Rooted IN SUCCESS 2021
the almond conference

STOCKPILE MANAGEMENT

Moderator: Guangwei Huang (ABC)
Speakers: Bruce Lampinen (UC ANR),
Themis Michailides (UC ANR),
Brad Craven (Minturn Hulling)

california almonds®
Almond Board of California

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Stockpile Management

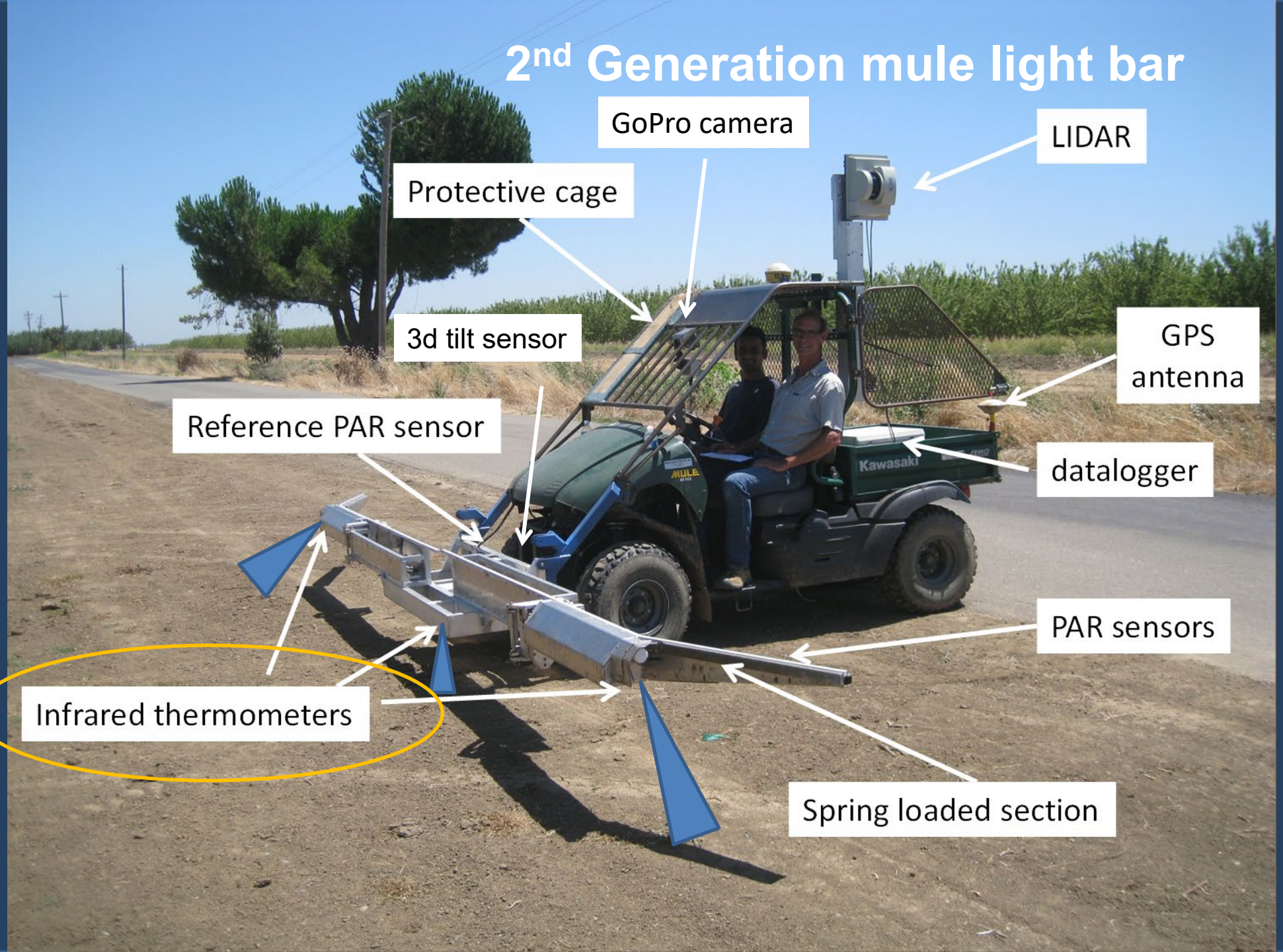
Bruce Lampinen (UC Davis)
Themis Michailides, (UC Davis/Kearney)
Jim Thompson, Sam Metcalf (UC Davis)
David Morgan, Heraclio Reyes, Y. Luo, and B. Kabak (UC Davis/Kearney)

Orchard microclimate influence on food safety risk

- Midday canopy light interception versus orchard floor temperature
- Nut drying on orchard floor- left in place versus conditioned and windrowed
- Row orientation- north/south versus east west facing

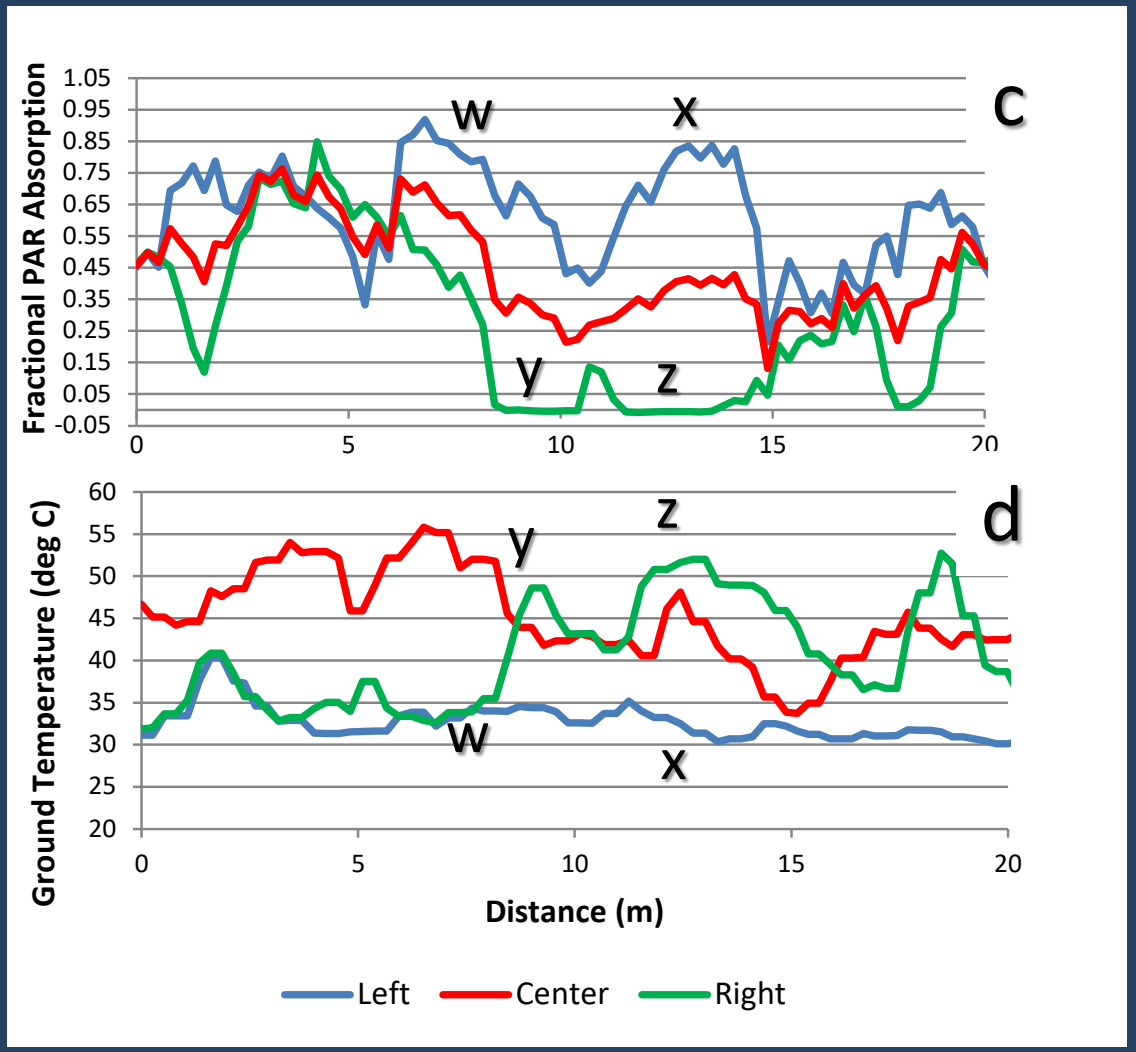
Stockpiling

- Tarp types
  - Clear, white, white on black
- Stockpile orientation
    - North south versus east west facing
- Moisture content- water activity versus moisture content


2nd Generation mule light bar
GoPro camera
LIDAR
Protective cage
3d tilt sensor
GPS antenna
Reference PAR sensor
datalogger
PAR sensors
Infrared thermometers
Spring loaded section


RaB
RbB
PeD
BcA
PfD


RaB
BcA
PfD



w, x = heavy shade- low soil surface temperatures
y, z = open area near missing tree- high soil temp

Canopy density as well as canopy size can have large impact on light interception/yield potential as well as food safety risk

Mechanically hedged- dense canopy letting very little light reach orchard floor under tree (cooler orchard floor temperatures under tree)

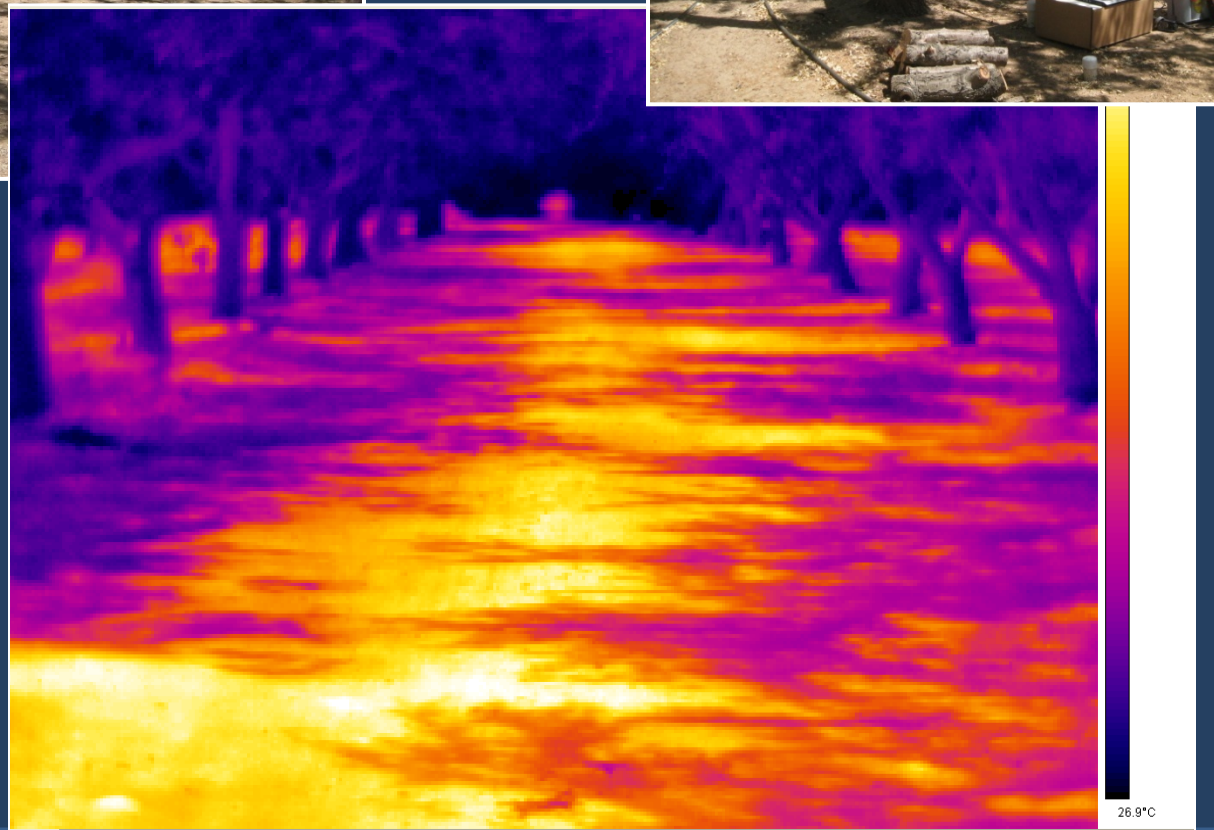
Unpruned- sparse canopy letting much more light reach orchard floor under tree (warmer temperatures under tree)

Hedgerow
(mechanical pruning)

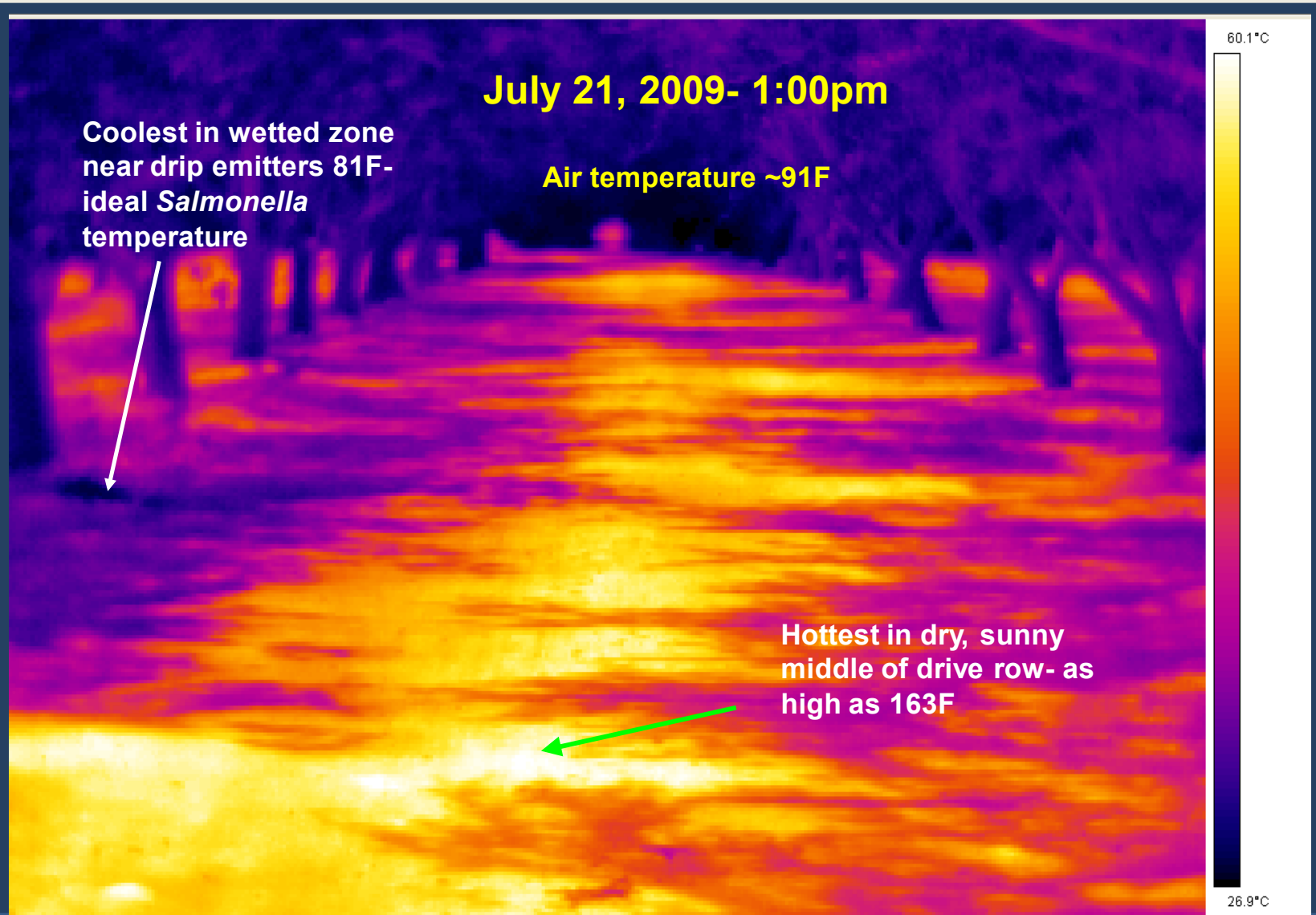
More traditional spacing
(hand pruning)

Result of cool, shaded conditions under tree canopy in dense mechanically hedged planting

Thermal imaging of orchard floor temperatures



Sunlight hitting bare orchard floor provides heat to sterilize surface- more traditional planting tends to give more varied light conditions on orchard floor compared to hedgerow



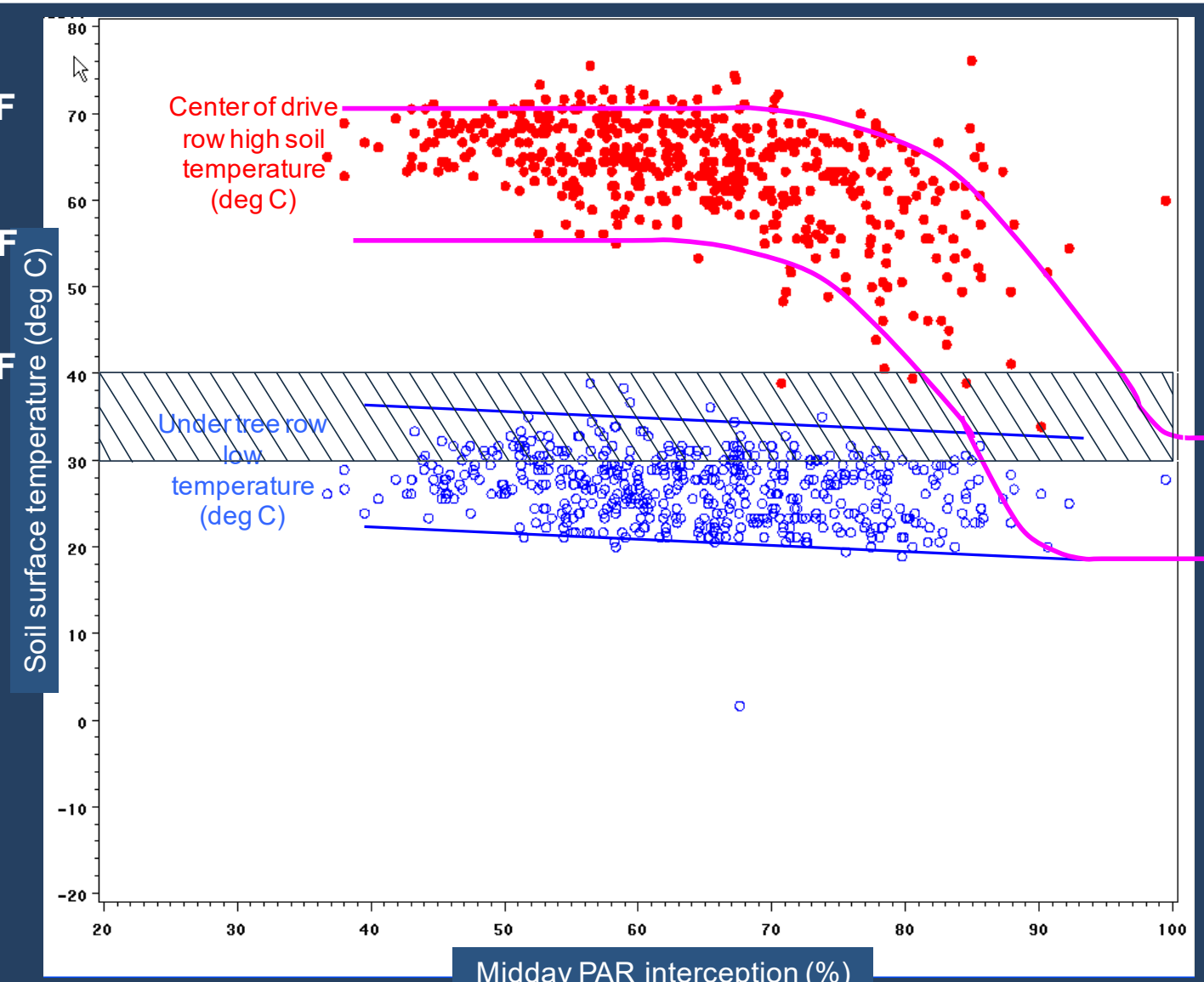
Maximum orchard floor temperature drops off dramatically as midday canopy light interception increases above about 70%.

