# Insect and Mite Research

**Project No.:** 06-ENTO6-Zalom

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**Interpretive Summary:**

This project continues to take a long term, comprehensive approach to almond insect and mite management, working closely with UC Cooperative Extension Farm Advisors to help develop management guidelines for many major arthropod pests. For the 2006 season, insect monitoring supplies purchased and distributed to UC Farm Advisors included 1090 wing traps and trap liners, 308 San Jose scale traps, 50 navel orangeworm egg traps, 450 'regular' pheromone lures, 203 'long-life' pheromone lures, and 9 lbs of navel orangeworm bait. The first flight biofixes for many of the insects monitored were delayed in 2006 because of the prolonged cold, rainy weather during spring. In some cases, it was difficult to detect the biofix. Because of the delay in flight initiation, there were likely fewer complete generations of insects such as peach twig borer, San Jose scale, oriental fruit moth and oblique banded leafroller than in "normal" years.

A 4-year study of San Jose scale intended to evaluate monitoring approaches and damage risk was concluded with analyses relating infestation to damage ratings and pruning rates. Conclusions from the 4 years of this study are that San Jose scale can be managed, even in a heavily infested orchard, by a pyriproxifen and oil application. In cases where horticultural mineral oil has been regularly applied in the dormant season, there is likely no need to tank mix with additional insecticides in the dormant spray to manage San Jose scale. The most accurate method of predicting the need for a San Jose scale treatment is sampling infested spurs, the number of spurs infested being a

more accurate predictor of damage than counting the number of scale found on the spurs. Finally, infestations in excess of six San Jose scale infested spurs in 100 samples will result in significant loss of tree growth as manifested by pruning weights if left uncontrolled.

An evaluation of new products and product timings for control of peach twig borer revealed significant differences between many of the treatments and an untreated check. Products, rates and treatment timings are presented in data tables in this report. Treatment timing may be important to mitigation of pesticide runoff from winter applications intended to control insects and mites, as indicated in published studies of pesticide runoff. However, there is concern in timing of winter sprays relative to efficacy aginst the target pests and any phytotoxicity that may occur to almond trees. A study was conducted to examine potential effects of earlier dormant season applications containing horticultural mineral oil on efficacy against peach twig borer and on almond bloom, with single sprays being applied at different timings beginning in October through delayed dormancy. Analysis of data obtained in Winter, 2006, revealed that peach twig borer shoot strikes for all treatments at any treatment timing were significantly lower than were found on untreated control trees. Analysis of variance to examine the three main effects on flower number per tree revealed significant block effects and variety effects, but no significant treatment effect on flower number per tree. The greatest effect of the oil application was on bloom timing. The December treatments advanced bloom by as much as 4-6 days over controls, with the primary effect being on the first half of bloom. The October and November sprays didn't accelerate bloom. The darkening of the bark from the oil application may have increased heat accumulation and therefore accelerated bloom following the December treatments. The January spray timing may have also had some effect in delaying bloom, but this was not as apparent as that resulting from the December spray timing, possibly because chilling requirements were satisfied by late December so all trees were well advanced towards bloom when the January spray was applied.

Field evaluation of new and registered miticides is important as there are many new products being developed. Products tested in the summer of 2006, against a mixed population of Pacific spider mites and European red mites included rosemary oil and peppermint oil (Ecotrol EC), acequinocyl (Kanemite), bifenezate (Acramite), hexathiozox (Onager), summer oil (Omni Supreme), spiromesefen (Envidor), fenpyroximate (Fujimite), and abamectin (Agri-mek). Results are presented in data tables included in this report. We have also been conducting bioassays to characterize the direct and residual effects of a number of these new miticides on survival, fecundity and fertility of *G. occidentalis* – so called 'side effects' that are not established by simply evaluating the direct mortality of predators following their exposure. Total affect on adult female reproductive potential were calculated and categories for persistence assigned according to the International Organization of Biological Control (IOBC) classification. Of the miticides tested, etoxizole and fenpyroximate had the greatest total effects on both species. Acequinocyl and bifenazate had the least total effect on *G. occidentalis*. Spiromesefen (which is closely related to spirodiclofen) was similar to acequinocyl and bifenazate when females were exposed to direct contact sprays, but was 'slightly harmful' when exposed to leaf surface residues.

## Objectives:

1. Purchase pheromone traps, navel orangeworm (NOW) bait traps, and lures for UC Cooperative Extension Farm Advisors for their ongoing monitoring and extension efforts. Assist in evaluating NOW pheromone blends and formulations.

2. San Jose Scale – complete analysis of the SJS monitoring and damage data collected from Kern County for the past 5 years to establish the relationship between scale infestation and damage.

3. Peach Twig Borer - evaluate efficacy and treatment timing for registered and candidate insecticides, and establish efficacy and possible phytotoxicity resulting from early dormant spray timing - a Best Management Practice (BMP) for mitigating impacts of dormant sprays.

4. Spider Mites – evaluate efficacy of registered and candidate miticides, and determine acute, sublethal and residual effects of several new miticides against predator mites.

## Materials and Methods:

**Objective 1, Monitoring supplies and regional trapping.**
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. For the 2006 season, supplies purchased and distributed included 1090 wing traps and trap liners, 308 San Jose scale (SJS) traps, 50 navel orangeworm (NOW) egg traps, 450 'regular' pheromone lures, 203 'long-life' pheromone lures, and 9 lbs of NOW bait.

As in the previous 4 years, funding was provided to Rich Coviello, UC Cooperative Extension Farm Advisor Emeritus in Fresno County, who uses these funds to provide information to growers and PCAs in Fresno County regarding the seasonal biology of key insect pests in almonds. His work is intended to supplement the data that growers and PCAs are collecting in their specific locations and not to substitute for their own efforts. Two almond orchards monitored during 2005 were again monitored in 2006. One orchard, "Laton", is located in the historical almond growing area of south-central Fresno County, and the other "Panoche" is an orchard located near the intersection of Interstate 5 and Panoche Road A new location was added on the far west side near Three Rocks in order to broaden the monitoring area. The key pests monitored included peach twig borer (PTB), Oriental fruit moth (OFM), San Jose scale (SJS), and navel orangeworm (NOW). Oblique-banded leafroller (OBLR) was included in the monitoring program for the first time during 2006, in order to obtain some data on its distribution and phenology.

**Objective 2, San Jose scale.**
Walt Bentley, together with Mario Viveros, has been conducting a long term experiment to develop sampling decision rules and management options for SJS. The study, which was initiated in 2002, was conducted in the Kern Co. Almond Pest Management Alliance Orchard in Wasco. The orchard was 160 acres in size. It was divided into 8 separate plots of 20 acres. The site had an established SJS population, enabling monitoring of densities in each treatment block as well as resulting damage. Four plots were treated with conventional organophosphate dormant and in-season sprays (conventional treatment). Four plots were treated with products considered to be reduced-risk pesticides that include horticultural mineral oil, spinosad and methoxyfenozide (Intrepid). Each of these 8 plots were further divided into 10 acre plots, half of which did not receive a dormant spray for 3 years from 2002-2004. Because of the severity of the SJS infestation in the untreated sections, it was possible to evaluate orchard recovery from a severe SJS infestation. In January, 2005, the plots received a delayed dormant treatment that included either 6 gallons of Volck Supreme oil, 8 gals of Volck Supreme oil, or no dormant treatment. In 2004, pyriproxifen (Seize 35WP) and 6 gallons of oil were applied across all plots. The conventional treated plots also received a hullsplit application of phosmet (Imidan 70WP) at the rate of 4 lbs per acre in 200 gals of water, and buffered to pH 6. The reduced risk plots were treated in May with methoxyfenozide at the rate of 16 ounces per acre in 200 gallons of water. Data collection was concluded during the winter of 2005 with the final estimation of pruning weight which was used as an indicator of tree growth. Data were analyzed and summarized during 2006-07.

**Objective 3, Peach Twig Borer.**
Three experiments involving dormant sprays as they relate to PTB control were conducted during Fall and Winter, 2006, in collaboration with Franz Niederholzer, UC Farm Advisor, in Sutter-Yuba Counties. The first was an experiment conducted to determine the efficacy of several insecticides applied for PTB control during orchard dormancy, and is a continuation of work from the previous two seasons intended to identify products that provide alternative to the organophosphates that were the primary products used for control until recently. The second experiment was the first year of a multiple year experiment intended to identify the impact, if any, of earlier dormant season applications that contain horticultural mineral oils on almond bloom. The third experiment was a study intended to determine whether the Landguard, an enzyme product from Orica Inc. that is intended to increase the rapidity of organophosphate breakdown, can be tank mixed with diazinon and still provide efficacy against peach twig borer.

The site of all experiments was a commercial third leaf almond orchard located in the North Buttes area northwest of Yuba City, Sutter Co., California. The orchard was a standard planting for the area comprised of 4 varieties, Aldrich, Butte, Carmel, and Padre, planted in consecutive rows, and was immediately adjacent to mature almond orchards on all sides which served as a source of migrating peach twig borers for the new planting.

