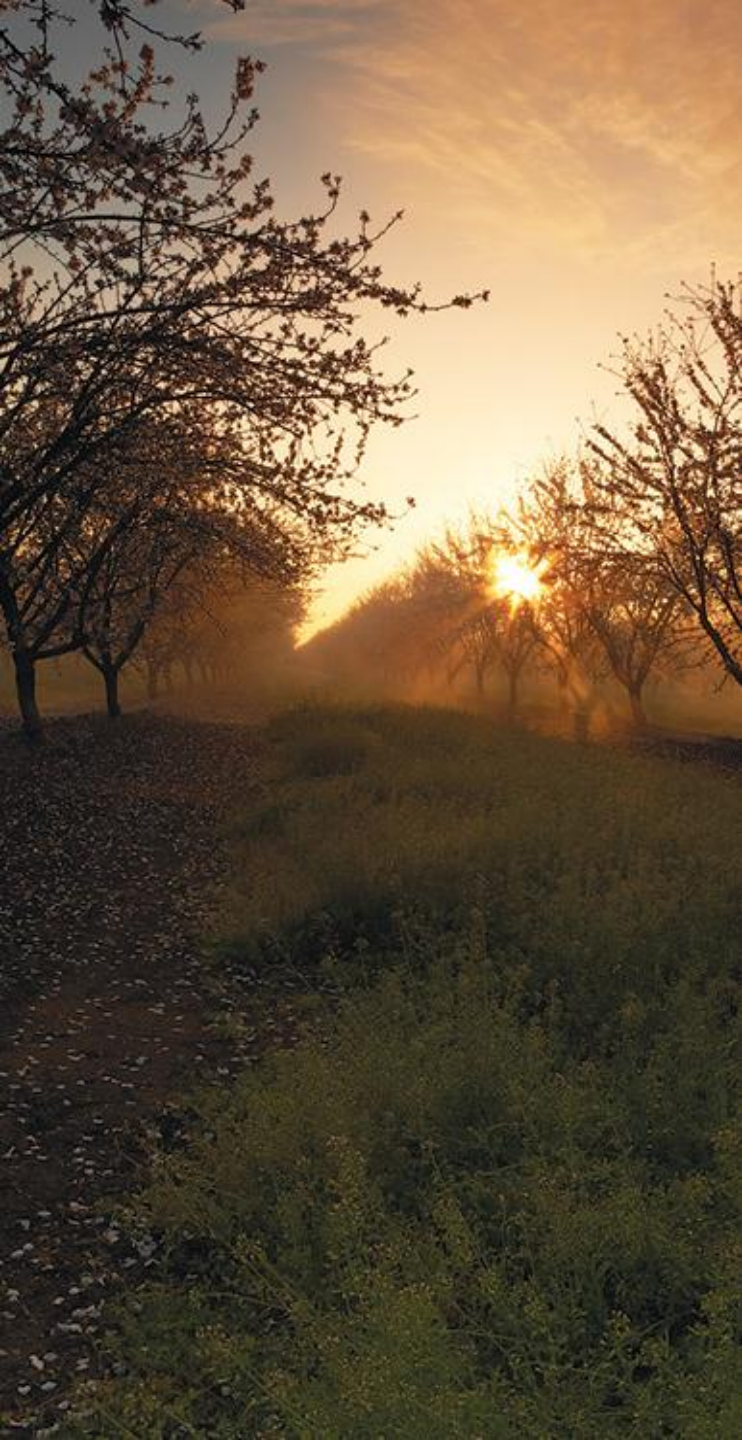
Spray Coverage: The Missing Link in PM



Spraying Basics: Safe, Effective, Efficient and Sustainable.

Franz Niederholzer

U.C. Farm Advisor

Colusa/Sutter/Yuba Counties

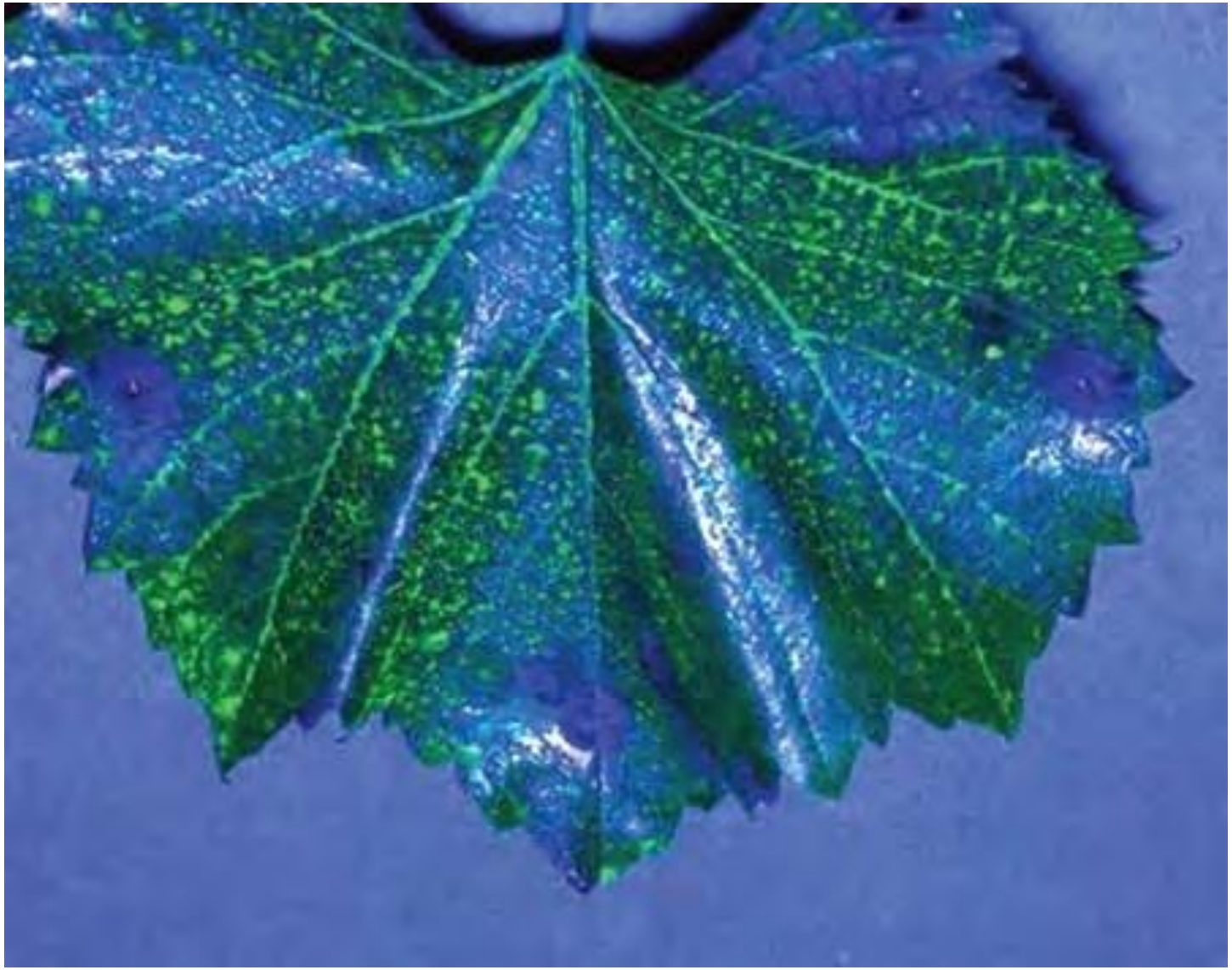
Efficacy

Objectives In Almond Spraying

Slide concept: Dr. Ken Giles, UC Davis

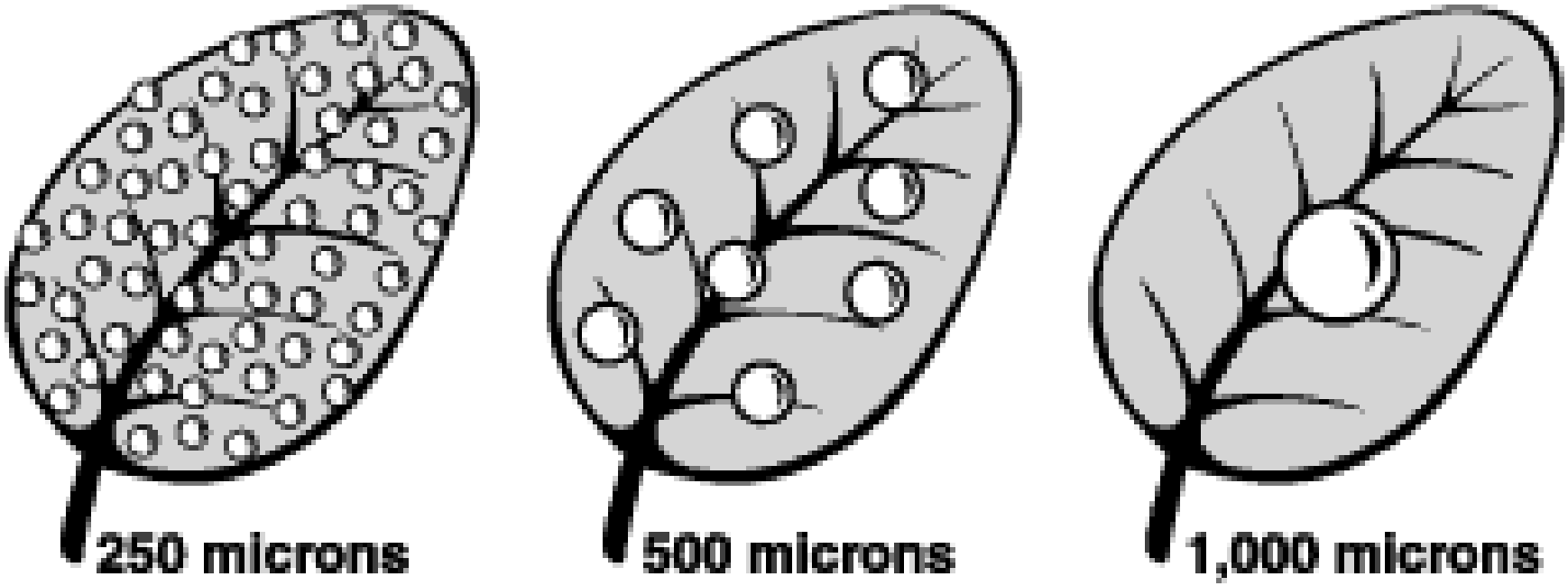
Talk Objectives

- **Review basic spraying terms and conditions**
- **Review optimization of conventional airblast sprayers for pest and drift control in almonds**



A. Landers, Cornell Univ.

Droplet Size and Surface Coverage



NDSU Agriculture Communication

Droplet diameter (µm)	drops/cm² from 1 liter volume	Fall time from 10' height
10	19,099	17 min.
20	2387	240 sec
50	153	40 sec
100	19	11 sec
200	2.4	4 sec
500	<0.5	2 sec

	68°F 80% RH	86°F 50% RH
Droplet size (initial)	Time to dry	Time to dry
50 µm	**14** sec	**4** sec
100 µm	**57** sec	**16** sec
200 µm	**227** sec	**65** sec

G.A. Matthews, Pesticide Application Methods 3rd ed.

Where to start for good coverage?

- D4-6
- 25 (2 hole) swirl plates
- 125 – 150 psi

Where to start for drift control?

- D8-12
- D25 (2 hole) swirl plates
- 125 – 150 psi
- Less sprayer fan air?
- More spray volume to compensate for larger droplets?

Practices that improve pesticide deposition on the target crop **also** reduce potential for pesticide drift and pesticide runoff from the orchard.

Calibration is an important legal and logistical step.

Basic Calibration

$$GPA = GPM/APM$$

$$GPA = \frac{\text{Spray rate}}{\text{Land rate}}$$

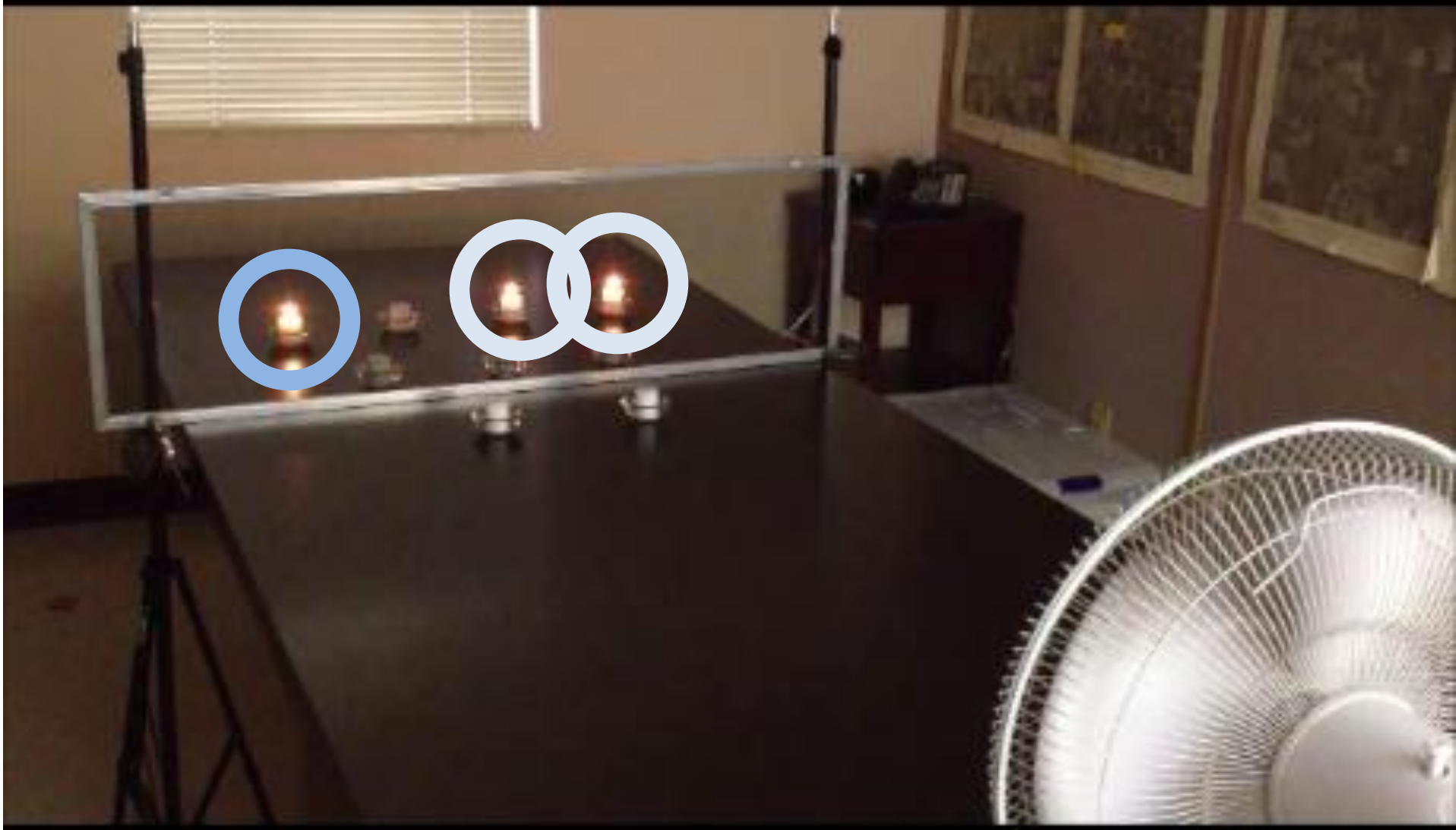
Accurate calibration does not insure effective coverage.

Basic equipment adjustments for spray targeting

- Air flow (direction/volume)
- Droplet size/spray volume
- Nozzle orientation

Air blast sprayers are air-carrier sprayers

Sufficient air volume is needed to move the spray thought out the target canopy...