158 deg F

136 deg F

104 deg F

73 deg F



If your orchard is producing above 3500 kernel pounds per acre (above 70% light interception), you should pay particular attention to food safety risk.


92%


4600 lbs/ac

Sampling nuts from orchard floor to decide if they are dry enough to harvest.

From across orchard floor in orchard where they are left to dry as shaken (2% wetter under tree)

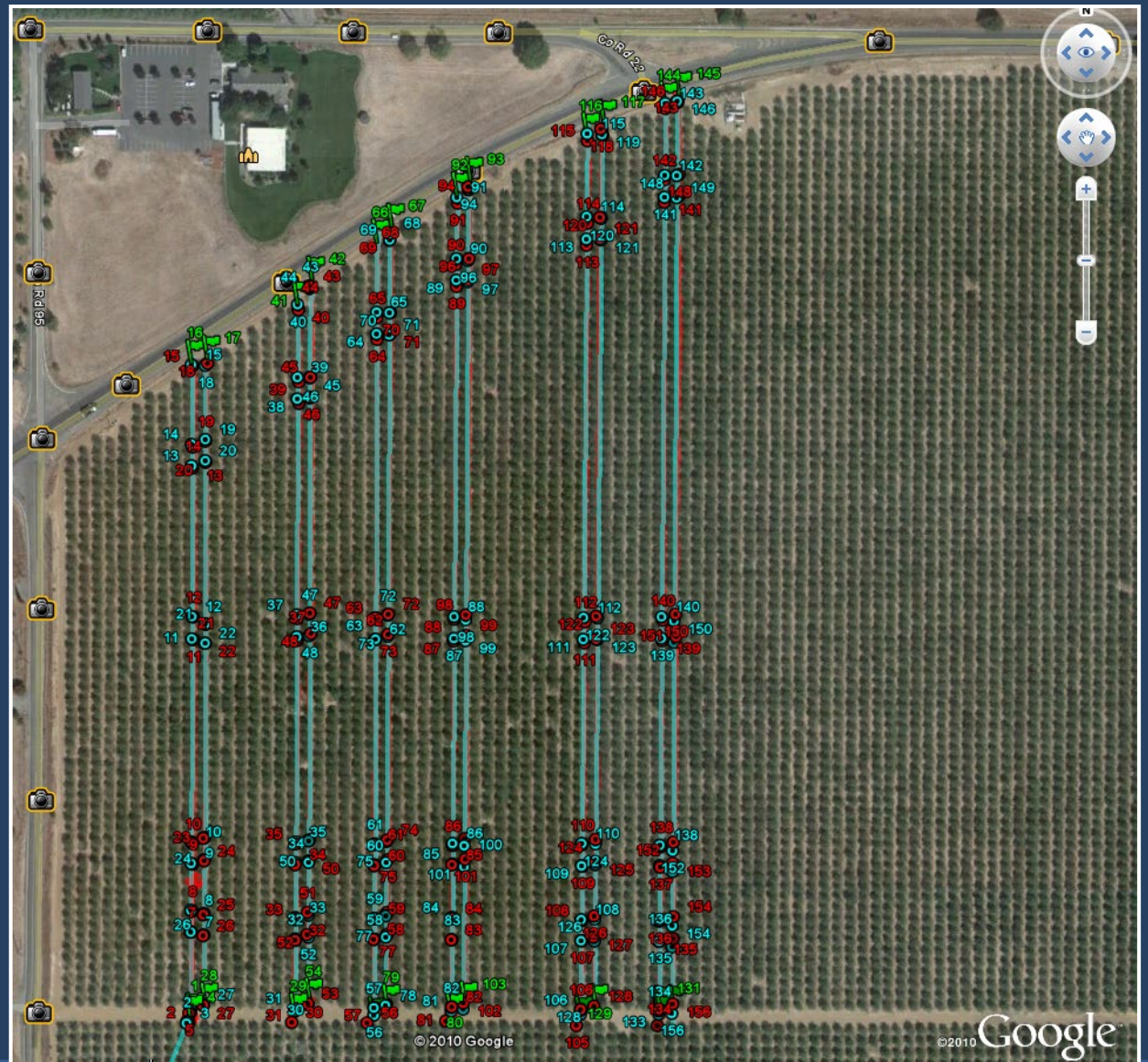
From top to bottom of windrow in orchard where nuts are dried in windrow (2% wetter at bottom than at top of windrow)

In both cases there is 2% difference in moisture content after drying

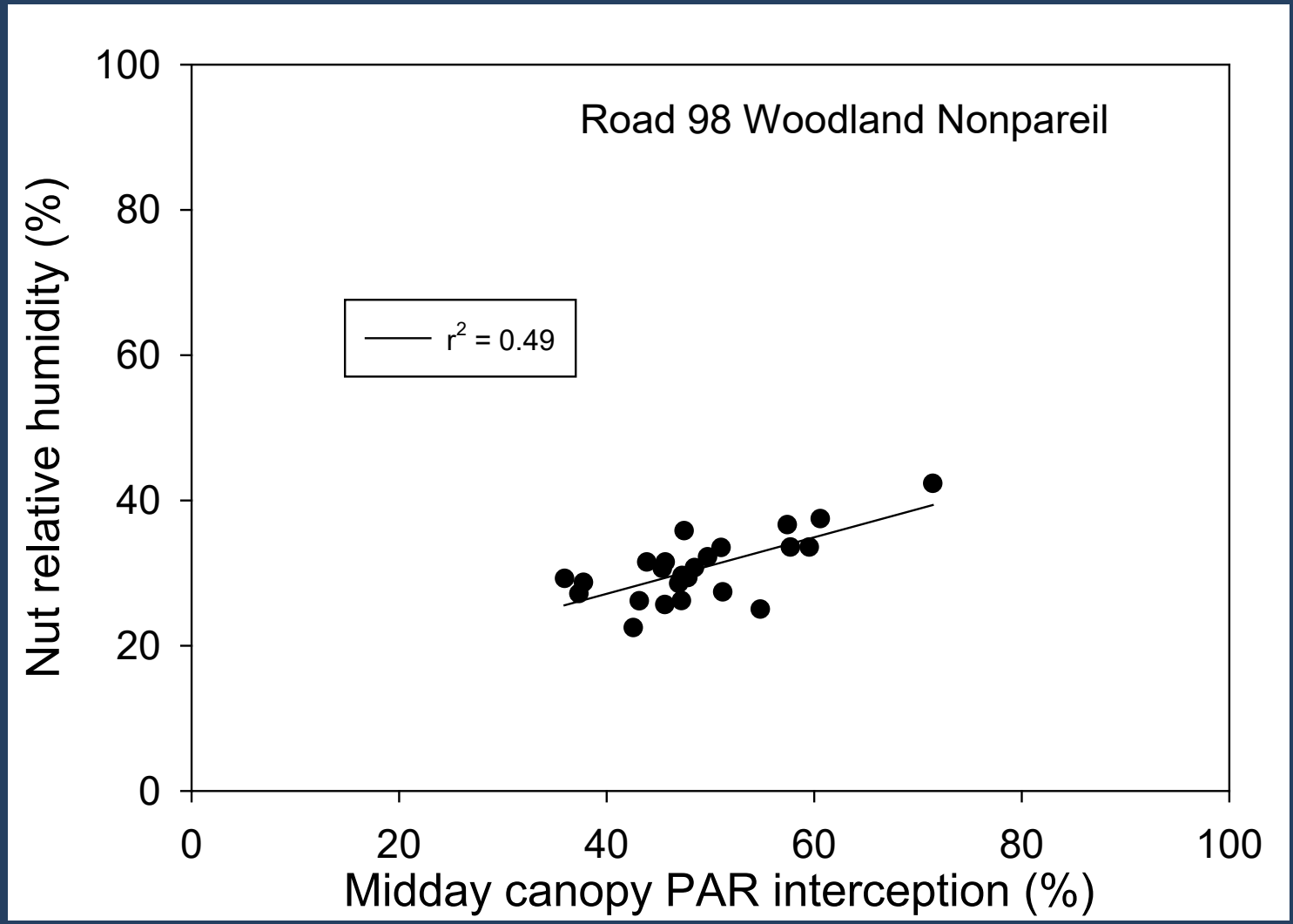
For nuts that were dried in windrow, moisture content was approximately 2% higher at bottom of windrow than at top

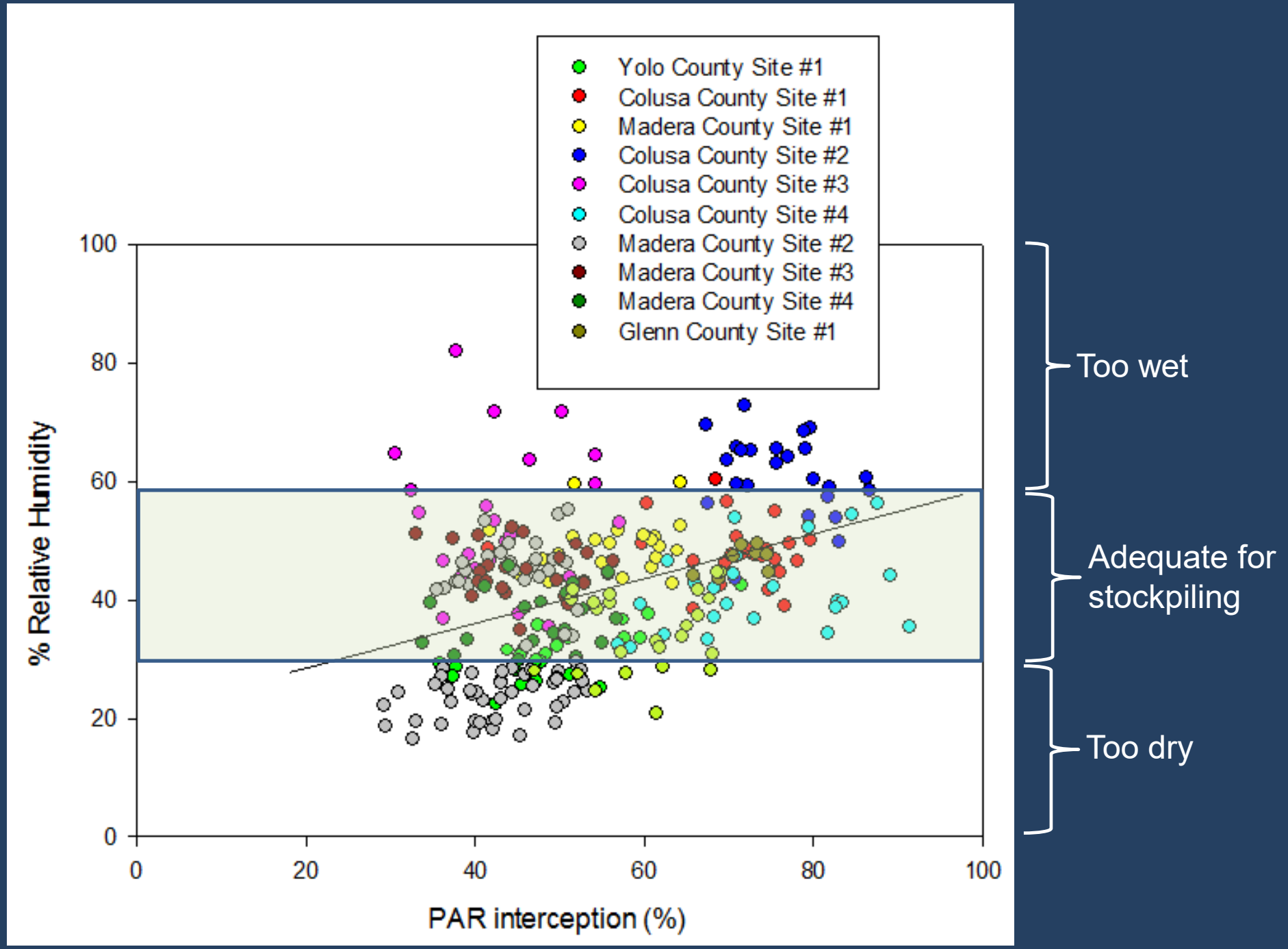
Probably best to condition nuts and spread them in a wider (but shallower) windrow for drying

Nut drying on orchard floor can vary depending on canopy size- be sure to sample across canopy size gradients



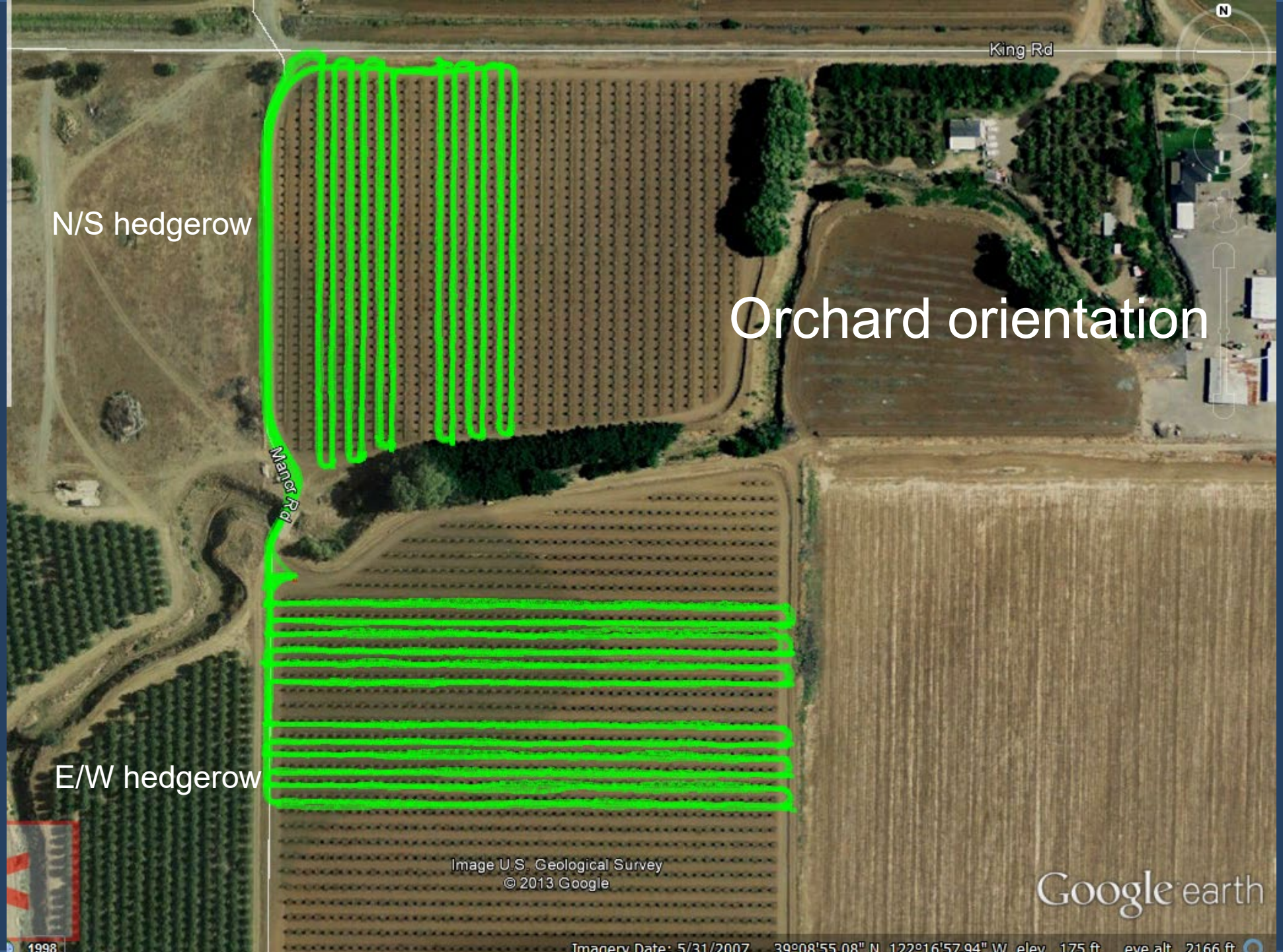
Nuts in lower light interception parts of orchard dried more rapidly than those in high light interception parts of orchard




Yolo County Site #1
Colusa County Site #1
Madera County Site #1
Colusa County Site #2
Colusa County Site #3
Colusa County Site #4
Madera County Site #2
Madera County Site #3
Madera County Site #4
Glenn County Site #1
% Relative Humidity
PAR interception (%)
0
20
40
60
80
100
Too wet
Adequate for stockpiling
Too dry

Sample nut moisture content in a systematic way across orchard before beginning harvest operation

More variable orchard requires more intensive sampling


King Rd
N/S hedgerow
Orchard orientation
Manor Rd
E/W hedgerow
Image U.S. Geological Survey
© 2013 Google
Google earth
1998
Imagery Date: 5/31/2007 39°08'55.08" N 122°16'57.94" W elev 175 ft eye alt 2166 ft

east/west 6:00AM north/south

east/west 7:00AM north/south

east/west 8:00AM north/south

east/west 9:00AM north/south

east/west 10:00AM north/south

east/west 11:00AM north/south

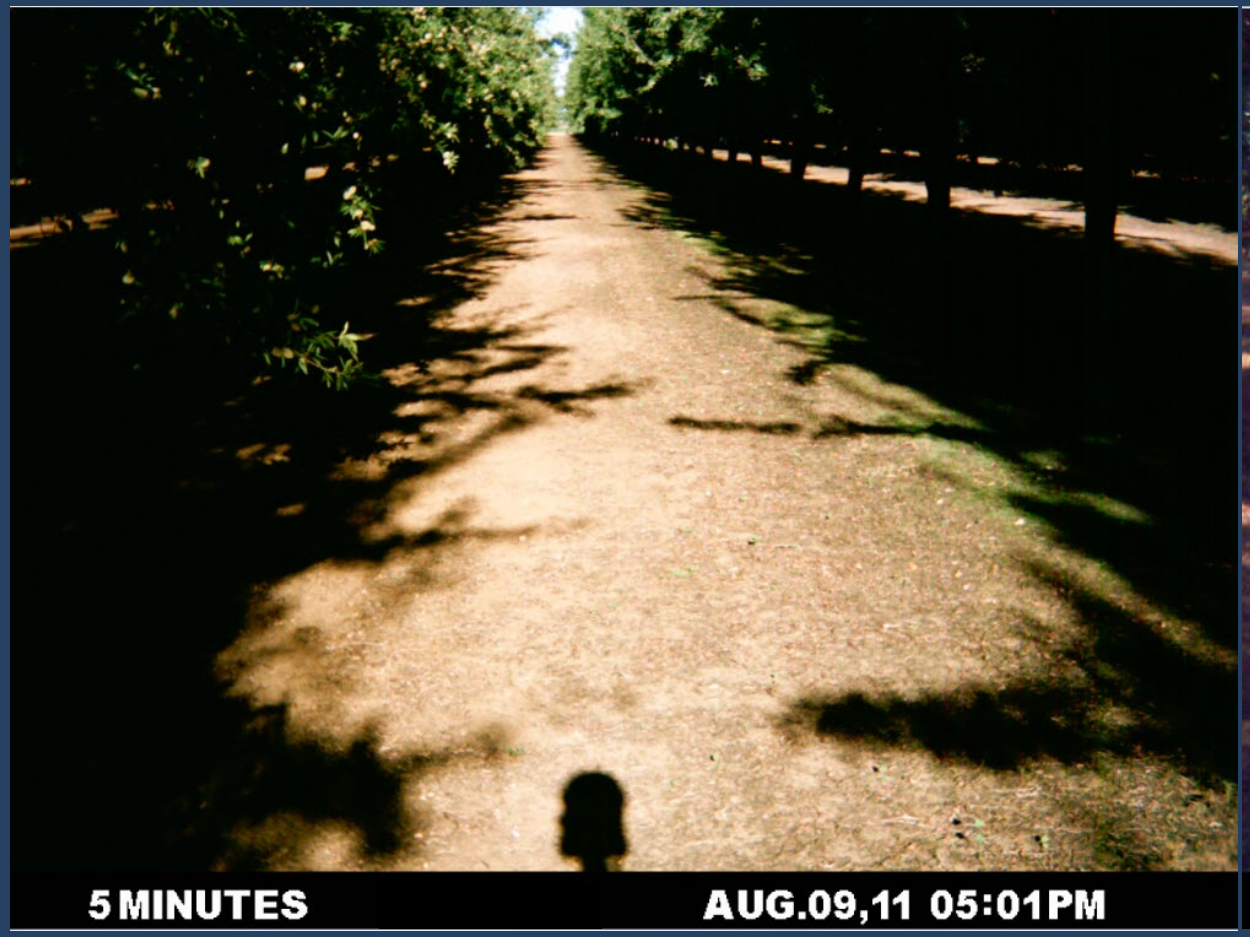
east/west 12:00PM north/south

east/west 1:00PM north/south

east/west 2:00PM north/south

east/west 3:00PM north/south

east/west 4:00PM north/south



east/west 5:00PM north/south

east/west 5:45PM north/south

North south oriented rows have better light distribution over the course of the day

