Research Update: Growing Almonds and Irrigation

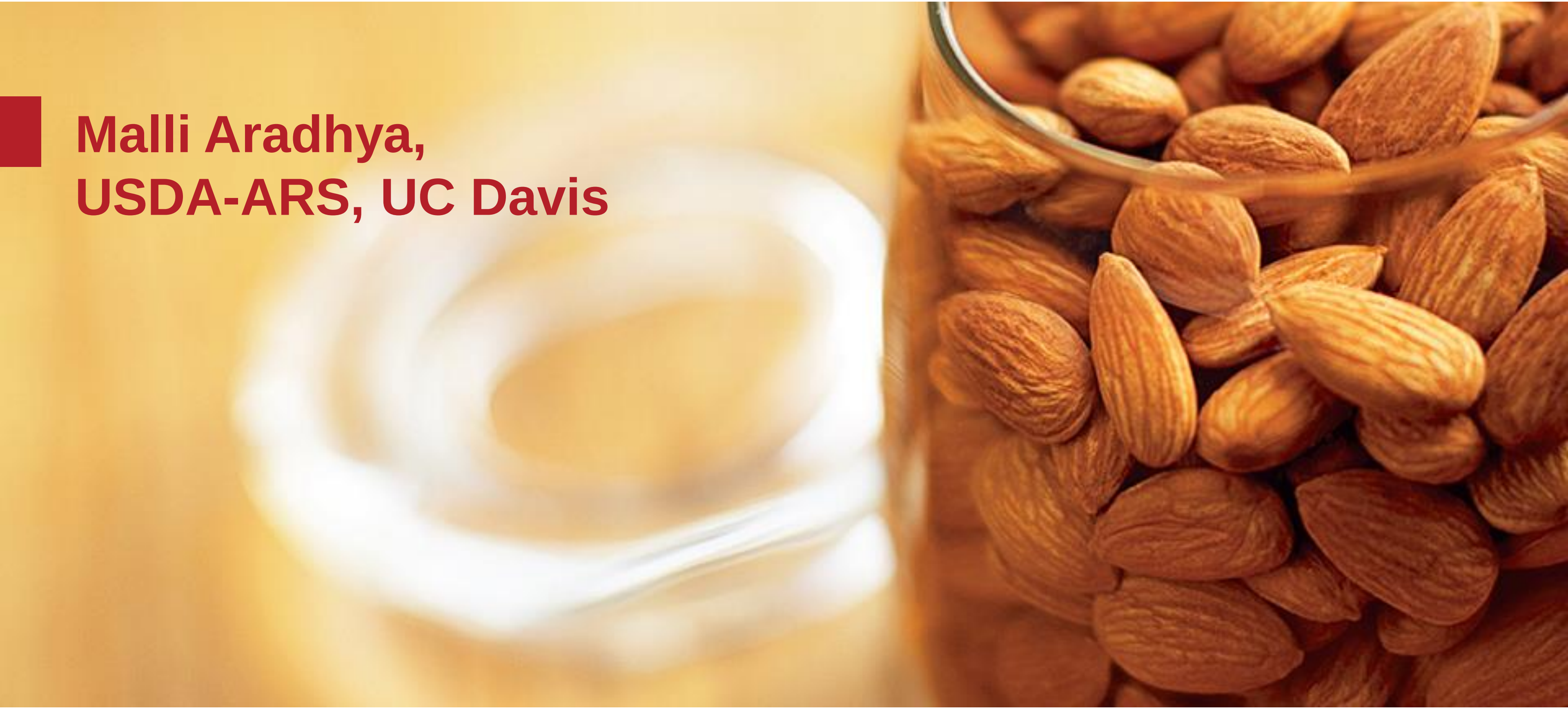
December 7, 2016

Almond Board of California

Research Update: Growing Almonds and Irrigation

- Bob Curtis, Almond Board of California (Moderator)
- Malli Aradhya, USDA-ARS, UC Davis
- Roger Duncan, UCCE - Stanislaus County
- Amelie Gaudin, UC Davis
- Jeff Mitchell, UC Kearney
- Astrid Volder, UC Davis
- Fraser Shilling, UC Davis
- Themis Michailides, UC Kearney
- Matthew Gilbert, UC Davis

Bob Curtis,
Almond Board of California



Malli Aradhya,
USDA-ARS, UC Davis

Integrated Conventional and Genomic Approaches to Almond Rootstock Development

A multidisciplinary breeding program

Team: Malli Aradhya, Craig Ledbetter, Dan Kluepfel and Greg Browne, USDA-ARS and Andreas Westphal, KAC, UC Riverside

Objectives

- Produce diverse rootstock hybrids involving *Prunus* spp. that are potential donors of resistance to soil borne diseases.
- Disease testing (PHY/CG/NEM) of commercial and experimental rootstocks to produce high quality disease data.
- Develop and use effective marker assisted selection strategies for rapid development of improved rootstocks.

Nuts and Bolts for a Sound Rootstock Breeding Program

Wide range of species are used in rootstock breeding (Peach/Almond/Plum)

Identify donor species

Both Eurasian and American (Old and New World Distribution – wide range of species - almond/peach/plum –NCGR, Davis)

Generate variability

Diverse crosses and numbers

Apply selection

Stringent disease screens

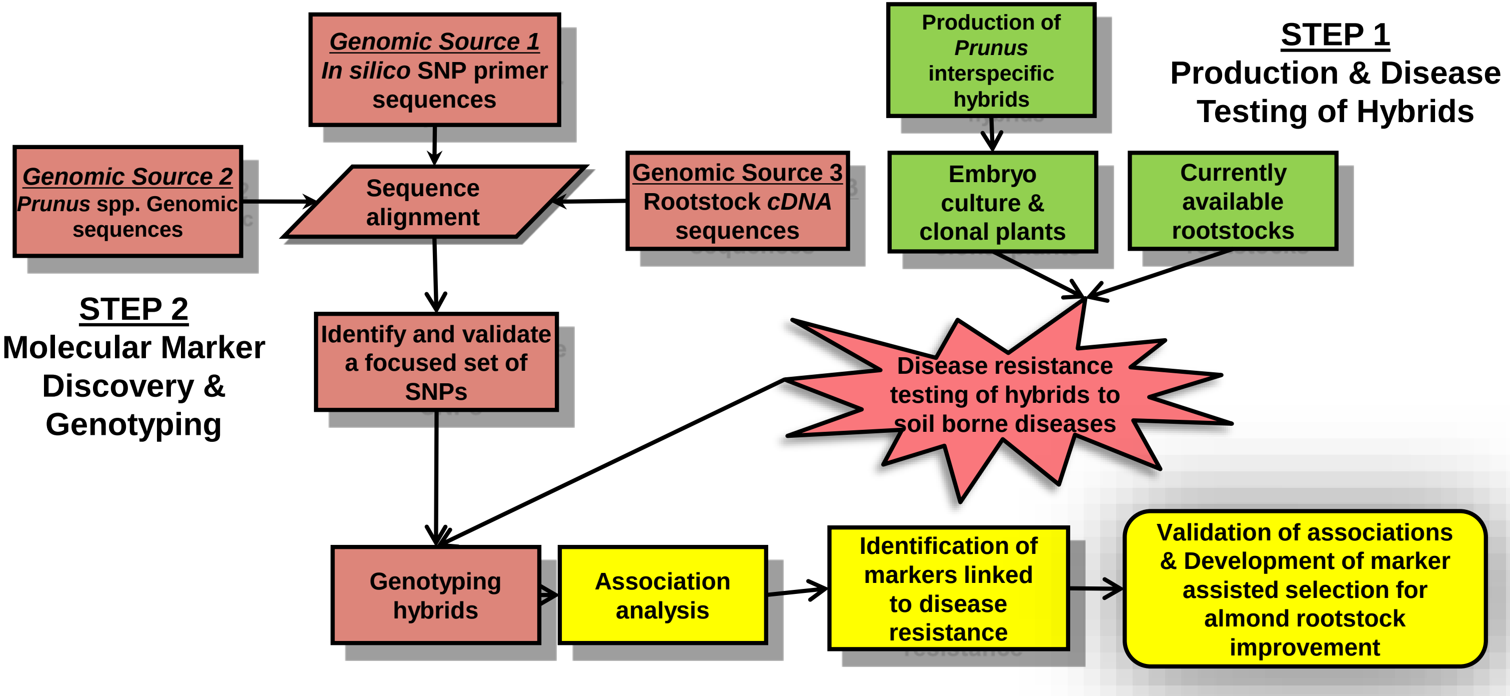
Look for response

Ideal rootstock

Donor Traits

Disease resistance
Drought tolerance
Graft compatibility
Propagability
Precocity, longevity, productivity

Road Map to Almond Rootstock Improvement



STEP 1
Production & Disease Testing of Hybrids

Production of *Prunus* interspecific hybrids

Embryo culture & clonal plants

Currently available rootstocks

Disease resistance testing of hybrids to soil borne diseases

STEP 2
Molecular Marker Discovery & Genotyping

Genomic Source 1
In silico SNP primer sequences

Genomic Source 2
Prunus spp. Genomic sequences

Genomic Source 3
Rootstock *cDNA* sequences

Sequence alignment

Identify and validate a focused set of SNPs

Genotyping hybrids

STEP 3
Association analysis & Marker Assisted Selection Schemes

Association analysis

Identification of markers linked to disease resistance

Validation of associations & Development of marker assisted selection for almond rootstock improvement

Step 1

Production of Interspecific Hybrid rootstocks

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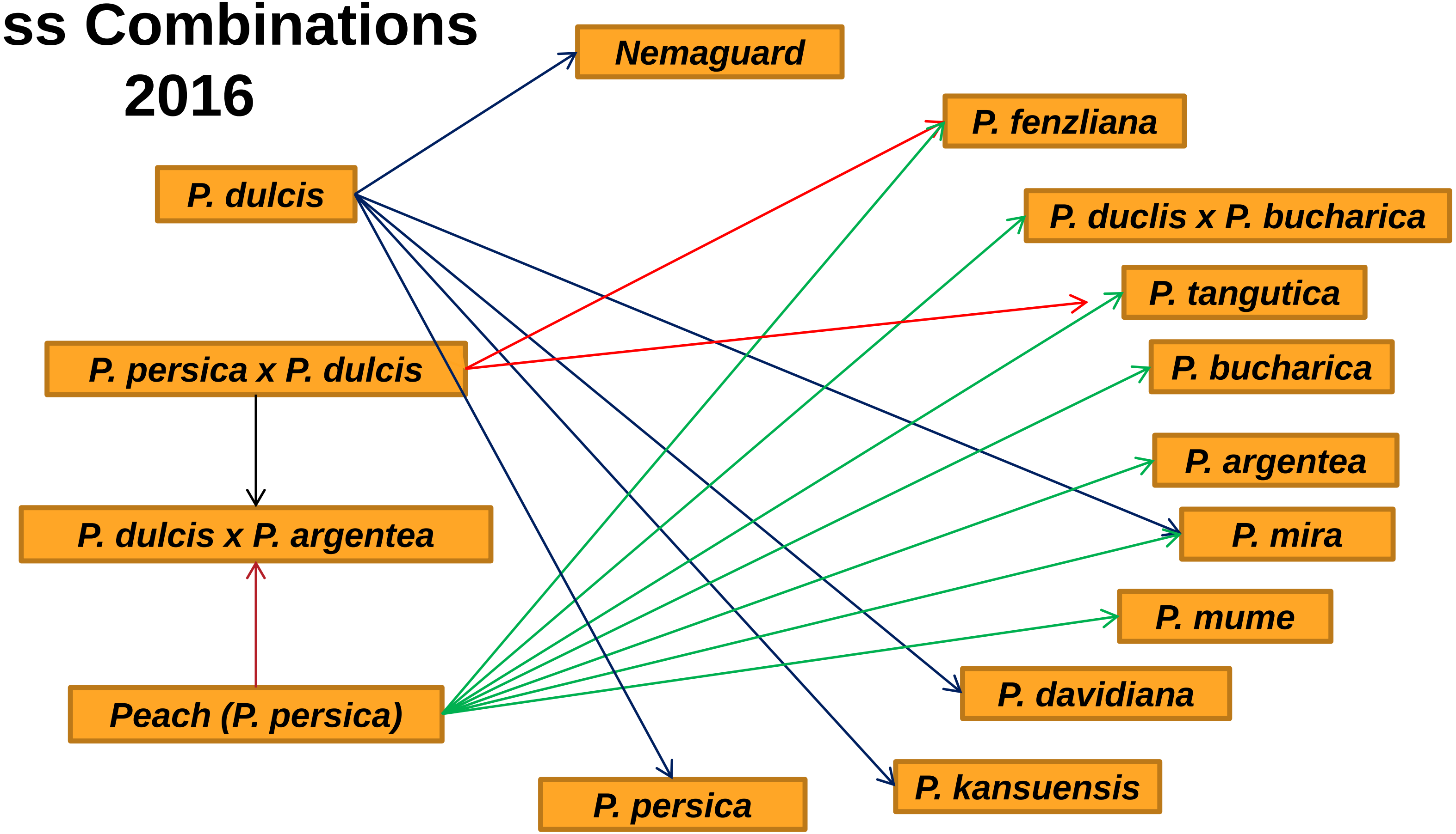
Cross Combinations 2016



P. dulcis

P. persica x P. dulcis

P. dulcis x P. argentea

Peach (P. persica)

Nemaguard

P. fenzliana

P. duclis x P. bucharica

P. tangutica

P. bucharica

P. argentea

P. mira

P. mume

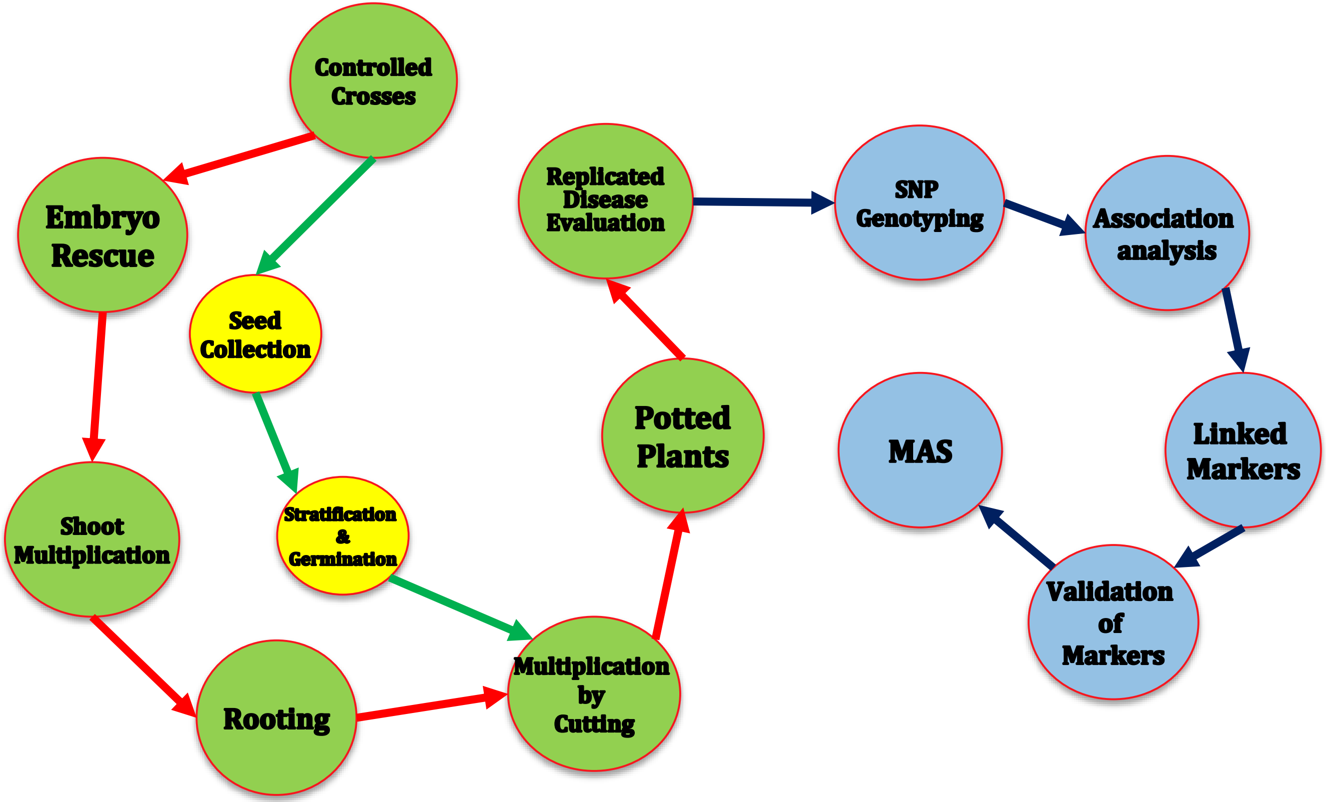
P. davidiana

P. kansuensis

P. persica

~300 hybrid genotypes produced from 22 crosses

Rootstock - Production Cycle



Prunus Hybrids, 2016 (Embryo Rescued – 100 embryos @ SGN)

Seed Parent	Pollen Parent
P. dulcis (DPRU 2957.15)	*P. persica (DPRU 3153)*
P. dulcis (DPRU 2961.26)	*P. mira (DPRU 2228.07*
P. dulcis (Q 45733.S7)	*P. kansuensis (DPRU 582)*
P dulcis x P. argentea (A13/46)	*P. persica (DPRU 3153)*
P. dulcis (DPRU 2960.18)	*P. davidiana (DPRU 2493.04)*
P. dulcis (DPRU 2961.08)	*P. persica (DPRU 3155)*
P. dulcis (DPRU 2960.06)	*Nemaguard (FPS)*
P. dulcis (DPRU 2958.02)	*P. kasuensis (DPRU 582)*
P. dulcis (Q 45733.S7)	*P. davidiana (DPRU 581)*
Peach x almond (DPRU 0536)	*P. fenzliana (DAV)*
Peach x almond (DPRU 0536)	*P. dulcis x P. argentea (DPRU 2912.05)*
Wild Peach (DPRU 2658)	*P. tangutica (DPRU 2327.01)*
Peach (DPRU 2466.12)	*P. dulcis x P. argentea (DPRU 2912.05)*
Peach (DPRU 0507)	*P. fenzliana (DAV)*
Peach (DPRU 2233)	*P. bucharica (DPRU 1971.01)*
Peach (DPRU 2363)	*P. bucharica (DPRU 1971.01)*
Peach (DPRU 2659.01)	*P. argentea (DPRU 194)*
Peach (DPRU 2654.01)	*P. tangutica (DPRU 2327.01)*
Peach (DPRU 3035)	*P. mira (DPRU 2228.07)*
Peach (DPRU 3036)	*P. dulcis x P. bucharica (DPRU 2910.02)*
Peach (DPRU 1612)	*P. mume (DPRU 2665)*
Peach (DPRU 2267)	*P. mira (DPRU 2561.18)*

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Prunus Hybrids, 2016 (seed germination)

Mother tree	species	Pollen donor	species	Seedlings
DPRU 2970.07	*dulcis*	DPRU 2493.02	*davidiana*	11
DPRU 2958.02	*dulcis*	DPRU 0582	*kansuensis*	10
DPRU 2960.18	*dulcis*	DPRU 2493.04	*davidiana*	22
DPRU 2961.26	*dulcis*	DPRU 2228.07	*mira*	33
DPRU 0507	*persica*	DPRU 2941	*fenzliana*	6
DPRU 2363	*persica*	DPRU 1871.01	*bucharica*	10
DPRU 2654.02	*persica*	DPRU 0581	*davidiana*	34
DPRU 2659.01	*persica*	DPRU 0194	*argentea*	1
DPRU 2654.01	*persica*	DPRU 2327.01	*tangutica*	15
DPRU 2586.02	*persica*	DPRU 2493.02	*davidiana*	21
DPRU 0535	*persica*	DPRU 2327.01	*tangutica*	5
DPRU 2267	*persica*	DPRU 2327.01	*tangutica*	10
DPRU 2267	*persica*	DPRU 2561.18	*mira*	54
			Total	**232**

Seed Propagation of Hybrids

Clonal propagation of rootstock hybrids for replicated disease testing

Year 2015 Rootstock Hardening and Ready for Disease Evaluation

Previous Years Rootstock Hybrids

Step 2

Disease Testing of Hybrids

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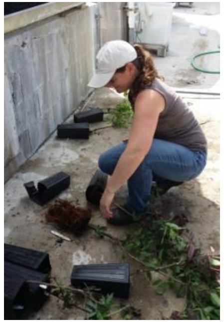
CG Inoculation – Infection Process

CG Resistance Evaluation Process



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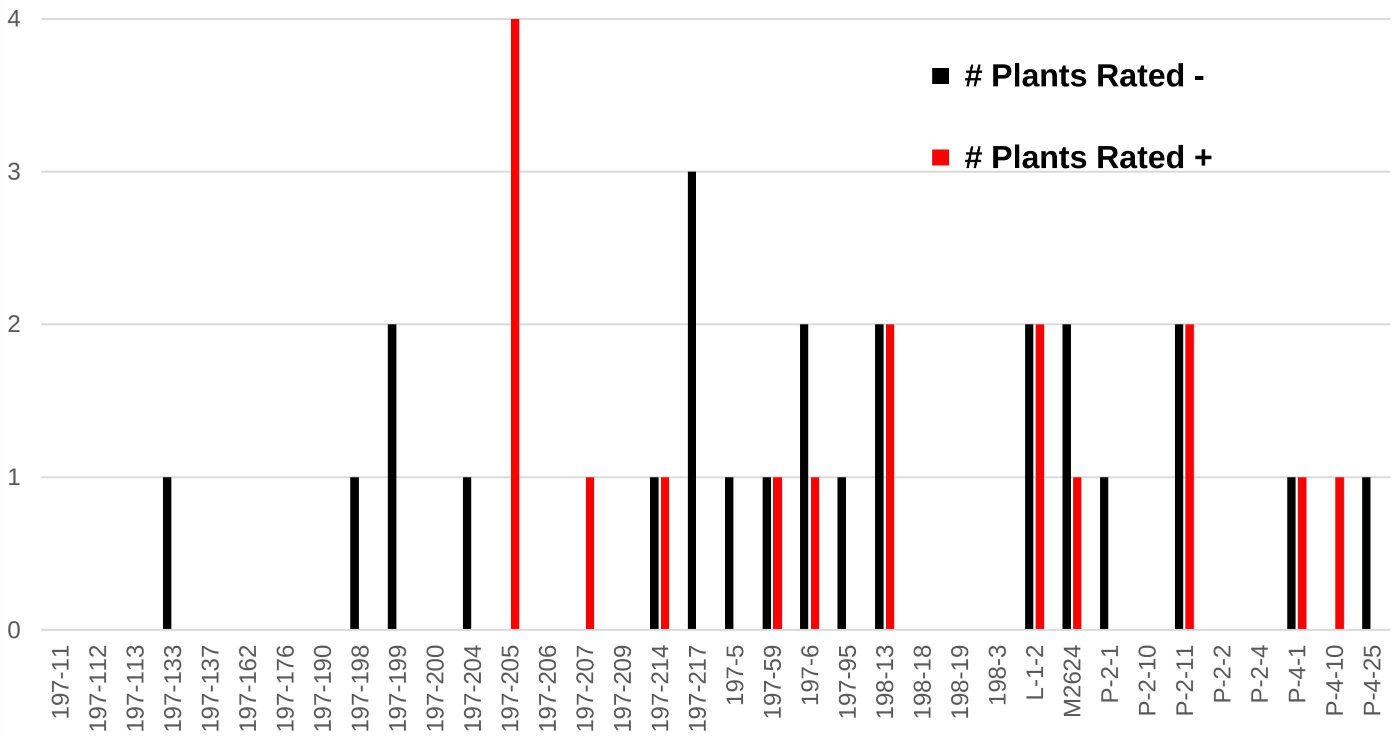
Interspecific hybrids (197-series) - crown gall screening eight weeks post-inoculation. Hybrid 197-113 (upper left) was virtually immune to CG while the others showed high tolerance to CG.

