In-Season Insecticide Control of Navel Orangeworm, Relative Photostability of Insecticides and Assessment of Application Coverage

Project No.: **10-ENTO11-Siegel/Walse**

Project Leader: Joel P. Siegel
9611 South Riverbend Avenue
Parlier, CA 93648
(559) 596-2735
(559) 596-2721 (fax)
joel.siegel@ars.usda.gov

Project Personnel:
Spencer Walse, USDA-ARS, SJVASC, CPQ

Cooperators: Gary Weinberger, Weinberger & Associates
James Bettiga, S&J Ranch
Chris Wiley, AgriWorld
Forrest Felger, Britz Inc.
Mike Strmiska, Mike Strmiska Consulting
Thomas Wang, Valley Orchard Management LLC
Barat Bisabri, Dow Chemical Company
Brent Davis, Air-O-Fan

Associated projects*:* Ken Giles, Jim Markle and Franz Niederholzer: insecticide drift project
May Berenbaum: navel orangeworm metabolism of aflatoxin

Objectives:

1. Persistence of insecticides applied at hullsplit on nut surfaces:
   A combination of bioassay and analytical chemistry will be used to establish both the duration of control and rate of degradation of insecticides on almonds.
2. Relative photostability of insecticides:
   The relative stability of the most commonly used insecticides in almonds will be evaluated using a photolysis chamber. Initially, the stability of these insecticides will be evaluated on glass slides, and then their stability on almonds collected at different times after hullsplit will be assessed.
3. Persistence of insecticides on leaves:
   We will collect leaves at intervals from treated almond bloacks, extract the insecticide, and determine its rate of decrease over time.
4. 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. Egg strips and spray cards will be placed in a zone 12 -18 feet above ground in order to assess insecticide penetration and the extent of coverage.

Objectives that were not met:
We experienced a delay in hiring the chemists necessary to conduct the analytical chemistry outlined in the original proposal. We did not meet our objectives for determining insecticide persistence and the rate of insecticide degradation by photolysis. Instead we emphasized bioassays and determined the ovicidal/larvicidal activity of selective insecticides and refined protocols designed to quantify spray coverage at heights from 8 - 20 feet. Research is ongoing on the relationship between insecticide coverage and height.

Interpretive Summary:

Two insecticides, Intrepid® and Brigade® were evaluated in a series of hullsplit field trials. All applications were part of the normal farm operations. Targets consisting of navel orangeworm egg masses were pinned onto Nonpareil almonds immediately before insecticide application and then removed the next day. The emergence/survival for each target was assessed 3 weeks after exposure to the insecticide. At their best, both insecticides provided excellent control in separate trials, with Brigade producing 100% reduction compared to the controls and Intrepid providing 99.13% reduction compared to the controls.

The ability of three selective insecticides to kill eggs was evaluated in a trial conducted at the Dow research farm in Fresno County. Intrepid® was the most lethal and Delegate® was the least lethal insecticide in terms of ovicidal activity. Altacor® was intermediate and equivalent to a mixture of Intrepid and Delegate. In order to maximize the ovicidal activity of these insecticides, they should be applied early (late suture crack or 1% hullsplit) so that eggs are laid on a treated hull. However, egg toxicity is only one route of insecticide activity and this assay did not evaluate either the contact toxicity to larvae or the toxicity of these products when ingested.

Research is continuing in almonds and pistachios on the vertical distribution of insecticides during application (**Figure 1**). At this point, the use of two nozzles at each position in a spray rig appears to significantly improve insecticide coverage. However, these data are still being analyzed and will be summarized next year.

Materials and Methods:

<u>Larval Activity of Intrepid® and Brigade® applied at hullsplit</u>
In Madera County, Nonpareil almonds were collected 1-3 days after an initial application of Intrepid®, 15.4 ounces delivered in 100 gallons per acre, applied at 2.5 mph by tractor. The almonds were brought back to the laboratory and infested, then placed at 50 nuts per 5 gallon bucket incubated at 80°F. Approximately 6-8 weeks after infestation every bucket was checked for adults and all nuts were dissected to count larvae and pupae. (**Table 1**).

Nonpareil almonds were collected as late as 20 days after hullsplit application of Intrepid and 1-3 days after a post hullsplit application of Brigade. The application rate and tractor speed were the same as the previous trial. **Table 2** and **Table 3** show Brigade results.

