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

Project No.: **09-ENTO8-Haviland/Holtz**

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Objectives:

Develop efficacy data for newly-registered and experimental insecticides against navel orangeworm (NOW) in almonds.

Interpretive Summary:

In many parts of California navel orangeworm is the most significant insect pest of almonds. Direct feeding on the kernels, in combination with worm-induced contamination by aflatoxins, makes effective management of navel orangeworm a necessity. In addition to cultural controls, such as winter sanitation and early harvest, insecticides provide a significant contribution towards management. The primary purpose of this project is to screen and identify new insecticides that are worth incorporating into navel orangeworm management programs while weeding out other insecticides that are not worth evaluating on larger scale. Data from 2009, in combination with the results of previous years, have shown that newer generation pyrethroids, such as Brigade and Danitol, can provide good navel orangeworm control. Good control in many trials has also been achieved with insecticides containing active ingredients in a new mode of action called anthranilic diamides. This includes Belt, Altacor, Tourismo, and Voliam Xpress (which is a premix of a diamide with a pyrethroid). Trials have also documented that several insecticides, though they may

have some benefit in individual trials, do not have consistent enough results to merit evaluation in larger scale trials. These include insecticides such as Clutch, Assail, Alverde, Dimilin, and NAI 2302.

Materials and Methods:

During 2009 we completed two navel orangeworm trials. The first trial was conducted in Madera County in a young almond orchard at a research facility owned by DuPont. A total of 56 Nonpareil almond trees on a 19' by 19' spacing were organized into a randomized complete block design with four blocks of 13 treatments and an untreated check. Insecticides were applied on July 23, 2009 with a Stihl Backpack Sprayer at 150 gallons per acre of water. Evaluations were made by placing tarps under the trees and using a pole to knock the nuts onto the tarp. Samples of at least 200 nuts per tree were collected and brought back to the lab for drying, freezing, and later evaluation. All nuts in each sample were counted and evaluated for navel orangeworm damage. Percentages of nuts with navel orangeworm damage were analyzed by ANOVA using an arcsin (sqrt(x)) transformation of the data with means separated by Fisher's Protected LSD. Data are reported as original percentages of damage with means separation from the transformed analysis.

The second trial was conducted in a 5-year-old almond orchard in Fresno County at the UC Kearney Agricultural Center. A total of 80 Nonpareil trees on a 20' by 16' spacing were organized into a randomized complete block design with four blocks of 18 treatments and two untreated checks. Due to space limitations at both trial locations we were not able to test all of the same products at each location. Insecticides were applied to each plot twice with the first application being made just prior to hull split on July 7 with the second application going on 14 days later July 21, 2009. Applications were made using a Stihl Backpack Sprayer at a water volume of 100 gallons per acre. The first evaluation was made on 25 Aug when at least 200 nuts were collected by hand from each plot. Samples were placed in paper bags, allowed to dry for approximately one week, and were frozen until they could be processed at a later date. Nuts were processed throughout the fall and early winter by thawing the nuts, removing the hull and shell, and evaluating the kernel for damage by navel orangeworm. Data were analyzed by ANOVA with means separated by Fisher's Protected LSD.

After the first evaluation the navel orangeworm trial in Fresno County was treated and evaluated a second time. All plots with insecticide treatments were sprayed on September 10, 2009 to coincide with the estimated fourth flight of navel orangeworm. Plots were then evaluated a second time on 5 Oct. The second round of applications, evaluations and statistical analyses were done according to the same methodology as previously described.

Results and Discussion:

The effects of insecticide treatments on the percentage of nuts with navel orangeworm at the Madera trial are shown in **Table 1**. Percentage damage ranged from 2.9 to 10.5%, with the untreated check having 7.6% damage. The top two treatments included

Imidan 70W (phosmet) with the addition of an experimental compound GWN-1971. These two treatments performed significantly better than either the untreated check or Imidan 70W by itself. The pyrethroids Brigade (bifenthrin), Athena (bifenthrin + the miticide abamectin), and Danitol (fenpropathrin) all provided reductions in damage that were either significantly lower than the untreated check at a *P*-value of 0.05, or that would be significantly reduced with only a minor increase in the *P*-value. The experimental product GWN-9807 also provided significant reductions in damage compared to the untreated check.

Other products tested in the trial were the experimental product NAI-2302, Tourismo, Clutch 2.13EC, and Dimilin. Percentage infested nuts in plots treated with these products ranged fro 5.4 to 10.5%, with none of the results being significantly reduced compared to the untreated check.