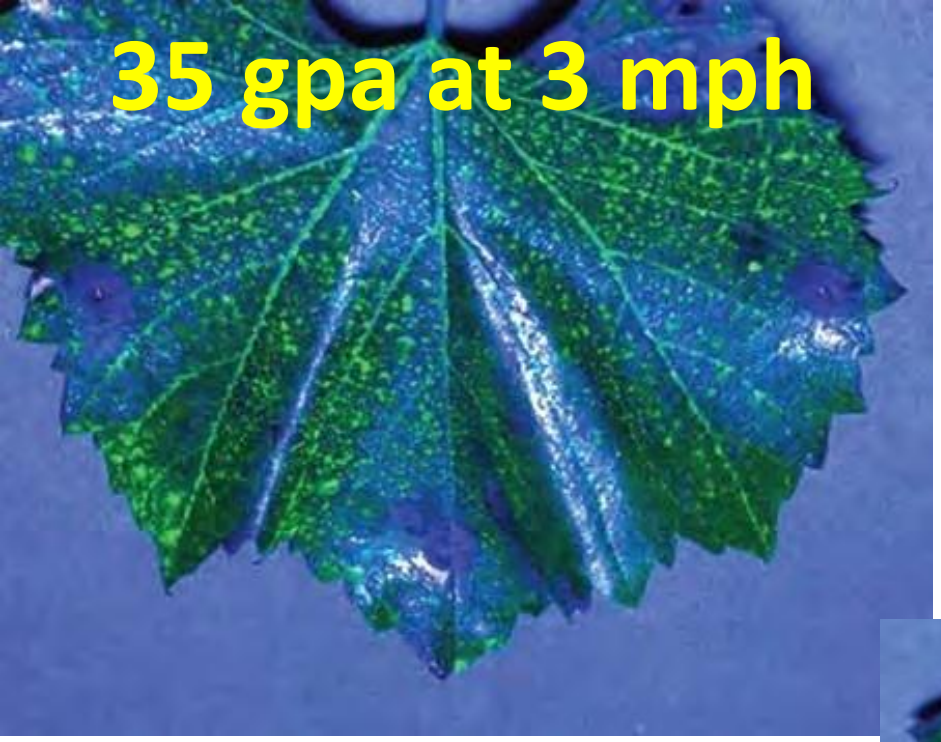


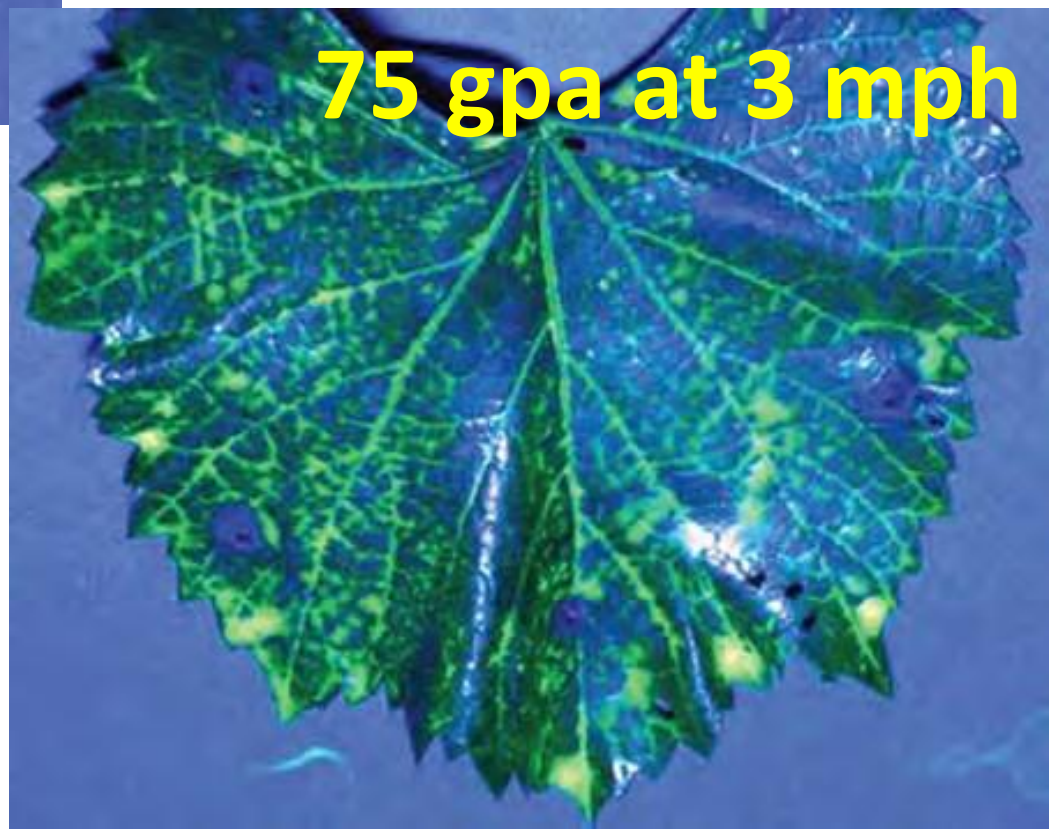
Air blast sprayers are <u>air-carrier</u> sprayers

Sufficient air volume is needed to move the spray thought out the target canopy...

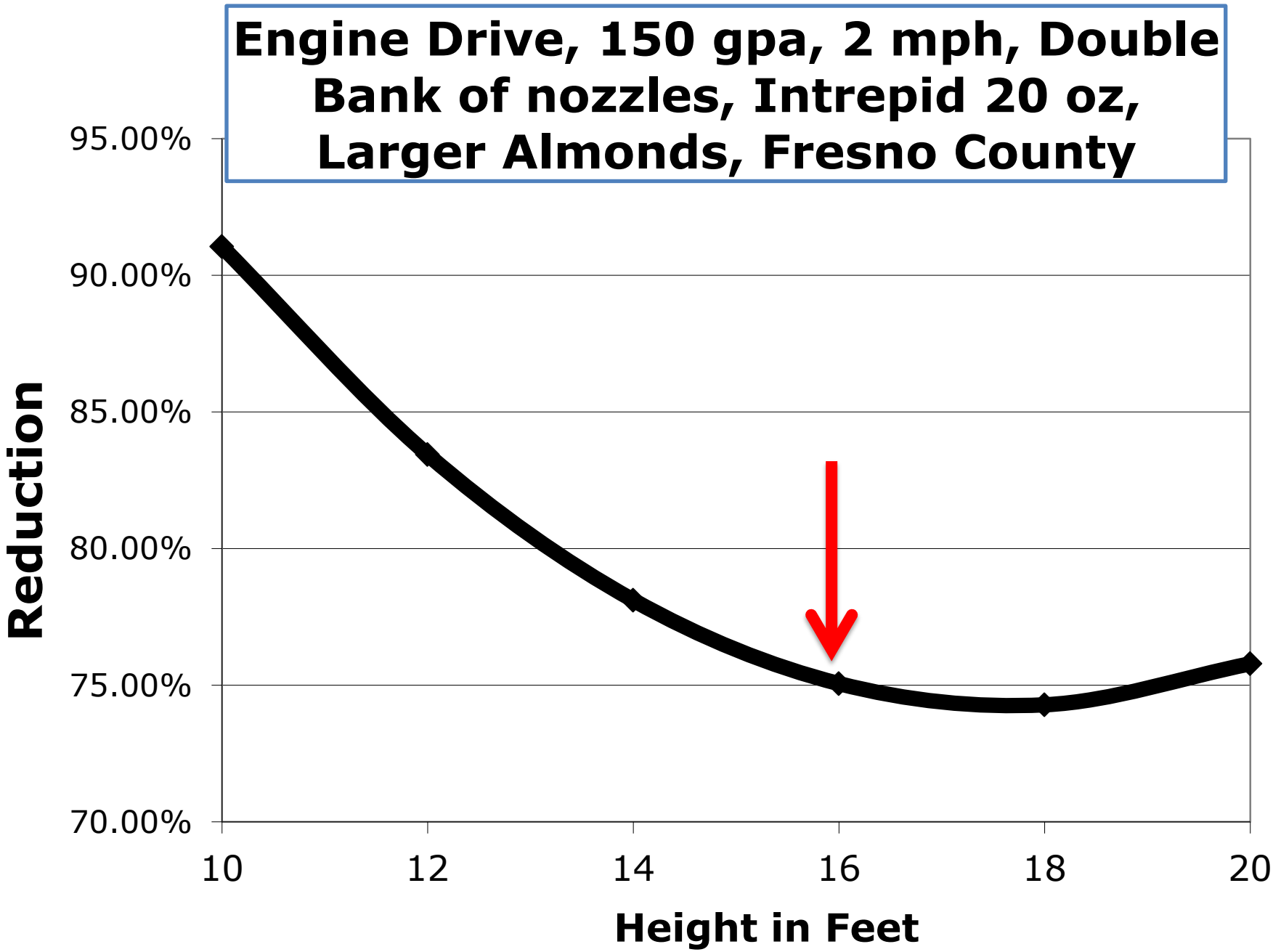
but no further

Spray Volume





A. Landers, Cornell Univ.

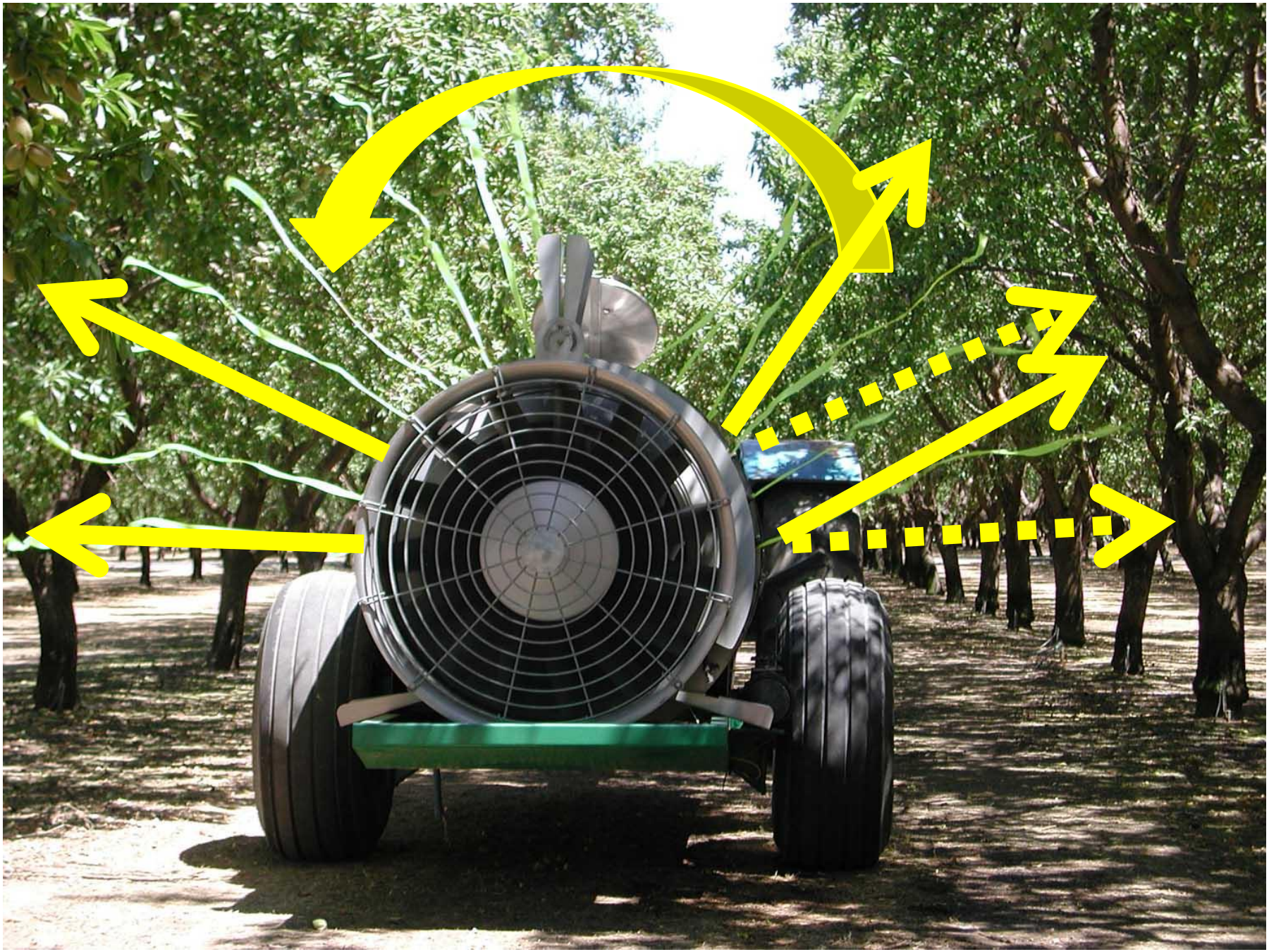

Engine Drive, 150 gpa, 2 mph, Double Bank of nozzles, Intrepid 20 oz, Larger Almonds, Fresno County
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
Reduction
10
12
14
16
18
20
Height in Feet

Loss with Height Variable Degradation

150 gpa
Better than
100 gpa

Just going from 1.8 to 2.2 mph reduced volume by 32%

Nozzle adjustment/placement



How do you check for proper tree coverage?

- Water
- Surround™
- Water sensitive paper
- Food coloring and photographic paper

Review

- Proper calibration (dial-in GPA)
- Balanced air delivery
  - Light on air early in the season
  - Full air as the canopy closes
- Sufficient volume to give good coverage once adequate carrier air is delivered
- Nozzle selection and orientation to effectively and efficiently target the canopy

Thank you

Evaluation of Insecticide Efficacy and Spray Coverage in Mature Almond Orchards – Kern County

Bradley S. Higbee
bradh@paramountfarming.com
Paramount Farming Co.
Bakersfield, CA, 93306

PARAMOUNT
FARMING COMPANY

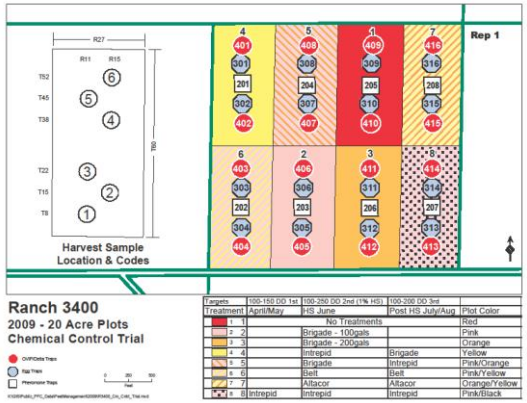
Navel Orangeworm Biology

- Pyralidae
- Highly polyphagous
- Primary pest of almonds and pistachios
- High dispersal capacity
- Multivoltine
- **Oviposition and feeding directly on nut**

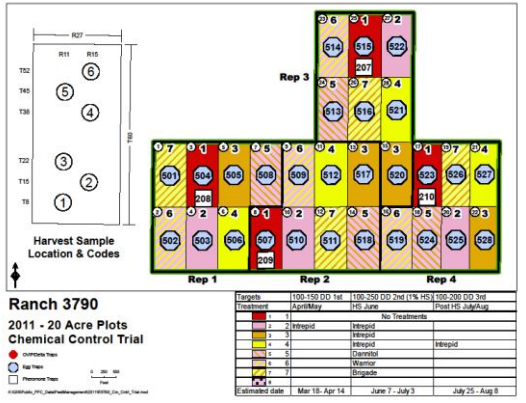
Insecticide Trials at Paramount

Trials

- 2 – 3 per Year
- 20 acre plot size
- 3 or 4 Replicates
- Testing Pyrethroids and Reduced Risk Chemistries



Treatment	100-150 DD 1st April/May	100-250 DD 2nd (1% HS) HS June	100-200 DD 3rd Post HS July/Aug	Plot Color
1		No Treatments		Red
2		Brigade - 100gals		Pink
3		Brigade - 200gals		Orange
4		Intrepid	Brigade	Yellow
5		Brigade	Intrepid	Pink/Orange
6		Belt	Belt	Pink/Yellow
7		Altacor	Altacor	Orange/Yellow
8	Intrepid	Intrepid	Intrepid	Pink/Black

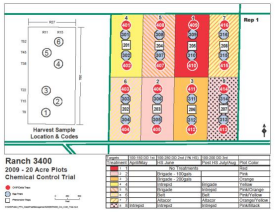


Treatment	100-150 DD 1st April/May	100-250 DD 2nd (1% HS) HS June	100-200 DD 3rd Post HS July/Aug
1		No Treatments	
2	Intrepid	Intrepid	
3		Intrepid	
4		Intrepid	Intrepid
5		Damitol	
6		Warrior	
7		Brigade	
8			
Estimated date	Mar 18- Apr 14	June 7 - July 3	July 25 - Aug 8

