Arthropod Pest Management in the Lower San Joaquin Valley

Project No.: **13-ENTO6-Haviland**

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Objectives:

1) Screen new miticides and miticide adjuvants for their potential benefit in IPM programs for Pacific spider mite.

2) Determine the ability of first flight (May) insecticide treatments to prevention reinfestation of mummy nuts in the tree.

3) Evaluate the affect of hull split treatment timings on the effectiveness of larvicides for navel orangeworm (NOW).

4) Evaluate Altrevin bait as part of an integrated strategy for fire ant management.

5) Maintain two University-based research and demonstration orchards for almond pest management research in the San Joaquin Valley.

Interpretive Summary:

Insect pests continue to be of significant concern to almond growers in the lower San Joaquin Valley. During 2013 our research program focused on those concerns by conducting trials on the management of Pacific spider mite, navel orangeworm and southern fire ant. Miticide trials showed that grower standard miticides such as Envidor, Fujimite, Onager, Zeal and Vigilant continue to be effective against spider mites. Similar control was provided by two new miticides called Magister and Nealta that are in the process of being registered. We also evaluated the organic miticide Grandevo that provided mite control similar to plots treated with 1% 415° Oil. Additional studies on surfactants documented that Vintre can be used as an alternative to 1% 415° Oil with five different miticides when applied in the summer, and that the addition of potassium nitrate as a tank mix did not improve, nor diminish, the effectiveness of miticides.

Navel orangeworm trials were conducted during May and at hull split. May trials evaluated the effectiveness of five different insecticides applied to mummies in almond trees for their ability

to prevent reinfestation by natural populations of navel orangeworm for a period of two weeks. Results showed no significant differences in the number of small larvae found in treated versus non-treated mummies. In hull split trials we evaluated six different larvicides (alternatives to pyrethroids) at five different application timings in trials in Kern and Fresno counties. There were no significant differences among treatments for any individual application date at either one of the trial locations. When treatment effect data were averaged across all application dates there were reductions in damage levels ranging from 11 to 43%. These data support the idea that applications of larvicides at hull split for navel orangeworm are only marginally effective and help explain why reduction of navel orangeworm populations using winter sanitation is so important.

Twelve different southern fire ant management strategies were evaluated in a large scale research trial totaling approximately 300 acres. Due to low ant density we were only able to make general statements about product efficacy based on trends among treatments. Overall, early to mid-season applications of Esteem performed well. Applications of Clinch caused a reduction in ant density, but those reductions were not as high as have typical been achieved by this product in trials in previous years. Applications of Altrevin provided mixed results with a mid-season application resulting in lower ant densities at the Nonpareil harvest, but not Monterey harvest. Applications of Altrevin four weeks prior to Nonpareil harvest did not result in any reductions in ant density at either the Nonpareil or Monterey harvests.

Materials and Methods:

<u>Objective 1. Spider mite management</u>
During 2013 we conducted a trial in Shafter, CA to evaluate the effects of miticides on the density of Pacific spider mites in almond. The trial was located in a 7.0 acre portion of a five year old orchard (20 x 22 spacing) that contained alternating rows of the varieties Nonpareil and Monterey. Plot size was three trees long by one row wide. The plots were organized into a randomized complete block design with 4 blocks of 14 treatments and an untreated check (**Table 1**). Treatments were applied on 4 or 5 June to individual trees with a hand gun at 150 PSI with a water volume equivalent to 200 gpa. All treatments were combined with 1% 415º Oil.

In addition to the abovementioned treatments we included 10 more treatments to evaluate the effects of surfactants. The trial already contained the miticides Envidor, Fujimite, Onager, Vigilant and Zeal. Five of the additional treatments included these same five miticides with a substitution of Vintre at a rate of 3 pt/ac instead of 1% 415° oil. The final five treatments included the original five miticides and 415° oil with the addition of 10 lbs/ac of potassium nitrate. This allowed us to compare the effectiveness of all five miticides with Vintre compared to 1% 415° oil as well as the same miticides and 1% 415° oil with the potassium nitrate, and to compare all of these to plots treated only with 1% 415° oil and an untreated check.

Mite densities were evaluated in each plot prior to treatment on 3 June and then on 10 June (7 DAT), 17 June (14 DAT), 24 June (21 DAT) and 1 July (28 DAT). On each sample date a total of 20 leaves were collected per plot. This included six to seven random leaves per tree from each of the three trees per plot. Leaves were transported to a laboratory where motile Pacific spider mites (larvae, nymphs, and adults) were counted. For each evaluation date the average number of motiles and eggs per leaf were analyzed by ANOVA using transformed data (square root (x + 0.5)) with means separated by Fisher's Protected LSD (P = 0.05).

The number of mite-days was also analyzed across all evaluation dates. This was done by calculating the cumulative number of mite-days (1 mite for 1 day) found in each plot. Steps to do this were 1) Multiply the number of mites 7 DAT by 7 days, 2) for data 14, 21 and 28 DAT calculate the average mites per leaf for the current and previous sample date, and then multiply each by 7 days, and 3) calculate the sum of the mite-days from all four evaluation dates. Mite-days were analyzed by ANOVA using transformed data (square root (x + 0.05)) with means separated by Fisher's Protected LSD (P = 0.05).

