ALMOND INSECT AND MITE RESEARCH

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UC DAVIS ENTOMOLOGY & NEMATOLOGY

Objectives for 2015-16:

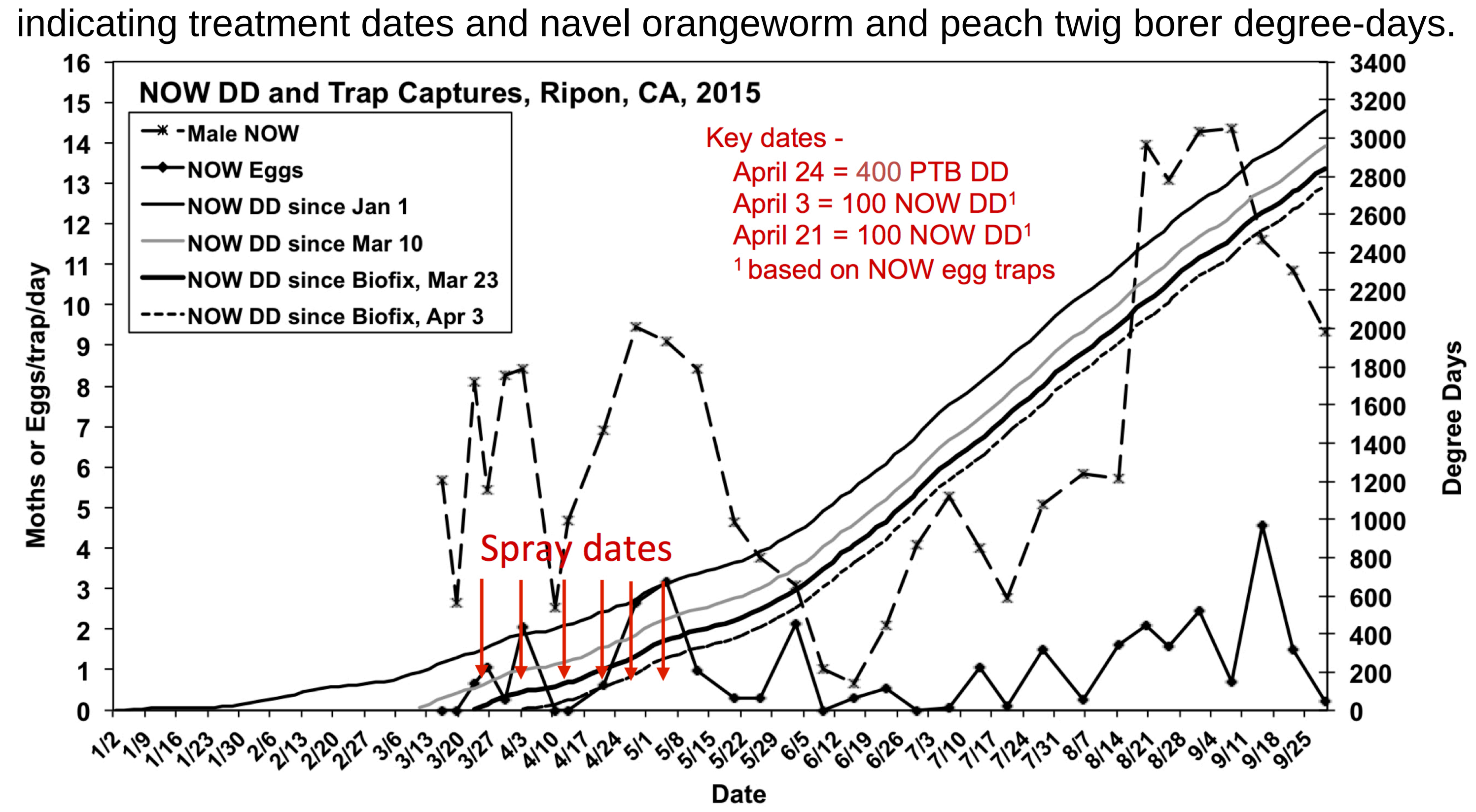
1. Determine treatment timing of chlornitraniliprone (Altacor), flubendiamide (Belt), methoxyfenozide (Intrepid), spinetoram (Delegate), and bifenthrin (Brigade) for NOW control in spring based on comparison of male trap captures using the Suterra NOW pheromone lure and egg-laying using the traditional black egg traps baited with almond presscake.
2. Evaluate residual efficacy of Altacor, Belt, Intrepid, and Brigade.
3. Determine if low temperatures delay mating or oviposition by NOW females.
4. Confirm that mummy nuts that were previously infested in fall are more likely to become reinfested in spring

