Improving Spray Deposition and Reducing Drift in Almond Orchards

Project No.: **13-WATER3-Giles/Markle**

Project Leader: Ken Giles
Department of Biological & Agricultural Engineering
UC Davis
One Shields Ave.
Davis, CA 95616
530.752.0687
dkgiles@ucdavis.edu

Project Cooperators and Personnel:
Franz Niederholzer, UCCE – Colusa, Sutter, and Yuba Counties
Brad Higbee, Paramount Farming Co., Bakersfield, CA
Jim Cook, Colusa County Farm Supply, Colusa CA
Joel Siegel, USDA/ARS, Parlier, CA
Jim Markle, Coalition for Urban/Rural Environmental Stewardship, Davis CA

Objectives:

The overall goal of this project is to improve spray deposition in almond trees, with the result of increased pest control efficacy and application efficiency while reduction in any undesirable environmental effects of pesticide spraying. The specific objectives were to integrate improved sprayer design, specifically a retrofit tower sprayer, into commercial use and to document mechanical and pest control performance from the sprayer and to evaluate the performance in spray deposition and pest control from commercially available sprayers under different operating conditions.

Interpretive Summary:

A conventional air-blast (“speed”) sprayer was modified by adding a vertical tower to support hydraulically-powered fans with additional spray nozzles at or near the tops of mature almond trees. By adjusting the size and pressure of spray nozzles, 50% to 70% of the applied spray could be focused in the tree tops, in an effort to improve spray deposition and pest control in the hard-to-reach areas. In this season, the sprayer was placed in commercial grower applications in Lost Hills and Maxwell, CA. The sprayer proved to be mechanically robust and durable and no significant failures occurred. Pest control (insecticide for navel orange worm in hull split sprays) results were encouraging and found that 100 gal/acre applied with the tower-modified sprayer provided results similar to 150 to 400 gal/acre applied by common ground sprayers; deposition from the tower sprayer was highest, compared to other application methods, in the 14 to 16 ft height range. The sprayer was also integrated into a season-long, grower-scale test of fungicide spray application methods for Alternaria control. Results are currently being evaluated. An experiment was conducted to compare spray deposition from a 50 gal/acre air shear sprayer application (3.3 mph ground speed) and a 150 gal/acre application (1.75 mph ground speed) using an axial fan sprayer. Spray deposition was similar

between the application methods; however, the higher-volume, lower ground speed application provided better pest control.

Materials and Methods:

Tower sprayer experiments:

A conventional axial-fan, air blast sprayer (PTO-powered) was modified as described in the 2012-2013 Almond Board of California (ABC) Final Report. Under previous season funding, a graduate student design project developed, fabricated and installed a retrofit tower for a conventional axial fan sprayer (**Figure 1**). This sprayer was used for both the insecticide spray trials in Lost Hills, CA (Paramount Farms) and the fungicide spray trials in Maxwell, CA (Emerald Farms).

In the insecticide spray tests, the tower sprayer was integrated into an application tests involving aerial application (helicopter) and ground application (three different sprayer methods) applying Rynaxypyr (Altacor, DuPont) at maximum label rate against navel orange worm. The spray applications methods are shown in **Table 1**. Note that some of the treatments (Nos. 1, 2 and 3) were combinations of aerial + ground applications. Also note that the tower sprayer was the lowest application volume of any ground or ground + aerial application method. In the early hull split period, when more deposition was desired in the upper parts of trees, the sprayer volume was configured for 70% from tower / 30% from lower fan; for the later hull split spray, when more deposition was desired in the lower parts of trees, the sprayer was configured for 50%/50% tower and lower fan spray.

Table 1. Spray application conditions for insecticide testing (Paramount Farming Co).