The first experiment had 2 parts. The main plot compared 15 treatments and an untreated check. Treatments and rates are provided on the data tables in the Results section of this report. Dormant treatments were applied on 20 January, 2006. Budswell sprays were applied on 26 January. Pink bud sprays were applied on 17 February. First bloom sprays were applied on 22 February. Full bloom sprays were applied on 3 March. Each treatment replicate was a single tree, and all treatments were replicated 8 times with two complete blocks of each treatment placed into each of the 4 adjacent rows of different varieties (Aldrich, Butte, Padre, and Carmel) all grafted on Marianna 2624 plum rootstock. Tree spacing was 20 feet across rows on all varieties, and 16 feet in the row for Carmel and Aldrich and 18 feet in the row for Padre and Butte. Treatments were applied using an Echo Duster-Mister Air Assist Sprayer to runoff at the equivalent volume of approximately 80 gallons per acre. All dormant and budswell treatments except for one of the E2Y45 WG treatments were tank mixed with Sunspray 11E Oil at 4% vol/vol. The Intrepid first bloom treatment was applied with Latron B-1956 spreader at 0.125% vol/vol. The Dipel and the Seize treatments applied at first bloom were tank mixed with Sunspray 11E Oil at 1% vol/vol. Prior research has shown that dormant oil alone does not significantly reduce PTB when applied in the absence of another insecticide. We used the number of twig strikes per tree counted in a 5 minute timed search on 20 April, 2006, as an indicator of the number of peach twig borer larvae present on a given tree.

A second, related study was situated in the same orchard rows used in the main plot, and consisted of 4 dormant treatments, Brigade (comparing 2 rates of oil), Asana, and diazinon, plus an untreated check. The dormant treatments were applied on 20 January, 2006. As in the main plot, each treatment replicate was a single tree, and all treatments were replicated 8 times with two complete blocks of each treatment placed into each of the 4 adjacent rows. All treatments were tank mixed with Sunspray 11E Oil at 4% vol/vol.

The second experiment was intended to examine potential effects of earlier dormant season applications containing horticultural mineral oil on efficacy against peach twig borer and on almond bloom. Treatments were applied using a Stihl SR420 or Echo Duster-Mister Air Assist Sprayer at a spray volume per tree of 20 oz. Pesticide concentrations in the spray solution were equivalent to 9.6 oz of Asana XL per acre, 0.5 gallons of Diazinon 4E per acre, and 4 gallons of Sunspray 11E oil per acre. Application were single applications made monthly, October, 2005, through January, 2006. Products applied, their rates and the time period when applied are presented on Table 1.

Table 1. Treatment timings. Spray materials applied on different dates in almond PTB control trial, Sutter County, October, 2005 through January, 2006.

| Application Date | Asana[1] + oil | Diazinon[2] + oil | Oil[3] | Asana[1] | Diazinon[2] |
|---|---|---|---|---|---|
| October 24 | X | x | x | x | x |
| November 17 | X | x | | | |
| December 19 | X | x | | | |
| January 20 | X | x | | | |

[1]Concentration applied = 9.6 oz Asana XL/acre at 100 gpa spray volume
[2]Concentration applied = 0.5 gallons Diazinon 4E/acre at 100 gpa spray volume
[3]Concentration applied = 4 gallons Sunspray 11E oil/acre at 100 gpa spray volume

The method of evaluating efficacy against peach twig borer was the same as in the previous experiment. Chilling accumulations were initiated on 1 September, 2005, and are presented in Table 2 for each application timing. Flowers began to open at the end of the first week of February, 2006, and flower counts were taken every 2 to 5 days thereafter beginning on 11 February. Open flowers per tree were counted through 28 February, and closed flowers per tree were counted beginning on 2 March. Total number of opened flowers and swelling buds were counted on 2 March. From that date on until 100 percent bloom, open flowers per tree were determined using the difference between total flowers counted on 2 March and closed flowers on the current date of counting. Flowers at petal fall and post petal fall were included in the 2 March count of total flowers per tree. All flowers in all varieties opened by 30 March.

Table 2. Chilling accumulation on different spray dates (hours below 45°F and chilling portions). Temperatures measured at the closest CIMIS weather station, Colusa, CA.

| Application Date | Hours below 45°F | Chilling portions |
|---|---|---|
| 10/25/2005 | 0 | 0 |
| 11/18/2006 | 55 | 7 |
| 12/20/2006 | 463 | 28 |
| 1/21/2006 | 584 | 48 |

The third experiment was intended to determine if Landguard, an enzyme product intended to mitigate the effect of organophosphates in the environment by increasing the rapidity of its breakdown, could be tank mixed with diazinon and still be effective in controlling peach twig borer. The method of application, dormant application date (20 January), and method of peach twig borer evaluation were the same as in the previous two experiments already described. Diazinon (Diazinon AG600 WBC, Platte Chemical Co.) treatments were applied at a rate of 4 pints formulated product per acre, and also included Sunspray 11E dormant oil at 4.0% vol/vol. Landguard was applied at the equivalent of 76 grams per 100 gallons of solution. Unfortunately, residue analysis was not conducted as part of this experiment due to lack of funds available for this purpose.

**Objective 4, Spider Mites.** An experiment to evaluate efficacy of several registered and candidate miticides was conducted at the Nickel's Estate near Arbuckle in collaboration with John Edstrom, UC Cooperative Extension Farm Advisor in Colusa County. The orchard consisted of mature almond trees at Nickel's Estate, planted 75 trees to the acre. Treatments were applied on 20 July, 2006, and leaves were collected for pretreatment mite counts immediately before the application. Pacific spider mite (*Tetranychus pacificus*) densities averaged 0.67 per leaf at the time of application, but hot conditions predicted plus dry conditions in the orchard in anticipation of harvest suggested that their densities could build rapidly. The action threshold for webspinning spider mites on almonds is about 4.0 motile mites per leaf. European red mite (*Panonychus ulmi*) densities averaged about 63.68 per leaf at the time of application. The action threshold for European red mites on almonds is not defined but is considered to be much higher than that of webspinning spider mites. Most growers would be very concerned about the level of European red mites present in our plots, and would likely treat them at this density. Treatments were applied using a gas-powered hand gun sprayer at the equivalent volume of 400 gallons per acre. Each treatment replicate was a single tree, and each treatment was replicated 3 times in a completely randomized design. Products tested included summer oil, rosemary oil and peppermint oil (Ecotrol EC), acequinocyl (Kanemite), bifenezate (Acramite), hexathiozox (Onager), summer oil (Omni Supreme), spiromesefen (Envidor), fenpyroximate (Fujimite), and abamectin (Agri-mek). Mites were sampled by removing 10 leaves per tree randomly from around the circumference of each tree, placing the leaves from each tree into a labeled plastic bag, and returning the leaves to the Zalom lab for counting. Using a mite brushing machine, the total number of Pacific spider mite motiles, European red mite motiles, and western orchard predator mite (*Galendromus occidentals*) motiles was determined. A pretreatment count was made on 18 July, 2006, with post-treatment counts taken one, two, three, six and seven weeks later. An eighth week of samples was collected for some of the treatments that appeared to remain effective.

For the last several years, we have been developing methods to study nontarget effects of miticides on predatory mites. Our work on almonds has concentrated on the common predatory mite, *G. occidentalis*, which is native to the western U.S., and is reared commercially by several insectaries. Several new miticides have been registered for use on almonds since 2000 which represent different chemical classes compared with the traditional products propargite (Omite) and fenbutatin oxide (Vendex) which has been widely used miticides during the previous two decades. Understanding the acute and side effects of these products is important to their successful integration into conservation and augmentation programs. The experimental results presented in this report were conducted using a rearing unit consisting of seven green bean leaf discs of 20-mm diameter, placed on wet filter paper inside of a Petri dish of 90-mm diameter with three holes drilled in the top to prevent an excess of humidity. One newly molted adult female *G. occidentalis* was transferred to each leaf disc. The day before the predators were transferred to the leaf discs, five twospotted spider mite females and eggs were placed on each leaf disc to provide a food soruce for the predator. Because we also wanted to expose the predators to treated prey, additional leaves containing spider mites were treated at the same time the experimental leaf discs were treated and these treated mites and eggs were refrigerated until they needed to be used as food for the predators. Acaricide applications were made using a hand sprayer 10.6±0.53 μl/cm$^2$ of the spray mixture being applied to each leaf disc. The acaricides to be evaluated were mixed with distilled water to achieve the labelled field rate. Control leaf discs were sprayed with distilled water alone. The treated leaf discs were air-dried for 5 minutes after spraying and then covered. The bioassay was conducted at 27±1°C, 50-60% RH and 16:8 photoperiod. Egg laying and survivorship of females, were recorded daily. Acaricide treatments and the control were replicated 20 times. To determine potential side effects on the development of offspring produced by treated females, 50 *G. occidentalis* eggs produced by females exposed to each treatment were placed individually on green bean leaf discs of new rearing units treated as previously described. Mortality, time of development of each developmental stage, and days needed to reach the adult stage were determined daily for each individual.