Objective 2. May NOW treatments

May is the period of time when overwintering navel orangeworm emerge from mummies, mate, and lay eggs to reinfest mummy nuts. This period of time marks a critical moment in navel orangeworm phenology. If moths cannot find a mummy on which to lay their eggs (aka. winter sanitation), the pest cycle is broken. Likewise, if adult moths or the eggs they lay can be killed, then pest suppression or control can be achieved.

In 2013 we conducted an experiment at the West Side Research and Extension Center to evaluate the ability of four different insecticides to prevent reinfestation of mummy nuts. The trial was designed as a randomized complete block with four blocks of four treatments and an untreated check. Each plot contained one Nonpareil and one NePlus tree. Treatments were Brigade at 2 lbs/ac, Altacor at 4 oz/ac, Delegate at 7 oz/ac and Intrepid at 24 fl oz/ac. Trees were sprayed on 2 May 2013 using a gas-powered wand sprayer at a water volume of 200 gpa. Approximately 2 weeks later on 17 May we collected an average of 257 nuts per tree (~500 per plot) and transported them to a laboratory for evaluation. Nuts were cracked open to determine the presence of live NOW and each larva that was found was categorized by size. Data of the percentage of nuts with small (first and second instar) worms that would have infested the nuts during the two weeks between application and evaluation were analyzed by ANOVA with means separated by Fisher's Protected LSD (P = 0.05)

Objective 3. Larvicides for NOW at hull split

Over the past few years almond growers have increased their reliance on pyrethroid insecticides for navel orangeworm control. However, there are concerns about the long-term viability of pyrethroid-based spray programs due to recent reports of the development of resistance as well as the potential that pyrethroids have to induce spider mite outbreaks. For that reason we focused our research efforts in 2013 on five different insecticides that are considered 'softer' and 'greener' than pyrethroids and that work primarily against navel orangeworm larvae.

Trials were established in two almond orchards located in Fresno and Kern Counties. Each trial was organized as a completely randomized factorial design with five repetitions of six treatments and six treatment timings (5 x 6 x 6 = 180 trees in each trial). Treatments included Altacor (chlorantraniliprole) at 4 oz/ac, Belt (flubendiamide) at 4 fl oz/ac, Delegate (spinetoram) at 6.4 oz/ac, Intrepid (methoxyfenozide) at 16 fl oz/ac, Proclaim (emamectin-benzoate) at 4.5 oz/ac and an untreated check. Timings in Kern Co. included a single application on 2 Jul, 5 Jul, 9 Jul, 12 Jul, or 16 Jul, or a double application on 2 Jul plus 16 Jul. Timings in Fresno Co.

included a single application on 5 Jul, 9 Jul, 12 Jul, 16 Jul, or 19 Jul, or a double application on 5 Jul plus 19 Jul. Applications were made using a hand wand with a water volume of 200 gal/ac with the inclusion of the surfactant Dyne-Amic at a rate of 4 fl/oz per 100 gallons of water.

Trees were evaluated by collecting approximately 250 nuts from each tree two weeks after the application was made. For example, for all trees sprayed in Kern Co. on 2 Jul nuts were collected on 15 Jul, whereas for trees sprayed on 5 Jul the nuts were collected 18 Jul, and so on. At the conclusion of the trial we also collected a sample of 250 nuts from all trees approximately four weeks after the start of the trial on 29 Jul (Kern Co.) and on 2 Aug (Fresno Co.) Nuts were placed on an asphalt surface for approximately 2 days to dry and then were placed in cold storage until the nuts could be cracked and evaluated for damage by navel orangeworm.

Objective 4. Ant bait programs

Southern fire ant is an important pest of almonds due to its ability to feed directly on the kernel during the period of harvest when nuts are on the ground. Currently, the standard practice for ant management is to make one or two applications of protein-based baits between April and June. Worker ants collect the baits, take them back to the colony, and feed them to the brood and queen. Over a period of one or two months this causes the queen to die or become sterile, thus resulting in a reduction in the number of worker ants that can feed on almond kernels during harvest.

During 2013 we evaluated eleven different treatment programs and an untreated check for their effects on southern fire ant at harvest. Each treatment program consisted of either one application of one bait or a combination of two baits applied at one to two month intervals. Baits included Clinch at 1 lb/ac (abamectin), Esteem at 1.5 lbs/ac (pyriproxifen), and Altrevin at 1.5 lbs/ac (metaflumizone). Two of the treatment programs also included a late-season application of Lorsban at 128 fl oz/ac (chlorpyrifos) applied directly to the soil. Total trial size was approximately 300 acres that was divided into a randomized complete block design with 48 plots. Each plot was approximately 18 rows wide by 30 trees (6.2 acres). Bait applications were made on 11 May (E = Early), 17 Jun (M = mid-season), or on 17 Jul (L = late-season) (**Figure 5**) using an ATV-mounted bait spreader that delivered the bait to a 4 ft swath in the center of the drive row. Applications of Lorsban were made directly to the soil on 17 Jul using 40 gal of water per acre with a tractor-mounted double-boom system with a 21-ft swath. All applications were made by commercial application crews employed by Paramount Farming Company

The effects of treatment programs on the number of foraging ants were evaluated at harvest on 9 Aug (one week before Nonpareil harvest) and on 12 Sept (one week before Monterey harvest). On each evaluation date a total of 1152 bait stations (24 per plot) were placed into the orchard when ants were active in the morning. Each bait station was a 50-ml snap-cap vial containing a 0.5-in slice of hot dog. After approximately 3 hours in the orchard each station was recovered, snapped closed, frozen, and evaluated for the number of southern fire ants at a future date. Data on the average number of ants per vial from each plot were analyzed by ANOVA with means separated by Fisher's Protected LSD ($P = 0.05$).