NOW Spray Coverage Trial - Almond - 2		R323							
Code	**Treatment Regime**	**Early HS appl**	**Rate (oz/ac)**	**mph**	**gals/ac**	**Post HS Appl**	**Rate (oz/ac)**	**mph**	**gals/ac**
1	Helicopter, AOF Hollow Cone	Helicopter	1.5	30	30	None			
		AOF	3	2.5	200	None			
2	Helicopter, AOF Hollow Cone	Helicopter	1.5	30	30	Helicopter	1.5	30	30
		AOF	3	2.5	200	AOF	3	2.5	200
3	Helicopter, AOF Hollow Cone	Helicopter	2.25	30	30	Helicopter	2.25	30	30
		AOF	2.25	2.5	200	AOF	2.25	2.5	200
4	Helicopter	Helicopter	4.5	30	30	Helicopter	4.5	30	30
5	Prog Ag 18 ft tower - 4 heads	Prog Ag	4.5	3	150	Prog Ag	4.5	3	150
6	Heli/AOF Hollow Cone	Helicopter	4.5	30	30	AOF	4.5	2.5	200
7	AOF Standard (2010) 2.0	AOF	4.5	2	200	AOF	4.5	2	200
8	Control	None				None			
9-1	UCDavis 16 ft. tower	Tower 70:30	4.5	2	100	Tower 50:50	4.5	2	100
9-2,3	AOF 400	AOF	4.5	2	400	AOF	4.5	2	400

Figure 1. Tower sprayer preparing to enter the fungicide experimental block in Maxwell, CA.

In the fungicide spray application tests, the tower was configured for a 50%/50% spray configuration and the following application were made throughout the season:

1/5/14:	Delayed Dormant – Helicopter
2/10/14:	Pink Bud – 1st Tower Sprayer
3/6/14:	Petal Fall – Helicopter (wet orchard)
3/28/14:	Pre-rain – Helicopter
4/17/14:	5 Weeks Post Petal Fall – 2nd Tower Sprayer
6/4/14:	"June Spray" BASF "Merivon Program - 3rd Tower Sprayer
7/9/14:	Hull Split + BASF Nealta Miticide + Belt (NOW) - 4th Tower Sprayer

Four applications were made by the tower sprayer. Tower sprayer applications were also paired with the "grower standard" Progressive Ag electrostatic sprayer.

Existing spray technology experiments:

A spray trial was conducted at the Nickels Soil Lab near Arbuckle, CA to evaluate spray coverage and navel orangeworm control using three sprayer configurations at hull split in a late pollinizer variety ('Fritz'). Spray deposition and pest (navel orangeworm; NOW) control was assessed after application using the following the use of 2 sprayers set up for 3 different sprayer configurations:

- Axial fan, air-blast sprayer (John Bean Spraying Co., 500 gallon tank, 36" fan, PTO driven; 143 gpa, 1.75 MPH, 170 psi system pressure)
- Air-shear, air-blast sprayer ***with*** electrostatic droplet charging (Progressive Ag, Model 2250, PTO driven; 50 gpa; 3.3 MPH and 30 psi system pressure).
- Air-shear, air-blast sprayer ***without*** electrostatic droplet charging (Progressive Ag, Model 2250, PTO driven; 50 gpa; 3.3 MPH and 30 psi system pressure).

Individual 8th leaf Fritz on Lovell trees planted in a 16' x 22' spacing in a mixed planting (75% Non-pareil, 25% Fritz) were sprayed using each of the sprayer configurations between 9:30 PM and midnight on September 11, 2013. Temperatures and relative humidity ranged from 62-71^{o}F and 65-82%, respectively, during application. Details for spray solution contents for all applications appear in **Table 2**. Ten percent difference in pesticide and tracer rate per acre was due to an error in tractor speed calculation at calibration.

On Day 1 and Day 14 after spraying, 50 nuts, each, were sampled from upper (15-20') and lower (5-7') canopies of individual treated trees. Nuts from untreated Fritz trees in an adjacent block of the same age were also sampled on both dates. Samples were placed on ice and transported to Dr. Joel Siegel's lab at the USDA ARS research facility in Parlier, CA, where they were exposed to NOW eggs under controlled conditions as reported previously. Navel orangeworm eggs were separately pined to hulls or tucked into the suture split. The government shutdown in fall, 2013 compromised the lab evaluation of Day 14 samples, and no results are available from that timing.