## Results and Discussion:

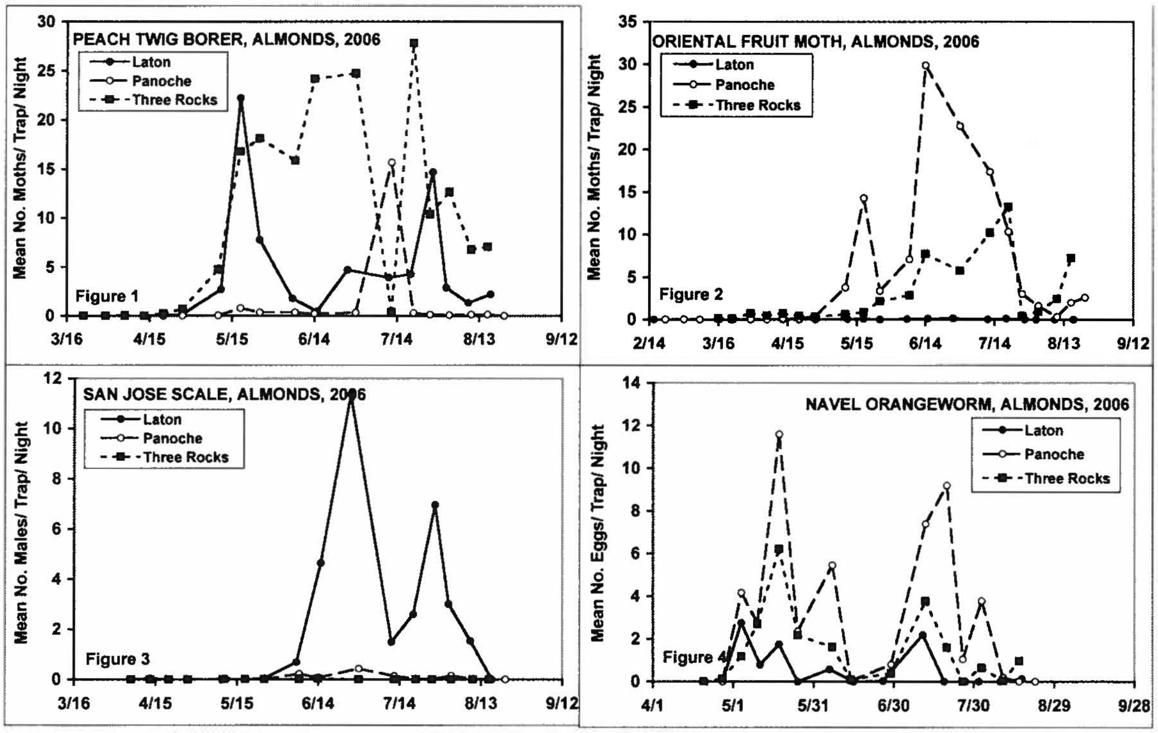
### Objective 1, Monitoring supplies and regional trapping.

As reported, supplies purchased and distributed for the 2006 season included 1090 wing traps and trap liners, 308 San Jose scale (SJS) traps, 50 navel orangeworm (NOW) egg traps, 450 'regular' pheromone lures, 203 'long-life' pheromone lures, and 9 lbs of NOW bait.

Results of the monitoring conducted by Rich Coviello in Fresno County for the summer of 2006 are shown in Figures 1–4. The first flight biofixes were delayed in 2006 because of the prolonged cold, rainy weather during spring. In some cases, it was difficult to detect the biofix as was the case for San Jose scale on the far west side of Fresno County. Because of the delay in flight initiation, there were likely fewer complete generations of these insects than in "normal" years.

The trap data indicate that San Jose scale was not present at damaging densities in the monitoring locations on the far west side, the males being barely detectable. San Jose scale parasitoidsweare found in the traps, however, indicating that the rather low population present may have been there for several years.

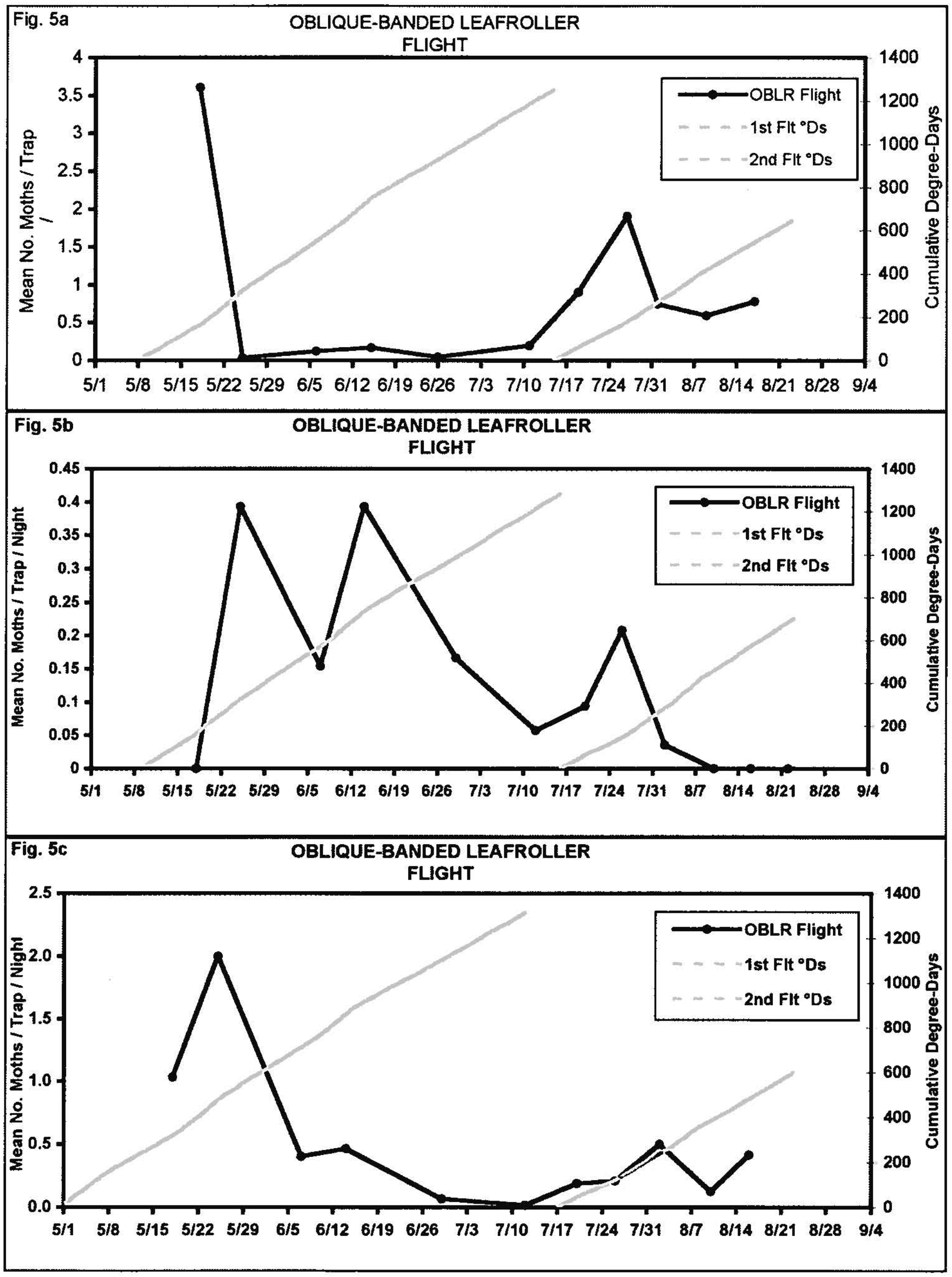
Figures 1-4. Peach twig borer, oriental fruit moth, San Jose scale, and navel orangeworm flights recorded in 3 Fresno County orchards, 2006.




The prolonged cool spring may have had some influence on an unusual occurrence regarding oriental fruit moth in one almond orchard and in a fruit orchard at the Kearney Agricultural Center. There was no separation between the second and third flights of oriental fruit moth, i.e. a distinct biofix for the third flight could not be detected, in either location. This was not an artifact of low trap numbers masking the biofix since it occurred in the orchards with the highest trapping counts.

Oblique banded leafroller were trapped in all three almond orchards that were monitored, although in such low densities as to indicate there should be no significant damage from them (Figures 5 a-c). The first flight biofix was missed in 2 of the 3 orchards because the traps were not placed into the orchards before the initiation of the first flight. It appears that in 2006 there were likely 2 flights instead of three which are believed to be the norm in most years. This is likely due to the later initiation of the first flight and the very high temperatures that occurred in late June and July which may have retarded their growth.

Figures 5a-c. Oblique banded leafroller males captured in pheromone traps located at Laton (5a), Panoche (5b), and Three Rocks (5c), in Fresno County almond orchards, 2006.




Rich Coviello has indicated that the 2006 season will be the last in which he plans to conduct this monitoring program, and further funding for this work will not be requested from the Almond Board of California for this purpose.

