Arthropod Pest Management in the Lower San Joaquin Valley

Project No.: **11-ENTO6-Haviland**

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Objectives:

1) Screen new miticides for their potential benefit in IPM programs for Pacific spider mite
2) Develop information on the efficacy of registered and experimental insecticides against navel orangeworm at hull split in almonds.
3) Maintain two University-based research and demonstration orchards for almond pest management research in the San Joaquin Valley

Interpretive Summary:

Arthropods such as Pacific spider mite and navel orangeworm are significant pests of almonds in the lower San Joaquin Valley. Direct feeding by navel orangeworm in combination with worm-induced aflatoxins makes effective management a necessity, just as feeding by Pacific spider mite can damage almonds through leaf feeding and defoliation. Over the past several years we have conducted a series of trials in the lower San Joaquin Valley to help improve IPM programs for these and other almond pests. During 2011 we conducted five spider mite and three navel orangeworm trials that focused on the efficacy of insecticide and miticide treatments for use as needed within an integrated pest management program.

The five spider mite trials were located in Shafter, Kern County, CA and each evaluated a different aspect of miticide efficacy. The first trial evaluated the use of potassium nitrate as an additive to improve efficacy. Results showed no significant differences in mite density when potassium nitrate was used, though numerical trends in the data suggest that further work is justified on the use of potassium nitrate with miticides that must come in contact with the mites to be effective. The second trial evaluated the use of Vigilant (a new formulation of bifenazate). Data showed a significant rate response when Vigilant is used with higher rates having higher efficacy. Data also showed that Vigilant should be included among the list of miticides that are effective for use by almond growers during the period near hull split, especially as a tank mix with insecticides used for navel orangeworm. The third trial evaluated the effects of a new adjuvant called Vintre that is described as a low surface tension surfactant with penetrating qualities. Data showed that Vintre is an acceptable alternative for 1% 415° Oil for use with other miticides. When used by itself, the efficacy of Vintre was statistically equivalent to both the untreated check and when 1% 415° oil was used alone. The fourth trial

evaluated the effects of pyrethroids in mite populations. Data showed that the new-generation pyrethroids Brigade, Danitol and Warrior II (all used with 1% 415° oil) are not as prone to flaring mites as the older-generation pyrethroid Asana. The final miticide trial evaluated insecticides and miticides that have been registered recently, or that have the potential to become registered in almonds, for their effects on mite density. Significant reductions in mite density were achieved in plots treated with Movento, Nealta, and Vigilant (all with 1% 415° oil) compared to the use of 1% 415° oil alone. Plots treated with Oroboost, Proclaim + 415° oil, and Stealth had mite densities that were statistically equivalent to when 1% 415° oil was used alone.

The three navel orangeworm trials were conducted in Parlier, Five Points and Shafter, CA. Navel orangeworm density in the three trials was not sufficient to make definitive statements regarding which treatments performed the best. However, when analyzed by mode of action it was evident that pyrethroids, pyrethroids plus diamides, and other larvicides all provided significant reductions in navel orangeworm density compared to the untreated check. Diamides by themselves provided numerical reductions in mite density to levels that were approximately one half of the density in untreated checks, but this difference was not significantly different.

Materials and Methods:

Objective 1) Miticide trials

During 2011 we conducted five trials in Shafter, CA to evaluate the effects of miticides on the density of Pacific spider mites in almond. The first trial evaluated the effects of using potassium nitrate as an additive to five commercial standard miticides. The second trial evaluated the effectiveness of Vigilant (a new formulation of bifenazate) as a stand-alone treatment at three different rates as well as in tank mixes with Onager or Brigade. The third trial evaluated the use of a new surfactant called Vintre as an alternative to 415° Oil. The fourth trial evaluated the effects of four pyrethroid insecticides for their effects on mites compared to an untreated check and the grower standard Zeal. The final trial evaluated the effects of six new miticides compared to 415° Oil and an untreated check.

Due to common treatments across multiple trials we decided to consolidate the treatments from all five trials into one large randomized complete block design with 29 treatments and one untreated check (**Table 1**). This allowed us to do a statistical analysis across all treatments, but also to analyze each preplanned trial independently from each other. Where appropriate, some treatments were used in more than one statistical evaluation (for example, the same untreated check was used during statistical analyses of trials one, two, four, and five that were previously described.

All treatments were made within a 7.0 acre portion of a third-leaf orchard that contained alternating rows of the varieties Nonpareil and Monterey. Plot size was four consecutive trees on a 20 ft by 22 ft spacing. Treatments were applied on 2-4 Aug to individual trees at 200 psi with a hand gun at a water volume equivalent of 100 gpa. All treatments were combined with 1% 415º Oil with the exception of Nealta 20SC (no oil), Oroboost, 415° Oil, products that included Vintre, and the Untreated Check.

Mite densities were evaluated in each plot prior to treatment on 1 Aug and then on 10 Aug (7 DAT [DAT = days after treatment]), 17 Aug (14 DAT), 24 Aug (21 DAT), 30 Aug (28 DAT), and 7 Sept (35 DAT). On each sample date a total of 20 leaves were collected per plot. This included five random leaves per tree from each of the four trees per plot. Leaves were transported to a laboratory where the numbers of motile Pacific spider mites larvae, nymphs, and adults) per leaf were counted. For each plot we also calculated the number of cumulative mite-days through 28 DAT. This was done by taking the average mites per day between each sample date, multiplying this by the number of dates between samples, and summing these results across each sampling date through 28 DAT in each plot. Data for all treatments across trials in each evaluation date were analyzed by ANOVA using transformed data (square root (x + 0.5)) with means separated by Fisher's Protected LSD (*P* = 0.05). For each of the five trials individually, cumulative data were analyzed by ANOVA using transformed data (square root (x + 0.5)) with means separated by Fisher's Protected LSD (P=0.05).