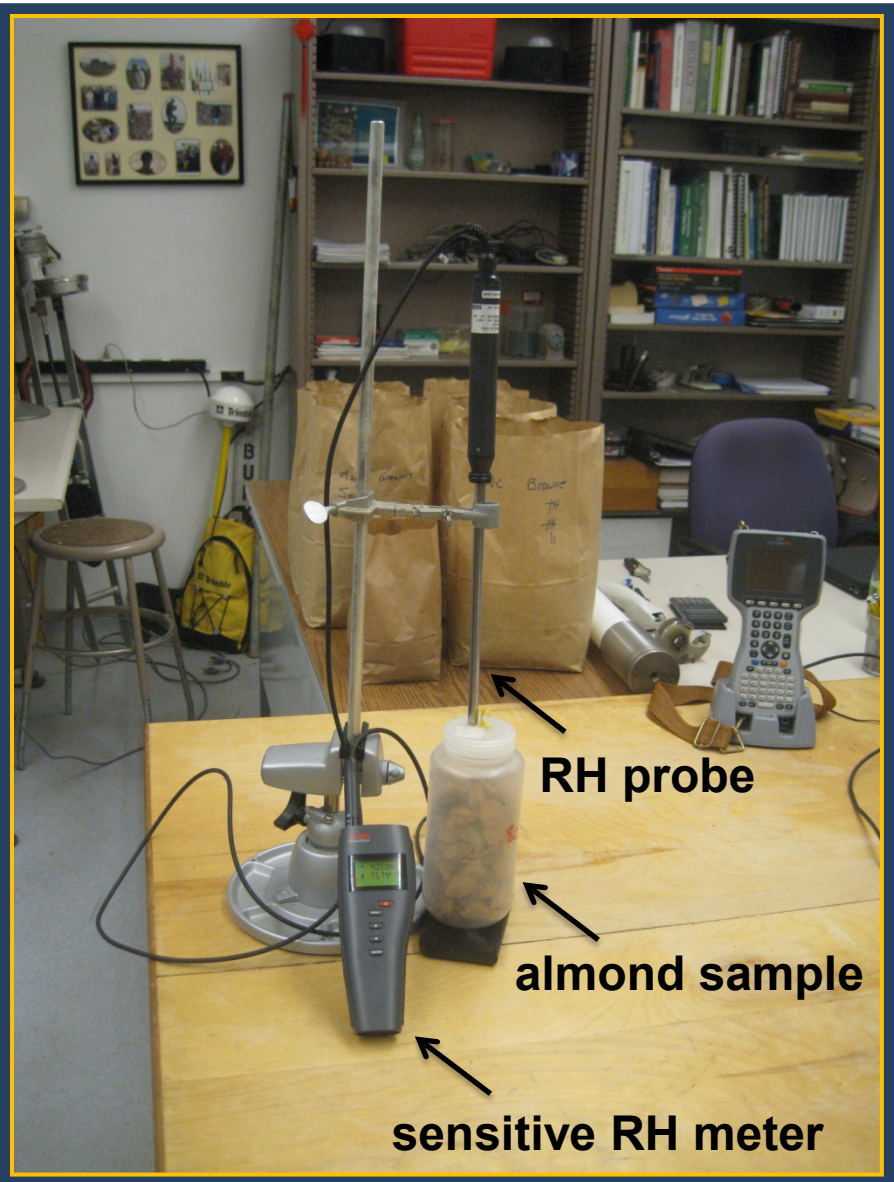
It can be difficult to dry nuts in east west oriented rows, particularly for late varieties

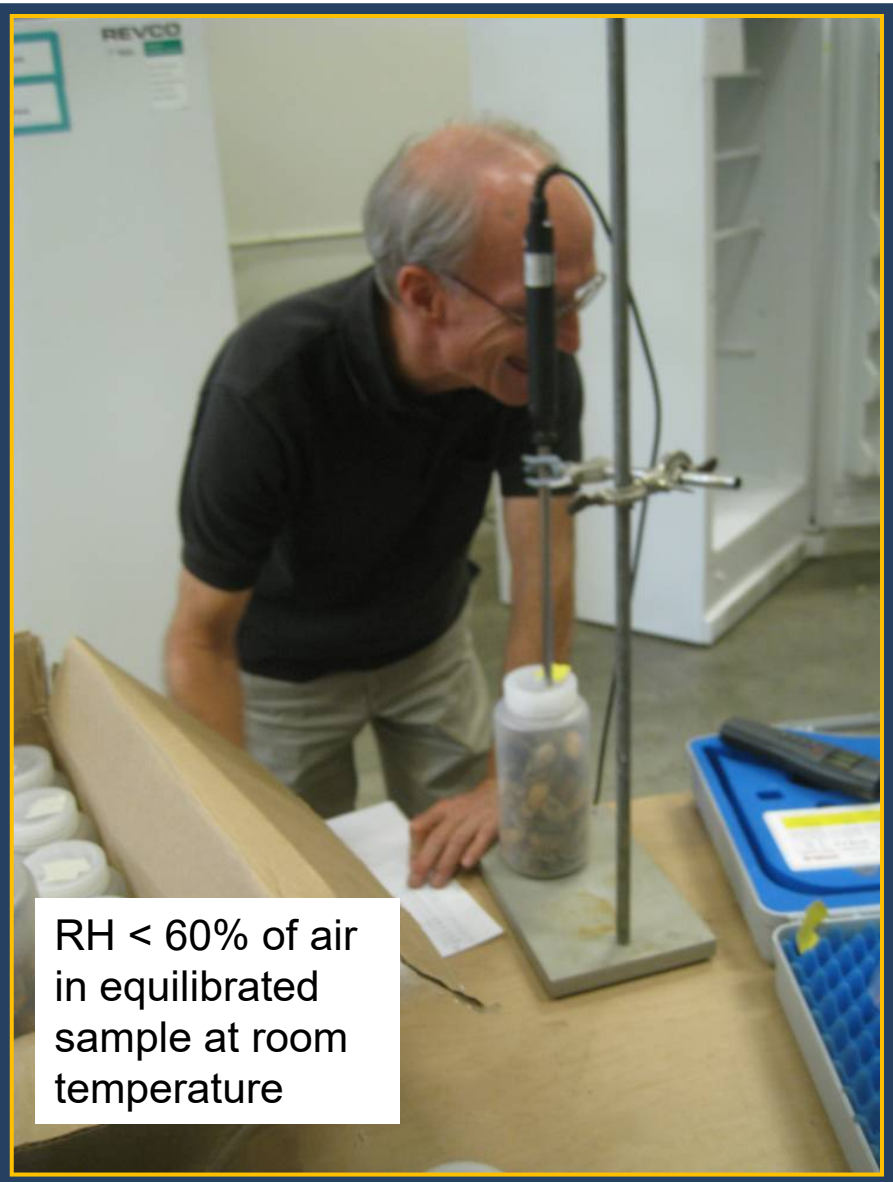
Water activity definition

Water activity - a measure of the availability of water in the food product which is available for bacterial or fungal growth

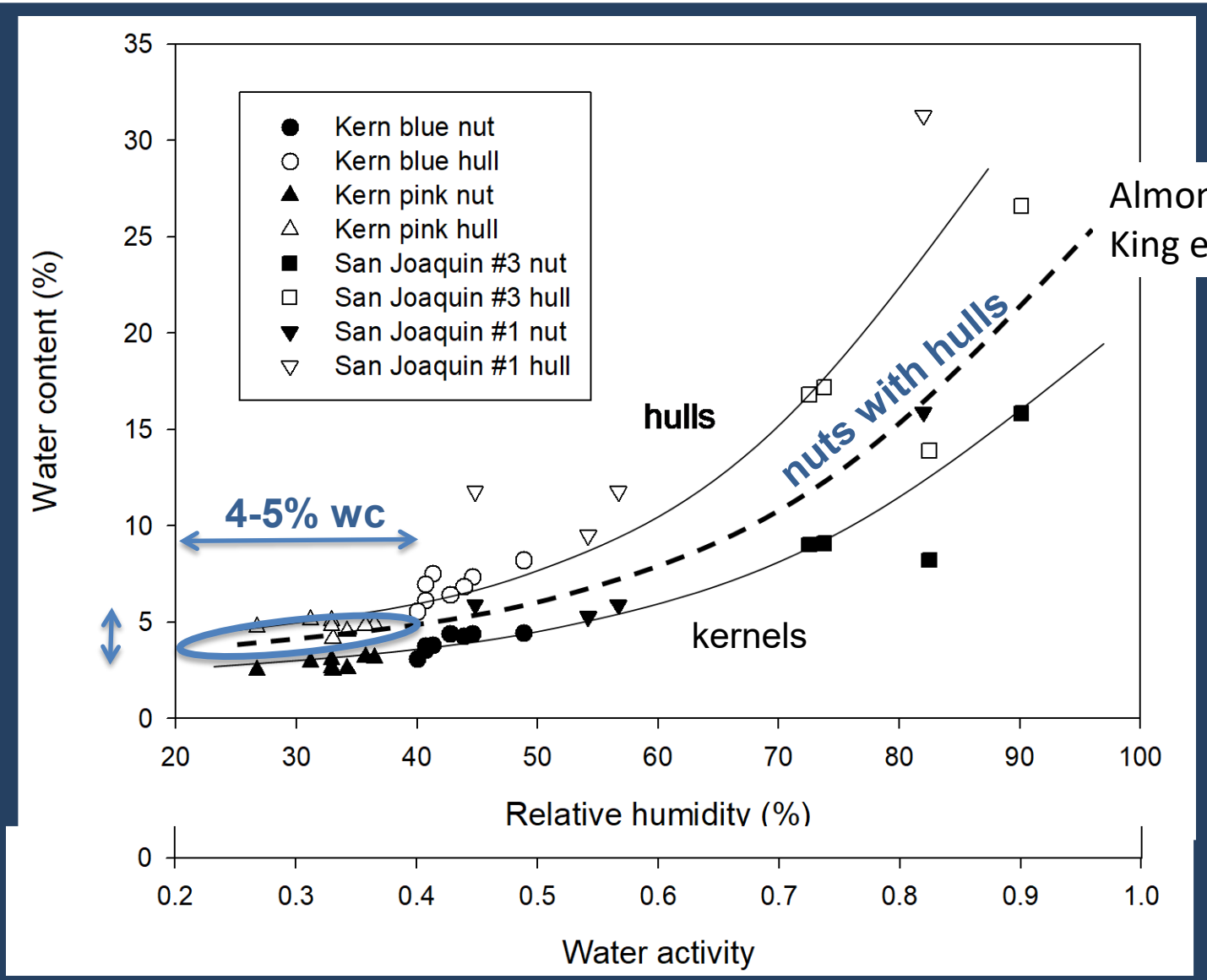
- It is water activity rather than water content that determines the potential for bacterial or fungal growth
- For almonds, a water activity of less than 0.6 is best
- A water activity of 0.6 is equivalent to a relative humidity of 60%

Measuring water activity (relative humidity) in an almond sample that has been allowed to equilibrate to room temperature





Relationship between relative humidity and water content for almond kernels with shell, hulls, and nuts with shells and hulls



Almond from
King et.al, 1983

Relationship between RH, water activity (at room temperature), and water content (kernels and hulls, hulls, and kernels)

Relative humidity	Water activity	water content		
		kernels+hulls	hulls	kernels
30	0.30	3.80	4.43	2.73
31	0.31	3.89	4.59	2.79
32	0.32	4.00	4.76	2.85
33	0.33	4.11	4.94	2.92
34	0.34	4.22	5.12	2.99
35	0.35	4.34	5.31	3.06
36	0.36	4.47	5.50	3.14
37	0.37	4.61	5.71	3.22
38	0.38	4.75	5.92	3.31
39	0.39	4.89	6.13	3.40
40	0.40	5.05	6.36	3.50
41	0.41	5.20	6.59	3.60
42	0.42	5.37	6.83	3.71
43	0.43	5.54	7.07	3.82
44	0.44	5.72	7.32	3.94
45	0.45	5.90	7.58	4.06
46	0.46	6.09	7.85	4.18
47	0.47	6.29	8.12	4.31
48	0.48	6.49	8.40	4.45
49	0.49	6.70	8.69	4.59
50	0.50	6.92	8.98	4.73
51	0.51	7.14	9.28	4.88
52	0.52	7.37	9.59	5.03
53	0.53	7.60	9.90	5.19
54	0.54	7.84	10.22	5.35
55	0.55	8.09	10.55	5.51
56	0.56	8.34	10.89	5.69
57	0.57	8.60	11.23	5.86
58	0.58	8.87	11.58	6.04
59	0.59	9.14	11.94	6.23
60	0.60	9.42	12.30	6.42
61	0.61	9.70	12.67	6.61
62	0.62	9.99	13.05	6.81
63	0.63	10.29	13.43	7.01
64	0.64	10.59	13.82	7.22
65	0.65	10.90	14.22	7.43
66	0.66	11.22	14.62	7.65
67	0.67	11.54	15.04	7.87
68	0.68	11.87	15.45	8.10
69	0.69	12.20	15.88	8.33
70	0.70	12.55	16.31	8.56
71	0.71	12.89	16.75	8.80
72	0.72	13.25	17.20	9.05

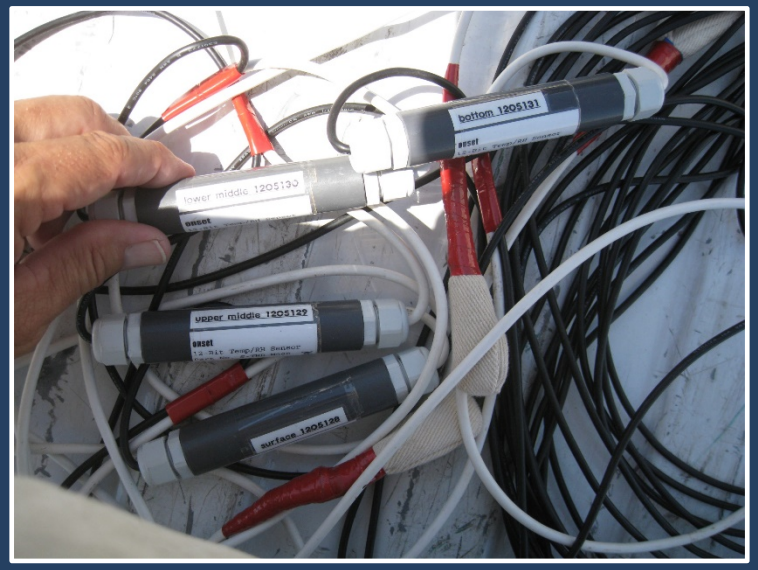
Relative humidity	Water activity	water content		
		kernels+hulls	hulls	kernels
73	0.73	13.61	17.65	9.30
74	0.74	13.97	18.11	9.55
75	0.75	14.34	18.58	9.81
76	0.76	14.72	19.06	10.07
77	0.77	15.11	19.54	10.34
78	0.78	15.50	20.03	10.61
79	0.79	15.89	20.52	10.89
80	0.80	16.30	21.02	11.17
81	0.81	16.71	21.53	11.45
82	0.82	17.12	22.05	11.75
83	0.83	17.55	22.57	12.04
84	0.84	17.97	23.10	12.34
85	0.85	18.41	23.64	12.64
86	0.86	18.85	24.18	12.95
87	0.87	19.30	24.74	13.27
88	0.88	19.75	25.29	13.59
89	0.89	20.21	25.86	13.91
90	0.90	20.68	26.43	14.24
91	0.91	21.15	27.01	14.57
92	0.92	21.63	27.60	14.90
93	0.93	22.11	28.19	15.25
94	0.94	22.60	28.79	15.59
95	0.95	23.10	29.39	15.94
96	0.96	23.60	30.01	16.30
97	0.97	24.11	30.63	16.66
98	0.98	24.63	31.26	17.02
99	0.99	25.15	31.89	17.39
100	1.00	25.68	32.53	17.76

Impact of different tarp materials on stockpile conditions

White on black

White

Clear

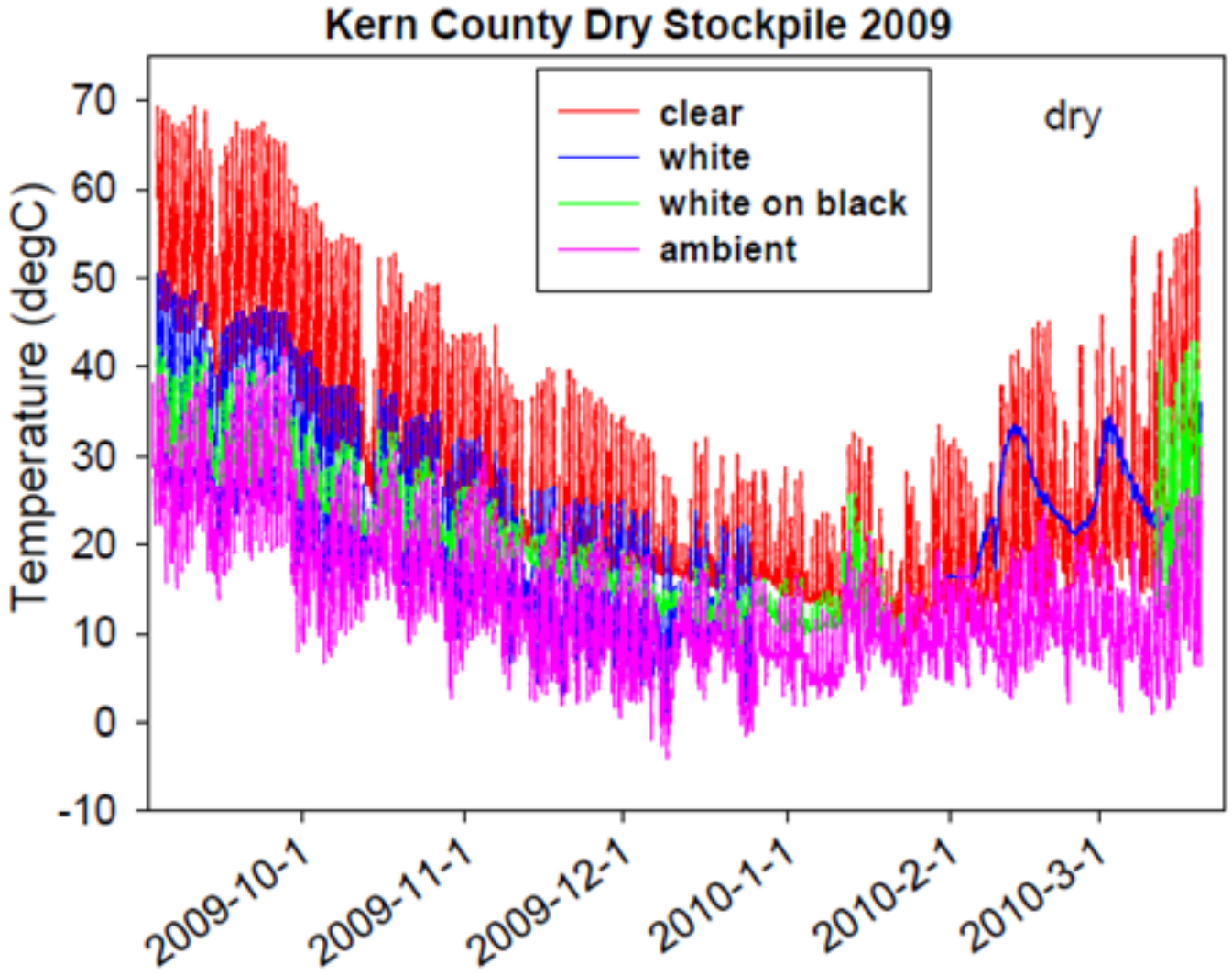

bottom 1205131
lower middle 1205130
upper middle 1205122
surface 1205129

Temperature and relative humidity sensor placement in stockpiles. Sensors were approximately in the middle of the stockpiles long dimension in line with the yellow measuring tapes.