**Objective 2, San Jose scale.**
Annual summaries from the long term San Jose scale study conducted by Walt Bentley and Mario Viveros since 2002, has been reported in previous Almond Board of California Annual Reports. For example, we have reported relationships between San Jose scale trap counts and double sided-sticky trap counts, San Jose scale trap counts and scales on spurs. We also reported weekly male San Jose scale, *Encarsia perniciosa*, and *Aphytis* spp. counts on these traps, and numbers of the parasitoids present on the traps under different treatment regimes.

The relationship between spur infestation and damage rating was pooled over the 4 year period 2002-05, yielding 64 data points. The results of the pooled regression analysis indicated a significant relationship between spur infestation, and the severity of damage due to live San Jose scales. The relationship between the average number of infested spurs and damage severity was highly significant ($R^2 = 0.615$, $Y = 0 + 0.031x$; $P < 0.001$, no intercept model) for the four year period (Figure 6). The relationship between the average number of San Jose scale per plot and damage severity was also highly significant, ($R^2 = 0.398$, $Y = 0 + 0.002x$; $P < 0.001$, no intercept model), but less precise, for the four year period.

Pruning weights taken during the winter of 2005-06 were shown to be significantly related to average spur infestation over the previous 4 years ($R^2 = 0.771$, $Y = 0.374 + 0.246x$; $P < 0.001$, no intercept model), quantifying damage produced by San Jose scales as reduced pruning weight. This reducting will have a significant effect on yield. Figure 7 presents the results of this analysis and shows that higher average scale infestation over the previous 4 years will effect the overall new growth of an almond tree. Infestations in excess of six San Jose scale infested spurs in 100 samples will result in significant loss of tree growth if this density of scale infrestation is left uncontrolled.

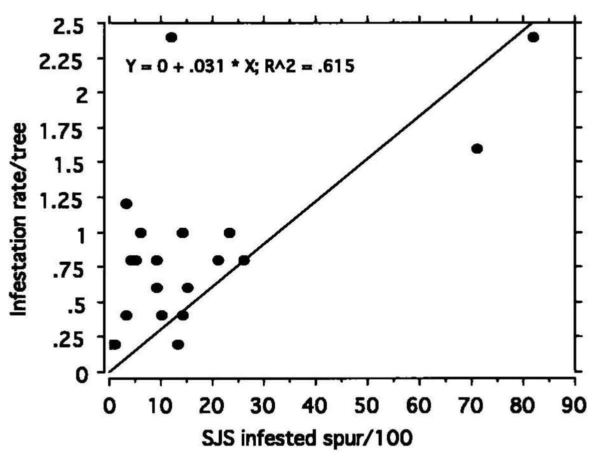



Figure 6. Relationship between San Jose scale infested spurs and infestation rating for the 4 years, 2002-05.

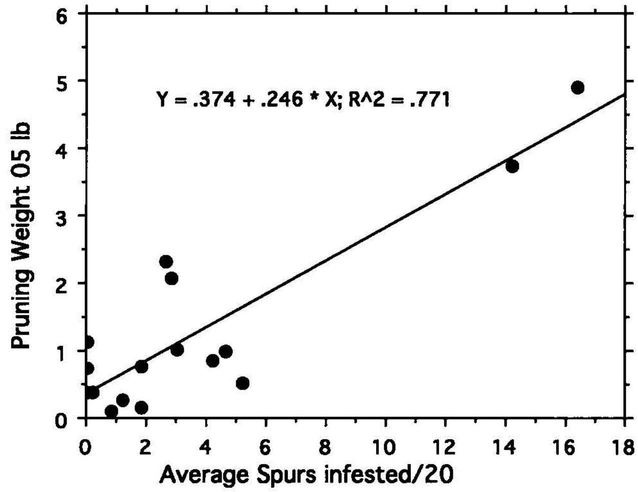



Figure 7. Relationship between averages San Jose scale spurs infested that were observed for the 4 years of the study, 2002-05, and pruning weights measured in winter 2005-06.

Conclusions from the 4 years of this study are that San Jose scale can be managed for at least two years, even in a heavily infested orchard, by a pyriproxifen and oil application. In cases where horticultural mineral oil has been regularly applied in the dormant season, there is no need to tank mix with additional insecticides in the dormant spray to manage San Jose scale. The most accurate method of predicting the need for a San Jose scale treatment is sampling infested spurs. The number of spurs infested is a more accurate predictor of damage than counting the number of scale found on the spurs. Finally, infestations in excess of six San Jose scale infested spurs in 100 samples will result in significant loss of tree growth if left uncontrolled.

This was the final year of the San Jose scale study, and no further funding will be requested for it from the Almond Board of California.

**Objective 3, Peach Twig Borer.**
ANOVA of data obtained for the evaluation of new products and timing for control of peach twig borer during Winter, 2006, revealed significant differences between treatments (ANOVA statistics, $F$=14.7216, df=15,127, $P$<0.0001). All treatments significantly reduced of peach twig borer shoot strikes relative to the untreated check (Table 3). Variety was not included as a factor in the analysis of variance for treatments because all treatment differences were significant from untreated without including variety as a factor. The second, smaller comparison of Brigade to Asana and diazinon revealed significant differences between treatments (ANOVA statistics, $F$=19.7272, df = 4,40, $P$<0.0001). All treatments significantly reduced the number of peach twig borer shoot strikes relative to the untreated check (Table 4).

From our previous experience, the mean number of peachtwig borer shoot strikes found in the untreated checks of both trials would be considered damaging, but not extremely high. Treatment at this level would probably be considered necessary for mature almond trees and for fresh or canned soft fruit to avoid direct damage to nut meats and fruit.

Table 3. Mean (± SE) peach twig borer shoot strikes per tree, 2006, n=8 replicates.

| Treatment | Rate (product/acre) | Application timing | Mean (± SE) [1] strikes/tree |
|---|---|---|---|
| Untreated | na | na | 9.06 ± 1.72 |
| Dimilin | 12 oz + 4 gal. | Delayed Dormant | 0.38 ± 0.26 |
| Intrepid + Sunspray 11E | 10 oz. + 4 gal. | Dormant | 0.63 ± 0.25 |
| Intrepid + Sunspray 11E | 10 oz. + 4 gal. | Delayed Dormant | 1.50 ± 0.57 |
| Intrepid + Latron B-1956 | 10 oz. + 0.125% v/v | Pink bud | 0.75 ± 0.37 |
| Danitol | 16 oz + 4 gal. | Dormant | 0.00 ± 0.00 |
| E2Y45 WG | 0.25 lb | Dormant | 0.00 ± 0.00 |
| E2Y45 WG + Sunspray 11E | 0.25 lb + 4 gal. | Dormant | 0.00 ± 0.00 |
| E2Y45 WG | 0.25 lb | Full Bloom | 0.00 ± 0.00 |
| Renounce 20WP + Sunspray | 3.5 oz + 4 gal. | Dormant | 0.00 ± 0.00 |
| Assail 30SG + Sunspray 11E | 5 oz. + 4 gal. | Dormant | 0.88 ± 0.58 |
| Assail 30SG + Sunspray 11E | 7 oz. + 4 gal. | Dormant | 0.88 ± 0.58 |
| Assail 30SG + Microthiol Disperss + Sunspray 11E | 5 oz. + 10 lb. + 4 gal. | Dormant | 0.75 ± 0.41 |
| Dipel + Sunspray 11E; Dipel | 1 lb + 1 gal.; 1 lb. | First Bloom; Full Bloom | 0.69 ± 0.45 |
| Seize 35 WP + Sunspray 11E; Dipel | 5 oz. + 1 gal.; 1 lb. | First Bloom; Full Bloom | 1.75 ± 0.82 |
| Warrior + Sunspray 11E | 3.0 oz + 4 gal. | Dormant | 0.00 ± 0.00 |

[1] Peach twig borer shoot strikes are significantly different from the untreated control by pairwise t-tests at $P<0.05$ in all cases.
Dormant spray application date: 20 January, shoot strikes counted 20 April.
ANOVA statistics, $F= 14.7216$, df = 15,127, $P<0.0001$.

Table 4. Mean (± SE) peach twig borer shoot strikes per tree, 2006, n=8 replicates.

| Treatment | Rate (product/acre) | Application timing | Mean (± SE) [1] strikes/tree |
|---|---|---|---|
| Untreated | na | na | 8.28 ± 1.73 |
| Diazinon + Sunspray 11E | 4 pints + 4 gal. | Dormant | 0.00 ± 0.00 |
| Asana + Sunspray 11E | 9.6 oz. + 4 gal. | Dormant | 0.06 ± 0.06 |
| Brigade + Sunspray 11E | 0.5 lb + 4 gal. oil | Dormant | 0.13 ± 0.13 |
| Brigade + Sunspray 11E | 0.5 lb + 2 gal. oil | Dormant | 0.00 ± 0.00 |

[1] Peach twig borer shoot strikes are significantly different from the untreated control by pairwise t-tests at $P<0.05$ in all cases.
Dormant spray application date: 20 January, shoot strikes counted 20 April.
ANOVA statistics, $F=19.7272$, df = 4,40, $P<0.0001$.

