ALMOND INSECT AND MITE RESEARCH

Frank Zalom[1], Hillary Thomas[1], Kelly Hamby[1], Nicole Nicola[1], Franz Niederholzer[2], Joel Siegel[2] and John Edstrom[4]

[1]Department of Entomology, University of California, Davis, CA, U.S.A. 95616; [2]UC Cooperative Extension, Sutter/Yuba Counties; [3]USDA-ARS San Joaquin Valley Agricultural Sciences Center, Parlier, CA; [4]UC Cooperative Extension, Colusa County

Objectives:

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

Evaluate efficacy and May treatment timing for newly registered and candidate insecticides against peach twig borer.

Evaluate efficacy and May treatment timing for newly registered and candidate insecticides against navel orangeworm; conduct associated research on applications and NOW biology.

Determine insecticide side effects on the predatory mite *Galendromus occidentalis*.

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 monitor the phenological activity of almond insect pests in their counties to update pest status for local growers and PCAs. For the 2010 season, supplies purchased and distributed included 250 traps of various kinds, 300 pheromone lures for peach twig borer (PTB), San Jose scale (SJS), and oriental fruit moth (OFM), and 8 lbs of NOW bait. Seven Farm Advisors received these supplies.

Peach twig borer 'May sprays'. An experiment to determine efficacy of registered and candidate insecticides for control of the spring PTB larval hatch was conducted on third leaf almond trees at a site east of the Sutter Buttes and northwest of Yuba City. Treatments were applied to Price, Sonora and Peerless varieties. The treatments were blocked by variety with 2 replicates of each insecticide treatment for each variety (6 replicates in all). UC researchers have not promoted the use of these 'May sprays' for many years because of the potential for disrupting natural enemies in the orchards. May sprays offer the potential to obtain some control of NOW which has flights that overlap somewhat with PTB flights. The current May spray timing recommendation (400 degree-days (DD) after the start of the spring flight) is based on research developed for organophosphates. Many of the newer insecticide products evaluated have different modes of action from those registered before this decade, so spray timing may need to be altered from that currently described.

PTB biofix for the site was determined to be April 19, and the NOW biofix April 24. We based the treatments on degree-days (DD), so most applications were applied at a timing of about 400 DD. Three products, Intrepid, Altacor and Delegate were applied at earlier and later treatment timings as well. All sprays were applied at a volume of 100 gal. PTB shoot strikes were evaluated June 28, 2010, at 944 DD following biofix. ANOV statistics revealed significant treatment differences (F=9.027; df=21, 143; p<0.0001; Table 1). Mean separation revealed that all treatments except for the middle treatment timing of Intrepid significantly reduced the number of PTB shoot strikes relative to the untreated check. The comparison of treatment timings of Altacor, Delegate and Intrepid indicated that efficacy for all treatment timings were statistically the same. In 2009 the earlier timings were as good as or better than the 400 DD treatment timing, but the 2010 results may be due to the rain and cool temperatures tht occurred during much of mid-May, following the first application. It is likely that Altacor or Delagate could have been successfully applied for NOW control in this experiment and also achieved control of PTB similar to what was observed at the early treatment timing of either product (Figure 1 - top). We do not recommend that pyrethroid insecticides (highlighted on Table 1 in red ink) as they are likely to disrupt natural control of spider mites and other arthropods.

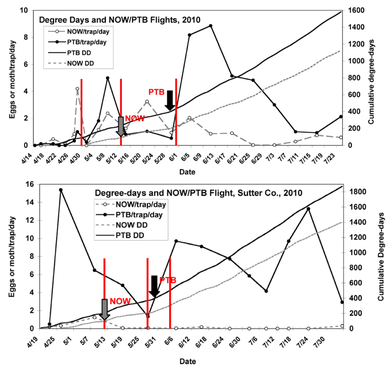
Table 1. Mean (± SE) peach twig borer shoot strikes per tree, 2010. Pyrethroids are in red.