Objective 2) Navel orangeworm (NOW) trials

In 2011 we conducted three trials for navel orangeworm (NOW). The first trial was located at the UC Kearney Agricultural Center in Parlier, Fresno Co., CA, the second was located at the UC Westside Research and Extension Center in Five Points, Fresno Co., CA, and the third was located at the UC Shafter Research Farm in Shafter, Kern Co., CA. Each trial evaluated the effects of insecticides on navel orangeworm in almonds. At Parlier, a total of 56 nonpareil trees were organized into a completely randomized design with four replications of 13 treatments and an untreated check (**Table 2**). Trees were approximately 5 years old with a tree spacing of 20’ x 16’. At Five Points and Shafter, a total of 128 Nonpareil trees were organized into a RCBD with six blocks of 17 treatments and two untreated checks. Five Points trees were 4 years old and planted to a spacing of 22’ x 15’. Shafter trees were 3 years old and planted to a spacing of 20’ x 22’.

Treatments were applied to individual trees with a hand gun at 200 GPA at 150 PSI on 25 July (Parlier), 26/27 July (Five Points), and 19/20 July (Shafter). This corresponded with the second flight of navel orangeworm and the initiation of hull-split on the Nonpareil trees. Trials were harvested by hand on 31 Aug (Parlier, Five Points) or Sept 1 (Shafter) by collecting 300 to 400 nuts per tree into brown paper sacks. Samples were taken to the lab and allowed to dry for approximately three weeks. At that time they were placed into a walk-in refrigerator to stop development of any insects and were stored until the nuts could be separated from the hulls and shells and evaluated for damage by navel orangeworm. A minimum of 200 nuts were cracked for each tree and the percentage of those nuts that were damaged were analyzed by ANOVA with means separated by Fisher’s Protected LSD (α=0.10) following arcsin (x) transformation of the data to satisfy model assumptions. Additionally, for each trial a second ANOVA was completed after grouping data by mode of action. To do this, all insecticide treatments were grouped into five categories: pyrethroids, anthranilic diamides, tank mix of pyrethroids and anthranilic diamides, other larvicides, and untreated checks. For each category we calculated the average NOW damage for each replication across treatments. For example, data from the first replication of data from plots treated with Altacor, Belt, HGW86 and Tourismo were all averaged to generate one-average damage for the first replication of the category anthranilic diamides. Once calculations for all replications of each category were completed, data were analyzed by ANOVA as a completely randomized design with mean's separated by Fisher's Protected LSD (α=0.10) after arcsin (x) transformation of the data.

We also did an evaluation of mite density at the Five Points trial. During harvest there were large populations of spider mites that had developed on the trees. Therefore, on 8 Aug and 22 Aug we collected a total of twenty random leaves from each individual tree. Leaves were transported to a laboratory where the numbers of motile Pacific spider mites (larvae, nymphs, and adults) per leaf were counted. Average number of mites per leaf were analyzed by ANOVA using transformed data (square root (x + 0.5)) with means separated by Fisher's Protected LSD (α=0.05).

Objective 3) Research orchard maintenance

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. These varieties were chosen due to their compatibility within an orchard and for the ability to conduct navel orangeworm trials in the Nonpareils (timed at the second flight when hull split occurs) and then again in the Montereys (timed at the third flight when they begin to split). 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, and as of the summer of 2011 all trees are alive and growing and will be harvested for the first time.

The second orchard is approximately 5 acres in size and is located at the UC Westside Research and Extension Center in Five Points in Fresno County. 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 managed for use in a variety of pesticide research trials.

Results and Discussion:

Objective 1) Miticide trials

The effects of miticide treatments on mite density across all treatments are shown in **Table 1**. Precounts averaged 3.8 mites per leaf across all treatments. In the untreated check mite densities averaged 15.8, 37.1, 48.7, 55.4 and 69.2 mites per leaf 7, 14, 21, 28 and 35 DAT, respectively. All treatments caused a significant reduction in mite density on at least one evaluation date with the exception of Asana XL; *P*-values for each evaluation data following treatments were <0.0001.

Trial 1- effects of adding potassium nitrate to miticides

During the past few years there have been reports of almond growers that use potassium nitrate as a tank mix with miticides to improve their efficacy. Some pest control advisors have theorized that it could be due to direct toxicity of potassium nitrate to spider mites. Other pest control advisors think that the potassium nitrate causes mites to become agitated such that they move more on the surface of the leaf, thus making them more likely to become exposed to a miticide. In 2011 we conducted a trial to determine if this practice was effective by comparing the use of Envidor, Acramite, Fujimite, Zeal and Onager with and without the use of 10 lb/ac of KNO_3. All treatments had the addition of 1% 415° oil. There were no significant differences in spider mite density in plots that were treated with miticides that did, or did not, have the addition of potassium nitrate (**Figure 1**). Numerically, mite density was lower where potassium nitrate was used with Envidor, Acramite and Fujimite, but higher for Zeal and Onager. The greatest reduction in mite density (though not significant) was with the use of Envidor. In order for Envidor to work it must come in direct contact with mites, meaning it is likely the miticide could benefit form the addition of potassium nitrate if the theory regarding its agitation of mites is correct. Due to the results of this trial we were unable to document that the addition of potassium nitrate improves the efficacy of miticides, but the results were interesting enough, particularly with Envidor, to justify a further evaluation in 2012 of its use with miticides that work on contact.

