2017 THE ALMOND CONFERENCE

RSEARCH UPDATE: VARIETY AND ROOTSTOCK STUDIES

Room 312-313 | December 6 2017

california almonds
Almond Board of California

growing ADVANTAGE
The Almond Conference

CEUs – New Process

Certified Crop Advisor (CCA)

- Sign in and out of each session you attend.
- Pickup verification sheet at conclusion of each session.
- *Repeat this process for each session, and each day you with to receive credits*

Pest Control Advisor (PCA), Qualified Applicator (QA), Private Applicator (PA)

- Pickup scantron at the start of the day at first session you attend; complete form.
- Sign in and out of each session you attend.
- Pickup verification sheet at conclusion of each session.
- Turn in your scantron at the end of the day at the last session you attend.

Sign in sheets and verification sheets are located at the back of each session room.

AGENDA

- **Bob Curtis,** Almond Board of California, moderator
- **Tom Gradziel**, UC Davis
- **Bruce Lampinen**, UC Davis
- **Malli Aradhya**, USDA-ARS
- **Roger Duncan**, UC Cooperative Extension, Stanislaus County
- **Georgia Drakaki**, UC Davis
- **Devinder Sandhu**, USDA-ARS US Salinity Lab
- **Francisco Valenzuela**, UC Davis

Tom Gradziel, UC Davis

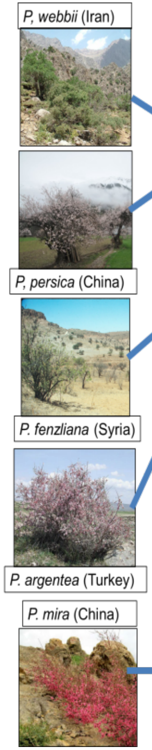
VARIETY AND ROOTSTOCK BREEDING

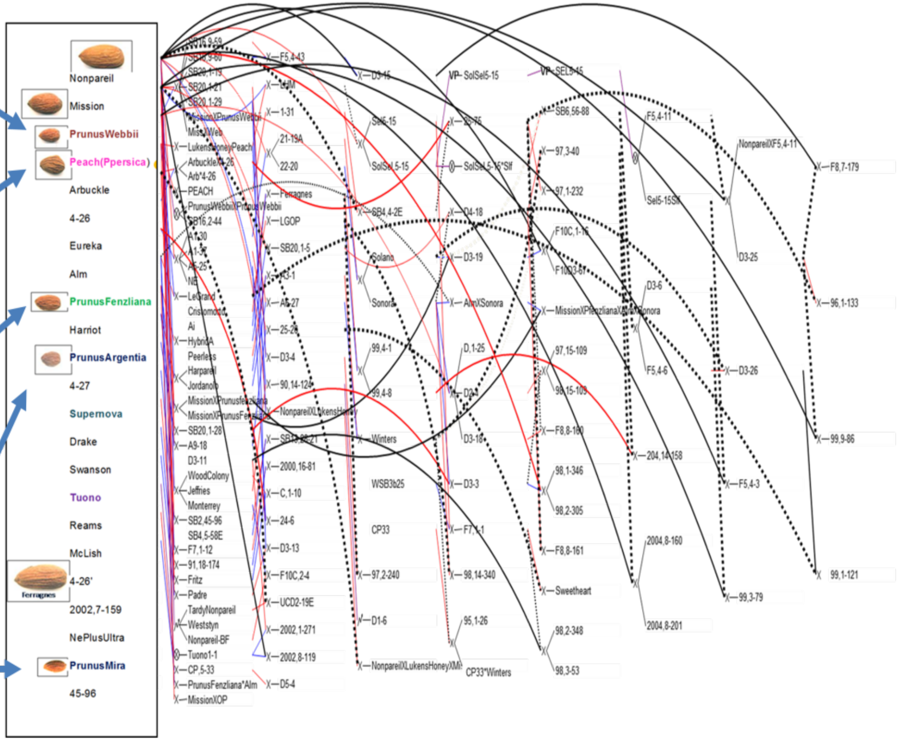
BREEDING SELF-FRUITFUL VARIETIES

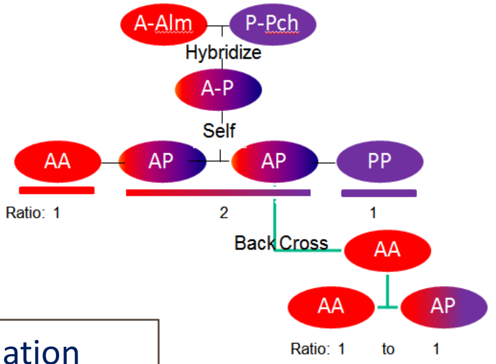
• Garden Prince (Zaiger, 1983)	*Peach*	Non-productive Small size
• All-in-One *Peach* (Zaiger, 1978)	Non-productive	Kernel quality
• Le Grand (Anderson, 1972)	*Peach*	Non-productive Hard to knock Not fully Self-fruitful
• Tuono seedlings (Italy, Spain, 1990s)	*P. webbii*	Non-productive -inbreeding Kernel crease

Breeding program targets improved options, both for Self-Fruitfulness as well as other production and processing traits

