Insect and Mite Research

Project No.: **09-ENT07-Zalom**

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Objectives:

1. Purchase pheromone traps, navel orangeworm (NOW) bait traps, and lures for UC Cooperative Extension Farm Advisors for their ongoing monitoring and extension efforts. Assist in evaluating NOW pheromone blends and formulations and in ten lined June beetle monitoring as necessary in collaboration with other UC researchers.
2. Evaluate efficacy and May treatment timing for newly registered and candidate insecticides against peach twig borer.
3. Evaluate efficacy and May treatment timing for newly registered and candidate insecticides against navel orangeworm; conduct associated research on applications and NOW biology.
4. Determine insecticide side effects on *Galendromus occidentalis*.

Interpretive Summary:

<u>Monitoring supplies and regional trapping.</u>
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 PCA's. The trapping supplies are standardized to insure consistency in data collected over years. For the 2009 season, supplies purchased and distributed included 1225 traps of various kinds, 600 pheromone lures for peach twig borer (PTB), SJS, oriental fruit moth, and obliquebanded leafroller, and 12 lbs of NOW bait. My lab also participates in the development and evaluation of new lures with other almond researchers. For example, during the past five years, my lab has helped assist Dr. Walter Leal in his field work to

evaluate NOW pheromone blends and formulations, and for monitoring ten lined June beetle populations.

Peach twig borer.

Several new products are now registered or in the registration process, that provide viable options to the organophosphates for PTB control. Our previous research has helped identify their efficacy, optimal rates and winter season timing. In 2009, we took a similar approach to determine the best use of new products for control of PTB as a May spray. UC researchers have not promoted the use of 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 in many years. The current May spray timing recommendation (400 degree-days (DD) after the start of the spring flight) is based on research developed for organophosphates that cause direct mortality to the PTB larvae. Many of the newer insecticide products have different modes of action, so spray timing may need to be earlier relative to products that kill larvae directly.

The site of our study was a third leaf almond orchard east of the Sutter Buttes in Sutter County. Materials and rates applied per acre and treatment dates are provided in the 2008 Almond Board Annual Report CD (Project 08-ENTO7-Zalom). The peach twig borer biofix for the site was determined to be April 13, and the navel orangeworm biofix April 24. It was our intention to base the treatments on degree-days (DD), so most applications were intended to be 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 the equivalent of 100 gal of water. PTB shoot strikes were evaluated June 2, 2009, at 781 DD following biofix. ANOV statistics revealed significant treatment differences (ANOVA statistics, F=4.8132, df=20, 109, p<0.0001). Mean separation revealed that all treatments except for the low rate of an experimental product from Nichino (NAI-3202 EC) and the middle treatment timing of Intrepid significantly reduced the number of peach twig borer shoot strikes relative to the untreated check. The comparison of treatment timings of Altacor, Delegate and Intrepid indicated that in each case the early treatment timing was as good as or better than the 400 DD treatment timing. ANOV statistics for the treatment timing for each product were Altacor (F=6.9897, df=3, 24, p<0.0019), Delegate (F=5.202, df=3, 24, p<0.0076), and Intrepid (F=2.4452, df=3, 24, p<0.0923). In each case, the later treatment timing was not as effective as the earlier timing. The treatment timing for navel orangeworm in the *UC Pest Management Guidelines for Almonds* (100 DD using navel orangeworm degree-day developmental thresholds) predicted the optimum timing on May 9 (316 DD using peach twig borer degree-day developmental thresholds), which was between our first and second treatment timing.

Navel orangeworm.

Many of the same products evaluated for PTB control may also provide navel orangeworm (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 navel orangeworm control study was a mature 20 acre almond orchard on E. Clinton South Ave, near Ripon. The block

had a mummy load recorded on January 31, 2009, averaging 7 per tree. Ten black NOW eggs traps were hung for better resolution of a biofix. The first eggs were found on May 1, 2009, and on the subsequent sampling date. PTB biofix was established as April 20. All products were applied as close to the 100 DD treatment timing as practical. Three products, Intrepid, Altacor and Delegate were applied at earlier and later treatment timings as well. Uninfested Nonpareil mummy nuts with hulls intact collected in Fall 2008, were hot glued to the outside of strands of vegetable mesh during April, 2009, and 220 strands were prepared in all. These sentinel mummies were hung at mid-canopy in Nonpareil trees on May 6, 49 DD after the May 1 biofix date, and close to the first possible date for exposure to NOW egg laying. There were 20 treatments (**Table 1**), with 10 mummy strands allocated for each treatment plus 20 strands for a water only control. Treatments of Intrepid, Altacor and Delegate were applied directly to the strands on May 6 (49 DD), May 14 (128 DD and equivalent to 324 PTB DD), and May 19 (234 DD and equivalent to 449 PTB DD). The mummies were removed from the trees on June 29, 2009 when 783 NOW DD had been accumulated, and hand-cracked for damage. The spray volume was 100 gal/acre.