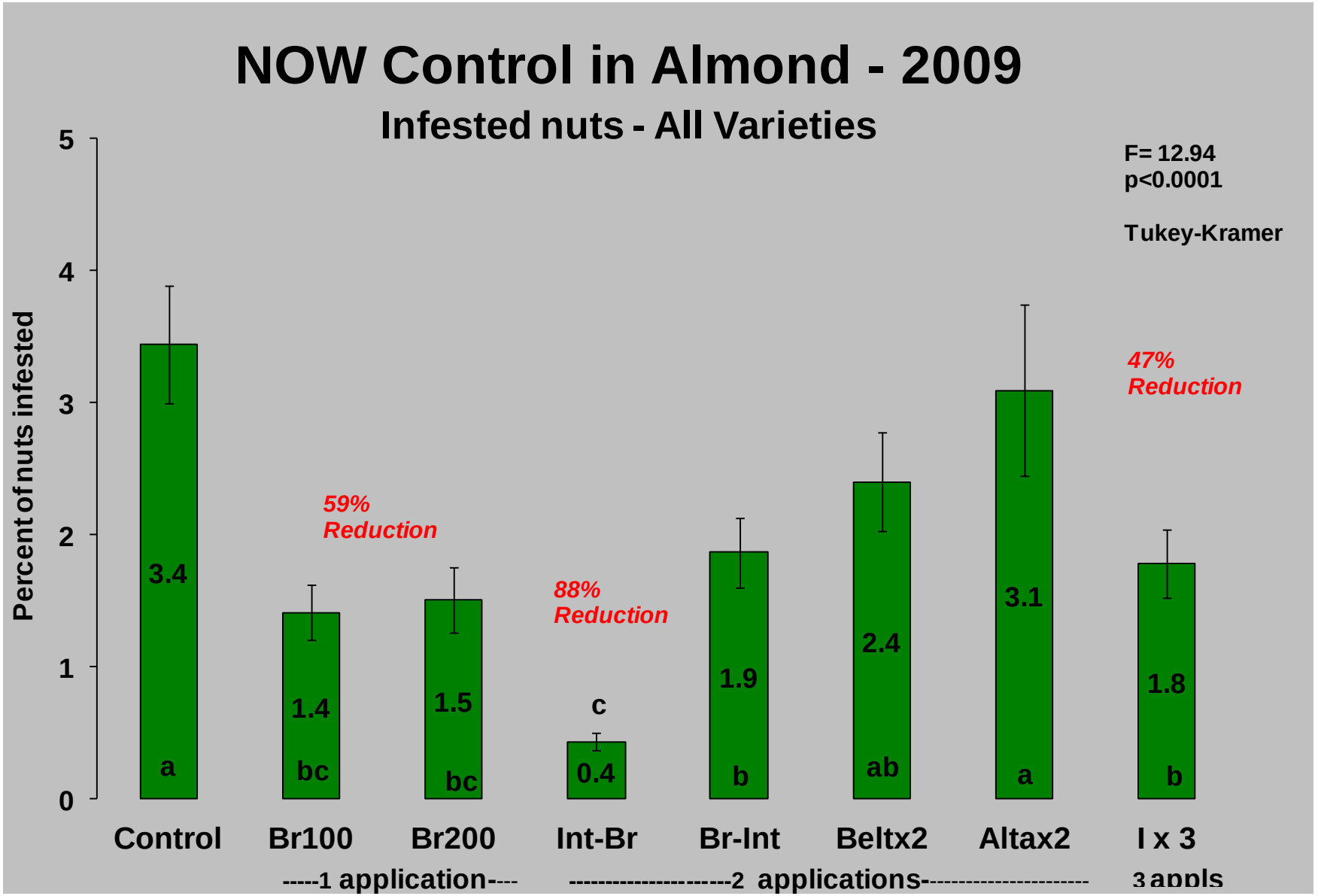
2009-2011 Insecticide Trials

growing ADVANTAGE
The Almond Conference

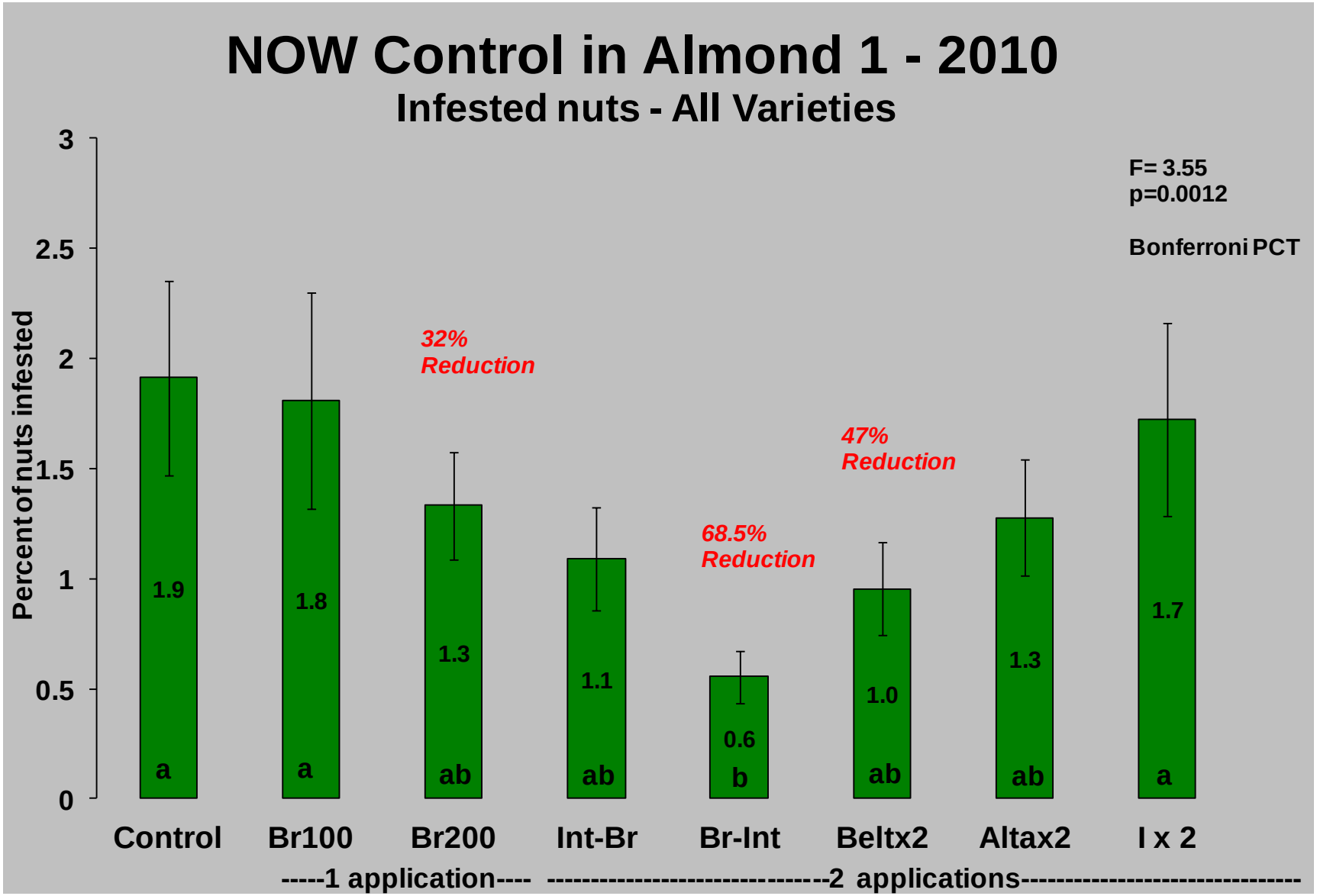
NOW Insecticide control trial - Almond - 2009			
	Timing		
Targets	100-150 DD 1st	100-250 DD 2nd (1% HS)	100-200 DD 3rd
Trtmnt	April/May	HS June	Post HS July/Aug
1	No Treatments		
2		Brigade - 100gals/ac	
3		Brigade - 200gals/ac	
4		Intrepid	Brigade
5		Brigade	Intrepid
6		Belt	Belt
7		Altacor	Altacor
8	Intrepid	Intrepid	Intrepid
Estimated date	Mar 18- Apr 14	June 7 - July 3	July 25 - Aug 8
Actual date	4/10	7/3	7/23
Deg days	160	1521	2032
Biofix	15-Mar		



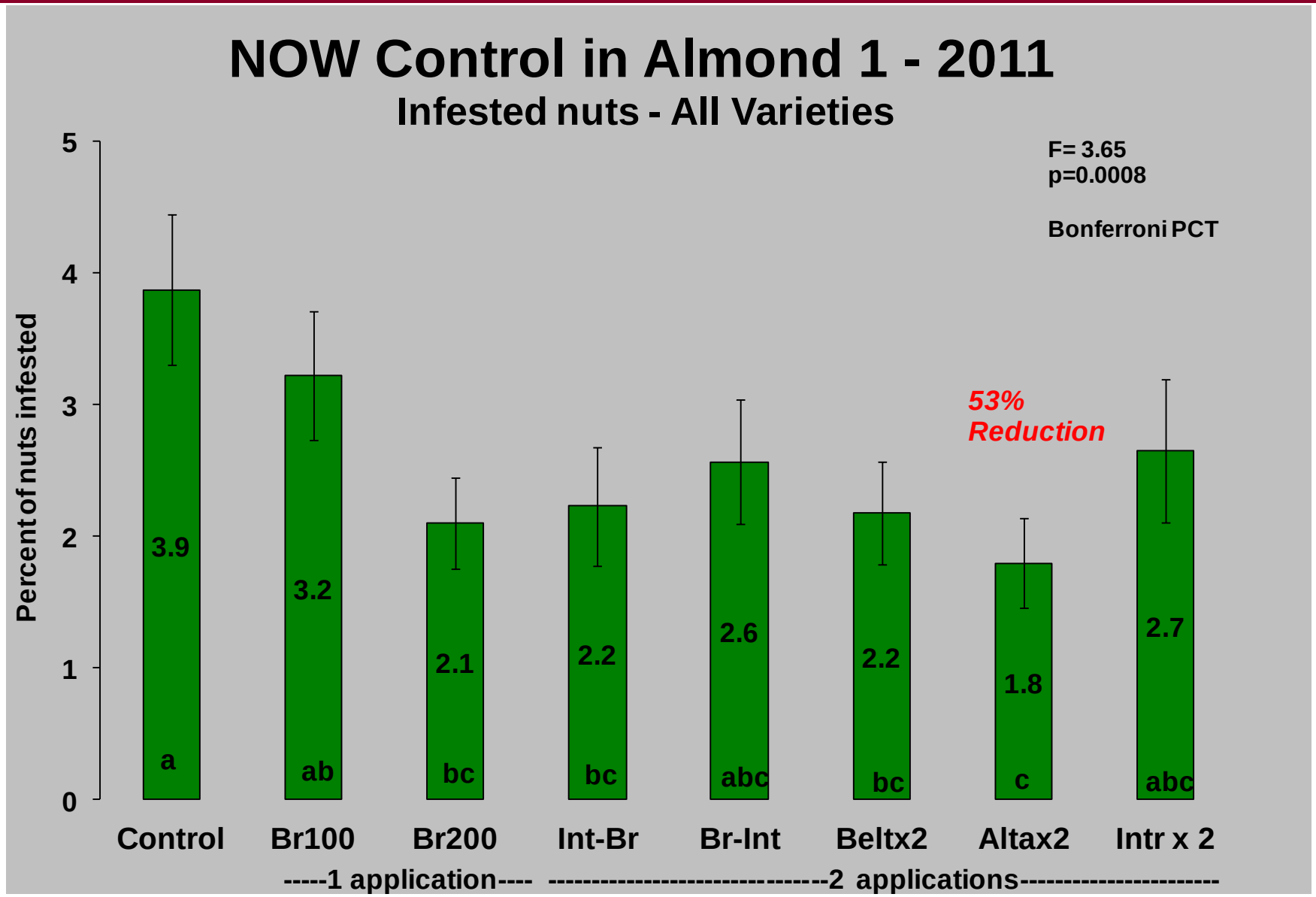
2009 Trial


NOW Control in Almond - 2009
Infested nuts - All Varieties
F= 12.94
p<0.0001
Tukey-Kramer
Percent of nuts infested
5
4
3
2
1
0
3.4
a
1.4
bc
1.5
bc
c
0.4
1.9
b
2.4
ab
3.1
a
1.8
b
59% Reduction
88% Reduction
47% Reduction
Control
Br100
Br200
Int-Br
Br-Int
Beltx2
Altax2
I x 3
-----1 application----
----------2 applications----------
3 appls

2010 Trial


NOW Control in Almond 1 - 2010
Infested nuts - All Varieties
Percent of nuts infested
3
2.5
2
1.5
1
0.5
0
F= 3.55
p=0.0012
Bonferroni PCT
32% Reduction
68.5% Reduction
47% Reduction
1.9
a
1.8
a
1.3
ab
1.1
ab
0.6
b
1.0
ab
1.3
ab
1.7
a
Control
Br100
Br200
Int-Br
Br-Int
Beltx2
Altax2
I x 2
-----1 application----
----------2 applications----------

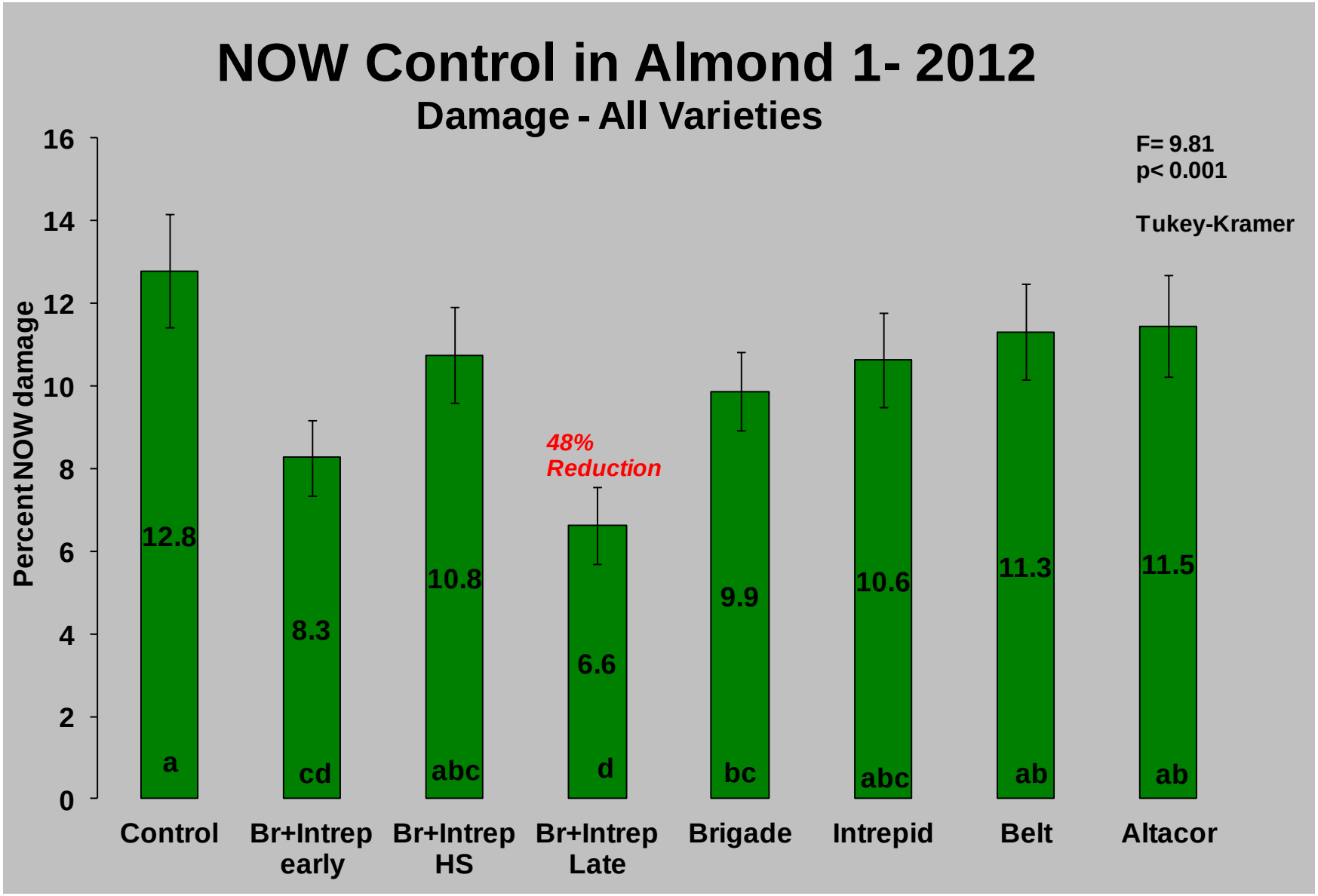
2011 Trial


NOW Control in Almond 1 - 2011
Infested nuts - All Varieties
F= 3.65
p=0.0008
Bonferroni PCT
Percent of nuts infested
0
1
2
3
4
5
3.9
a
3.2
ab
2.1
bc
2.2
bc
2.6
abc
2.2
bc
1.8
c
2.7
abc
53%
Reduction
Control
Br100
Br200
Int-Br
Br-Int
Beltx2
Altax2
Intr x 2
-----1 application----
----------2 applications----------