The effects of treatment programs on kernel damage was evaluated on 19 August (Nonpareil) and 30 September (Monterey) by collecting approximately 500 nuts from each of 4 locations in each plot. A 3-tree composite sample was taken from the windrows at 6 days after shaking. Nuts were returned to the lab and kernels were evaluated for feeding by ants.

Objective 5. Maintain two research orchards

Funding provided by the Almond Board of California has allowed us to maintain two research orchards in the San Joaquin Valley. The first site is a 7-acre orchard in Shafter in Kern County on land that used to be part of the UC Shafter Research and Extension Center. The orchard is planted on a 20' by 22' spacing with alternating rows of Nonpareil and Monterey. Irrigation is set up using microsprinklers with the capability to turn water on and off on each individual row. The orchard has a total of 700 trees that were harvested for the first time in 2011

The second orchard is 5 acres and is located at the UC West Side Research and Extension Center in Five Points, Fresno Co. The orchard is planted on a 22' x 15' spacing with a three-tree alternating pattern down each row of Nonpareil, Carmel and NePlus Ultra. The orchard was designed and planted under the direction of Dr. Brent Holtz in 2008 to conduct research on almond diseases. It is now utilized for trials related to pest management.

Results and Discussion:

Objective 1. Spider mite management

Mite density was very high at the initiation of the trial (**Table 1**). There were no significant differences in precounts (*P* = 0.5289) that ranged from 55.6 to 121.6 mites per leaf among treatments (avg. 89.1). By 7 DAT there were significant reductions in mite density compared to the untreated check for all treatments that were not pyrethroids. The lowest mite densities were in plots treated with Magister and Zeal (3.4 mites per leaf) that were statistically equivalent to plots treated with Acramite, Fujimite, Nealta, Onager and Vigilant (5.8 to 15.6 mites per leaf). By 14 DAT mite densities in all miticide treatments except for Grandevo were below 7.1 mites per leaf compared to 34.1 in the untreated check. By 21 and 28 DAT mite densities in all miticide treatments and the untreated check were reduced to less than 6.0 and 0.2 mites per leaf, respectively. Reductions in mite densities were due to an influx of predatory six-spotted thrips and minute pirate bugs that became established within the trial.

Treatments with pyrethroids initially reduced mite densities 7 DAT by approximately 60 to 75% (28.8 to 43.6 mites per leaf) compared to the untreated check (118.8 mites per leaf) (**Table 1**). By 14 DAT mite densities were statistically equivalent to the untreated check for Asana, Brigade and Danitol, and were slightly lower for Warrior II. By 21 DAT mite densities in plots treated with pyrethroids were approximately double (6.3 to 9.2 mites per leaf) the mite density in the untreated check (3.7 mites per leaf), even though this difference was not significantly different. By 28 DAT beneficial predators reduced mites in all plots to less than 0.2 mites per leaf regardless of treatment.

Figure 1 shows a graphical representation of the cumulative mite-days found in each trial. Five miticides in the trial are registered and have been used successfully for mite control within the almond industry. This includes Acramite, Envidor, Fujimite, Onager, Vigilant and Zeal. Each of these miticides performed well in this trial. There were also several new miticides under evaluation. These included one organic product that is registered for use in almonds (Grandevo) and two unregistered experimental miticides (Magister and Nealta). Mite densities in plots treated with Grandevo, an organic biopesticide from Marrone Bio Innovations, were numerically higher on all evaluation dates than any of the other treatments classified as miticides. Mite density in plots treated with Grandevo was statistically equivalent to the untreated check on all evaluation dates except for 7 DAT.

The other two new miticides are Magister and Nealta. Magister is a new METI miticide (mitochondrial complex I electron transport inhibitor) containing the active ingredient fenazaquin (IRAC group 24) from Gowan. Nealta contains the active ingredient cyflumetofen that also affects the mitochondria, but in a different way. It is classified as a mitochondrial complex II electron transport inhibitor (IRAC group 25). Mite densities in plots treated with both of these miticides were consistently among the lowest in the trial and were similar to mite densities in plots treated with the grower standards.

