ALMOND INSECT AND MITE RESEARCH

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UC DAVIS ENTOMOLOGY & NEMATOLOGY

Objectives for 2014-15:

1. Determine chlornitraniliprone (Altacor), flubendiamide (Belt), methoxyfenozide (Intrepid), bifenthrin (Brigade), and spinetoram (Delegate) timing for NOW control in spring in comparison to male trap captures using the NOW pheromone lure and egg traps baited with almond presscake and oil.
2. Evaluate residual efficacy of Altacor, Belt, Intrepid, and Brigade.
3. Determine if low temperatures delay mating or oviposition by NOW females.

Background. The 'May spray' timing offers the potential to obtain some level of control of both navel orangeworm (NOW) and peach twig borer (PTB) as these insects have flights that overlap somewhat in many years. The May spray controls the first generation of NOW following spring moth emergence. Females of the first flight lay their eggs on the mummy nuts that remain in the orchards, so the infestation of mummy nuts can be quite high. The May spray timing recommended for NOW for many years is 100 degree-days (DD) after the first eggs are laid for 2 consecutive sampling periods on egg traps, but this will probably be modified when the relationship between male flights as recorded using the new navel orangeworm pheromone is better understood relative to egg hatch as monitored with egg traps. The recommended PTB treatment timing is at 400 degree-days (DD) after the first females are captured in pheromone traps.

Insect trapping. NOW egg traps, NOW pheromone traps baited with the new Suterra Biolures, and PTB pheromone traps baited with Trece 'long life' lures were hung in March of 2013 and 2014, in a mature 20 acre almond orchard near Ripon, but in San Joaquin Co., and monitored to determine the spring flights of NOW and PTB.

Treatment timing. Using the same protocol as proved successful for us in the last 4 years, twenty uninfested Nonpareil nuts saved from the previous harvest were hot glued to strands of vegetable mesh during early March, and these served a surrogate mummies for all insecticide field studies (Figure 1). 260 strands (2013) and 329 strands (2014) were hung in the orchard April 16, 2013, and March 27, 2014, so that females ovipositing on these mummies or larvae already present prior to the subsequent experimental applications would be exposed to the insecticides as they would in naturally occurring mummies in the orchard. Eight strands each were treated with either Altacor, Belt, Intrepid, Brigade, or Delegate weekly starting the week that the strands were first deployed.

Figure 1. Uninfested almond strands used as surrogate mummies for the navel orangeworm insecticide studies.

Twenty strands remained untreated as controls to establish the damage level in the absence of treatment. The rates of the insecticides applied were Altacor (4 oz), Belt (4 oz.), Intrepid (16 oz.), Brigade (16 oz.), and Delegate (7 oz.). All were mixed into the equivalent of 100 gal per acre, and included the nonionic surfactant, Dyne-amic, at 0.25% v/v. The strands were removed from the trees once eggs were no longer laid on the egg traps, and returned to the lab where they were hand-cracked to determine infestation (nuts with larvae or pupae present) and damage (nuts with larvae, pupae or damage present). Data were analyzed by ANOV following arcsine transformation, with individual treatments and treatment timing compared to the untreated control and means for treatment timings for each product compared to one another by Students t-test.

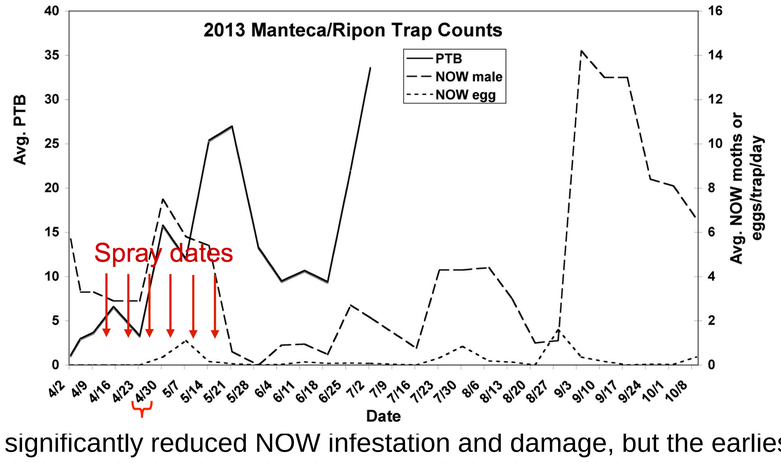
Table 1. Infestation and damage of almond mummies treated with different registered insecticides at weekly intervals starting at the initiation of oviposition of the overwintering flight of navel orangeworm at Manteca/Ripon, 2013.