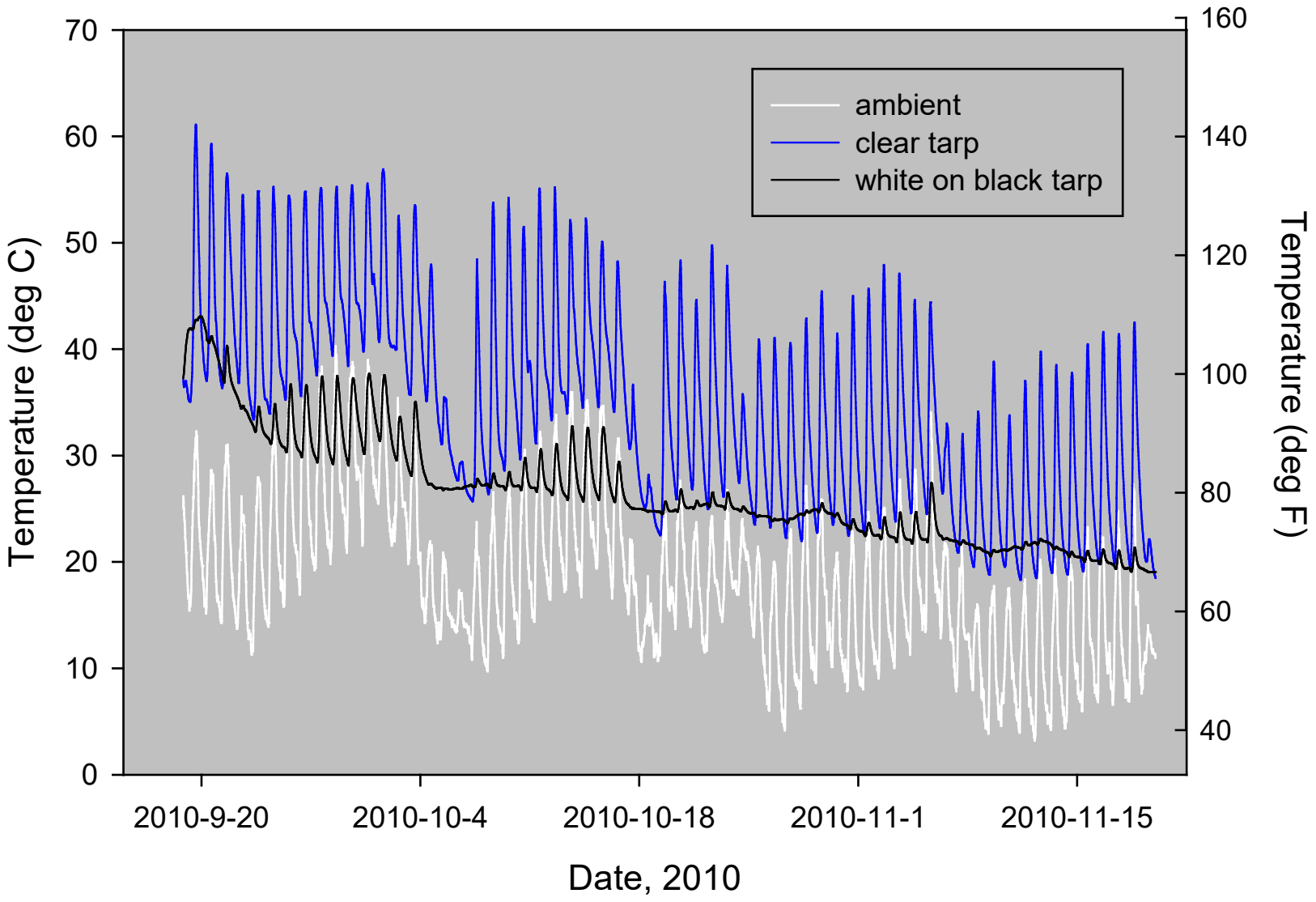
Impact of different tarp materials on stockpile conditions

Temp. top of pile

- White better and white on black tarps much better than clear
- less day-to-night temperature fluctuations
- Less condensation



Impact of different tarp materials on stockpile conditions



White on black tarp ran up to 40 deg F cooler than commonly used clear tarp and had much smaller day to night temperature fluctuations

Table 1. Starting and ending moisture content for in hull nuts from dry and wet stockpiles covered with either clear or white on black tarp in 2010-11. Samples taken from location labeled 3' down are from 3' down from the top/center of pile (indicated with arrows) are the most representative of conditions in the overall pile. Samples labeled top and side are taken on outer surface of pile where condensation is most likely. Note that moisture content increased during storage period in all stockpiles at all locations.

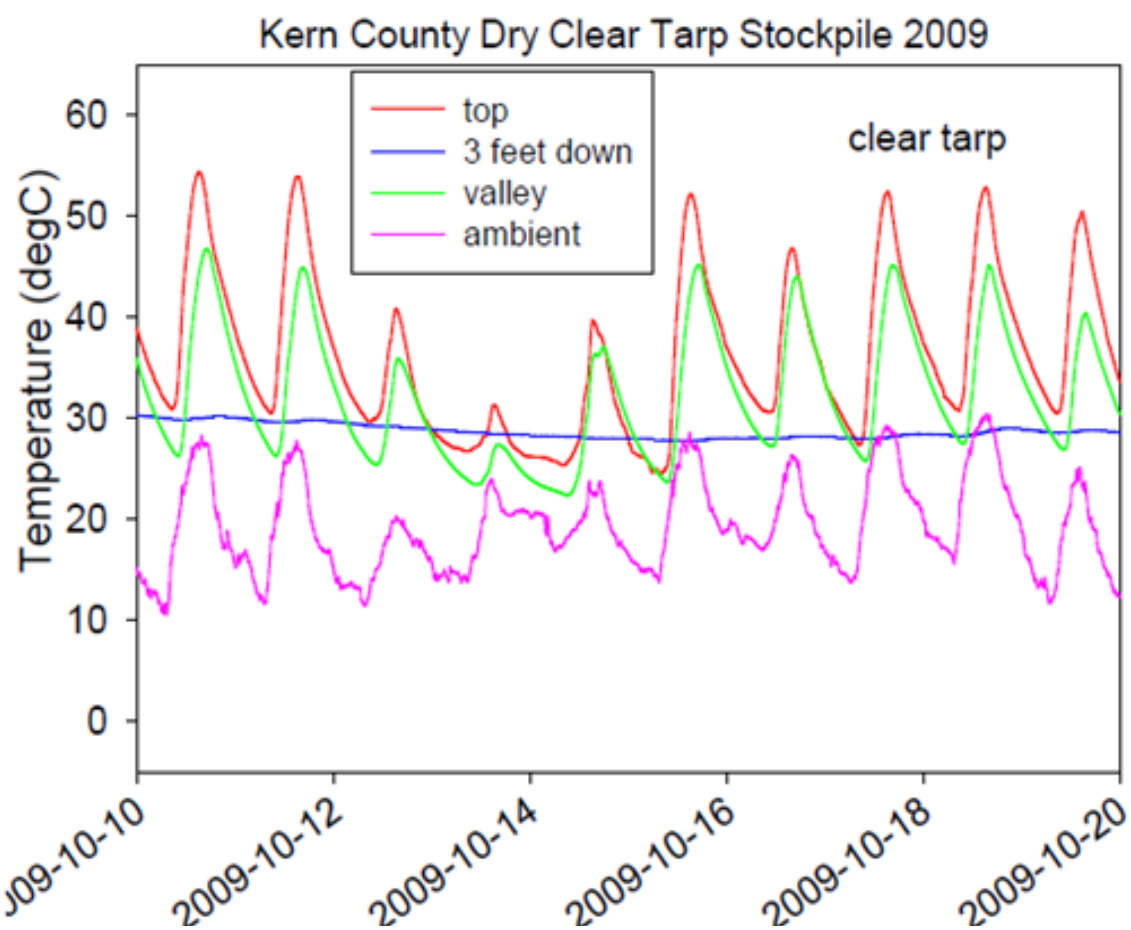
Dry stockpile

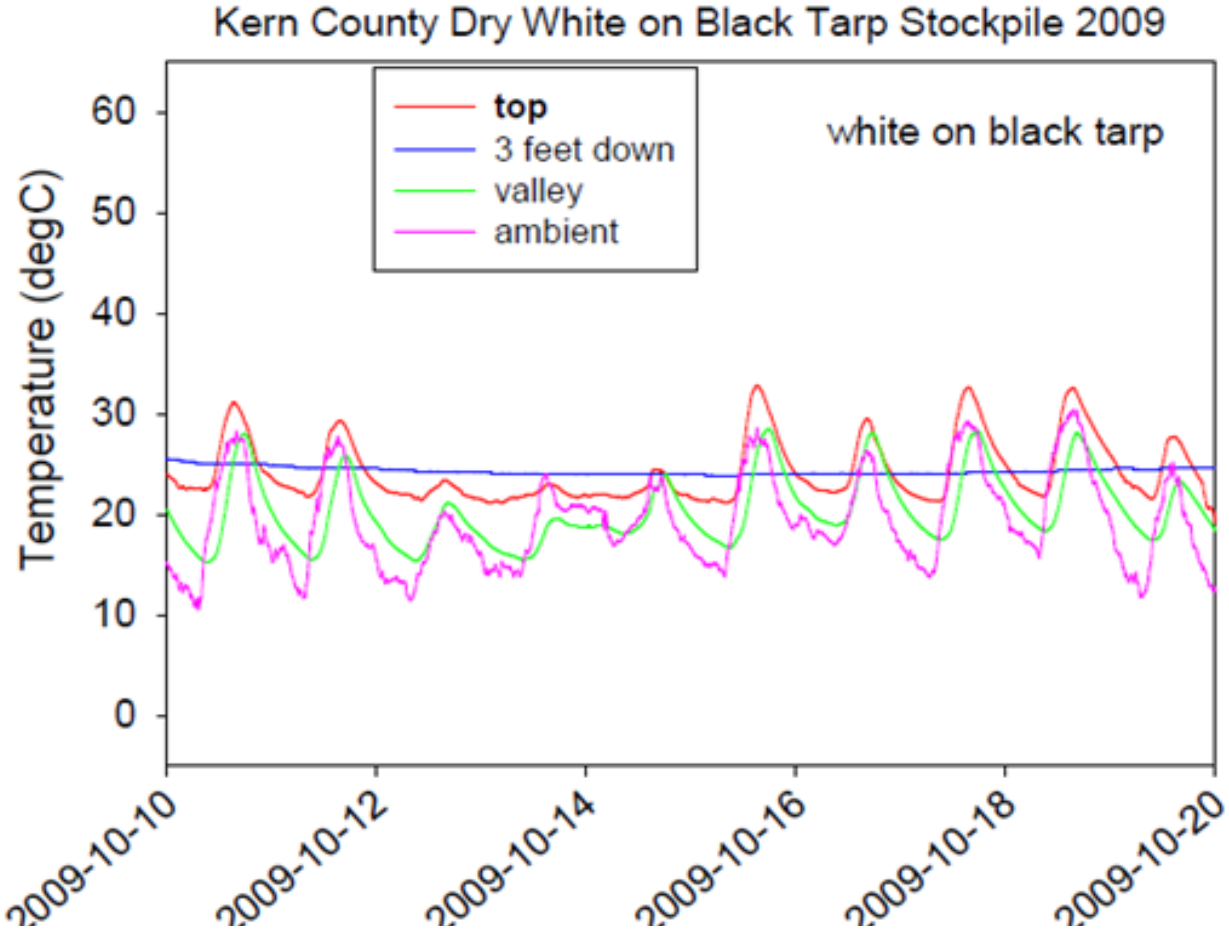
	Location	Starting % moisture	Ending moisture	Change in % moisture
clear	Top	4.9	31.6	+26.7
	3' down	3.7	9.9	+6.2
	Side	4.3	6.3	+2.0
White on black	Top	4.1	9.2	+5.0
	3' down	5.2	7.2	+2.0
	Side	4.7	9.9	+5.2

Much more increase in moisture content with clear tarp

Less increase in moisture content with white on black tarp

Conditions in pile much more uniform with white on black tarp





Impact of different tarp materials on stockpile conditions

Clear tarp north end

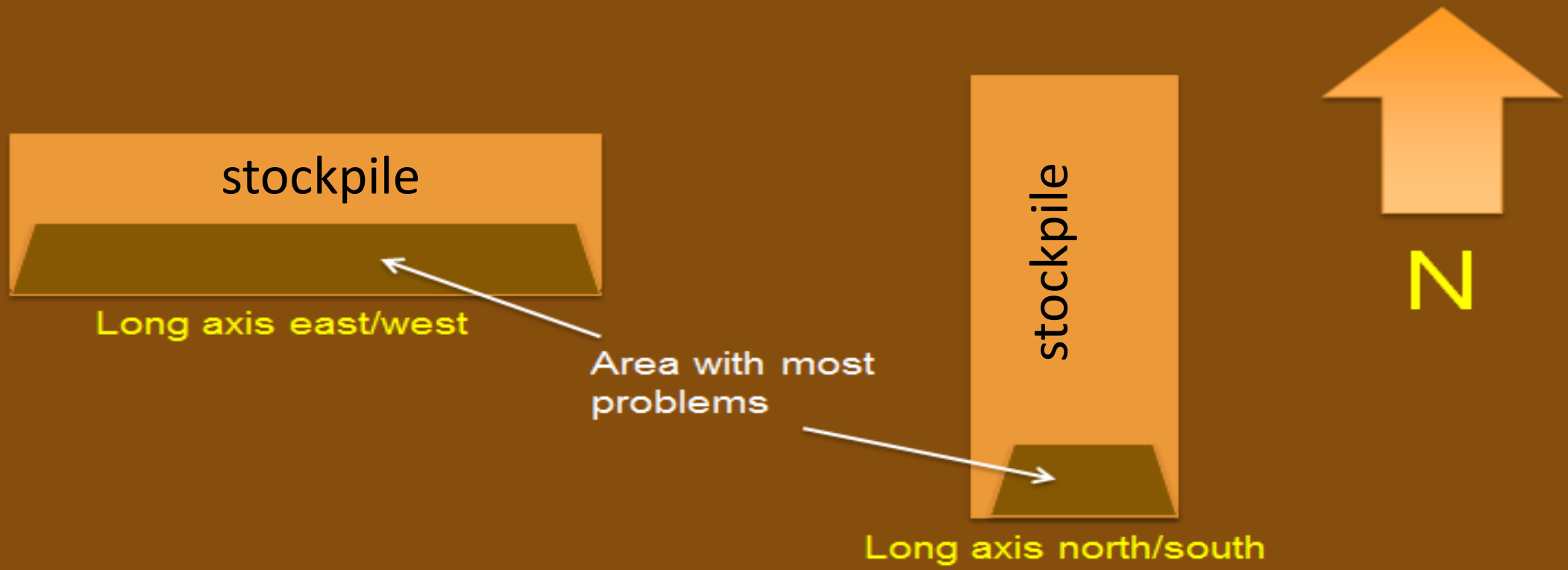
White on black tarp north end

Smaller temperature fluctuations under white on black tarp led to less condensation problems and correspondingly less mold growth


February 22 (stockpiled since late August)
Clear tarp
white on black tarp

Large humps on top of piles leads to valleys where condensed water can collect and contact nuts leading to mold growth

Flattening tops of piles leads to less concentration of condensate. Orienting piles with long axis in north/south direction is also beneficial


stockpile
Long axis east/west
Area with most problems
stockpile
Long axis north/south
N

Stockpiling Guidelines

Do not stockpile if either the hull moisture content exceeds 13% or the kernel moisture content exceeds 6%

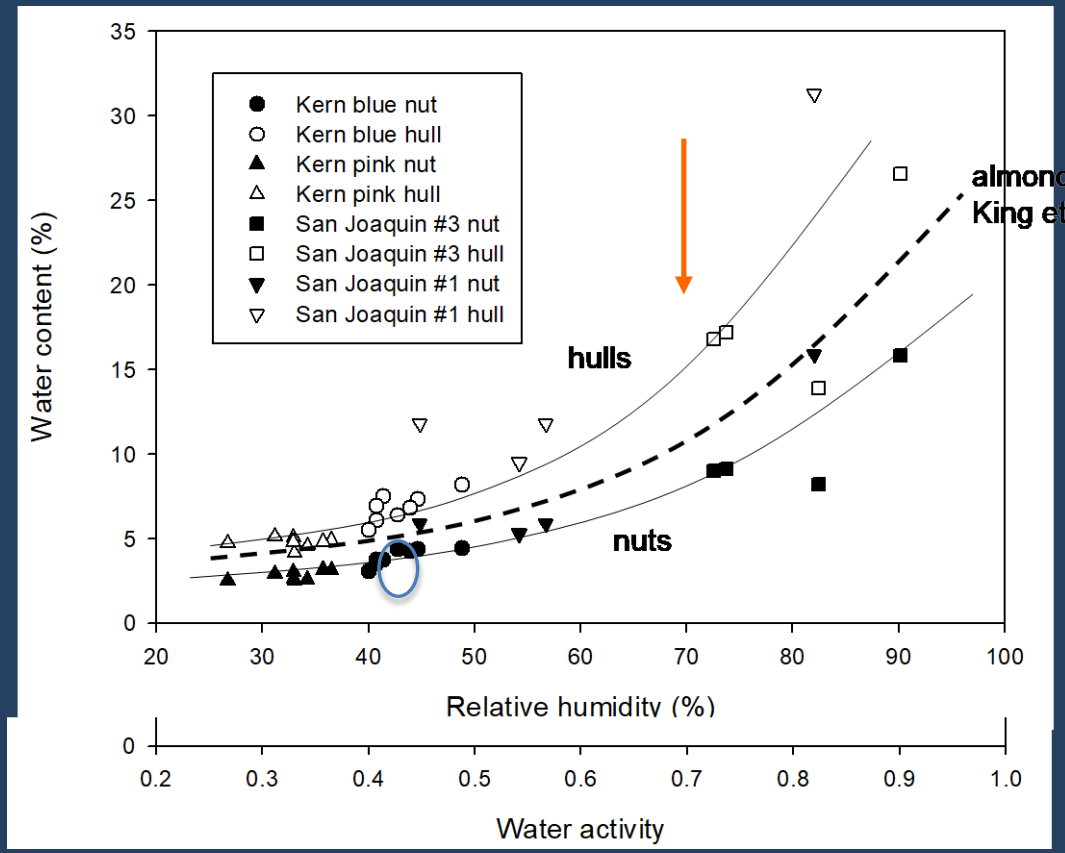
This is equivalent to a sample water activity of 0.6 or a relative humidity of 60% (at room temperature)

Hull moisture content

11-12%	Acceptable (the hull snaps)
>13%	Too high

Kernel moisture content

4-5%	Excellent
< 6%	Acceptable
> 6%	Too high



Food safety risk should be assessed in relation to orchard planting design and canopy structure

- More uniform orchard canopy development leads to more uniform nut drying on orchard floor
- Hedgerow plantings lead to more dense shade under tree row which may increase food safety risk
- More conventional tree spacing leads to more varied light/temperature patterns across orchard floor
- North/south oriented rows better than east/west
- Any orchard producing above 3500 kernel pounds per acre likely has increased potential for food safety related problems

•Stockpiling.