Table 1. Mean (± SD) proportion of NOW infested mummies, Manteca, 2009.

			Proportion of infested mummies					
			All NOW			Live NOW		
Treatment	Rate (form/ac)	DD	Mean ± SD[1]			Mean ± SD[1]		
Control (water)			0.147 ± 0.12		A	0.097 ± 0.10		A
Belt	4.0 oz	128	0.018 ± 0.04		B	0.018 ± 0.04		B
Belt[2]	4.0 oz	128	0.000 ± 0.00		B	0.000 ± 0.00		B
Dimilin 2L	12 oz	128	0.122 ± 0.07		A	0.096 ± 0.06		A
Dimilin 2L+Lorsban	12 oz+4 pt	128	0.000 ± 0.00		B	0.000 ± 0.00		B
Athena EW[3]	805.7 ml	128	0.000 ± 0.00		B	0.000 ± 0.00		B
Danitol 2.4EC	16 oz	128	0.024 ± 0.03		B	0.000 ± 0.00		B
Assail 30SG[4]	6.4 oz	128	0.048 ± 0.05		B	0.016 ± 0.03		B
Assail 70WP[4]	2.7 oz	128	0.056 ± 0.10		B	0.017 ± 0.03		B
Bifenture 10DF[4]	16 oz	128	0.010 ± 0.02		B	0.005 ± 0.02		B
Intrepid 2F	16 oz	49	0.025 ± 0.05		B	0.010 ± 0.03		B
Intrepid 2F	16 oz	128	0.023 ± 0.04		B	0.012 ± 0.02		B
Intrepid 2F	16 oz	234	0.017 ± 0.03		B	0.011 ± 0.02		B
Delegate	7 oz	49	0.027 ± 0.04		B	0.015 ± 0.03		B
Delegate	7 oz	128	0.029 ± 0.05		B	0.007 ± 0.02		B
Delegate	7 oz	234	0.017 ± 0.03		B	0.017 ± 0.03		B
Altacor 35WG[5]	4.5 oz	49	0.006 ± 0.02		B	0.006 ± 0.02		B
Altacor 35WG[5]	4.5 oz	128	0.005 ± 0.02		B	0.005 ± 0.02		B
Altacor 35WG[5]	4.5 oz	234	0.007 ± 0.02		B	0.000 ± 0.00		B
Altacor 35WG+Asana XL[5]	4.5 oz+10 oz	128	0.006 ± 0.02		B	0.006 ± 0.02		B
Proclaim	4.0 oz	128	0.011 ± 0.02		B	0.006 ± 0.02		B

[1] Means followed by the same letter do not differ significantly at *P*=0.05 by Student's t-test.
[2] Mixed with a NIS surfactant at 0.25% v/v.
[3] Mixed with summer oil at 1.0% v/v.
[4] Mixed with a silicone surfactant at 1.0% v/v.
[5] Mixed with Induce at 1.0% v/v.

ANOV statistics revealed significant treatment differences for both total NOW infestation (includes live or dead larvae or frass in the meats or hulls (ANOVA statistics, F=7.2826, df=20, 193, p<0.0001) and live NOW only (ANOVA statistics, F=6.6166, df=20, 193, p<0.0001). The analysis revealed that all treatments except for the Dimilin alone treatment significantly reduced the proportion of infested mummies by both methods of evaluation (**Table 1**). Of course, these data must be considered optimal since coverage was near perfect. Applications made with grower equipment would not likely be as good. That said these data show that with excellent coverage of remaining mummy nuts there are alternatives for NOW control at the May Spray timing. While cracking nuts, we found a considerable number of green lacewing larvae and pupae in the hulls and split nuts, so we recorded these data. Treatment differences approached significance (p<0.0706). The most notable observations were that no lacewing larvae or pupae were found in treatments with Dimilin + Lorsban, Bifenture (bifentrin) alone, and Delegate at the late treatment timing. Other treatments also appeared to have reduced numbers of lacewings relative to untreated.

Spider mite treatments and non-target effects.

