Efficacy Trials of Registered and Developmental Insecticides for Navel Orangeworm (NOW)

Project No.: **10-ENTO8-Haviland**

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Objectives:

Develop information on the efficacy of registered and experimental insecticides against navel orangeworm at hull split in almonds.

Interpretive Summary:

Navel orangeworm (NOW) is the most important insect pest of almonds in the lower San Joaquin Valley. Direct feeding on the kernels in combination with worm-induced contamination by aflatoxins makes effective management of navel orangeworm a necessity. Management programs currently consist of winter sanitation coupled with one or more insecticide treatments. The purpose of this project is to compare the effects of hull-split applications of registered and experimental insecticides against this pest. In general, navel orangeworm populations within the trials (as well as throughout the lower San Joaquin Valley) were very low in 2010. As a result, significant differences among individual treatments were not obtained in the trials. However, as has occurred in previous trials, treatments including both a larvicide and an adulticide (either as a premix or a tank mix) had superior results in both trials compared to treatments containing a single mode of action. Data from one trial were also collected to determine the effects of treatments that target navel orangeworm on spider mite densities at harvest. The results showed that diamides, spinosyns, avermectins, and diacylhydrazines had no effect on mite densities. However, plots treated with pyrethroids had mite densities that were 1.4 to 2.3 times higher than in the untreated check.

Materials and Methods:

In 2010 we conducted two trials for navel orangeworm. The first trial was located at the UC Kearney Agricultural Center in Parlier, Fresno Co., CA and at the second was located at the UC Westside Research and Extension Center in Five Points, Fresno 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 RCBD with four blocks of 13 treatments and an untreated check (**Table 1**). Trees were approximately 6 years old with a tree spacing of 20’ x 16’. At Five Points, a total of 84 nonpareil trees were organized into a RCBD with six blocks of the same 13 treatments and an untreated check. Trees were 3 years old and planted to a spacing of 22’ x 15’.

Treatments were applied to individual trees with a hand gun at 200 GPA at 150 PSI on 22 Jul (Parlier) and 23 Jul (Five Points). This corresponded with the second flight of navel orangeworm and the initiation of hull-split on the nonpareil trees. Both trials were harvested by hand on 16 Aug 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=0.05).

At the Five Points trial we also evaluated the effects of navel orangeworm treatments on mite density. During harvest there were large populations of spider mites that developed on the trees. Therefore, on 17 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 LSD (P = 0.05).

Results and Discussion:

The effects of insecticide treatments on the percentage of nuts with navel orangeworm are shown in **Table 1**. Percentage damage at Parlier ranged from 0.13 to 1.93% with the untreated check averaging 0.99%. At Five Points damage ranged from 0.00 to 0.45% with the untreated check averaging 0.09%. Overall, when data were analyzed by individual treatments there were no significant differences at a P value of 0.05. However, further analysis of data where insecticides were grouped and analyzed by their modes of action revealed significant differences (**Table 2**). At Parlier, larvicides caused a significant reduction in worm density compared to pyrethroids whereas at West Side pyrethroids resulted in a significant reduction in worm damage compared to larvicides. However, in both cases the two premix and tank mix products that included both a larvicide and an adulticide had the overall least amount of damage. This suggests that applications of larvicides or adulticides can be effective, but that there is a potential added benefit of using a premix or tank mix of the two at the same time.

Table 1. Effects of insecticide treatments on the percentage of almond nuts infested by navel orangeworm.

Treatment/Forumlation[1]	Rate Form. Prod/acre	Parlier		Five Points	
		No. nuts	NOW damag e (%)	No. nuts	NOW damag e (%)
Tourismo SC	14 fl oz	801	0.39a	1128	0.24a
Belt 480SC	4 fl oz	800	0.58a	1190	0.09a
Delegate 25WG	6.4 oz	808	0.50a	1248	0.32a
Intrepid 2F	16 fl oz	811	0.51a	1167	0.43a
Altacor 35WG	4 oz	846	0.58a	1119	0.45a
HGW86 10SE	13.5 fl oz	798	1.13a	1135	0.07a
Voliam Xpress 1.25ZC	12 fl oz	818	0.23a	1160	0.00a
Proclaim 5SG	4 oz	788	0.88a	1155	0.26a
Danitol 2.4EC	21.3 fl oz	821	1.87a	1210	0.24a
Brigade 10WSB	1 lb	822	1.34a	1148	0.09a
Tourismo SC + Brigade 10WSB	14 fl oz + 1 lb	786	0.13a	1170	0.08a
Athena	13.5 fl oz	823	1.18a	1317	0.05a
Hero EW	11.2 fl oz	637	1.93a	1176	0.00a
Untreated Check	--	812	0.99a	1210	0.09a
		F =	1.35	F =	1.50
		P =	0.2261	P =	0.1430

[1] Dyne-Amic used as a surfactant at 32 fl oz per 100 gallons.