NOVEL TRAITS REQUIRE NOVEL GERMPLASM







Trait variation

Genotype	Origin	Kernel Mass (g)	Kernel Thickness (mm)	Soluble protein (g/10g)	Allergenicity (vs. Nonpareil)
Peach	Peach	0.11	3.35	2.37	0.51
F10D,2-18	P.webbii	0.8	8.47	2.24	0.76
SB,36-54	P.mira	0.98	8.84	2.55	1.73
F10D,3-13	P.webbii	0.83	8.03	1.71	0.47
F5,4-10	P.webbii	0.78	7.22	2.21	0.53
F10D,3-2	P.webbii	0.77	6.99	1.78	0.66
F10C,12-28	Peach	1.08	9.02	1.93	1.76
A7-25	P.webbii	0.82	7.26	1.91	0.51
F10D,3-7	P.webbii	0.69	6.74	1.54	0.42
2005,20-192	Peach	0.99	7.37	2.39	0.63
F10D,1-2	P.webbii	0.84	7.15	2.04	0.68
F10D,2-5	P.webbii	0.76	8.07	1.80	0.47
F5,10-9	P.fenzliana	0.82	7.04	1.81	0.61
F5,20-42	P.webbii	1	8.18	1.67	0.65
F8N,6-68	P.webbii	0.96	7.19	2.35	0.88
F10D,1-22	P.webbii	0.97	7.72	2.11	1.78
F5,6-13	P.fenzliana	0.84	6.71	2.56	0.95
F8N,7-4	P.webbii	0.76	6.21	1.95	0.65
F5,6-1	P.fenzliana	1.33	7.38	2.59	0.92
SB13,25-75	P.webbii	1.17	7.76	2.22	1.78
F10D,3-3	P.argentea	0.96	7.01	1.75	0.26
97,1-232	P.mira	1.29	8.16	2.06	2.06
F5,13-54	P.fenzliana	1.05	8.31	1.63	0.7
97,2-240	P.webbii	1.28	9.45	2.22	0.4
F5,16-60	P.argentea	0.87	7.34	2.41	0.44
Ha5-36	Peach	1.12	7.46	2.11	0.66
A1-31	Peach	1.53	8.75	1.38	0.75
F10D,3-15	P.webbii	0.96	7.18	1.86	0.33
F10D,3-26	P.webbii	0.93	7.45	2.13	1.06
2000,8-27	P.webbii	1.2	8.62	2.39	0.55
2004,9-1	P.mira	1.24	7.54	1.45	1.89
F10C,20-51	Peach	1.1	7.31	2.39	0.56
2004,18-20	Peach	1.54	8.7	1.87	0.68
F1-01	P.webbii	1.58	8.22	1.71	0.32
F6-21	Peach	1.48	8.29	1.94	1.56
F10D,3-50	P.fenzliana	1.59	8.75	1.54	2.18
Ha2-68	Peach	1.44	7.34	1.24	1.57
2004,8-160	P.mira	1.77	8.64	1.98	2
95,1-26	Peach	1.98	9.47	2.09	1.1
97,3-40	P.webbii	2.08	8.7	2.53	0.9
				0.00	
Nonpareil	Almond	1.31	7.86	2.31	1.02

Most introduced genes are undesirable and need to be removed

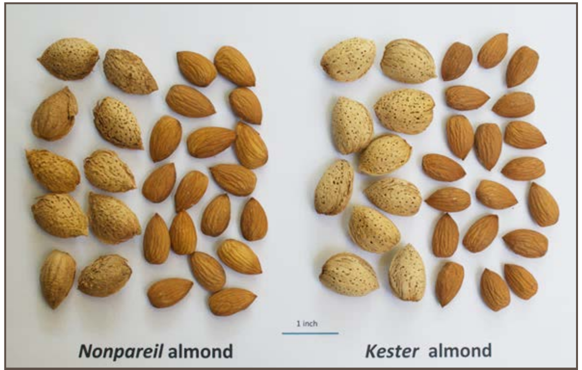
ADVANCED SELECTIONS NOW IN REGIONAL VARIETY TRIALS (OVER 20 SF SELECTIONS NOW AVAILABLE FOR GROWER TESTING)

Samples from 2017 Chico RVT

Item	Kernel Crack-Out	Kernel mass (g)	Heat Tolerance
UCD 1-271	0.59	1.39	9.20
UCD 7-159	0.74	1.54	10.20
UCD 8-201	0.55	0.98	8.60
UCD 18-20	0.55	1.18	10.10
UCD 1-16	0.64	1.08	9.50
UCD 1-232	0.47	1.16	10.10
UCD 3-40	0.48	1.48	9.40
UCD 8-160	0.59	1.42	11.00
UCD 8-27	0.60	1.08	7.90
Nonpareil	0.67	1.05	9.30

Selection has been effective not just for self-fruitfulness but also improved kernel quality as well as improved stress & disease resistance.

Need multi-year/location data to verify.



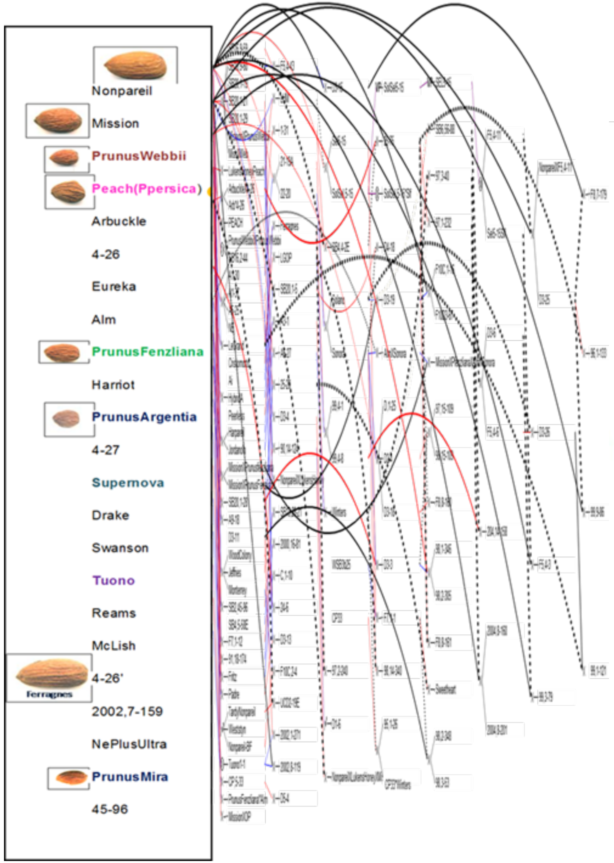
Kester variety, developed in mid 1990s and released in 2016 following over 15 years of regional grower testing.

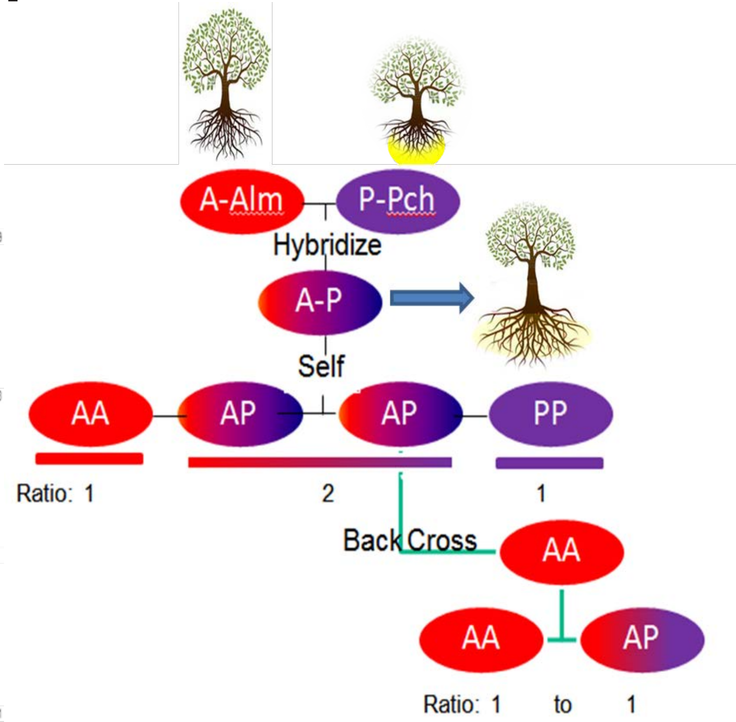
The challenge is moving from developing new genetic options to facilitate production,

to the thorough testing for long-term and region stability of overall performance/production.