The second experiment was intended to examine potential effects of earlier dormant season applications containing horticultural mineral oil on efficacy against peach twig borer and on almond bloom.

Flowers began to open at the end of the first week of February, 2006, and flower counts were taken every 2 to 5 days thereafter beginning on 11 February. All flowers in all varieties were opened by 30 March. Bloom progression on all varieties is presented on Figure 8.

Analysis of variance indicated that there was a significant difference ($F = 8.2068$, df = 11,95, $P < 0.0001$) between treatments with respect to peach twig borer shoot strike counts. Table 5 presents the results of this study. Pairwise t-test analysis for each treatment compared to the untreated control revealed that peach twig borer shoot strikes for all treatments at any treatment timing were significantly lower than untreated.

Table 5. Mean ± SE peach twig borer shoot strikes per tree on almond trees treated at different timings (n=8) except for those treatments footnoted below.

| Treatment | Rate (form. / ac.) | Application date | Mean ± SE number of strikes/tree[1] |
|---|---|---|---|
| Untreated [2] | na | na | 8.28 ± 1.73 |
| Diazinon + Sunspray 11E | 4 Pints + 4 gal. | 10/24 | 0.00 ± 0.00 |
| Diazinon + Sunspray 11E | 4 Pints + 4 gal. | 11/17 | 0.38 ± 0.38 |
| Diazinon + Sunspray 11E | 4 Pints + 4 gal. | 12/19 | 0.00 ± 0.00 |
| Diazinon + Sunspray 11E | 4 Pints + 4 gal. | 1/20 | 0.00 ± 0.00 |
| Asana + Sunspray 11E | 9.6 oz. + 4 gal. | 10/24 | 0.69 ± 0.69 |
| Asana + Sunspray 11E | 9.6 oz. + 4 gal. | 11/17 | 1.38 ± 0.79 |
| Asana + Sunspray 11E | 9.6 oz. + 4 gal. | 12/19 | 0.25 ± 0.16 |
| Asana + Sunspray 11E | 9.6 oz. + 4 gal. | 1/20 | 0.06 ± 0.06 |
| Diazinon | 4 Pints | 10/24 | 0.75 ± 0.41 |
| Asana | 9.6 oz. | 10/24 | 0.88 ± 0.61 |
| Sunspray 11E [3] | 4 gal. | 10/24 | 4.93 ± 2.40 |

[1] Peach twig borer shoot strikes for all treatments are significantly different from the untreated control by pairwise t-tests at $P < 0.05$.
[2] n=9
[3] n=7

Three-way analysis of variance to examine the three main effects on flower number per tree revealed a significant block effect ($P$=0.0011), a significant variety effect ($p$=0.000), but no significant treatment effect ($P$=0.3304) on flower number per tree. The treatments that included the 4% oil resulted in noticeable defoliation in October. The two pesticide only treatments at that time did not cause early leaf drop. The greatest effect of the oil applications was on bloom timing (Figure 9). The December treatments advanced bloom by as much as 4-6 days over controls, with the primary effect being on the first half of bloom. The October and November sprays didn't accelerate bloom. The darkening of the bark from the oil application may have helped with heat accumulation and therefore accelerated bloom following the December treatments (since chilling requirements had been essentially met by that time). The effect of oil resulting from the December treatments might have been even greater if the oil had been applied soon after 7 December, since 300 degree-hours had accumulated by then and the chilling requirement for almonds is thought to be 450 degree-hours below 45°F or less. The January spray timing may have also had some effect in delaying bloom, but this was not as apparent as that resulting from the December spray timing, possibly because chilling requirements were satisfied by late December so all trees were well advanced towards

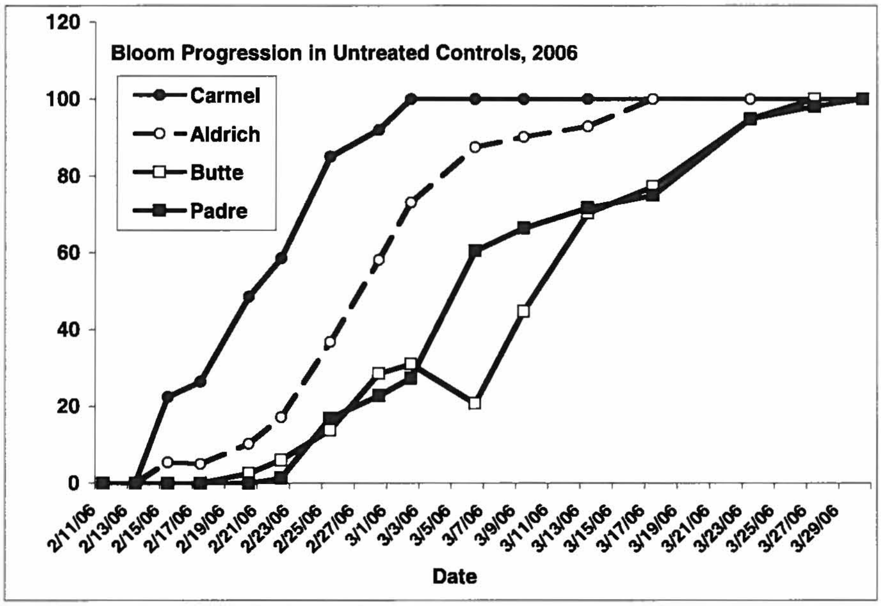



Figure 8. Bloom progression on the 4 almond varieties evaluated in 2006.

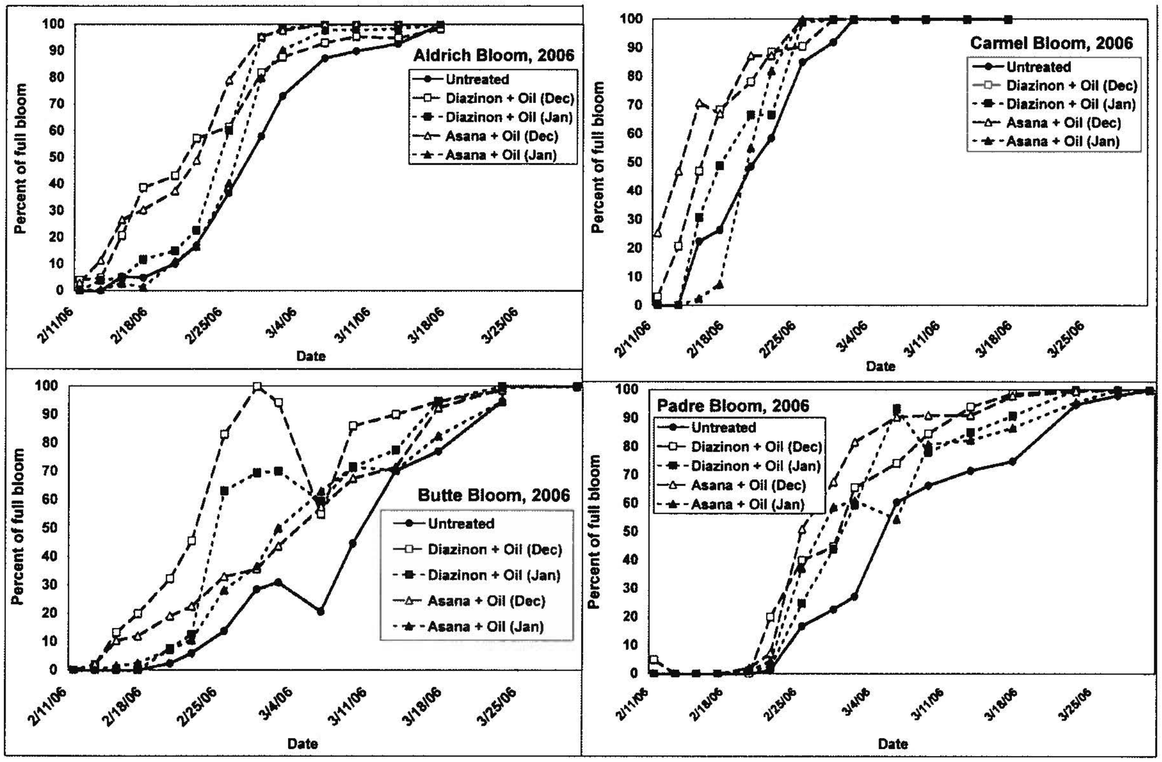



Figure 9. Bloom progression for the 4 almond varieties treated in December or January, 2006, with diazinon and oil or Asana and oil bloom when the January spray was applied. These observations support research conducted on apples which indicate that oil can be used to break dormancy, but that oil treatments are only effective after at least 70% of the chilling requirement has been reached.