Table 1. The effects of miticide treatments on the density of Pacific spider mite in almond, Shafter 2013

Treatment[1]	Rate	Mean spider mites per leaf				
		Pre-count	7 DAT	14 DAT	21 DAT	28 DAT
Miticides						
Acramite 50WS	1 lb	88.6a	5.8ab	6.2a-d	3.4a	0.03ab
Envidor 240SC	18 fl oz	69.4a	20.3b-e	7.1a-d	0.9a	0.00a
Fujimite 5EC	32 fl oz	74.5a	6.9a-c	5.1a-c	1.5a	0.00a
Grandevo	3 lb	93.7a	26.5de	15.1c-f	3.6a	0.20c
Magister 10EC	32 fl oz	72.1a	3.4a	1.7a	2.7a	0.03ab
Nealta 20SC	13.5 fl oz	86.6a	5.8ab	6.4a-d	6.0a	0.00a
Onager 1EC	24 fl oz	102.7a	6.6a-c	2.4a	0.4a	0.00a
Vigilant 4SC	24 fl oz	82.5a	15.6a-d	3.6ab	0.6a	0.00a
Zeal 72WP	3 oz	83.5a	3.4ab	2.6a	2.9a	0.00a
Pyrethroids						
Asana XL	9.6 fl oz	104.8a	43.6ef	26.1f	7.8a	0.03ab
Brigade WSB	1 lb	114.8a	42.3ef	20.5ef	9.2a	0.15bc
Danitol 2.13EC	21.3 fl oz	93.5a	28.8de	16.3d-f	6.3a	0.03ab
Warrior II	2.56 fl oz	55.6a	27.6c-e	9.1a-e	6.6a	0.20c
415° Oil	1%	93.0a	22.0a-e	16.8b-f	4.0a	0.03ab
Untreated Check	--	121.6a	118.8f	34.1ef	3.7a	0.04ab
	F =	0.94	5.39	3.97	1.78	2.61
	P =	0.5289	<.0001	0.0003	0.0757	0.0083

[1]All miticide and pyrethroid treatments included 415° Oil at 1% v/v.
Means in a column followed by the same letter are not significantly different ($P > 0.05$, Fisher's protected LSD) with square root (x + 0.5) transformation of the data. Untransformed means are shown.

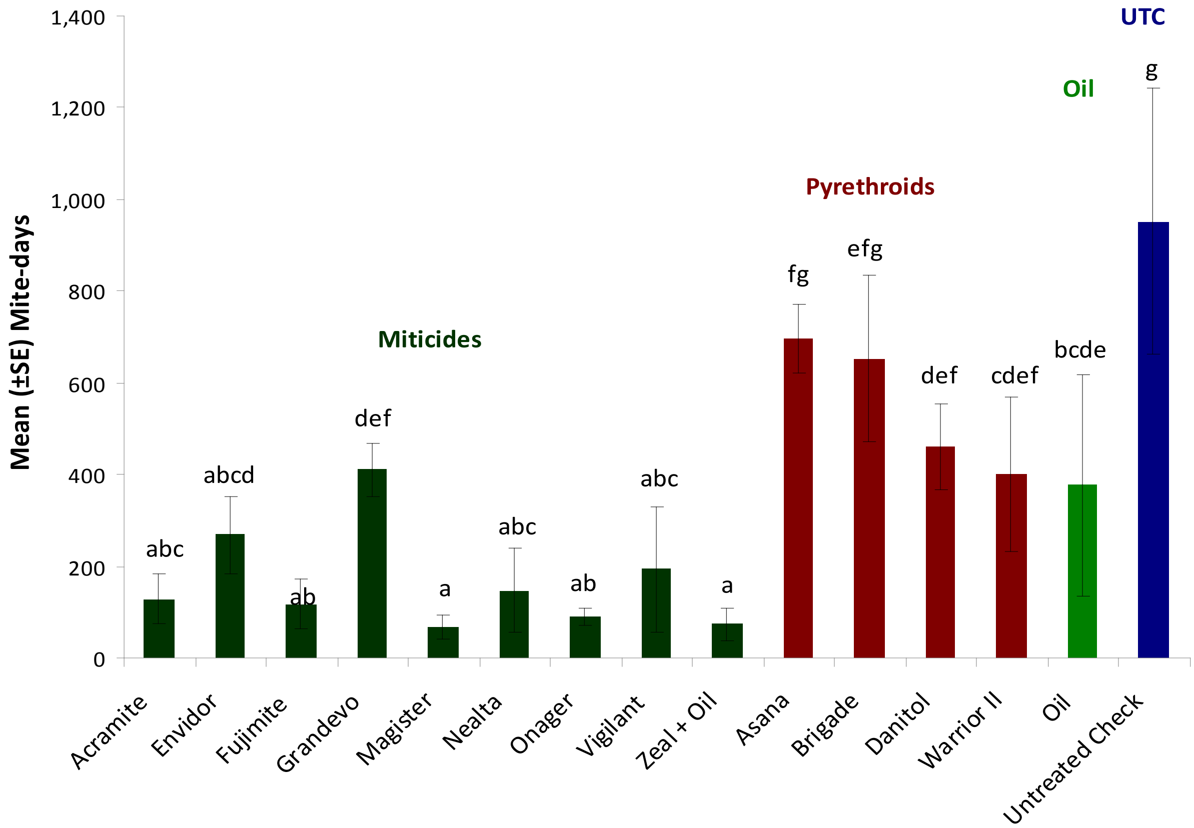

Figure 1. The effects of miticide treatments on the density of Pacific spider mite in almonds. Columns with the same letter are not significantly different ($P > 0.05$, Fisher's protected LSD) following square root (x + 0.5) transformation of the data. Untransformed means are shown.