HYBRID ROOTSTOCK DEVELOPMENT

Item	Genetic background
Atlas	Almond, Peach, P. davidiana, Plu8m
Bright Hybrid	Almond, Peach, P. davidiana
Cadaman	Peach x P. davidiana
Citation	Almond, Plum
Compass	P. besseyi x P. americana
Controller 5	P. salicina x Peach
Cornerstone	Peach x Almond
Empyrean#1	Peach x P. davidiana
Flordaguard	Peach x P. davidiana
Hansen 536	Almond, Peach, P. davidiana
Hiawatha	P. besseyi x P. salicina
Ishtara	P. cerasifera, P. saliciana, Peach
Krymsk#86	Peach x P. cerasifera
Marianna 2624	P.munsoniana x P. cerasifera x P. hortulana
Nemaguard	Peach x P. davidiana
Nemared	Peach x P. davidiana
Nickels	Almond, Peach, P. davidiana
Paramount	Peach x Almond
Viking	Almond, P. blireiana, P. cerasifera, P. Mume



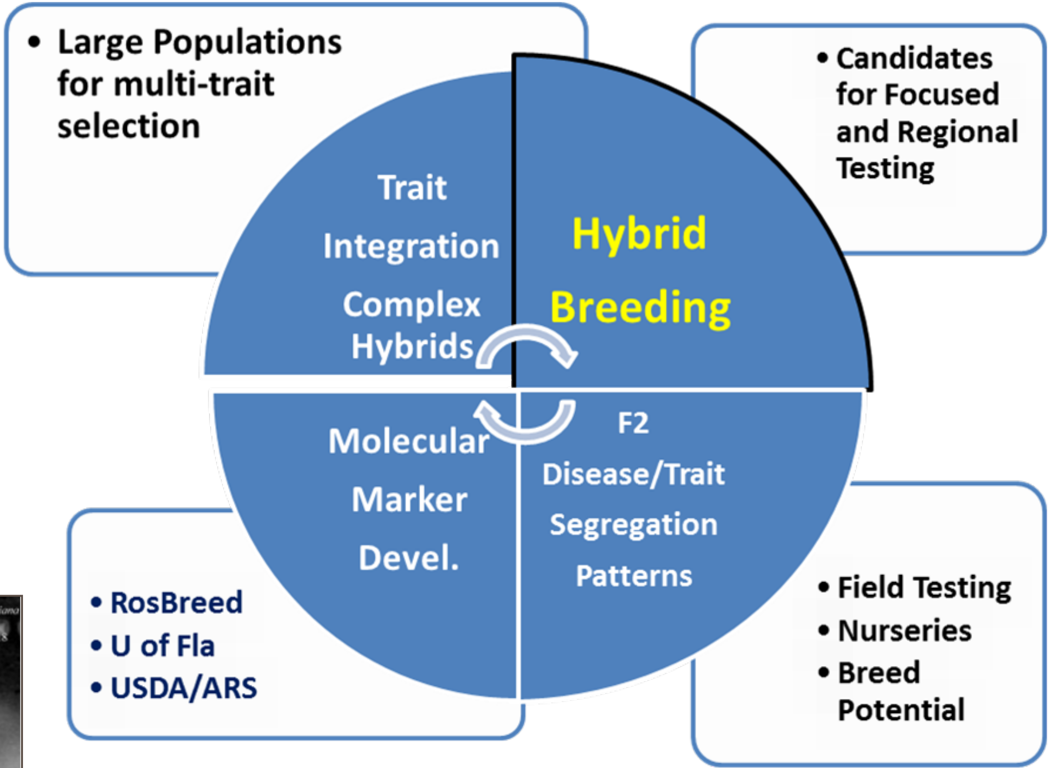


2017 Interspecific hybrids at UCD

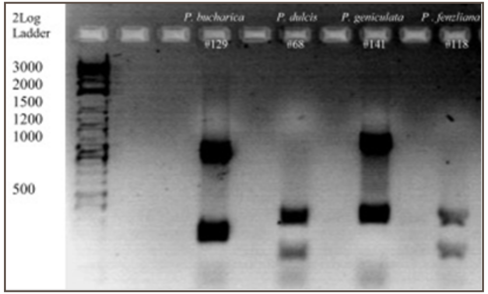
Large populations required for:

-accurate molecular mapping

-recombine the numerous traits required for commercial success



Molecular marker development



Nematode screening at KAC

BREEDING ENGINE: QUALITY & QUANTITY

BREEDING EXPLOITS GENETIC DIVERSITY AS WELL AS RANGE OF EXPERT COLLABORATORS

Trait	Cooperator	Material under evaluation	*Speciesevaluated*	Status
Heat Tolerance	M. Gilbert	15 clones	***a, f, m, p, w***	Under analysis
Botryophaeria resistance	J. Chaparro (U. Fla)	40 cl., 100 sdlings	***a, b, f, m, pd, p, plsp, t, tr, w***	Field plots established with preliminary results
Root lesion Ring, and Root-knot nematode	A. Westphal	25 clones	***a, dv, m, p, t, w***	Field plots established for 7 cl. with 19 clones propagated.
Phytophthora	Greg Browne	3 clones	***pl***	Plants established
Crown gall	D. Kluepfel	~200 seedlings	***p, t,***	>100 sdlings in field, ~100 sdlings greenhouse,
Salinity tolerance	P. Brown	12 clones	***d, a, , f, m, p, t, w***	Greenhouse testing
Botryophaeria, Oxyporus and other wood rot diseases	Rizzo/Johnson	15 clones	***d, a, , f, m, p, t, w***	10 clones under test with 10 to 20 additional clones to be added
Effect on scion architecture	Fowler/Wonderful	7 clones	***a, dv,***	Field plots in commercial production
Nonpareil Compat. & Replant decline	Burchell Nursery	50 clones	***a, b, dv, m, p, plsp, s, t, w***	Field testing
Replant decline	Sierra Gold Nursery	20 clones & ~1000 seed	***a, dv, m, p, s, t, w***	Field testing
Dryland culture	A. Langford	Almond seedlings	***d***	Field testing
Armillaria	In-house	~200 seedlings	***d, p***	Seed being prepared for planting
Asphyxia	In-house	~100 seed	***d, p***	Seed being prepared for planting
Verticillium & Phytophthora	In-house	6 cl. & ~240 sdlings	***d, p***	Seed being prepared for planting
Architecture & disease	In-house	90 cl., ~40, 000 sdlings	***a, b, dv, m, p, s, t, w***	Field testing
High density plantings.	G. Thorp, Australia	20 cl., ~400 seedlings	***d, , f, m, p, w***	12 clones propagated, >1000 crosses (hybrids and F2's)
Tissue culture, plant-regeneration, transformation	Abhaya Dandekar	~200 developing seed; 6 clones	***d, p, dv***	Ease of in-vitro regeneration underway