Single Application Timing Trial 2012

NOW Insecticide control trial 1 - Almond - 2012			R3400, 3410, 3470
	Timing		
Targets	1st HS/1100 dd	1-5% HS 1350 dd	10%+HS 1600 dd
Treatments	Early HS	HS	Late-HS
1	No Treatments		
2	Brigade+Intrepid		
3		Brigade+Intrepid	
4			Brigade+Intrepid
5		Brigade	
6		Intrepid	
7		Belt	
8		Altacor	
Estimated date	June 10 - 25	June 25 - July 15	July 25 - Aug 8
Actual date	June 23	July 7	Aug 1
Deg days	1230	1500	2105
Biofix	7-Mar		

2012 Trial


NOW Control in Almond 1- 2012
Damage - All Varieties
F= 9.81
p< 0.001
Tukey-Kramer
Percent NOW damage
16
14
12
10
8
6
4
2
0
12.8
a
8.3
cd
10.8
abc
48%
Reduction
6.6
d
9.9
bc
10.6
abc
11.3
ab
11.5
ab
Control
Br+Intrep early
Br+Intrep HS
Br+Intrep Late
Brigade
Intrepid
Belt
Altacor

Can we improve performance?

- Trials evaluating efficacy of reduced risk (primarily ovi-larvicides) insecticides typically result in a maximum of 50-60% damage reduction in almonds vs NOW
- These same products have better results in other crop-pest systems (such as Apples/codling moth)
- Target site for residues is the almond
- Suspected problems:
  - Canopy density
  - Spatiotemporal dynamics of nut split/susceptibility
- Evaluate spray coverage, identify weaknesses

Spray Coverage Trials 2010-2012
Orchard Characteristics

- Nonpareil and Monterey varieties, in 1:1 ratio, planted in alternating rows, 21 ft (m) x 24 ft
- Orchard planted in 1999 (12 yrs at time of study in 2010), hedged in 2009 and 2012
- Mean distance between tree canopies in drive row = 3.1 ft (0.5 – 4 ft)
- Mean height above ground (measured to highest nut), NP = 20.5 ft, range 19-24 ft; Mo = 15.8 ft, range 14.5-18 ft
- Canopy radius at base, NP = 9.5 ft (19 ft diameter)

Overview
Trials conducted in 2010, 2011 and 2012

- **8 treatments (including control)- using chloroantraniliprole (Altacor®) @ 4.5 oz/ac along with surfactant (Li-700) @ 0.125% (v/v) in 2010, 0.25% (v/v) in 2011, 0.08% (v/v) in 2012 and Fujimite @ 2 pts/ac all years – <u>One application at HS</u>**
- **8 ac plots, 3 replicates, Nonpareil/Monterey varietal mix**
- **Sampling:**
  - **Spray cards – water sensitive papers (WSP) (26 x 76mm = 1" x 3") – 2 trees/plot, 6 trees/treatment – digital analysis, CIAS 2.0**
  - **Hull residues - LC//MS/MS – 2 trees/plot, 6 trees/treatment**

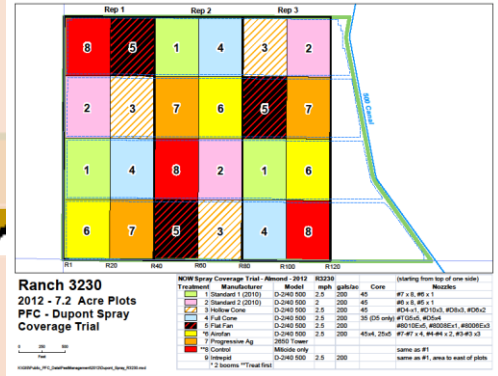
  Harvest samples – evaluate NOW infestation
  - **Nut samples from 2 trees/plot at 4 vertical heights just prior to harvest –"Tree samples"**
  - **Nut samples from ground (6 trees /plot) after shaking – "Ground samples"**

WSP and Nut Residue Sampling Positions
10/tree

Nut Sampling Position

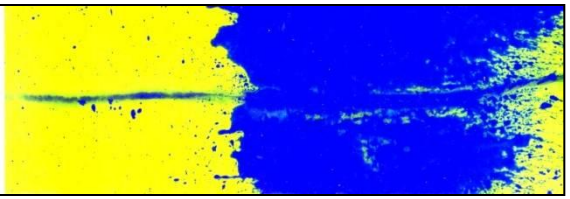
Levels

- **Level 1 – Lower canopy, 6-8 ft**
- **Level 2 – mid-canopy, 10-12 ft**
- **Level 3 – upper canopy, 14-16 ft**
- **Level 4 – top of canopy, 18+ ft**

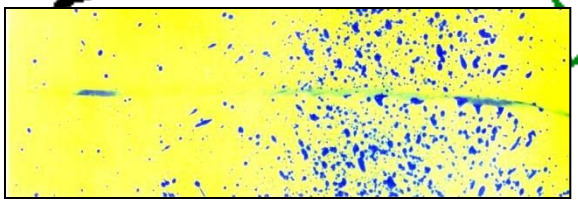


Positions

- **Levels 1-3**
- **Position 1 – outer periphery**
- **Position 2 - central interior**
- **Position 3 - lateral periphery**



51%



6%

Sprayer Technology

Progressive Ag 3 head
2650 w/ 16 ft tower

Air O Fan
D-2/40 500

Progressive Ag
2650

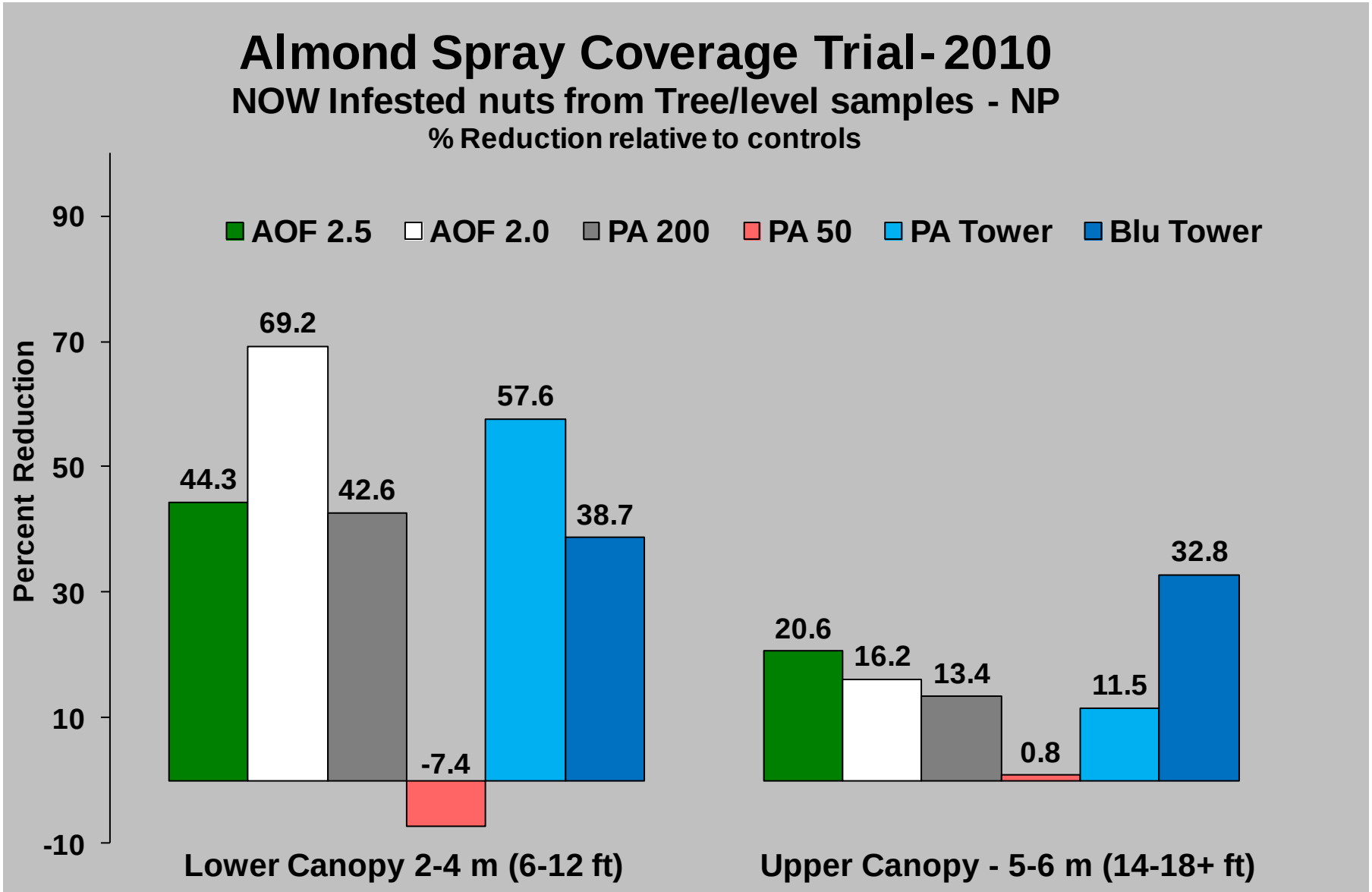
Blueline
Accutech
10 head tower

Progressive Ag 2 head
2650 w/ 13 ft tower

2010/2011 Conclusions

- **Coverage and residue deposition tended to be greater at slower speeds by 30-40%.**
- The **best treatments** in these tests only resulted in about **50% coverage overall.**
- **Electrostatic** treatments did not perform well on the WSPs (small droplet size is a suspected), but they were **among the best in residue deposition at full volume and delivered surprising residues at high speeds/low volumes**.
- Tower sprayers had the most consistent coverage and residues across vertical levels
- For the conventional ground-based sprayers, **most of the residues where deposited in the lower half of the tree while the highest levels of NOW infestation occurred in the upper half of the tree.**
- None of these spray approaches resulted in the coverage required for **optimum performance** of ovi-larvicidal products. However, we plan to address these shortcomings and hope to improve this performance in our 2012 trial.

Damage Reductions from 2010 Trial



B. Higbee, Paramount Farming Co.

2012 Coverage Trial

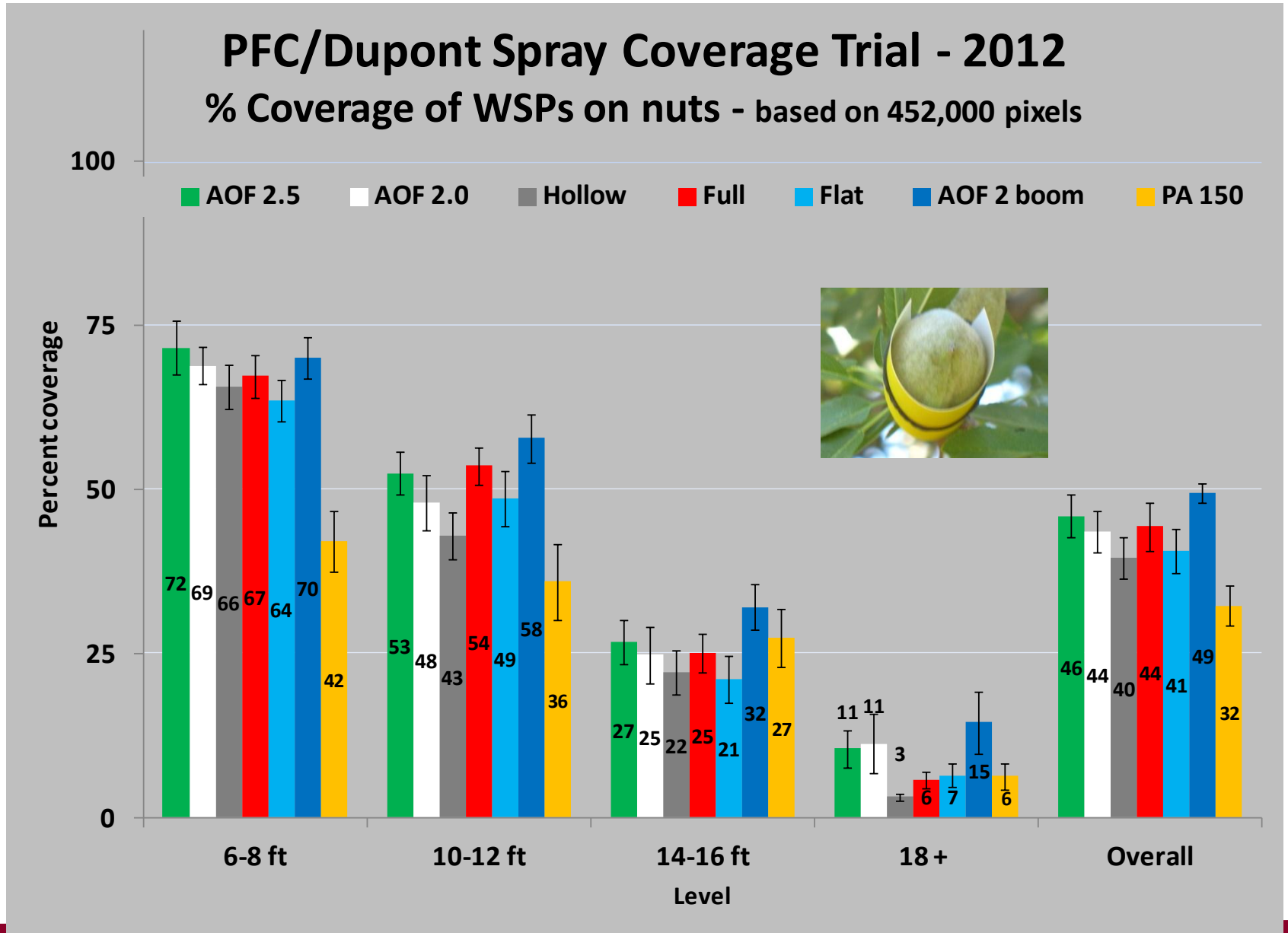
2 Applications of Altacor® - 6/29 & 7/25

NOW Spray Coverage Trial - Almond - 2012			R323			(starting from top of one side)
Trtmnt	**Manufacturer**	**Model**	**mph**	**gals/ac**	**Core**	**Nozzles**
1	AOF (2010) 2.5	D-2/40 500	2.5	200	45	#7 x 8, #6 x 1
2	AOF (2010) 2.0	D-2/40 500	2	200	45	#6 x 8, #5 x 1
3	Hollow Cone	D-2/40 500	2.5	200	45	#4-x1, #10x3, #8x3, #6x2
4	Full Cone	D-2/40 500	2.5	200	35 (D5 only)	#TG5x5, #D5x4
5	Flat Fan	D-2/40 500	2.5	200		#8010Ex5, #8008Ex1, #8006Ex3
*6	AOF 2 boom	D-2/40 500	2.5	200	45x4, 25x5	#7-#7 x 4, #4-#4 x 2, #3-#3 x3
7	Prog Ag 150	2650 16' Tower	3	150		3 manifolds, 3/8' air shear
**8	Control	Miticide only				same as #1
	* 2 booms **Treat first					

