Pest Management: Fine-tuning Spray Efficacy

December 8, 2016
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Brad Higbee, Wonderful Orchards
Joel Siegel, USDA-ARS, Parlier
Matt Strmiska, Adaptiv
Ali Pourreza, University of California
Survey
Almond Spray Application
Almond Conference, Sacramento CA
December 6-8, 2016

googl/bghXzy
10 Questions - 3 Minutes

Alireza Pourreza
CE Advisor
Agricultural Engineer Kearney
Agricultural Research & Extension Center

Franz Niederholzer
Farm Advisor
Orchard Systems
Cooperative Extension
Sutter-Yuba Counties

University of California
Agriculture and Natural Resources
1. What is your main relationship to agriculture industry?

- Grower
- PCA or CCA
- Supplier (fertilizer, pesticides, seed, machinery, etc.)
- Regulation/policy
- Scientist/researcher
- Other: ________________________________
2. What is your age?

- 24 or younger
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- 65 - 74
- 75 years or older
3. Who do you contact most often to obtain spray technology/application information?

- University academics (Advisors, Specialists, Faculties)
- PCAs or other industry reps
- Other growers
- Family
- Not Applicable
4. Which of the following concepts are familiar for you? (Select all that apply)

- Precision Agriculture
- Variable rate technology/application
- Prescription map
- Yield map
- GPS (Global Positioning System)
- GIS (Geographic Information Systems)
- Remote Sensing
5. What kind of sprayer equipment do you own/use? (Select all that apply)

- [ ] Air Blast Sprayer
- [ ] Tower attachment
- [ ] Other:
6. Rank the following issues in almond spray application based on their priorities and importance?

|                | Slightly important | Medium important | Very important |
|----------------|--------------------|------------------|               |
| Coverage       | ○                  | ○                | ○             |
| Efficacy       | ○                  | ○                | ○             |
| Calibration    | ○                  | ○                | ○             |
| Drift          | ○                  | ○                | ○             |
| Penetration    | ○                  | ○                | ○             |
7. What practice have you conducted to improve spray coverage, and how it worked?

<table>
<thead>
<tr>
<th></th>
<th>Coverage improved</th>
<th>Coverage did not change</th>
<th>Coverage declined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slower speed</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Higher air pressure</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Smaller droplet size</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Use of tower sprayer</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
</tbody>
</table>
8. Is the status quo in spray application sustainable?

- Yes
- No
- I am not sure
9. On a scale of 1 to 5, how satisfied are you with your current spray application?
10. What is your preferred way of receiving information from UCCE?

☐ Personal Contact

☐ Printed Material

☐ Electronic form (Email, e-newsletter, blog, website)

☐ Smartphone application

☐ Educational Video

☐ Online training tool

☐ Field day and workshop

☐ Podcast
Optional

Email
Your answer

First name
Your answer

Last name
Your answer
Thank you very much for your time!
Brad Higbee,
Wonderful Orchards
Navel Orangeworm Control in Almonds – the Challenge of Delivering Residues to the Target Site

Bradley S. Higbee
Director, Entomology Research
Wonderful Orchards
Bakersfield, CA
brad.higbee@wonderful.com
NOW Control in Almonds

- Past – heavy reliance on Ops, then pyrethroids
- Current – pyrethroids less effective
- Diamides, IGRs, MD
  - Primarily ovi-larvicides
  - Target site for residues is the almond hull/nut
  - Suspected problems
    - Canopy density
    - Spatiotemporal dynamics of hull splitting (=susceptibility)