On Day 1 after spraying, leaf and nut samples from the upper and lower canopy of each sprayed tree as well as control trees were taken. In the lab, leaf and hull surface areas were measured and specific leaf and hull weights determined from surface areas and dried sample weights. The dried tissue samples analyzed for molybdenum (Mo) by the UC Davis Plant Sciences Department Lab. Tracer results were calculated as micrograms of Mo per square centimeter of leaf or hull.

Table 2. Comparison of spray volumes and pesticide rates for Arbuckle spray tests.

Sprayer	Spray volume	DowAgroSciences Delegate® WG insecticide	Molybdendum tracer rate	Molybdendum tracer concentration (ppm Mo)	Adjuvant (Wilbur-Ellis Sylgard ® 309)
Air shear airblast sprayer (Progressive Ag, Model 2250)	50 gpa	7 oz/acre	1.5 pints/acre	193	3 oz/100 gallons
Axial fan airblast sprayer (John Bean Redline)	143 gpa	8 oz/acre	1.7 pints/acre	59	3 oz/100 gallons

Results and Discussion:

Tower sprayer experiments:

The Lost Hills insecticide spray trials were assessed by measuring spray coverage on water sensitive cards and also by measuring insecticide residue and navel orangeworm infestations on nuts. Spray "coverage", as measured by water sensitive paper, is shown in **Figure 2**. Data for 18 ft and above were not collected for the tower sprayer because the tower was shorter than that height and no deposition would be expected.

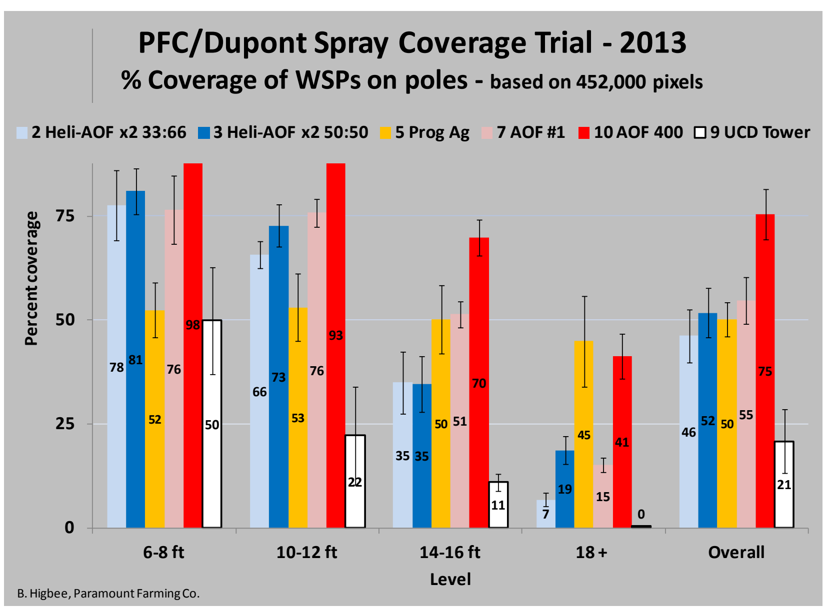

Figure 2. Spray coverage results for application methods described in **Table 1**.

The results showed that the tower sprayer achieved lower coverage results in the upper elevations of the tree. However, it should be noted that the tower sprayer was applying the lowest volume (100 gal/acre) compared to the other ground treatments (150 to 230 gal acre). Therefore comparisons based on surface area coverage cannot be made directly.

Insecticide residue results are shown in **Figure 3**. These results indicate that the tower sprayer achieved the highest residues of any treatment in the upper (12 – 16 ft) regions of the trees and also achieved some of the most uniform (i.e., variation with elevation) deposition. Results from evaluation of infested nuts are shown in **Figures 4** and **5**. In these cases, it can be seen that the tower sprayer provided some of the best pest control as measured by infested nuts in the Nonpareil and also all varieties. As with the water sensitive paper coverage results, it is important to consider that the tower spray applications were at the lowest ground spray volume (100 gal/acre) and therefore the highest concentration of active ingredient in carrier.