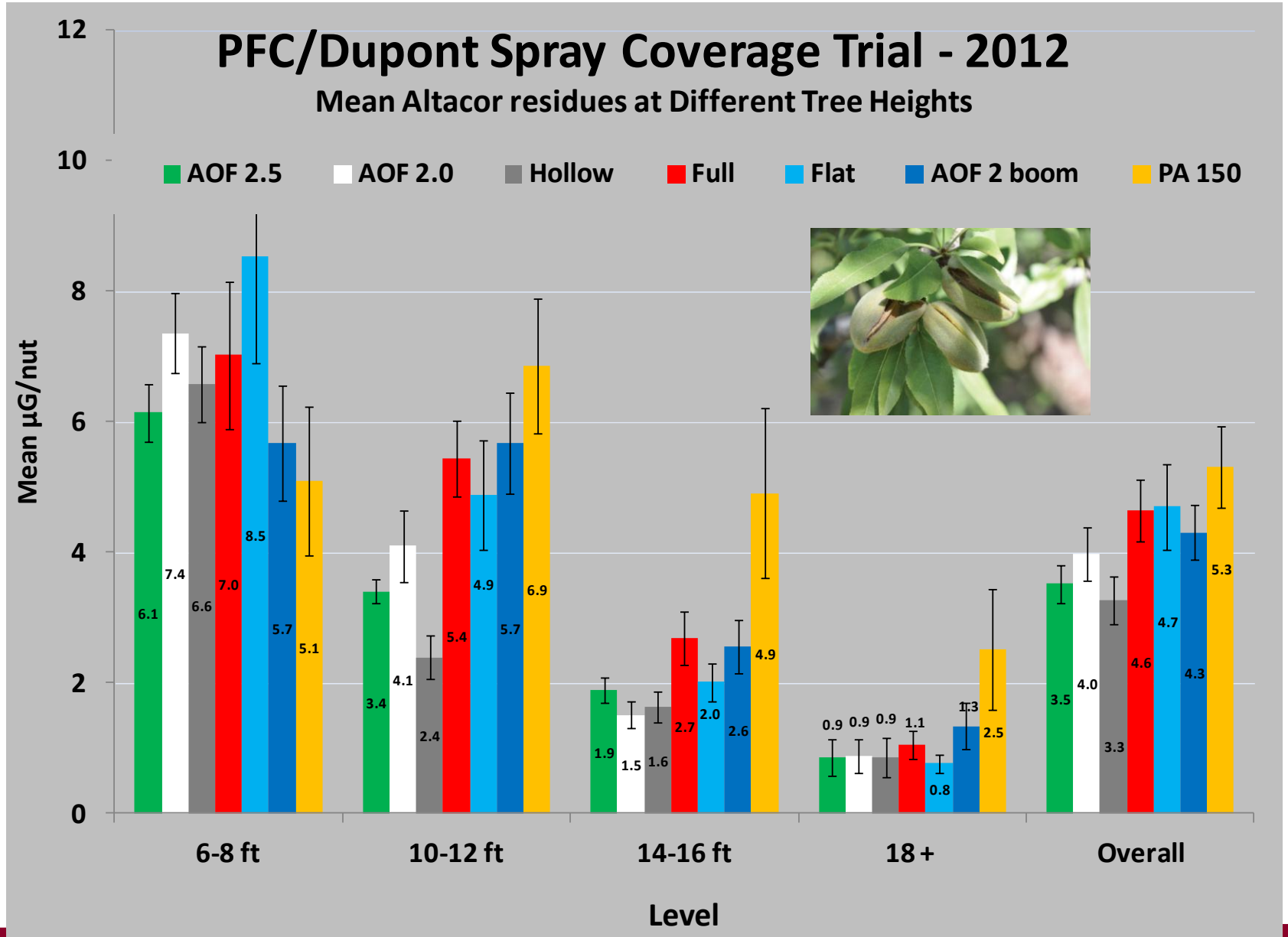
Air O Fan
D-2/40 500

Progressive Ag 3 head
2650 w/ 15 ft tower

Water Sensitive Papers

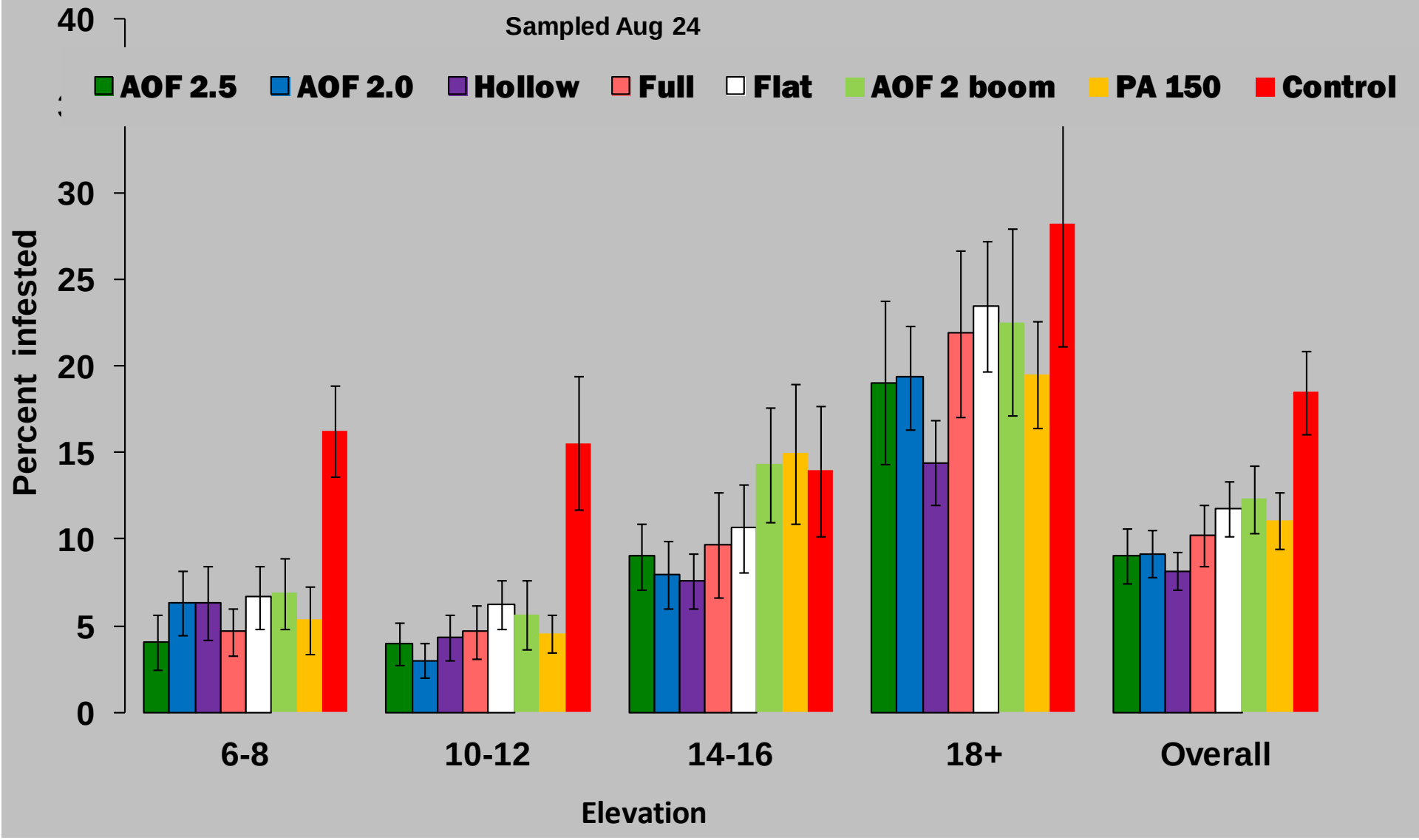


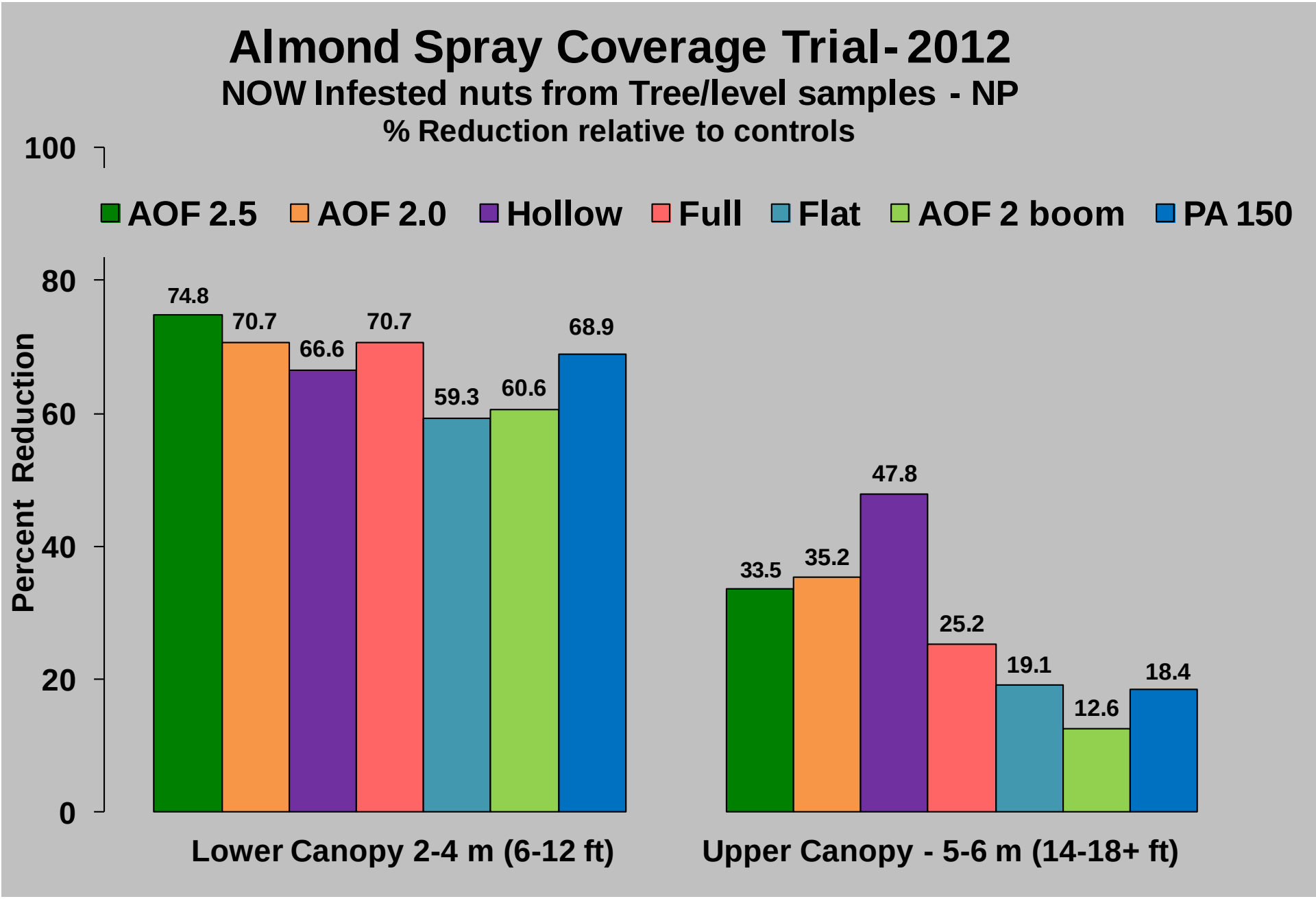
Altacor® Residues



Almond Spray Coverage Trial- 2012

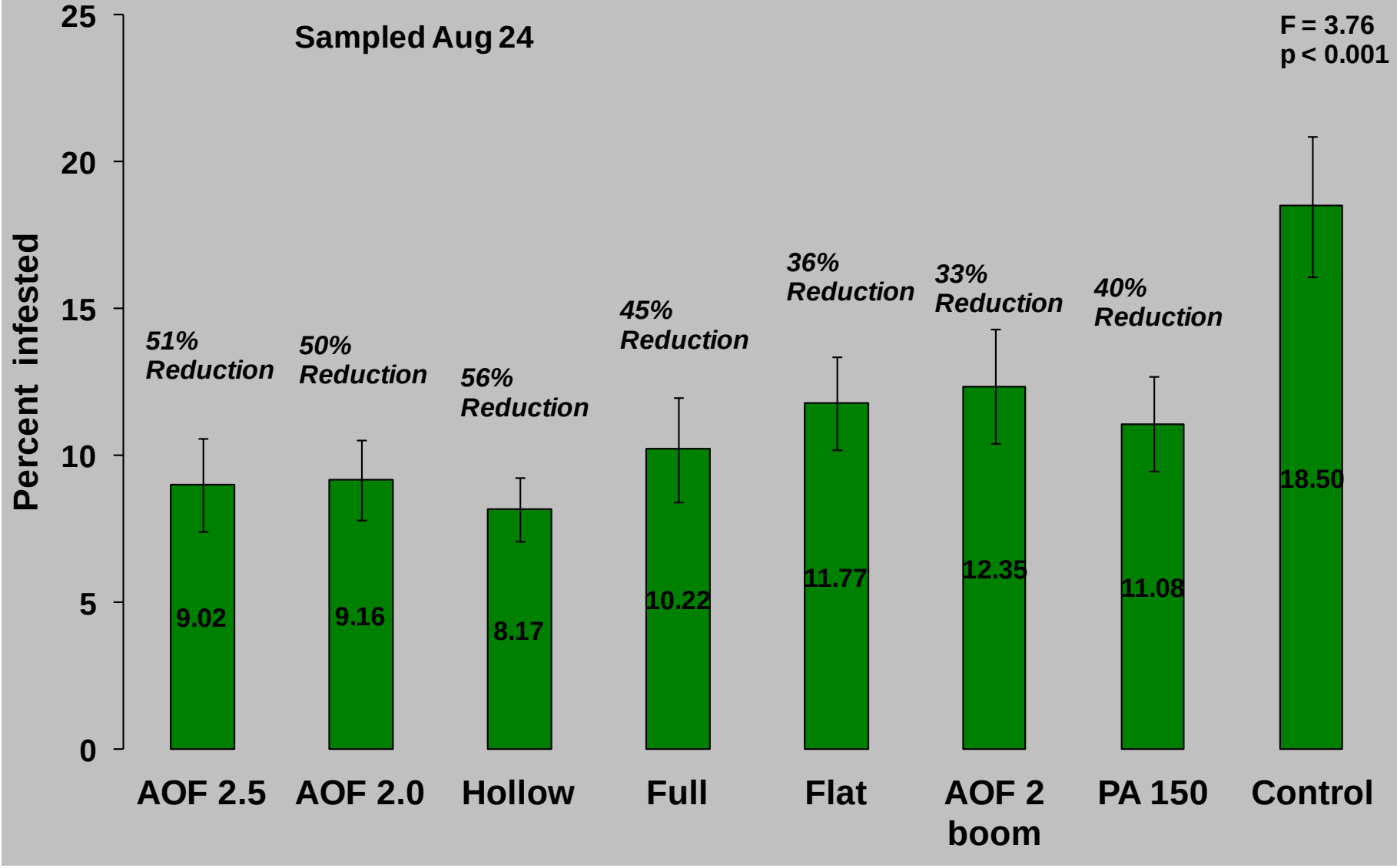
NOW Infested nuts from Tree/level samples - NP




Almond Spray Coverage Trial - 2012
NOW Infested nuts from Tree/level samples - NP
% Reduction relative to controls
100
80
60
40
20
0
Percent Reduction
AOF 2.5
AOF 2.0
Hollow
Full
Flat
AOF 2 boom
PA 150
74.8
70.7
66.6
70.7
59.3
60.6
68.9
33.5
35.2
47.8
25.2
19.1
12.6
18.4
Lower Canopy 2-4 m (6-12 ft)
Upper Canopy - 5-6 m (14-18+ ft)