Treatment	Chemical	Rate	Date	DD	Shoot strikes/tree Mean ± SD[1]
untreated					10.4 ± 2.6 A
Belt[2]	flubendiamide	4.0 oz	5/28	376	3.0 ± 2.4 EFG
Tourismo[2]	flubendiamide, buprofezine	10 oz	5/28	376	3.8 ± 1.5 DEFG
Tourismo[2]	flubendiamide, buprofezine	14 oz	5/28	376	2.5 ± 1.6 EFG
NAI-2302 EC[2]	tolfenpyrad	14 oz	5/28	376	7.5 ± 4.5 BC
NAI-2302 EC[2]	tolfenpyrad	21 oz	5/28	376	5.2 ± 1.8 CDE
Proclaim	emamectin benzoate	4.0 oz	5/28	376	3.7 ± 2.6 EFG
Intrepid 2F[3]	methoxyfenozide	16 oz	5/12	211	8.1 ± 3.8 B
Intrepid 2F[3]	methoxyfenozide	16 oz	5/28	376	8.7 ± 5.1 AB
Intrepid 2F[3]	methoxyfenozide	16 oz	6/4	507	6.8 ± 4.3 BCD
Delegate[3]	spinetoram	6.4 oz	5/12	211	1.5 ± 1.4 G
Delegate[3]	spinetoram	6.4 oz	5/28	376	1.7 ± 2.3 FG
Delegate[3]	spinetoram	7 oz	6/4	507	1.2 ± 1.0 G
Altacor 35WG[3]	chlornitraniliprole	4.0 oz	5/12	211	2.0 ± 1.1 FG
Altacor 35WG[3]	chlornitraniliprole	4.0 oz	5/28	376	1.7 ± 1.9 FG
Altacor 35WG[3]	chlornitraniliprole	4.0 oz	6/4	507	1.3 ± 1.4 G
Assail 30SG[2]	acetamiprid	6.4 oz	5/28	376	2.7 ± 2.8 EFG
Voliam Xpress	lamda-cyhalothrin, chlorantraniliprole	7.0 oz	5/28	376	1.5 ± 1.5 G
Lambda-Cy 1EC[2]	lamda-cyhalothrin	5.0 oz	5/28	376	4.7 ± 3.1 CDEF
Athena EW[2]	bifenthrin, abamectin	27.2 oz	5/28	376	5.3 ± 2.8 CDE
Brigade 10 WP	bifenthrin	0.5 lb	5/28	376	1.0 ± 1.3 G
Bifenture 10DF[2]	bifenthrin	16 oz	5/28	376	1.7 ± 1.5 FG

[1] Means followed by the same letter do not differ significantly at p=0.05 by Student's t-test.
[2] Mixed with Dyne-Amic at 0.25% v/v
[3] Mixed with Induce at 1.0% v/v

Navel orangeworm, 'May sprays'. Many of the same products evaluated for PTB control may also provide NOW control during the 'May Spray' period. The current May spray timing recommendation for NOW is 100 DD after the first eggs are laid for 2 consecutive sampling periods on egg traps. The site of our May NOW control study was a 20 acre almond orchard near Ripon. Biofix dates were April 30 for NOW and April 19 for PTB. Treatments with most all products were made at 99 NOW dregree-days (May 13). In addition, treatments with Altacor, Delegate and Intrepid were made at the biofix (April 30) and near the recommended PTB DD treatment timing May 31 at 441 PTB DD). Mummies per tree when traps were deployed in the orchard were 3.1 in the Nonpariel trees and 22.5 in the Fritz trees. Nonpariel mummies collected in Fall 2009 were glued to the outside of strands of vegetable mesh during April, 2010, and hung with 11 strands assigned per treatment at mid-canopy on May 1.

Figure 1. Cumulative degree-days from PTB and NOW biofix dates.



The mummies were removed on July 16 when 976 NOW DD had been accumulated, and hand-cracked for damage. ANOV statistics revealed significant treatment differences for NOW infestation (F=7.5143, df=19, 223, p<0.0001). All products significantly reduced nut infestation except for Assail. In spite of the challenges of the weather during May that resulted in treatment timings being spread out for a month, there were no differences between the 3 treatment timings for Delegate, Intrepid and Altacor. Of course, these results are optimal since coverage was near perfect, but they do illustrate that a number of products will provide excellent control if the insecticide reaches its target.