Many of the new products we are evaluating for PTB and NOW control are being thought of as 'reduced-risk' or less harmful for beneficials. Using methods we have developed to study direct and side-effects of acaricides, we have initiated a study to determine total effects of these products on *Galendromus occidentalis*. It would be very time consuming to test all possible products, so we have begun the study by selecting products that share similar modes of action in anticipation that others with similar activity will also have similar effects on non-target species. Products and IRAC category numbers of products being tested are Altacor (chlorantraniliprole, #28, Dupont), Avaunt (indoxacarb, #22, Dupont), Brigade WSB (bifenthrin, #3A, FMC), Delegate (spinetoram, #5, Dow), Dimilin 2L (diflubenzuron, #15, Chemtura), and Intrepid (methoxyfenozide, #18). We have completed studies to evaluate the effects of both direct treatment of adults females and of females placed on treated leaf surfaces on their survival, fecundity and fertility. The predators used in our experiments are from a colony of *G. occidentalis* originally obtained from Sterling Insectary (McFarland, CA), and maintained on twospotted spider mites in growth chambers at 24±1ºC, 75-85% RH and 16:8 photoperiod. For both experiments, 2 cm leaf disks were cut from leaves using a cork borer then placed on wet filter paper in Petri dishes. Three leaf disks were placed into each Petri dish, and this served as an arena. Seven of these arenas were used for each experimental treatment, and the same number of arenas treated only with water served as controls for the experimental treatments. An excess of spider mites and eggs were provided so that the females remained satiated. Survival and number of eggs laid by each female was observed daily for three days, then the females were removed and the eggs transferred to untreated leaf disks. The eggs were observed thereafter for hatching.

The first experiment was intended to determine direct and side-effects on gravid females placed on recently treated leaves with the insecticide residues - similar to what might be expected from females that had escaped direct contact of a spray but must crawl onto leaf surfaces with insecticide residue to search for prey. Results for survivorship are presented on **Table 2**. As expected, the pyrethriod, Brigade, killed all

of the females by the end of the first day. Of these products, Altacor and Dimilin resulted in the least mortality to females over the 3 days of post treatment observations. **Table 3** presents the number of eggs laid by the original 21 females and the number that hatched. *G. occidentalis* fecundity was reduced by all insecticide applications. Altacor had the least total impact on total eggs laid, while Dimilin and Intrepid had moderate effects. There were no eggs laid and no surviving female beyond the first day in the Brigade treatment.

Table 2. Survival of gravid female *G. occidentalis* on leaf disks with dried residues.

	Rate	Mean ± SD surviving females		
Treatment	(form./ac.)	Day 1	Day 2	Day 3
Control	na	2.62 ± 0.58	2.52 ± 0.67	2.23 ± 0.88
Altacor	6.0 oz	2.85 ± 0.37	2.29 ± 0.48	2.00 ± 0.57
Avaunt	4.5 oz	1.28 ± 1.38	0.57 ± 0.53	0.28 ± 0.48
Brigade WSB	32 oz	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Delegate	7.0 oz	1.43 ± 0.53	0.85 ± 0.69	0.42 ± 0.53
Dimilin 2L	16 oz	2.57 ± 0.53	2.42 ± 0.53	2.28 ± 0.48
Intrepid	16 oz	1.57 ± 0.79	1.42 ± 0.79	1.14 ± 1.06

Table 3. Total eggs laid and hatched by the 21 initial females when exposed to residues and when treated directly.

	Exposed to residues		Treated	
Treatment	Total laid	Total hatched	Total laid	Total hatched
Control	87	41	32	28
Altacor	55	35	11	7
Avaunt	13	10	3	3
Brigade WSB	2	0	6	4
Delegate	11	8	17	14
Dimilin 2L	34	23	11	5
Intrepid	32	25	1	0

The second experiment evaluated effects of direct treatment of females. Results for survivorship are presented on **Table 4**. Interestingly, the effect was not as great as was observed for females exposed to surface residues. **Table 3** presents the number of eggs laid by the original 21 females and the number that hatched. *G. occidentalis* fecundity was reduced by all insecticide applications. The effect was greater than observed for the leaf surface residues for all products except for Delegate.

Table 4. Survival of gravid female *G. occidentalis* directly treated with each product.

Treatment	Rate (form./ac.)	Mean ± SD surviving females Day 1	Day 2	Day 3
Control	na	3.00 ± 0.00	2.86 ± 0.38	2.57 ± 0.53
Altacor	6.0 oz	2.42 ± 0.96	2.23 ± 1.11	2.00 ± 1.15
Avaunt	4.5 oz	2.57 ± 0.53	2.14 ± 0.90	1.86 ± 1.07
Brigade WSB	32 oz	2.29 ± 0.49	2.00 ± 0.82	1.71 ± 0.76
Delegate	7.0 oz	2.71 ± 0.49	2.29 ± 0.76	1.43 ± 0.79
Dimilin 2L	16 oz	2.57 ± 0.53	1.86 ± 0.69	1.14 ± 0.90
Intrepid	16 oz	2.29 ± 1.11	1.57 ± 0.98	1.14 ± 0.90