- •Sample nut moisture content in a systematic way across orchard before beginning harvest operation
- •Make sure nuts are adequately dry before stockpiling (water activity less than 0.6)
- Choose appropriate tarp materials to minimize condensation potential- white on black tarp performed best
- Orient stockpiles with long axis north/south


Questions?

Rooted IN SUCCESS 2021
the almond conference

Aflatoxin Management in Almond Production

8 Dec 2021/ Themis J. Michailides

california almonds
Almond Board of California

People Involved

1. Ramon Jaime [1]
2. Victor Gabri [1]
3. Alejandro Ortega Beltran [1]
4. Ryan Puckett [1]
5. Juan Moral [1,2]
6. Teresa Garcia Lopez [2]
7. John Lake [1]
8. Giuseppe Fiore [3]

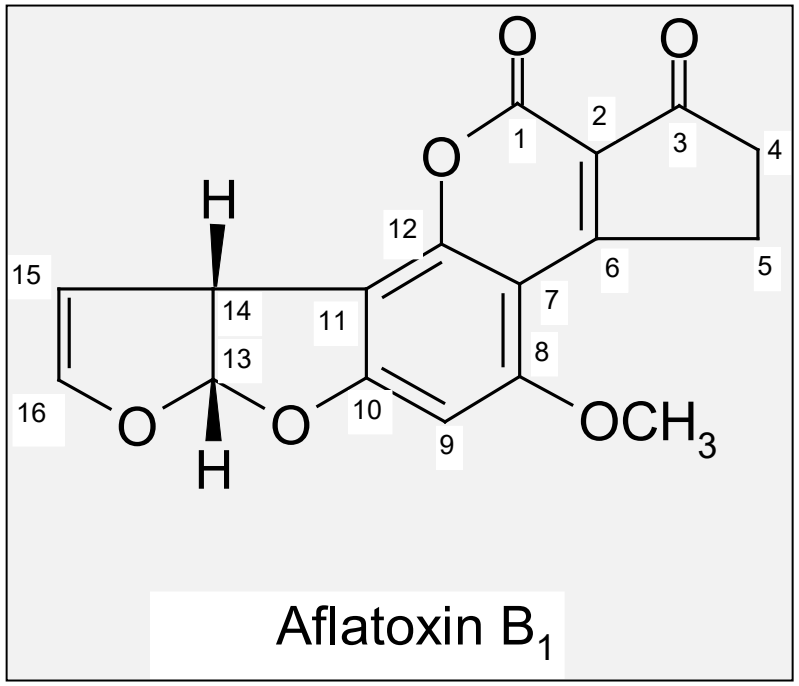
[1] University of California Davis/Kearney Agric. Research & Extension center, USA

[2] University of Cordoba, Spain

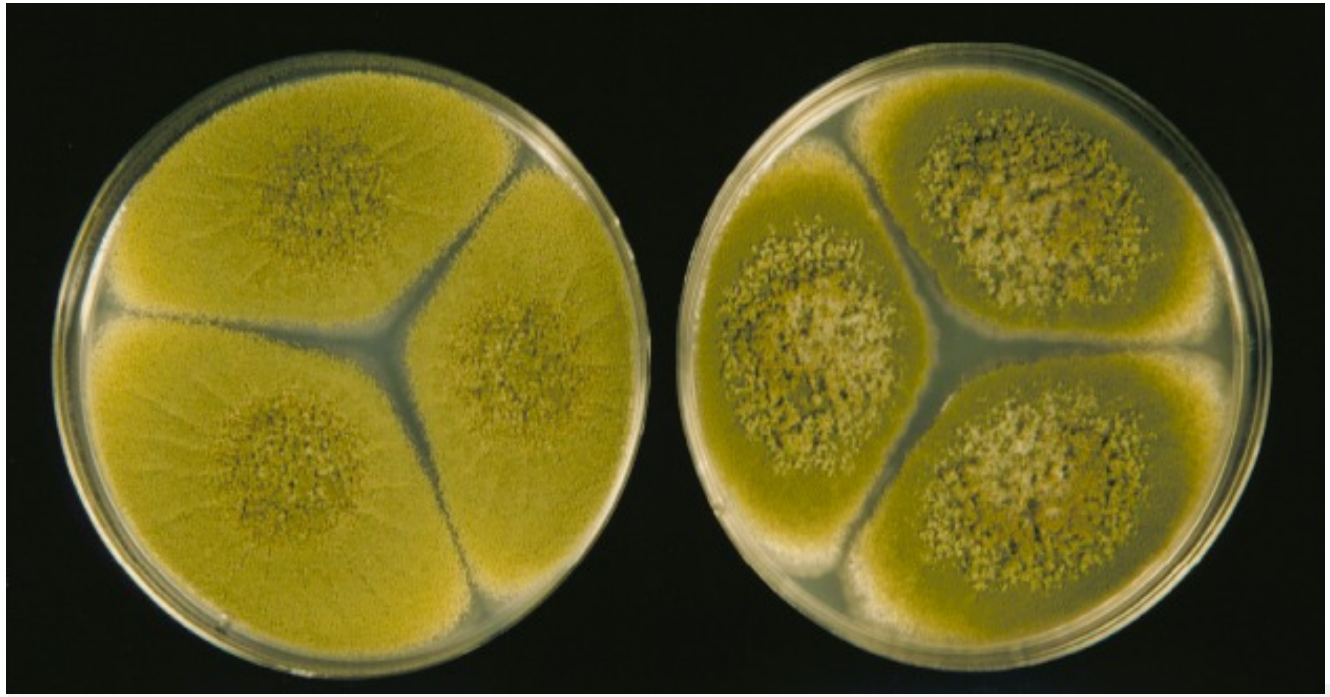
[3] University of Bari, Italy

Aflatoxins are produced by *Aspergillus flavus* and *A. parasiticus*

B1: The most potent; it can cause liver cancer



Aflatoxin B_1



Aspergillus flavus (B1,B2) *Aspergillus parasiticus* (B1,B2,G1,G2)

Regulatory limits for aflatoxins

- **USA**
  Total aflatoxins➔ 20 ppb

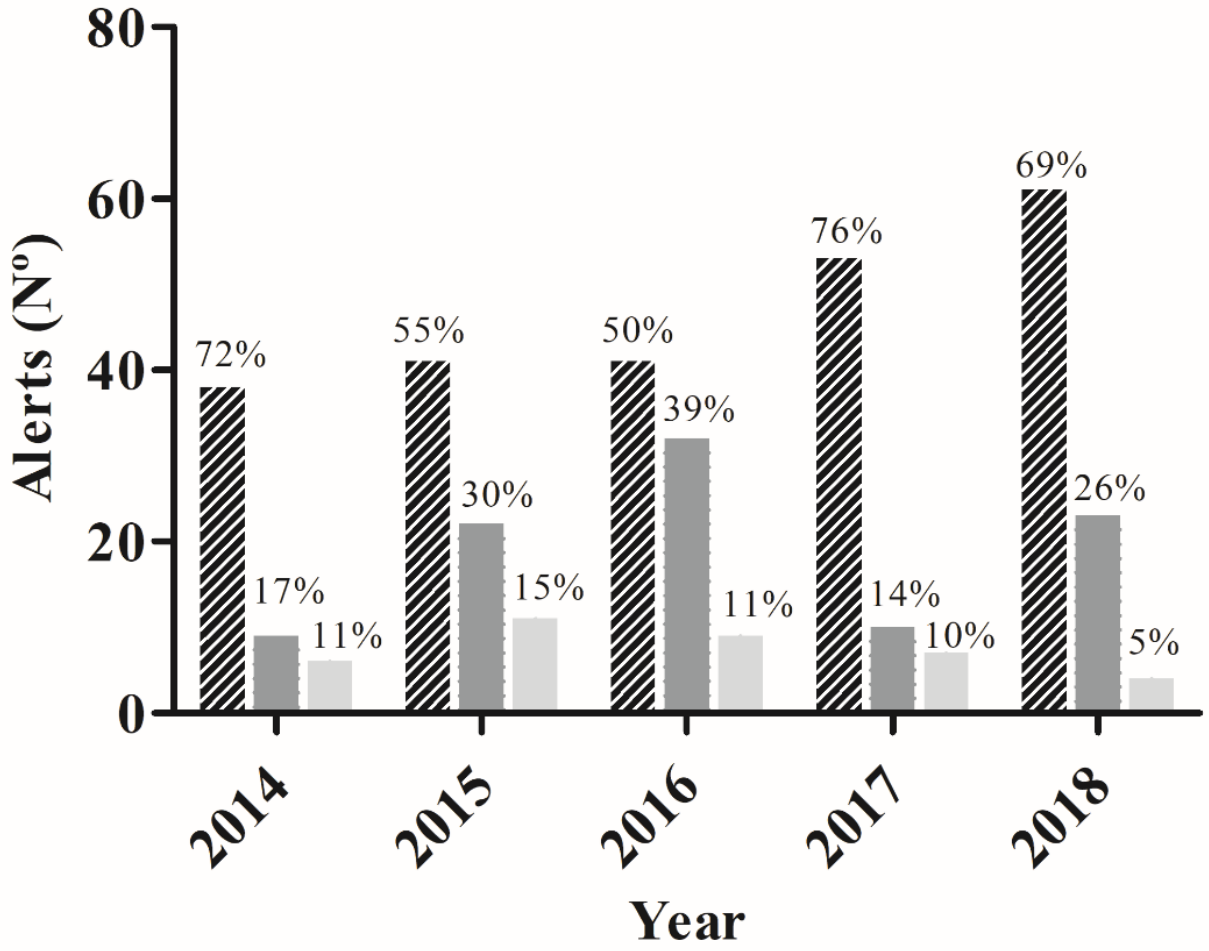
- **European Union**
  Total aflatoxins➔10 ppb
  ***Aflatoxin B1*➔ 8 ppb**

(pistachios, almonds, and figs for direct consumption)

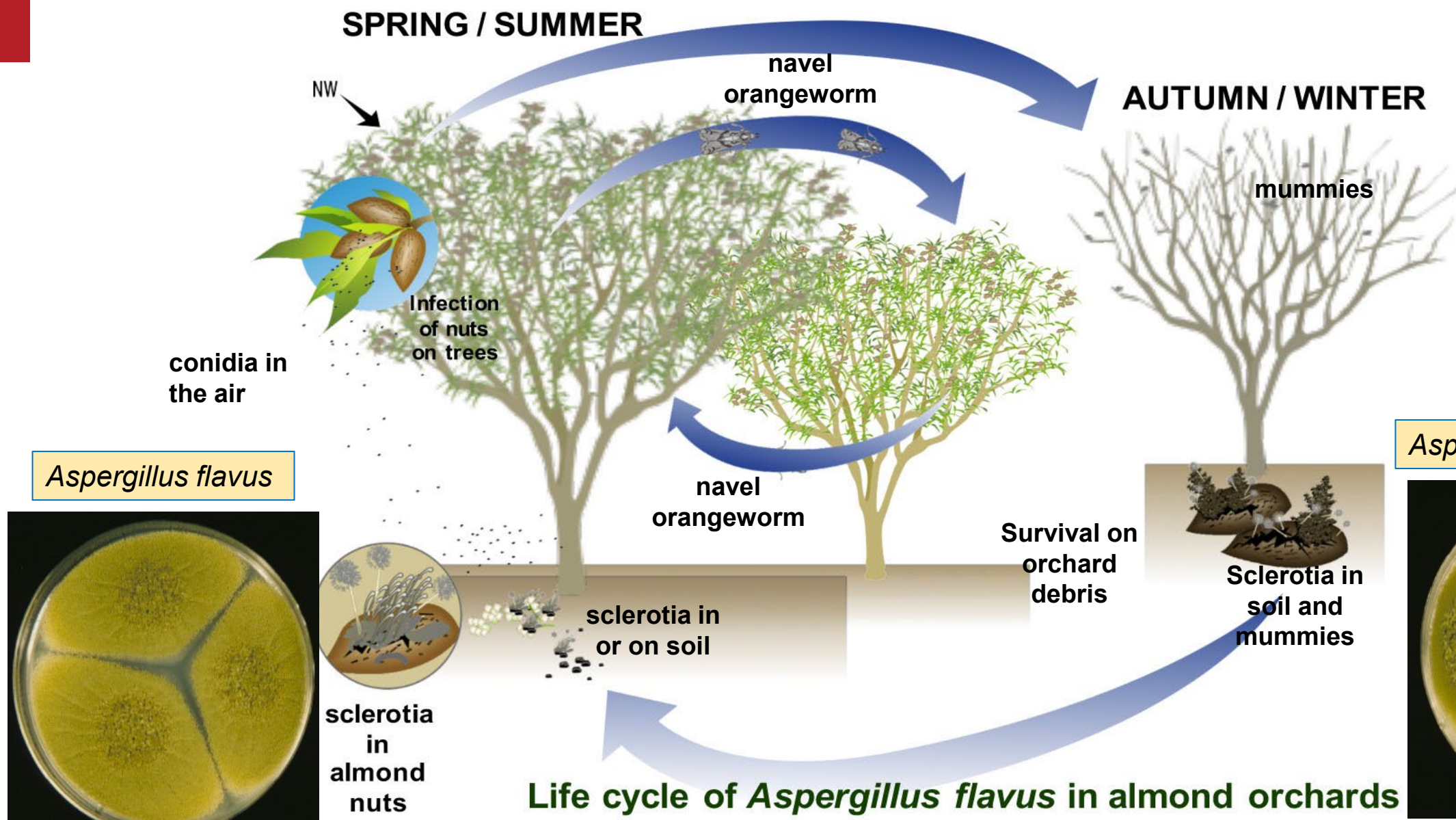
walnuts and dried fruit
- **Total aflatoxins➔ 4 ppb**
- ***Aflatoxin B1*➔ 2 ppb**

dried figs
- **Total aflatoxins➔ 10 ppb**
- ***Aflatoxin B1*➔ 6 ppb**

Percent Rapid Alerts on aflatoxins, ochratoxins, & other mycotoxins in various crops



The almond industry has taken extensive measures and supports pre- and post-harvest research to control aflatoxins and to assure compliance with aflatoxin regulations.

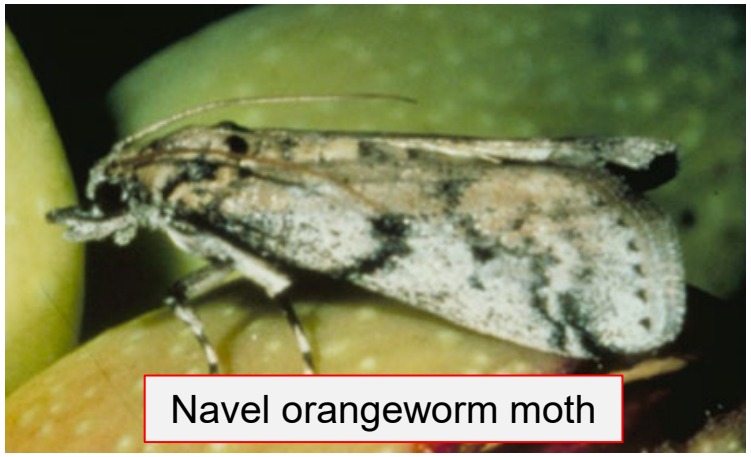


Aspergillus flavus

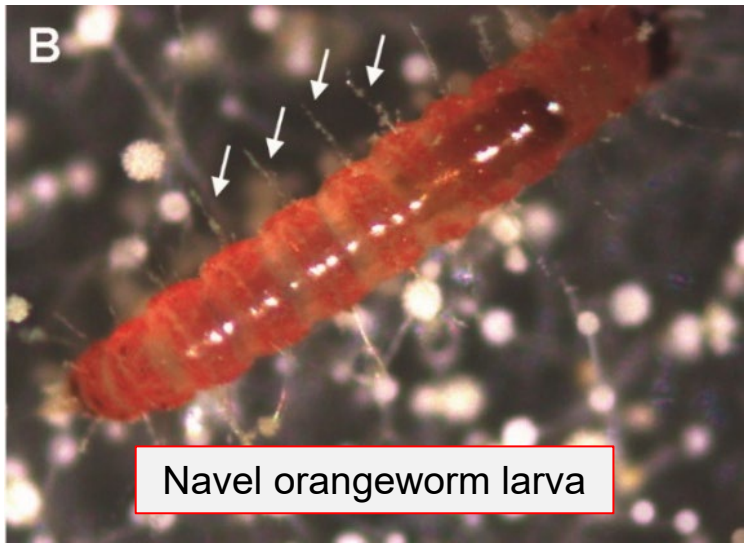
Aspergillus parasiticus

Acquisition and transmission of *Aspergillus flavus* by navel orangeworm

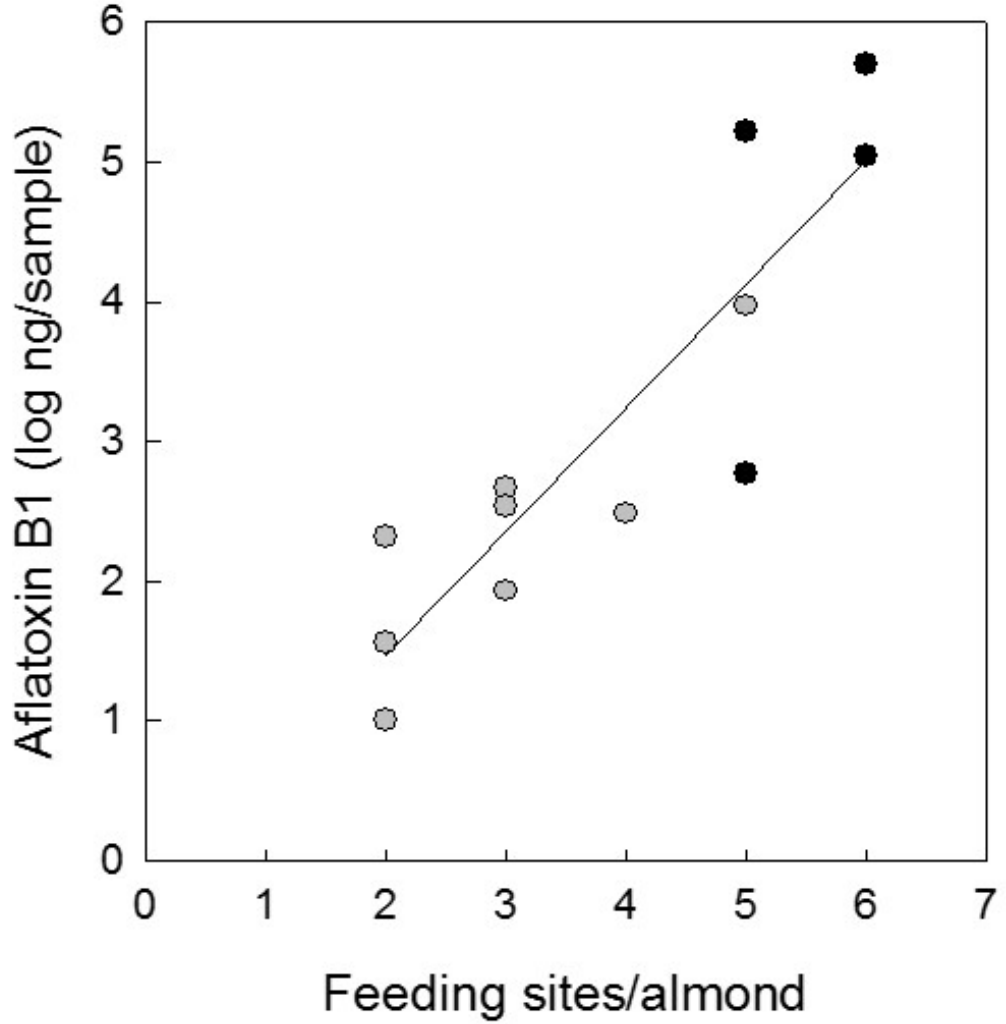
(in coop. with Dr. Palumbo, ARS/USDA, Albany)