Rootstock 197-113 showing immunity to CG

Crown Gall Ratings of Root Inoculated Prunus Genotypes



Research Highlights

New Rootstocks Showing High Levels of Resistance to CG & PHY

Hybrid	Selections
‘Nemared’ x *P. argentea*	*P2-4*
‘Nemared’ x *P. fenzliana*	*P4-1**, *P4-10*, *P4-25**
P. persica x *P. tangutica*	*197-95*, *197-113*
P. persica x *P. davidiana*	*197-199*
P. persica x *P. kuramica*	*17-217*
P. cerasifera	L1-2*

* Combined Resistance to Both CG & PHY

Cooperators

John Preece	Research Leader, NCGR, USDA-ARS
Carolyn DeBuse	Prunus Horticulturist, USDA-ARS
Tom Gradziel	Professor, Plant Sciences, UCD

Thanks for Listening

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Roger Duncan,
UCCE - Stanislaus County

Seeking Armillaria (Oak Root Fungus) Rootstock Resistance

Roger Duncan, UCCE, Stanislaus County
Kendra Baumgartner, USDA - ARS

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Armillaria root rot (Oak Root Fungus) is a devastating disease that persists in the soil for many years and for which there is no cure.


UC Statewide IPM Project
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UC Statewide IPM Project
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Recent Laboratory Rootstock Screening Effort by K. Baumgartner

Approach

- Rooted cuttings of almond rootstocks in tissue culture.
- Inoculated the pathogen (*Armillaria mellea*) to the surface of the medium; roots were infected within 2 weeks.
- Plants are incubated for two months, during which time dead plants are tallied.

Rootstock	% Mortality at 2 MPI	Notes
Krymsk 86	33.44a	More resistant than Marianna 2624
Krymsk 1	41.11ab	As resistant as Marianna 2624
Marianna 2624	**46.11ab**	**Resistant control**
Lovell	71.79c	As susceptible as Nemaguard
Nemaguard	**76.44c**	**Susceptible control**
Hansen536	89.12d	More susceptible than Nemaguard

Next step: confirm laboratory results in potted tree experiment

Rootstocks tested:

1.	**Nemaguard**	(peach: *Prunus persica*)
2.	**Marianna 26-24**	(plum: *P. munsoniana x P. cerasifera*
3.	**Marianna 40**	(plum: *P. munsoniana*)
4.	**Krymsk 86**	(peach x plum: *P. persica x P. cerasifera*)
5.	**Citation**	(plum x peach: *P. salicina x P. persica*)
6.	**Rootpac R**	(plum x almond: *P. cerasifera x P dulcis*)
7.	**Viking**	(Nemaguard x (*P. dulcis x (P. cerasifera x P. mume* apricot)))
8.	**Atlas**	(Nemaguard x (*P. dulcis x (P. cerasifera x P. mume* apricot)))
9.	**Empyrean 1**	(peach x wild peach: *P. persica x P. davidiana*)
10.	**Hansen**	(peach x almond: *P. persica x P. dulcis*)
11.	**Sam-1**	(unknown)

Thirty replications of eleven rootstocks. Planted October 2015 & 2016.

Each tree inoculated with grape cane segments colonized by Armillaria

Monitoring root infection and tree mortality over 18 months

Signs of Armillaria / Oak Root Fungus disease in March, April, 2016

Preliminary Rootstock Infection Rates by *Armillaria mellea*

	Percent killed
Marianna 40	12
Empyrean 1	8
Viking	8
Nemaguard	4
Atlas	4
Marianna 26-24	4
Hansen	0
Citation	0
Krymsk 86	0
Rootpac R	0
SAM-1	0

Data are very preliminary and insufficient to determine relative resistance yet

In October 2016, a second trial was initiated with additional inoculum collected from affected almond orchard.

Chipped and placed around roots in addition to Baumgartner inoculum

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Now we wait…

Thanks to:
Duarte Nursery
Sierra Gold
Dave Wilson

University of California
Agriculture and Natural Resources

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Amelie Gaudin,
UC Davis

Do Mycorrhizae Play a Role in Almonds?

Amélie Gaudin

Assistant Professor of Agroecology, Department of Plant Science UC Davis

Astrid Volder, Bruce Lampinen

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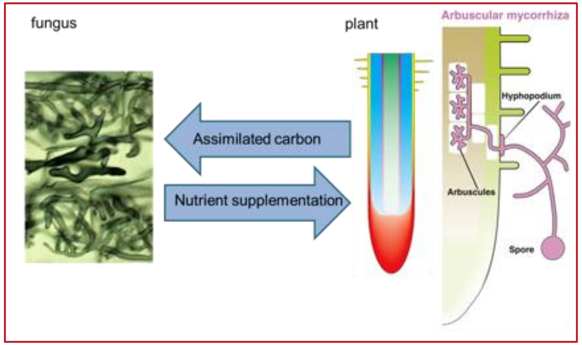
Promote interactions between almond trees and the soil microbial community to improve water and nutrient use efficiency

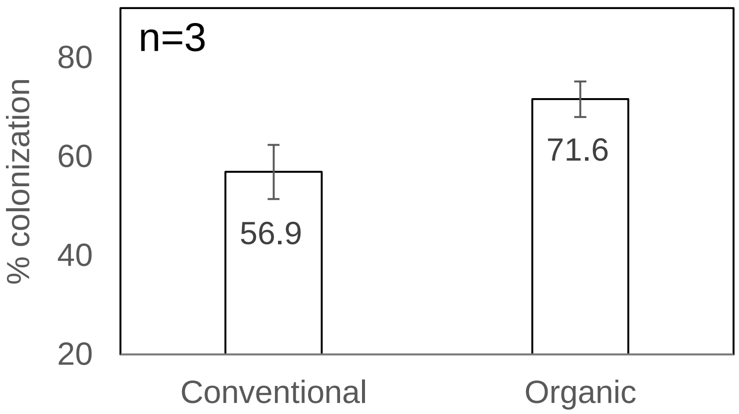


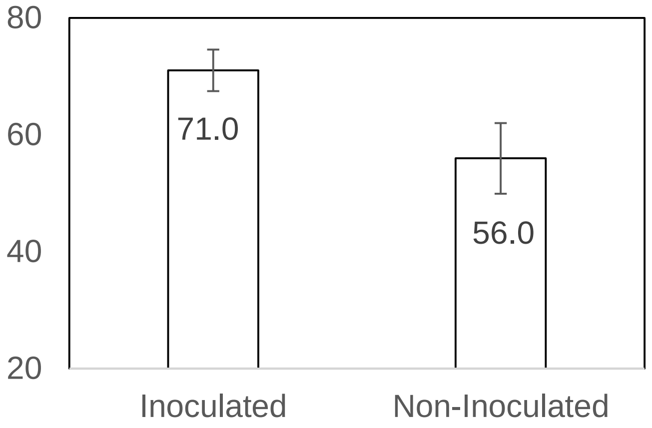
- Are roots of commercial almond orchards colonized ?
- Are there differences between rootstocks?
- Which management practices promote root colonization and benefits ? Soil carbon?
- Does mycorrhizal inoculation improve water/nutrient uptake and tree water status under water stress?

First survey of mycorrhizal colonization of almond orchards in CA

6 orchards in 2015
13 orchards in 2016
Conventional/Organic
+/- planted/natural vegetation cover crop
+/- Fumigation
+/- Inoculation
Rootstocks
Inputs (composts, biochar, hulls or whole tree inputs)

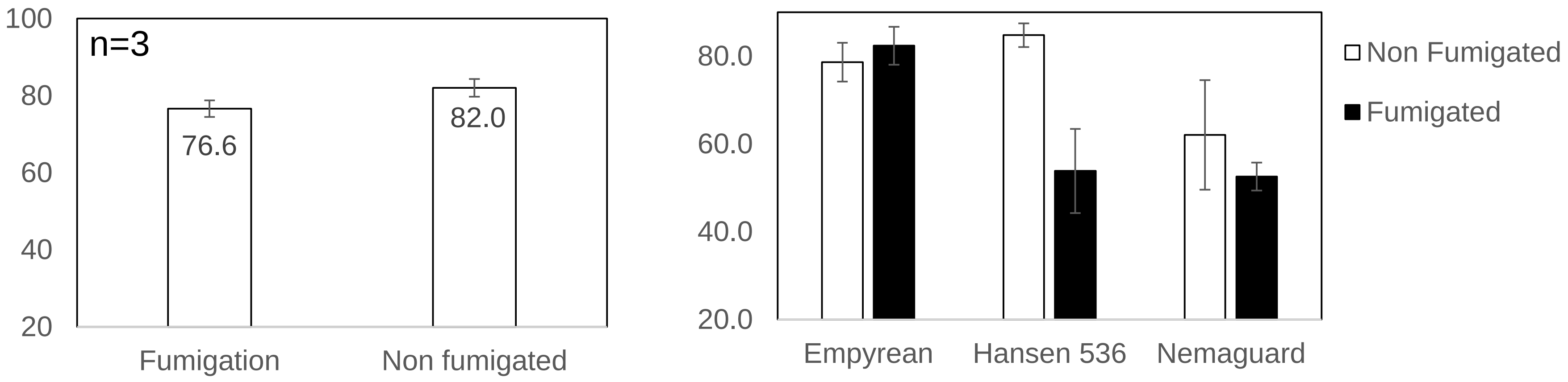
Management impacts colonization rates





Organic management improves colonization rates, especially the presence of soil cover. No impact of compost addition only.

Inoculation at planting of conventional orchards increases colonization to levels found under organic management.



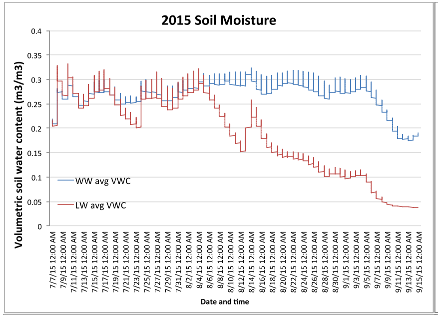
Fumigation also decrease colonization rates but it varies with rootstocks.
No apparent correlation with soil C and OM levels but multivariate approaches considering other measure of soil health are necessary.

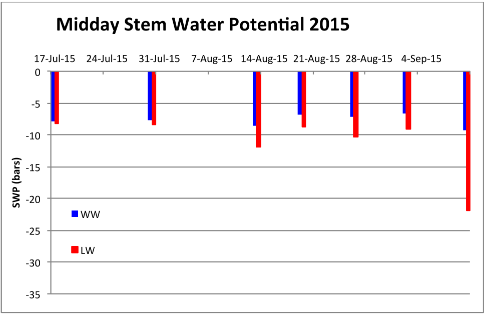
Does mycorrhizal inoculation improve water/nutrient uptake and tree water status under water stress?

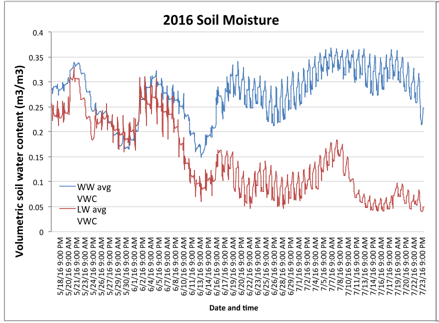
Pot experiments, 2015 & 2016

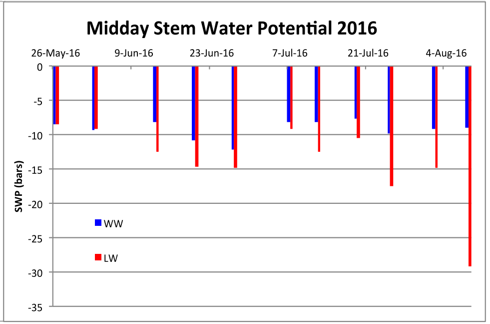
Inoculated / non inoculated
Well watered / water stress

Astrid Volder, Tamara McClung, image and results



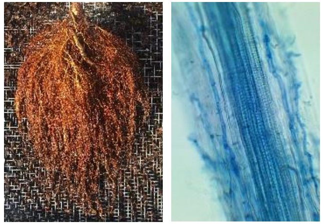


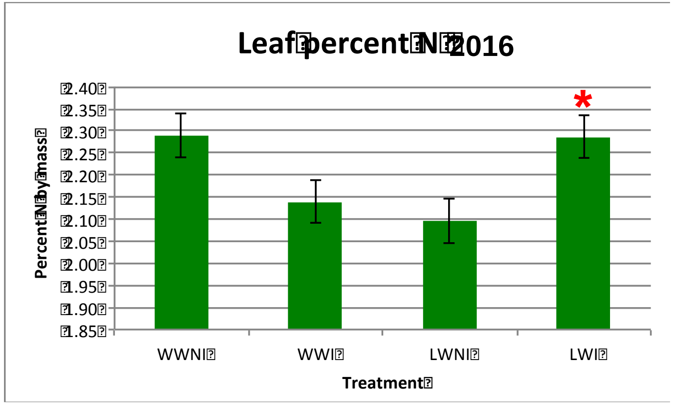


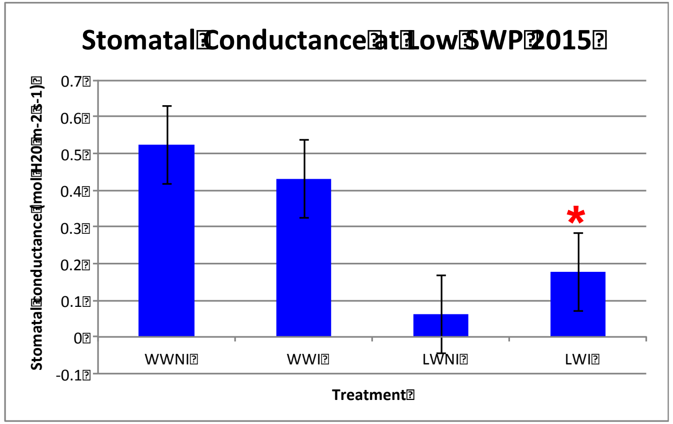


Tree nutrient and water status

- Inoculation did not improve sapling growth. Impact on root traits and biomass allocation in progress
- **Leaf percent N** at harvest was significantly higher for the inoculated plants than for the non-inoculated plants under water stress (2016)
- **Stomatal conductance** was higher for inoculated plants than for non-inoculated plants under water stress on the date when deficit irrigation was most severe (2015)







Astrid Volder, Tamara McClung, image and results

Thank you

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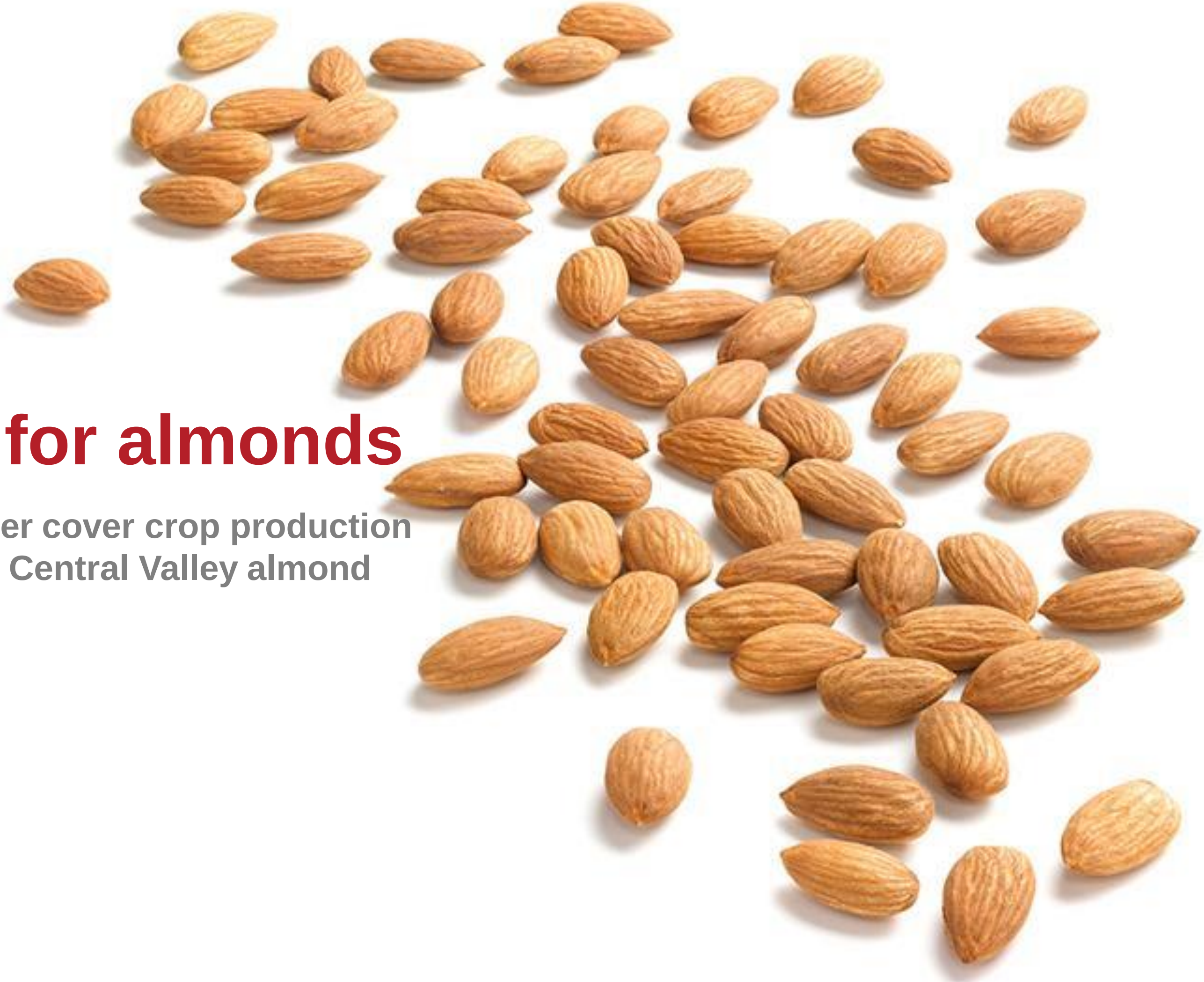
Jeff Mitchell,
UC Kearney



Cover crops for almonds

Trade-offs between winter cover crop production and soil water depletion Central Valley almond orchards

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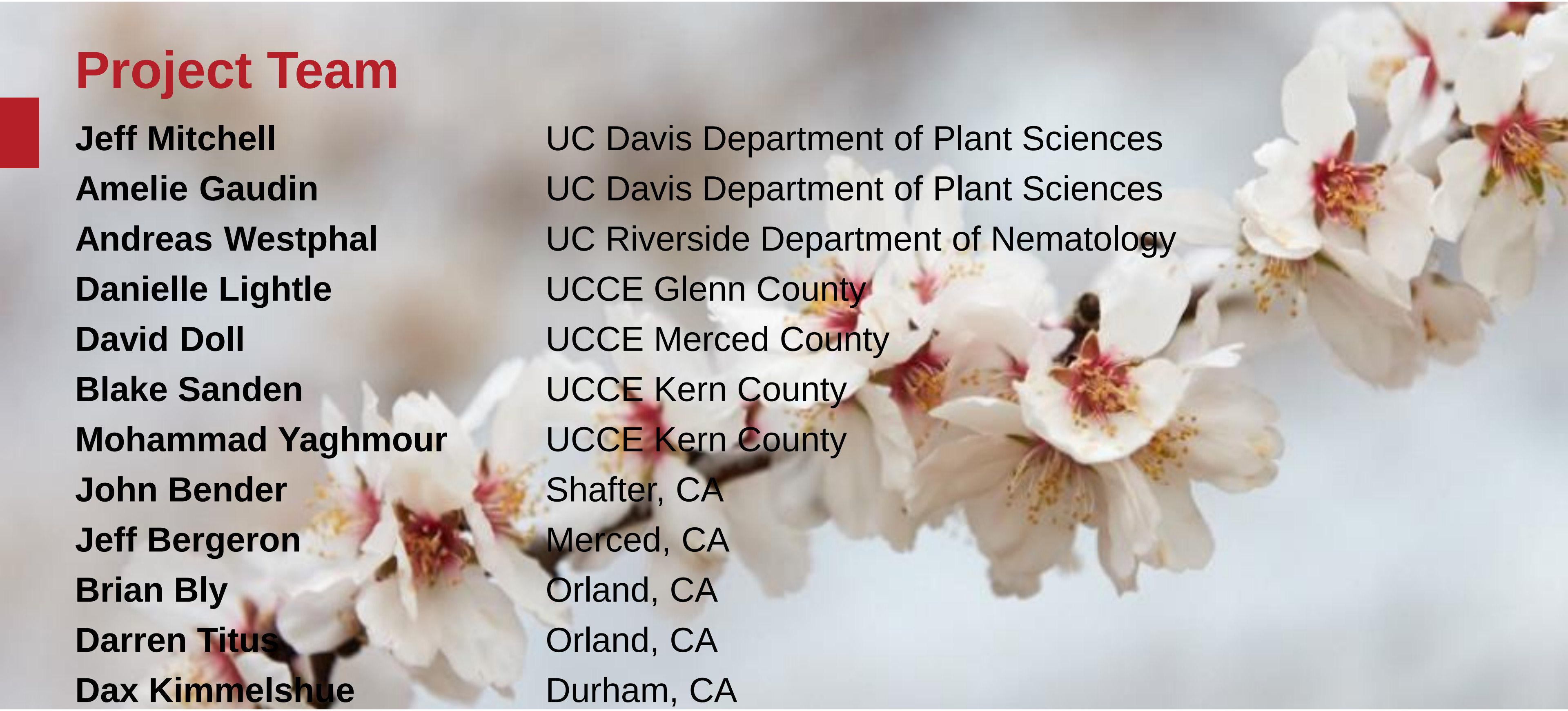

Project Team

Jeff Mitchell	UC Davis Department of Plant Sciences
Amelie Gaudin	UC Davis Department of Plant Sciences
Andreas Westphal	UC Riverside Department of Nematology
Danielle Lightle	UCCE Glenn County
David Doll	UCCE Merced County
Blake Sanden	UCCE Kern County
Mohammad Yaghmour	UCCE Kern County
John Bender	Shafter, CA
Jeff Bergeron	Merced, CA
Brian Bly	Orland, CA
Darren Titus	Orland, CA
Dax Kimmelshue	Durham, CA

Project Goals

to determine trade-offs associated with winter cover cropping in terms of soil water capture, storage and depletion in orchards in the Central Valley, and

to broadly and effectively share this information with farmers, consultants, crop managers, and other agencies so that they might beneficially use it.

