ALMOND INSECT AND MITE RESEARCH

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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 NOW development on selected cultivars.

Determine potential for *Blattisocius keegani* (Acari: Ascidae) as a biological control for navel orangeworm.

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. The trapping supplies are standardized to insure consistency in data collected over years. For the 2012 season, supplies purchased and distributed included 220 traps of various kinds, 250 pheromone lures for peach twig borer (PTB), San Jose scale (SJS), and oriental fruit moth (OFM), and 8 lbs of NOW bait. Six Farm Advisors received these supplies.

Peach twig borer 'May sprays'. The diamide insecticides provided similar or better control of PTB to the standard insecticides during the 3 previous years of our May spray studies, but we did not compare all of these products in a single year. In Spring, 2012 we evaluated the registered diamide products Altacor, Belt and Tourismo as well as cyazypyr (not registered). We also applied Altacor at the same three treatment timings as in our 2012 NOW study that was conducted in a nearby orchard. Although the full impact of the diamides insecticides is not known, they are believed to be less toxic to natural enemies than the organophosphate or pyrethroid insecticides and they appear to be effective against both PTB and NOW. Unpublished data suggest that Altacor might have some negative impact on green lacewings. Tourismo, a mixture of flubendiamide and buprofezin, has the added benefit of providing some control of Hemipterans. However, not all Hemipterans are pests and some are beneficial insects, so the choice of products is important depending on the target pest species. It has also been suggested that buprofezin may have a negative impact on predaceous lady beetles. Results from our 2012 study revealed significant differences between treatments, and that all of the treatments significantly reduced the number of PTB shoot strikes relative to the untreated check (Table 1).

Table 1. Mean (± SE) peach twig borer shoot strikes per tree, Ripon, 2012.

Treatment	Rate	Application date [2]	PTB strikes/tree* Mean ± SD	
Control	NA	NA	5.83 ± 2.76	A
Dipel	1 lb	5/7/12 + 5/17/12	2.17 ± 1.83	B
Lorsban [1]	4 pt	5/14/12	1.67 ± 1.63	BC
Belt SC [1]	4 oz	5/14/12	1.00 ± 1.10	BC
Tourismo [1]	14 oz	5/14/12	1.00 ± 1.26	BC
Altacor [1]	4 oz	4/26/12	0.67 ± 0.82	BC
Altacor [1]	4 oz	5/14/12	0.50 ± 0.84	C
Altacor [1]	4 oz	5/17/12	0.67 ± 1.03	BC
Cyazypyr 10SE [1]	13.5 oz	5/14/12	0.50 ± 0.84	C
Cyazypyr 10SE [1]	16.9 oz	5/14/12	0.33 ± 0.52	C

* Means followed by the same letter do not differ significantly at *P*=0.05 by Student's t-test following arcsine transformation.
[1] Dyne-Amic added @ 0.25%% v/v
[2] PTB biofix date, 4/19/2012

Navel orangeworm, 'May sprays'. May sprays offer the potential to obtain some level of control of NOW which has flights that overlap somewhat with PTB flights in many years. In addition, there is less overlapping of NOW and PTB generations in May than in subsequent generations. The current May spray timing recommendations depending on the primary target are 100 DD after the NOW biofix or 400 DD after the start PTB biofix. Ten NOW eggs traps and 10 peach twig borer (PTB) pheromone traps baited with 'long life' lures were hung during the second week of April at both of the sites and monitored to determine NOW and PTB biofix. The site of our May NOW control study was a 20 acre almond orchard near Manteca. Biofix date for NOW was April 26. There were 18 treatments in all plus a water only control, with 10 mummy strands allocated for each treatment including 20 for the controls. Treatments were timed to the start of NOW oviposition April 26 (0 DD), May 7 (100 NOW DD), or May 14 (400 PTB DD). The products included most of the diamides that are registered or being considered for registration, the IGRs diflubenzuron and methoxyfenozide, Bt and oil, plus the conventional organophosphate Lorsban (chlorpyrifos). The nuts were removed from the field on June 25 at 769 NOW DD. Figure 1 shows the NOW and PTB degree-day accumulations for the Manteca site and recommended treatment timings for NOW and PTB. Results are presented in Table 2. ANOV indicated significant treatment differences (F=3.1868, df=18, 198). All products significantly reduced nut infestation except for the 2 TriTek oil treatments, the diflubenzuron treatment, and the earlier timings of the Bt product Dipel. There were no differences between the 3 treatment timings for Altacor (chlorantraniliprole) or Belt (flubendiamide).