In our surfactant studies evaluating Vintre and potassium nitrate, all miticide applications resulted in a significant reduction in mite densities compared to the untreated check. In the Vintre trial, all five insecticides provided similar mite control regardless of whether they were applied with 3 pt/ac of Vintre or with 1% 415° Oil (**Figure 2**). This suggests that Vintre can be used with miticides late in the season by growers and PCAs that are trying to find alternatives to traditional oil.

In our potassium nitrate trial all miticide applications including 1% 415° oil provided similar control as when the same miticides including 1% 415° oil also had the inclusion of 10 lb/ac of potassium nitrate (**Figure 3**). These results suggest that the addition of potassium nitrate to summer applications of miticides is not likely to increase the effectiveness of a miticide treatment. However, it also didn't cause any reductions in efficacy such that grower who wish to use foliar applications of potassium nitrate for plant health can do so in conjunction with miticide sprays without any adverse affects on mite control.

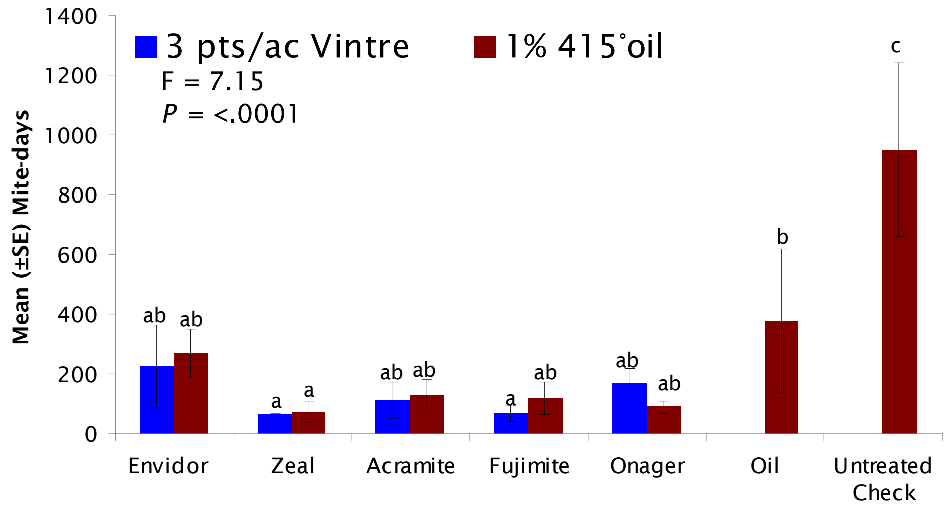

Figure 2. Evaluation of the effects of Vintre as an alternative of 1% 415° Oil with five different miticides.

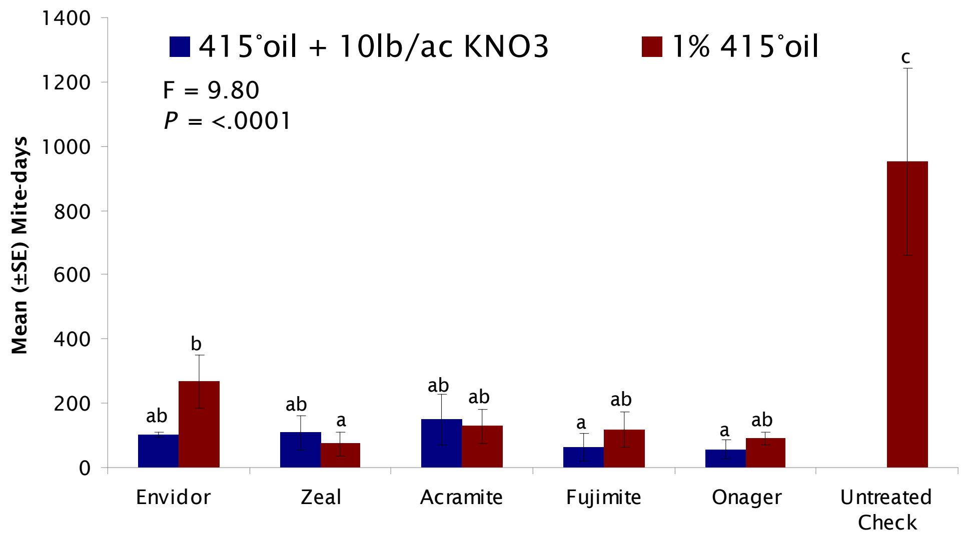

Figure 3. Evaluation of the effects of adding 10 lbs/ac of potassium nitrate to applications of five different miticides with 1% 415° Oil.

<u>Objective 2. May NOW treatments</u>

Insecticide applications in early May did not cause any significant reductions in the number of mummy nuts that were reinfested by navel orangeworm. For Nonpareil the percentages of almond mummies with small larvae (first and second instars that would have hatched in the 2 weeks between the application date and the date nuts were collected) were 1.9% (Brigade), 2.0% (Intrepid), 3.3% (Delegate) and 4.1% (Altacor) compared to 2.3% in the untreated check. Mummy NePlus nuts had very few small worms with treatments resulting in reinfestation levels of 0.8 to 0.2% for treated plots compared to 0.2% in the untreated check.