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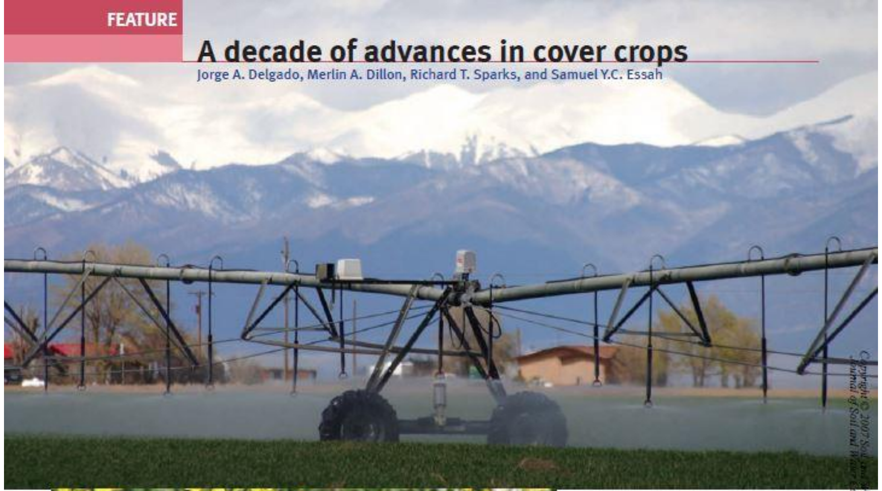
FEATURE

A decade of advances in cover crops

Jorge A. Delgado, Merlin A. Dillon, Richard T. Sparks, and Samuel Y.C. Essah



Jorge A. Delgado is a soil scientist at the Soil Plant Nutrient Research Unit, USDA Agricultural Research Service, Fort Collins, Colorado. **Merlin A. Dillon** is an extension agronomist and **Samuel Y.C. Essah** is a horticultural research scientist at the San Luis Valley Research Center, Colorado State University, Center, Colorado. **Richard T. Sparks** is an irrigation water management specialist for the USDA Natural Resources Conservation Service, Center, Colorado.

Cover crops have been defined as crops grown to protect the soil from erosion losses and losses of nutrients via leaching and runoff (Reeves 1994). This definition was expanded in the *Encyclopedia of Soil Sciences* to those crops that are grown for improving soil, air, and water conservation and quality; nutrient scavenging, cycling and management; increasing populations of beneficial insects in integrated pest management; and/or for short-term (e.g., over-winter) animal-cropping grazing systems (Delgado et al. 2006). A detailed review on the use of winter cover crops for weed suppression and integrated pest management was presented by Dabney et al. (2001).

Several researchers have reported the benefits of cover crops to reduce sediment off-site transport (Frye et al. 1985; Mutchler and McDowell 1990; Holderbaum et al. 1990; Bilbro 1991; Langdale et al. 1991; Decker et al. 1994; Dabney 1998; Delgado et al. 1999). Additionally, several studies have reported the impacts of cover crops increasing nutrient use efficiencies (Lal et al. 1991; Lal 1997; Reicosky and Forcella

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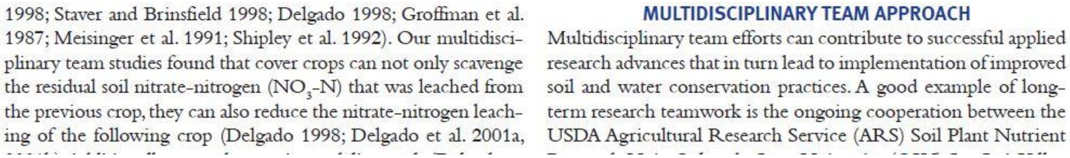
Cover crops with limited irrigation can increase yields, crop quality, and nutrient and water use efficiencies while protecting the environment.



1998; Staver and Brinsfield 1998; Delgado 1998; Groffman et al. 1987; Meisinger et al. 1991; Shipley et al. 1992). Our multidisciplinary team studies found that cover crops can not only scavenge the residual soil nitrate-nitrogen (NO_3-N) that was leached from the previous crop, they can also reduce the nitrate-nitrogen leaching of the following crop (Delgado 1998; Delgado et al. 2001a,

MULTIDISCIPLINARY TEAM APPROACH

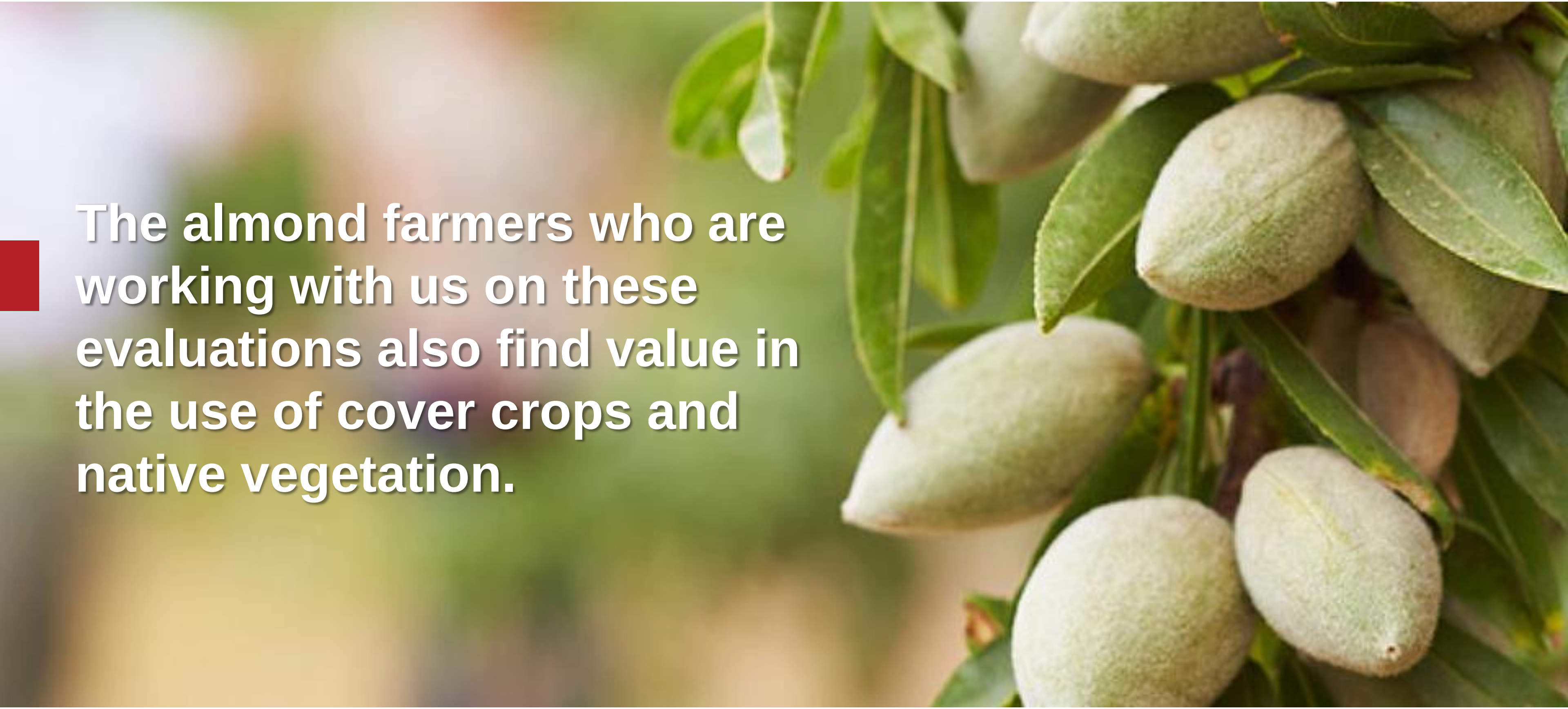
Multidisciplinary team efforts can contribute to successful applied research advances that in turn lead to implementation of improved soil and water conservation practices. A good example of long-term research teamwork is the ongoing cooperation between the USDA Agricultural Research Service (ARS) Soil Plant Nutrient

Journal of Soil and Water Conservation 62(5):110A-117A www.swcs.org

A big concern related to the use of
cover crops in the Central Valley is of course,
their water use.

“Nobody will ever use cover crops
because they use water!”

Statement made at January 27, 2016
Soil Health Assessment Tools Workshop
Davis, CA

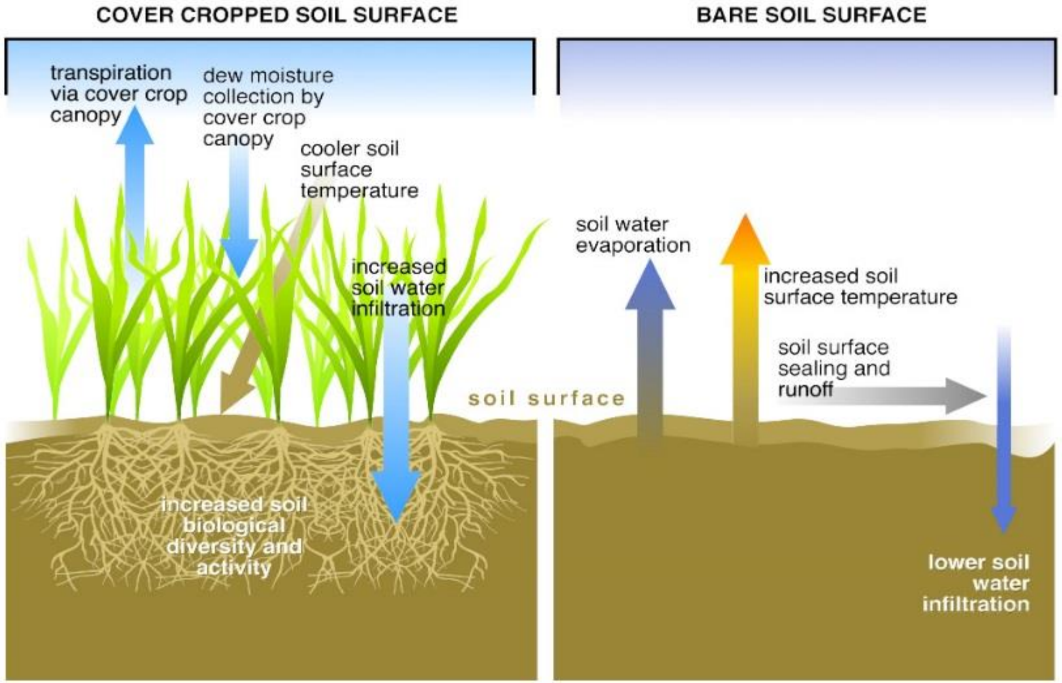


The almond farmers who are working with us on these evaluations also find value in the use of cover crops and native vegetation.

We are testing the hypothesis that long-term cover cropping or native vegetation practices increase soil water infiltration, movement, storage, and overall water use efficiency, compared to bare surface systems without cover crops or vegetation, and that modest soil water depletion by winter cover crops or native vegetation in the Central Valley may actually support the long-term use of this practice as a means to increase orchard water use efficiency.

The context

Possible mechanisms for water relations in cover cropped versus fallow systems




Shafter, CA


Merced, CA

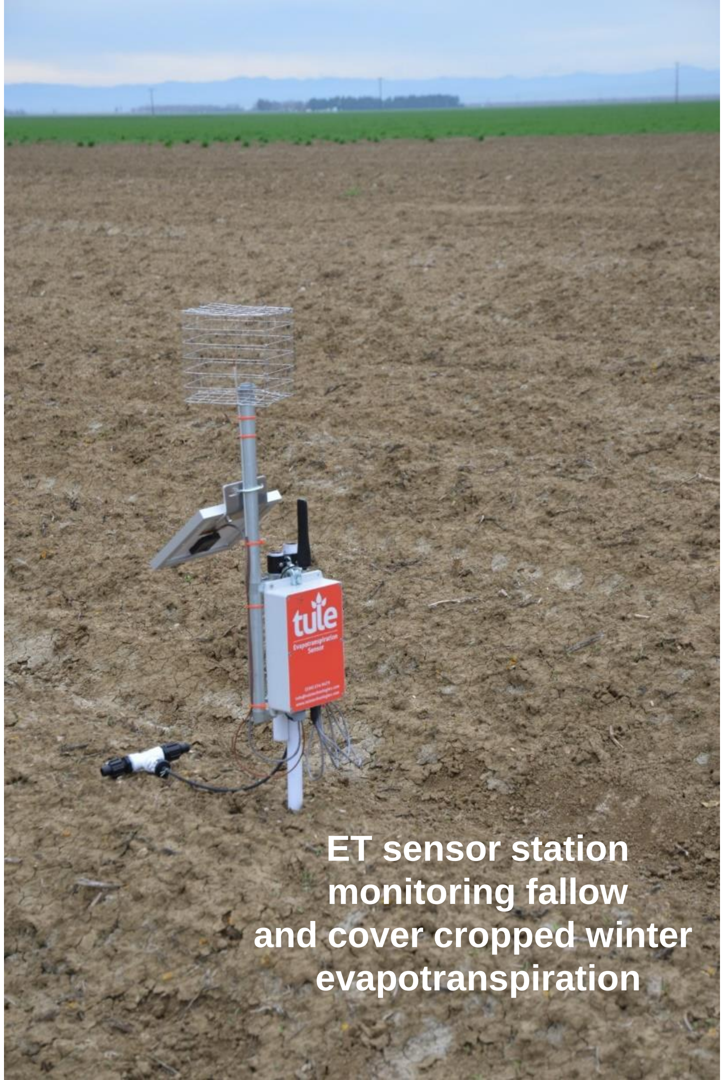

Orland, CA


Durham, CA

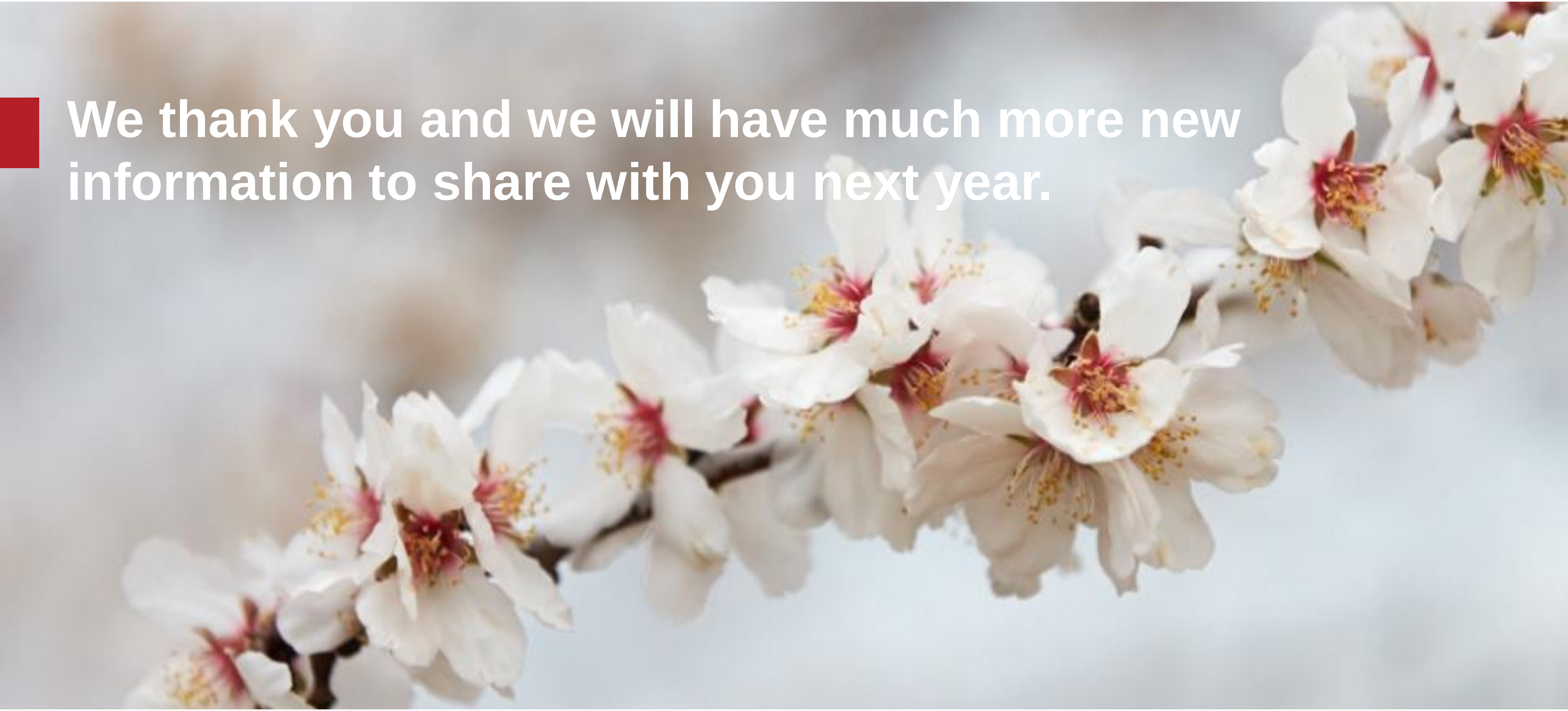
Soil water content monitoring

0 – 4 ft soil water content sampling in fall and spring

0 – 9 ft neutron probe time-course monitoring throughout winter



ET sensor station
monitoring fallow
and cover cropped winter
evapotranspiration



We thank you and we will have much more new information to share with you next year.

Astrid Volder,
UC Davis

Winter Water Management in Almond Orchards

16-PREC9

Astrid Volder, Ken Shackel, Helen Dahlke, Roger Duncan, David Doll, Bruce Lampinen

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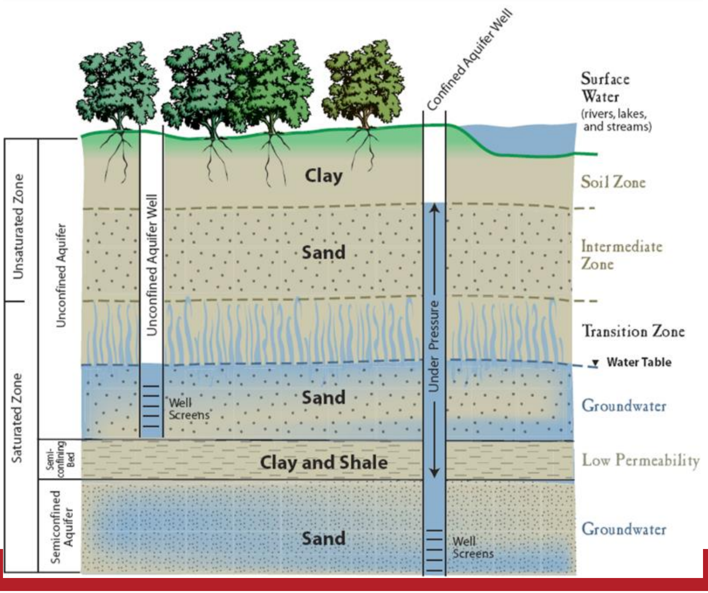
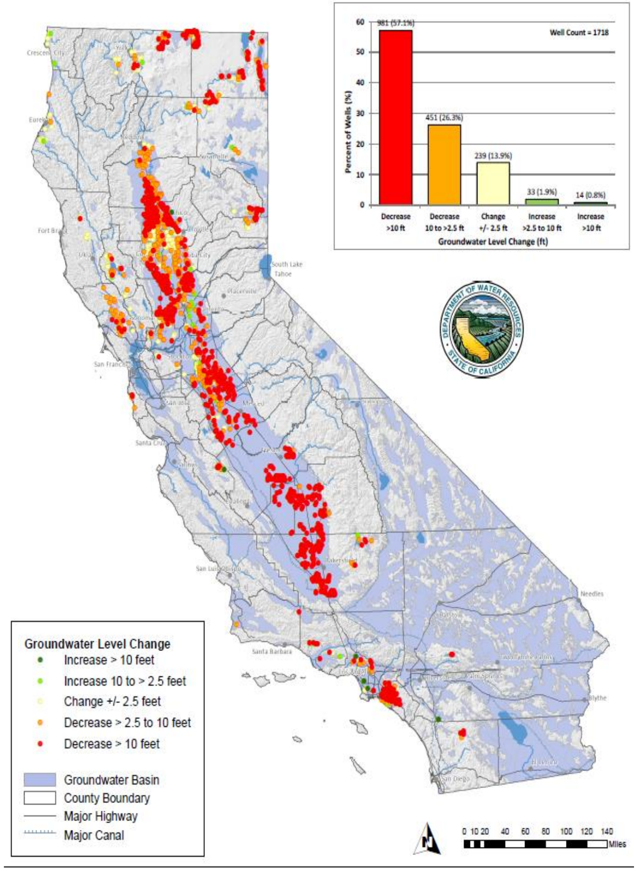
Background