Almond {P.dulcis} (d), Peach {P.persica} (p), P.argentea (ar), P.fenzliana (f), P.mira (m), P.webbii (w),
P.bucharica (b), P.pedunculata (pd), Plum spp. (pl), P.tangutica (t), P.triloba (tr), P.davidiana (dv), P.scoparia (s)

Field Evaluation of Almond Varieties and Selections

Bruce Lampinen[1], Luke Milliron[2], Dani Lightle[2], Roger Duncan[3], Phoebe Gordon[4], David Doll[5], Joe Connell[6], Samuel Metcalf[1], Loreto Contador[1], Sabrina Marchand[1], and Tom Gradziel[1]

[1]UC Davis Plant Sciences [2]UCCE Butte/Glenn/Tehama Counties, [3]UCCE Stanislaus County, UCCE [4]Madera County , [5]UCCE Merced County, [6]UCCE Butte County

The next generation almond variety trials were planted in the winter of 2014 in Butte County (Chico State University), Stanislaus County (Salida School District Site), and Madera County (Chowchilla grower site).

Objective- evaluate new varieties and selections compared to standard varieties in three different almond production areas in the Central Valley.

Site	Rootstock	Spacing	#trees/acre
Butte	Krymsk 86	18’ x 22’	110
Stanislaus	Nemaguard	16’ x 21’	130
Madera	Hansen 536	12’ x 21’	173

Table 2. Varieties and selections planted at the next generation regional almond variety trials. Items 1-30 are planted at all 3 sites while additional material planted at individual sites is listed at the end.

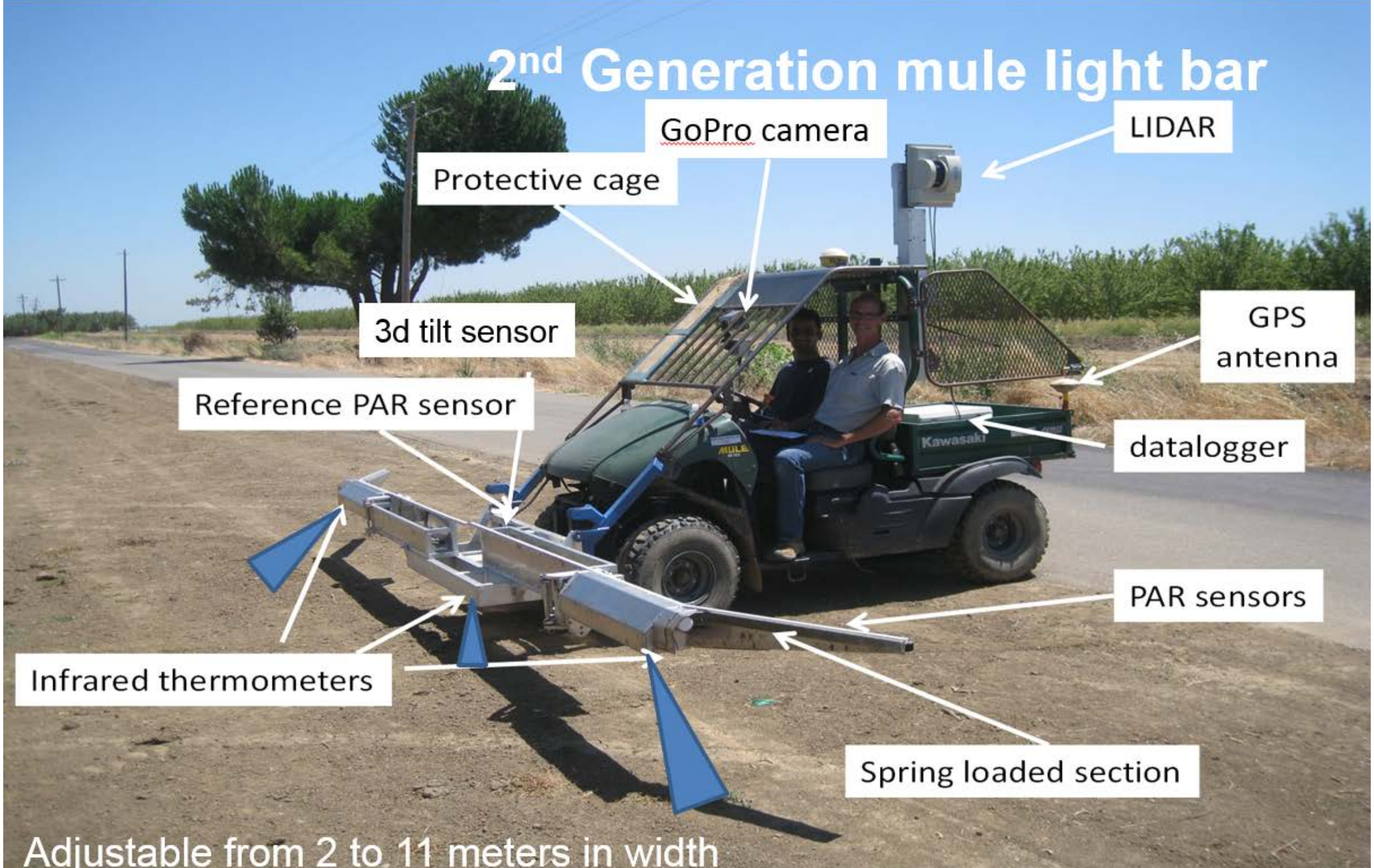
	Variety	Source
1	Eddie	Bright's
2	Capitola	Burchell
3	Supareil	Burchell
4	self-fruitful P16.013	Burchell
5	Self-fruitful P13.019	Burchell
6	Booth	Burchell
7	Sterling	Burchell
8	Bennett	Duarte
9	Nonpareil	Fowler
10	Durango	Fowler
11	Jenette	Fowler
12	Aldrich	Fowler
13	Marcona	Spain
14	Winters	UCD
15	Sweetheart	UCD
16	Kester (2-19e)*	UCD
17	UCD3-40	UCD
18	UCD18-20	UCD
19	UCD1-16	UCD
20	UCD8-160	UCD
21	UCD8-27	UCD
22	UCD1-271	UCD
23	UCD1-232	UCD
24	UCD7-159	UCD
25	UCD8-201	UCD
26	Y121-42-99	USDA
27	Y117-86-03	USDA
28	Y116-161-99**	USDA
29	Y117-91-03	USDA
30	Folsom	Wilson
31	Wood Colony on Krymsk 86 (Butte only)	
31	Lone Star on Hansen 536 (Chowchilla only	