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

Table 2. Effects of Mode of Action of insecticides on the percentage of almond nuts infested by navel orangeworm

	Insecticides included	NOW damage (% ± SEM)	
Mode of Action		Parlier	Five Points
Larvicide	Altacor (Diamide) Belt (Diamide) Delegate (Spinosyn) HGW86 (Diamide) Intrepid (Diacylhydrazine) Proclaim (Avermectin) Tourismo (Diamide)	0.65 ± 0.14ab	0.25 ± 0.06b
Adulticide	Athena (Pyrethroid) Brigade (Pyrethroid) Danitol (Pyrethroid) Hero (Pyrethroid)	1.58 ± 0.38c	0.10 ± 0.05a
Both	Tourismo+Brigade Voliam Xpress	0.18 ± 0.09a	0.04 ± 0.04a
Untreated Check	Untreated Check	0.99 ± 0.19bc	0.09 ± 0.11 ab
	F=	5.65	2.61
	P=	0.0021	0.0574*

Means in a column followed by the same letter are not significantly different ($P > 0.05$, Fisher's protected LSD) after arcsin (x) transformation of the data. Untransformed means are shown. *Significant at $P > 0.1$, Fisher's protected LSD.

The use of premixes or tank mixes of a larvicide and adulticide has the potential to benefit almond growers. This is particularly true for two reasons. First, the ideal application timing for navel orangeworm sprays is often difficult to determine. This is due to the complexity of factors related to crop development and susceptibility, such as the ever-changing status of hull split, as well as biological characteristics of NOW, such as predicting when a flight will occur and whether or not the flight is highly synchronized or completely asynchronous. The second benefit of tank mixes is for growers who have limited amounts of equipment that must cover large amounts of acreage. In this case it is not possible to spray at the optimal timing (assuming that one even exists). Instead, due to equipment limitations many fields need to be sprayed well before the ideal application timing while others must be sprayed after. Under both of these scenarios, mixing a larvicide with an adulticide of two different modes of action has the potential to provide the added flexibility needed to ensure that NOW control is as good as it possibly can be under all scenarios. Premixes or tank mixes of different modes of action also have the added benefit of helping to reduce the risk of the development of resistance to single mode of action products, such as pyrethroids. This is particularly important where almonds are grown in close proximity to pistachios where NOW may have already been exposed to pyrethroid applications five or more times during the season prior to dispersing into almonds at hull split.

Many insecticide treatments for navel orangeworm also have an effect on spider mite populations. These effects can be either detrimental or beneficial depending on the situation. **Table 3** and **Figure 1** show the effects of treatments for navel orangeworm on the populations of Pacific spider mite at harvest. Generally speaking, plots treated with spinosyns (Delegate), diacylhydrazines (Intrepid), avermectins (Proclaim), or diamides that weren’t premixed or tank mixed with a pyrethroid (Tourismo, Belt, Altacor, HGW86) had the lowest mite densities and were statistically inseparable from the untreated check. While this means they didn't reduce mites, it also means that they didn't cause them to increase either. Mite densities in plots treated with pyrethroids or with treatments that were premixed or tank mixed with pyrethroids (Voliam Xpress, Danitol, Brigade, Tourismo + Brigade, Athena, Hero) had mite densities ranging from 37.3 to 60.2 mites per leaf compared to 26.7 mites per leaf in the untreated check. These averages of mites per leaf ranged from 1.4 to 2.3 times higher than in the untreated check. The highest mite densities came in plots treated with bifenthrin. This included plots treated with Brigade (bifenthrin), Brigade + Tourismo (bifenthrin + buprofezin + flubendiamide), Athena (bifenthrin + the miticide abamectin), and Hero EW (bifenthrin + a second pyrethroid zeta-cypermethrin).

With all treatments combined, average mite densities per leaf in plots treated with the following chemistries were as follows: untreated check (26.7), diacylhydrazines (30.3), spinosyns (30.3), diamides (30.7), and pyrethroids (47.4). If pyrethroids are broken apart into three categories the results show: pyrethroids not bifenthrin (38.5), pyrethroids including just bifenthrin (49.5), pyrethroids including bifenthrin plus an additional pyrethroid (60.2).

These results suggest that growers using pyrethroids at hull split need to be cautious regarding whether or not they include a miticide with their application. In trials conducted in previous years we have sometimes identified a short-term reduction in mite densities in plots treated with newer pyrethroids such as bifenthrin and fenpropathrin. However, in this year these treatments caused increased mite densities compared to the untreated check. As a result growers need to be aware of mite densities at hull split and make the decision of whether or not to add a miticide accordingly.

Table 3. Effects of navel orangeworm treatments on the density of motile spider mites on almond leaves 25 DAT.