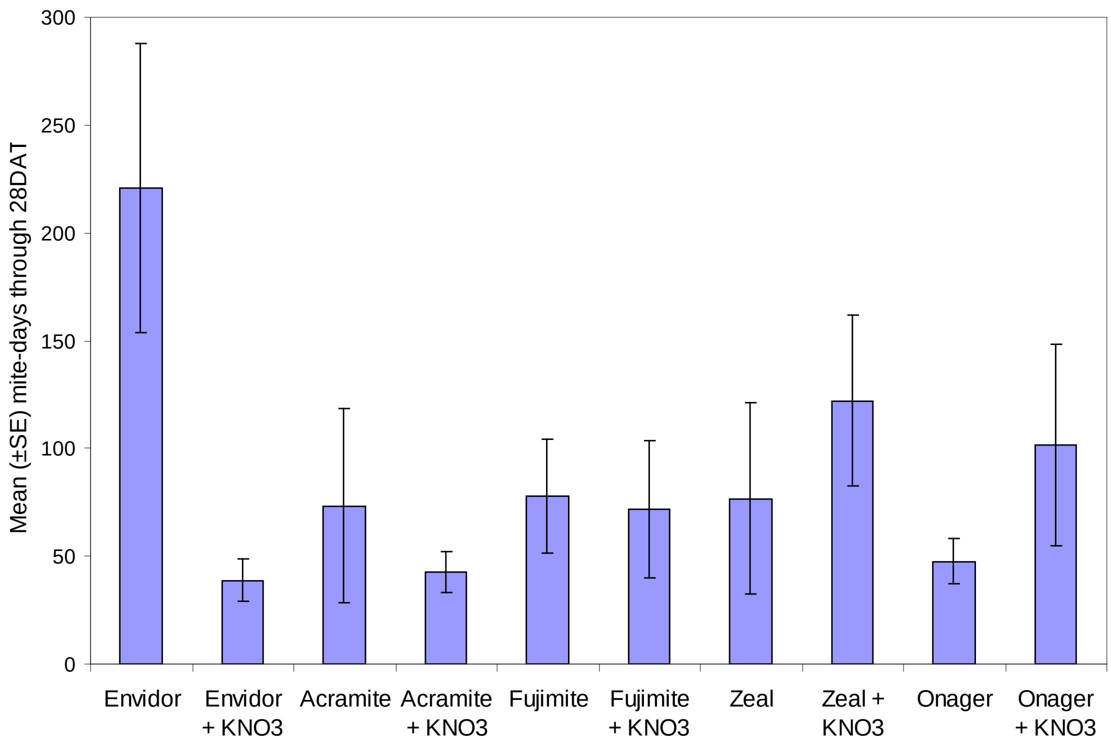

Figure 1. Effects of the addition of KNO_3 to five commercial miticides on the cumulative density of spider mites through 28 DAT, Shafter 2011. ($F = 1.67$; df = 9, 27; $P = 0.1456$)

Trial 2- evaluation of Vigilant

Vigilant is a new 4SC formulation of bifenazate; most commonly recognized within the almond industry as the active ingredient in Acramite. It is being promoted as a knock-down miticide with primary usage within a few weeks of hull split at rates ranging from 16 fl oz for low mite densities to 24 fl oz for high mite densities. During 2011 we conducted a trial to evaluate the effectiveness of three rates of Vigilant in our orchard with high mite densities. We compared the effectiveness of Vigilant to the use of a standard rate of 1 lb of Acramite. We also evaluated the effects of Vigilant as a tank mix with a miticide (Onager) and a pyrethroid insecticide (Brigade). All treatments included the addition of 1% 415° oil and caused a significant reduction in spider mite density (**Figure 2**). In the rate portion of the study, increased rates of Vigilant caused increased reduction in mite density; the 24 fl oz rate Vigilant reduced mite density to a level that was statistically equivalent of 1 lb of Acramite. As a tank mix, the tank mix of Vigilant (16 fl oz) and Onager (16 fl oz) resulted in similar control to what was achieved by Onager (24 oz) by itself. When tank mixed with Brigade, Vigilant resulted in excellent reductions in spider mite density compared to when the insecticide was used by itself. This suggests that Vigilant can be included along with Envidor, Onager, Zeal, Fujimite, and Acramite as the primary options for growers who desire to include a miticide as a tank mix with pyrethroids or other insecticides used for navel orangeworm at hull split.

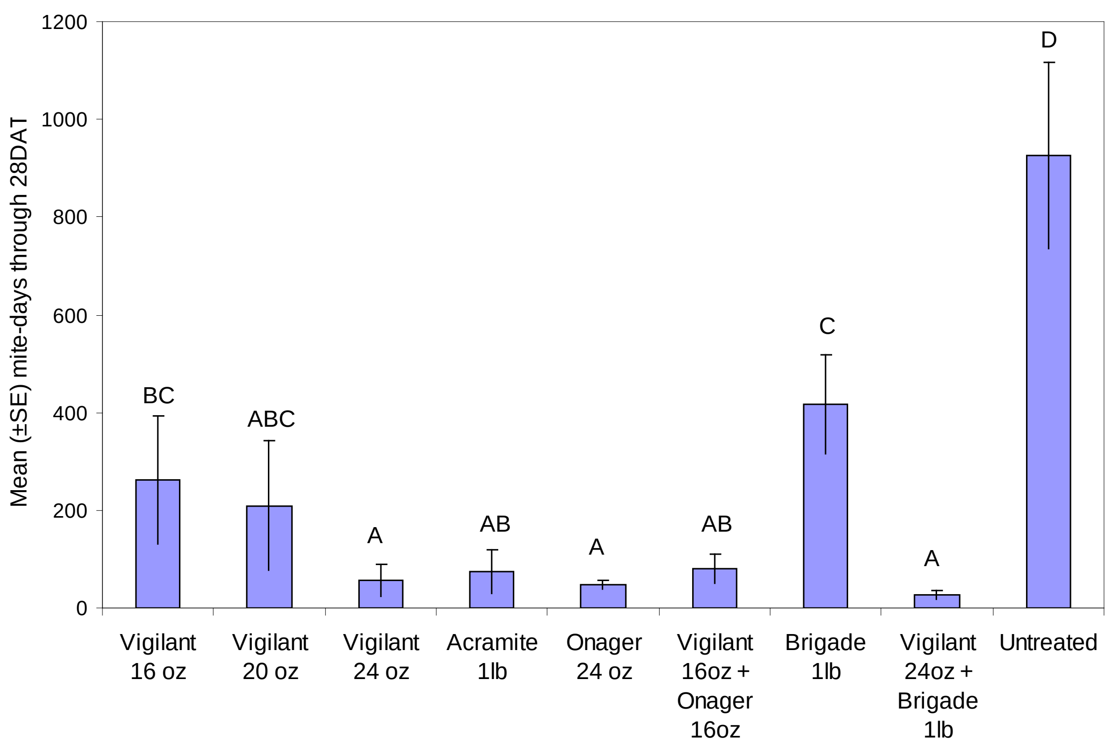

Figure 2. The effects of Vigilant on spider mite density in almond, Shafter 2011 (F = 8.91; df = 8, 24; P = <0.0001)