Table 1. Effects of insecticides on navel orangeworm in Almonds, Madera Co, 2009

Treatment	Surf-actant[1]	Rate Form Prod/Ac	NOW damage (%)
Imidan 70W + GWN-1971	n/a	2.5 lb + 2 fl oz	2.9a
Imidan 70W + GWN-1971	n/a	2 lb + 4.66 fl oz	3.1ab
Brigade	415º Oil	1 lb	3.2ab
GWN-9807	n/a	2.8 lb	3.3abc
Athena	415 º Oil	13.5 fl oz	4.5abcd
Danitol 2.4EC	R11	21.3 fl oz	4.8abcd
Tourismo	Surfix	14 fl oz	5.4abcde
NAI-2302	Surfix	17 fl oz	5.4abcde
NAI-2302	Surfix	21 fl oz	5.6abcde
Clutch 2.13EC	R11	6 fl oz	6.5bcdef
Imidan 70W	n/a	5 lb	7.0cdef
NAI-2302	Surfix	24 fl oz	8.8ef
Dimilin	415 º Oil	16 oz	10.5f
UTC	n/a	n/a	7.6def
F =			2.92
P =			0.0048

Means in a column followed by the same letter are not significantly different (*P* > 0.05, Fisher's protected LSD) after an (arcsin (square root(x))) transformation of the data. Untransformed means are shown.
[1] Surfactant rates were 0.25% v/v for Surfix and R11, and 1.0% v/v for 415º oil in 150 gallons of water per acre.

Table 2 shows the effects of insecticide treatments on navel orangeworm damage at the Fresno County trial. For the first evaluation, which evaluated damage from the second flight of navel orangeworm, damage in plots treated with insecticides ranged from 0.00 to 0.76%. This was in comparison to the two sets of untreated checks that had 0.39 and 2.16% damage. This meant that all treatments resulted in levels of navel orangeworm damage that were statistically equivalent to one set of untreated checks, but that were significantly reduced compared to the other set of untreated checks. For this reason we decided to continue the trial by spraying the trees a second time during the fourth flight so that we could collect another set of data.

Percentage damage during the 5 Oct evaluation was higher than during the first evaluation and ranged from 0.20 to 5.95% damage, with 1.20 and 3.24% damage in the two sets of untreated checks. The top eleven treatments all resulted in significantly less damage (less than 1%) compared to one of the untreated checks, but were statistically equivalent to the other. These treatments included Lorsban Advanced, Voliam Xpress, Cyazypyr, Danitol, Baythroid, Battalion, Guthion, Belt, Altacor, HGW86SEI, and Delegate. With regard to mode of action of these eleven insecticides, two of them were organophosphates (Lorsban Advanced and Guthion), three were pyrethroids (Danitol, Baythriod, and Battalion), four were diamides (Cyazypyr, Belt, Altacor and HGW86SEI), one was a spinosyn (Delegate), and one was a premix of a diamide plus a pyrethroid (Voliam Xpress). Levels of navel orangeworm damage in plots treated with the other seven treatments were statistically equivalent to both sets of untreated checks, with the exception of Alverde that had the highest damage levels of the trial.

Table 2. Effects of insecticides on navel orangeworm in Almonds, Fresno Co, 2009

Treatment	Surf-actant[1]	Rate Form Prod/Ac	NOW damage (%)	
			Aug 25	Oct 5
Lorsban Advanced	n/a	4 pt	0.11a	0.20a
Voliam Xpress	Dyne-Amic	8 fl oz	0.22a	0.35a
Cyazypyr (HGW86)	Induce	20.7 fl oz	0.00a	0.37a
Danitol 2.4EC	n/a	21.3 fl oz	0.23a	0.37a
Baythroid	415 º Oil	2.4 fl oz	0.21a	0.44a
Battalion	n/a	14 fl oz	0.21a	0.44a
Guthion	n/a	4 lb	0.50a	0.47a
Belt	415 º Oil	4 fl oz	0.32a	0.81a
Altacor	n/a	4 oz	0.00a	0.88a
HGW86SEI	Induce	13.6 fl oz	0.32a	0.89a
Delegate	B1956	6.4 oz	0.65a	0.95a
Imidan	B1956	5 lb	0.19a	1.29ab
HGW86SE	Induce	13.6 fl oz	0.53a	1.31ab
Proclaim	Dyne-Amic	4.8 oz	0.34a	1.36ab
Brigade	415 º Oil	1 lb	0.11a	1.73ab
Tourismo	Surfix	14 fl oz	0.76a	2.15ab
Intrepid	B1956	16 fl oz	0.10a	2.16ab
Alverde	n/a	16 fl oz	0.45a	5.95c
Untreated Check 1	n/a	n/a	2.16b	3.24b
Untreated Check 2	n/a	n/a	0.39a	1.20ab
		F =	2.76	3.05
		P =	0.0015	0.0005

Means in a column followed by the same letter are not significantly different (*P* > 0.05, Fisher's protected LSD).

[1] Surfactant rates were 0.125% v/v for Induce, 0.25% v/v for Dyne-Amic and Surfix, 0.5% v/v for B1956, and 1% v/v for 415º Oil in 100 gallons of water per acre.

It is very difficult to make statements about which products are the best for use in almonds based on one or two trials. However, when data from 2009 are combined with previous data the results suggest that diamides, including Belt, Altacor, Cyazypyr, and Voliam Xpress (which is a tank mix with a pyrethroid) have the greatest potential as newer reduced-risk chemistries and are worth looking at further on larger scale in

almonds for navel orangeworm control. The spinosad Delegate is also reduced-risk and has performed sufficiently in trials to justify further work. Newer pyrethroids such as Brigade, Danitol, Athena, Baythroid and Battalion represent the most effective of the newer broad-spectrum insecticides, along with the new low-VOC formulation of Lorsban. Other products such as Clutch, Dimilin, Assail, and Alverde are not good candidates for navel orangeworm control in California almonds.