- California agriculture relies heavily on groundwater reserves
  - During drought periods reliance on groundwater increases from 30% to 60% of state water usage
  - Replenishment occurs slowly – years to decades

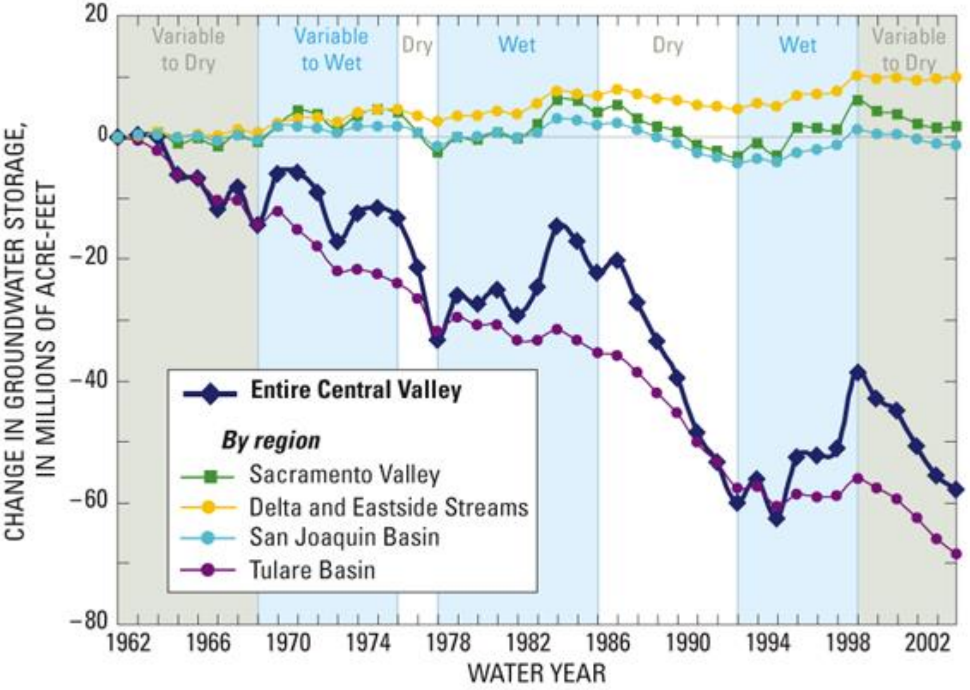


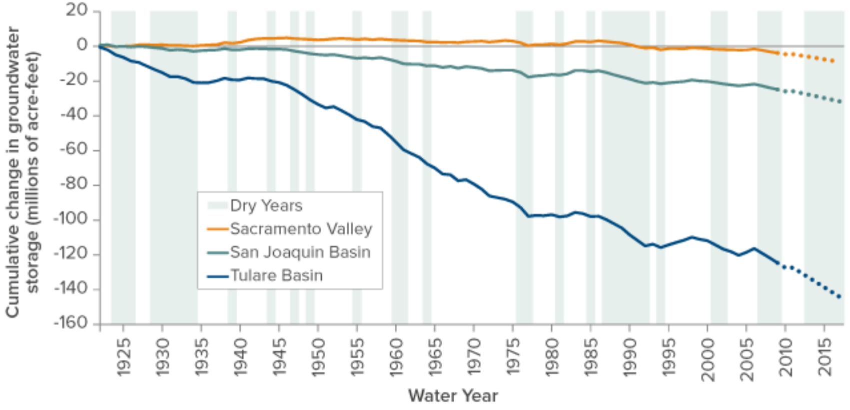
http://www.water.ca.gov/groundwater/images/saturated_zone.png

Groundwater Level Change* - Spring 2006 to Spring 2016



*Groundwater level change determined from water level measurements in wells. Map and chart based on available data from the DWR Water Data Library as of 04/26/2016. Document Name: DOTMAP_DRAFT_S1606 Updated: 4/27/2016 Data subject to change without notice.





http://www.ppic.org/main/publication_quick.asp?i=1160

http://pubs.usgs.gov/fs/2009/3057/

Sustainable Groundwater Management Act (SGMA) – 2014

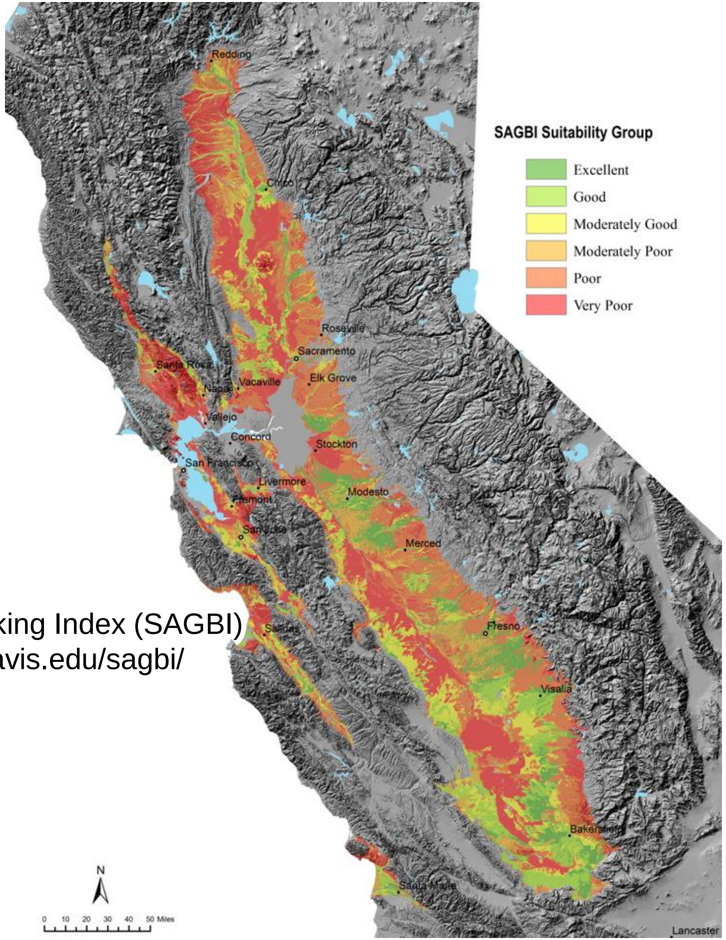
- Use suitable orchards for recharge
  - Can we apply extra flood water specifically for recharge in the winter?
    - Does extra water during a very dry winter alleviate potential drought stress?
  - Can we apply extra flood water during the spring/early summer?

SUSTAINABLE GROUNDWATER MANAGEMENT ACT OF 2014

Fact Sheet

The Sustainable Groundwater Management Act of 2014 is a comprehensive three-bill package that provides a framework for sustainable management of groundwater supplies by local authorities, with a limited role for state intervention only if necessary to protect the resource.

http://www.acwa.com/sites/default/files/post/groundwater/2014/04/2014-groundwater-fact-sheet.pdf



Soil Agricultural Groundwater Banking Index (SAGBI)
http://casoilresource.lawr.ucdavis.edu/sagbi/

Test locations for soil agricultural ground water banking in almond orchards

- Modesto – SAGBI moderate
- Delhi – SAGBI excellent?
- Selma – SAGBI moderate
- Madera – SAGBI moderate

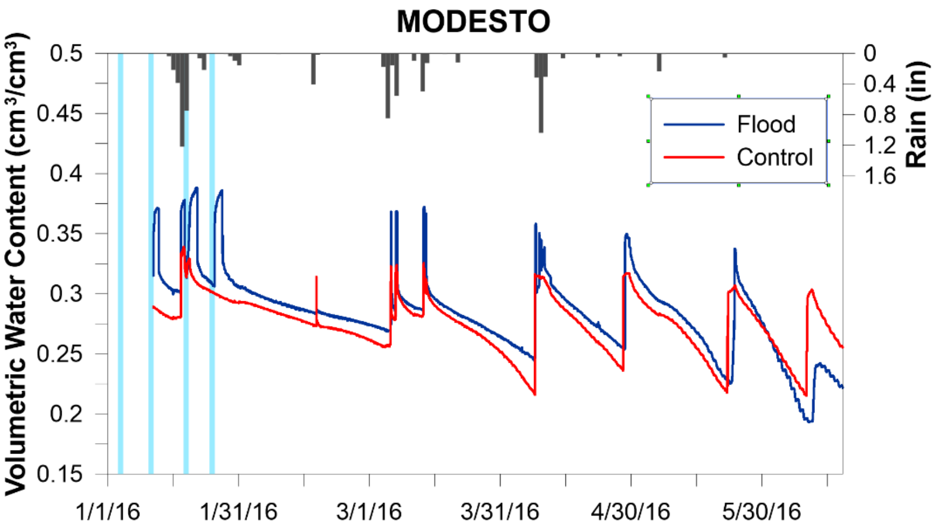
24” winter recharge applied

Logistics prevented spring/summer flood at these locations

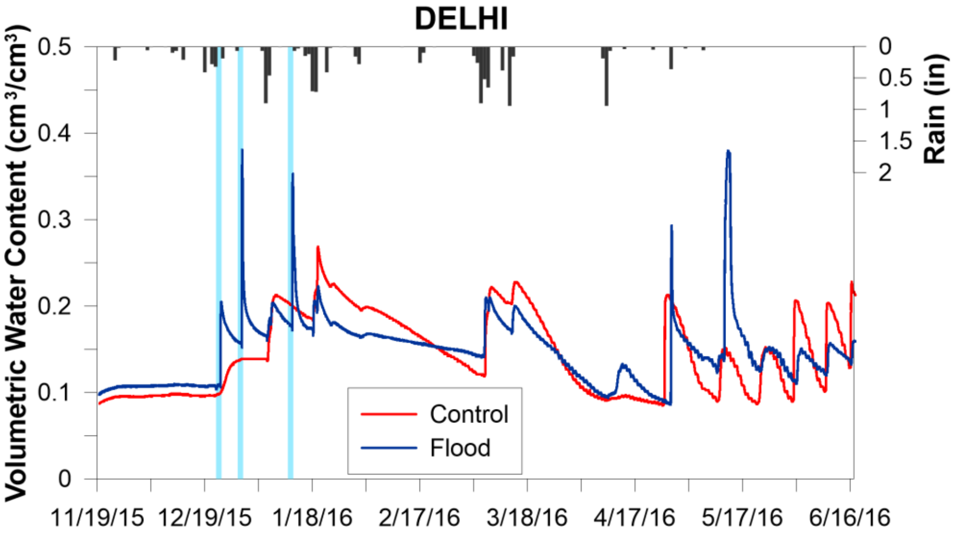
Experimental setup

- 3 treatments at each site
  - Recharge (24” in 3 events at Delhi and 4 events at Modesto)
  - Grower treatment
  - Added winter irrigation (not applied this year)
- (Bi)weekly stem water potential – 15 trees, 5 per treatment
- Root observation – 5 tubes per recharge and grower control treatment, every 3 weeks
- Soil water content, temperature & EC x, y, z depths, every 10 minutes
- Light interception (July)
- Yield

Soil water results (at 2 feet depth)

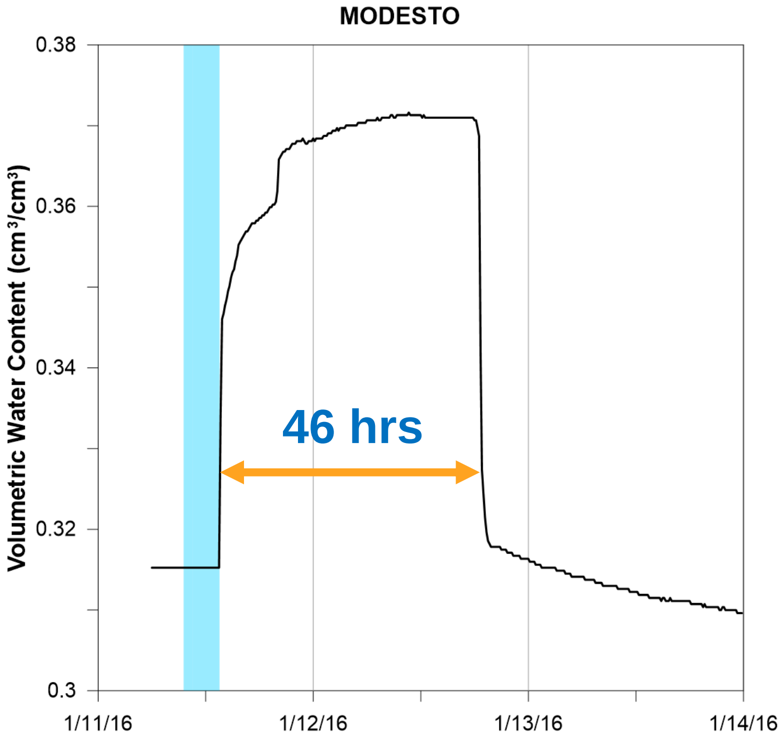


Fine sandy loam

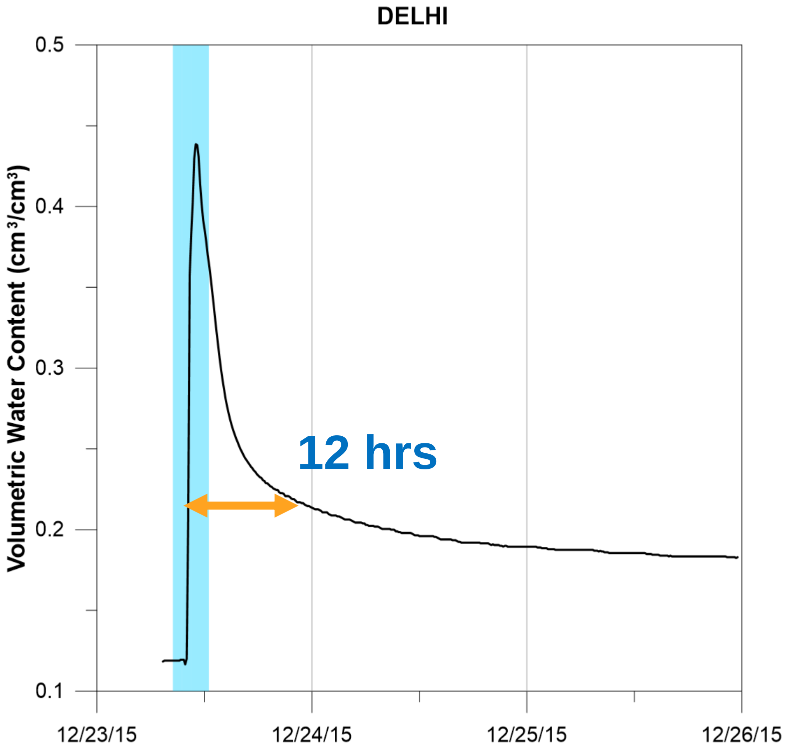


Sandy

Root Zone Residence Time (at 2 ft depth)

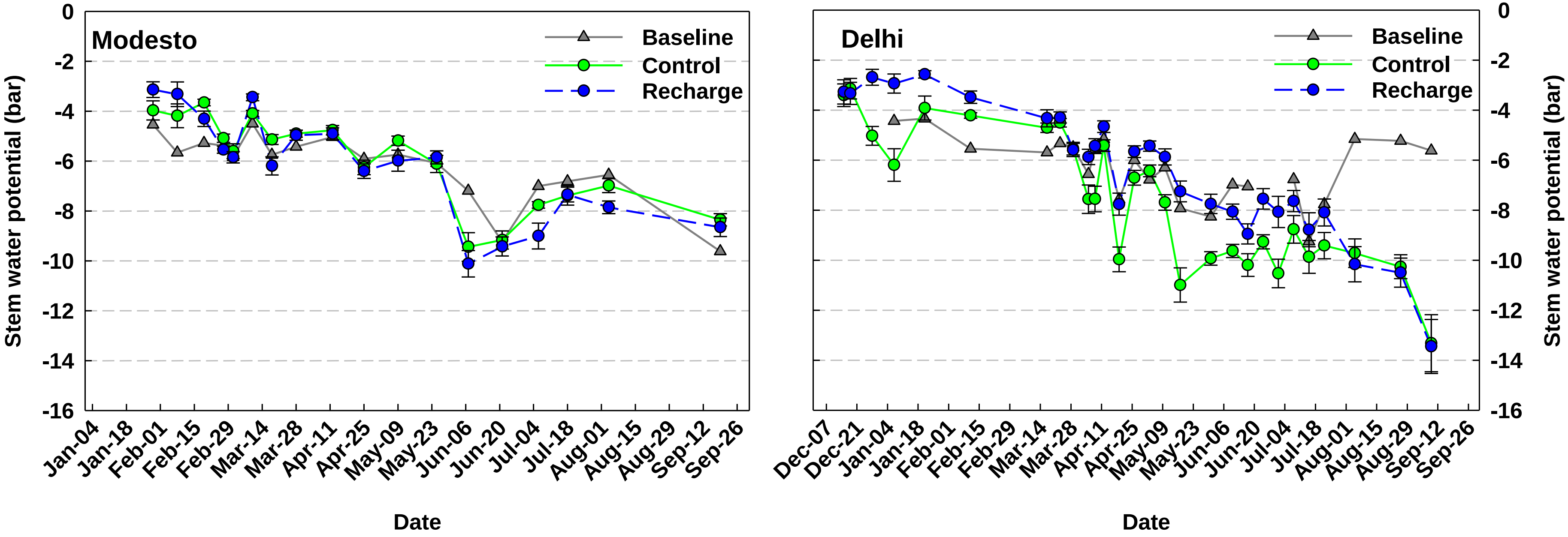


Fine sandy loam



Sandy

Stem water potential

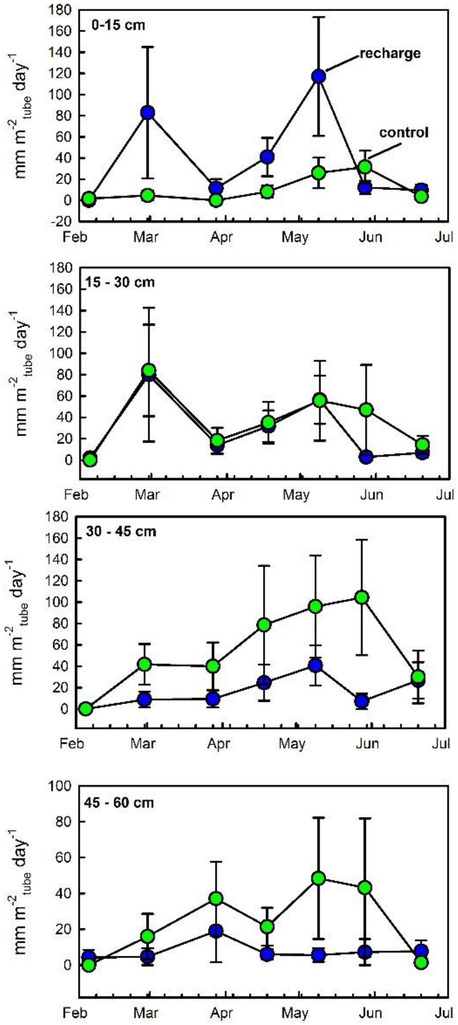


Fine sandy loam

Sandy

New root production

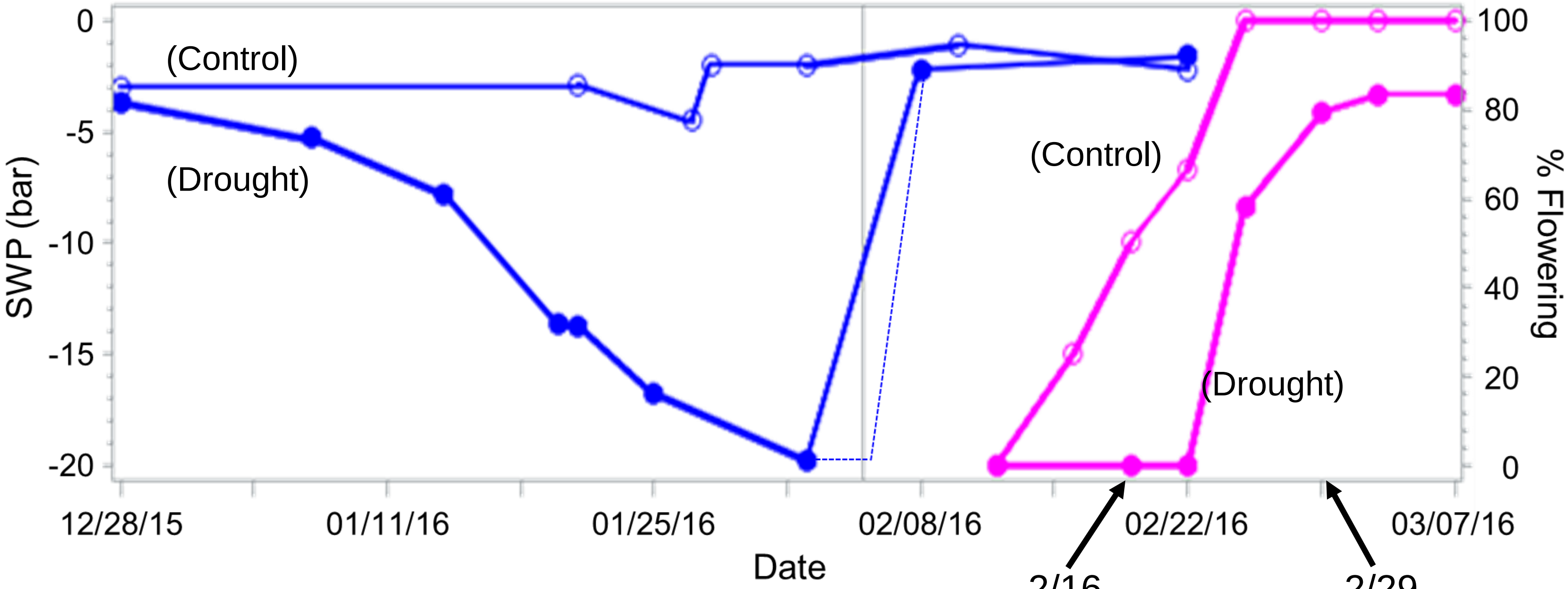
New root length production
mm m^{-2} window per day

