
Control of Navel Orangeworm (NOW) in Almonds Using Insecticides and Assessing Spray Coverage

Project No.: 12-ENTO11-Siegel/Walse

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Objectives:

1. Persistence of insecticides on nut surfaces:
We will combine bioassay with analytical chemistry to establish both the duration of control and rate of degradation of insecticides on almonds.
2. Relative photostability of insecticides:
We will determine the relative stability of the most commonly used insecticides in almonds using our photolysis chamber. Initially, the stability of these insecticides will be evaluated on glass slides, and once we have perfected this technique, their stability on almonds collected at different times will be assessed.
3. Insecticide penetration into the upper canopy:
In our previous studies we noted a substantial reduction in the number of droplets per square inch at distances greater than or equal to 12 feet. We have established that the use of two nozzles per vane provides superior coverage compared to a single vane and that engine powered insecticide sprayers provide superior coverage to PTO sprayers in almonds, up to 20 feet. This research will be continued with an emphasis on improving penetration into the canopy.
4. Importance of insecticide coverage of the suture/exposed nut:
It has been my contention that coverage of vulnerable areas on the nut (suture crack, exposed shell) is less important than assumed because NOW larvae wander before becoming established. While wandering, larvae are exposed to insecticide on the hull. Field trials will be conducted to specifically address this issue by covering the suture before spraying and then challenging these nuts with eggs. Larval success, measured by adult emergence, will be contrasted with both unsprayed nuts and regularly sprayed almonds from the same block.

Interpretive Summary:

Experiments are currently underway to meet the objectives listed above. Unfortunately, we have not yet begun our photolysis chamber studies of photostability, and we are still conducting our studies on the duration of protection of Nonpareil almonds. We report data

(June - July 2013) on the adult activity, ovicidal/neonate activity, and contact toxicity of four insecticides, including a novel Dow product containing Delegate, Intrepid, Delegate, and Altacor. With the exception of Intrepid, all had substantial adult activity in our assays. Maximum mortality occurred by the third day following exposure, but many moths that were counted as alive at 24 hours were barely responsive to shaking or touch and probably would be killed in the field. Adult activity was greater when the adjuvant Latron B-1956 was included at a concentration of 3.2 ounces per 100 gallons. All insecticides tested had ovicidal activity and substantial contact activity as well. The data on the ovicidal activity of these narrow spectrum insecticides underscores the need to apply these materials early; 3 days early is far better than 3 days late. One percent (1%) hull split is the preferred time for application. In collaboration with other researchers funded by the Almond Board of California, research is underway to document the duration of control of these insecticides in the upper and lower canopy.

Materials and Methods:

Adult mortality was assessed using mesh bags made from window screen, 3 adults of the same sex per bag. The bags were hung near the center of the tree in the canopy at a height of 5 - 6 feet. The moths were sprayed and retrieved 24 hours after they were hung. Adults were scored as living, in distress, or dead. The adults were kept at room temperature and scored at 24-hour intervals until Control mortality exceeded 20%. Differences among treatments were assessed using Chi Square analysis and multiple regression analysis.

Ovicidal activity was assessed using egg masses that were pinned to nuts in the field (50 eggs per mass) and exposed to commercial applications of insecticide. The egg masses were removed after 24 hours, placed on diet and incubated at 80 - 85°F for 3 weeks. Eggs were examined 7 - 9 days after exposure and scored as either a dead egg, dead egg containing embryo (blackhead stage) or emerged. Dead larvae within 2 mm of the egg were also counted to calculate neonate mortality. At 3 weeks, the remaining larvae were counted and overall survival/mortality calculated for each treatment.

Contact Toxicity was assessed by hanging filter papers in the trees, exposing these papers to field applications, and removing the filter papers 24 hours later. The filter papers were cut in half and placed on diet in petri dishes, one half-paper per petri dish. An egg paper containing 50 eggs was then placed on the filter paper so that the newly emerged larvae had to crawl over the treated filter paper. Survival/mortality was assessed 3 weeks after exposure.

Results and Discussion:

Adult mortality following spray exposure 2012 - 2013. Similar trials are currently being conducted in pistachios.

2012

Almonds, July 5, 2012. Dow Research Farm, Fresno County.

Application rate of 200 gallons per acre, 2 mph, 3.2 ounces Latron B-1956 per 100 gallons.

Daytime High of 90.7°F, Night time low of 55.5°F, Kerman-01.P Weather Station

24 Hour Mortality

Treatment	Mortality	Adults
Control	3.08%	162
Intrepid 16 oz/ac	2.29%	102
Altacor 4.0 oz/ac	79.67%	108
Delegate 6.4 oz/ac	79.60%	49

Almonds, August 7, 2012. Dow Research Farm, Fresno County.

Application rate of 200 gallons per acre, 2 mph, 3.2 ounces Latron B 1956 per 100 gallons.

Daytime High of 95.3°F, Night time low of 60.8°F, Kerman-01.P Weather Station

Mortality

Treatment	Time (Hr)	Mortality	Adults
Control	24	34.68%	124
	48	29.75%	
	72	32.23%	
Delegate Mix (16 oz/ac)	24	50.43%	117
	48	51.28%	
	72	66.67%	
Delegate (6.2 oz/ac)	24	66.67%	123
	48	83.33%	
	72	98.33%	
Altacor (3.5oz/ac)	24	32.46%	120
	48	46.67%	
	72	65.83%	

2013

Almonds, June 12, 2013. Dupont Research Farm, Madera County.

Application rate of 200 gallons per acre, 2 mph, 2.0 ounces Latron B 1956 per 100 gallons.