These data suggest that applications of insecticides in May to the surface of mummy nuts may have limited ability to prevent reinfestation of the mummies. One possible reason is that eggs are often laid in cracks and crevices between nuts or inside the split hull where insecticide coverage is difficult to attain with commercial application equipment. However, this does not mean that May insecticide applications can't be effective. Historically, insecticide treatments targeting NOW in May function primarily by killing adult moths (e.g. organophosphates and pyrethroids) on a large scale. Our study did not evaluate the effect on adult moths due to the small scale of each plot. It only evaluated whether or not young larvae were able to infest the nuts within two weeks after the insecticides were applied to nuts on the tree.

Objective 3. Larvicides for NOW at hull split

During 2013 we completed navel orangeworm trials in Kern Co. and Fresno Co. Both sites had good populations of navel orangeworm with damage levels across the whole trials of 3.0% at the Kern Co. trial harvest on 29 Jul and 5.1% at the 2 Aug harvest in Fresno County. However, due to a large amount of variation among plots we were unable to determine any significant differences in the amount of damage between Belt, Altacor, Proclaim, Intrepid, Delegate or untreated plots on any of the six different evaluation dates at either the Kern Co. (**Figure 4a**) or Fresno Co. (**Figure 4b**) trials.

When data for each treatment were averaged across all application dates there were likewise no significant differences in the effects of the five treatments in data for the Kern Co. trial harvest two weeks after application or at the Fresno Co. trial harvests two weeks after each application or on 2 Aug (**Table 2**). Marginally significant differences (P = 0.0617) were found in the 29 Jul harvest evaluation in Kern Co. On that evaluation date plots treated with Altacor, Proclaim, Belt, Delegate and Intrepid had reductions in NOW damage of 43, 29, 27, 23 and 11% compared to the untreated check, respectively. Evaluations of the effects of application date did not result in any significant differences among the treatment dates (data not shown).

These results show the difficulty in getting effective control of navel orangeworm with insecticides that primarily work by controlling larvae. These data are consistent with previous trials where insecticides typically provide between 0 and 45% reductions in damage. In our 2013 trials larvicides provided 11 to 43% reductions in damage in one trial but no reductions in the other trial. Due to limitations of larvicide insecticides to prevent NOW damage it is essential that application timing be optimized. This is typically done through the use of degree-day models based on eggs captured on egg traps or adult males captured on pheromone traps. Information on how to time treatments based on degree-days can be obtained from the UC Statewide IPM Program at http://ucipm.ucanr.edu.

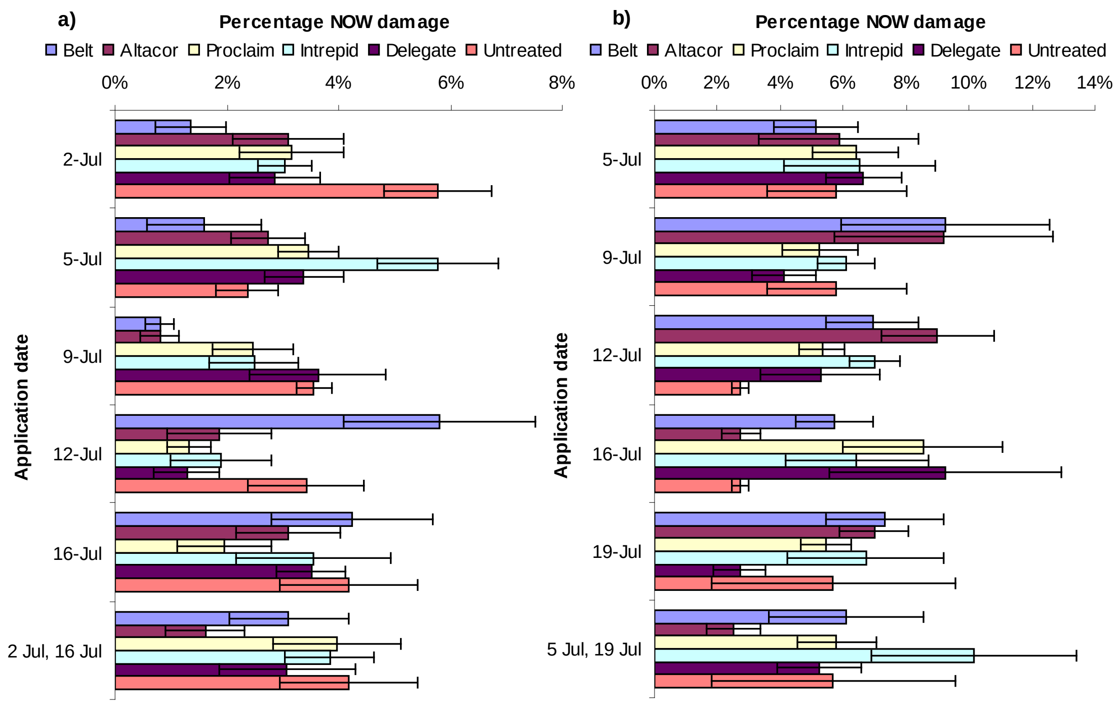

Figure 4. The effects of five insecticides and an untreated check on navel orangeworm damage two weeks after application for six different application timings in a) Kern Co. and b) Fresno Co. trials.