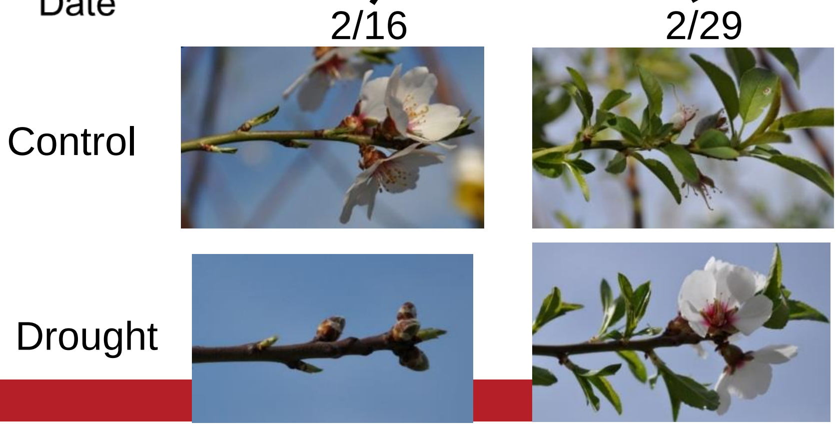


Increasing soil depth

No indication that winter recharge affects yield

		Year	
Site	Treatment	2015 (pre-treatment)	2016
Modesto	Grower	3220	3090
	(Dry Winter)	3360	3290
	Recharge	3430	3130
Delhi	Grower	1230	1250
	(Dry Winter)	1190	1140
	Recharge	1410	1200





Potential impact of winter irrigation on drought stressed trees (pot grown trees)

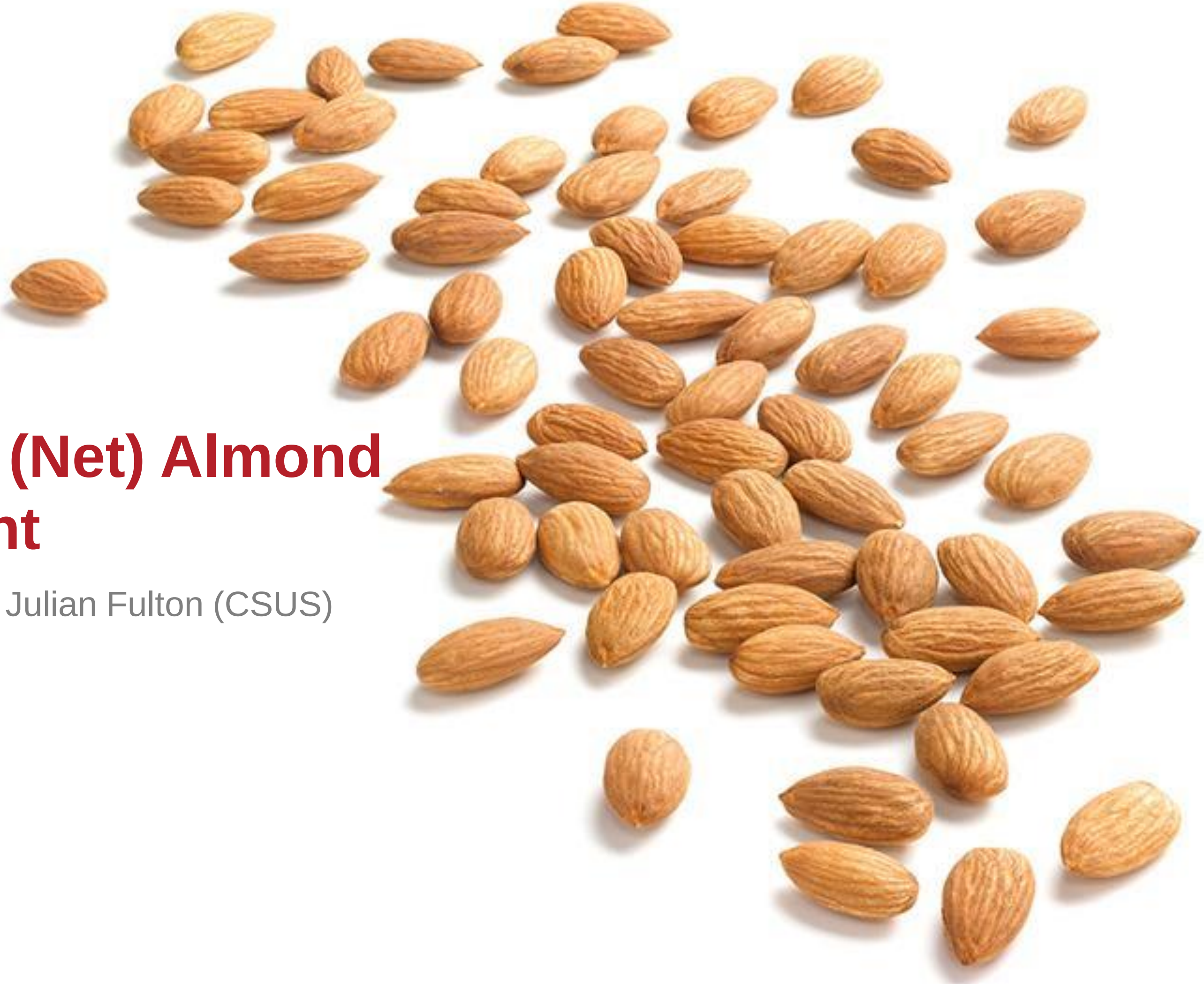
Summary

- First year of winter recharge treatments suggests little impact on stem water potential or yield
- At the very sandy Delhi site we may see some improved tree water status and a shift to shallower root production – this needs to be tested at multiple sites and through time as the experimental layout is confounded by lack of replication
- In young pot grown trees, waiting with irrigation until early February still yielded a bloom percentage >80%, even when trees were exposed to severe drought stress, although bloom was delayed by ~ 10 days

Continuation

- Add a third, well replicated, site in the Northern valley
- Longer term monitoring for delayed effects
- Late spring recharge?
- Field test of winter irrigation if dry winter

Fraser Shilling, UC Davis



Improving the (Net) Almond Water Footprint

Fraser Shilling (UCD) and Julian Fulton (CSUS)

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Almond Board of California

What is Water Footprint?

Blue Water refers to applied water, whether from surface or ground sources, that is utilized in orchard development.

Green Water refers to rainwater and residual soil moisture that is utilized in orchard development.

Gray Water refers to contamination and is expressed as the volume of water needed to dilute non-utilized nutrients and other pollutants to acceptable levels.

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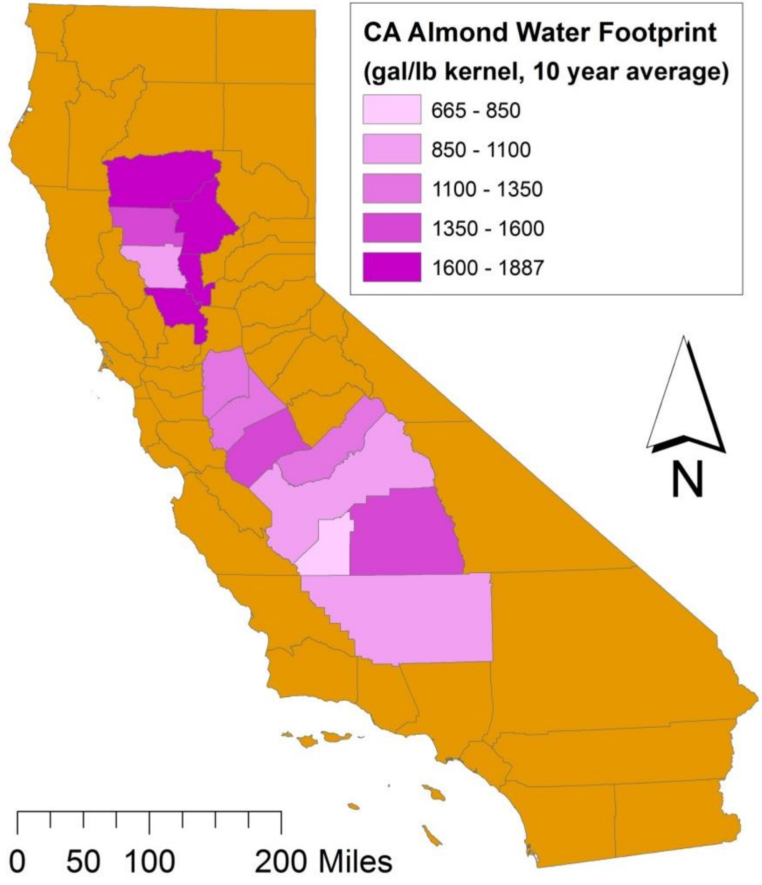
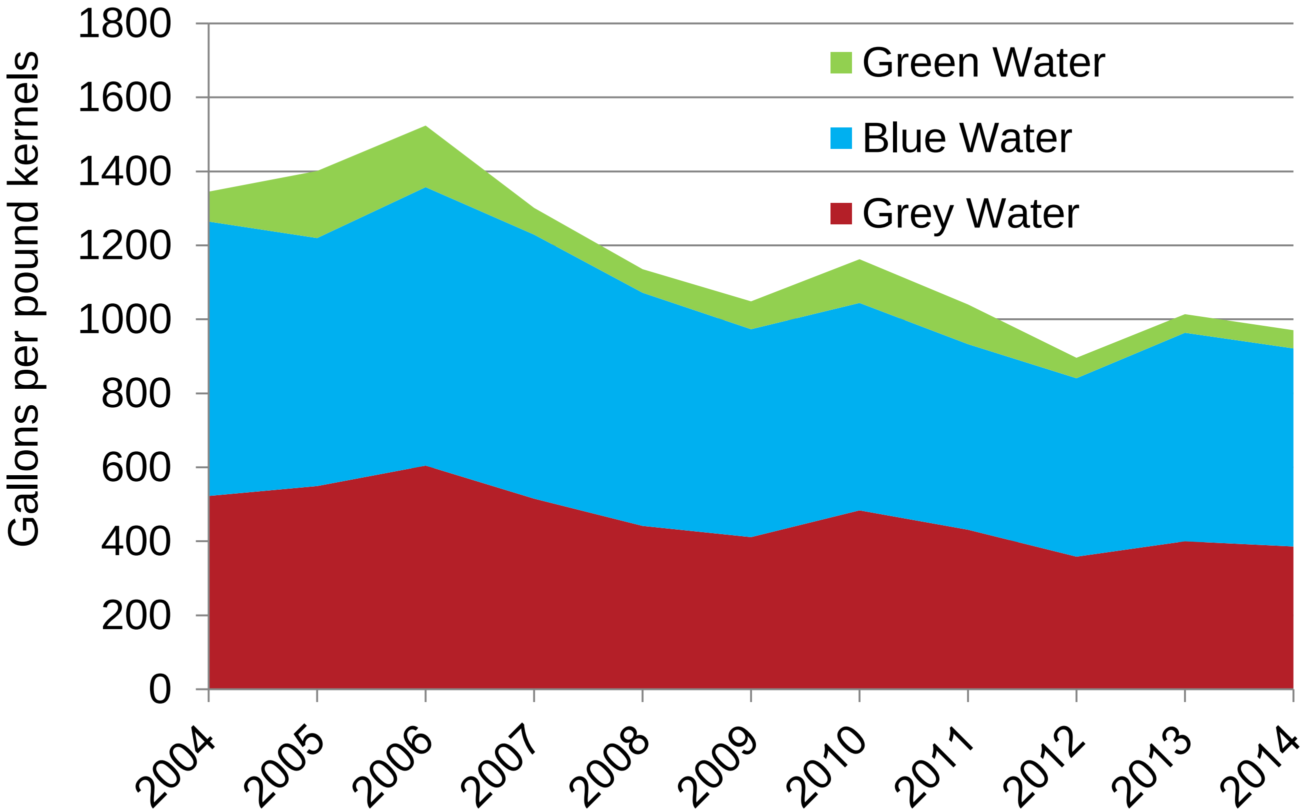
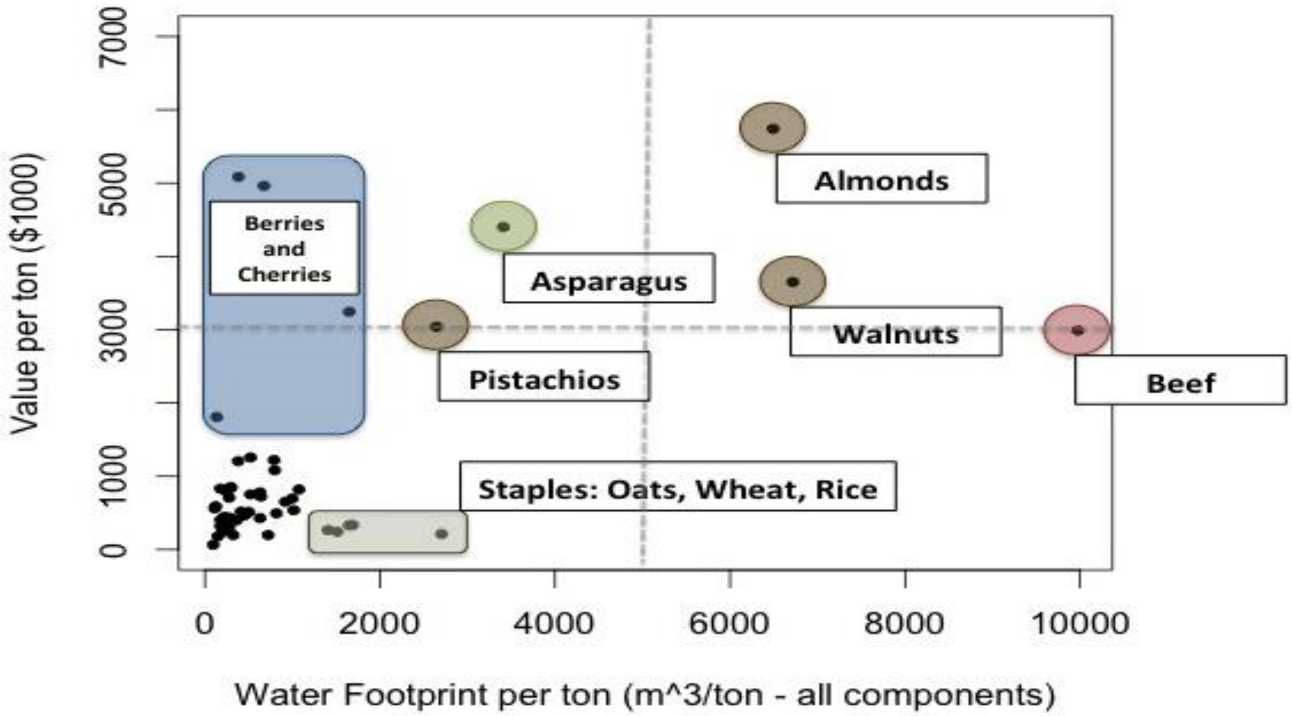
Phase 1: Water Footprint Varies by County



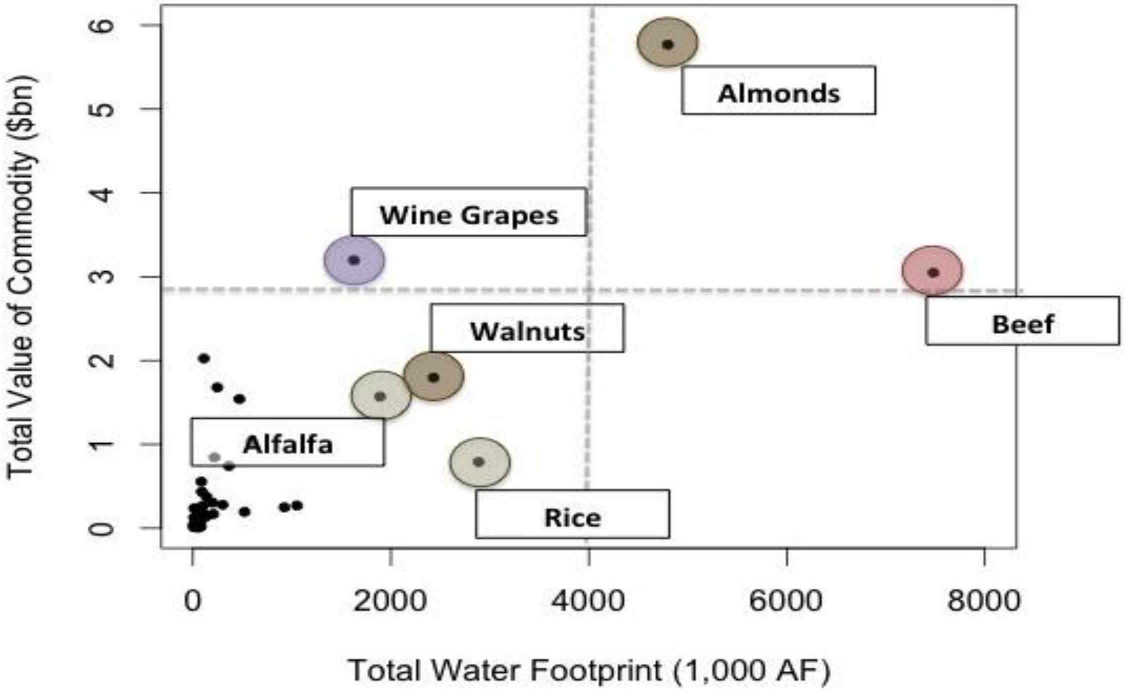
Phase 1: Water Footprint is Declining



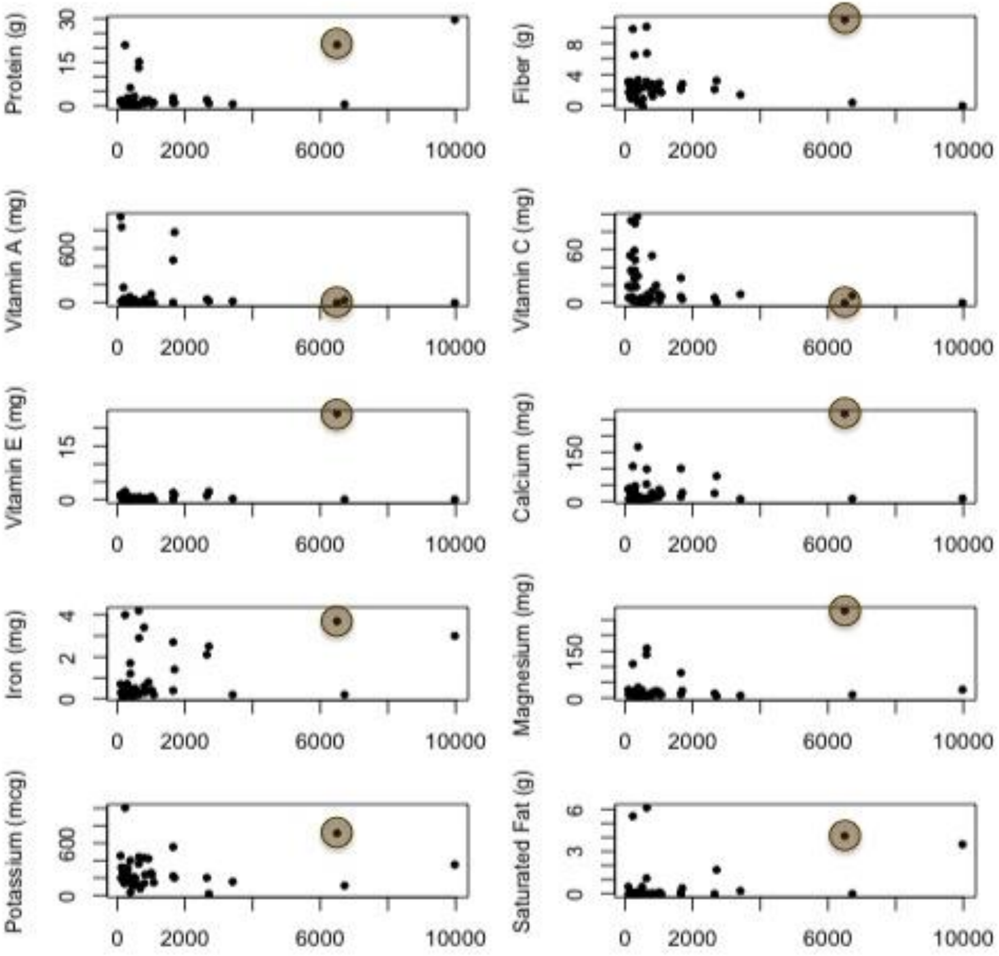
Inter-Crop Comparison of WF and Sales Value



Inter-Crop Comparison of WF and Total Value



WF & Dietary Benefits



Phases 2/3: Objectives

- Match water footprint and LCA/water to existing sustainability reporting carried out by ABC.
- Associate water footprint and LCA with types and sources of water.
- Investigate geographic variation of current and potential future water availability as it relates to water footprint

- Describe trade-offs and benefits between water footprint and conservation activities.
- Compare California almond water footprint to other regions globally and asses overall industry water savings gained through trade.