Treatment/Forumlation[1]	Rate Form. Prod/acre	Avg. no of mites/leaf	LSD (raw data)	LSD (trans-formed data)
Tourismo SC	14 fl oz	23.8	a	a
Untreated Check	--	26.7	a	ab
Belt 480SC	4 fl oz	28.9	a	ab
Delegate 25WG	6.4 oz	30.3	a	abc
Intrepid 2F	16 fl oz	30.3	a	abc
Altacor 35WG	4 oz	34.1	ab	abc
HGW86 10SE	13.5 fl oz	36.0	ab	abcd
Voliam Xpress 1.25ZC	12 fl oz	37.3	abc	abcd
Proclaim 5SG	4 oz	39.0	abc	abcd
Danitol 2.4EC	21.3 fl oz	39.2	abc	abcde
Brigade 10WSB	1 lb	41.3	abcd	bcde
Tourismo SC + Brigade 10WSB	14 fl oz + 1 lb	50.4	bcd	cde
Athena	13.5 fl oz	55.8	cd	de
Hero EW	11.2 fl oz	60.2	d	e
		F =	2.48	2.43
		P =	0.0081	0.0097

[1] Dyne-Amic used as a surfactant at 32 fl oz per 100 gallons.
Means in a column followed by the same letter are not significantly different (P > 0.05, Fisher's protected LSD). Data are presented as original means followed by means separation of untransformed followed by transformed (square root (x + 0.5)) data.

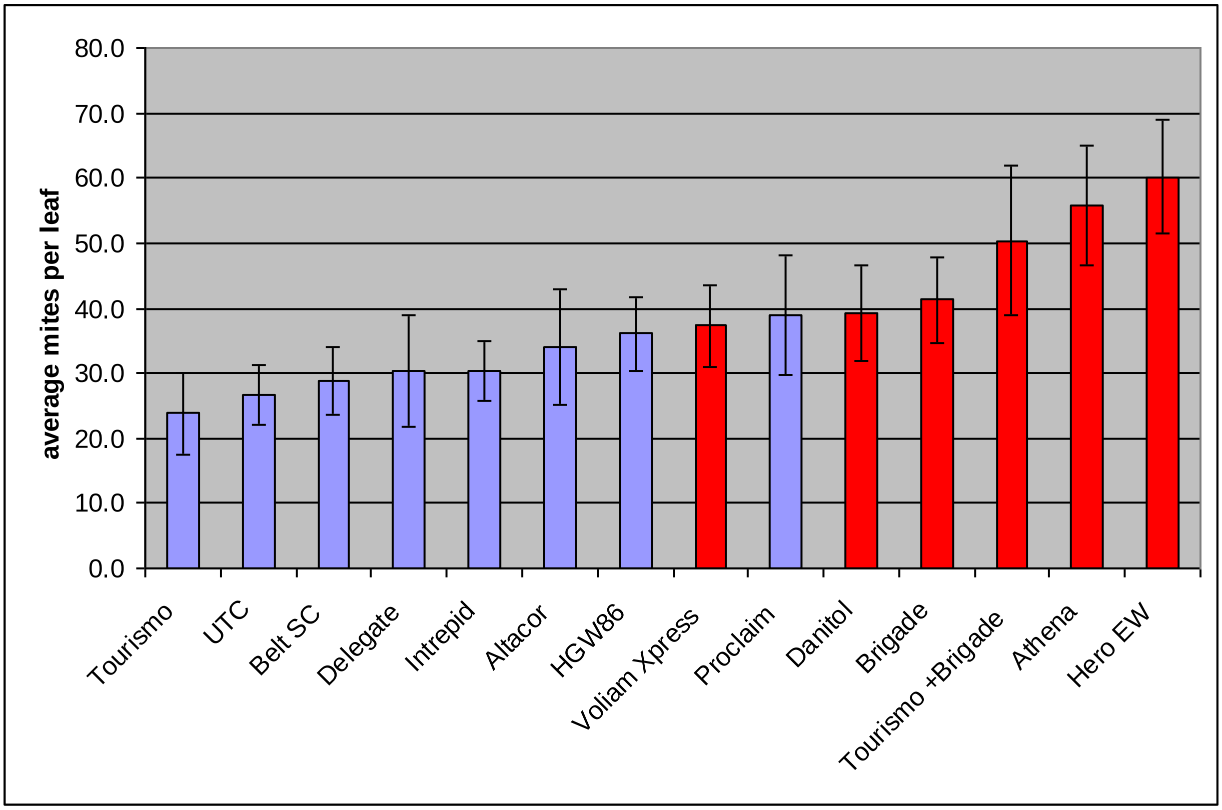

Figure 1. Effects of treatments for navel orangeworm on the spider mite density approximately 4 weeks after treatment. Bars in red indicate treatments including pyrethroids whereas blue bars indicate either the untreated check or plots treated with non-pyrethroid chemistries.