Trial 3- evaluation of the surfactant Vintre

Vintre is a new adjuvant from Oro Agri that is being promoted as a low surface tension surfactant for use with miticides as an alternative to 415° oil. We evaluated the use of Vintre (3 pt/ac) as a surfactant with Envidor, Onager and Zeal and compared the results to the use of the same three products with 1% 415° oil (2 gal/ac). We also evaluated the use of Vintre by itself (= Oroboost), 415° oil by itself, and an untreated check. All plots treated with Envidor, Onager or Zeal caused a significant reduction in mite density compared to the untreated check, Oroboost or 415° oil (**Figure 3**). Mite density in plots treated with Oroboost was statistically equivalent to the untreated check and plots treated with 415° oil had reductions in mite density of approximately 50%. For each of the three miticides there were no significant differences in mite density for plots where Vintre was used compared to 415° oil. This suggests that Vintre can be an acceptable alternative to 415° oil. There was also an interesting result that the greatest benefit (numerically but not significantly different) from Vintre was with the use of Zeal. Zeal works best when translaminar activity occurs after application compared to Envidor and Onager that work primarily through contact on the leaf surface. Therefore, Zeal has the greatest potential to benefit from a penetrating surfactant that may facilitate translaminar activity. As a result of the numerical differences seen in this trial, and the fact that Zeal and other translaminar products may have the greatest to benefit from Vintre, we will be conducting additional follow-up research in this area during the 2012 research season.

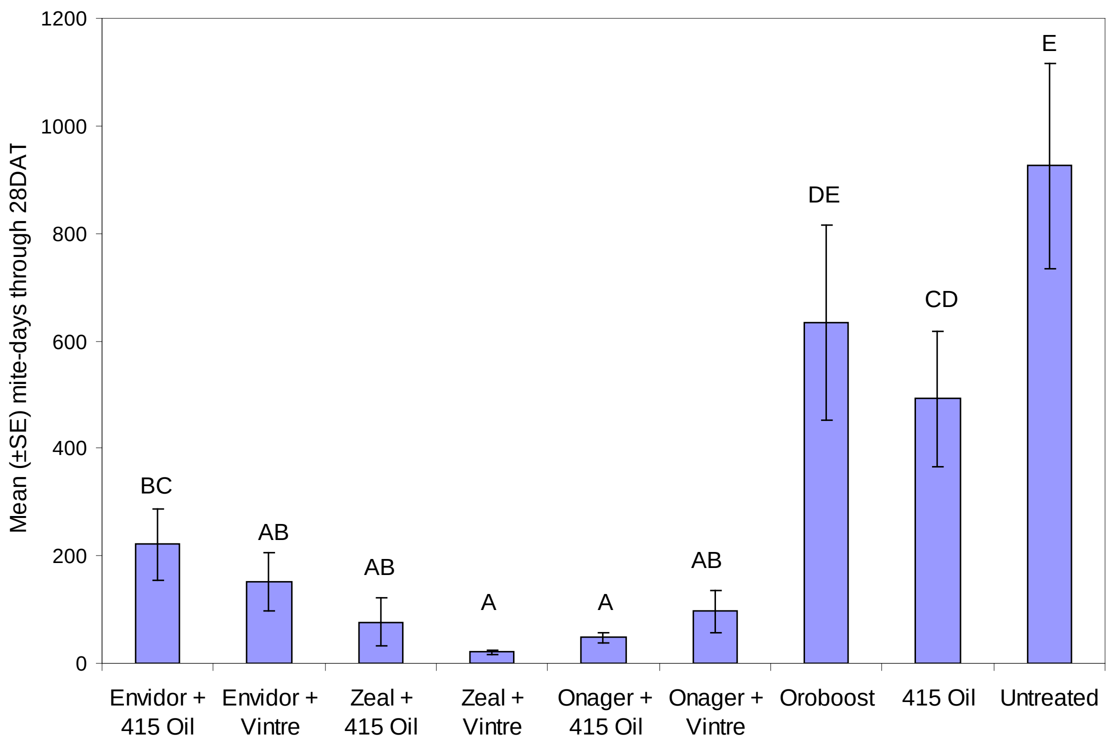

Figure 3. The effects of Vintre and 415° Oil on miticide density, Shafter 2011. (F = 12.14; df = 8, 24; P = <0.0001)

Trial 4- effects of pyrethroids on spider mites

During the past few years pyrethroid use has increased significantly in California almonds for control of navel orangeworm. One of the concerns with increased use of newer pyrethroids has been the potential negative impact on mite populations. Due to this concern we conducted a miticide trial to evaluate the use of an older-generation pyrethroid (Asana) to three new-generation pyrethroids (Brigade, Danitol and Warrior II) and a grower standard miticide Zeal. All treatments included the addition of 1% 415° oil. Cumulative mite density in plots treated with 415° Oil had mite reductions of approximately 50% (**Figure 4**). Plots treated with the new-generation pyrethroids Brigade, Danitol and Warrior II (each with 1% 415° oil) had mite densities that were statistically equivalent to plots treated with 415° oil by itself. This suggests that the three pyrethroids did not cause a significant reduction in mite density, but likewise they did not cause a significant increase in mite density, either. Asana, on the other hand, caused a significant increase in mite density. This comes from the assumption that the 415° oil used with Asana should have reduced mite densities by approximately 50%; however, mite density increased and caused an end result to be similar to the untreated check. These results are similar to previous studies that suggest that use of newer pyrethroids is not as disruptive to mite populations as was the use of older generation pyrethroids. This is especially true if newer pyrethroids are tank mixed with 415° oil and/or a miticide.