Figure 1. Cumulative degree-days from PTB and NOW biofix dates, Manteca, 2012.

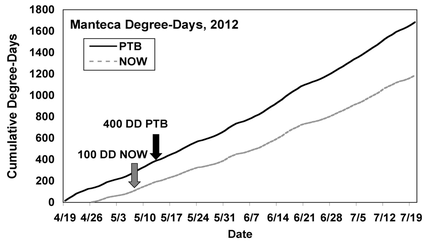


Table 2. Proportion of navel orangeworm infested mummies (total with larvae in meats and hulls), Manteca, 2012.

Treatment	Rate/ Acre	Treatment date [2]	Degree-days	Percent damage Mean ± SD*	
Control				2.7 ± 3.2	A
Cyazypyr [1]	13.5 oz.	5/7	109 NOW	0.0 ± 0.0	D
Cyazypyr [1]	16.9 oz.	5/7	109 NOW	0.0 ± 0.0	D
Altacor [1]	3 oz.	5/7	109 NOW	0.0 ± 0.0	D
Altacor [1]	4 oz.	4/26	0 NOW	0.5 ± 1.7	CD
Altacor [1]	4 oz.	5/7	109 NOW	0.5 ± 1.7	CD
Altacor [1]	4 oz.	5/14	402 PTB	0.0 ± 0.0	D
Belt [1]	4 oz.	4/26	0 NOW	0.0 ± 0.0	D
Belt [1]	4 oz.	5/7	109 NOW	1.2 ± 2.6	BCD
Belt [1]	4 oz.	5/14	402 PTB	0.0 ± 0.0	D
Tourismo [1]	10 oz.	5/7	109 NOW	0.6 ± 1.9	CD
Tourismo [1]	14 oz.	5/7	109 NOW	0.0 ± 0.0	D
Intrepid [1]	16 oz.	5/7	109 NOW	0.0 ± 0.0	D
Dimilin 2L [1]	12 oz.	5/7	109 NOW	2.2 ± 2.9	AB
Dipel	1 lb.	5/14 & 5/24	402 PTB+10 days	0.0 ± 0.0	D
TriTek	1 gal.	5/7 & 5/17	109 NOW+10 days	2.2 ± 2.9	AB
TriTek	2 gal.	5/14 & 5/24	402 PTB+10 days	1.2 ± 2.4	ABCD
Lorsban[1]	4 pt.	5/7	109 NOW	0.0 ± 0.0	D

* ANOVA statistics, F=3.1868, df=18, 198, P<0.000. Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test following arcsine transformation.
[1] Dyne-Amic @ 0.25% v/v
[2] PTB biofix date, 4/27/2012

Cultivar and navel orangworm success. In a previous study *(Hamby, K.A., Gao, L.W., Lampinen, B., Gradziel, T., and F.G. Zalom. 2011. Hullsplit date and shell seal in relation to navel orangeworm (Lepidoptera: Pyralidae) infestation of almonds. J. Econ. Entomol. 104(3): 965-969.)*, we analyzed data for a number of cultivars from the 3 Regional Almond Variety Trials, and correlated percent damage to both their hullsplit dates and shell seal. Hullsplit date and shell seal were significantly related to damage across cultivars, but some were outliers that seemed to have more or less damage than expected. Eleven of the cultivars that did not fit the trend lines were collected at the time of each of their harvests from the RAVT that is still maintained at Delta College in Manteca, and these were used in a lab and field study.

Lab study. Ten nuts of each cultivar were placed into jars with 20 first instar NOW larvae. Three treatments consisted of shelled nuts with a 1 mm scratch through the pellicle (Figure 2), undamaged shelled nuts, and unshelled nuts. The jars were placed into a growth chamber at 25°C, and checked daily for emergence. Results (Figure 3) indicated that both the number of adult NOW emerging and development time was affected by the interaction of cultivar and damage, with NOW in the scratched treatment developing faster and with a greater proportion emerging as adults.