Navel orangeworm moth

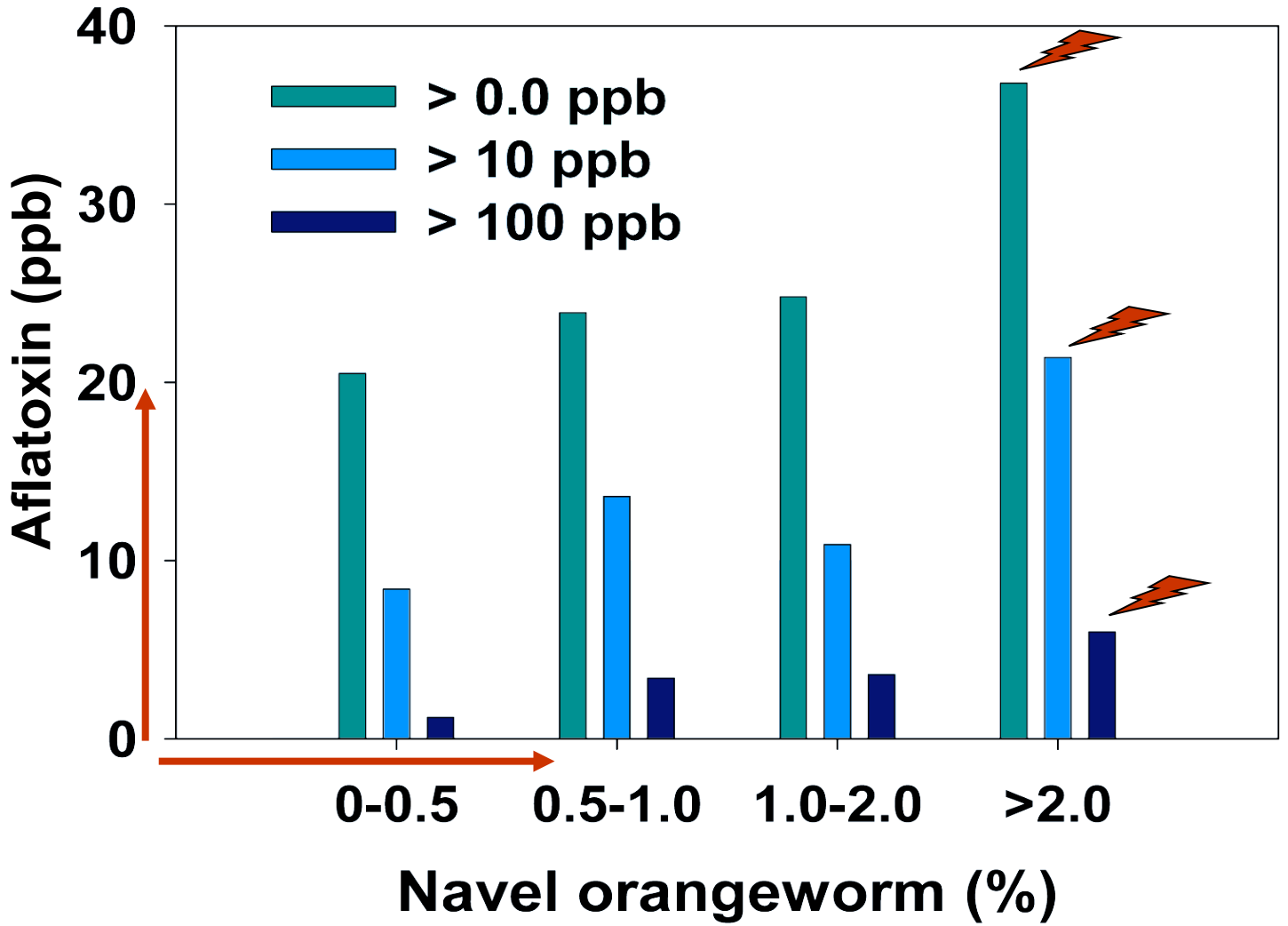


Navel orangeworm larva



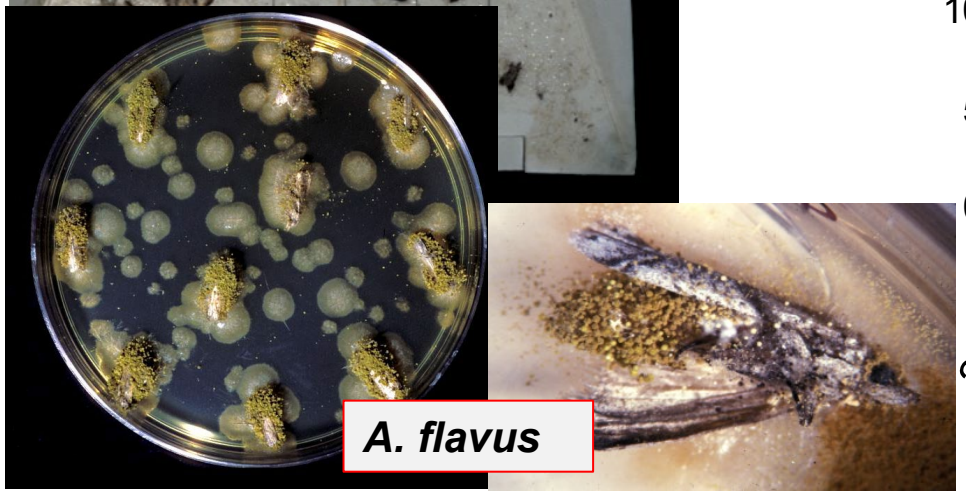
Palumbo et al. 2015, Plant Disease 98:1194-1199.

Relationship of navel orangeworm damage and aflatoxin levels

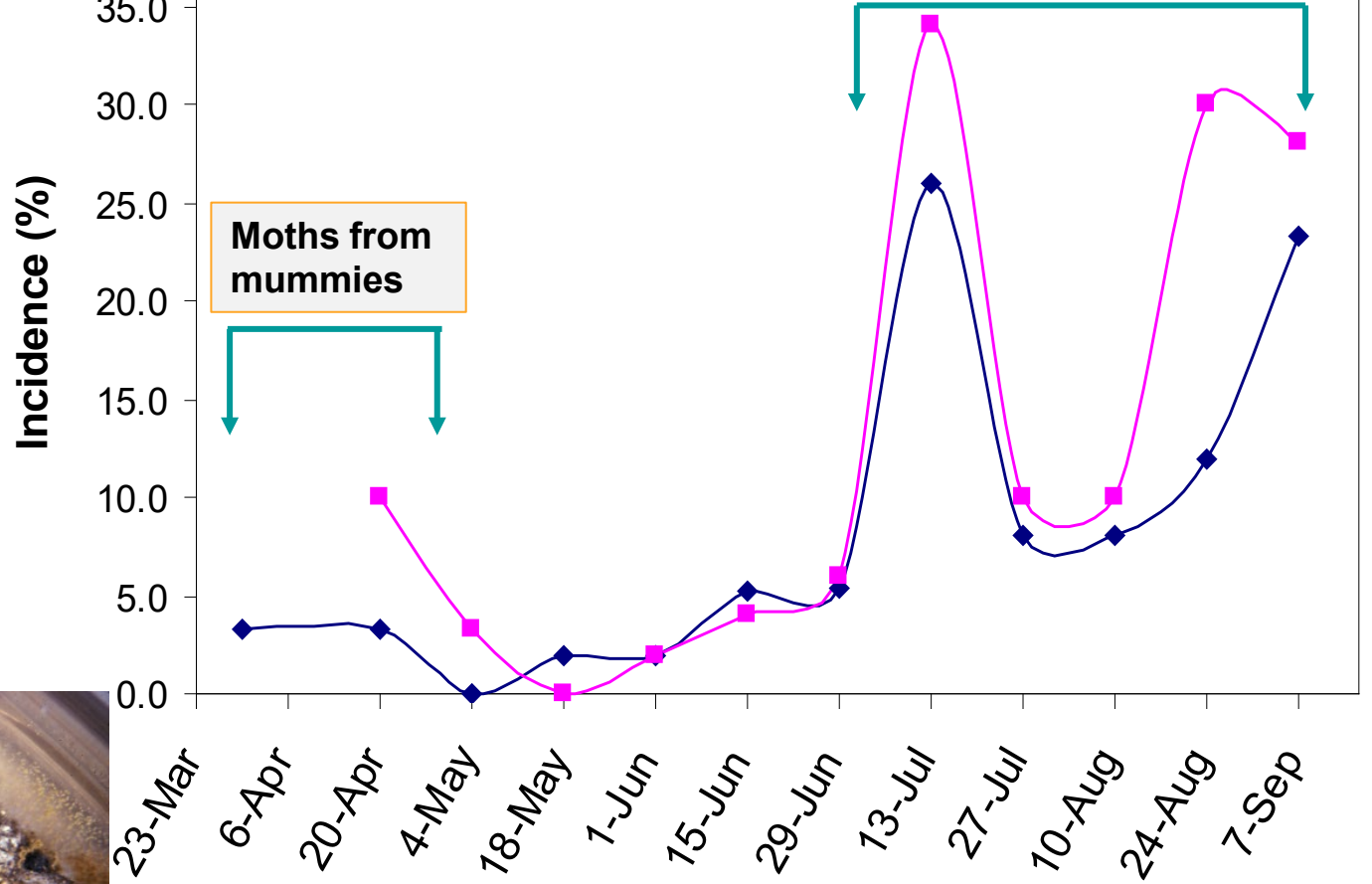


Aspergillus sect. *Flavi* on NOW moths trapped in almond orchards (Madera Co.) (in cooperation with Dr. Joel Siegel, ARS/USDA, Parlier)

A sticky trap with NOW moths

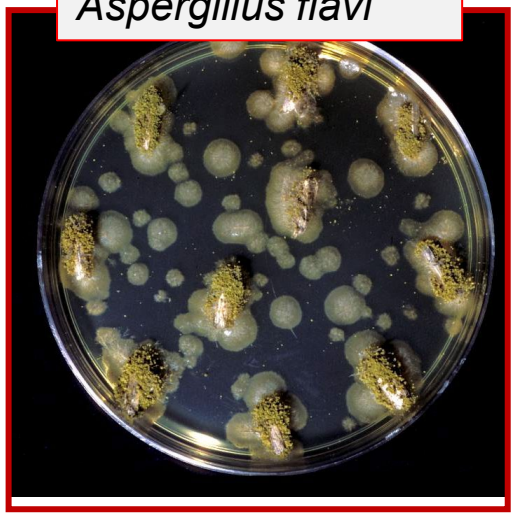


A. flavus



Mummies on trees contribute to both NOW and *Aspergillus flavus/parasiticus*

Aspergillus flavi



Incidence of *A. flavus/ parasiticus* in mummies:

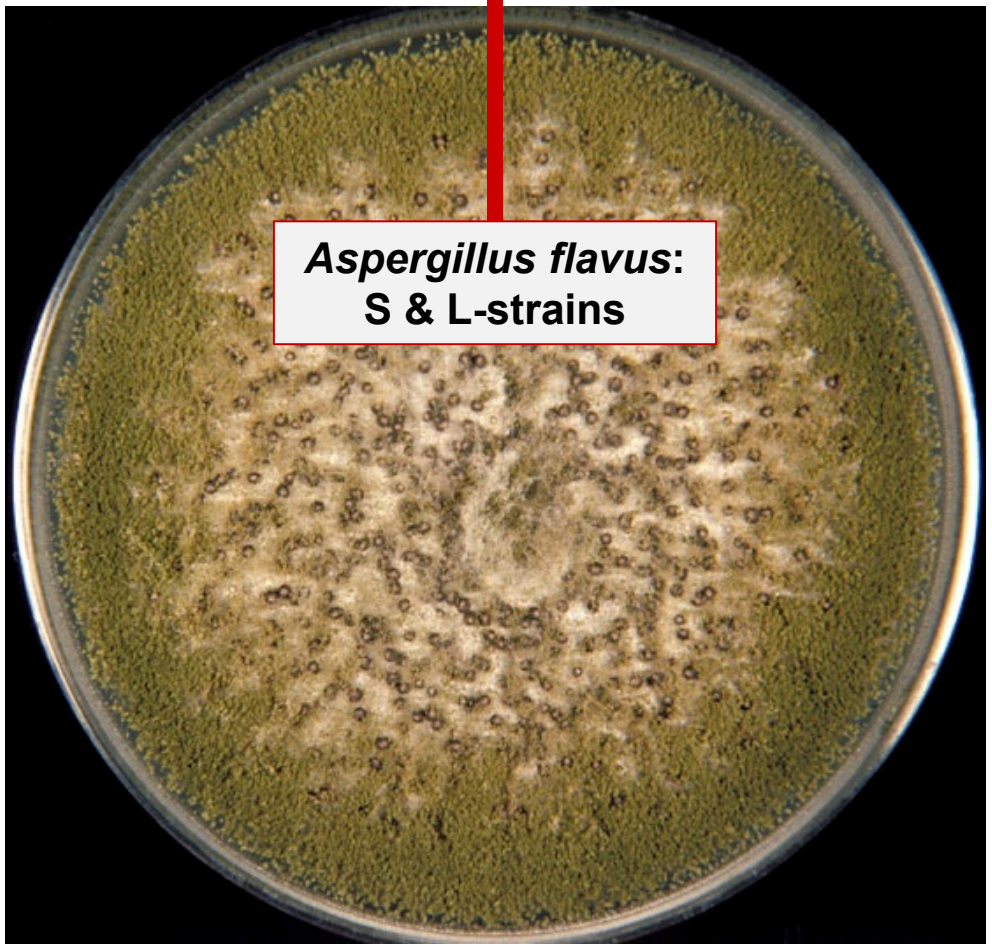
- ✓ Nonpareil: 9.5%
- ✓ Butte: 2.4%
- ✓ Padre: 2.0%

NOW moths from mummies in 3 almond orchards:

Orch. 1: **45-70%**; Orch. 2: **50%**; Orch. 3: **43- 57%** *A. flavus/parasiticus*

Perhaps kernels from mummies contribute to aflatoxin contamination of the current season's crop