Currently Available AIs in Almonds

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>IRAC Number</th>
<th>MOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bifenthrin</td>
<td>3</td>
<td>Sodium channel modulators</td>
</tr>
<tr>
<td>Lambda-cyhalothrin</td>
<td>3A</td>
<td>Sodium channel modulators</td>
</tr>
<tr>
<td>Chlorantraniliprole</td>
<td>28</td>
<td>ryanodine receptor modulators</td>
</tr>
<tr>
<td>Flubendiamide</td>
<td>28</td>
<td>ryanodine receptor modulators</td>
</tr>
<tr>
<td>Methoxyfenozide</td>
<td>18</td>
<td>ecdysone receptor agonists</td>
</tr>
<tr>
<td>Spinetoram</td>
<td>6</td>
<td>chloride channel activators</td>
</tr>
<tr>
<td>Emamectin benzoate</td>
<td>5</td>
<td>nicotinic acetylcholine receptor agonists</td>
</tr>
</tbody>
</table>
Spray Coverage in Almonds 2010-2016

• Objectives:
  – Characterize and quantify spray coverage at various elevations and positions within the tree canopy.
  – Test and compare ground speeds, spray volumes, nozzling, adjuvant type and concentration, airspeed, and machine type (engine drive, PTO, tower, etc) in an effort to improve performance of the residual insecticides used in this test against NOW.
  – The standard used to compare against each year is the Air-O-Fan (AOF) engine drive (D2-40) at 2 mph delivering about 200 gals/acre.
Application Variables

- Residue Placement on the nut
- Sprayer Speed
- Shadowing
- Hull Split %
- Sprayer type
- Hull Split by Variety
- Electrostatics
- Tower
- Nozzle Type
- Fan Air Speed
- Spray Timing
- Tree Density
- Spray Mixture
- Temperature
- Gallons/Acre
- Number of Sprays
- Spray Pressure
- Adjuvant Rate
- Adjuvant type
- PHI
- Droplet Size
- Spray Coverage
- Redistnution (or not)
Evaluation

Analysis of spray coverage included 3 measures

- Water sensitive papers (% coverage)
- Product residue on nuts (micrograms/nut)
- Efficacy (% infestation or damage)

Each year, 1,500 – 2,000 individual nuts analyzed for product residues, 200-400 WSPs scanned, and 150,000+ nuts dissected for infestation and damage.

1. Water sensitive paper is great for a qualitative assessment
2. Residue analysis on nuts quantifies product placement
3. Efficacy is where the rubber meets the road, but you need the first 2 to understand how to get there

Spray Coverage comes in many varieties

- For NOW and the products tested, residues must be deposited on the hull/nut
Machines Tested 2010-2014

Air-O-Fan D-240
200 gals/ac @ 2 and 2.5 mph

Progressive Ag 2650

Progressive Ag 3 head
2650 w/ 16 ft tower

Bell 206
30 gals/ac @ 30 mph

Progressive Ag Tower
150 gals/ac @ 3 mph

Blueline Accutech
10 head tower
Machines Tested 2015

- Rears PTO 38” Fan
- Curtec AC 1000 TRX cone jet nozzles
- Progressive Ag Tower
- Air-O-Fan D-240 Disc and core hollow cone
- Air-O-Fan 232 PTO 1000 gal tank Hollow cone
- Air-O-Fan D-240 TRX cone jet nozzles Maximal configuration
Machines Tested 2016

- Rears PTO 38” Fan
- ZeferSpray PTO TRX cone jet Nozzles – 4/fan
- Progressive Ag Tower - PTO Air
- Air-O-Fan D-240 Disc and core hollow cone
- Air-O-Fan D-240 TRX cone jet nozzles Minimal configuration
- Air-O-Fan 232 PTO 1000 gal tank
- Nelson-Hardie PTO 34” twin fans
# Experimental Variables Targeted – 4 Seasons