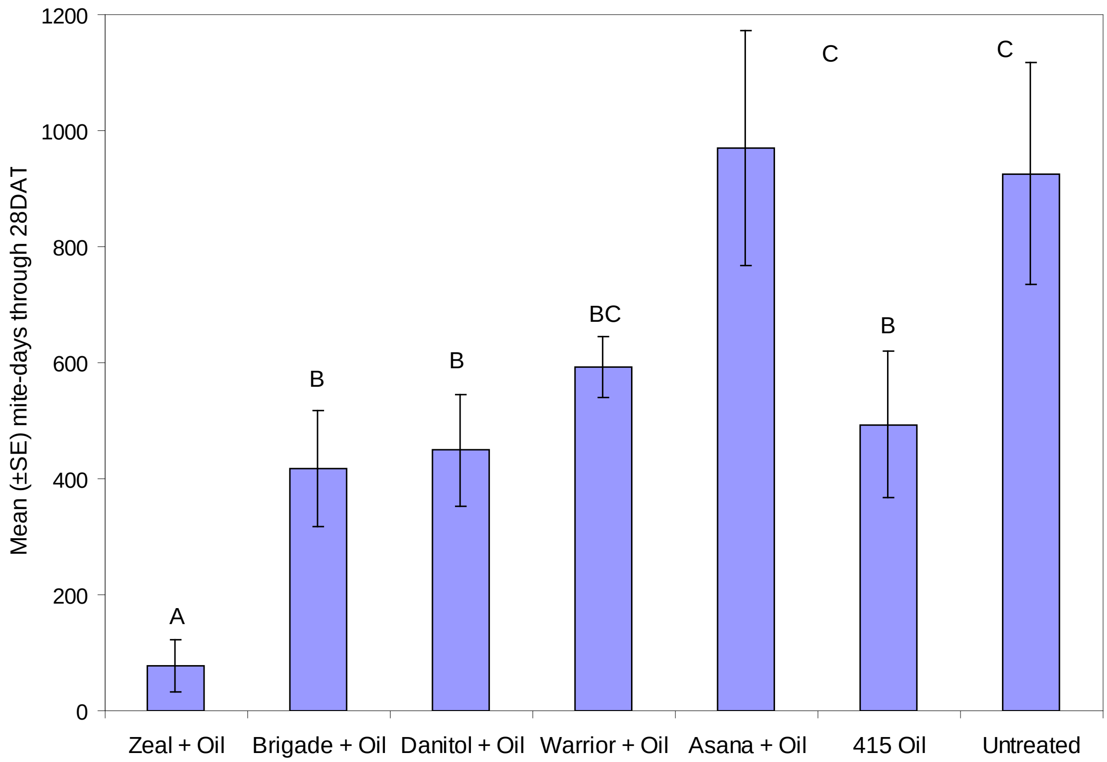

Figure 4. The effects of pyrethroid insecticides on mite density, Shafter 2011. (F = 9.22; df = 6,18; P = 0.0001)

Trial 5- evaluation of newer pesticides for use against spider mites

Every year there are new miticides that have the potential to be used in almonds against spider mites. During 2011 we evaluated the use of six new miticides or insecticides that are either registered or have the potential to be registered in almonds for their effectiveness against spider mites. Each treatment (with the exception of Oroboost and Stealth) was applied with the addition of 1% 415° oil. The effects of treatments were compared to the use of 1% 415° oil by itself and an untreated check. Significant reductions in mite density were achieved in plots treated with Movento (a lipid synthesis inhibitor containing spirotetramat), Nealta (a METI II inhibitor containing cyflumetofen), and Vigilant (20 fl oz rate)(a nerve toxin containing bifenazate) (**Figure 5**). Plots treated with Oroboost (an orange peel extract), Proclaim (an avermectin), and Stealth (a plant-based extract) had mite densities that were numerically very similar to plots treated with 415° oil alone and that were statistically equivalent to both the untreated check and the 415° oil treatment.