Contact Us

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Julian Fulton julian.fulton@csus.edu

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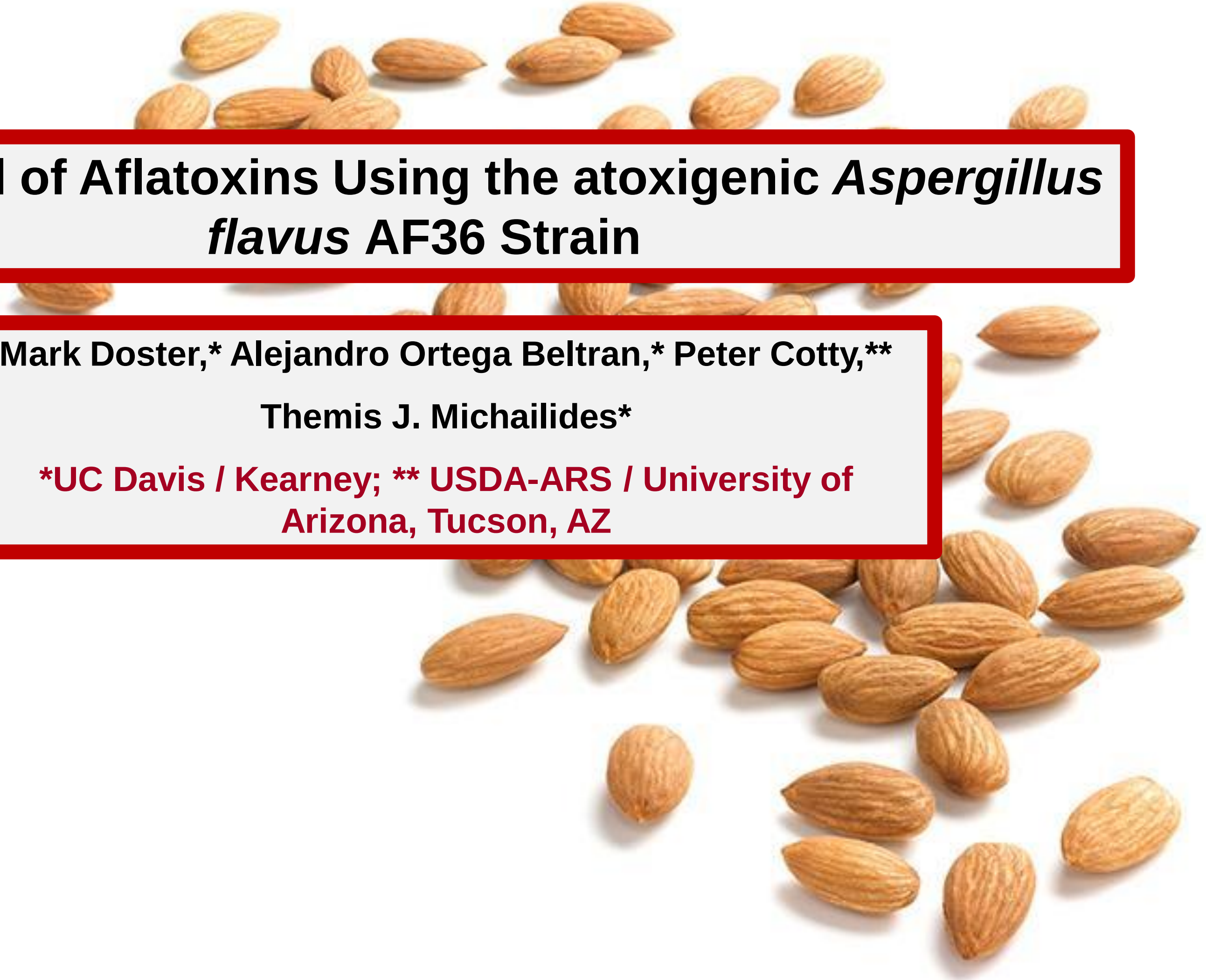
Themis Michailides,
UC Kearney



Biocontrol of Aflatoxins Using the atoxigenic *Aspergillus flavus* AF36 Strain

Mark Doster,* Alejandro Ortega Beltran,* Peter Cotty,**

Themis J. Michailides*

*UC Davis / Kearney; ** USDA-ARS / University of Arizona, Tucson, AZ

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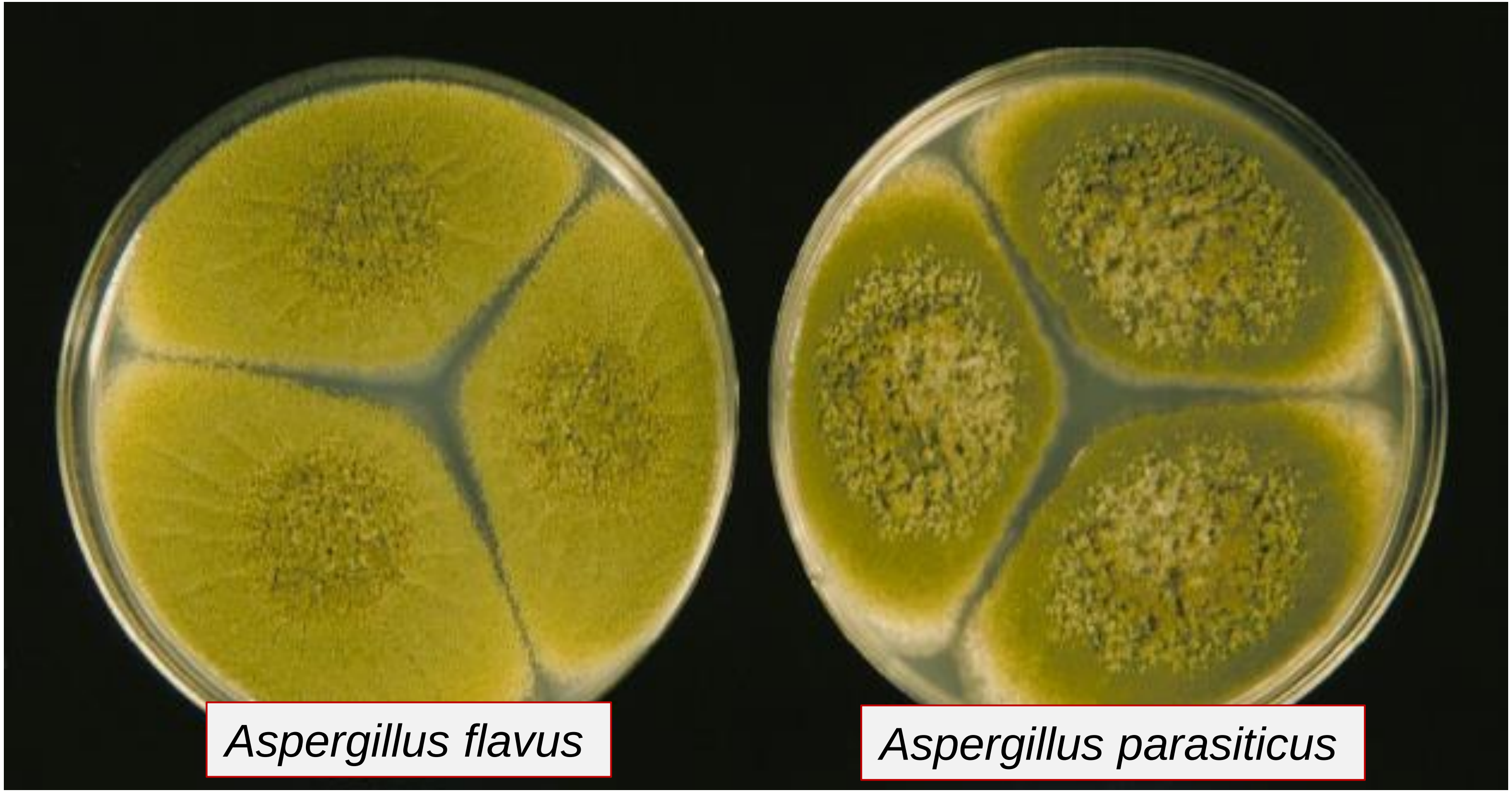
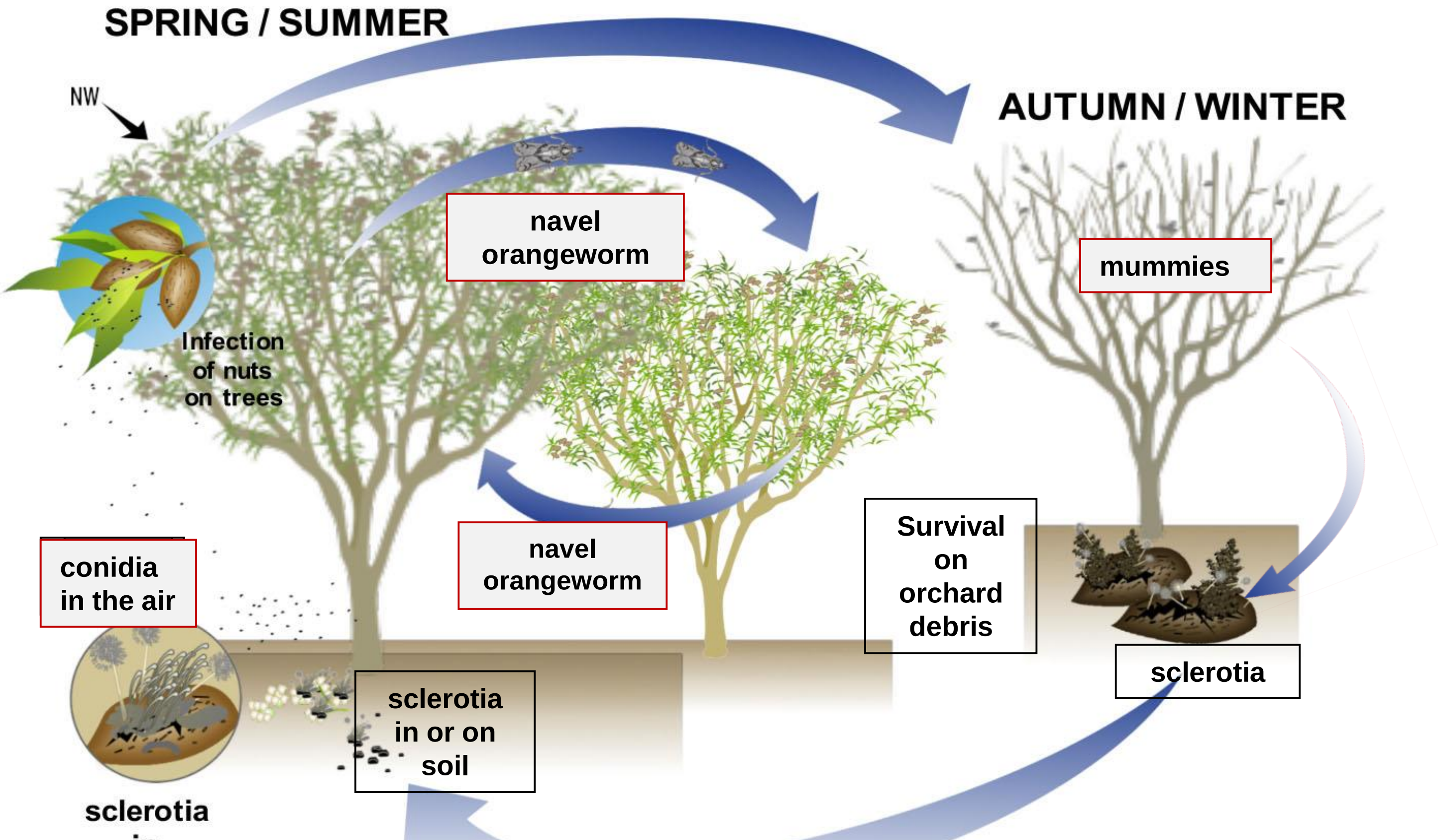
Almond Board of California

Molds that can produce aflatoxin in almond orchards in California



Aspergillus flavus

Aspergillus parasiticus



navel orangeworm

mummies

conidia in the air

navel orangeworm

Survival on orchard debris

sclerotia

sclerotia in or on soil

Life cycle of *Aspergillus flavus* in almond orchards

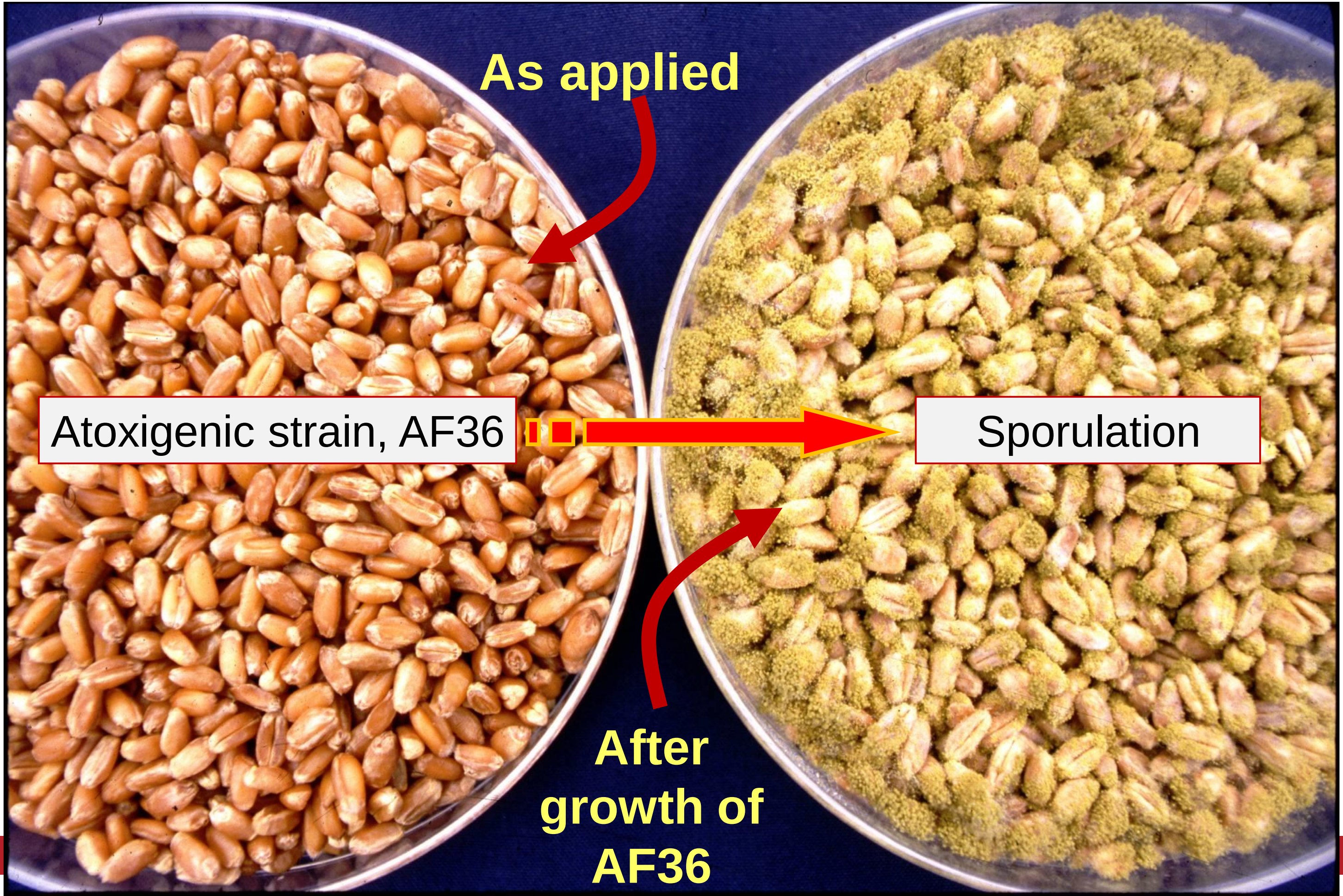
Strains of *Aspergillus flavus*

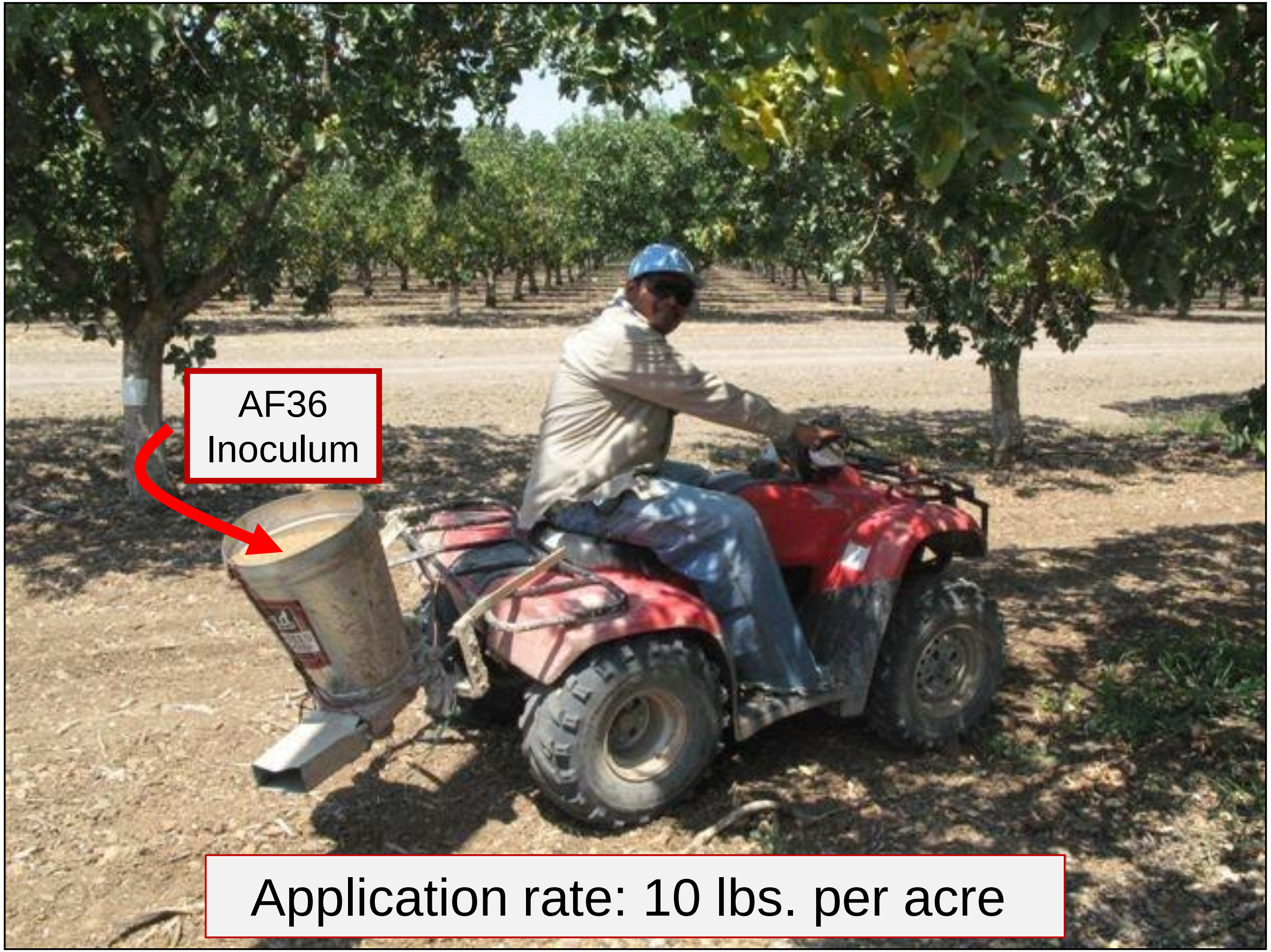
L - strain → about 50:50 toxigenic: atoxigenic

M - strain → undescribed

S - strain → most toxigenic

Irrigation is needed for spore production by the AF36

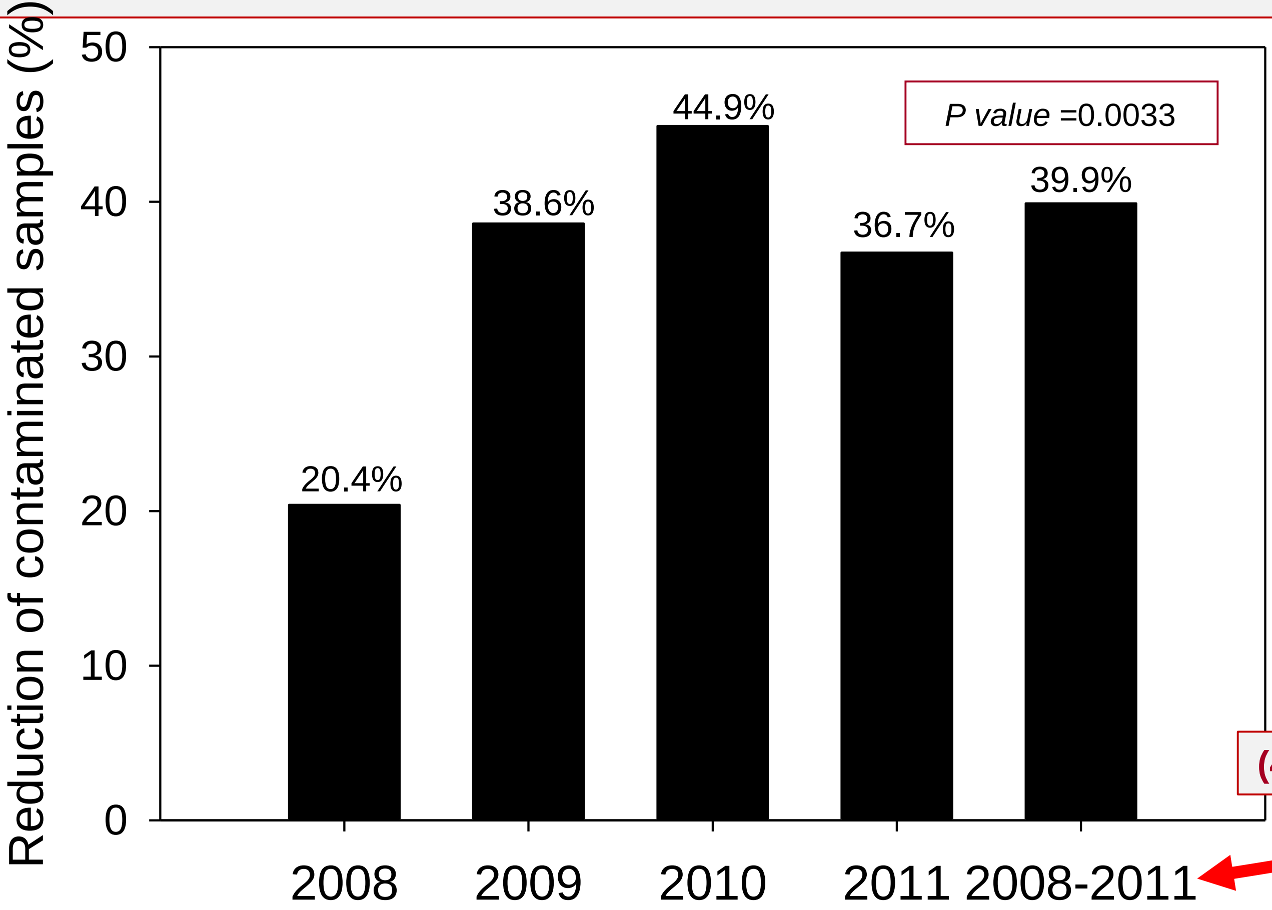




AF36 Inoculum

Application rate: 10 lbs. per acre

Reduction in contaminated samples with aflatoxin – all harvests

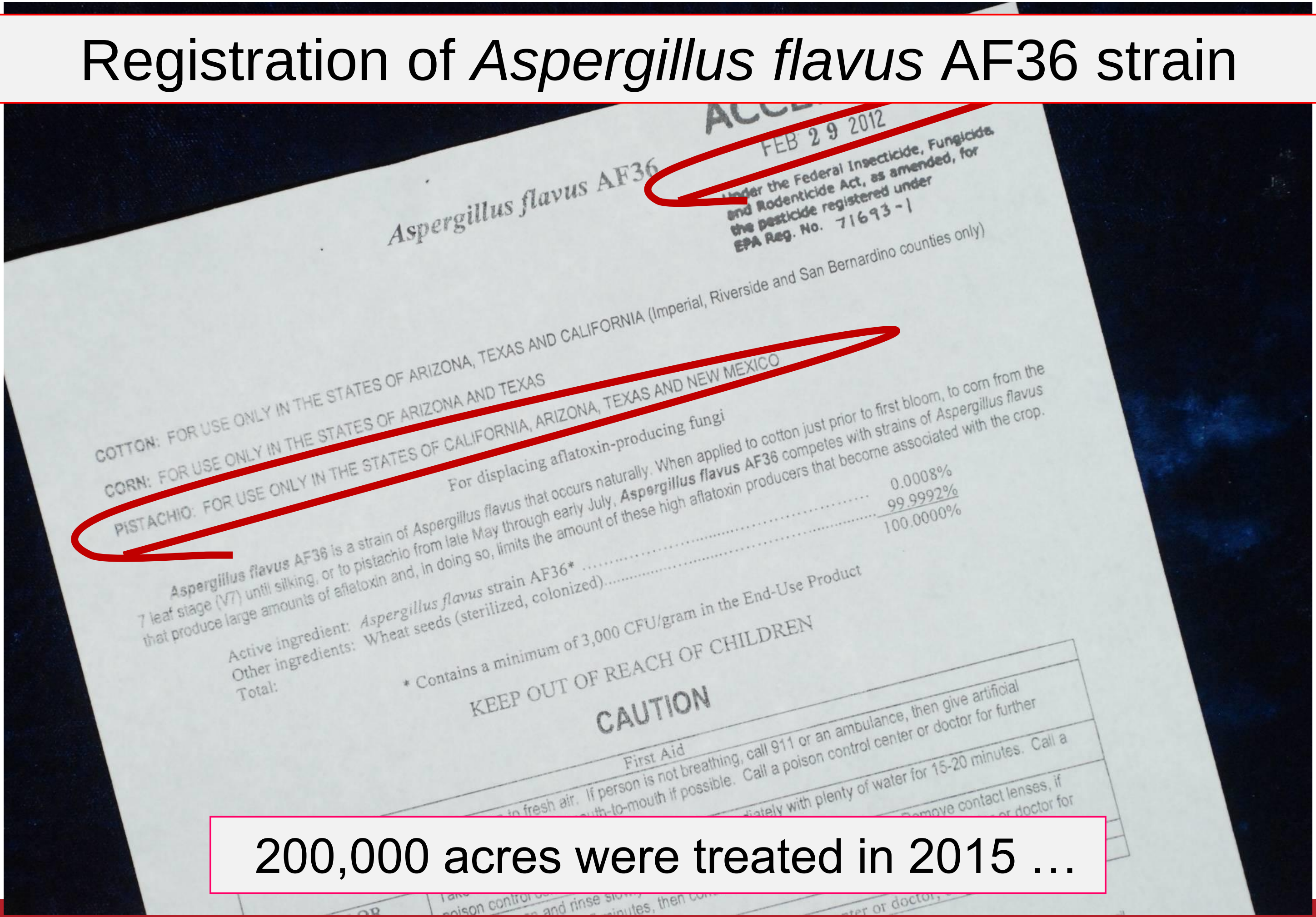


P value =0.0033

(4 years average)