Background. Navel orangeworm (NOW) remains the key insect pest of almonds in California. New management practices including pheromone mating disruption and insecticides that serve as alternatives to the organophosphates used in the 1970s through early 2000s are now commonly used to compliment cultural controls such as sanitation and early harvest. Indeed, insecticide applications are arguably more justified economically today given the historically high return for almond meats and the desire to produce a crop with exceedingly low damage levels. Research has identified a number of effective reduced-risk products including chlornitraniliprone (Altacor), flubendiamide (Belt), methoxyfenozide (Intrepid), and spinetoram (Delegate) that are assumed to be less disruptive of spider mites than organophosphates or pyrethroids. In addition to the preferred hull split timing for NOW, these products can also reduce NOW damage from the spring flight. This 'May spray' timing offers the potential to obtain some level of control of both NOW and peach twig borer (PTB) as these insects have flights that overlap somewhat in most years. Females of the first NOW flight lay their eggs on the mummy nuts that remain in the orchards, so the infestation of remaining mummy nuts can be quite high and serve as a source of NOW within the orchard that can infest the new crop. The traditional May spray timing recommended for 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 once a relationship between male flight as recorded using the new Suterra NOW pheromone lure relative to egg hatch as monitored with egg traps is established. The recommended PTB treatment timing is at 400 degree-days (DD) after the first females are captured in PTB pheromone traps.

Insect trapping. NOW egg traps, pheromone traps baited with the new NOW Suterra Biolures, and PTB pheromone traps baited with Trece 'long life' lures were hung in March 2015 in almond orchards near Ripon and Manteca, and monitored to determine the spring flights of NOW and PTB. NOW monitoring results for the Ripon site are presented on Figure 1 with notations (in red) for the 100 DD NOW and 400 PTB treatment timings. The NOW flights and oviposition at both sites started early in 2015 presumably due to warmer than normal winter temperatures and suppressed egg trap counts occurring early April. The reduced captures raised a question as to selecting the correct biofix date, so we note two possible biofix dates on this graph with associated DD accumulations. .

Treatment timing. Using the same protocol that we have used successfully for years, twenty uninfested Nonpareil nuts saved from the previous harvest were hot glued to strands of vegetable mesh, and these served as surrogate mummies for\ field studies. In 2015, 400 strands were hung in the orchard March 26 which was also the first of 6 weekly treatment dates (noted on Figure 1).

Figure 1. Navel orangeworm pheromone and egg trap trap captures at Ripon, 2015, indicating treatment dates and navel orangeworm and peach twig borer degree-days.



Eight strands each were treated with either Altacor, Belt, Intrepid, Brigade, or Delegate on each of these dates. Sixteen 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 arcsin 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 March 26 at /Ripon, 2015.