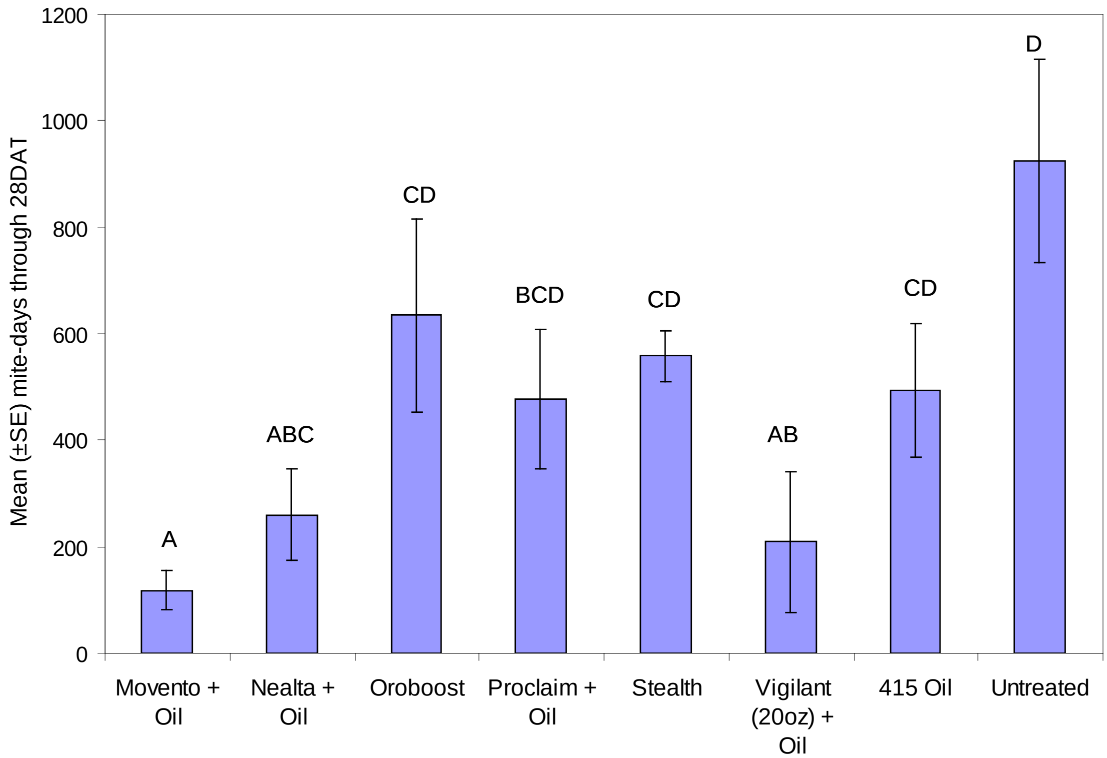

Figure 5.. The effects of treatments of newer miticides and insecticides on spider mite density, Shafter, 2011. (F = 3.98; df = 7, 21; P = 0.0064)

<u>Objective 2) Navel orangeworm trials</u>

The effects of insecticide treatments on navel orangeworm damage are shown in **Table 2**. At the Parlier trial, where data were analyzed as individual treatments, the untreated check had 2.3% damage compared to 0.3 to 2.7 for treated plots. Overall there were no significant differences among individual treatments (P = 0.1035) at an alpha level of 0.10. This is despite the fact that plots treated with eleven of the thirteen treatments had damage levels that were less than or equal to 1.0% compared to 2.3% in the untreated check. Despite lack of significant differences among individual treatments, there were significant differences (P = 0.0474) when data were analyzed by mode of action (MOA). The lowest navel orangeworm densities were in plots treated with a combination of an anthranilic diamide and a pyrethroid (0.4%). This damage was statistically equivalent to plots treated with pyrethroids (0.6%). Plots treated with anthranilic diamides (which are larvicides) or other larvicides had 1.3 and 1.1% damage levels, respectively, that corresponded to approximately 50% reduction in damage compared to the untreated check. The untreated checks averaged 2.3%.

At Five Points the two untreated checks had 0.48 and 0.60% damage compared to 0.0 to 0.71% in treated plots. When treatments were analyzed individually, significant reductions compared to both untreated checks were found in plots treated with Altacor + Asana, Altacor + Bifenthrin, Hero, Warrior, the low rate of HGW86, Intrepid and Proclaim. All of these treatments had 0.08% or less damage compared to the 0.54% average damage from the two untreated checks. In total, fourteen of the seventeen treatments reduced damage levels by at least 50% compared to the average of the untreated checks; the three exceptions were all anthranilic diamides. When data were analyzed by categories of mode of action, reductions in damage were observed in plots treated with other larvicides (0.05%), pyrethroids (0.06%), or combinations of pyrethroids with anthranilic diamides (0.11%). Plots treated with only anthranilic diamides had 0.35% damage that was significantly equivalent to the untreated check (0.54%).

In the Shafter trial damage levels were very low such that there were no significant differences among treatments. When data were organized by categories, all categories of insecticides reduced damage levels by at least 50% compared to the untreated check; however, these differences were not statistically different.

The effects of navel orangeworm treatments on spider mite density at the Five Points trial are shown in **Table 3**. There were no significant differences in the density of spider mites 2 WAT [weeks after treatment] ($P = 0.2386$) or 4 WAT ($P = 0.7842$) for individual treatments. Likewise, there were no significant differences in mite density for plots treated with different modes of action ($P = 0.2113$ and $P = 0.3391$ for 2 WAT and 4 WAT, respectively). This means that insecticides for navel orangeworm that are also considered miticides, such as Proclaim, did not cause significant reductions in mite density. Likewise, pyrethroids (that have a history of flaring mites) did not cause any significant increases in mite density through four weeks after treatment.

Objective 3) Research orchard maintenance

During 2011 there were a total of 12 research trials completed within the two research orchards that are maintained in part by funding from the Almond Board of California. The trials are as follows: 1) five miticide trials by David Haviland in Shafter, 2) navel orangeworm trial by David Haviland in Shafter, 3) a navel orangeworm trial by David Haviland at West Side, 4) a miticide trial by Syngenta at West Side, 5) a miticide trial by Nichino America at West Side, 6) a miticide trial by Nichino America at Shafter 7) an herbicide trial by Kurt Hembree at West Side, 8) an herbicide trial by Brad Hansen at Shafter, and 9) a nutritional study by Brian Marsh at Shafter. In total over the past two years (2010 and 2011) these research orchards have now been used for a total of 19 trials.

Results from each individual project are being reported independently by the researchers that are responsible for them. Results of the three projects by David Haviland are available within reports that were submitted to the Almond Board of California for the 2010-2011 research cycle. Trials by Syngenta and Nichino were considered internal preliminary trials for those companies and are not available publicly. However, the results were used by these companies and David Haviland to determine treatments and rates for products from those trials that are being tested in UC miticide trials by David Haviland during the summer of 2011. Results of the herbicide trials are available through Kurt Hembree and Brad Hansen.

Table 1. The effects of miticide treatments on the density of Pacific spider mite in almond, Shafter 2011.