(Doster et al. (2014), Plant Disease 98:948-956)

Registration of *Aspergillus flavus* AF36 strain



FEB 29 2012
Under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, for the pesticide registered under EPA Reg. No. 71693-1

Aspergillus flavus AF36

COTTON: FOR USE ONLY IN THE STATES OF ARIZONA, TEXAS AND CALIFORNIA (Imperial, Riverside and San Bernardino counties only)

CORN: FOR USE ONLY IN THE STATES OF ARIZONA AND TEXAS

PISTACHIO: FOR USE ONLY IN THE STATES OF CALIFORNIA, ARIZONA, TEXAS AND NEW MEXICO

For displacing aflatoxin-producing fungi

***Aspergillus flavus* AF36** is a strain of *Aspergillus flavus* that occurs naturally. When applied to cotton just prior to first bloom, to corn from the 7 leaf stage (V7) until silking, or to pistachio from late May through early July, ***Aspergillus flavus* AF36** competes with strains of *Aspergillus flavus* that produce large amounts of aflatoxin and, in doing so, limits the amount of these high aflatoxin producers that become associated with the crop.

Active ingredient:	*Aspergillus flavus* strain AF36*	0.0008%
Other ingredients:	Wheat seeds (sterilized, colonized)	99.9992%
Total:		100.0000%

* Contains a minimum of 3,000 CFU/gram in the End-Use Product

KEEP OUT OF REACH OF CHILDREN

CAUTION

First Aid

in fresh air. If person is not breathing, call 911 or an ambulance, then give artificial

uth-to-mouth if possible. Call a poison control center or doctor for further

diately with plenty of water for 15-20 minutes. Call a

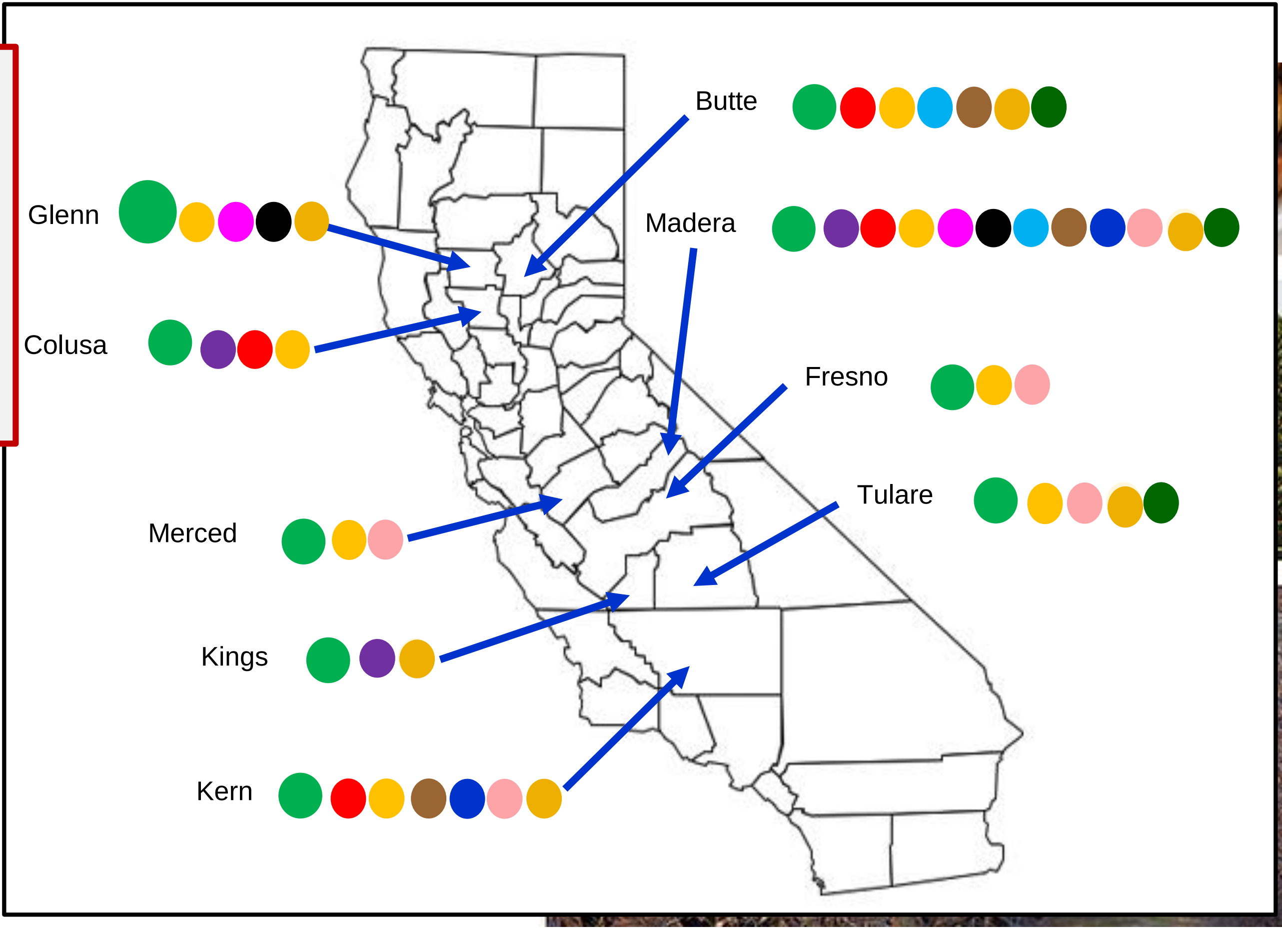
Remove contact lenses, if

or doctor for

200,000 acres were treated in 2015 …

Occurrence of *A. flavus* atoxigenic vegetative compatibility groups (VCGs) in **almond-growing counties** of California.

*****AF36 in green *****



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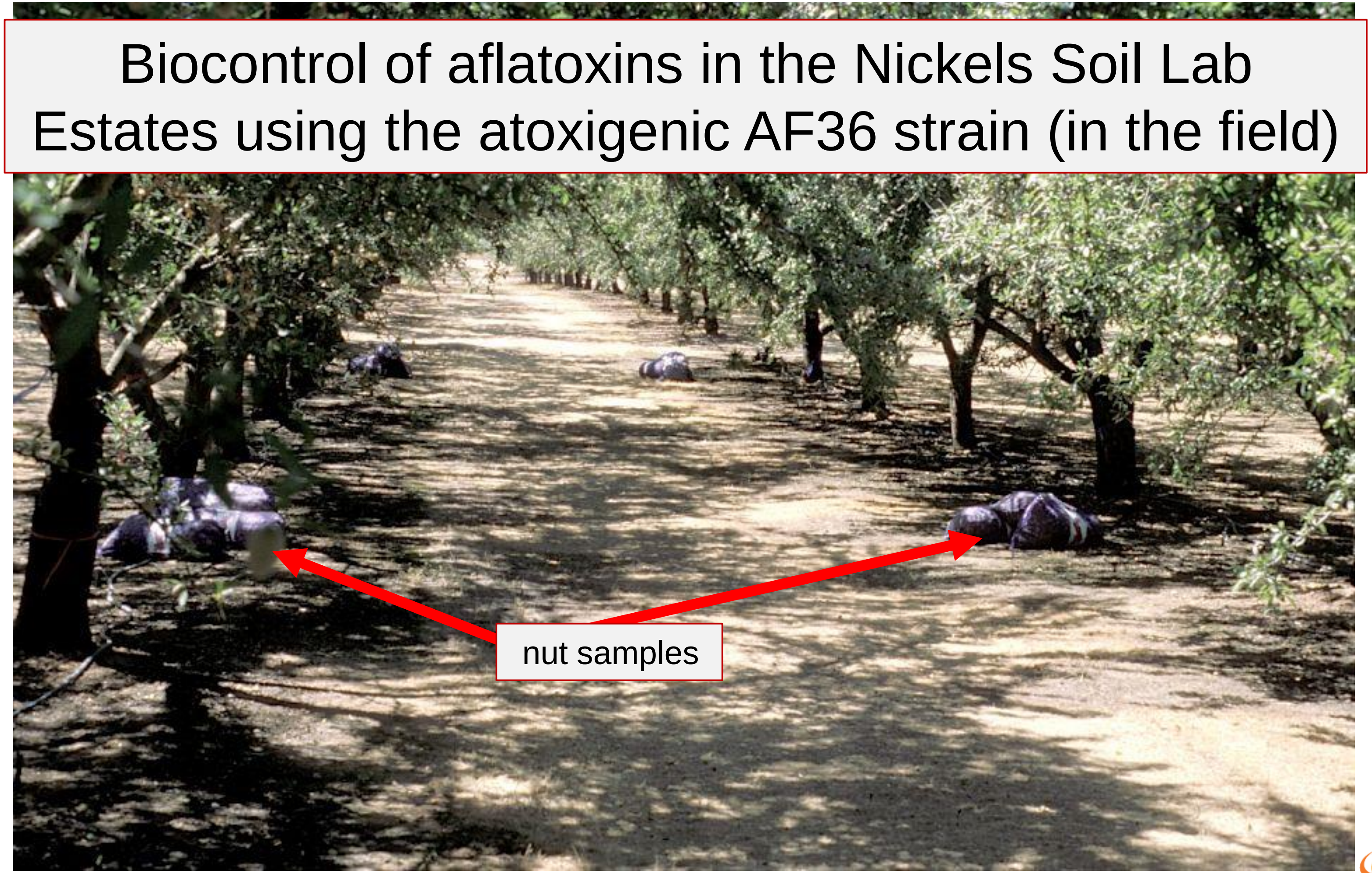
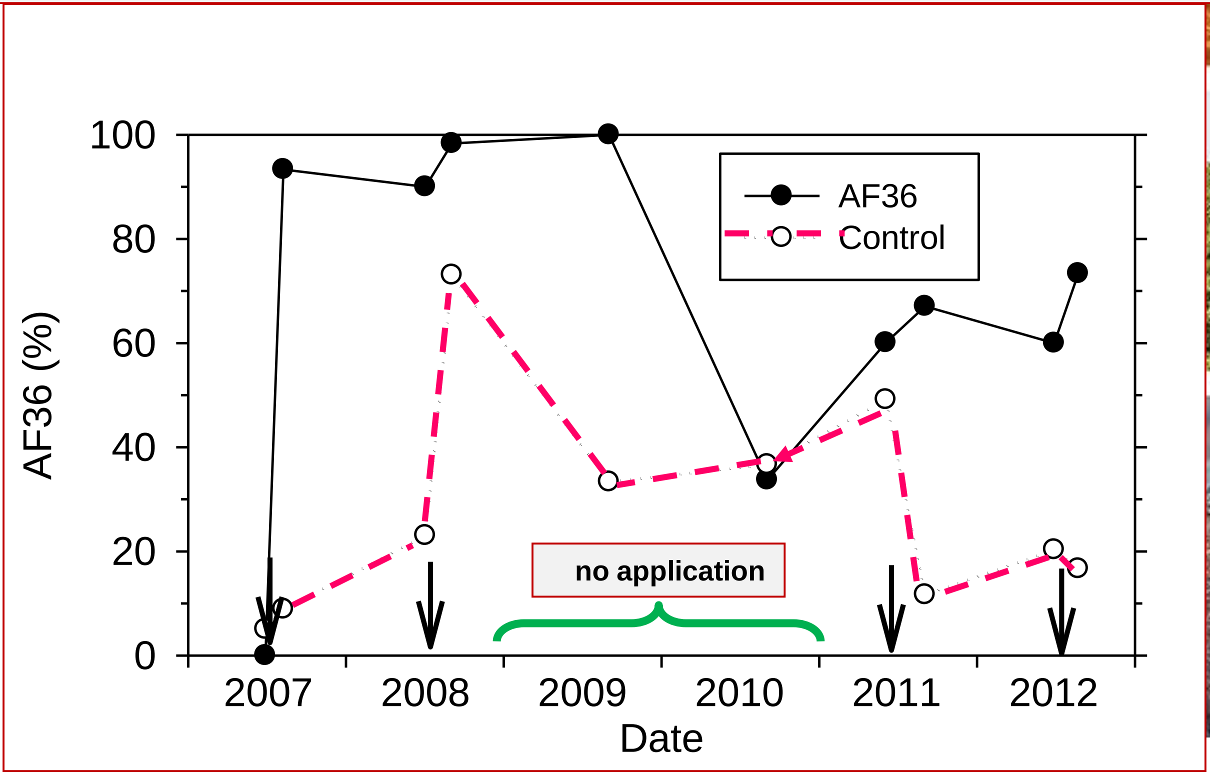
Biocontrol of aflatoxins in the Nickels Soil Lab Estates using the atoxigenic AF36 strain (in the field)



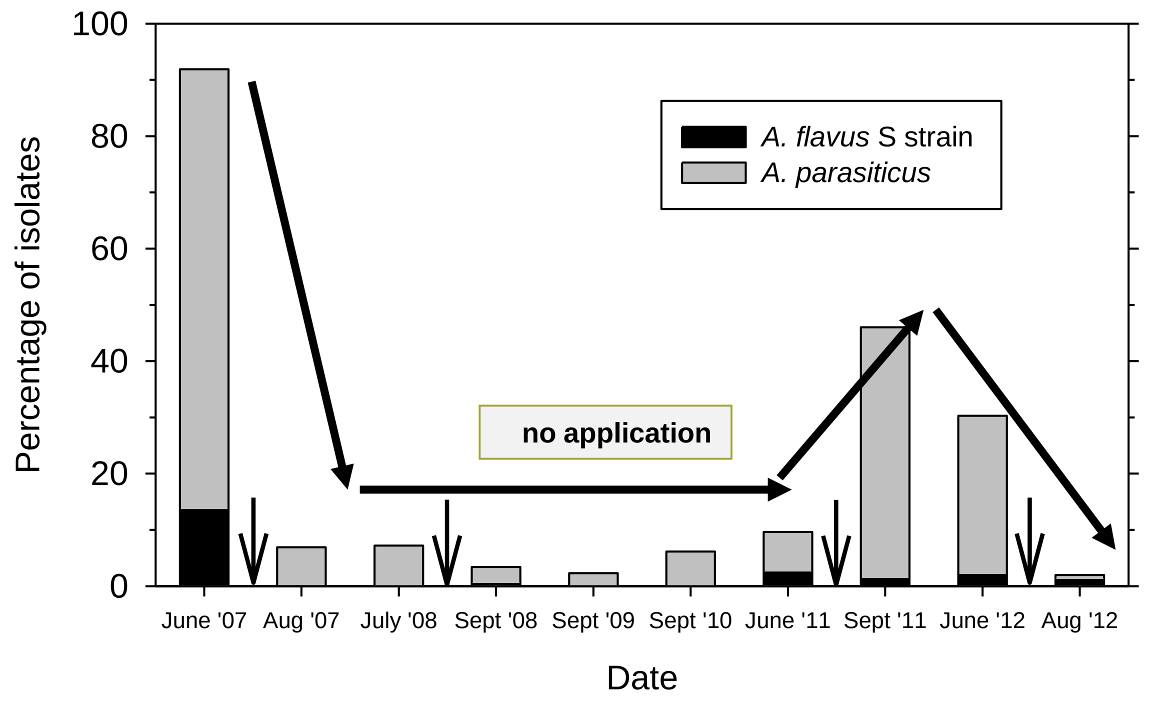
nut samples

Percentage of *Aspergillus flavus* isolates from soil collected from Nichels almond orchard

(arrows indicate application dates)

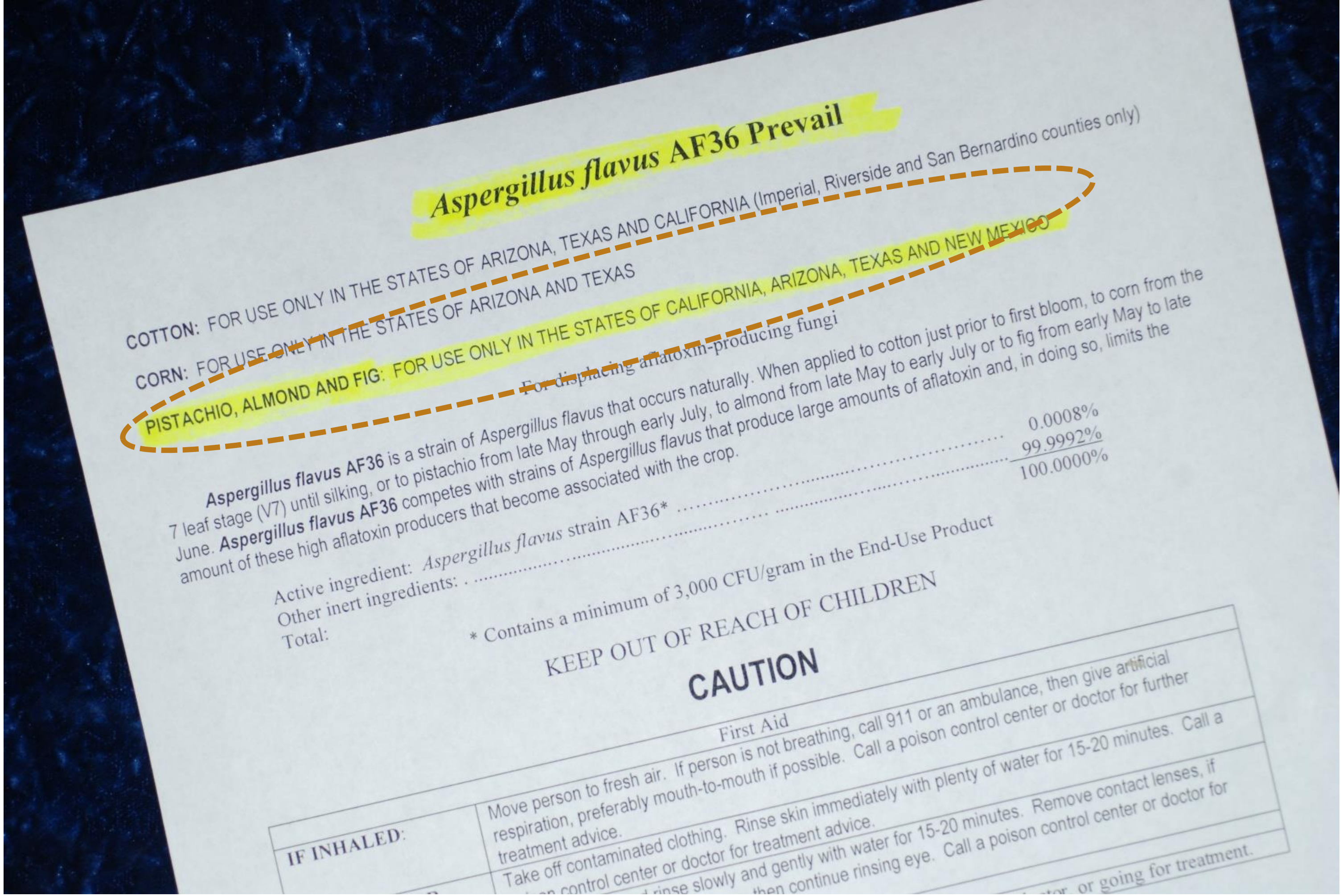


Reduction of aflatoxin-producing *Aspergillus flavus/A. parasiticus* isolates in areas of the almond orchard treated with the AF36 product



Conclusions from the AF36 studies in almonds

- ✓The atoxigenic strain AF36 of *Aspergillus flavus* is widespread and is the most common atoxigenic strain.
- ✓The atoxigenic strain AF36 became the dominant strain in the soil after application.
- ✓The atoxigenic strain AF36 persisted well in the soil.
- ✓No increase in decay of almond nuts.
- ✓In general, results were similar to pistachio results.
- ✓Aflatoxins were reduced substantially when AF36 was co-inoculated with highly-toxigenic strains in almonds (lab study).