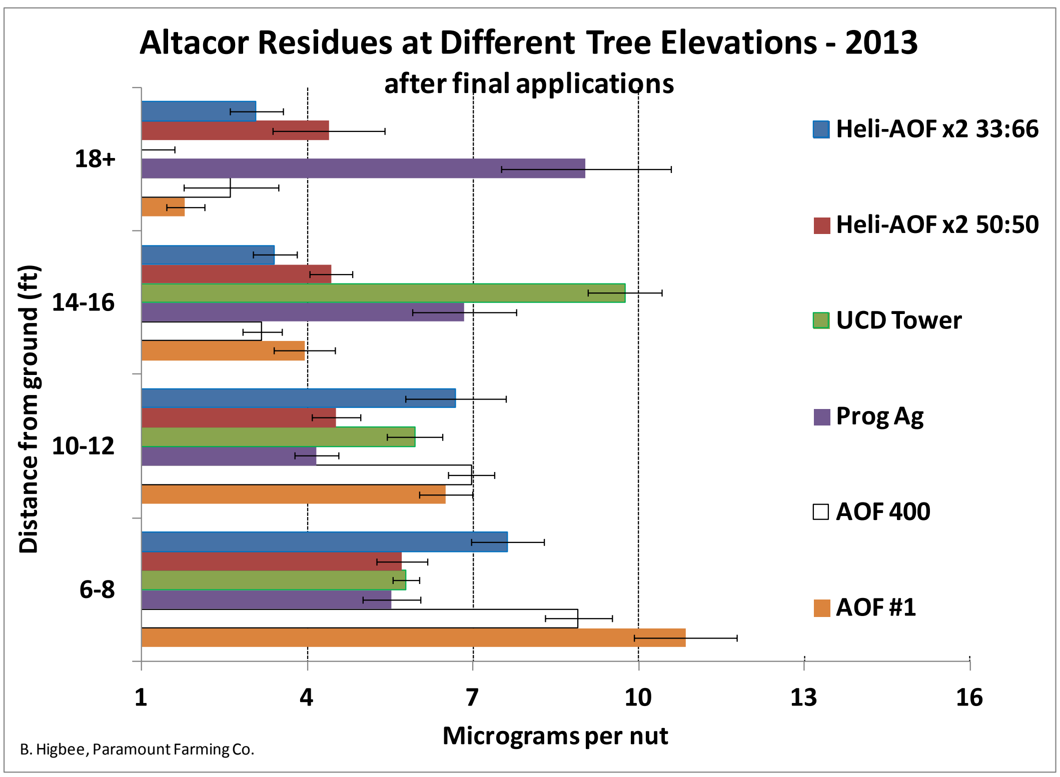

Figure 3. Spray residue results for application methods described in **Table 1**.

Overall, the performance of the tower sprayer, in a large-scale commercial production evaluation was very encouraging. Spray residue and pest control results indicated that the tower spray method was among the best performance. Moreover, the mechanical performance was also encouraging in that the sprayer was operated by the grower's operators and no failures, due to design or operation occurred. (One small failure of the hitch occurred prior to spraying and was easily repaired in the field.)

Results from the season-long fungicide spray trial are still being collected through harvest and will be reported when available.