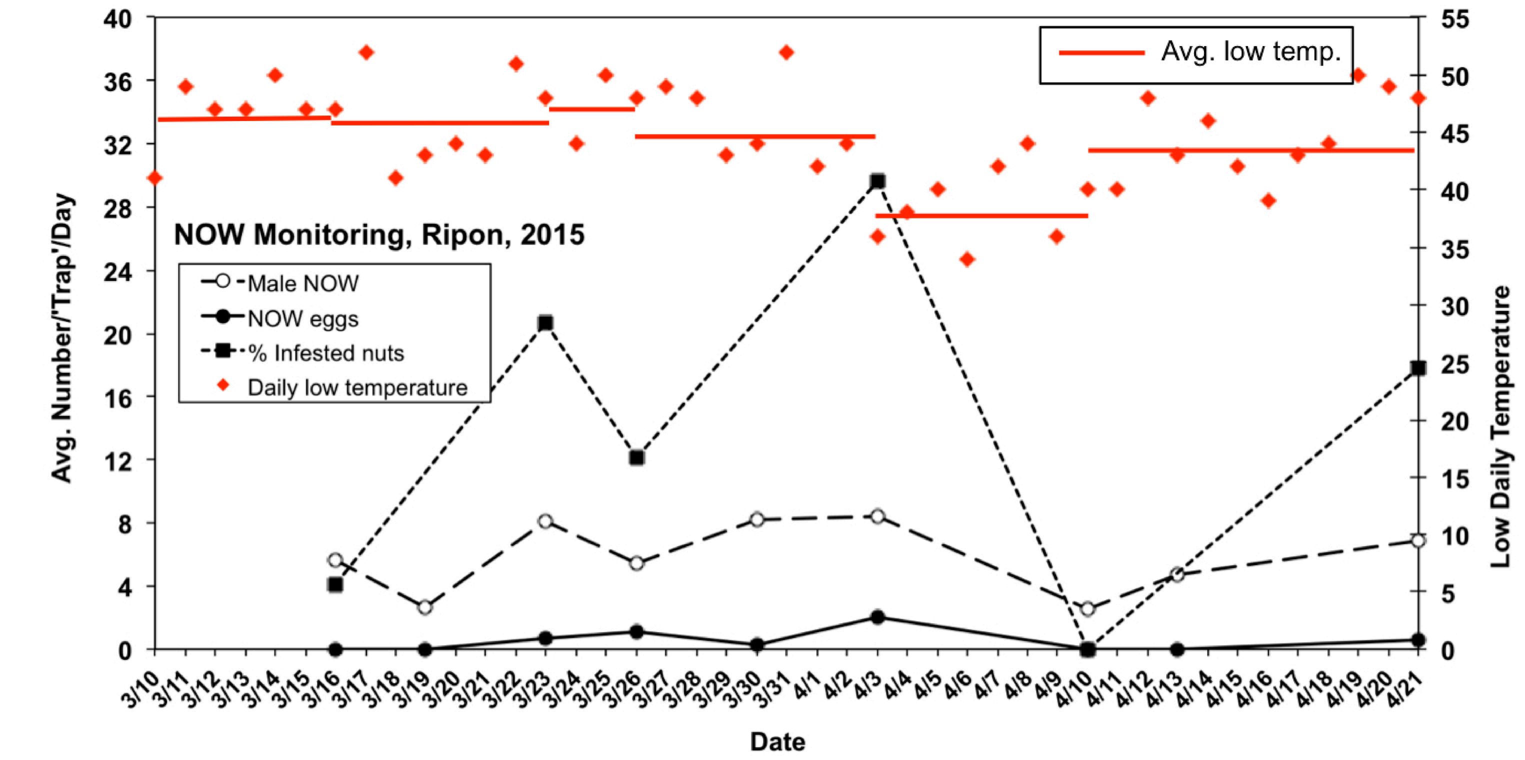
Treatment	Spray date	Rate/ac	Mean + SD[1,2] % infestation				Mean + SD[1,3] % damage			
Control	n/a	n/a	2.01	±	3.39	A	9.35	±	10.72	A
Altacor	3/26	4 oz.	0.00	±	0.00	B	0.96	±	2.72	BCD
Altacor	4/3	4 oz.	0.00	±	0.00	B	0.00	±	0.00	D
Altacor	4/13	4 oz.	1.48	±	2.74	AB	2.95	±	5.48	BCD
Altacor	4/21	4 oz.	0.63	±	1.77	AB	2.02	±	2.80	BCD
Altacor	4/28	4 oz.	0.00	±	0.00	B	1.48	±	2.74	BCD
Altacor	5/5	4 oz.	0.00	±	0.00	B	0.66	±	1.86	CD
Belt	3/26	4 oz.	0.00	±	0.00	B	0.00	±	0.00	D
Belt	4/3	4 oz.	0.00	±	0.00	B	2.22	±	4.54	BCD
Belt	4/13	4 oz.	0.00	±	0.00	B	0.00	±	0.00	D
Belt	4/21	4 oz.	0.83	±	2.36	AB	3.81	±	3.26	BCD
Belt	4/28	4 oz.	0.00	±	0.00	B	2.22	±	3.08	BCD
Belt	5/5	4 oz.	0.00	±	0.00	B	0.89	±	2.53	BCD
Intrepid	3/26	16 oz.	0.00	±	0.00	B	1.14	±	3.21	BCD
Intrepid	4/3	16 oz.	0.00	±	0.00	B	0.78	±	2.21	BCD
Intrepid	4/13	16 oz.	0.00	±	0.00	B	1.52	±	2.81	BCD
Intrepid	4/21	16 oz.	0.00	±	0.00	B	4.71	±	5.27	BCD
Intrepid	4/28	16 oz.	0.00	±	0.00	B	2.17	±	4.34	BCD
Intrepid	5/5	16 oz.	0.83	±	2.36	AB	1.67	±	4.71	BCD
Brigade	3/26	16 oz.	1.67	±	3.11	AB	2.46	±	3.40	BCD
Brigade	4/3	16 oz.	1.25	±	3.54	AB	5.10	±	5.25	BC
Brigade	4/13	16 oz.	0.00	±	0.00	B	0.00	±	0.00	D
Brigade	4/21	16 oz.	1.32	±	2.44	AB	3.59	±	5.04	BCD
Brigade	4/28	16 oz.	1.59	±	2.97	AB	2.28	±	3.19	BCD
Brigade	5/5	16 oz.	2.30	±	4.48	A	5.46	±	5.27	B
Delegate	3/26	17 oz.	0.00	±	0.00	B	0.83	±	2.36	BCD
Delegate	4/3	17 oz.	0.71	±	1.89	AB	1.55	±	2.67	BCD
Delegate	4/13	17 oz.	0.00	±	0.00	B	1.56	±	2.89	BCD
Delegate	4/21	17 oz.	0.00	±	0.00	B	1.73	±	3.20	BCD
Delegate	4/28	17 oz.	0.00	±	0.00	B	0.69	±	1.96	CD
Delegate	5/5	17 oz.	0.00	±	0.00	B	1.67	±	4.71	BCD