Targets (paper towel containing 50 navel orangeworm eggs) were pinned onto individual almonds at a height 5-7 feet above the ground. The egg targets were collected on the next day after application and placed on artificial diet and incubated as described above. The ovicidal/neonate activity of Intrepid was assessed by comparing survival at 3 weeks between exposed and unexposed eggs (**Table 4**). The tractor speed and application rate was as described above.

Ovicidal/neonate activity of selective insecticides

The combined neonate and ovicidal activity of several insecticides applied to egg targets in almonds was evaluated at the Dow Research Farm in Fresno County using the procedure above. Egg targets were pinned onto Nonpareil nuts immediately before application, collected post treatment, incubated and ovicidal/neonate activity was assessed 3 weeks after exposure. Controls were pinned onto nuts in an adjacent orchard. The insecticides were applied between 9:30-11:30 A.M. on September 1 at 2 mph at the doses listed in **Table 5**.

Results and Discussion:

Table 1. Survival on almonds collected 1-3 days after application of Intrepid® at hullsplit

Treatment	Live NOW (larvae, pupae, adults)	Total Eggs	Percent Survival
Control	72	1,400	5.14
Treated	60	4,200	1.42

Reduction in survival was 72.2% compared to control survival

Table 2. Survival on almonds collected 1-3 days after application of Brigade® as a post hullsplit spray

Treatment	Live NOW (larvae, pupae, adults)	Total Eggs	Percent Survival
Treated	23	5,750	0.40

Table 3. Survival on almonds collected 7-10 days after application of Brigade® as a post hullsplit spray

Treatment	Live NOW (larvae, pupae, adults)	Total Eggs	Percent Survival
Treated	0	2,400	0

Table 4. Ovicidal/neonate activity of Intrepid® as measured by larval survival 3 weeks after treatment

Treatment	**Living**	**Survival**	**Reduction***	**Total Eggs**
Control	1,226	87.57% A		1,400
Intrepid	29	0.76% B	99.13%	3,800

Table 5. Ovicidal/neonate activity of selective insecticides as measured by larval survival 3 weeks after treatment

Treatment (per acre)	Living	Survival	Reduction*	Total Eggs
Control	1,133	49.26% A		2,300
Delegate 6.4 oz	401	13.37% B	72.86%	3,000
Delegate 3.2 oz.+ Intrepid 9 oz	70	3.41% C	93.08%	2,050
Intrepid 18 oz	33	1.83% D	96.29%	1,800
Altacor 4 oz.	55	3.54% C	92.81%	1,550

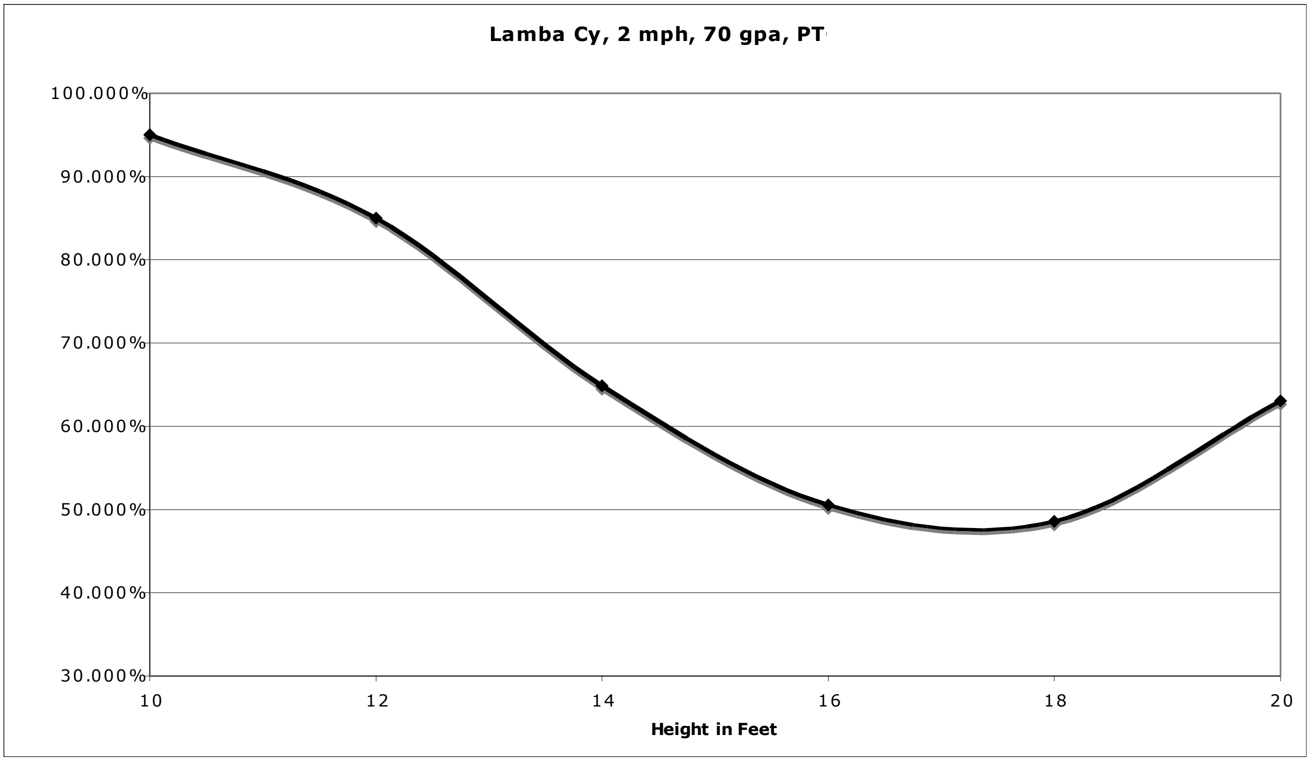
*Reduction is relative to the Control survival at 3 weeks of 49.26%
Means separated by a different letter differ at $P < 0.0001$