*Kester (2-19e) was planted at all three sites on the usual rootstock f
In addition at the Butte and Stanislaus sites it was also planted in t
replicated trial on Hansen 536 rootstock
** Y116-161-99 planted only in two reps outside of main trial at Butte

There are 4 replications of each variety and selection at each site

Data collected

- Bloom timing
- Hullsplit timing
- Midday canopy PAR interception
- Yield
- Nut quality
- Harvestability
- Disease incidence
- Tree loss


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
Adjustable from 2 to 11 meters in width


Butte RAVT- June 28, 2017


Stanislaus RAVT- July 22, 2017


Madera RAVT- June 18, 2017

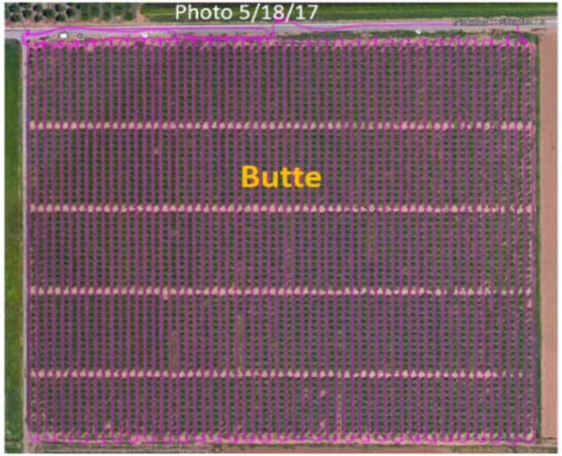
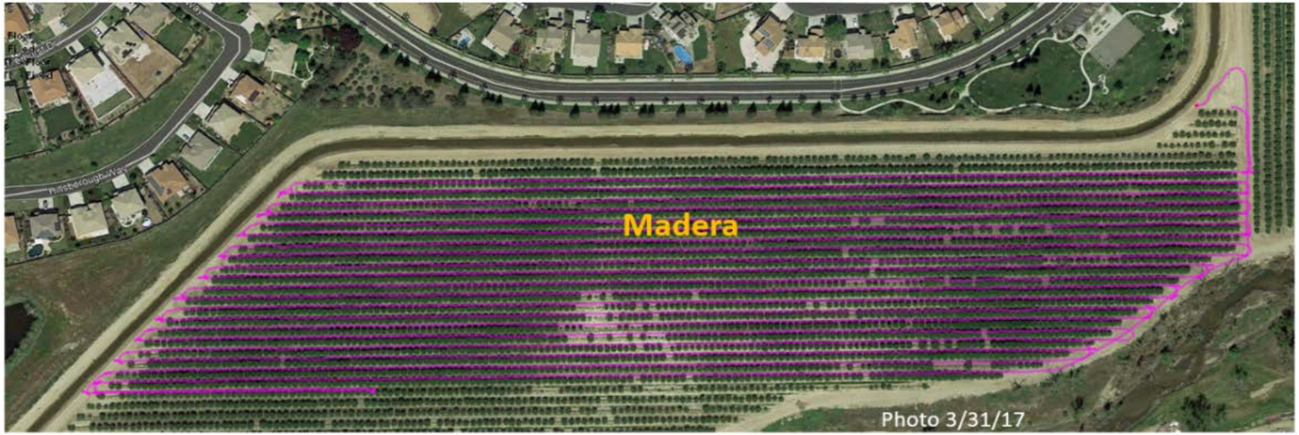


Photo 5/18/17
Butte


Stanislaus
Photo 3/2016


Madera
Photo 3/31/17

2017

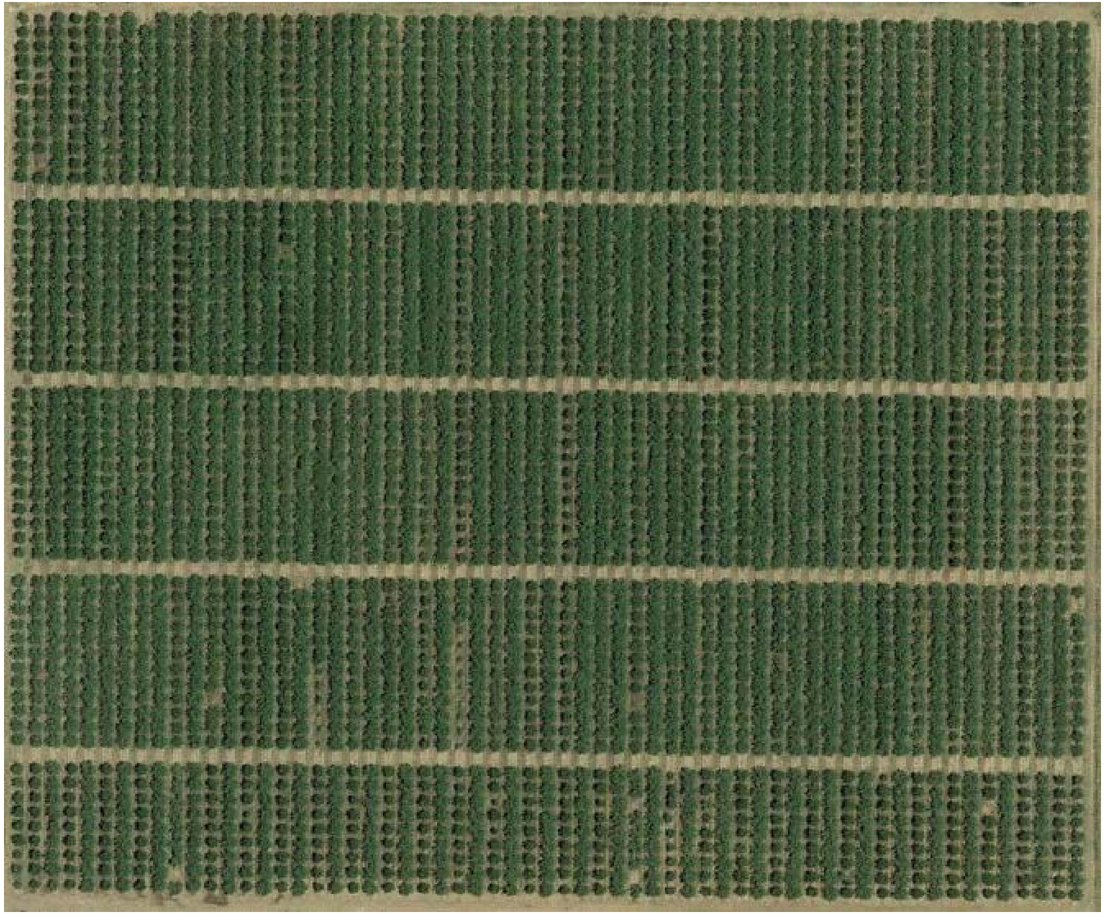
Site	Midday PAR interception (%)
Butte	35-67
Stanislaus	38-51
Madera	41-70