<table>
<thead>
<tr>
<th>Variable</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray Volume (GPA)</td>
<td>50, 200</td>
<td>50, 200</td>
<td>150, 200</td>
<td>30, 150, 200, 400</td>
</tr>
<tr>
<td>Sprayer Speed (mph)</td>
<td>1.5 – 4</td>
<td>2 – 4</td>
<td>2 - 3</td>
<td>2 – 3 (30 H)</td>
</tr>
<tr>
<td>Spray Nozzle Type</td>
<td>Disc/Core, Air Shear</td>
<td>Disc/Core, Air Shear</td>
<td>Disc/Core, Full Cone, Flat Fan, Air Shear</td>
<td>Disc/Core, Air Shear</td>
</tr>
<tr>
<td>Nozzle Configuration</td>
<td>Varied</td>
<td>5 configs of Disc/Core</td>
<td>Varied</td>
<td>Varied</td>
</tr>
<tr>
<td>Adjuvant</td>
<td>LI-700@0.125%</td>
<td>LI-700@0.25%</td>
<td>Dyne-Amic@0.5%</td>
<td>Non-Ionic@.125%</td>
</tr>
<tr>
<td>Spray Timing</td>
<td>Single Spray @ 1 - 5%</td>
<td>Single Spray @ 1 - 5% HS</td>
<td>2 Sprays (1 mo apart) 2%/50%</td>
<td>2 Sprays (1 mo apart) 1%/60%</td>
</tr>
<tr>
<td>Vertical Spray Proportion</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Multiple Applications</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Summary 2010 – 2014 Trials

- First 4 years of testing showed that spray coverage in the upper ½ to 1/3 of trees was limited
  - Towers helped improve upper tree coverage significantly, but lower canopy coverage was not as good as the standard AOF.
  - NOW Infestation levels highest (3-4x) in upper half of canopy

- Application Variables such as nozzle type, adjuvant, droplet size did not have significant impacts on efficacy
  - Small positives with full-cone nozzles, using dual spray booms with small hollow cones, DyneAmic adjuvant (2012), electrostatic at 3 mph

- Number of Applications an important factor
  - 2012 -13 had a solid increase in performance with 2nd spray
  - Residues were relatively stable and are additive

- Damage reductions typically 15-25% with a single application in initial trials vs. 55-60% with two applications in subsequent tests.
Air-O-Fan Spray Coverage (2 sprays)

- Extremely rugged design
- 100 mph, Hi Volume air
- Nozzle flexibility a plus
  - Multi-Boom

2013 Trial

<table>
<thead>
<tr>
<th>Altacor® Residue (micrograms/nut)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>% infested</td>
<td>20</td>
<td>8</td>
<td>5.8</td>
<td>5.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* WSP mean values do not indicate individual papers
Challenging Coverage Due To Shadowing, Angle

- Lower branches/leaves block spray targeting upper level
- Too many nozzles targeting lower level – restrictive radius
- Proportional nozzle sizing? – largest in red (Did not help)
- Begs for a short tower
**Electrostatic Tower Spray Coverage (2 sprays)**

- Multi-head Towers – Very Good Coverage
- 10,000 Volt Charge – small droplets
- High Velocity Air (200 mph)
- Higher Speed: 3-4 mph
- Air shear

2013 Trial

* WSP mean values do not indicate individual papers
B. Higbee,
Wonderful Orchards
100% Coverage by Dipping Nuts

Each nut numbered

Mix spray solution

Dip nut for 5 secs

NP dipped at each spray timing (3x)
Mo only dipped at final spray timing (1x)

Determine maturity status

B. Higbee, Wonderful Orchards
At each of the 3 spray application timings, 300 NP nuts were dipped for 5 secs in the spray tank solution.

Interior trees, 5-6’ from ground.

% NP split:
- June 19 = 0%
- July 17 = 66%
- July 24 = 94%

Aug 17 - % NOW NP
- Damage = 26% vs 2% = 92.3% reduction

Many dead neonates on treated nuts (96.4% vs 7.4% of larvae were dead)

Therefore: Under heavy pressure, the best this 3 spray program can achieve is 2% damage, or a reduction of 92%!