The third experiment was intended to determine if Landguard, an enzyme product intended to mitigate the effect of organophosphates in the environment by increasing the rapidity of its breakdown, could be tank mixed with diazinon and still be effective in controlling peach twig borer. ANOVA revealed significant differences between treatments (ANOVA statistics, $F = 19.7155$, df = 2,24, $P = <0.0001$). A mean separation test further revealed that there was no significant treatment different between the Landguard and Diazinon and Diazinon alone treatment in terms of number of peach twig borer shoot strikes per tree (Table 6). Both treatments dramatically reduced peach twig borer shoot strikes relative to the untreated check. Assuming that the Landguard reduced Diazinon residues as expected, our finding is significant in that it indicates that the PTB is likely controlled on contact in the hibernacula with a diazinon plus oil dormant spray. These results are also promising in that this could be an easy approach for mitigating the residual environmental effects of Diazinon while maintaining its ability to control peach twig borer. However, it must be cautioned that residue analysis was not conducted as part of this experiment, so efficacy of the landguard in breaking down the diazinon in the tank mix was not controlled for. We intend to further study and refine this approach in Winter, 2007.

Table 6. Mean ± SEM peach twig borer shoot strikes per tree on almond, Sutter, Co., CA, 2006.

| Treatment | Rate (form. / ac.) | Application date | Mean | ± | SEM | |
|---|---|---|---|---|---|---|
| Untreated [1] | Na | na | 8.28 | ± | 1.73 | a |
| Diazinon + Sunspray + Landguard | 4 pints + 4 gal. + 76 g. | 1/20/06 | 0.13 | ± | 0.13 | b |
| Diazinon + Sunspray | 4 pints + 4 gal. | 1/20/06 | 0.00 | ± | 0.00 | b |

[1] Means followed by the same letter are not significantly different at $P < 0.05$ by LSD.

**Objective 4, Spider Mites.**
At the time of application of the field efficacy trial for registered and new acaricides, Pacific spider mite densities averaged 0.67 per, but hot conditions predicted plus dry conditions in the orchard in anticipation of harvest suggested that their densities could build rapidly. The action threshold for webspinning spider mites on almonds is about 4.0 motile mites per leaf. European red mite densities averaged about 63.68 per leaf at the time of application. The action threshold for European red mites on almonds is not defined but is considered to be much higher than that of webspinning spider mites such as Pacific spider mite. Most growers would be very concerned about the level of European red mites present in our plots, and would likely treat them at this density. No predator mites were found in the pretreatment samples.

Results of this study are presented on Tables 7, 8 and 9. These tables present means and standard deviations of all treatments with the results of ANOVA and Student's t-test at $P$=0.05 with treatment means being compared to the untreated control. The Pacific spider mite densities were relatively low at the time of the application, but increased in the control plots to reach 3.8 per leaf by 4 weeks after application. Because of a large number of eggs present, we chose to wait to sample again later, 6 weeks after application. By that time densities of Pacific spider mite motiles in the untreated control trees had reached over 60 per leaf and considerable leaf damage was present. European red mite densities declined somewhat from pretreatment levels after the application, but they remained high for the first 3 weeks following application. Significant differences were not always observed for the weekly samples, but this is not surprising since there was so much variability among the untreated control plots. European red mite densities were too low to be meaningful beginning with the 29 August sampling date and thereafter. Predator mites did not begin to appear until the Pacific spider mites began to build, and only data from the 9 August, 2006 sampling date and thereafter are presented (Figure 10).

Table 7a. Mean (± SD) motile Pacific spider mites per leaf, Nickels Estate, Arbuckle, CA, 2006.

| Treatments | Rate (Form/ac) | Mean ± SD Pacific mites per leaf | | | |
|---|---|---|---|---|---|
| | | 7-18-06 Pre | 7/26/06 | 8/2/06 | 8/9/06 |
| Control | NA | 1.00 ± 0.69 | 3.00 ± 2.16 | 3.40 ± 3.86 | 3.80 ± 3.67 |
| Envidor 2SC | 18.0 oz | 1.20 ± 2.08 | 0.00 ± 0.00* | 0.80 ± 0.35 | 1.13 ± 1.27 |
| Envidor 2SC + summer oil | 18.0 oz + 1% v/v | 0.00 ± 0.00 | 0.00 ± 0.00* | 0.73 ± 0.81 | 4.30 ± 4.23 |
| Ecotrol + Natural Wet | 2.0 pts + 0.13% v/v | 1.60 ± 0.92 | 0.60 ± 0.60* | 1.80 ± 2.62 | 7.00 ± 5.10 |
| Ecotrol + Natural Wet | 4.0 pts + 0.13% v/v | 0.00 ± 0.00 | 0.60 ± 0.60* | 3.40 ± 3.30 | 3.47 ± 3.82 |
| Kanemite | 25.0 oz | 1.20 ± 1.20 | 0.00 ± 0.00* | 2.20 ± 3.30 | 2.87 ± 4.29 |
| Kanemite | 31.0 oz | 0.20 ± 0.35 | 0.03 ± 0.06* | 0.20 ± 0.35 | 1.40 ± 1.25 |
| Fujimite 5EC + LI7000 | 1 pt + 0.25% v/v | 0.40 ± 0.69 | 0.07 ± 0.06* | 0.43 ± 0.67 | 1.10 ± 1.21 |
| Fujimite 5EC + LI7000 | 2 pts + 0.25% v/v | 0.80 ± 1.39 | 0.13 ± 0.23* | 0.20 ± 0.20 | 3.63 ± 5.00 |
| Agri-mek + LI7000 | 15.6 oz + 0.25% v/v | 1.60 ± 2.77 | 0.40 ± 0.69* | 0.00 ± 0.00 | 2.00 ± 3.46 |
| Omni Supreme | 1% v/v | 1.20 ± 2.08 | 0.60 ± 0.60* | 1.20 ± 0.00 | 3.40 ± 1.83 |
| Omni Supreme | 4% v/v | 0.20 ± 0.35 | 0.00 ± 0.00* | 0.40 ± 0.35 | 1.87 ± 1.10 |
| Acramite WS | 1 lb | 0.60 ± 1.04 | 0.20 ± 0.35* | 0.20 ± 0.35 | 0.57 ± 0.60 |
| Onager | 20 oz | 0.00 ± 0.00 | 0.40 ± 0.69* | 0.00 ± 0.00 | 0.80 ± 0.92 |
| Zeal | 3 oz | 0.00 ± 0.00 | 0.00 ± 0.00* | 0.00 ± 0.00 | 0.13 ± 0.23 |

*Means significantly different from untreated control at $P<0.05$ by Student's t-test.
abamectin (Agri-mek) and etoxazole (Zeal). Treatments and application rates are provided on the tables.

Table 7b. Mean (± SD) motile European red mites per leaf, Nickels Estate, Arbuckle, CA, 2006.

| Treatments | Rate (Form/ac) | Mean ± SD European red mites per leaf 8/29/06 | | | 9/6/06 | | | 9/13/06 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | NA | 65.00 | ± | 51.95 | 49.40 | ± | 46.14 | 16.98 | ± | 16.98 |
| Envidor 2SC | 18.0 oz | 32.40 | ± | 43.98 | 12.53 | ± | 10.94 | 12.80 | ± | 13.86 |
| Envidor 2SC + summer oil | 18.0 oz + 1% v/v | 22.03 | ± | 20.53 | 15.73 | ± | 12.93 | 3.80 | ± | 2.77 |
| Ecotrol + Natural Wet | 2.0 pts + 0.13% v/v | 61.73 | ± | 49.14 | 10.37 | ± | 15.97 | NA | ± | NA |
| Ecotrol + Natural Wet | 4.0 pts + 0.13% v/v | 45.00 | ± | 60.85 | 40.30 | ± | 68.51 | NA | ± | NA |
| Kanemite | 25.0 oz | 38.80 | ± | 45.95 | 22.60 | ± | 27.21 | NA | ± | NA |
| Kanemite | 31.0 oz | 37.40 | ± | 19.41 | 30.40 | ± | 12.73 | NA | ± | NA |
| Fujimite 5EC + LI7000 | 1 pt + 0.25% v/v | 32.93 | ± | 44.69 | 34.80 | ± | 40.07 | NA | ± | NA |
| Fujimite 5EC + LI7000 | 2 pts + 0.25% v/v | 40.90 | ± | 37.77 | 24.87 | ± | 27.15 | NA | ± | NA |
| Agri-mek + LI7000 | 15.6 oz + 0.25% v/v | 6.07 | ± | 9.82 | 3.17 | ± | 5.05 | 0.50 | ± | 0.17 |
| Omni Supreme | 1% v/v | 68.00 | ± | 40.27 | 35.10 | ± | 35.71 | NA | ± | NA |
| Omni Supreme | 4% v/v | 45.20 | ± | 33.70 | 11.07 | ± | 11.93 | NA | ± | NA |
| Acramite WS | 1 lb | 20.93 | ± | 24.58 | 6.97 | ± | 7.78 | 3.73 | ± | 2.89 |
| Onager | 20 oz | 5.80 | ± | 5.50 | 8.10 | ± | 8.65 | 11.30 | ± | 10.41 |
| Zeal | 3 oz | 2.60 | ± | 2.59 | 1.57 | ± | 1.34 | 1.97 | ± | 2.81 |

*Means significantly different from untreated control at $P$<0.05 by Student's t-test.