[1] Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test
[2] F=1.4936, df=30,265 p<0.0541
[3] F=2.6559, df=30,265 p<0.0001

Results (Table 1) indicated that all treatment timings of all products resulted in lreduced NOW infestation when compared to the untreated control. For all but Brigade, the earlier NOW treatment timing had lower infestation than the later (April 21) timing. The entire orchard was unexpectedly sprayed with Altacor two days iafter the April 28 treatment date.

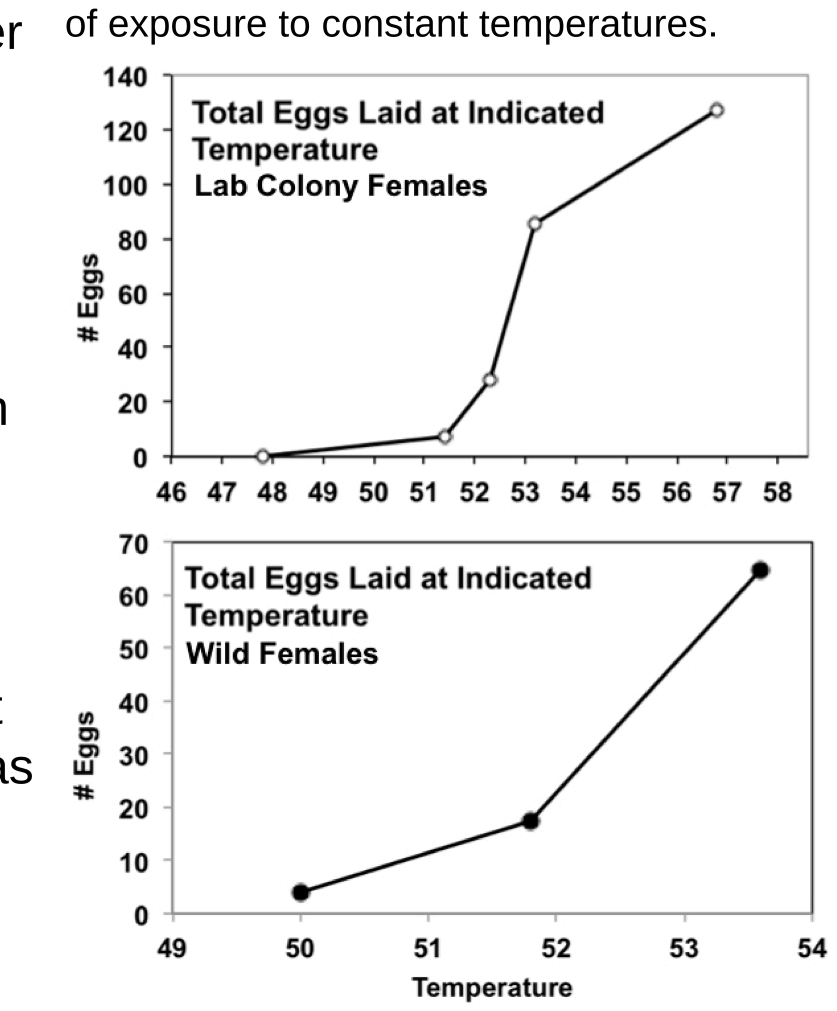
Low temperatures. It is curious that initial male NOW moth captures and the start of NOW egg-laying as indicated by NOW egg traps differed by several weeks to a month in more northernly growing areas in both 2013 and 2014, while the difference was seldom more than a week in the central and southern San Joaquin Valley. One possible hypothesis for this observation could simply be sampling error resulting from the lower levels of NOW eggs laid on egg traps. while another possibility is the generally cooler temperatures occurring during the overwintering NOW flight farther north. Figure 2 presents pheromone and egg trap captures from 2015 together with average number of infested mummy nuts from 10 strands hung during 6 consecutive periods between March 1 and April 21 with associated daily minimum temperatures and average low temperature for each period. Although egg traps at our Ripon site indicated egg-laying in March 2015, no eggs were recorded and no nut infestation was observed during the period from April 3-9 when the average daily minimum temperature was 38.6ºF.