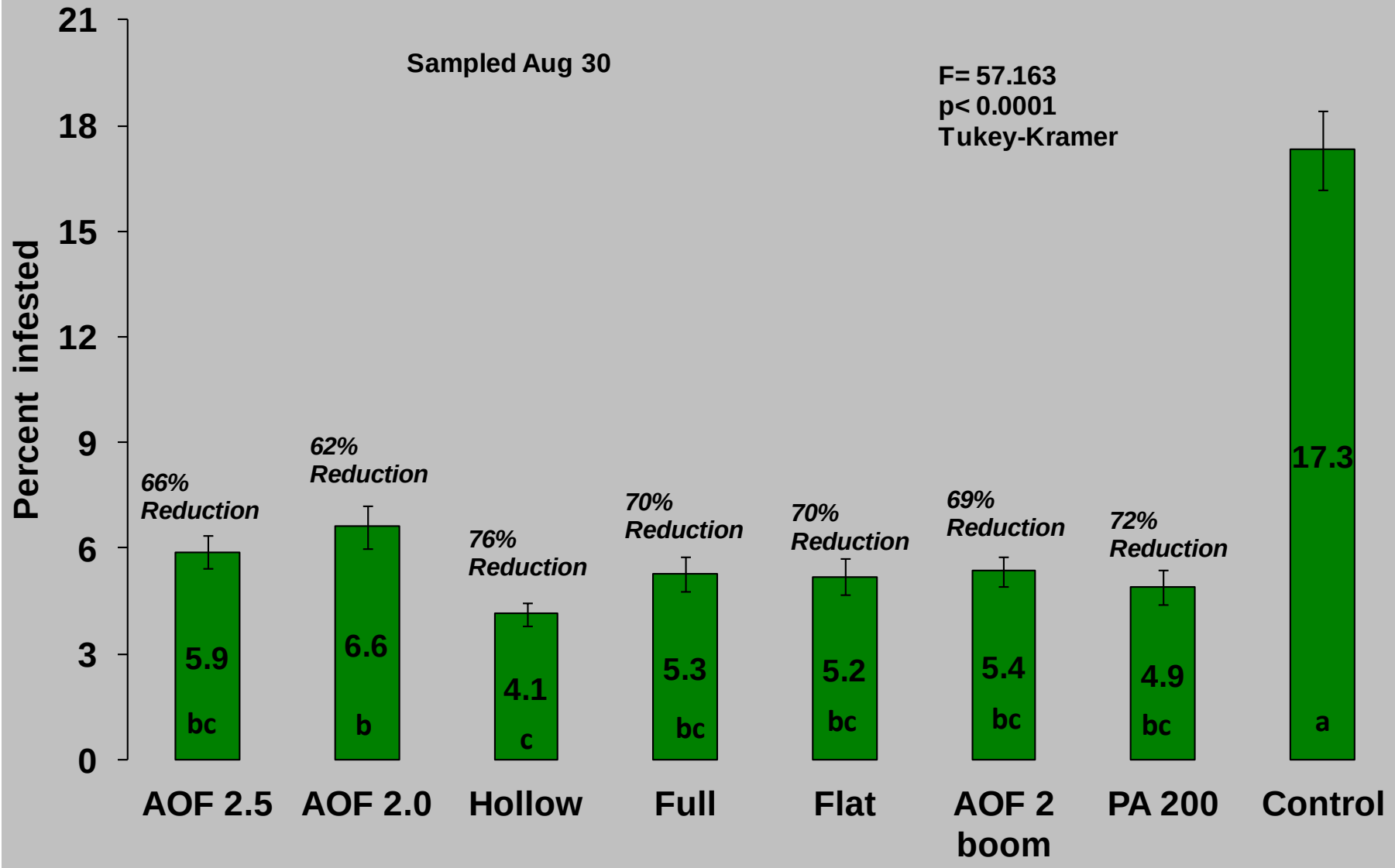
Almond Spray Coverage Trial- 2012

NOW Infested nuts from Tree/level samples - NP



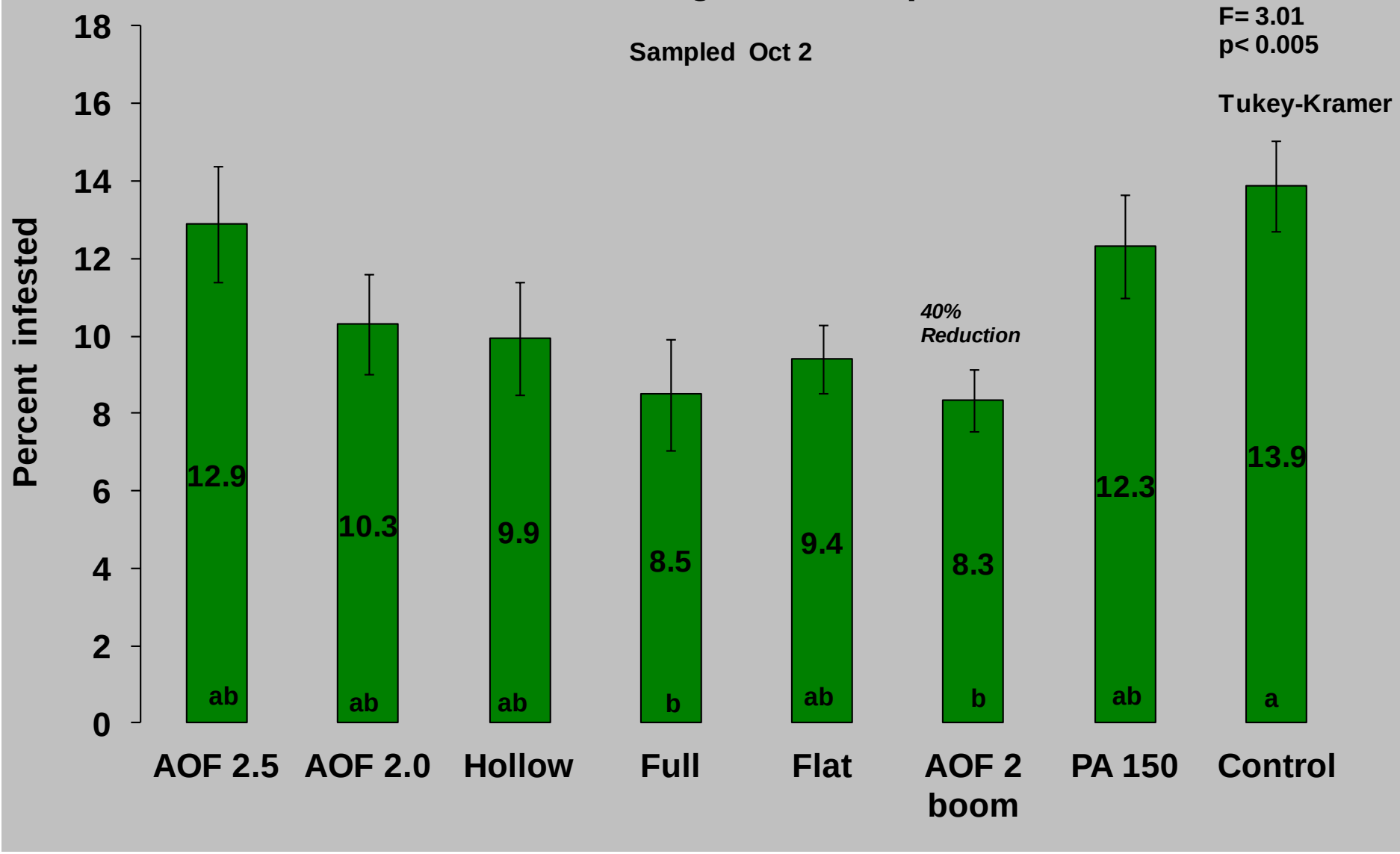
Almond Spray Coverage Trial- 2012

NOW Infested nuts from ground samples - NP

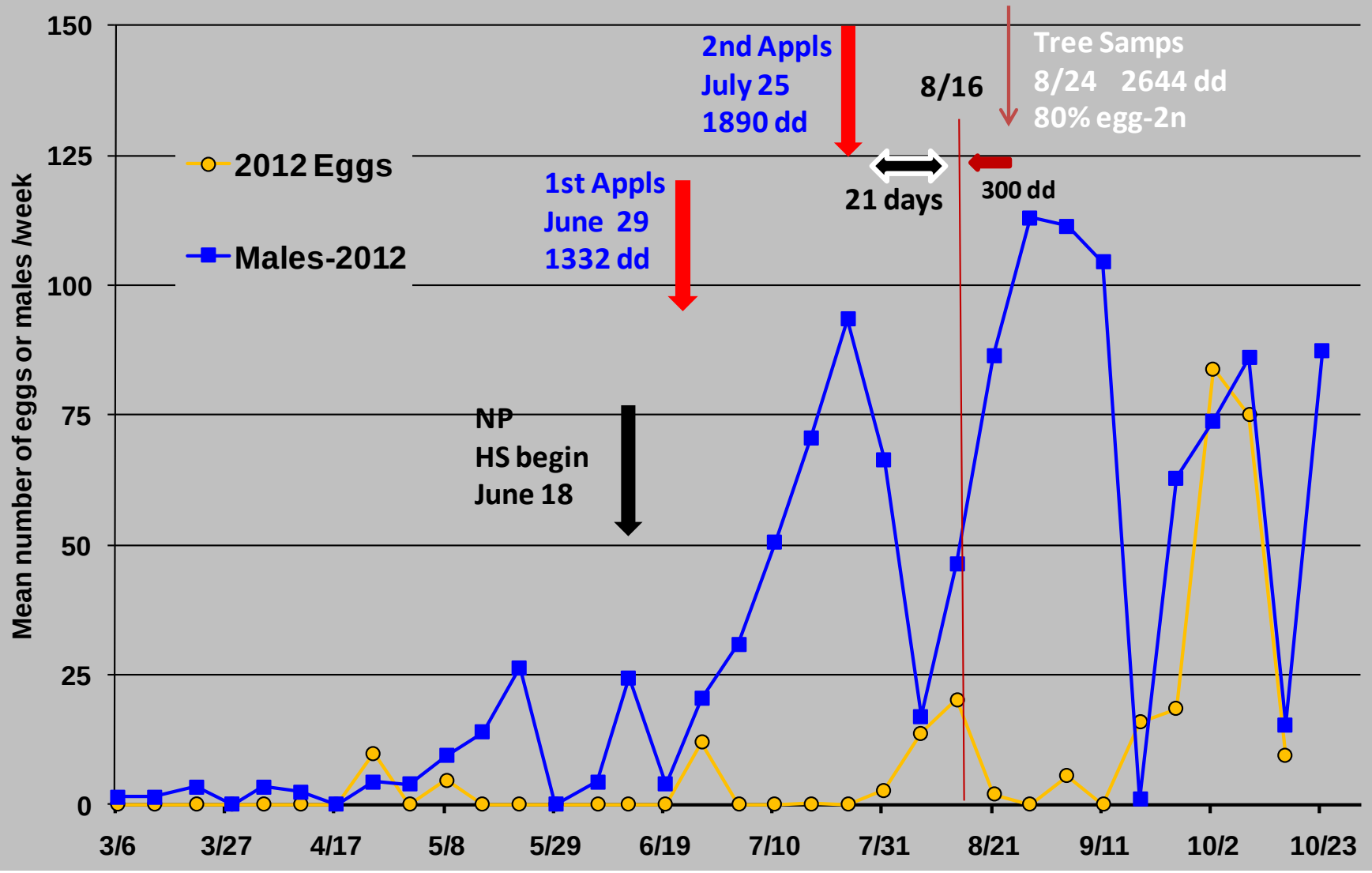


Altacor Spray Coverage Trial- 2012

NOW Infested nuts from ground samples - Mo



Almond Insecticide Spray Coverage Trial 2012



Tentative, unofficial and possibly meaningless rankings

8 points for top performer, 2 for bottom in each category

	Pooled ranking										
		Points								No WSP for Prog Ag	
	Treatment	Residues	WSPs	Tree-Infest	Grnd Mo i	Grnd-NP Inf	Pole WSP	Total	Rank	Avg	
6	AOF 2 boom	5	8	2	8	4	8	35	1	5.8	1
4	Full Cone	6	6	5	7	5	4	33	2	5.5	2
5	Flat Fan	7	4	3	6	6	7	33	2	5.5	2
3	Hollow Cone	2	3	8	5	8	5	31	4	5.2	5
1	AOF (2010) 2.5	3	7	7	2	3	6	28	5	4.7	6
7	Prog Ag 150	8	2	4	3	7	2	26	6	5.5	2
2	AOF (2010) 2.0	4	5	6	4	2	3	24	7	4.0	7

Spray Coverage Trials

- Two application programs make a big difference
- Incremental improvements made with 2 booms, full cone and hollow cone nozzles
- Trends among metrics not consistent
- Maybe coverage is not the driving force?
- Combine with aerial applications?

Acknowledgements

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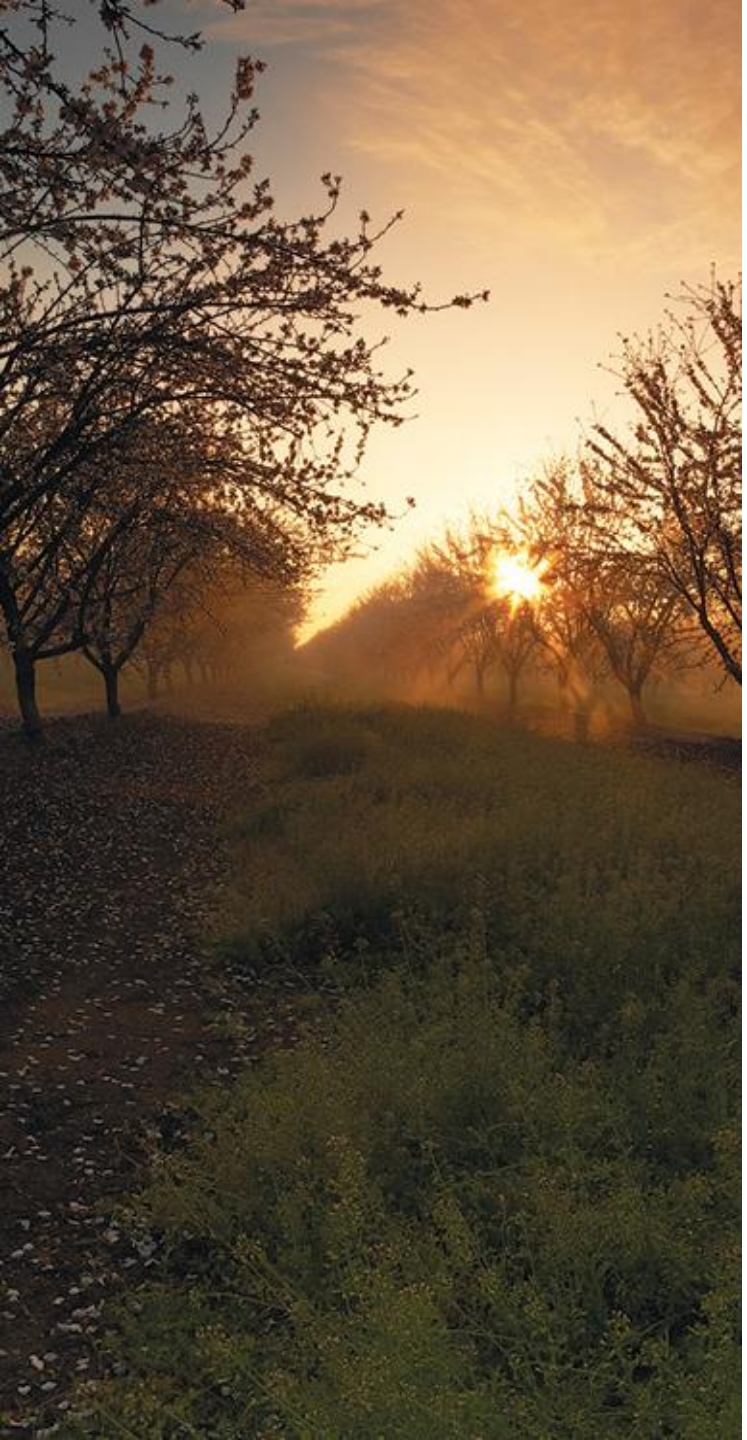
Yogi Berra

"In theory, there is no difference between theory and practice. But in practice, there is."



Orchard Spraying – New Technologies and Outlook

Ken Giles

Bio. & Ag. Engineering Dept.