ANOVA statistics for each sampling date:

| Date | $F$= | df= | $P$= |
|---|---|---|---|
| 7-18-06 Pre | 0.7068 | 14, 44 | 0.7506 |
| 7/26/06 | 3.7438 | 14, 44 | 0.0012 |
| 8/2/06 | 1.3769 | 14, 44 | 0.2241 |
| 8/9/06 | 1.0789 | 14, 44 | 0.4127 |
| 8/29/06 | 0.9495 | 14, 44 | 0.5221 |
| 9/6/06 | 0.8017 | 14, 44 | 0.6607 |
| 9/13/06 | 0.8530 | 6, 20 | 0.5511 |

Record high temperatures occurred at the time of application and for a period thereafter. High temperatures exceeded 100°F for 12 consecutive days during this period. Applications were made at the beginning of this record setting period. The decline in European red mites in control plots was likely due to the hot temperatures and the sustained high mite densities. Similarly, the delay in Pacific spider mite buildup was also likely due to the extremely hot conditions, but the heat also likely contributed to the rapid increase later by adding additional stress to the trees.

Table 8a. Mean (± SD) motile Pacific spider mites per leaf, Nickels Estate, Arbuckle, CA, 2006.

| | | Mean ± SD Pacific mites per leaf | | |
|---|---|---|---|---|
| Treatments | Rate (Form/ac) | 8/29/06 | 9/6/06 | 9/13/06 |
| Control | NA | 0.40 ± 0.35 | 0.80 ± 0.92 | 0.00 ± 0.00 |
| Envidor 2SC | 18.0 oz | 0.47 ± 0.23 | 0.33 ± 0.31 | 0.27 ± 0.46 |
| Envidor 2SC + summer oil | 18.0 oz + 1% v/v | 0.30 ± 0.52 | 1.20 ± 1.59 | 0.00 ± 0.00 |
| Ecotrol + Natural Wet | 2.0 pts + 0.125% v/v | 0.67 ± 0.61 | 0.70 ± 0.89 | NA ± NA |
| Ecotrol + Natural Wet | 4.0 pts + 0.125% v/v | 0.60 ± 0.60 | 0.03 ± 0.05 | NA ± NA |
| Kanemite | 25.0 oz | 0.60 ± 1.04 | 1.00 ± 0.92 | NA ± NA |
| Kanemite | 31.0 oz | 1.60 ± 2.27 | 0.42 ± 0.68 | NA ± NA |
| Fujimite 5EC + LI7000 | 1 pt + 0.25% v/v | 0.43 ± 0.67 | 0.33 ± 0.58 | NA ± NA |
| Fujimite 5EC + LI7000 | 2 pts + 0.25% v/v | 0.43 ± 0.67 | 0.00 ± 0.00 | NA ± NA |
| Agri-mek + LI7000 | 15.6 oz + 0.25% v/v | 0.30 ± 0.36 | 0.27 ± 0.31 | 0.17 ± 0.21 |
| Omni Supreme | 1% v/v | 0.40 ± 0.35 | 0.43 ± 0.67 | NA ± NA |
| Omni Supreme | 4% v/v | 0.83 ± 1.36 | 0.00 ± 0.00 | NA ± NA |
| Acramite WS | 1 lb | 2.03 ± 3.44 | 0.00 ± 0.00 | 0.43 ± 0.67 |
| Onager | 20 oz | 1.23 ± 2.05 | 0.00 ± 0.00 | 0.00 ± 0.00 |
| Zeal | 3 oz | 0.23 ± 0.32 | 0.00 ± 0.00 | 0.00 ± 0.00 |

*Means significantly different from untreated control at $P<0.05$ by Student's t-test.

ANOVA statistics for each sampling date:

| Date | $F=$ | df= | $P=$ |
|---|---|---|---|
| 8/29/06 | 0.4639 | 14, 44 | 0.9350 |
| 9/6/06 | 1.1036 | 14, 44 | 0.3936 |
| 9/13/06 | 0.8968 | 6, 20 | 0.5236 |

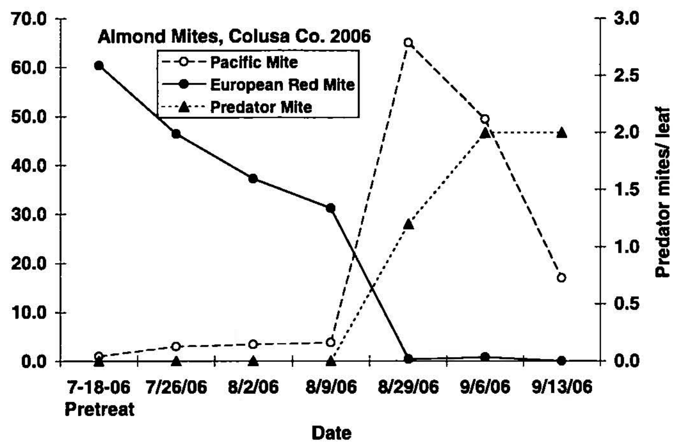



Figure 10. Average Pacific spider mites, European red mites and *G. occidentalis* in untreated plots at Nickels Estate, Arbuckle, CA, 2006.

Table 8b. Mean (± SD) motile European red mites per leaf, Nickels Estate, Arbuckle, CA, 2006.

| Treatments | Rate (Form/ac) | Mean ± SD European red mites per leaf 7-18-06 Pre | 7/26/06 | 8/2/06 | 8/9/06 |
|---|---|---|---|---|---|
| Control | NA | 60.40 ± 20.23 | 46.40 ± 16.52 | 37.20 ± 12.25 | 31.20 ± 19.25 |
| Envidor 2SC | 18.0 oz | 50.70 ± 23.28 | 17.00 ± 9.57* | 11.20 ± 7.50 | 3.63 ± 1.60 |
| Envidor 2SC + summer oil | 18.0 oz + 1% v/v | 63.20 ± 44.41 | 9.40 ± 2.11* | 5.20 ± 4.40 | 6.37 ± 5.04 |
| Ecotrol + Natural Wet | 2.0 pts + 0.13% v/v | 37.00 ± 15.95 | 12.80 ± 5.00* | 36.00 ± 31.87 | 10.20 ± 4.20 |
| Ecotrol + Natural Wet | 4.0 pts + 0.13% v/v | 69.31 ± 68.68 | 17.40 ± 3.34 | 17.60 ± 3.02 | 9.13 ± 6.13 |
| Kanemite | 25.0 oz | 66.80 ± 36.28 | 8.03 ± 7.95* | 30.80 ± 40.38 | 10.00 ± 2.77 |
| Kanemite | 31.0 oz | 72.40 ± 61.24 | 5.53 ± 2.95* | 9.60 ± 0.60 | 12.80 ± 2.42 |
| Fujimite 5EC + LI7000 | 1 pt + 0.25% v/v | 81.00 ± 54.67 | 2.57 ± 1.76* | 7.27 ± 6.00 | 2.23 ± 0.80 |
| Fujimite 5EC LI7000 | 2 pts + 0.25% v/v | 27.40 ± 22.64 | 2.29 ± 3.10* | 3.17 ± 3.15 | 7.49 ± 10.29 |
| Agri-mek + LI7000 | 15.6 oz + 0.25% v/v | 44.40 ± 35.74 | 18.60 ± 3.00 | 25.20 ± 21.22 | 15.00 ± 8.88 |
| Omni Supreme | 1% v/v | 46.00 ± 15.84 | 15.00 ± 1.59* | 13.00 ± 5.67 | 5.65 ± 4.43 |
| Omni Supreme | 4% v/v | 75.60 ± 64.53 | 8.60 ± 3.52* | 8.33 ± 3.10 | 19.53 ± 20.04 |
| Acramite WS | 1 lb | 75.60 ± 34.88 | 15.60 ± 6.26 | 13.40 ± 8.68 | 16.20 ± 15.04 |
| Onager | 20 oz | 75.80 ± 71.72 | 6.80 ± 1.93* | 8.00 ± 2.71 | 10.00 ± 5.44 |
| Zeal | 3 oz | 109.60 ± 16.48 | 14.00 ± 3.81* | 14.40 ± 13.63 | 4.40 ± 1.56 |

*Means significantly different from untreated control at $P<0.05$ by Student's t-test.