Figure 2. Navel orangeworm pheromone, egg trap trap and almond mummy infestation during successive spring periods at Ripon, 2015, indicating daily minimum temperatures and average low temperatures for each period of mummy deployment.



Temperature cabinet studies with lab cotony and females emerging from field collected nuts indicated that number of eggs laid was reduced when held for 72 hours at constant temperatures below 53.6ºF (Figure 3). Percent fertile eggs produced by lab colony females was reduced from over 67.7% at 57.2ºF to 10.5% at 53.6ºF. Fertility of eggs laid by wild females was below 5% at all temperatures below 53.6ºF

Figure 3. Eggs laid by lab colony and wild navel orangeworm females during 72 hours of exposure to constant temperatures.



Total eggs laid during the first 72 hours after placing 20 virgin NOW females and males from our lab colony at variable temperatures, and percent fertility of those eggs held at 71.6ºF did not show significant reductions at daily conditions as low as 60.8ºF maximum and 41.0ºF minimum (Table 2). However, reductions in total eggs and percent fertility were significant at cooler variable temperature regimes when using NOW emerging from nuts. Additional studies are ongoing to more precisely determine temprature effects on mating and egg laying at critical periods of these activities during the daily cycle.

Table 2. Eggs laid by lab colony and wild navel orangeworm females during 72 hours of exposure to variable temperatures.and fertility of those eggs held at 71.6ºF.

Lab virgin females, variable temperature

Max./Min. Temp (ºF)	Total Eggs Mean ± SD[1]	% Fertility Mean ± SD[2]
60.8/41.0	489.0 ± 198.5	33.7 ± 9.5
64.4/44.6	535.0 ± 125.0	41.1 ± 20.8
68.0/48.2	764.3 ± 250.1	54.4 ± 7.4

[1] F=1.6653, df=2, 8, P<0.2659
[2] F=1.7190, df=2, 8, P<0.2569

Wild virgin females, variable temperature

Max./Min. Temp (ºF)	Total Eggs Mean ± SD[1]	% Fertility Mean ± SD[2]
60.8/41.0	171.3 ± 107.2	15.1 ± 10.2
64.4/44.6	173.0 ± 74.6	32.6 ± 14.5
68.0/48.2	347.3 ± 41.2	62.6 ± 12.5

[1] F=4.9098, df=2, 8, P<0.0546
[2] F=11.0423, df=2, 8, P<0.0098