Altacor and Intrepid lab studies. Unhulled Nonpariel almonds were obtained from an untreated orchard after the initiation of hullsplit. Seventy-five mated NOW females were placed in a mating chamber and permitted to oviposit. Number of eggs were counted prior to applying treatments directly to the eggs.

Table 2. Proportion of navel orangeworm infested mummies, 2010. Pyrethroids are in red.

Treatment	Chemical	Rate (form/ac)	Date	DD	Proportion infestation Mean ± SD[1]
Control (water)			5/13	99 NOW	0.14 ± 0.1 A
Belt[2]	flubendiamide	4.0 oz	5/13	99 NOW	0.01 ± 0.0 B
Tourismo[2]	flubendiamide, buprofezin	14.0 oz	5/13	99 NOW	0.01 ± 0.0 B
Proclaim	emamectin benzoate	4.0 oz	5/13	99 NOW	0.01 ± 0.0 B
Intrepid 2F[3]	methoxyfenozide	16 oz	4/30	0 NOW	0.00 ± 0.0 B
Intrepid 2F[3]	methoxyfenozide	16 oz	5/13	99 NOW	0.03 ± 0.1 B
Intrepid 2F[3]	methoxyfenozide	16 oz	5/31	441 PTB	0.02 ± 0.0 B
Delegate[3]	spinetoram	6.4 oz	4/30	0 NOW	0.01 ± 0.0 B
Delegate[3]	spinetoram	6.4 oz	5/13	99 NOW	0.01 ± 0.0 B
Delegate[3]	spinetoram	6.4 oz	5/31	441 PTB	0.01 ± 0.0 B
Altacor 35WG[3]	chlornitraniliprole	4.0 oz	4/30	0 NOW	0.00 ± 0.0 B
Altacor 35WG[3]	chlornitraniliprole	4.0 oz	5/13	99 NOW	0.02 ± 0.0 B
Altacor 35WG[3]	chlornitraniliprole	4.0 oz	5/31	441 PTB	0.02 ± 0.0 B
Assail 30SG[2]	acetamiprid	6.4 oz	5/13	99 NOW	0.10 ± 0.1 A
Lambda-Cy 1EC	lambda-cyhalothrin	5.0 oz	5/13	99 NOW	0.00 ± 0.0 B
Tourismo + Warrior	flubendiamide, buprofezin + lamda-cyhalothrin	14.0 oz + 5 oz	5/13	99 NOW	0.00 ± 0.0 B
Voliam Xpress	lamda-cyhalothrin, chlorantraniliprole	7.0 oz	5/13	99 NOW	0.01 ± 0.0 B
Athena EW[2]	Bifenthrin, abamectin	27.2 oz	5/13	99 NOW	0.01 ± 0.0 B
Brigade 10WP	bifenthrin	0.5 lb	5/13	99 NOW	0.01 ± 0.0 B
Bifenture 10DF[2]	bifenthrin	16 oz	5/13	99 NOW	0.00 ± 0.0 B

[1] Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test.
[2] Mixed with Dyne-Amic at 0.25% v/v
[3] Mixed with Induce at 1.0% v/v

On average, 30.5±3.24 eggs were laid on each unhulled almond. Significant treatment differences were detected (F=16.9; df=4, 20; p<0.0001; Table 3). Tukey post-hoc comparison revealed egg hatch was significantly reduced in the Altacor 4.0 oz/acre plus horticultural mineral oil, Altacor 4.0 oz only and Sunspray 1% v/v only treatments. The experiment was repeated except that the almonds were treated prior to exposure to mated females to determine potential avoidance behavior by NOW females and effects of residue on eggs. Ten unhulled almonds were dipped into each of the treatments and allowed to air dry before being placed into a mating chamber with 75 mated females. After 48 hours the almonds were removed from the chamber, examined for NOW eggs, and number of eggs on each almond recorded. The eggs were evaluated daily after treatment until all eggs from the control treatment had eclosed. There were no significant treatment differences (p=0.61) in the mean number of eggs laid, but the proportion of eggs hatched differed significantly by treatment (F=6.50; df=4, 45; p=0.0003; Table 3). Tukey post-hoc analysis revealed that the significance was due to reduced egg hatch in the Sunspray at 1% v/v and Intrepid treatments.