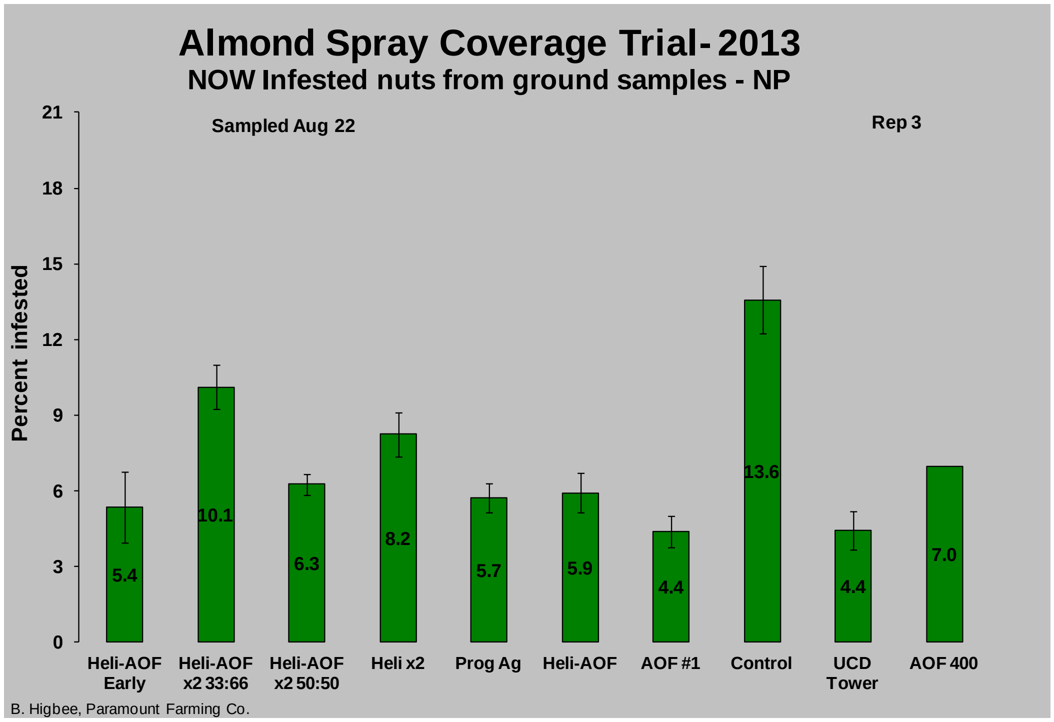

Figure 4. Nut (Nonpareil) infestation results for application methods described in **Table 1**.

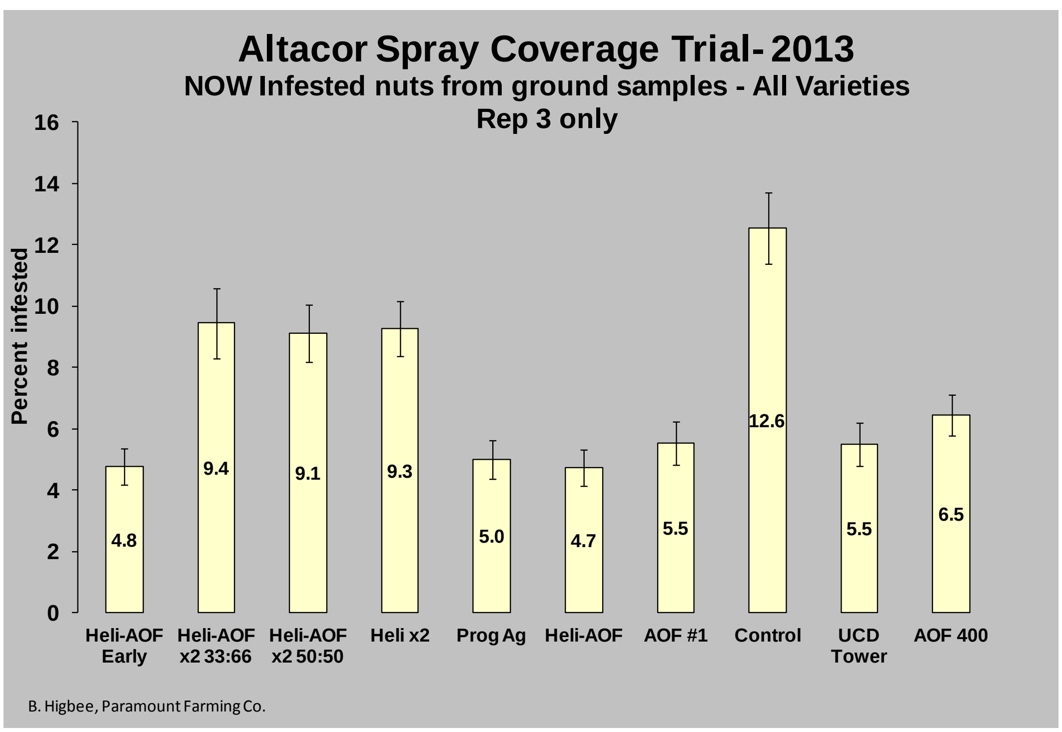

Figure 5. Nut infestation results for application methods described in **Table 1**.