Treatment[1]	Rate per acre	Mean mites per leaf					
		Precounts	7 DAT[2]	14 DAT	21 DAT	28 DAT	35 DAT
Acramite 50WP	1 lb	2.0a	0.4abc	0.5ab	5.0a-e	7.1a-e	33.7b-g
Acramite 50WP + KNO3	1 lb + 10 lb	4.3a	0.6abc	0.6ab	2.1abc	1.4a	14.6a-d
Asana XL	9.6 fl oz	4.3a	14.4f	39.5k	51.7l	61.7l	57.8g-j
Brigade WSB	1 lb	2.5a	2.5a-e	10.4efg	26.9g-k	37.1h-l	60.9hij
Danitol 2.4EC	21.3 fl oz	2.9a	3.5cde	9.8def	35.8i-l	27.4f-j	32.0c-h
Envidor 240SC,	18 fl oz	4.0a	1.0a-e	5.9b-f	14.9d-g	15.8b-g	35.3c-h
Envidor 240SC + KNO3	18 fl oz + 10 lb	1.7a	0.6abc	0.4ab	2.4abc	2.9a-d	9.8ab
Envidor 240 SC + Vintre	18 fl oz + 3 pt	5.1a	2.1a-e	3.2a-d	7.4a-f	12.8b-f	34.6c-h
Fujimite 5EC	32 fl oz	1.7a	0.4abc	0.3ab	3.0a-d	13.0b-f	13.1abc
Fujimite 5EC + KNO3	32 fl oz + 10 lb	1.7a	0.5abc	1.5ab	2.1abc	10.4a-f	16.0a-d
Movento 2SC	8 fl oz	2.1a	2.2a-e	2.8a-d	6.1a-e	9.4a-f	38.6d-i
Nealta 20SC (no oil)	13.7 fl oz	1.7a	0.7a-d	7.9c-f	12.2c-g	15.6c-h	31.4b-g
Nealta 20SC)	13.7 fl oz	7.7a	3.3b-e	2.7abc	15.9d-g	23.0e-j	38.8c-g
Onager 1EC	24 fl oz	4.3a	0.6abc	1.6abc	1.1ab	2.8ab	12.4abc
Onager 1EC + KNO3	24 fl oz + 10 lb	3.0a	0.9a-e	3.8a-e	3.7a-e	9.3a-e	22.1a-f
Onager 1EC + Vintre	24 fl oz + 3 pt	2.3a	1.5a-e	2.5abc	7.1a-e	3.1a-d	16.7abc
Oroboost	3 qt	2.3a	3.7cde	28.2ijk	35.1h-l	45.0jkl	34.5c-h
Proclaim 5SG	4.5 oz	5.5a	4.5e	11.5fgh	28.2g-j	42.5i-l	80.1j
Stealth NOW	2 gal	1.2a	4.4e	20.8ghi	43.1jkl	21.7e-i	41.2e-i
Vigilant 4SC	16 fl oz	8.4a	1.1a-e	6.5a-f	16.7e-h	18.0d-h	33.5c-h
Vigilant 4SC	20 fl oz	6.5a	2.2a-e	0.8ab	13.7b-f	19.9b-g	51.7f-j
Vigilant 4SC	24 fl oz	1.9a	0.1a	1.6ab	1.3ab	8.1a-e	17.5a-e
Vigilant 4SC + Brigade WSB	24 fl oz + 1 lb	2.0a	0.0a	0.8ab	0.9a	2.1a	9.1a
Vigilant 4SC + Onager 1EC	16 fl oz + 16 fl oz	2.5a	0.2ab	2.6abc	4.5a-e	5.7a-e	20.1a-e
Warrior II	2.56 fl oz	3.1a	5.2e	12.3fgh	34.2i-l	62.6l	80.0j
Zeal 72WP	3 oz	1.5a	0.5abc	2.4a-d	5.5a-e	3.5abc	15.1abc
Zeal 72WP + KNO3	3 oz + 10 lb	11.3a	2.9a-e	1.8abc	3.0a-d	8.2a-e	15.9a-d
Zeal 72WP + Vintre	3 oz + 3 pt	1.3a	0.6abc	0.3a	0.7a	1.4a	6.1a
415° Oil	2 gal	5.5a	4.4de	25.8hij	21.8f-i	31.4h-k	55.6g-j
Untreated		5.9a	15.8f	37.1jk	48.7kl	55.4kl	69.2ij
	F (df=29, 87)	1.41	3.77	9.62	7.97	6.99	4.57
	P	0.1124	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]All treatments except for Nealta 20SC (no oil), Oroboost, treatments with Vintre, and 415° oil and were made with 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.
[2] DAT = days after treatment

Table 2. Effects of insecticide treatments on the percentage of almond nuts infested by navel orangeworm.