Table 2. Evaluation of the effects of insecticide treatments on NOW damage after data for each treatment were averaged across all application dates.

	Mean ± SE percentage navel orangeworm damage			
	Kern Co. 2 WAA*	Kern 2 29 Jul	Fresno Co. 2 WAA*	Fresno Co. 2 Aug
Altacor	2.3 ± 0.5 a	2.2 ± 0.3 a	4.1 ± 0.7 a	6.0 ± 0.9 a
Belt	2.7 ± 0.6 a	2.8 ± 0.5 abc	3.6 ± 0.5 a	6.7 ± 0.8 a
Delegate	2.1 ± 0.4 a	3.0 ± 0.4 bcd	3.6 ± 0.9 a	5.5 ± 0.8 a
Intrepid	2.2 ± 0.5 a	3.4 ± 0.4 cd	5.0 ± 1.1 a	7.1 ± 0.8 a
Proclaim	2.1 ± 0.3 a	2.7 ± 0.3 ab	4.9 ± 0.9 a	6.1 ± 0.6 a
Untreated	2.1 ± 0.4 a	3.9 ± 0.4 d	3.9 ± 0.7 a	4.7 ± 1.0 a
F, P (df = 5)	0.24, 0.9419	2.15, 0.0617	0.57, 0.7233	1.06, 0.3828

Means followed by the same letter are not significantly different using Fishers's protected LSD (P = 0.10).
* Evaluations were made two weeks after application (WAA) for each of six different application dates.

Objective 4. Ant bait programs

Results showed that overall ant activity in the trial was low. Damage to nut samples within each treatment ranged from 0.07 to 0.24% (average 0.14%) for Nonpareil and from 0.01 to 0.11% (average 0.07) for Monterey. This was compared to 0.12% and 0.07% in the untreated checks for the two harvests, respectively. Due to the low level of damage we were unable to determine any statistical differences in the relative effectiveness of different treatment programs to prevent damage because levels of damage in the untreated check were negligible.

However, despite negligible damage to nuts, we did get statistical differences in the density of foraging ants that were caught in bait stations. All five programs including an application of Esteem at the early or mid-season timing had less than 2.9 ants per vial compared to 26.5 in the untreated check at the Nonpareil harvest (**Figure 5a**) and less than 10.9 ants per vial compared to 60.7 in the untreated check at the Monterey harvest (**Figure 5b**). Four of the programs included an application of Clinch at the mid-season timing. Plots treated only with Clinch by itself had ant densities that were statistically equivalent to the untreated check on both evaluation dates. Plots treated with Clinch in combination with an early Esteem, late Altrevin, or late Lorsban had variable results depending on the product and evaluation date. Three of the programs included an application of Altrevin. When Altrevin was used by itself at the mid-season timing there was a significant reduction in damage at the Nonpareil harvest (2.4 ants per vial compared to 26.5 per vial in the UTC, **Figure 5a**), but not at the Monterey harvest (44.4 ants per vial compared to 60.7 per vial in the UTC, **Figure 5b**). Altrevin used by itself at the late timing did not reduce ant density compared to the UTC, nor did it reduce ant density in the mid-season Clinch plus late Altrevin treatment program to levels any lower than where Clinch was used by itself mid-season. Lorsban at the late timing was used as part of two of the programs. In both cases it caused a significant reduction in ant density compared to the untreated check.

The purpose of this trial was to give insight into the most effective ant baiting strategies. However, due to the overall low ant density we are only able to make some general statements about general trends among similar treatment programs. First, Esteem was an effective ant bait regardless of whether it was used early or mid-season. Second, mid-season applications of Clinch were not highly effective. However, it is important to note that this trial is the exception to the rule. Historically Clinch has provided similar results as Esteem in multiple trials conducted by the authors of this research. We are uncertain why it underperformed in this trial. Third, growers should be cautious about using Altrevin until more is understood about the product. Data from small plot trials in previous almond board reports has shown that Altrevin works faster than other baits and can reduce the number of foraging ants within two weeks. However, those trials were too small to evaluate how long Altrevin was effective. In this trial, there was no evidence that applications on 11 July were able to reduce the number of foraging ants during Nonpareil and Monterey harvests approximately one and two months later, respectively. Lastly, the overall low ant density in this trial reiterates the fact that not all orchards need applications of ant baits. Growers that are trying to determine the need for bait applications should consult the University of California Statewide IPM Program's web site (http://ucipm.ucanr.edu) for more information on using mound count evaluations to determine the need for a treatment.