UC Davis

Previous Discussion…

Droplet size effects

Need for proper nozzle placement and adjustment

Importance of air volume for displacing canopy

Balance between runoff, drift and efficacy

Improvements in Application

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Top Priority – calibration, ground speed, air speed and monitoring of current technology.

Before buying new technology, give your existing technology the same attention you would give a new piece of equipment.

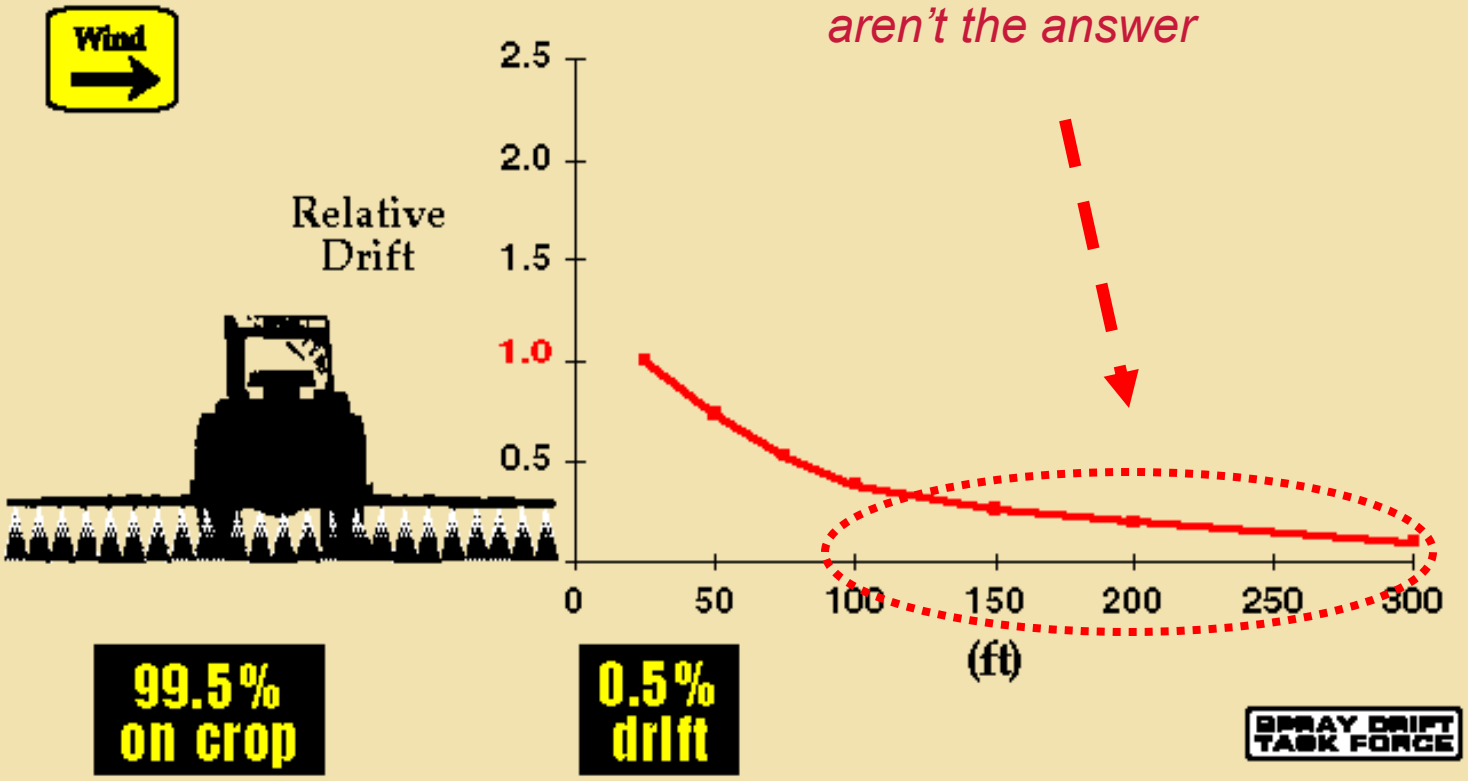
New technologies require more attention, especially at first.

Spray Drift

Drift from the SDTF Control Application

1.0 = 0.08 oz per acre

Why large buffer zones aren't the answer



Drift and spraying orchards

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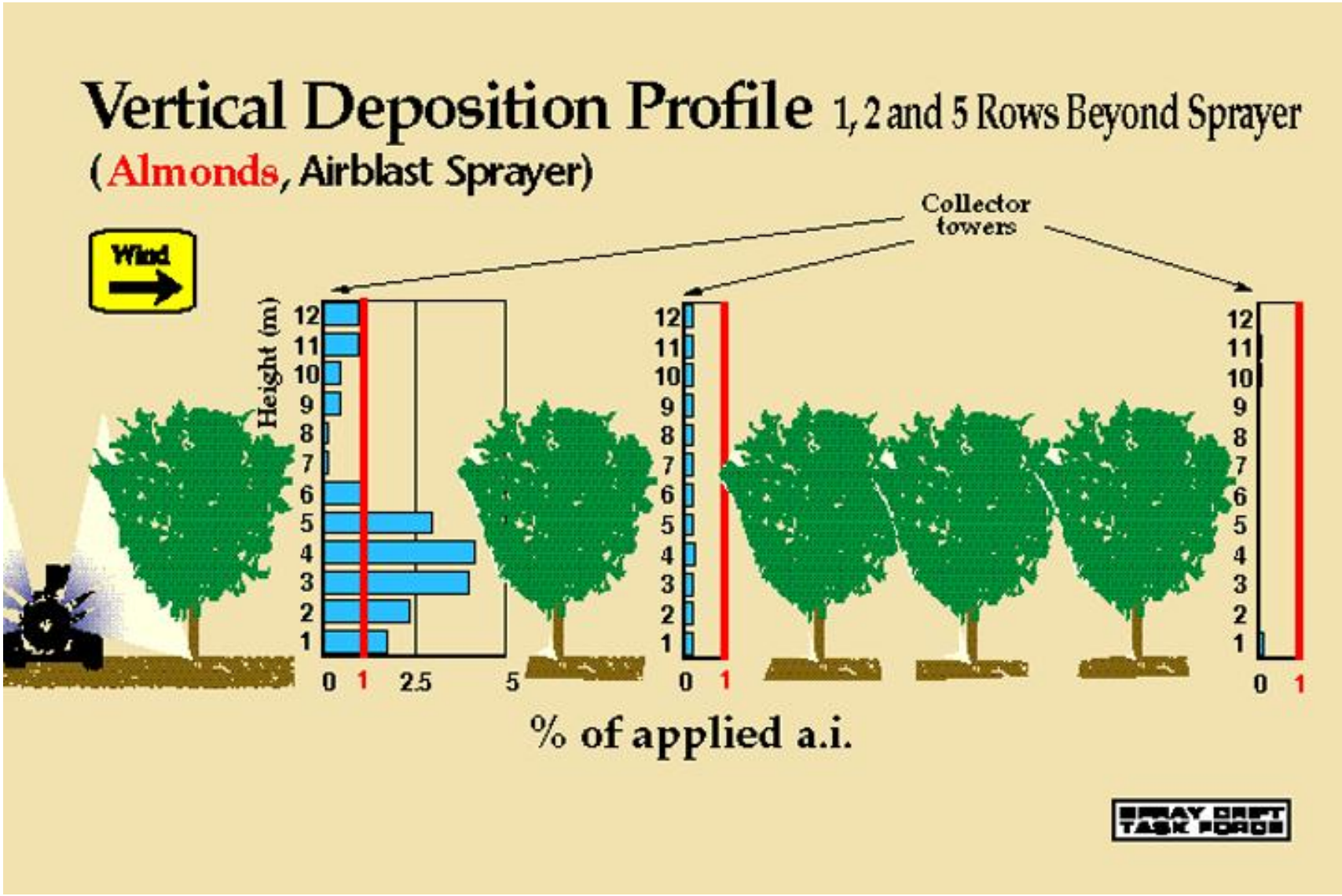
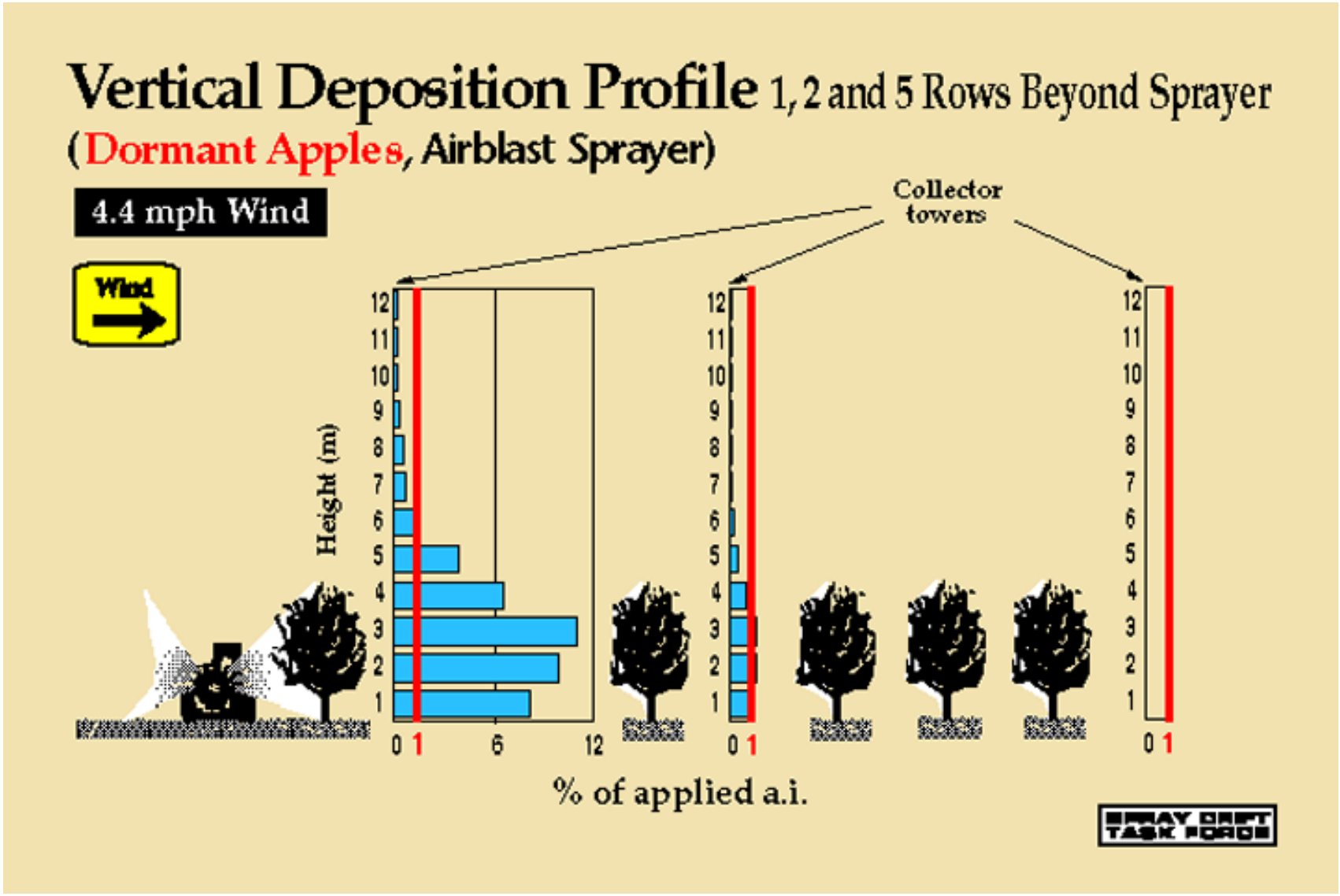
Miller *et al.* (2003) concluded:
"Most of the spray movement out of the tree canopy was in the spaces between trees…"

"One way to reduce drift may be to turn off the spray between tree crowns…"