Mode of Action	Treatment/Formulation[1]	Rate Form. Prod/acre	Navel Orangeworm Damage (%)					
			Results by Treatment			Results by MOA[2]		
			Parlier	Five Points	Shafter	Parlier	Five Points	Shafter
Anthranilic Diamide + Pyrethroid	Altacor WG 35PC + Asana XL	3 oz + 9.6 fl oz	N/A	0.00 ± 0.00a	0.36 ± 0.29	0.4 ± 0.3a	0.11 ± 0.04ab	0.16 ± 0.08
	Altacor WG 35PC + Bifenthrin 2E	3 oz + 6.4 fl oz	N/A	0.07 ± 0.07ab	0.08 ± 0.08			
	Belt SC + Baythroid XL	4 fl oz + 2.8 fl oz	N/A	0.17 ± 0.17abc	0.30 ± 0.23			
	Tourismo + Brigade WSB	14 fl oz + 1 lb	N/A	0.16 ± 0.10abcd	0.07 ± 0 .07			
	Voliam Xpress	9 fl oz	0.4 ± 0.3	0.14 ± 0.09abcd	0.00 ± 0.00			
Pyrethroid	Athena	19.2 fl oz	0.9 ± 0.3	0.15 ± 0.09abcd	0.07 ± 0.07	0.6 ± 0.2ab	0.06 ± 0.03a	0.04 ± 0.03
	Brigade WSB	1.5 lb	0.4 ± 0.2	N/A	N/A			
	Brigade+ Danitol	1.5 lb + 21.3 oz	N/A	0.08 ± 0.08abc	0.00 ± 0.00			
	Danitol 2.13EC	21.3 fl oz	0.6 ± 0.4	N/A	N/A			
	Hero EW	11.2 fl oz	0.7 ± 0.3	0.00 ± 0.00a	0.08 ± 0.08			
	Warrior II	2.56 fl oz	0.6 ± 0.4	0.00 ± 0.00a	0.00 ± 0.00			
Anthranilic Diamide	Altacor WG 35PC	4 oz	0.7 ± 0.4	0.71 ± 0.48bcd	0.16 ± 0.10	1.3 ± 0.4bc	0.35 ± 0.12bc	0.15 ± 0.06
	Belt SC	4 fl oz	2.7 ± 1.1	0.30 ± 0.21abcd	0 00 ± 0.00			
	HGW86 10SE	13.5 fl oz	N/A	0.08 ± 0.08ab	0.30 ± 0.23			
	HGW86 10SE	20.5 fl oz	1.0 ± 0.2	0.21 ± 0.09abcd	0.24 ± 0.11			
	Tourismo	14 fl oz	0.6 ± 0.2	0.46 ± 0.24bcd	0.07 ± 0.07			
Other Larvicides	Delegate	6.4 oz	0.8 ± 0.3	0.15 ± 0.15abc	0.07 ± 0.07	1.1 ± 0.4abc	0.05 ± 0.05a	0.10 ± 0.06
	Intreprid	16 fl oz	2.0 ± 1.2	0.00 ± 0.00a	0.07 ± 0.07			
	Proclaim	4 oz	0.7 ± 0.4	0.00 ± 0.00a	0.15 ± 0.15			
Untreated Check	Untreated Check 1	-	2.3 ± 0.9	0.48 ± 0.22cd	0.15 ± 0.09	2.3 ± 0.9c	0.54 ± 0.15c	0.32 ± 0.18
	Untreated Check 2	-	N/A	0.60 ± 0.22d	0.50 ± 0.35			
		F	1.67	1.67	0.92	3.11	4.35	1.05
		df	13, 42	18,95	18, 95	4, 15	4, 25	4, 25
		P	0.1035	0.0584	0.5571	0.0474	0.0083	0.4013

Means in a column followed by the same letter are not significantly different (*P* > 0.10, Fisher's protected LSD) after arcsin (x) transformation of the data. Untransformed means are shown.

[1] Buffer Xtra Strength used as a surfactant for HGW86 at 32 fl oz per 100 gallons. All other treatments were made with Dyne-Amic used as a surfactant at 32 fl oz per 100 gallons for all treatments.

[2] Damage levels were averaged across treatments within each mode of action for each rep. Data were analyzed by ANOVA as a completely randomized block design with 5 treatments and four (Kearney) or six (Five Points) repetitions.

Table 3. Effects of navel orangeworm treatments on spider mite density two and four weeks after application, Five Points 2011

Mode of Action	Treatment[1]	Spider mites per leaf ± SEM			
		2 WAT		4 WAT	
		Individual Treatment	Results by Mode of Action[2]	Individual Treatment	Results by Mode of Action[2]
Anthranilic Diamide + Pyrethroid	Altacor + Asana	6.0 ± 3.4	5.4 ± 1.4	5.2 ± 3.9	11.4 ± 3.0
	Altacor + Bifenthrin	3.5 ± 1.8		16.9 ± 10.5	
	Belt + Baythroid	9.8 ± 0.6		7.4 ± 4.7	
	Tourismo + Brigade	5.4 ± 1.8		14.6 ± 9.0	
	Voliam Xpress	2.4 ± 0.7		12.8 ± 3.8	
Pyrethroid	Athena	2.2 ± 0.9	2.4 ± 0.7	17.2 ± 9.1	16.2 ± 5.8
	Brigade + Danitol	1.7 ± 0.6		7.5 ± 4.3	
	Hero	1.5 ± 0.6		28.5 ± 20.2	
	Warrior II	4.4 ± 2.3		11.9 ± 7.5	
Anthranilic Diamide	Altacor	10.5 ± 3.7	7.1 ± 1.6	25.8 ± 12.8	19.2 ± 4.6
	Belt	6.6 ± 2.7		19.6 ± 15.4	
	HGW86 (high rate)	5.8 ± 1.8		31.0 ± 7.1	
	HGW86 (low rate)	2.2 ± 1.3		7.5 ± 5.3	
	Tourismo	10.3 ± 6.6		11.9 ± 8.3	
Other Larvicides	Delegate	9.2 ± 3.9	6.2 ± 1.8	10.9 ± 5.7	13.3 ± 4.1
	Intrepid	6.9 ± 3.8		15.1 ± 10.8	
	Proclaim	2.6 ± 1.0		14.0 ± 4.7	
Untreated Check	Untreated Check 1	6.8 ± 2.5	5.5 ± 1.2	6.4 ± 1.7	7.4 ± 1.7
	Untreated Check 2	4.2 ± 0.7		8.4 ± 3.1	
	F	1.25	1.58	0.72	1.19
	df	18, 95	4, 25	18, 95	4, 25
	P	0.2386	0.2113	0.7842	0.3391

Means in a column followed by the same letter are not significantly different ($P > 0.05$, Fisher's protected LSD) after square root (x + 0.5) transformation of the data. Untransformed means are shown.

[1] Buffer Xtra Strength used as a surfactant for HGW86 at 32 fl oz per 100 gallons. All other treatments were made with Dyne-Amic used as a surfactant at 32 fl oz per 100 gallons for all treatments.

[2] Damage levels were averaged across treatments within each mode of action for each rep. Data were analyzed by ANOVA as a completely randomized block design with 5 treatments and four (Kearney) or six (Five Points) repetitions.