Butte RAVT- June 28, 2017


Stanislaus RAVT- July 22, 2017


Madera RAVT- June 18, 2017

CHALLENGES - BUTTE



2016

Extensive rust damage

2017

Bacterial blast

Extensive hull rot

Gopher damage

Nonpareil
Folsom
Nonpareil
UCD8-160
Nonpareil
Supareil
Nonpareil
Y117-86.013
Nonpareil
Aldrich
Nonpareil
Eddie
Nonpareil
P15.013
Nonpareil
UCD8-201
Nonpareil

CHALLENGES - STANISLAUS

2015
- Extensive verticillium wilt

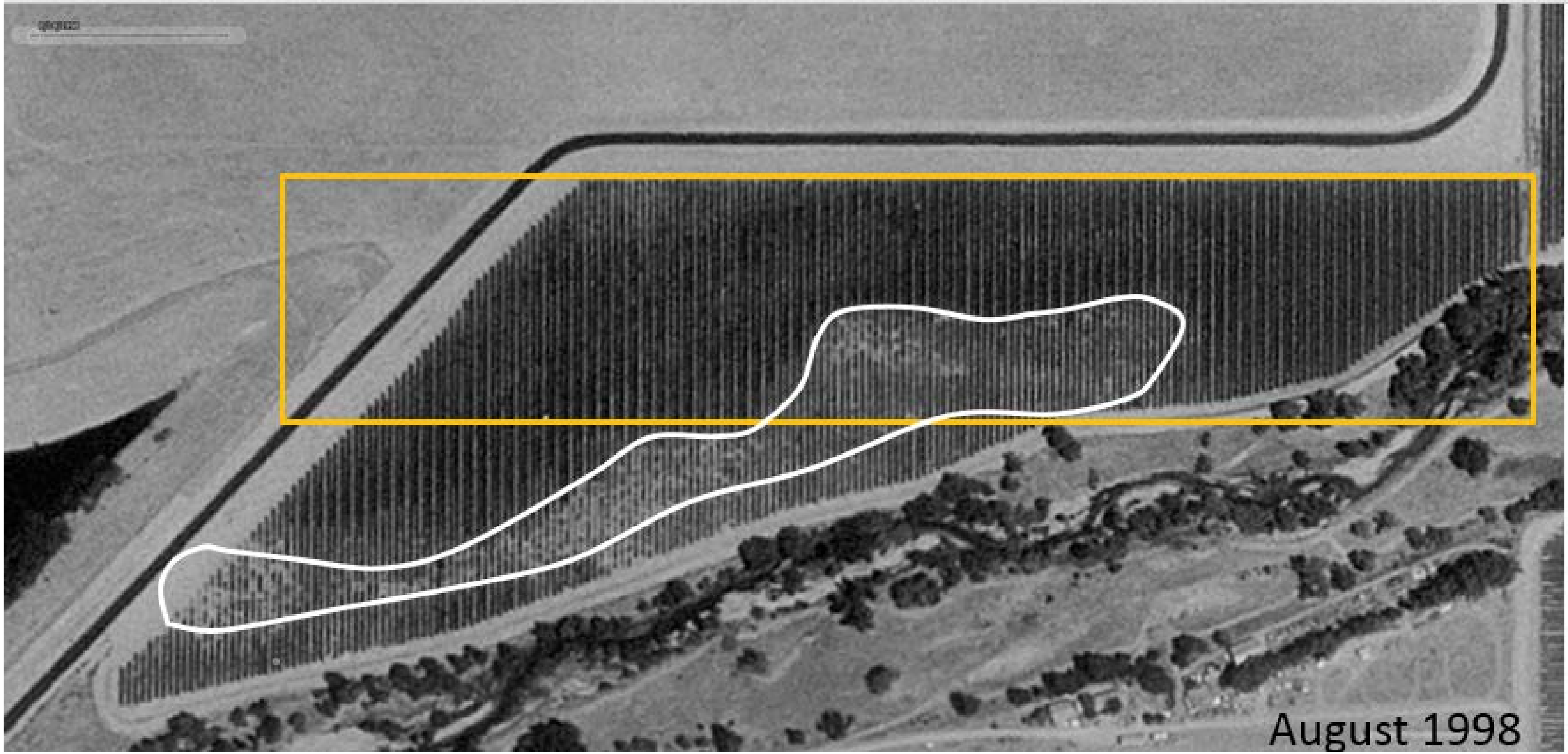
2016
- Glyphosonate drift
  during bloom
- Band canker

2017
- Band canker (~100
  Nonpareil trees lost)
- Also some on Y121-42-99,
  Sterling and
  Kester/Hansen 536