B. Higbee, Wonderful Orchards
### Total Residues - 2016

**Day 3 mean for whole tree**

- **Dipped Silwet**: 210 micrograms per nut
- **Dipped Act 90**: 190 micrograms per nut
- **Nelson PTO**: 100 micrograms per nut
- **Prog Ag Tower**: 80 micrograms per nut
- **Rears PTO**: 70 micrograms per nut
- **AOF 2.0 TXR**: 60 micrograms per nut
- **AOF PTO**: 50 micrograms per nut
- **Dipped Act 90**: 40 micrograms per nut
- **ZeferSpray fixed...**: 30 micrograms per nut
- **AOF 2.0**: 20 micrograms per nut

**Day 3 Alta + Intrep**
Almond Spray Coverage Trial- 2015
NOW Infested nuts from ground samples - NP + Mo

Sampled 8/22 and 10/2

57 - 71% Reduction

F= 52.31
p< 0.0001
Tukey-Kramer

B. Higbee, Wonderful Orchards.
Spray Coverage

- Under the conditions of the 2015 trial (≈ 30% infestation, 3 sprays) max potential is 92% damage reduction
- The standard ground application @ 2 mph (AOF) remains the among the best. But, above 12 ft there is a severe dropoff in coverage and residue deposition.
- PTO based machines look as effective as engine drive
- Large arrays of XTR (AKA Cone-jet) nozzles did not provide any significant advantage at 2 mph, but may have potential at higher speeds (4 mph in this trial)
- The Progressive Ag tower is a top performer, but not sig better than the standard AOF application

B. Higbee, Wonderful Orchards.
Spray Coverage (cont)

• Residues from serial applications are additive and relatively stable
• Helicopter applications in combination with ground applications did increase residues in the upper canopy, but did not result in greater damage reduction relative to the standard AOF application.
• The addition of a 3rd spray increased damage reduction up to 80%  
• Hulls splitting after application are likely an impediment to 100% control

B. Higbee, Wonderful Orchards.
Keep your equipment well maintained and calibrated properly
Acknowledgements

Dupont Crop Protection – Ray Kazmarcyck
Wonderful Orchards
WO Entomology Research Group

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Emmanuel Higuera    Johnny Magana
Kyle Lemucchi       Sarah Gooder
Eddie Placentia     Cristian Higuera
Vince Phillips      Ricardo Trigueros
Assessing Spray Coverage

Joel P. Siegel, USDA-ARS, SJVASC, CPQ
9611 South Riverbend Avenue, Parlier
Thanks to DuPont for sponsoring this research, also Dow AgroSciences, Almond Board of California, Pistachio Research Board

Work done in collaboration with Matt Strmiska, Adaptiv
Learning
To deal
With loss
Half-life
Pretend that the dose needed for control is 10 units
Chemical has a half life of 7 days
You want 28 days of control
You need to deposit at least 4 half lives of material, or
160 units
Go for the most challenging zone: the suture
Survival, Suture vs Hull:
1.24X greater in suture

With insecticide:

$T_0 = \text{NO Difference}$

$T_{14} = 1.8X \text{ increase in survival,}$

$P < 0.0001$

46,610 eggs, 4,661 almonds
How much reaches target?

Vertical Component
Other ways to measure?
My contribution

• Addition of Biological Targets
**Aerial Bifenthrin + Cypermethrin (Mustang) Sept 11, 12.5 oz/ac total, 20 gpa**  
Contact Mortality **GOOD**

<table>
<thead>
<tr>
<th>Height</th>
<th>Mortality</th>
<th>Eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>57.2%</td>
<td>1,150</td>
</tr>
<tr>
<td>10</td>
<td>66.5%</td>
<td>400</td>
</tr>
<tr>
<td>12</td>
<td>68.3%</td>
<td>400</td>
</tr>
<tr>
<td>14</td>
<td>82.0%</td>
<td>400</td>
</tr>
<tr>
<td>16</td>
<td>84.0%</td>
<td>400</td>
</tr>
<tr>
<td>18</td>
<td>87.0%</td>
<td>4600</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>70.1%</strong></td>
<td><strong>7,350</strong></td>
</tr>
</tbody>
</table>
Ultimate Combination

Frank Zalom, UC Davis
How much reaches target?