Aspergillus flavus AF36 Prevail

COTTON: FOR USE ONLY IN THE STATES OF ARIZONA, TEXAS AND CALIFORNIA (Imperial, Riverside and San Bernardino counties only)

CORN: FOR USE ONLY IN THE STATES OF ARIZONA AND TEXAS

PISTACHIO, ALMOND AND FIG: FOR USE ONLY IN THE STATES OF CALIFORNIA, ARIZONA, TEXAS AND NEW MEXICO

For displacing aflatoxin-producing fungi

Aspergillus flavus AF36 is a strain of Aspergillus flavus that occurs naturally. When applied to cotton just prior to first bloom, to corn from the 7 leaf stage (V7) until silking, or to pistachio from late May through early July, to almond from late May to early July or to fig from early May to late June. **Aspergillus flavus AF36** competes with strains of Aspergillus flavus that produce large amounts of aflatoxin and, in doing so, limits the amount of these high aflatoxin producers that become associated with the crop.

Active ingredient: *Aspergillus flavus* strain AF36*	0.0008%
Other inert ingredients:	99.9992%
Total:	100.0000%

* Contains a minimum of 3,000 CFU/gram in the End-Use Product

KEEP OUT OF REACH OF CHILDREN

CAUTION

First Aid	
IF INHALED:	Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or doctor for further treatment advice.
	Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a n control center or doctor for treatment advice.
	rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if then continue rinsing eye. Call a poison control center or doctor for
	tor, or going for treatment.

Matthew Gilbert,
UC Davis

Applying an Improved Heat Ratio Method Sap Flow Sensor to Almonds to Test Variation in Water Use between Nonpareil and Pollinizers

Matthew E. Gilbert, Dept. Plant Sciences UC Davis

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Almond Board of California

Applying an Improved Heat Ratio Method Water Flow Sensor to Almonds to Test Variation in Water Use between Nonpareil and Pollinizers

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Almond Board of California

Overview

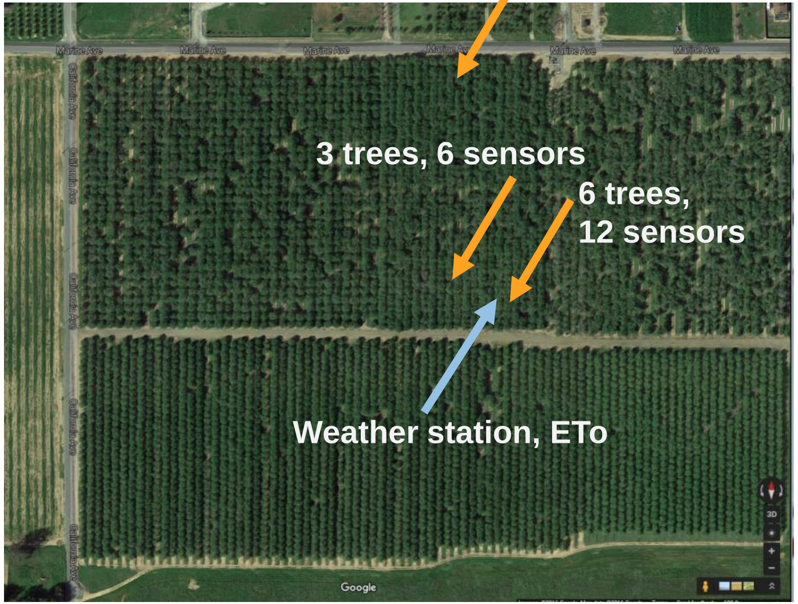
Objectives:

1. Do Nonpareil and pollinizers require the same irrigation timing and amount? Nonpareil, Aldrich are tall, Winters and Monterey are short
2. Is it beneficial to have differential irrigation between rows? Does Nonpareil "steal" excess water from the pollinizers?
3. Does the combined sap flow method compare to CIMIS ETo, stem water potentials, soil moisture?

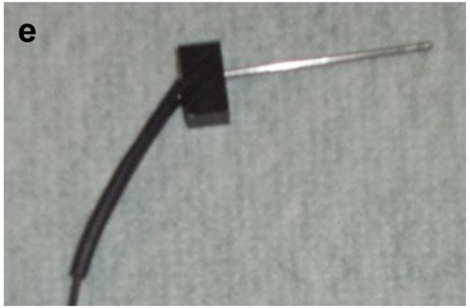
Student: Heather Vice

Help from: Sam Metcalf

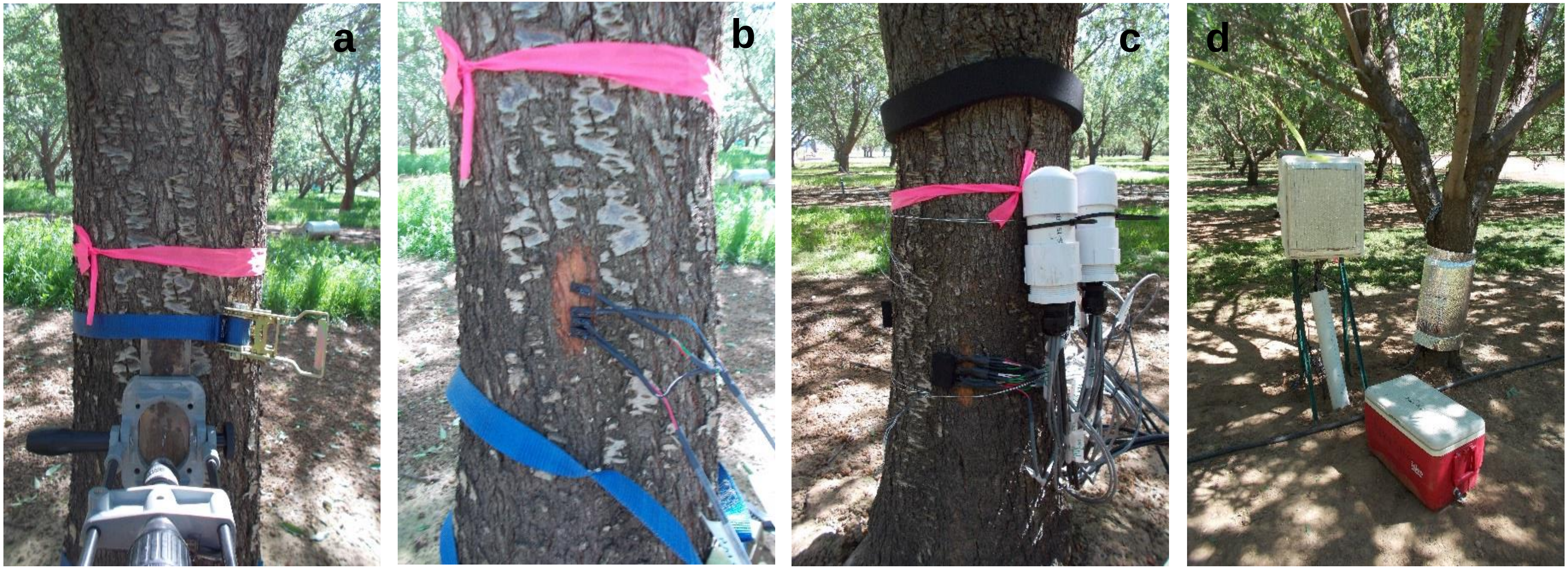
+Soil water content sensors
+Weekly water potentials



Nickels Soil Laboratory

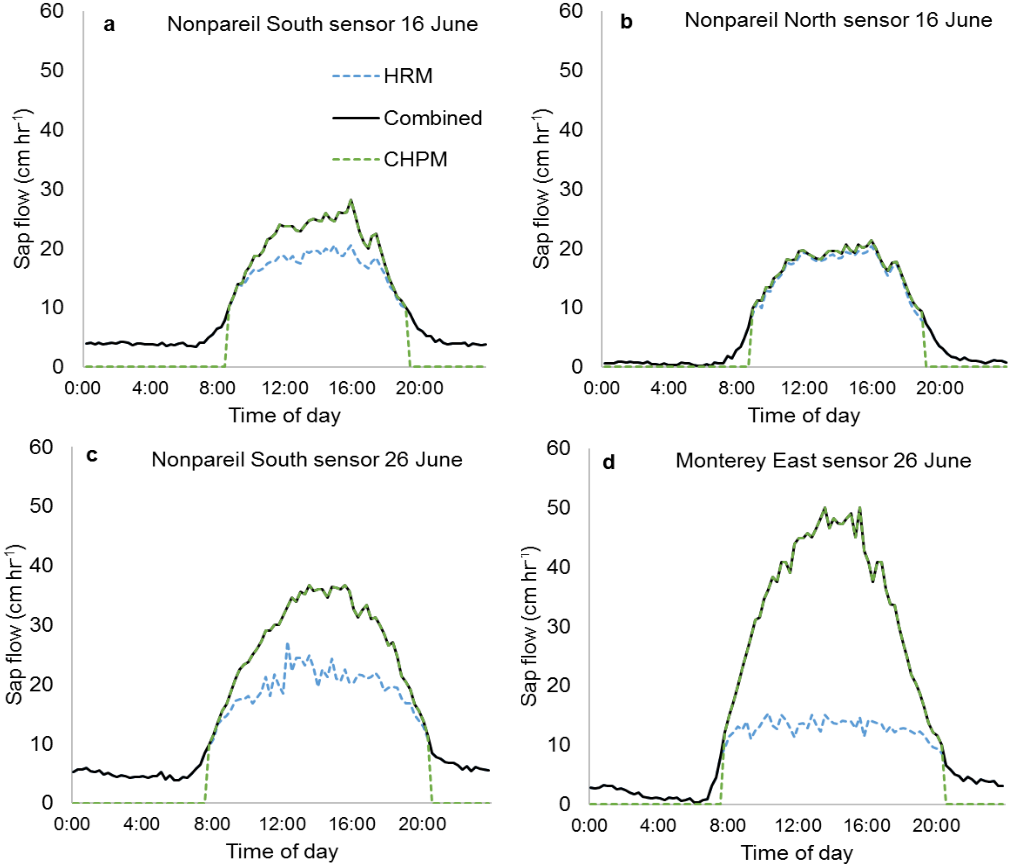


What is this method? What does it look like?



What is the combined method?

- Heat ratio method (HRM) doesn't function well under high flows (almonds, daytime)
- Compensation heat pulse method (CHPM) doesn't function well under low flows (night time)



IF $V_{\text{CHPM}} > V_{\text{HRM}}$ and $V_{\text{HRM}} > 5$ cm hr^{-1}
THEN $V_{\text{Combined}} = V_{\text{CHPM}}$
ELSE $V_{\text{Combined}} = V_{\text{HRM}}$

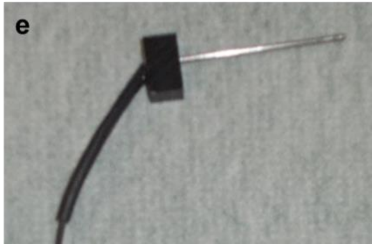
Problems…

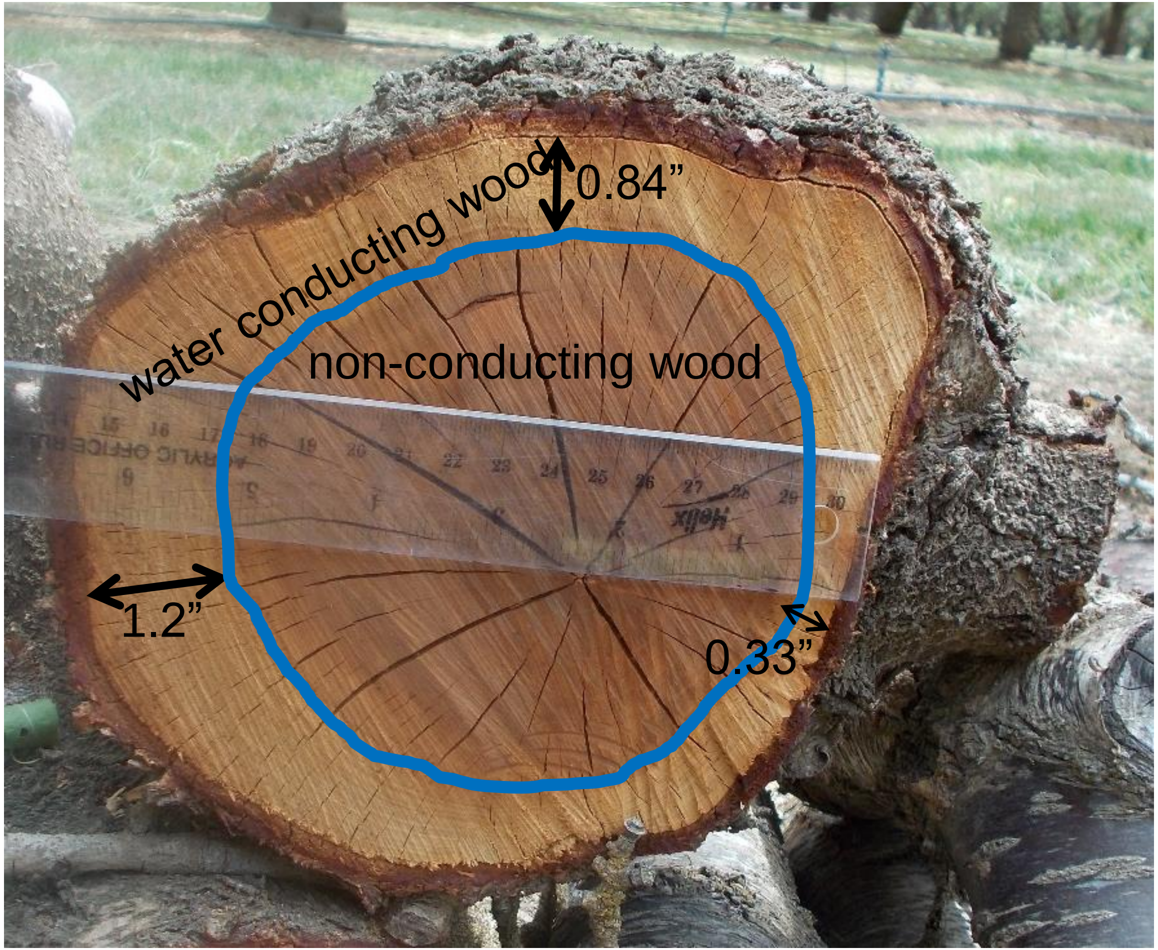
Problems…

In order for **any** sap flow method to be quantitative we need to know the:

(gallons/day)

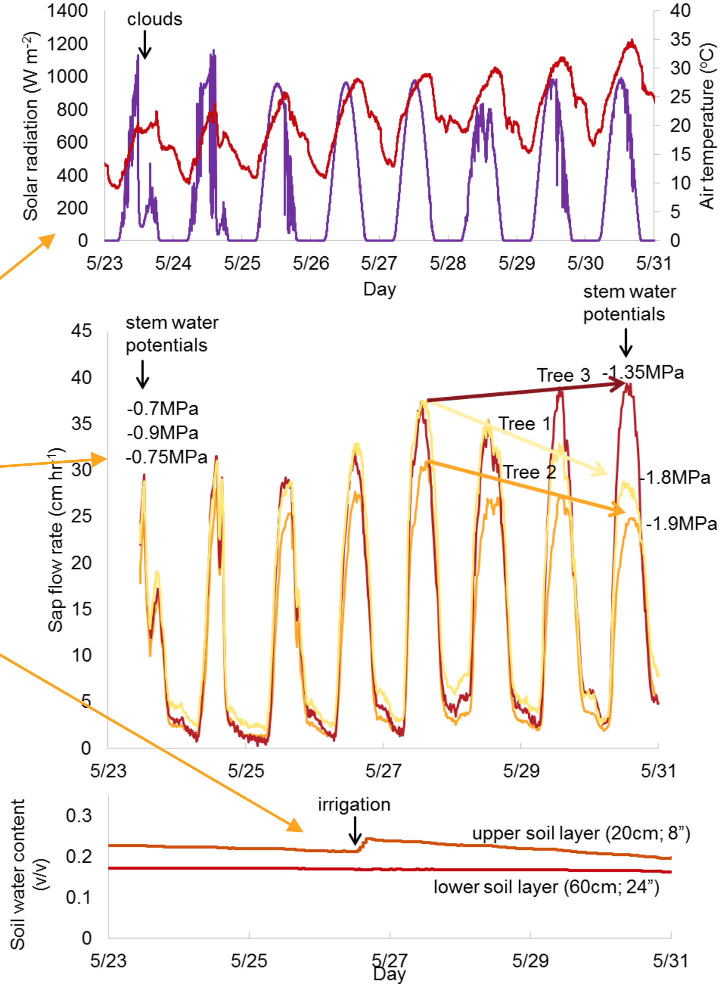
- sap flow in different areas of the stem, and the
- sap wood area of the stem.



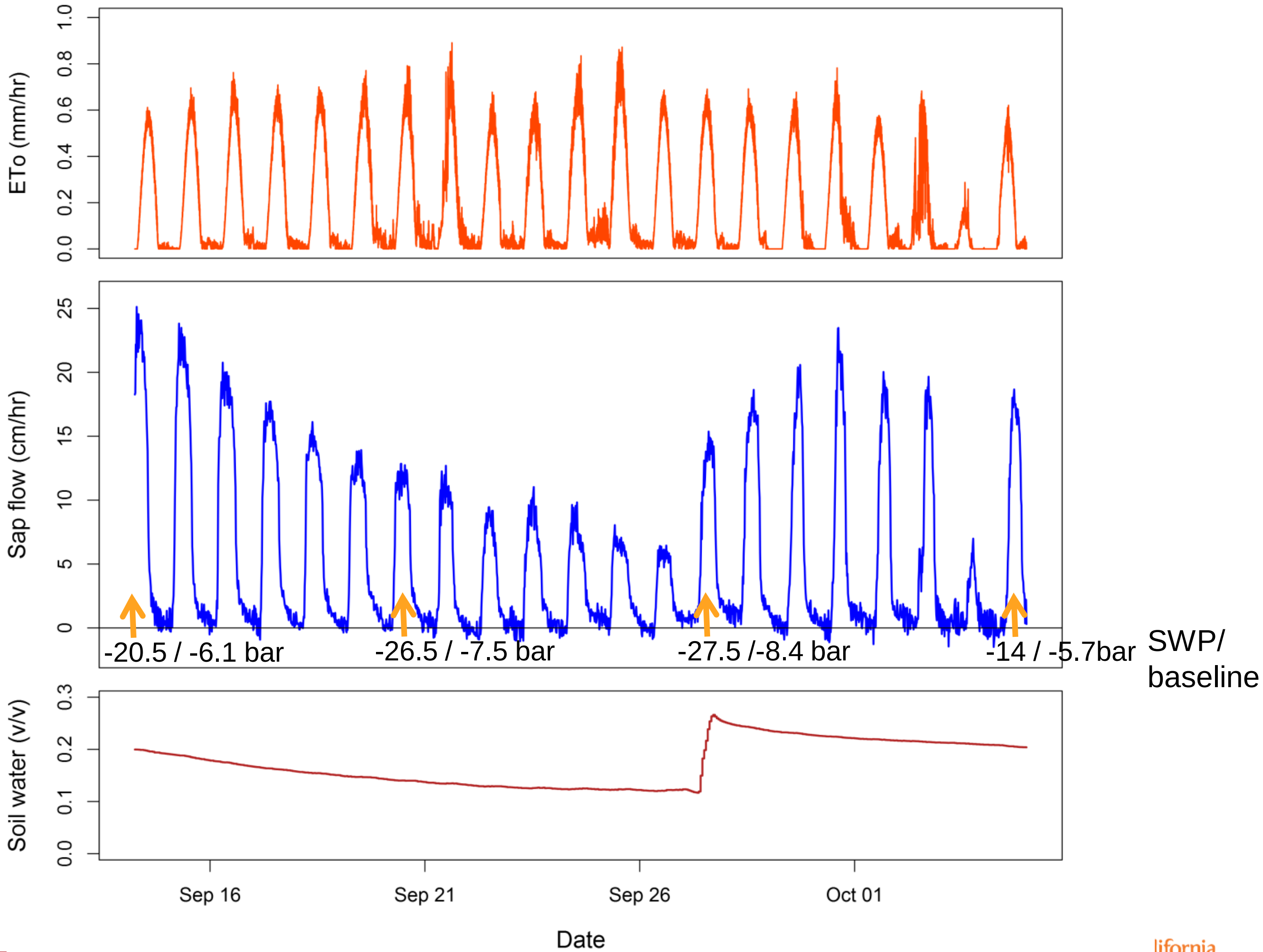


Performance under soil water deficit

Sap flow compares favorably with evaporative demand (ETo) and stem water potentials driven by variation in soil water



Performance during harvest



In general, sap flow sensors…

All sap flow sensors are:

- Measuring water use directly
- Power hungry (need cables, batteries and solar panels)
- Use expensive dataloggers ($1000+)
  - Easy/cheap: many sensors at one site
  - Difficult/expensive: a few sensors at many sites
- Reliable over a year or more
- Easy to use as a relative measure, difficult to use quantitatively

(speed of water flow) **(volume of water flow)**

Summary of commercially available sap flow sensor technologies

Sensor system*	Technology	Wireless	Cost/tree	Cons
Dynamax TDP	Thermal dissipation	Yes	***	Cons: unknown performance in almonds?
ICTInternational	Heat ratio method	Yes	***	Cons: poor performance in almonds at high flows?
ABC supported UC Davis and U. Sydney sensor system	Heat ratio method and CHPM	No current interface	~$2500/site, with up to 5 trees. Up to 15 trees/site for $500 more.	Pros: designed for research of almond water use, a high end sensor with best in class measurement of sap flow at high and low flow rates, but, Cons: no current integrated system suitable for growers.
Fruition Sciences	Heat balance	Yes	***	 Fruition Sciences
Dynamax Dynagauge	Heat balance	Yes	***	Cons: limited to small diameter trunks, or branches of less than 6.5inches in diameter
Phytech dendrometer	Branch growth	Cellular	Seasonal package?	Pros: complete integrated system that includes interface on any internet connection (incl. smartphones). Cons: indirect measure of water status

* East30 has thermal dissipation sensors, but no integrated package

Thank You

Questions?