CHALLENGES - MADERA

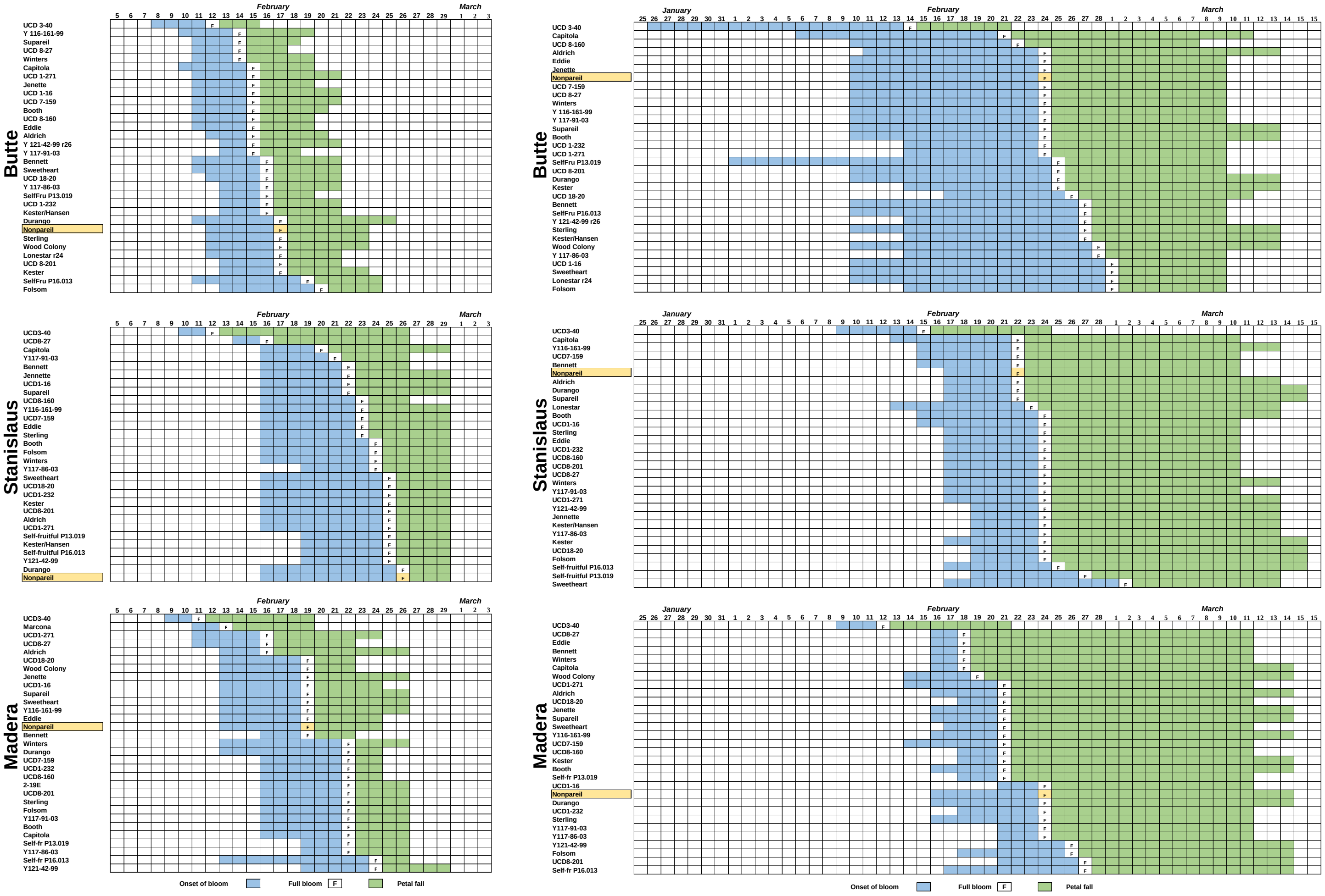
2016 and 2017

- Shaker damage (a few Nonpareil and Wood colony)
- Shot-hole like symptoms
- Cankers (all Y-121-42-99 in one block, some Jenette)
- Dead trees due to infiltration issues in blocks 3 and 4)

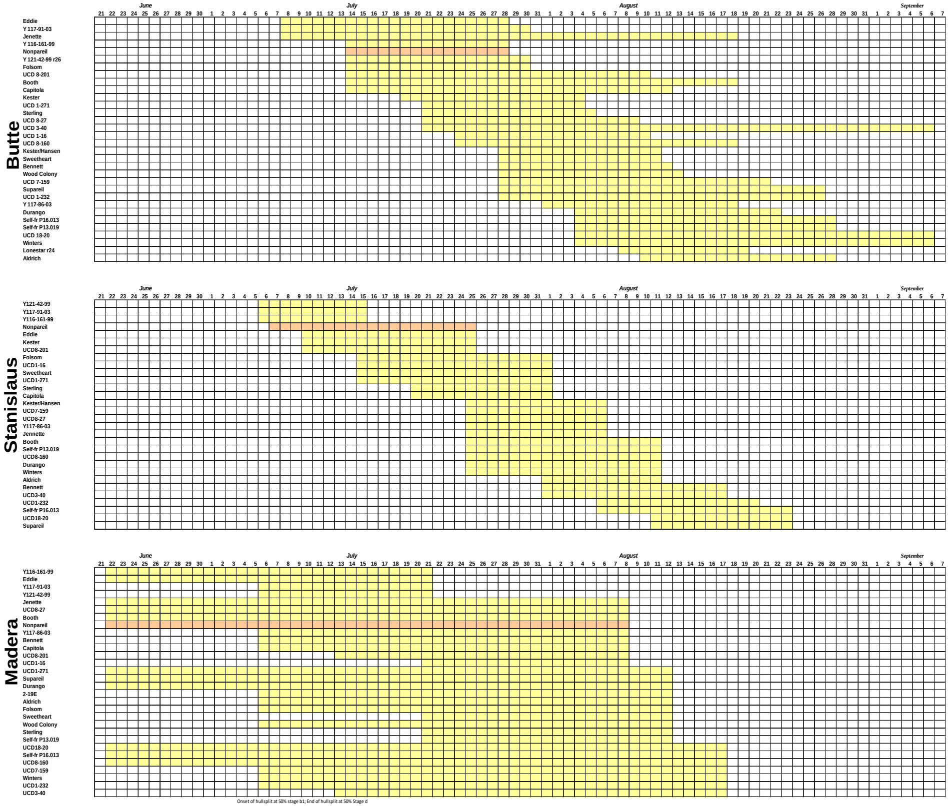

August 1998

2016 Bloom

2017 Bloom



2016 Hullsplit



Onset of hullsplit at 50% stage b1; End of hullsplit at 50% Stage d

Varieties with defect	Butte	(%)	Stanislaus	(%)	Madera	(%)
Double kernels	UCD 18-20	15	Booth	22	UCD8-201	25
(both ovules in ovary developed)	UCD 8-201	14	UCD 18-20	21	Y121-42-99	20
	Booth	12	UCD 8-201	17	Booth	16
	Self-Fru P16.013	10	P16-013	14	UCD1-232	7
	UCD 1-232	10	Y121-42-99	10	Y117-86-03	7
	Jenette	8	P13-019	8	UCD18-20	6
	UCD 8-27	7	Capitola	6	UCD8-27	6
	UCD 1-16	6				
	UCD 8-160	6				
Twin kernels	UCD 3-40	27	Jenette	21	UCD8-201	18
(two kernels within the same pellicle)	Sweetheart	20	UCD 8-27	19	Kester	12
	Jenette	19	UCD 3-40	16	Jenette	12
	UCD 8-201	17	Sweetheart	12	Sweetheart	6
	UCD 8-27	13	Folsom	11	Wood Colony	6
	UCD 8-160	11	P16-013	11		
	Nonpareil	11	UCD 8-160	10		
	Kester	8	UCD 8-201	10		
	Bennett	8	Booth	9		
	UCD 7-159	8	Kester/Hanser	9		
	Kester/Hansen	7	Capitola	9		
	Eddie	7	Kester	9		
	UCD 1-232	7	Supareil	7		
	Y-117-91-03	6	Aldrich	7		
			Nonpareil	7		
			Durango	7		
			UCD 1-232	7		
			UCD 7-159	7		