Treatment	Spray date	Rate/ac.	Mean ± SD[1] % infestation			Mean ± SD[2] % damage		
Control	n/a	-	14.4		A	18.8 ± 12.4		A
Altacor	4/16	4 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Altacor	4/23	4 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Altacor	4/30	4 oz.	0.0 ± 0.0		B	1.3 ± 2.4		B
Altacor	5/7	4 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Altacor	5/15	4 oz.	1.4 ± 2.5		B	2.9 ± 4.2		B
Altacor	5/21	4 oz.	1.3 ± 3.5		B	2.5 ± 3.8		B
Belt	4/16	4 oz.	0.7 ± 1.9		B	0.7 ± 1.9		B
Belt	4/23	4 oz.	0.0 ± 0.0		B	0.7 ± 2.0		B
Belt	4/30	4 oz.	0.0 ± 0.0		B	0.8 ± 2.2		B
Belt	5/7	4 oz.	0.0 ± 0.0		B	0.7 ± 1.9		B
Belt	5/15	4 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Belt	5/21	4 oz.	0.0 ± 0.0		B	2.1 ± 3.0		B
Intrepid	4/16	16 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Intrepid	4/23	16 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Intrepid	4/30	16 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Intrepid	5/7	16 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Intrepid	5/15	16 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Intrepid	5/21	16 oz.	0.0 ± 0.0		B	0.7 ± 2.1		B
Brigade	4/16	16 oz.	0.0 ± 0.0		B	1.4 ± 2.6		B
Brigade	4/23	16 oz.	0.7 ± 2.0		B	0.7 ± 1.9		B
Brigade	4/30	16 oz.	0.0 ± 0.0		B	2.0 ± 4.1		B
Brigade	5/7	16 oz.	3.0 ± 4.2		B	3.3 ± 3.5		B
Brigade	5/15	16 oz.	1.7 ± 3.3		B	2.8 ± 4.2		B
Brigade	5/21	16 oz.	0.7 ± 2.0		B	3.8 ± 5.2		B
Delegate	4/16	17 oz.	0.0 ± 0.0		B	0.8 ± 2.0		B
Delegate	4/23	17 oz.	0.0 ± 0.0		B	1.3 ± 2.4		B
Delegate	4/30	17 oz.	0.0 ± 0.0		B	0.0 ± 0.0		B
Delegate	5/7	17 oz.	0.0 ± 0.0		B	0.7 ± 1.9		B
Delegate	5/15	17 oz.	0.7 ± 2.0		B	1.4 ± 2.5		B
Delegate	5/21	17 oz.	1.4 ± 3.9		B	1.4 ± 3.9		B

[1] ANOVA statistics, F=8.1816, df=30,258, P<0.0001. Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test following arcsine transformation.
[2] ANOVA statistics, F=10.9699, df=30,258, P<0.0001. Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test following arcsine transformation.

Results from 2013 (Table 1) indicated that all treatment timings of all products resulted in less navel orangeworm infestation when compared to the untreated control. However, in general, the earlier treatment timings had less damage than the later (May 15 and May 21) treatment timings. Figure 2 shows 2013 trap captures. The 400 DD PTB treatment date occurred on April 28 and the 100 DD NOW treatment date using NOW egg traps to set the biofix occurred on April 26. Results from 2014 (Table 2) again indicated that all treatment timings

Figure 2. Peach twig borer and navel orangeworm pheromone trap captures and navel orangeworm egg trap captures, 2013.



significantly reduced NOW infestation and damage, but the earliest timings of Brigade and Delegate tended to have higher NOW infestation and damage than did later timings. Figure 3 shows 2014 trap captures and NOW DD from various starting dates. The 400 DD PTB treatment date occurred on May 4 and the 100 DD NOW treatment date using NOW egg traps to set the biofix occurred on May 12.

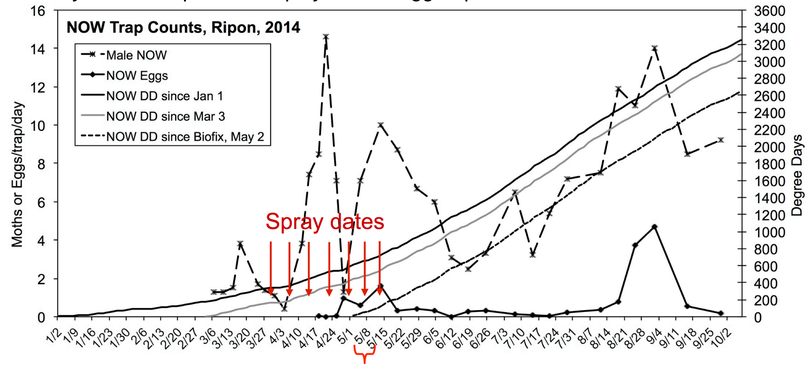
Residues. The almond strand approach described previously was used in 2013 to provide a better estimate of residual activity of 4 of the products, and 176 strands were used. Forty strands were designated for each chemical, and 16 strands for the untreated control. Each week starting April 15, 8 of the 40 strands designated for each chemical were treated with the same rate as in the prior study and hung within the tree canopy of isolated

Table 2. Infestation and damage of almond mummies treated with different registered insecticides at weekly intervals starting at the initiation of oviposition of the overwintering flight of navel orangeworm at Manteca/Ripon, 2014.