***Aspergillus flavus*: L-strains**



L - strains

about 50:50
toxigenic: atoxigenic

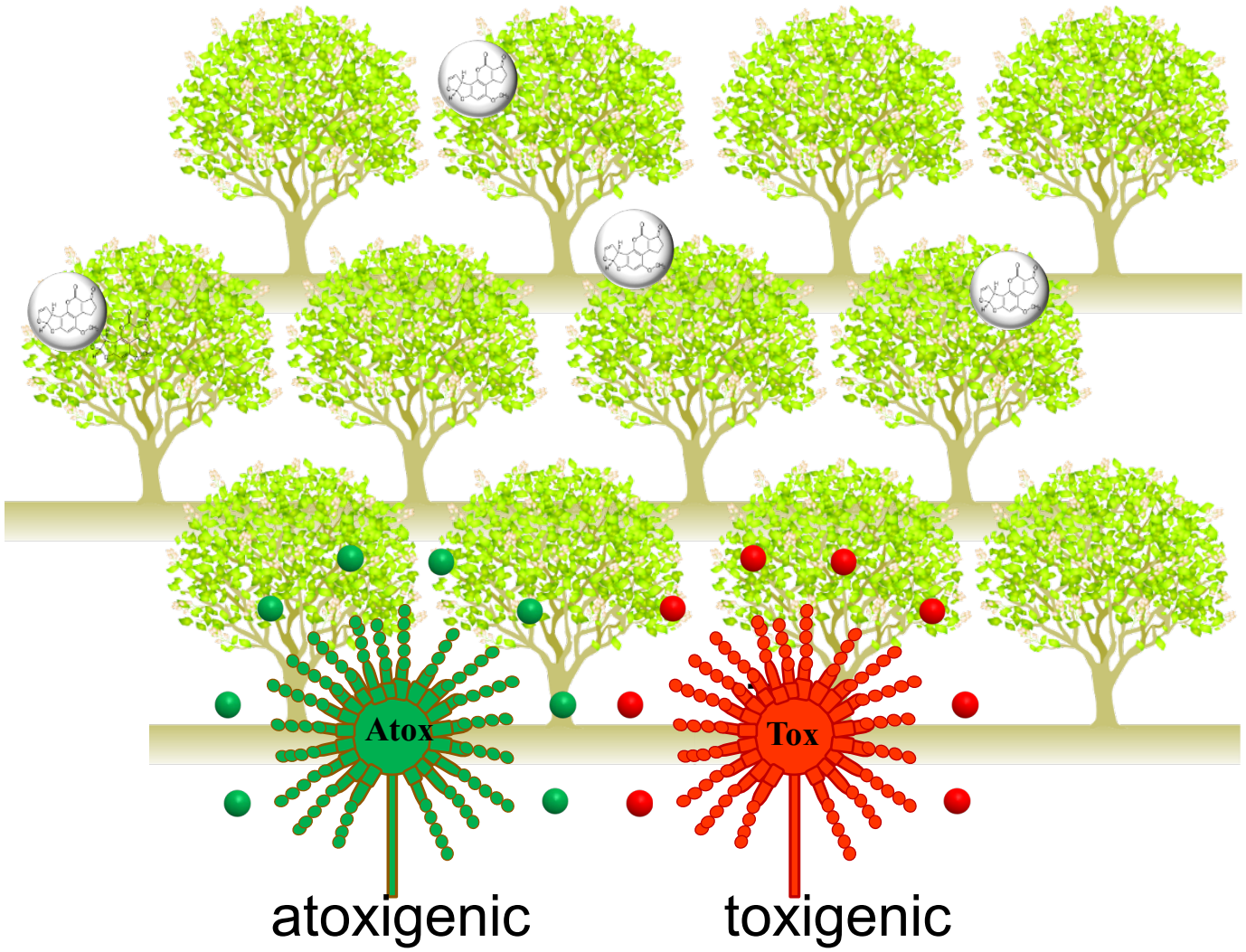
Atoxigenic AF36

0 ppb alfatoxin

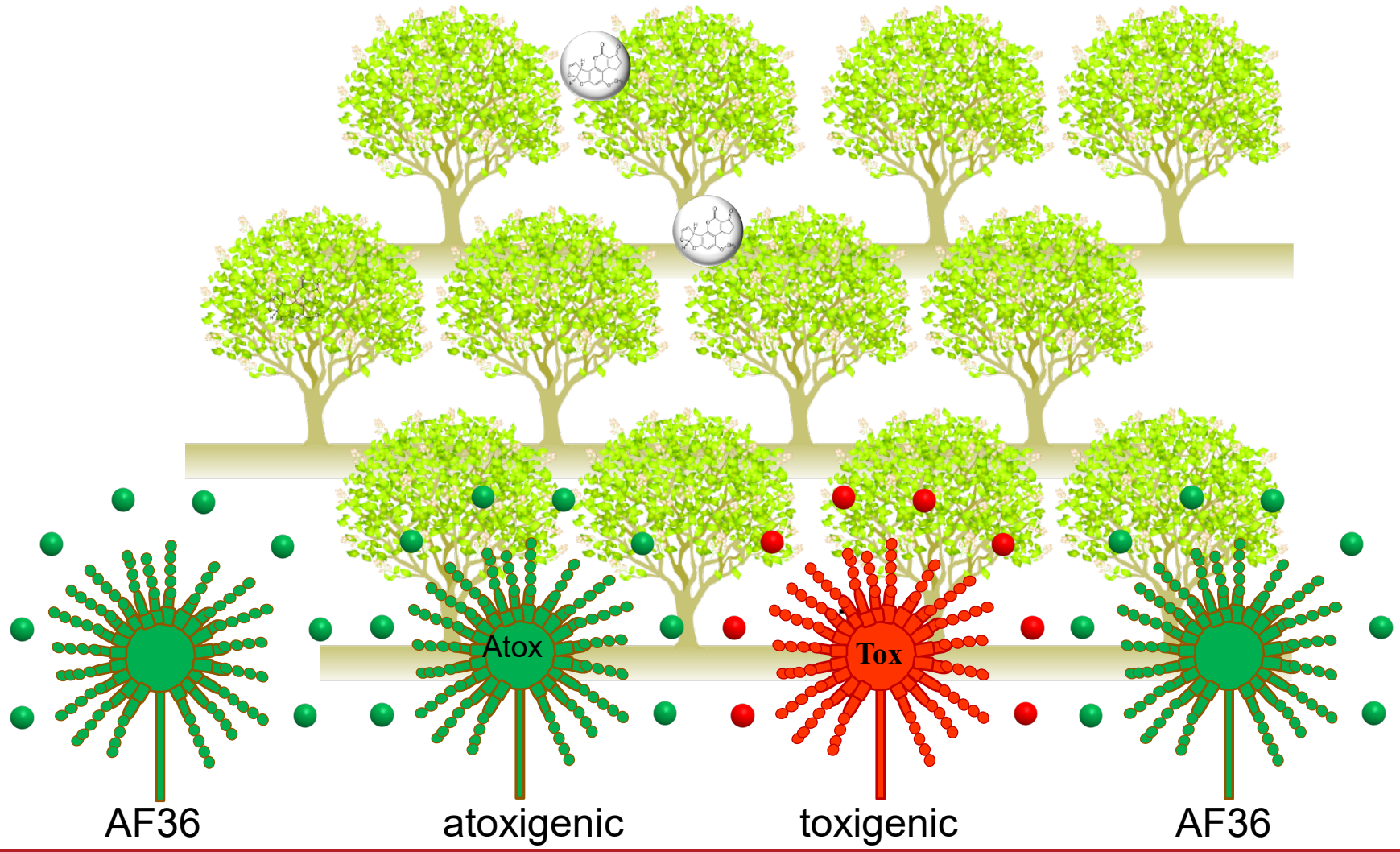
Rationale: Increase the atoxigenic strain population in the orchard to displace the toxigenic strain population.

Application rate: 10 lbs. per acre

Non-treated orchard



Treated orchard with the AF36 Prevail®



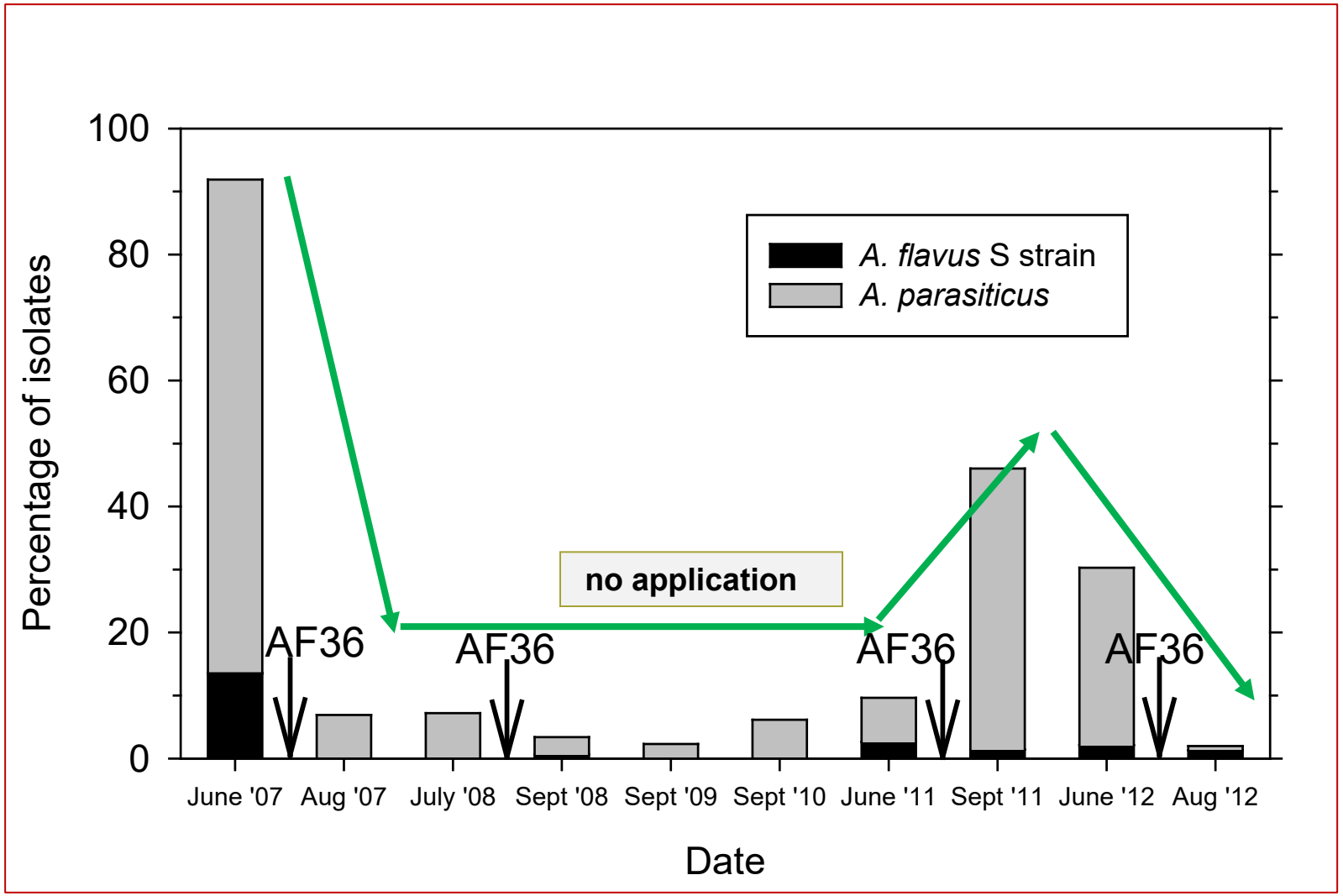
Nickels Soil Laboratory Nonpareil orchard treated with AF36

1. Soil samples Collection of soil samples before and after application to determine displacement

2. I.d. the isolates Native *Aspergillus vs*. AF36 popul.

3. Nut samples Aflatoxin analyses

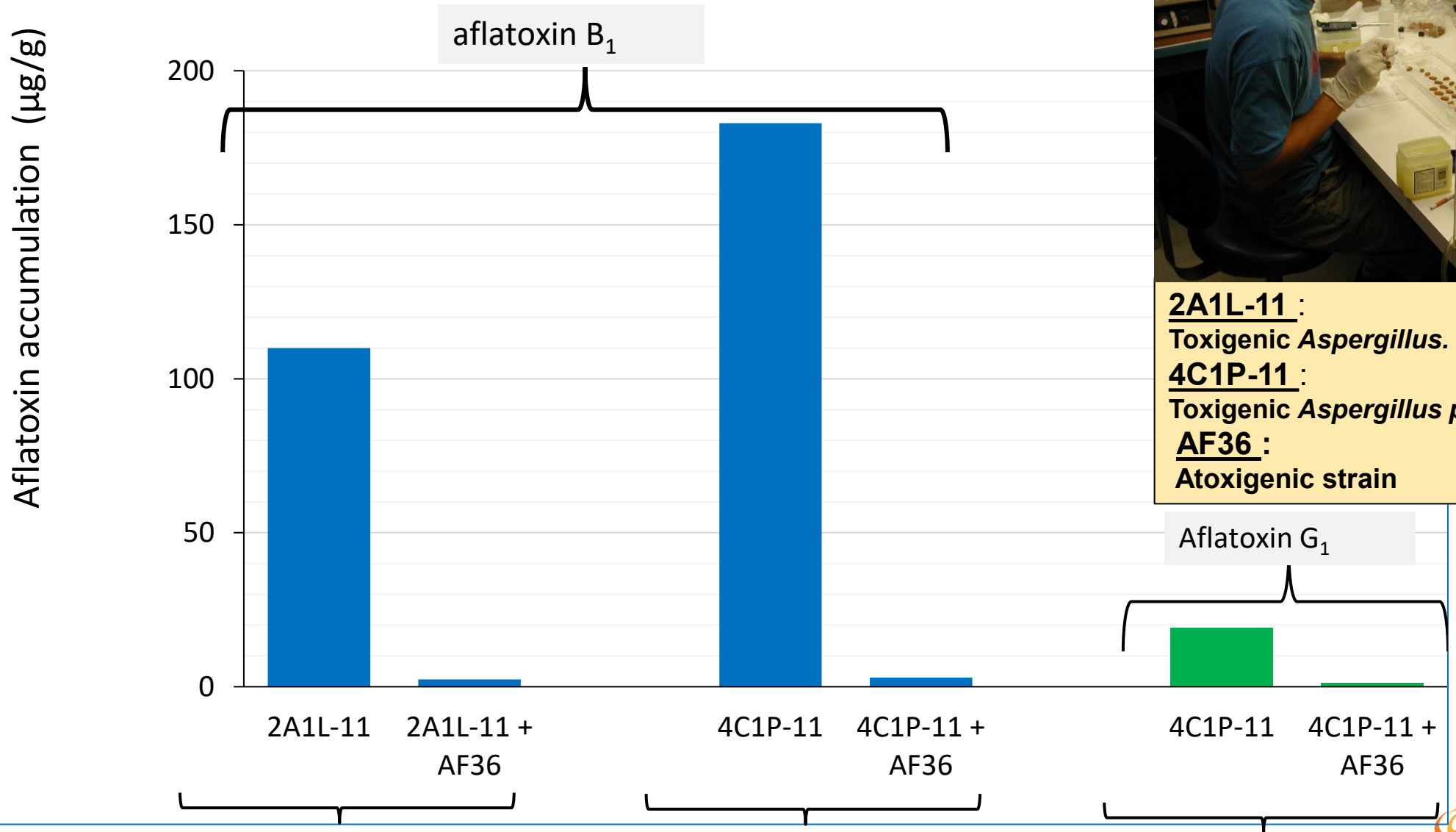
Reduction of toxigenic *Aspergillus flavus/A. parasiticus* isolates in areas of the almond orchard treated with the AF36 product (2007- 2012)



= Application of AF36

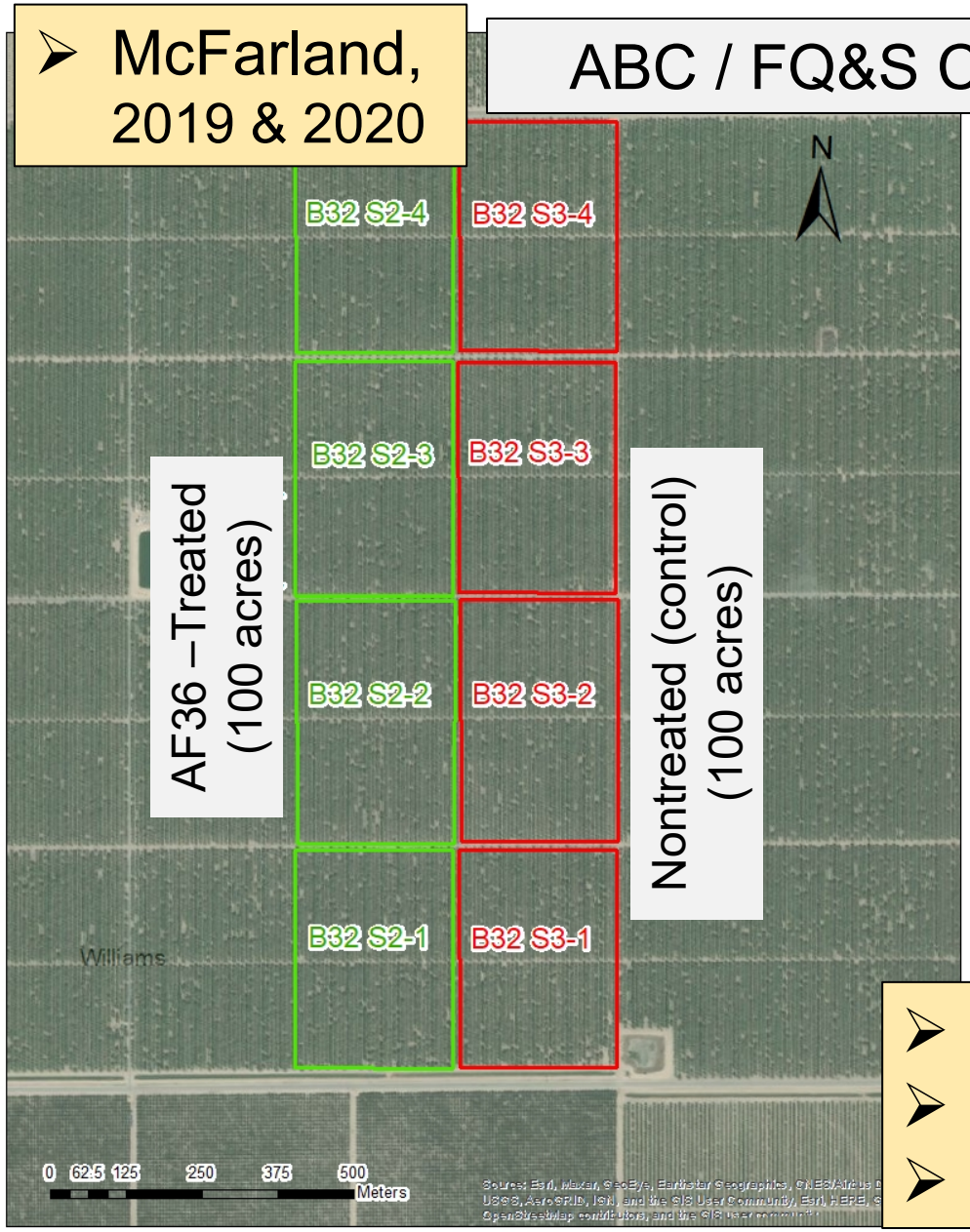
The AF36 reduced aflatoxin production by the toxigenic strains

2A1L-11 :
Toxigenic *Aspergillus. flavus*
4C1P-11 :
Toxigenic *Aspergillus parasiticus*
AF36 :
Atoxigenic strain