Assume 90% loss
Pretend that an Acre is a Flat Carpet

4,046,856,000 mm² (= 1 acre)
Start with Altacor at 4.5 oz/ac:
= 44,650,515,000 nanograms applied
= 11.033 nanograms/mm²
Whole Nut: 1,596.4 nanograms at 15 feet; 1.11 nanograms per mm$^2$
Loss is 89.97%

Intact Shell: 202.1 nanograms per nut
Loss is 87.3% compared to whole nut
Using 1,441.9 mm$^2$ as area of hull

Total loss compared to tank: 98.78% or only 1.22% reaches suture
Filter Paper Theory:
11.03 nanograms mm$^2$

Recovery: 0.997 nanograms mm$^2$

Loss is 90.97%

Filter Paper in Suture:
0.33 nanograms per mm$^2$

Loss is 67.3% compared to filter paper outside

Total loss compared to tank:
97.05% or 2.95% reaches suture
Loss is 97.1 - 98.8 %
Only 1.2 – 3 % of applied material reaches suture!!!
Matt Strmiska, Adaptiv
The 80/20 Rule of Spraying
How To Get More From What You Own

Matt Strmiska
Adaptiv
Pareto Principle

It is easy to get started and see immediate results, but investing 4x the effort will double your results.

- 5% Effort: 40% Results
- 10% Effort: 63% Results
- 20% Effort: 80% Results
Effort In Understanding Factors Of Spray Quality

- Method
- Weather
- Equipment
- Operator
- Product
- Target

Catalog 51
Leaders in precision application components, control system technology, and application data management.
Thinking About Air

- Slower Air: Spray Wraps
- Faster Air: Spray Deflects

Diagram:
- Spray over target
- Drenching
- Gaps
- Blow through
- Spray under target
Applying Air with Effort

If you’re assuming what you want is happening, then your assumption is incorrect.

The air must adequately reach your target.

Waste as little air as possible when reaching your target.
These cards represent a range of results and are correlated ($P = .0003$) with percent kill of Naval Orangeworm in contact toxicity bioassays.
Samples taken at 13 feet
1 to 2 mph winds
Minimal prune: 20’ tall almonds

Card Rating 1
10 volts measured 6 inches from tip
PTO LectroBlast 36” 4mph - 50gpa

Card Rating 2.5
20 TXR nozzles 70psi
PTO Rears 33” 2.7mph - 100gpa

Card Rating 3
56 TXR nozzles 115psi
PTO Air-o-Fan 2/32” 2.7mph - 100gpa

Card Rating 4
56 TXR nozzles 115psi
Engine Air-o-Fan D40R 2.7mph - 100gpa

Effort With Machine Selection

Effort With What You Own

Spray Height Feet
Rears 33" 2.7mph 130gpa DC (old pitch blades)

Desired Level

Spray Height Feet
Rears 33" 3.3mph 100gpa 20TXR (new max pitch blades)
Effort With What You Own

- **AOF GB36R 2.5mph**
  - 120gpa 36TXR

- **John Bean 44" 2.5mph**
  - 105gpa 36TXR 1700RPM

- **John Bean 44" 2.5mph**
  - 105gpa 20TXR 2100RPM
2014 Summary

25 Treatments Evaluated by USDA

Engine Drive

PTO Drive

4.5oz/ac Altacor

2.0 mph

46 NOW Treatments Evaluated by USDA

Percent Kill

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

6' 10' 15' 20' 25'

71% 78% 69% 67% 57%

67% 54% 55% 39%

Thank you!

Matt Strmiska
Info@AgSprayHelp.com
Questions?