Table 3. Mean (± SE) proportion of NOW eggs laid on untreated almonds and then treated that hatched, and number of eggs laid on treated almonds and proportion that hatched.

Treatment	Eggs treated	Almond treated before eggs laid	
	Mean ± SE proportion hatched[1]	Mean ± SE eggs laid[1]	Mean ± SE proportion hatched[1]
Sunspray Horticultural Oil @ 1% v/v	0.573 ± 0.090 A	16.8 ± 3.09 A	0.82 ± 0.047 A
Altacor @ 4.0 oz/acre	0.785 ± 0.059 A	10.9 ± 1.97 A	0.96 ± 0.019 B
Altacor @ 4.0 oz/acre + Sunspray @ 1%	0.506 ± 0.039 A	15.3 ± 2.99 A	0.96 ± 0.022 B
Intrepid @ 16.0 oz/acre	0.871 ± 0.038 B	12.8 ± 2.36 A	0.80 ± 0.06 A
Control	0.985 ± 0.015 B	13.2 ± 2.15 A	0.98 ± 0.02 B

[1] Means followed by the same letter do not differ significantly at P=0.05 by Tukey's test..

Insecticide non-target effects. The *Galendromus occidentalis* used in this study were supplied by Sterling Insectary (Delano, CA). Insecticides and concentrations applied were Altacor at 164.06 ppm, Brigade at 94.64 ppm, Dimilin at 275.00 ppm, Avaunt at 105.47 ppm, Intrepid at 282.50 ppm, and Delegate at 136.72 ppm. Contact treatments were applied to runoff to whole cowpea leaves that were inhabited by gravid female *G. occidentalis.* Residue treatments were similarly applied but allowed to dry before transferring the females to the leaves.

Significant differences were found in female survival between residue insecticide treatments (F=7.50; df=7, 42; p<0.0001) but not among contact insecticide treatments (F=1.86; df=7, 42; p=0.1108; Table 4). However, when compared individually against the control, individual insecticide treatments were different in the contact experiment.

Table 4. Mean ± SD *G. occidentalis* mortality and fecundity following residue and contact exposure.

Treatment	Exposure	Survival Adj. mean	p[1]	Fecundity Adj. mean	p[1]
Control	Contact	0.86 ± 0.08	-	1.81 ± 0.5	-
	Residue	0.75 ± 0.08	-	3.04 ± 0.8	-
Brigade	Contact	0.57 ± 0.12	0.25	0.76 ± 0.3	0.46
	Residue	- ± -	-	- ± -	-
Altacor	Contact	0.67 ± 0.12	0.54	0.69 ± 0.4	0.44
	Residue	0.67 ± -	0.97	3.83 ± 0.6	0.17
Dimilin	Contact	0.38 ± 0.12	0.04	1.30 ± 0.5	0.98
	Residue	0.76 ± 0.05	1.00	4.67 ± 0.7	0.64
Avaunt	Contact	0.62 ± 0.11	0.37	0.33 ± 0.2	0.18
	Residue	0.10 ± 0.08	0.00	3.00 ± 1.0	0.28
Intrepid	Contact	0.38 ± 0.12	0.04	0.20 ± 0.2	0.22
	Residue	0.38 ± 0.08	0.04	3.50 ± 0.7	0.14
Delegate	Contact	0.48 ± 0.12	0.10	1.83 ± 0.6	1.00
	Residue	0.14 ± 0.08	0.00	1.00 ± 0.5	0.81

[1] Comparisons between treatment groups and control were made using Dunnett's method following adjustments for over-dispersion.