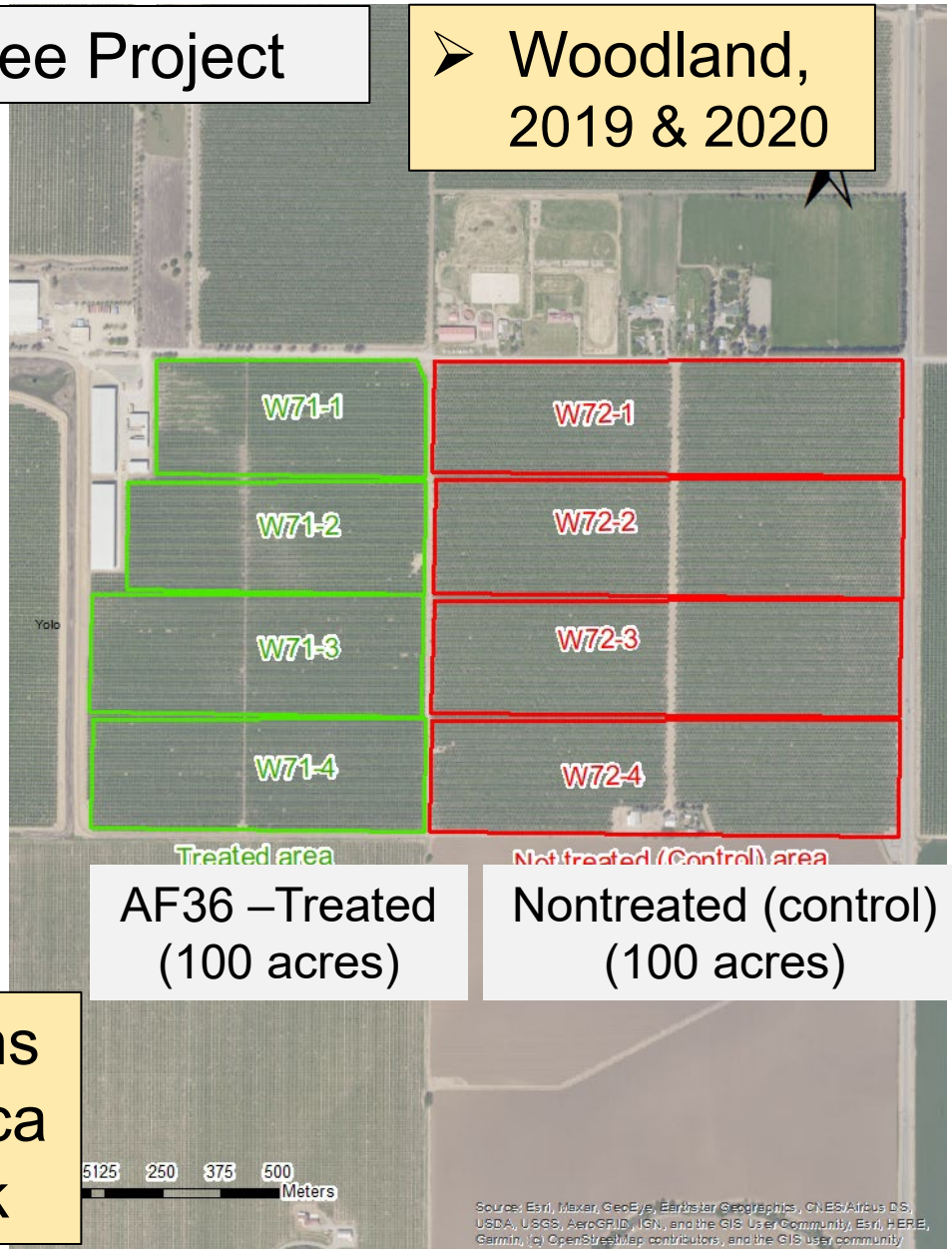
ABC / FQ&S Committee Project

- McFarland, 2019 & 2020



- Williams
- Manteca
- Turlock

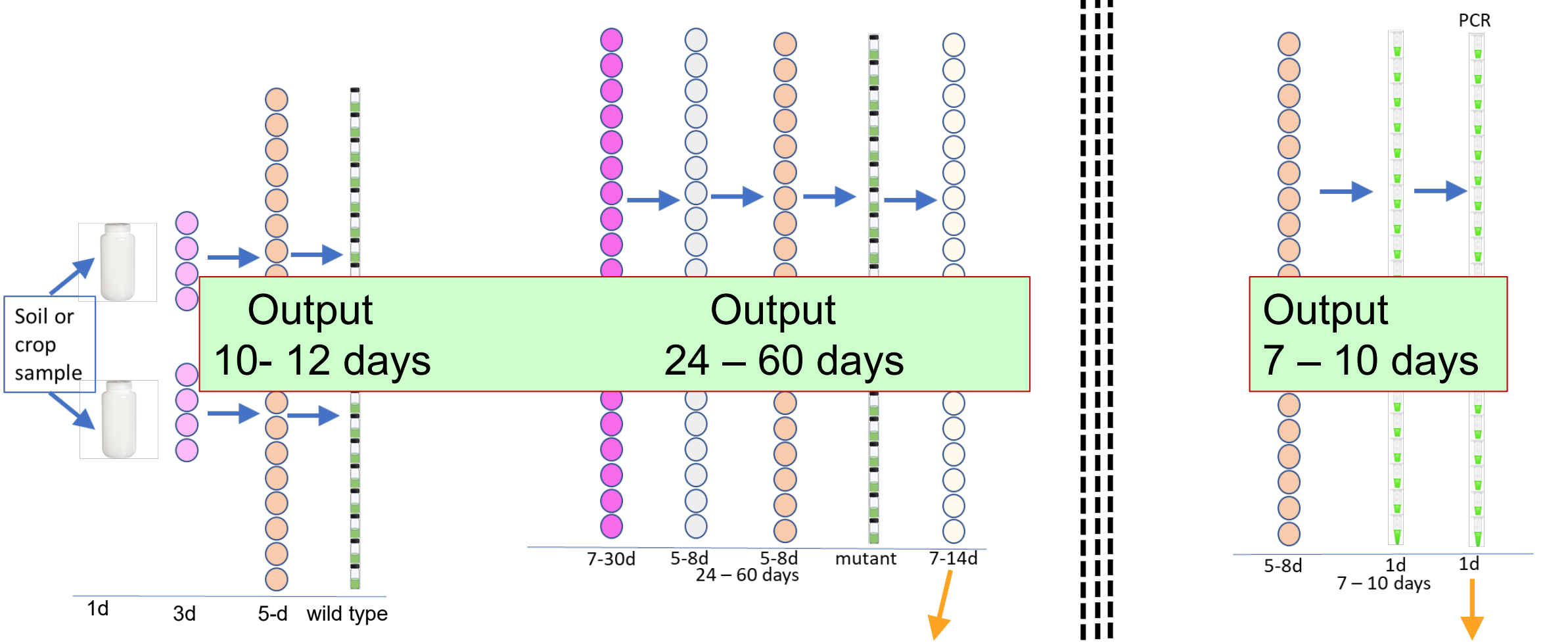
- Woodland, 2019 & 2020



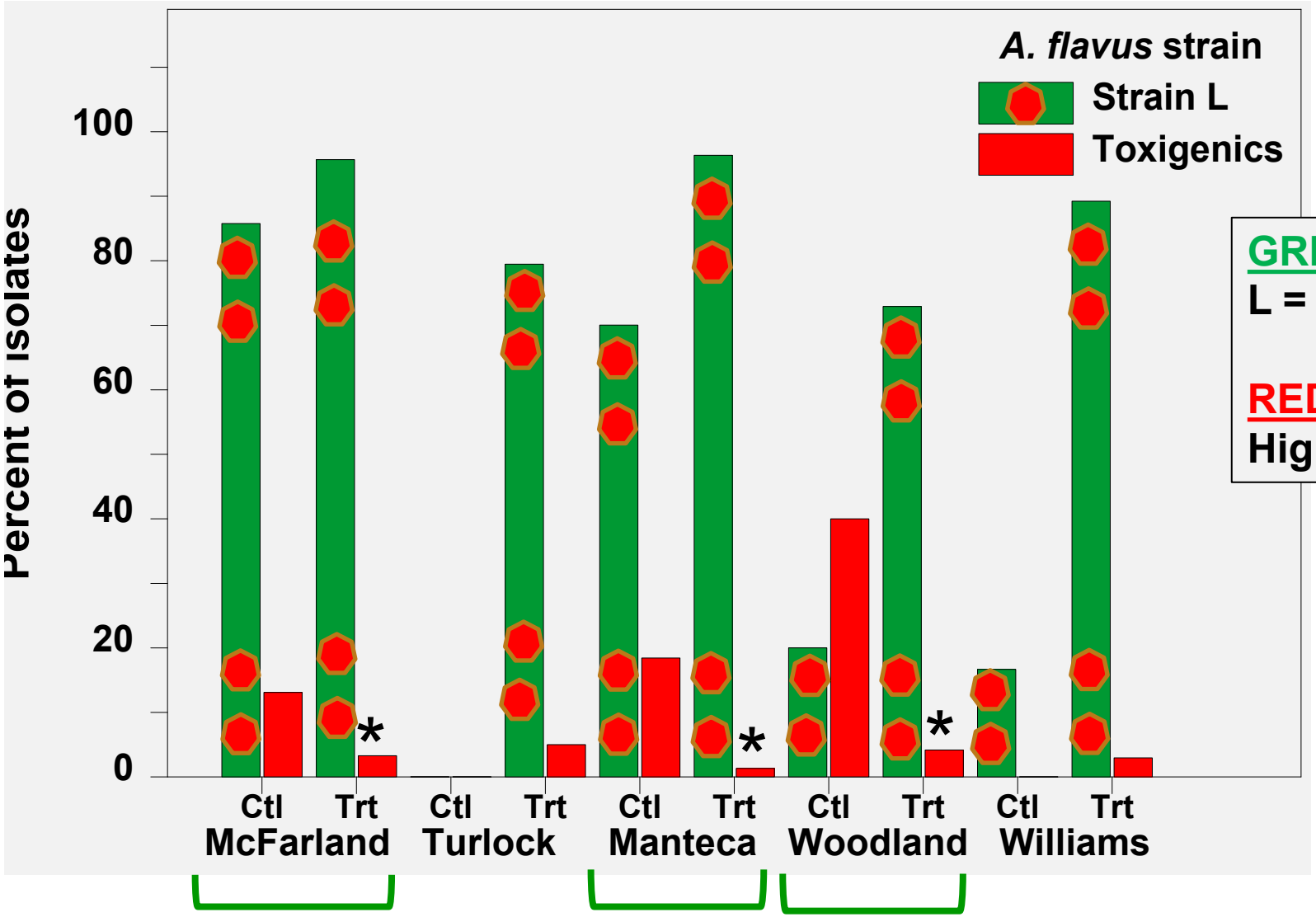
Fungal Isolation

VCG analysis

PCR analysis



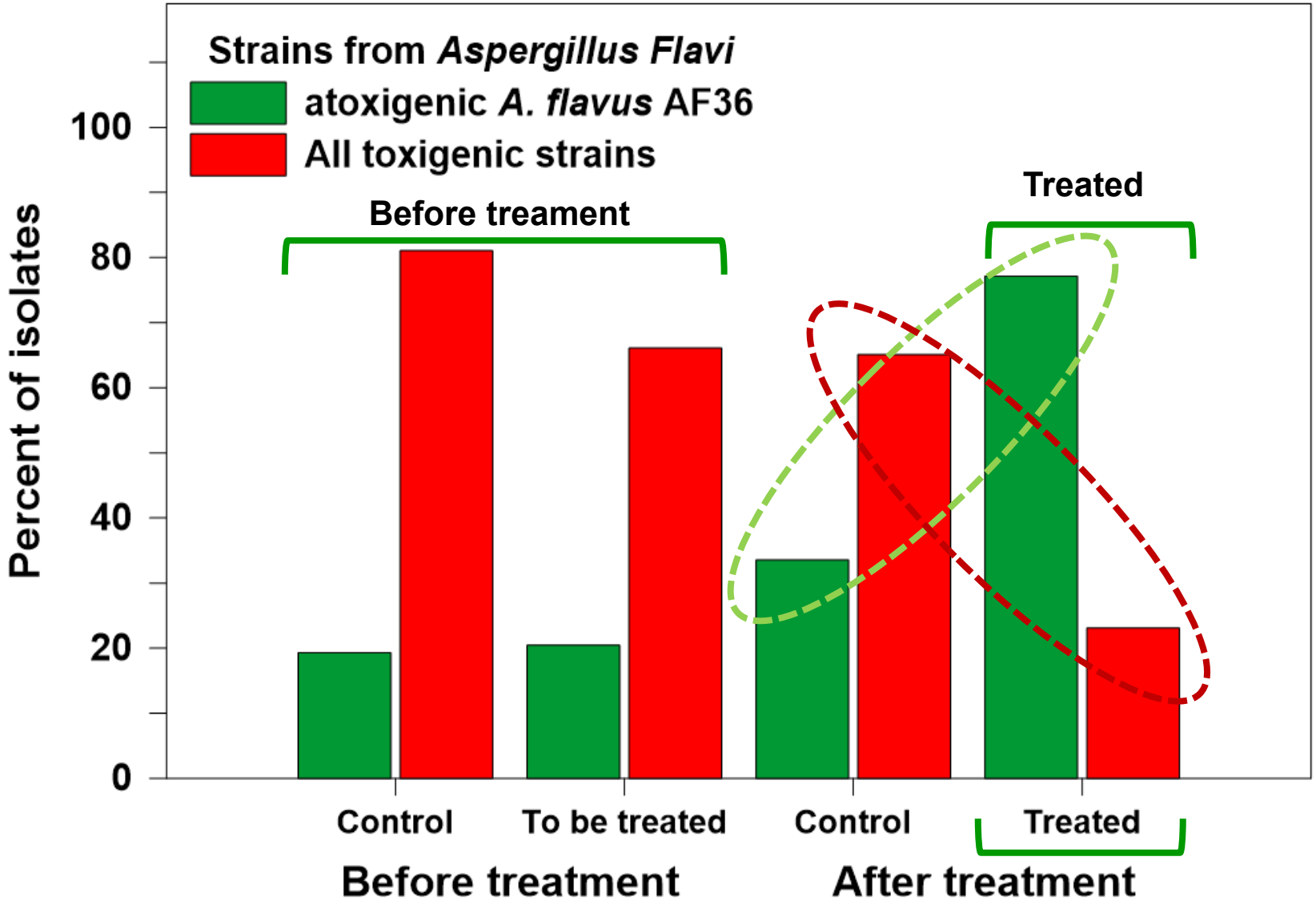
A. flavus AF36 Prevail® treatments by regions, 2019



GREEN BARS WITH : **Strain**
L = atoxigenic + AF36 + toxigenic

RED BARS:
Highly toxigenic strains

Aspergillus strains of *Aspergillus Flavi (Aspergillus flavus & A. parasiticus)* recovered from soil samples before and after treatment with AF36 Prevail®



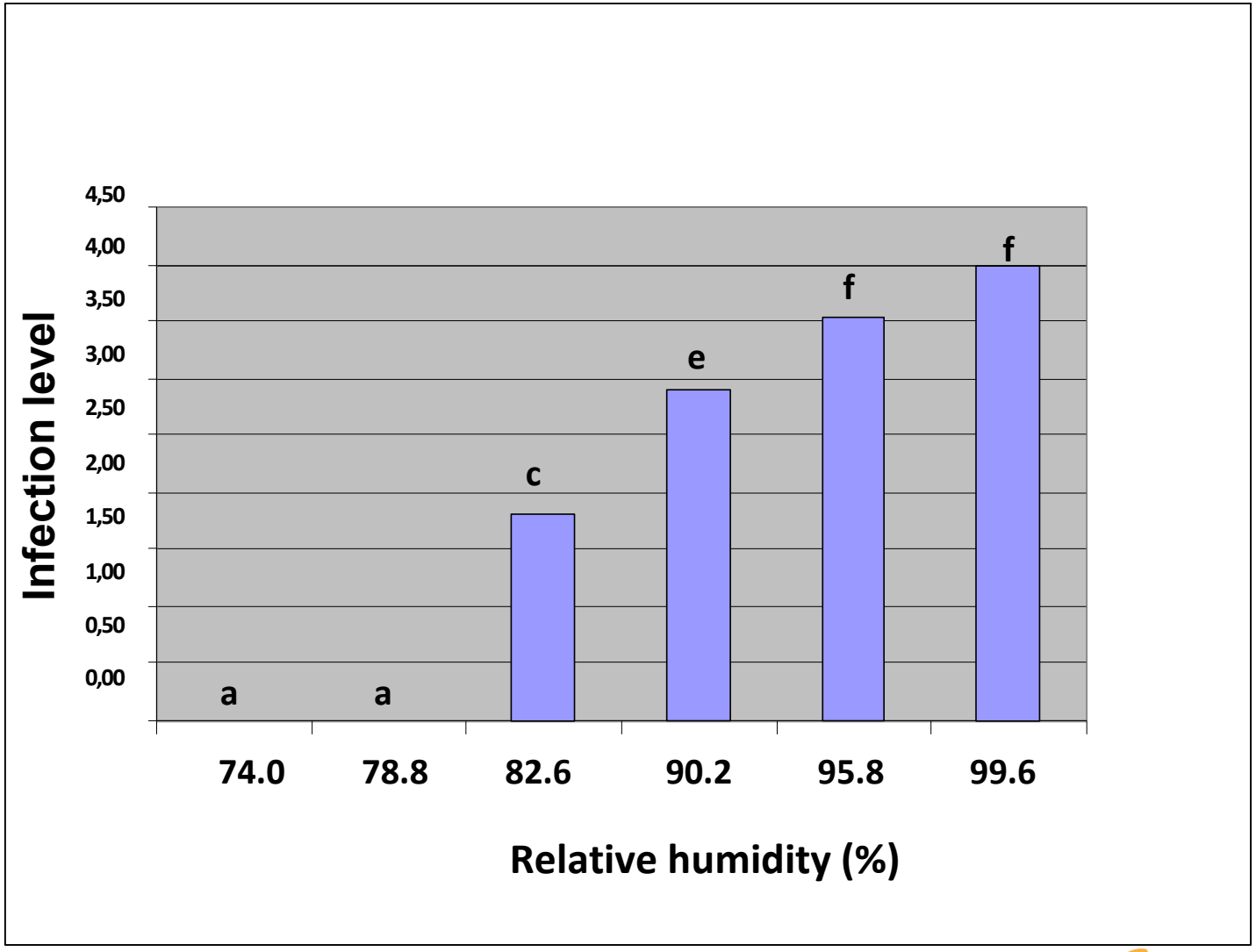
40% reduction

AF36 Prevail® on the ground

AF36 Prevail in the stockpile

Infection of almond kernels by *Aspergillus flavus /A. parasiticus* at various RHs

Infection scale of kernels



Tools to manage aflatoxins:

1. Remove mummies – orchard sanitation (“mummy shake”)
2. Reduce NOW damage of the crop in season
3. Apply AF36 Prevail® on late May to mid July at 10 lbs./acre
4. Irrigate before or immediately after application of the biopesticide
5. Do not spray herbicides 1 to 2 weeks after application
6. Control the ants, other arthropods, and birds in the orchard
7. Avoid wetting the nuts on the ground after shaking
8. Follow proper stockpiling to avoid moisture under the plastic cover
   (65% – 70% max recommended RH)

Thank You

UC Kearney Agricultural Center

- All the personnel involved

Almond Board of California

- Guangwei Wang
- Tim Birmingham
- Ashley Correia
- Miranda Thomas

Almond Industry

Matt LaGrande
Justin Moncur
Nick Gatzman
Payton Solf
Kyle McGary
Lizzette Casas

ALMOND STOCKPILE MOISTURE MANAGEMENT

Practical application of moisture research at hulling/shelling facilities

ALMOND STOCKPILE MOISTURE MANAGEMENT

Moisture Management Protocols

Harvest Controls

Receiving Loads

Stored Product Monitoring

Critical Processing Decisions

Moisture Levels

Almond Kernels: USDA discounts above 5%

Almond Hulls: CDFA classifies 13% as "Damaged"

ABC Harvest Guidelines

Inhull Almonds	9%
Almond Kernels	6%
Almond Hulls	12%

Relative Humidity & component moisture levels

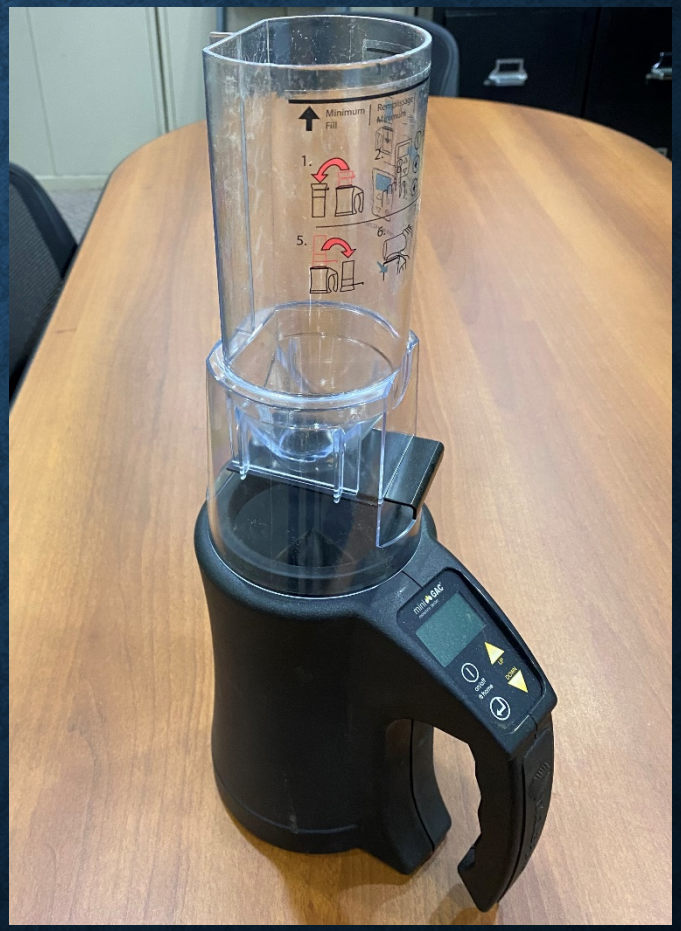
RH	Inhull	Hulls	Kernels
52	7.37	9.59	5.03*
58	8.87	11.58	6.04
62	9.99	13.05*	6.81
65	10.9	14.22	7.43

*CDFA damaged hull and USDA kernel discount levels

MOISTURE METERS

MOISTURE METERS

MOISTURE METERS



MOISTURE METERS

MOISTURE METERS

MOISTURE METERS

HARVEST PROTOCOLS

Hull Snap test

Field Representatives available for consultation

Sample Testing Equipment at Huller or Processor

Check forecast before shaking or harvesting

Coordinate trucking with harvest schedule

POST RAIN PROTOCOLS

Hullers may retrieve empty trailers as a precaution

Don’t shake or windrow immediately following a rain

Blow wet nuts off berm but do not windrow – leave them spread out for optimal drying

Pick up wet windrows and lay them down flat for best drying

Conditioners can remove leaves, grass and debris to improve drying

Never pile or windrow wet nuts – no drying will happen in a pile

RECEIVING PROTOCOLS

Sampling

Accept or Refuse

Drying options

Moisture criteria

Kernel	Hull	Suitable placement
6% or less	12% or less	Can be stockpiled or processed
6% or more	12% or more	Process promptly, short term stockpile
8% or more	15% or more	Dry, or evaluate damage potential

STOCKPILING PROTOCOLS

Storage area preparation

Drainage

Tarp Selection

Monitoring Moisture

Aeration

MONITORING INVENTORY MOISTURE

Regular schedule

Entire inventory, or identified concerns

Monitor moisture content, how many loads received, stockpile location and how long they have been stored

Schedule processing priority for stockpiles with quality concerns

Recordkeeping

CRITICAL DECISIONS

- **Harvesting wet nuts**
  - Processing penalties v. damage & quality losses
- **Stockpiling wet nuts**
  - Limit time in stockpile
- **Processing wet nuts**
  - Evaluate potential storage losses v. potential processing damage losses

THANK YOU FOR YOUR SPELLBOUND ATTENTION

Thank You