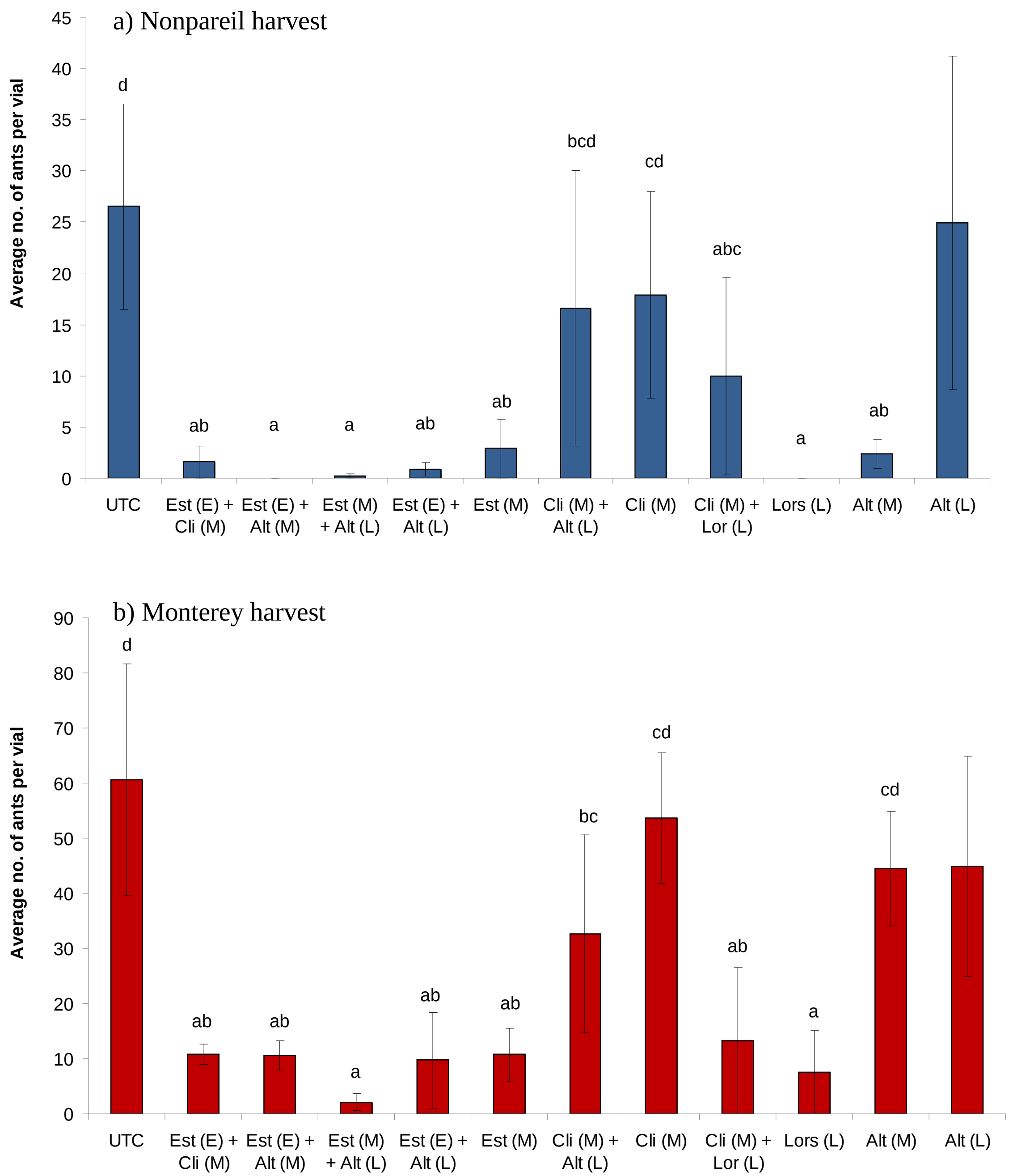

Figure 5. The effects of ant treatment programs on the number of foraging ants collected in bait stations approximately one week prior to a) Nonpareil harvest and b) Monterey harvest. Programs include applications of Esteem (Est), Clinch (Cli), Altrevin (Alt) or Lorsban (Lors) applied early (E) on 11 May, mid-season (M) on 17 Jun, or late (L) on 17 Jul. Means followed by the same letter are not significantly different (Fisher's Protected LSD) at a significance level of 0.05.

Objective 5. Maintain two research orchards

During 2013 there were a total of nine research projects completed within the two research orchards that are maintained in part by funding from the Almond Board. This included five miticide trials, two navel orangeworm trials, one herbicide trial, and one project on resistance to insecticides. Four of the trials were spearheaded by University of California researchers, four involved University of California cooperators in trials led by private companies trying to develop insecticides for use in almonds, and one was led by a California almond production company. In total over the past four years (2010-2013) these research orchards have now been used for a total of 39 trials.

During 2013 we successfully maintained both research orchards using funding from the Almond Board matched by funding from other sources, such as chemical companies that sponsor trials to evaluate their products. Currently the Kern Co. orchard is healthy and promises to be able to house numerous research projects in the future. On the other hand, the orchard at the West Side Research and Extension Center is struggling. Due to the drought situation we were only able to provide the trees with minimal amounts of irrigation with relatively salty groundwater. As of the end of 2013 the trees are okay, but we question the long-term viability of this orchard if a minimal-irrigation program with salty water has to be maintained for a second year in 2014.