Figure 3. NOW female degree-days to emergence and total female moths emerging (n) from different cultivars and damage treatments in a lab study.

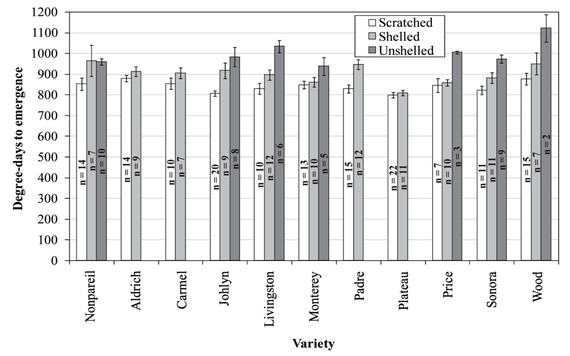
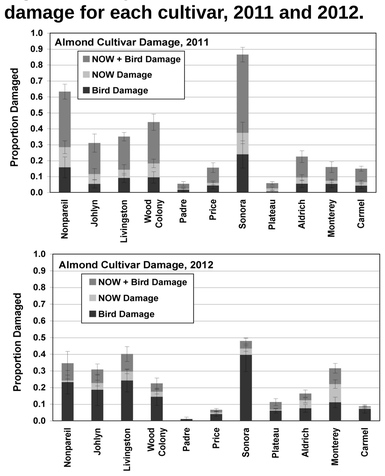


Figure 3. The 'scratched' and 'shelled treatments.

Field study. Twenty uninfested nuts with hulls intact of each cultivar were hot glued to strands of plastic vegetable mesh and returned to an orchard in San Joaquin Co. where they were hung at random in Nonpariel rows of the orchard at the NOW biofix in both 2011 and 2012. There were replicates for each of the 11 cultivars. The strands were collected before the start of the second generation flight, and returned to the lab where they were hand-cracked and scored for presence of NOW larvae, pupae, damage and evidence of bird damage. On average 9 strands of each cultivar were recovered, and 84.3% of the 20 nuts per strand were recovered. Cultivar, year, and the multiplicative effect of cultivar*year were significant in terms of NOW infestation: Cultivar $F_{10,203}$ =18.69, P < 0.0001; Year $F_{1,203}$ = 13.43, P = 0.0003, Cultivar*Year $F_{10,203}$ = 4.35 P < 0.0001 (Figure 4). NOW infestation was significantly greater in 2011 than 2012. There was appositive correlation between bird damage and NOW damage when considering all cultivars and years (r = 0.7969, n = 22, p < 0.0001).

Figure 4. Proportion NOW and bird damage for each cultivar, 2011 and 2012.



***Blattisocius keegani* field studies.** A predatory mite, *Blattisocius keegani* (Acari: Ascidae), was found feeding in a NOW lab colony at UC Davis in 2009. My lab has conducted laboratory feeding studies with *B. keegani* to determine how many NOW eggs a single female will eat and other biological parameters of its development. We have determined how to mass rear the mite in culture on both eggs of NOW and another pyralid, *Ephestia kuehniella*, the meal moth, which is often used by insectaries to mass-rear the parasitic wasp, *Trichogramma* spp., and published these findings *(Thomas, H.Q., F.G Zalom and N.L. Nicola. 2010. Laboratory studies of Blattisocius keegani (Fox) (Acari: Ascidae) reared on eggs of navel orangeworm: potential for biological control. Bull. Entomol. Res. 101: 499-504)*. The mite appears to be phoretic meaning that it can cling to a moth and be dispersed in this manner. All of our work to date has been in the laboratory. Whether this mite could be released and survive in the field and its capacity of distribution by phoresy in the field was evaluated in 2011 and 2012.

Figure 5. Predator mite and NOW egg.

B. keegani were recaptured on NOW eggs laid on paper toweling in release trees for 2 days following releases on egg cards (eggs were generally all consumed after 2 days), and on NOW egg papers in non-release trees for 2 weeks following the last of 3 releases (July 14, 2011) indicating that survival and dipersal is possible in the field. Six of 400 released female NOW carrying mites were recaptured in wing traps baited with NOW egg traps containing almond presscake for up to 9 days following releases, confirming dispersal by phoresy.