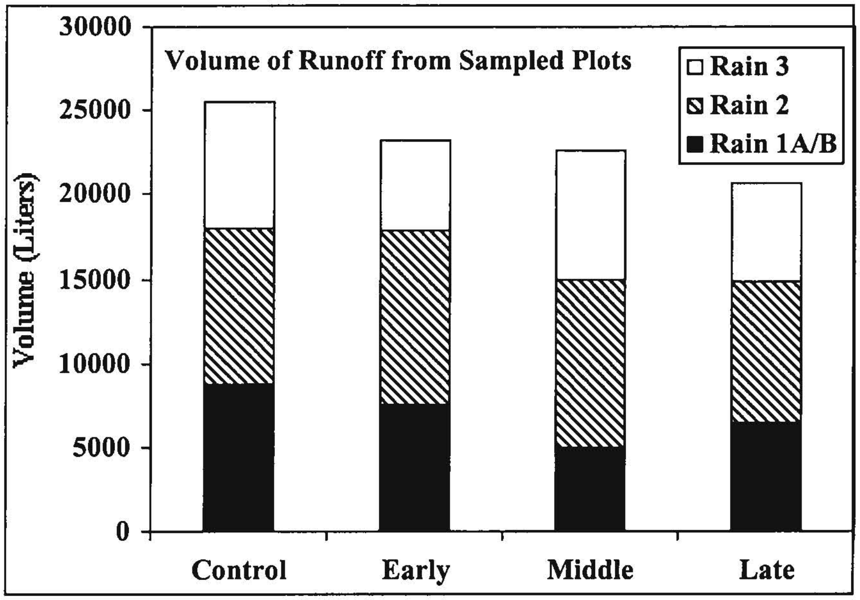
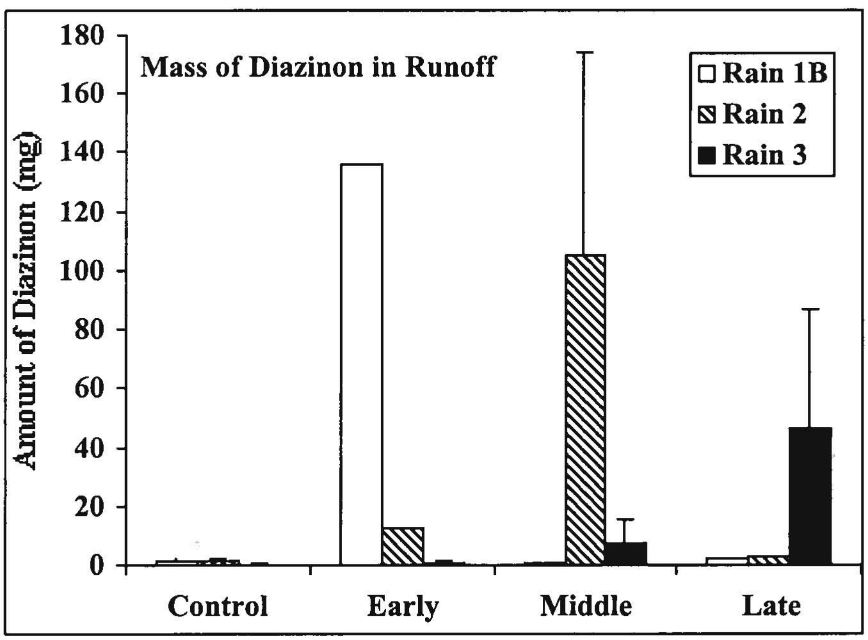


Figure 9. Diazinon mass (mg) leaving plots treated at different treatment timings during orchard dormancy or untreated, Sutter, County, 2003.



A second study was intended to evaluate the efficacy of different widths of vegetative buffer strips (10 m, 20 m and 30 m strips) in reducing the concentration of diazinon in surface runoff from dormant sprayed orchards. Unfortunately, no rainfall events sufficient to result in runoff from this orchard occurred after the sprays were applied. We repeated this experiment in the late Fall of 2003, using 'artificial rain', that is sprinklers set up in the orchard to simulate a rainfall event. The study design incorporated five treatments including a control treatment (sprayed 50 m of row with no vegetated buffer) and four vegetated buffer treatments, 50 m + 10m buffer, 50 m + 20 m buffer, 50 m + 30 m buffer, and 100m + 20 m buffer. Treatments were placed in 4 non-randomized, fully replicated blocks in a dormant, mature dormant orchard where the trees were planted on berms approximately 20 feet apart. A dormant spray with diazinon (4 gallons active ingredient plus 96 gallons of water per acre) was applied by backpack sprayer directly to the ground within the 50 m target area of each plot so that drift could be avoided onto the adjacent vegetated buffer area. Each plot had a dam on its upper end to prevent water from flowing into the plot from above the sprayed area, and a dam with one of our autosampler units was place at the downslope end at the end of the vegetated buffer area. The sprinklers were run across all treatments and replicates until runoff occurred, and then samples were collected for residue analysis after the first 400 gal. of runoff occurring in each plot. Table 4 presents the diazinon concentrations in the runoff samples. There was considerable variation in diazinon concentration between the replicates, but when data were transformed to concentration as a proportion of the treated control, significant differences were observed.

Table 4. Mean ± SE concentration (ppb) of diazinon in first 400 gal. of runoff and mean diazinon concentration of runoff from each treatment as a proportion of the no buffer strip control.

Treatment	Mean ± SE ppb [1]	Mean ± SE proportion [2]
No buffer	332.100 ± 99.641	1.000 ± 0.000
50 m + 10 m buffer	178.133 ± 101.309	0.470 ± 0.136 **
50 m + 20 m buffer	229.500 ± 129.907	0.500 ± 0.261 **
50 m + 30 m buffer	67.933 ± 13.763	0.273 ± 0.119 **
100 m + 20 m buffer	143.633 ± 99.151	0.373 ± 0.171 **

[1]ANOV results; F=1.034; df=4,10; p=0.4364

[2]ANOV results following arcsin transformation; F=4.819; df=4,10; p=0.0200;

** mean is significantly different from no buffer control at p<0.05 by pairwise t-test.