ANOVA statistics for each sampling date:

| Date | F= | df= | P= |
|---|---|---|---|
| 7-18-06 Pre | 0.6531 | 14, 44 | 0.799 |
| 7/26/06 | 8.8208 | 14, 44 | <.0001 |
| 8/2/06 | 1.4976 | 14, 44 | 0.1719 |
| 8/9/06 | 1.8588 | 14, 44 | 0.0756 |

Predatory mites in the family Phytoseiidae, especially *Galendromus occidentalis*, have been shown to be effective as biological control agents in California almond orchards. *G. occidentalis* is native to the western U.S., and is reared commercially by several insectaries. Previous research in our lab has shown that pyrethroid insecticides in particular were harmful to this predator through both contact and residual activity. Harmful residues were shown to exist for over a year on bark, and for at least 5 months on treated leaves. Several new miticides have been registered for use on almonds since 2000 including etoxazole (Zeal), spirodiclofen (Envidor), fenpyroximate (Fujimite – nonbearing use only), bifenazate (Acramite), acequinocyl (Kanemite), hexythiazox (Onager), pyridaben (Nexter) and others. Abamectin (Agri-mek), although registered for many sites prior to these other chemicals, has enjoyed dramatically increased use as applications of older products such as Omite and Vendex has declined. Understanding the acute and side effects of these new miticides is important to their successful integration into conservation and augmentation programs. Results of our bioassays have characterized the direct (Table 10) and residual (Table 11) effects of a number of these new miticides on survival, fecundity and fertility of *G. occidentalis*. Total effect on adult female reproductive potential were calculated and categories for persistence assigned according to the International Organization of Biological Control (IOBC) classification (Table 12). Of the miticides tested, etoxizole and fenpyroximate had the greatest total effects on both species. Acequinocyl and bifenazate had the least total effect on *G. occidentalis*. Spiromesefen (which is closely related to spirodiclofen) was

Table 9. Mean (± SD) predator mites per leaf, Nickels Estate, Arbuckle, CA, 2006.

| | | Mean ± SD predator mites per leaf | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Rate (Form/ac) | 8/9/06 | | | 8/29/06 | | | 9/6/06 | | | 9/13 | | |
| Control | NA | 0.00 | ± | 0.00 | 1.20 | ± | 2.08 | 2.00 | ± | 1.51 | 1.23 | ± | |
| Envidor 2SC | 18.0 oz | 0.07 | ± | 0.12 | 0.40 | ± | 0.35 | 0.60 | ± | 0.60 | 0.87 | ± | |
| Envidor 2SC + summer oil | 18.0 oz + 1% v/v | 0.07 | ± | 0.12 | 0.03 | ± | 0.06 | 0.67 | ± | 0.50 | 3.67 | ± | |
| Ecotrol + Natural Wet | 2.0 pts + 0.13% v/v | 0.00 | ± | 0.00 | 3.80 | ± | 4.08 | 3.63 | ± | 3.00 | NA | ± | |
| Ecotrol + Natural Wet | 4.0 pts + 0.13% v/v | 0.20 | ± | 0.35 | 3.00 | ± | 2.62 | 1.25 | ± | 1.33 | NA | ± | |
| Kanemite | 25.0 oz | 0.00 | ± | 0.00 | 0.20 | ± | 0.35 | 1.40 | ± | 1.25 | NA | ± | |
| Kanemite | 31.0 oz | 0.00 | ± | 0.00 | 1.80 | ± | 2.62 | 0.44 | ± | 0.28 | NA | ± | |
| Fujimite 5EC + LI7000 | 1 pt + 0.25% v/v | 0.00 | ± | 0.00 | 0.40 | ± | 0.69 | 0.97 | ± | 0.64 | NA | ± | |
| Fujimite 5EC LI7000 | 2 pts + 0.25% v/v | 0.07 | ± | 0.12 | 0.10 | ± | 0.17 | 0.10 | ± | 0.17 | NA | ± | |
| Agri-mek + LI7000 | 15.6 oz + 0.25% v/v | 0.00 | ± | 0.00 | 0.80 | ± | 0.72 | 0.67 | ± | 0.46 | 0.70 | ± | |
| Omni Supreme | 1% v/v | 0.00 | ± | 0.00 | 1.60 | ± | 2.27 | 1.43 | ± | 1.29 | NA | ± | |
| Omni Supreme | 4% v/v | 0.00 | ± | 0.00 | 0.23 | ± | 0.40 | 0.97 | ± | 1.27 | NA | ± | |
| Acramite WS | 1 lb | 0.00 | ± | 0.00 | 0.67 | ± | 1.15 | 0.43 | ± | 0.40 | 1.17 | ± | |
| Onager | 20 oz | 0.00 | ± | 0.00 | 2.40 | ± | 4.16 | 0.30 | ± | 0.30 | 2.73 | ± | |
| Zeal | 3 oz | 0.00 | ± | 0.00 | 0.43 | ± | 0.40 | 0.47 | ± | 0.38 | 0.27 | ± | |

ANOVA statistics for each sampling date:

| Date | F= | df= | *P*= |
|---|---|---|---|
| 7-18-06 Pre | . | 14, 44 | . |
| 7/26/06 | 1.0000 | 14, 44 | 0.4777 |
| 8/2/06 | 1.6786 | 14, 44 | 0.1143 |
| 8/9/06 | 0.8571 | 14, 44 | 0.6078 |
| 8/29/06 | 1.0020 | 14, 44 | 0.4760 |
| 9/6/06 | 1.7942 | 14, 44 | 0.0877 |
| 9/13/06 | 1.3928 | 6, 20 | 0.2843 |

similar to acequinocyl and bifenazate when females were exposed to direct contact sprays, but was 'slightly harmful' when exposed to leaf surface residues. We did not evaluate side effects of hexythiazox (a mite growth regulator that has an unknown mode of actionbut is believed to be similar to that of etoxazole) or pyridaben (a site I electron transport inhibitor like fenpyroximate) on *G. occidentalis*, but studies we have reported in prior Almond Board Production Research Conference Proceedings indicated that hexythiazox did not cause significant direct mortality to adult females and that pyridaben did cause significant adult female mortality. These results are consistent with those of our current studies on etoxazole and fenpyroximate for adult female survival, and we would expect results for the side effects on fecundity, fertility and survival to be similar to those products as well.

Table 10. *G. occidentalis* survival, fecundity and fertility resulting from exposure of adult females to direct contact spray with label rates of five miticides.

| Active ingredient | Concentration (ppm) | % Survival [1] | Total eggs/ female [1] | Sterility (% hatch) [1] | *E* |
|---|---|---|---|---|---|
| Control | -- | 100.0±0.0a | 12.4±0.8a | 100.0±0.0a | -- |
| Acequinocyl | 62.50 | 100.0±0.0a | 9.2±0.6b | 96.0±4.9a | 28.5 |
| Bifenazate | 24.12 | 100.0±0.0a | 9.4±0.5b | 92.3±3.4a | 30.2 |
| Etoxazole | 158.00 | 98.3±2.2a | 9.4±0.7b | 0.0±0.0b | 100.0 |
| Spiromesifen | 112.75 | 98.3±2.2a | 8.6±0.5b | 96.1±4.0a | 34.0 |
| Fenpyroximate | 76.20 | 0.0±0.0b | 0.0±0.0c | 0.0±0.0b | 100.0 |

[1] Means followed by the same letter are significantly different at $P<0.05$ by LSD.

Table 11. *G. occidentalis* survival, fecundity and fertility resulting from exposure of adult females to leaf surface residues of label rates of five different miticides.

| Active ingredient | Concentration (ppm) | % Survival | Total eggs/ female | Sterility (% hatch) | *E* |
|---|---|---|---|---|---|
| Control | -- | 98.3±2.2a | 11.2±1.0a | 100.0±0.0a | -- |
| Acequinocyl | 62.50 | 93.4±3.0a | 9.6±0.5a | 92.2±4.9a | 25.1 |
| Bifenazate | 24.12 | 95.1±2.7a | 9.6±0.9a | 96.0±4.0a | 20.1 |
| Etoxazole | 158.00 | 93.4±3.0a | 9.0±0.5a | 0.0±0.0b | 100.0 |
| Spiromesifen | 112.75 | 91.7±3.2a | 5.0±0.7b | 92.6±4.3a | 61.7 |
| Fenpyroximate | 76.20 | 0.0±0.0b | 0.0±0.0c | 0.0±0.0b | 100.0 |

Means followed by the same letter are significantly different at $P<0.05$ by LSD.

Table 12. Total effects of five miticides following exposure of *G. occidentalis* adult females to direct contact spray or leaf surface residues, with corresponding IOBC classification.

| | Direct contact spray | | Leaf surface residues | | |
|---|---|---|---|---|---|
| Chemical | *E* | IOBC class | *E* | IOBC class | Apparent cause |
| Acequinocyl | 28.5 | Harmless (1) | 25.1 | Harmless (1) | |
| Bifenazate | 30.2 | Harmless (1) | 20.1 | Harmless (1) | |
| Spiromesifen | 34.0 | Harmless (1) | 61.7 | Slightly harmful (2) | Reduced fecundity |
| Etoxazole | 100.0 | Harmful (4) | 100.0 | Harmful (4) | Increased sterility |
| Fenpyroximate | 100.0 | Harmful (4) | 100.0 | Harmful (4) | Direct mortality |

The results reported here reflect only the effects on adult females exposed to 3 day old residues. Our research on side effects of miticides on predator mites is continuing in 2007 and the present study will report exposure to residues up to 5 weeks after a field application.

**Recent Publications:**


Zalom, F. G., N. C. Toscano and F. J. Byrne. 2005. Managing resistance is critical to future use of pyrethroids and neonicotinoids. Calif. Agric. 59(1): 11-15

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Brodt, S., F. Zalom, R. Krebill-Prather, W. Bentley, C. Pickel, J. Connell, L. Wilhoit, and M. Gibbs. 2005. Almond growers rely on pest control advisers for integrated pest management. Calif. Agric. 59(4): 242-248.

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