Existing spray technology experiments:
Leaf and hull tracer deposition for all treatments were not significantly different in the upper canopy (**Table 3** and **4**). In the lower canopy, spraying with the airshear sprayer, with or without electrostatic droplet charging, improved leaf and hull Mo concentrations compared with the axial fan airblast sprayer (**Table 3** and **4**). There was no difference in NOW larvae survival between the air shear sprayer treatments (with or without electrostatic charging), so the results from those treatments were pooled. There were no differences between treatments when eggs were pinned to the hulls (<0.1% survival) and results are not presented. For eggs tucked into the suture split, NOW larval survival was significantly less (better pest control) with the axial fan airblast sprayer vs airshear airblast sprayer in both the lower and upper canopies (**Table 4**).

Table 3. Comparison of molybdenum deposits (µg Mo per cm^2 leaf) on 8^{th} leaf 'Fritz' almond leaves in upper and lower tree canopies following applications described in the text. There is a 95% chance that data in the same column are significantly different if they do not share a letter, based on Tukey's HSD test.

Sprayer Treatment	Leaf Mo deposition - Upper canopy	Leaf Mo deposition- Lower canopy
Standard axial fan airblast sprayer	0.06 a	0.03 a
Airshear sprayer ***without*** electrostatic	0.06 a	0.08 b
Airshear sprayer ***with*** electrostatic	0.06 a	0.08 b

Table 4. Comparison of tracer deposits (µg Mo per cm^2 hull) and (%) navel orangeworm (NOW) larvae survival on 8th leaf 'Fritz' nuts sampled from upper and lower tree canopies one day after applications and methods described in the text. There is a 95% chance that the tracer data (ppm Mo) in the same column are significantly different if they do not share a letter, based on Tukey's HSD test.

Sprayer Treatment	Hull Mo deposition - Upper canopy	% NOW survival - Upper canopy	Hull Mo deposition - Lower canopy	% NOW survival - Lower canopy
Standard axial fan airblast sprayer	0.06 a	1.64% a	0.09 a	0.19% a
Airshear sprayer ***without*** electrostatic	0.07 a	3.20% b	0.15 b	1.01% b
Airshear sprayer ***with*** electrostatic	0.05 a	--**	0.18*	--**

*not included in stats analysis due to variable data. ** Results pooled with those from airshear sprayer without electrostatic for this analysis.

From the tests of existing technology, the following conclusions were drawn:

- At lower spray volumes and faster ground speed, the air shear sprayer – with or without electrostatic charging – provided similar or improved leaf and hull deposition compared to conventional, axial fan airblast sprayer in the same region of the canopy.
- Higher volume, slow ground speed spraying with conventional axial fan airblast spraying provided better pest control when NOW eggs were placed in the suture -- a hard-to-reach area of the nut – compared to low volume, high ground speed spraying with an airshear airblast sprayer with or without electrostatic charging. This improved pest control was obtained with a lower pesticide concentration in the spray solution and similar or reduced tracer deposition on the hulls using the axial fan airblast sprayer compared to the air shear sprayer.
- Tracer data was not representative of pest control observed in this study. This indicated the importance of including pest control evaluations in sprayer trials.

Acknowledgements:

The work reported under this project represents an extensive degree of collaboration from growers, material suppliers, registrants, cooperating researchers and equipment suppliers. The efforts and resources of Brad Higbee (Paramount Farming Co.), Jim Cook (Colusa Country Farm Supply) and Joel Siegel (USDA/ARS) were critical to the productivity of this project. Thanks to Rick Fortier, almond grower, for the loan of his electrostatic sprayer for the Arbuckle experiment and Mark Ryckman, Progressive Ag. Inc., for guidance and expertise in calibration and set up of the electrostatic sprayer used at Arbuckle. Additionally, the sprayer design and fabrication by Andrew Dasso, former graduate student at Bio. & Ag. Engineering, UC Davis, have proven to be superior and exceeded the expected design life.