Daytime High of 91.0°F, Night time low of 67.0°F, Madera-T Weather Station

Mortality

Treatment	Time (Hr)	Mortality	Adults
Control	24	0	96
	48	0	
	72	2.01%	
	96	6.25%	
	120	21.87%	
Altacor 3.5 oz/ac	24	11.46%	96
	48	11.46%	
	72	14.58%	
	96	14.58%	
	120	26.04%	
Altacor 4.5 oz/ac	24	24.44%	68
	48	31.11%	
	72	33.33%	
	96	42.22%	
	120	53.33%	

Almonds, June 21, 2013. Grower, Fresno County.

Application rate of 200 gallons per acre, 2 mph, PHT 415 oil at 1.5%, Potassium Nitrate.

Daytime High of 85.0°F, Night time low of 51.0°F, Firebaugh WSFS Weather Station

Mortality

Treatment	Time (Hr)	Mortality	Adults
Control	24	5.10%	98
	48	7.14%	
	72	15.31%	
Delegate Mix Premix 14 oz/ac	24	85.29%	102
	48	95.10%%	
	72	100.00%	
Delegate Mix Tank Mix 14 oz/ac	24	66.67%	126
	48	88.89%	
	72	96.03%	
Altacor 4.0 oz/ac	24	83.87%	93
	48	90.32%	
	72	91.40%	

Almonds, July 2, 2013. Dupont Research Farm, Madera County.

Application rate of 200 gallons per acre, 2 mph, PHT 415 oil at 1.5%, Latron B-1956 at 3.2 ounces per 100 gallons.

Daytime High of 103.0°F, Night time low of 62.0°F, Madera T Weather Station

Mortality

Treatment	Time (Hr)	Mortality	Adults
Control + PHT 415 oil	24	13.58%	87
	48	20.69%	
	72	29.89%	
Altacor 4.5 oz/ac + PHT 415 oil 1.5%	24	20.60%	141
	48	53.00%%	
	72	62.30%	
Altacor 4.5 oz/ac + Latron B-1956 3.2 ounces per 100 gal	24	15.80%	114
	48	60.20%	
	72	68.10%	

**Ovicidal Neonate Activity, Survival at 3 weeks, Contact Toxicity Almonds,
Fresno County
Representative Assay**

Egg strips (50 eggs per strip) were pinned onto almonds and recovered 24 hours later. The strips were laid on bran diet, egg side down, incubated at 80°F, and larvae counted 14-18 days later. Application speed by engine driven sprayer was 2 mph. This assay **does not** assess mortality following ingestion of treated almonds.

Treatment	Dead Egg + Blackhead	Dead Neonate by egg	% Survival	Eggs
Control + PHT 415 1.5%	31	0	95.23	650
Control + Latron B-1956 at 3.2 oz/ac	26	12	94.93	750
Altacor 4.0 oz/ac + PHT 415 oil 1.5%	115	26	79.86	700
Altacor 4.0 oz/ac + Latron B-1956 at 3.2 oz/100 gal	131	10	79.86	700
Intrepid 17.5 oz/ac + Latron B-1956 at 3.2 oz/100 gal	112	26	80.29	700
Delegate 3oz/ac + Latron B-1956 at 3.2 oz/100 gal	92	5	87.07	750
Delegate Mix 14 oz/ac + Latron B-1956 at 3.2 oz/100 gal	109	17	83.20	750
*Delegate Mix 14 oz/ac + PHT 415 oil 1.5%	42	9	93.20	750

*Note that PHT 415 oil at 1.5% eliminated the ovicidal activity of the Delegate Mix

Total survival assessed at 3 weeks

Treatment	Living	Dead	% Survival	Eggs
Control + PHT 415 1.5%	62	588	9.54	650
Control + Latron B-1956 at 3.2 oz/ac	70	580	10.77	650
Altacor 4.0 oz/ac + PHT 415 oil 1.5%	38	662	5.43	700
Altacor 4.0 oz/ac + Latron B-1956 at 3.2 oz/100 gal	19	681	2.71	700
Intrepid 17.5 oz/ac + Latron B-1956 at 3.2 oz/100 gal	20	680	2.86	700
Delegate 3oz/ac + Latron B-1956 at 3.2 oz/100 gal	6	744	0.80	750
Delegate Mix 14 oz/ac + Latron B-1956 at 3.2 oz/100 gal	9	741	1.20	750
*Delegate Mix 14 oz/ac + PHT 415 oil 1.5%	3	747	0.40	750

Contact Toxicity, survival assessed at 3 weeks. Unexposed eggs were placed on treated filter paper (field exposure) and survival assessed at 3 weeks

Treatment	Living	Dead	% Survival	Eggs
Control + PHT 415 1.5%	398	602	39.90	1,000
Control + Latron B-1956 at 3.2 oz/ac	399	601	39.80	1,000
Altacor 4.0 oz/ac + Latron B-1956 at 3.2 oz/100 gal	139	861	13.90	1,000
Intrepid 17.5 oz/ac + Latron B-1956 at 3.2 oz/100 gal	77	923	7.70	1,000
Delegate 3oz/ac + Latron B-1956 at 3.2 oz/100 gal	54	1,146	4.50	1,200
Delegate Mix 14 oz/ac + Latron B-1956 at 3.2 oz/100 gal	399	801	33.25	1,200
*Delegate Mix 14 oz/ac + PHT 415 oil 1.5%	14	986	1.40	1,000

Research Effort Recent Publications:

Manuscripts will be written and submitted after this research and perhaps one more year of trials are included. Experiments of this intricacy require at least two years of field data.