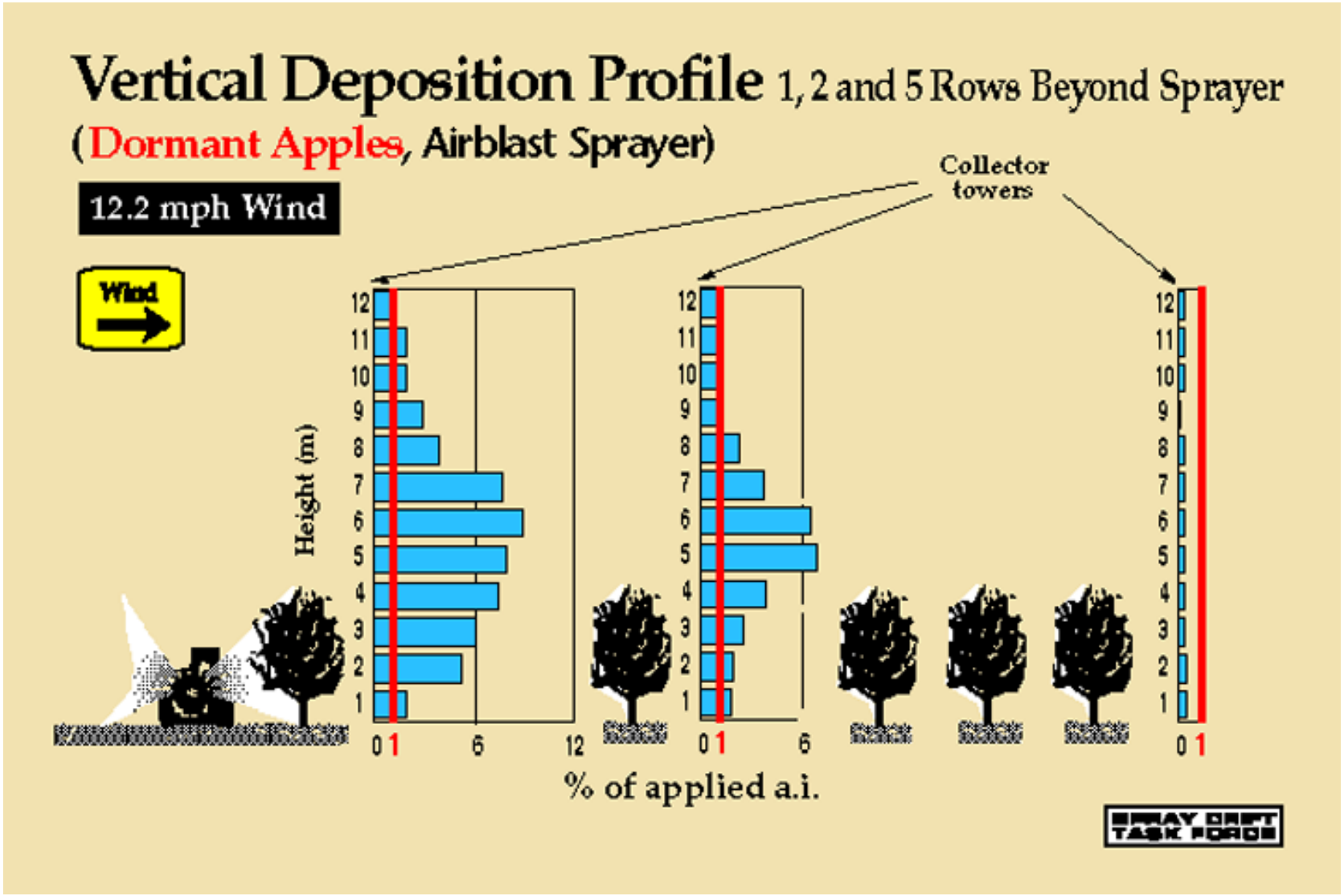
Data from Spray Drift Task Force



Data from Spray Drift Task Force



Data from Spray Drift Task Force



Data from Spray Drift Task Force

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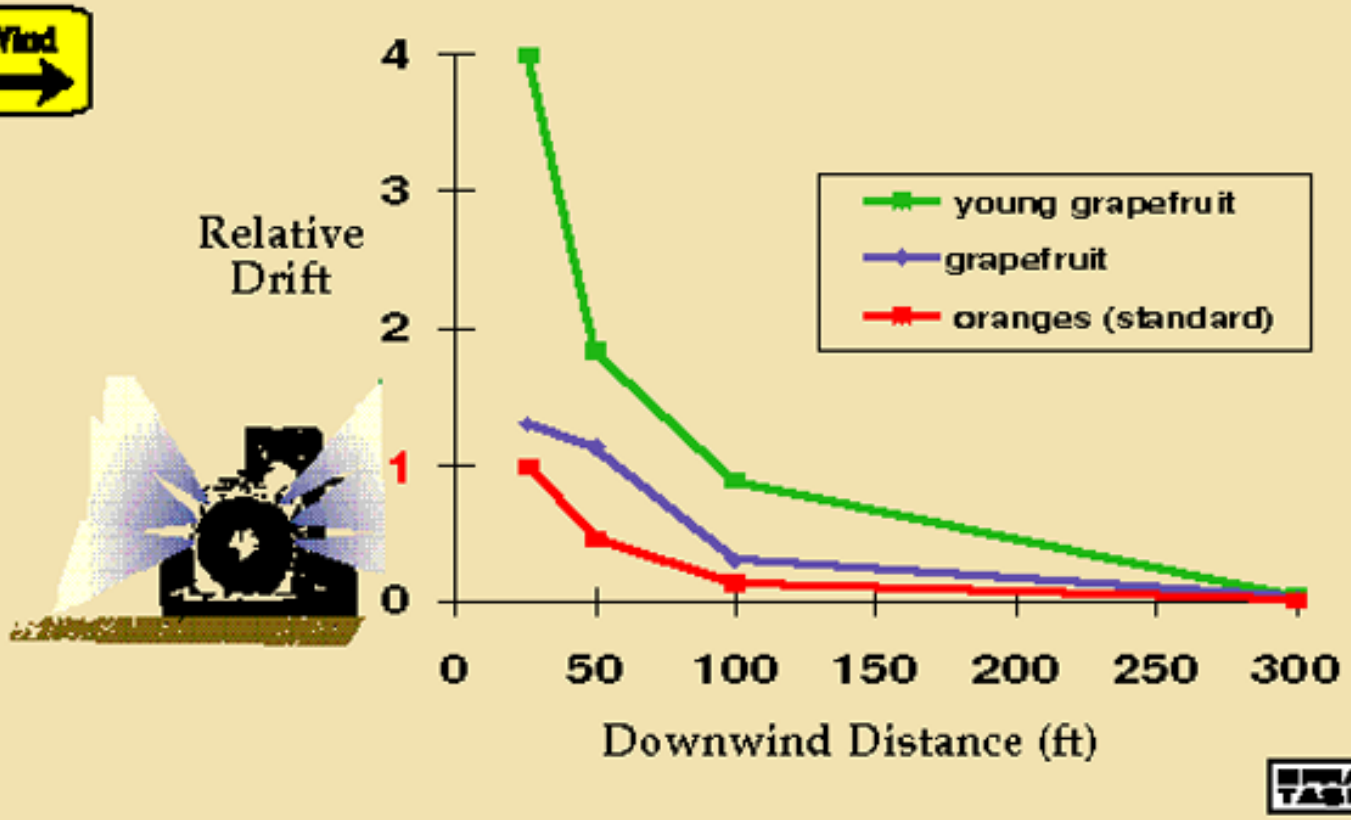
How open spaces between trees affect ground deposition



Orchard Spray Deposit Accountability

Author	Condition	Ground	Target	Drift
Seiber	Dormant	25 – 45%	-	-
Cross	Both	43 - 63%	-	16%
Vercruysse	Both	-	56 – 68%	-
Pergher	In season	-	37 – 62%	-
Fox	“Sparse”	57%	-	-
Miller	In season	22%	57%	4.6 (16%)

Case Study
Ultrasonic measurement of trees for control of spray sections.

Savings depends on orchard age, size, gaps, etc.

Some trials have shown 50 - 70 % savings.

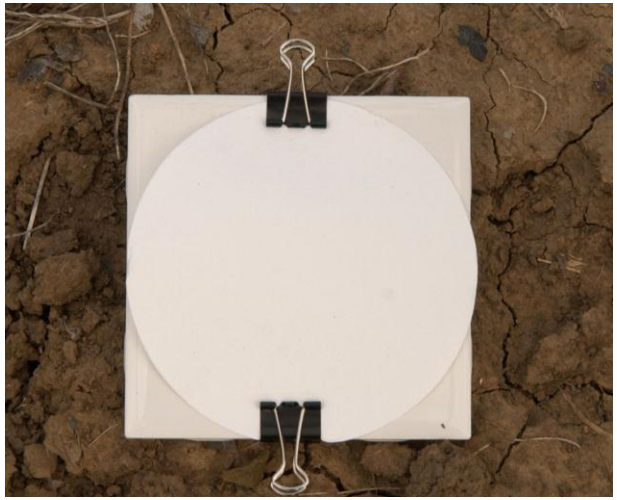
Field test – dormant almonds

Durand-Wayland AF500 Smart Sprayer

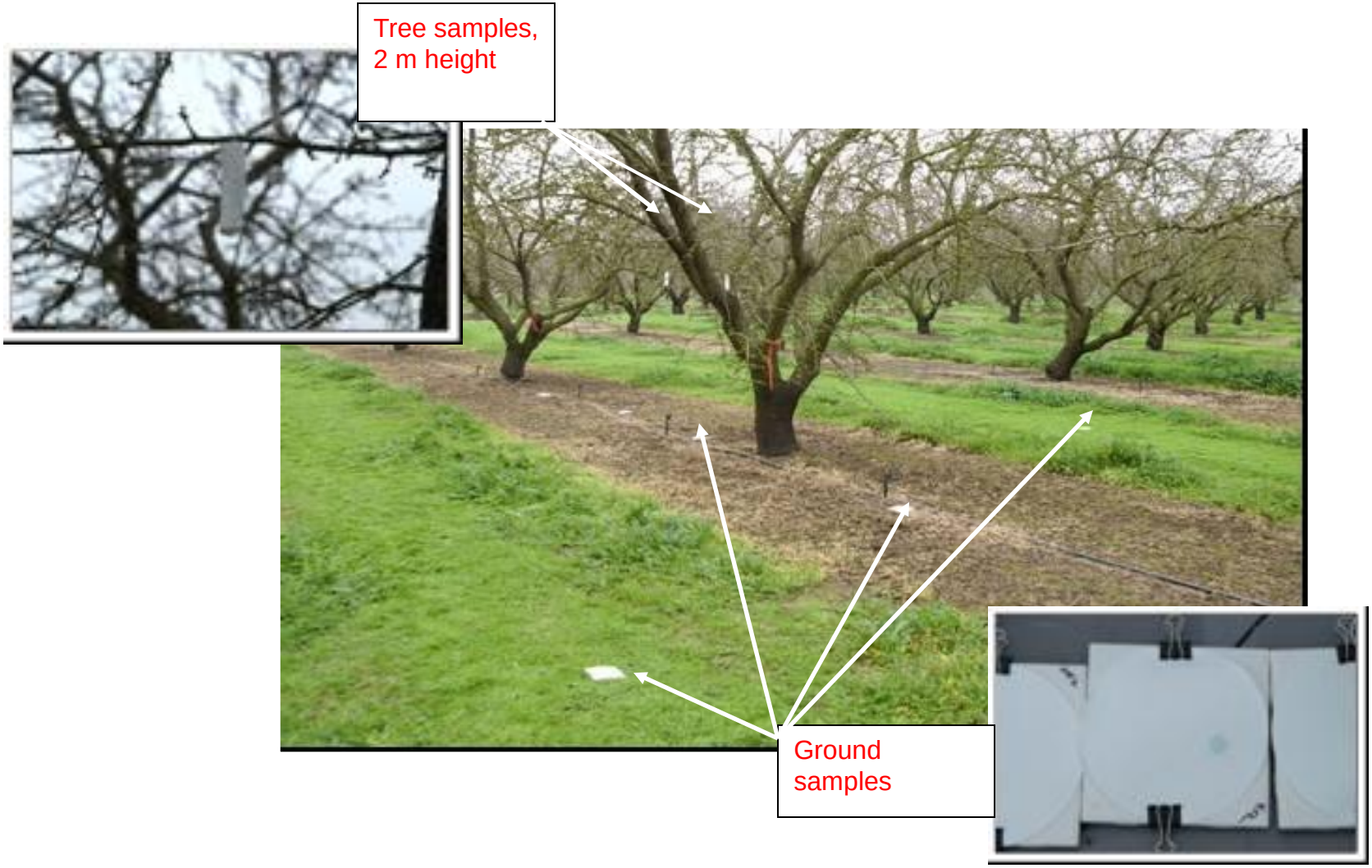
Nozzle configuration was “center-weighted” spray

0.5 kg/ha Lorsban (chlopyrifos)

Field test – sampling



Field test – sampling



Performance results

Use of system had no significant effect on target deposition

Plum orchard –
- **15% reduction in a.i. rate**
- **5% less ground deposit**

Walnut orchard –
- **45% reduction in a.i. rate**
- **58% less ground deposit**

Almond orchard -
- **22% reduction in a.i. rate**
- **71% less ground deposit**

Performance results

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Based on these results, a run-off experiment was conducted in a 40 acre prune orchard

Performance

Spray Savings: 39%
Ground Deposit: - 54%
Diazinon in Runoff: - 44%

Economic Efficiency?

University of California Production Costs
Dept. of Agricultural and Resources Economics
- Cost and Return Studies

Sacramento Valley Almonds

San Joaquin Almonds

Economic Efficiency?

Annual cost of materials for disease and insect sprays

- $233 Sacramento Valley Almonds
- $203 San Joaquin Almonds

Variable application cost (labor and fuel) = $9.50 - 10.00 / acre

Economic Efficiency?

Assuming 20% material savings and 10% application cost savings, we can calculate
"break even acreage"

160 acres

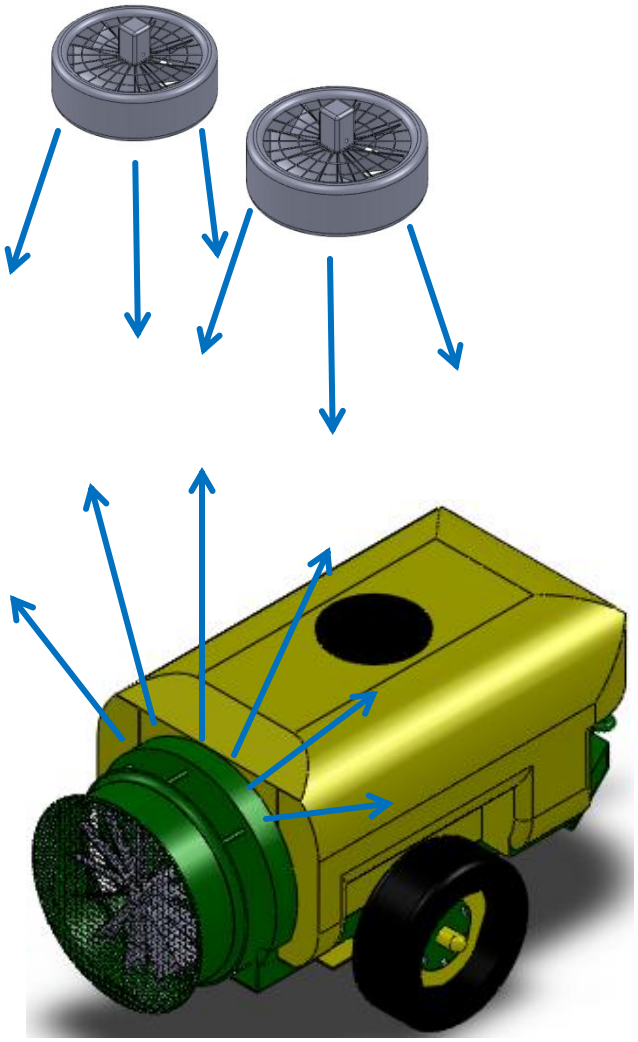
$15,000 investment and 2 year payback period

Improving Deposition / Control in Tops

Improving Deposition / Control in Tops

Create air and fluid

interaction among fans to generate turbulence that could improve uniformity and decrease drift



Improving Deposition / Control in Tops

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Fan Interaction: 70/30 Configuration

Improving Deposition / Control in Tops

Trial Configurations:

Trial	Axial Fan Speed (Low/High/Off)	Upper Fan Nozzle Count	Axial Fan Nozzle Count	Upper Fans Speed (%)	Upper Fan Fluid (%)	Axial Fans Fluid (%)
Control	Low	0	8	0	0	100
1	Low	0	8	70	0	100
2	Low	8	8	70	50	50
70/30	Low	8	8	70	70	30

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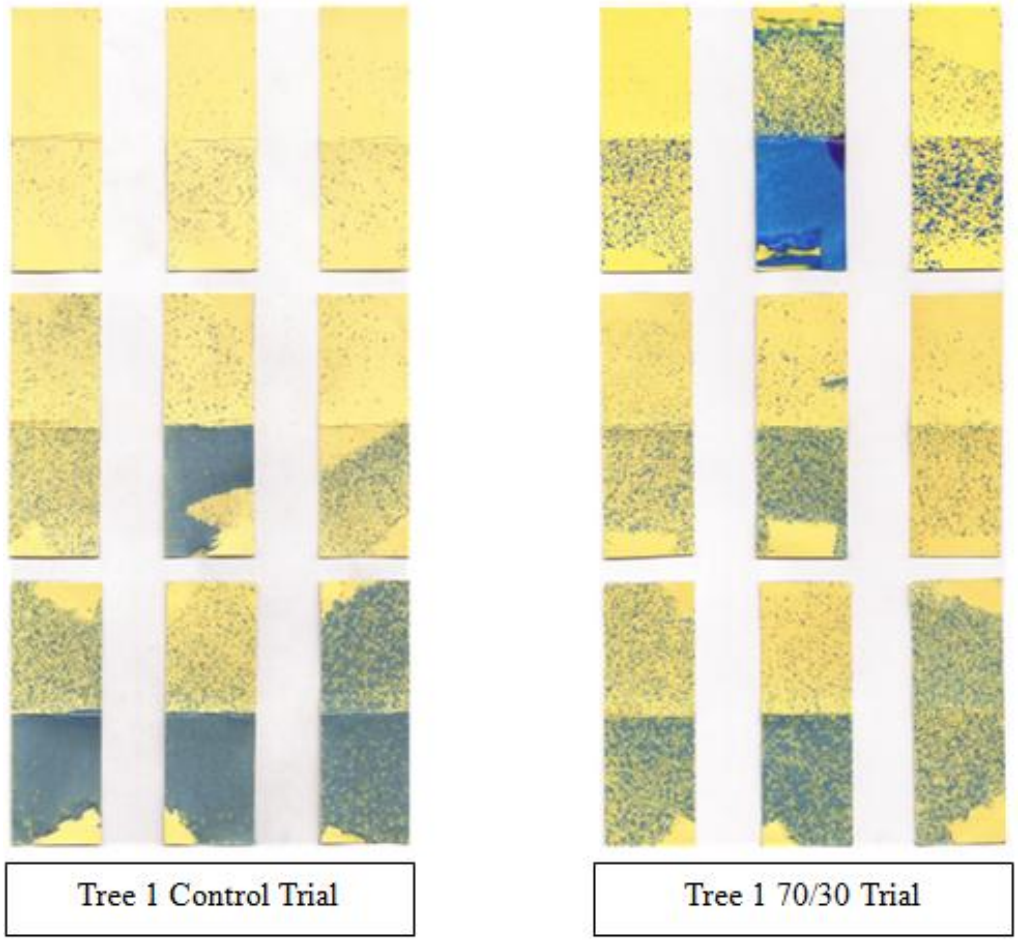
Control vs. 70/30

Upper Canopy

Middle Canopy

Lower Canopy



Tree 1 Control Trial

Tree 1 70/30 Trial

Improving Deposition / Control in Tops

Naval Orange Worm – 1 Day After Treatment

Treatment	Survival	Reduction	Eggs
High			
Control	33.30% ± 47.10 A		2,130
Conventional	22.00% ± 41.40 B	33.93%	3,930
Multifan	12.40% ± 33.00 C	62.76%	2,540
Low			
Control	15.90% ± 36.60 A		1,990
Conventional	1.70% ± 12.90 B	89.31%	2,250
Multifan	7.90% ± 27.00 C	50.31%	1,930

Improving Deposition / Control in Tops

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Improving Deposition / Control in Tops

Questions