In the application efficacy/coverage trials (**Tables 1-4**) there is some variability between trials, which may be due to an application speed of 2.5 mph; the recommended speed is 2.0 mph. At its best, the reduction attributable to the insecticides tested was 99.1-100%. However, the difference between 72.2% reduction and 99.1% reduction may be the difference between a successful treatment and failure.

In the ovicidal/larvicidal trial, Intrepid was the most effective insecticide, reducing survival by 96.3% and Delegate was the least effective, reducing survival by 72.9%. When the two were combined there was no additivity or synergism, despite two different modes of action, and Delegate appeared to dilute the effect of Intrepid. Larvicidal insecticides impact navel orangeworm at several points in the life cycle, egg, neonate larva exiting the egg, neonate larva tunneling into the thost, and it is possible that Delegate may be as toxic or more toxic than Intrepid when ingested. In order to take advantage of the excellent ovicidal activity of Intrepid, this insecticide should be applied early so that eggs are laid on a treated hull.

The experiment summarized by **Figure 1**, although conducted in pistachios, illustrates the challenge of producing uniform insecticide coverage. In this trial coverage decreased with height, and at 16 feet coverage was only half of what was obtained at 10 feet. The breakdown in coverage only intensifies at higher application speeds.

Figure 1. The relationship between insecticide efficacy and height in pistachios. The pyrethroid Lambda Cy was applied at 2 mph and 70 gpa using a PTO rig.



Research Effort Recent Publications:

Higbee, B. S. and Siegel, J. P. New navel orangeworm sanitation standards could reduce almond damage. Calif. Agricul. 63 (1):24-28. 2009.

Niu, G., Siegel, J. P., Schuler, M. A. and Berenbaum, M. R. Comparative toxicity of mycotoxins to navel orangeworm (*Amyelois transitella*) and corn earworm (*Helicoverpa zea*). J. Chem Ecol. 35(8):951-957. 2009.

Kuenen, L. P. S., and Siegel, J. P. Protracted emergence of overwintering *Amyelois transitella* (Lepidoptera: Pyralidae) from pistachios and almonds in California. Environ. Entomol. 39 (4): 1059-1067. 2010.

Siegel, J. P., Kuenen, L. P. S., and Ledbetter, C. Variable development rate and survival of navel orangeworm (*Amyelois transitella*, Lepidoptera: Pyralidae) on wheat bran diet and almonds. J. Econ. Entomol. 103 (4): 1250-1257. 2010.

Niu, G., Rupasinghe, S. G., Zangerl, A. R., Siegel, J. P., Schuler, M. A., and Berenbaum, M. R. A substrate-specific cytochrome P450 monoxygenase, CYP6AB11, from the polyphagous navel orangeworm (*Amyelois transitella*). Insect Biochem. Mol. Biol. 41: 244-253. 2011.

Burks, C. S., Higbee, B. S., Siegel, J. P., and Brandl, D. G. Comparison of trapping for eggs, females and males of the navel orangeworm *Amyeolis transitella* (Walker) in almonds. Environ. Entomol. 40(3): 706-713. 2011