Treatment	Spray date	Rate/ac.	Mean ± SD[1] % infestation			Mean ± SD[2] % damage		
Control	n/a	-	11.6	12.2	A	12.9 ± 10.8		A
Altacor	3/27	4 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Altacor	4/4	4 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Altacor	4/11	4 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Altacor	4/21	4 oz.	0.9 ± 2.5		BC	1.3 ± 3.5		DE
Altacor	4/28	4 oz.	0.0 ± 0.0		C	2.1 ± 2.8		CDE
Altacor	5/5	4 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Altacor	5/13	4 oz.	0.9 ± 2.5		BC	0.7 ± 1.9		DE
Belt	3/27	4 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Belt	4/4	4 oz.	0.7 ± 1.9		C	6.5 ± 8.8		BC
Belt	4/11	4 oz.	0.0 ± 0.0		C	1.9 ± 2.7		CDE
Belt	4/21	4 oz.	0.0 ± 0.0		C	0.0 ± 0.0		E
Belt	4/28	4 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Belt	5/5	4 oz.	0.0 ± 0.0		C	0.0 ± 0.0		E
Belt	5/13	4 oz.	0.0 ± 0.0		C	1.3 ± 2.4		DE
Intrepid	3/27	16 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Intrepid	4/4	16 oz.	0.0 ± 0.0		C	0.7 ± 2.0		DE
Intrepid	4/11	16 oz.	0.0 ± 0.0		C	0.8 ± 2.2		DE
Intrepid	4/21	16 oz.	0.0 ± 0.0		C	0.7 ± 1.9		DE
Intrepid	4/28	16 oz.	0.0 ± 0.0		C	1.3 ± 2.4		DE
Intrepid	5/5	16 oz.	0.0 ± 0.0		C	0.0 ± 0.0		E
Intrepid	5/13	16 oz.	0.0 ± 0.0		C	1.3 ± 2.4		DE
Brigade	3/27	16 oz.	5.7 ± 9.1		B	5.7 ± 7.8		BCD
Brigade	4/4	16 oz.	1.4 ± 2.6		BC	7.4 ± 11.5		B
Brigade	4/11	16 oz.	1.0 ± 2.9		BC	3.3 ± 3.9		BCDE
Brigade	4/21	16 oz.	1.7 ± 3.3		BC	1.9 ± 2.6		CDE
Brigade	4/28	16 oz.	2.2 ± 3.1		BC	2.6 ± 2.8		BCDE
Brigade	5/5	16 oz.	0.0 ± 0.0		C	1.9 ± 2.7		CDE
Brigade	5/13	16 oz.	2.1 ± 5.9		BC	1.9 ± 2.7		CDE
Delegate	3/27	7 oz.	2.2 ± 6.2		BC	4.6 ± 5.8		BCDE
Delegate	4/4	7 oz.	0.0 ± 0.0		C	1.9 ± 2.7		CDE
Delegate	4/11	7 oz.	0.0 ± 0.0		C	1.9 ± 2.7		CDE
Delegate	4/21	7 oz.	0.9 ± 2.5		BC	1.9 ± 3.8		CDE
Delegate	4/28	7 oz.	0.0 ± 0.0		C	0.6 ± 1.8		DE
Delegate	5/5	7 oz.	0.0 ± 0.0		C	1.3 ± 2.4		DE
Delegate	5/13	7 oz.	0.0 ± 0.0		C	0.0 ± 0.0		E

[1] ANOVA statistics, F=5.0621, df=35,317, P<0.0001. Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test following arcsine transformation.
[2] ANOVA statistics, F=5.3717, df=35,317, P<0.0001. Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test following arcsine transformation.

Figure 3. Navel orangeworm pheromone and egg trap captures with degree-days from January 1, date traps were deployed, and egg trap biofix, 2014.



roadside olive trees, a non-host for NOW with no obvious sources nearby. All of the strands were transferred to the Ripon almond orchard on May 14. The strands were left in the orchard for 2 weeks, then returned to the lab and held separately by treatment and date until 600 NOW DD were accumulated then cracked. The results are presented on Figure 4. Although these results were not statistically different by ANOV, it is interesting to note after which period damage was first observed; Brigade 2 weeks, Intrepid 4 weeks, Altacor 3 weeks, and Belt 3 weeks.

Figure 4. Average percent navel orangworm damage to nuts pre-treated weekly over a six week period then all exposed to navel orangeworm oviposition for two weeks in an almond orchard near Ripon in May, 2013.