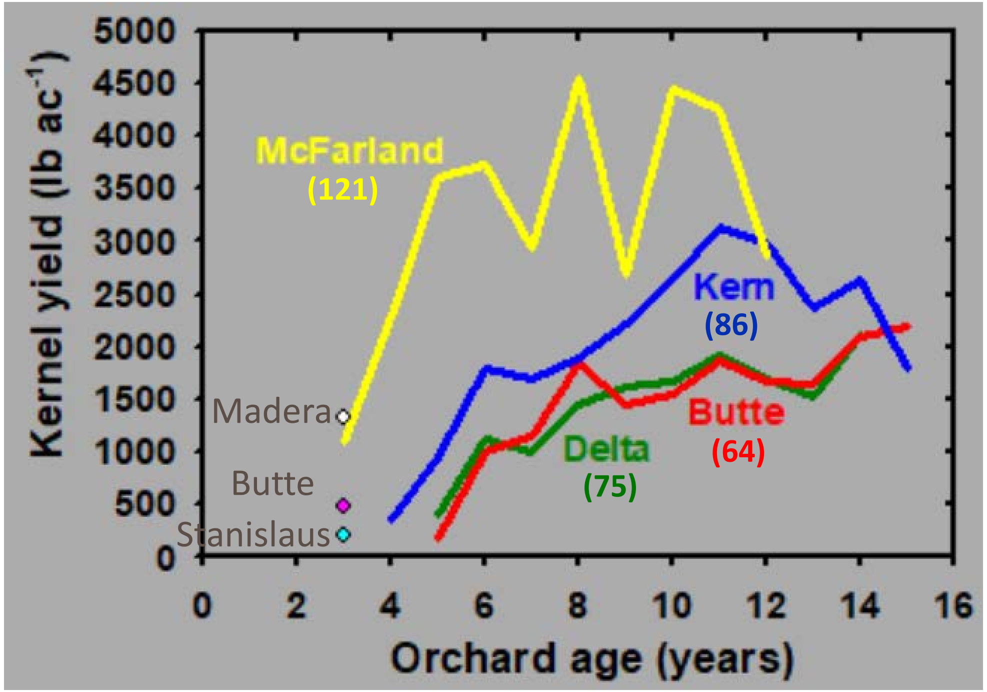
Varieties or selections with defect

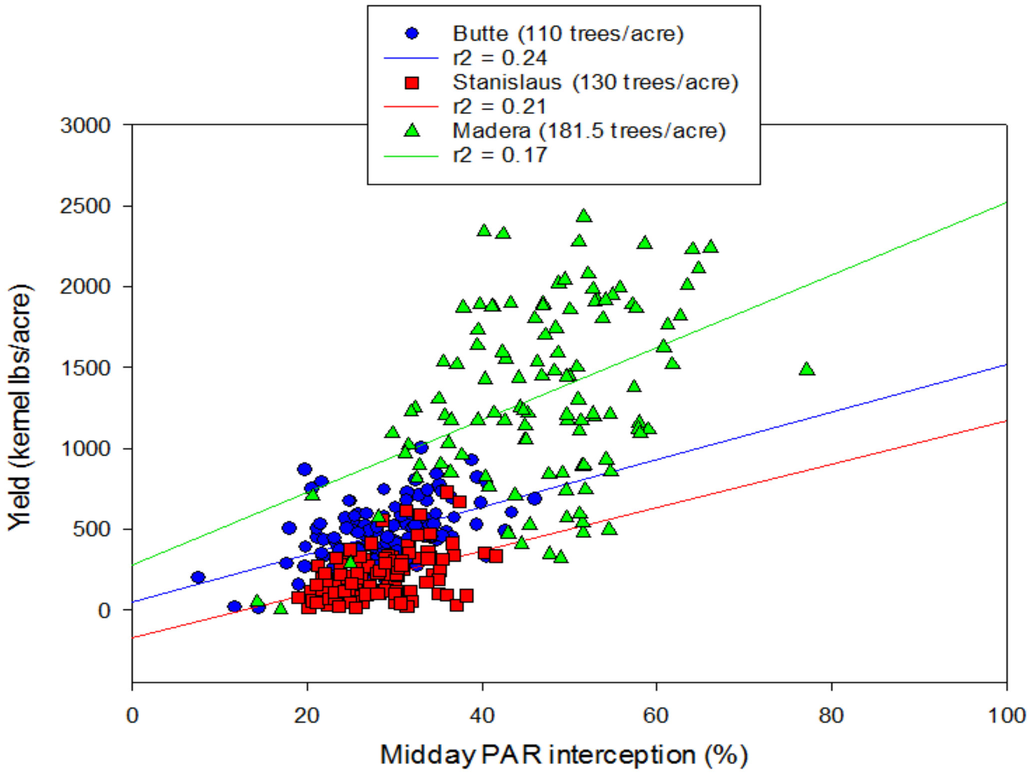
Varieties or selections with defect

Varieties with defect	Butte	(%)	Stanislaus	(%)	Madera	(%)
Naval orange worm damage	(none)		Booth	14	(none)	
			Y116-161-99	8		
			Eddie	7		
Blank kernels	UCD 1-232	10	Folsom	13	(none)	
			Booth	11		
			UCD 1-232	11		
			UCD 8-27	9		
			UCD 7-159	7		
Severe shrivel	Capitola	12	Capitola	24	Folsom	14
	Folsom	12	UCD 7-159	23	Wood Colony	8
	Self Fru P13.019	11	Folsom	19	Eddie	7
	Supareil	8	UCD 8-201	18	Booth	6
	Y-117-91-03	8	Y117-86-03	17	UCD8-27	6
	Bennett	7	Jenette	16	Y117-91-03	6
	Y117-86-03	7	UCD 8-160	16		
	UCD 1-271	7	UCD 8-27	15		
	Self-Fru P16.013	6	Bennett	11		
	Sweetheart	6	Booth	11		
	UCD 8-201	6	Sweetheart	11		
			UCD 1-232	11		
			Supareil	10		
			P16-013	9		
			Sterling	8		
			UCD 1-271	8		
			UCD 18-20	8		
			Durango	7		
			P13-019	7		
			Y117-91-03	7		
			UCD 1-16	7		
			Kester	7		
			UCD 3-40	6		

2016

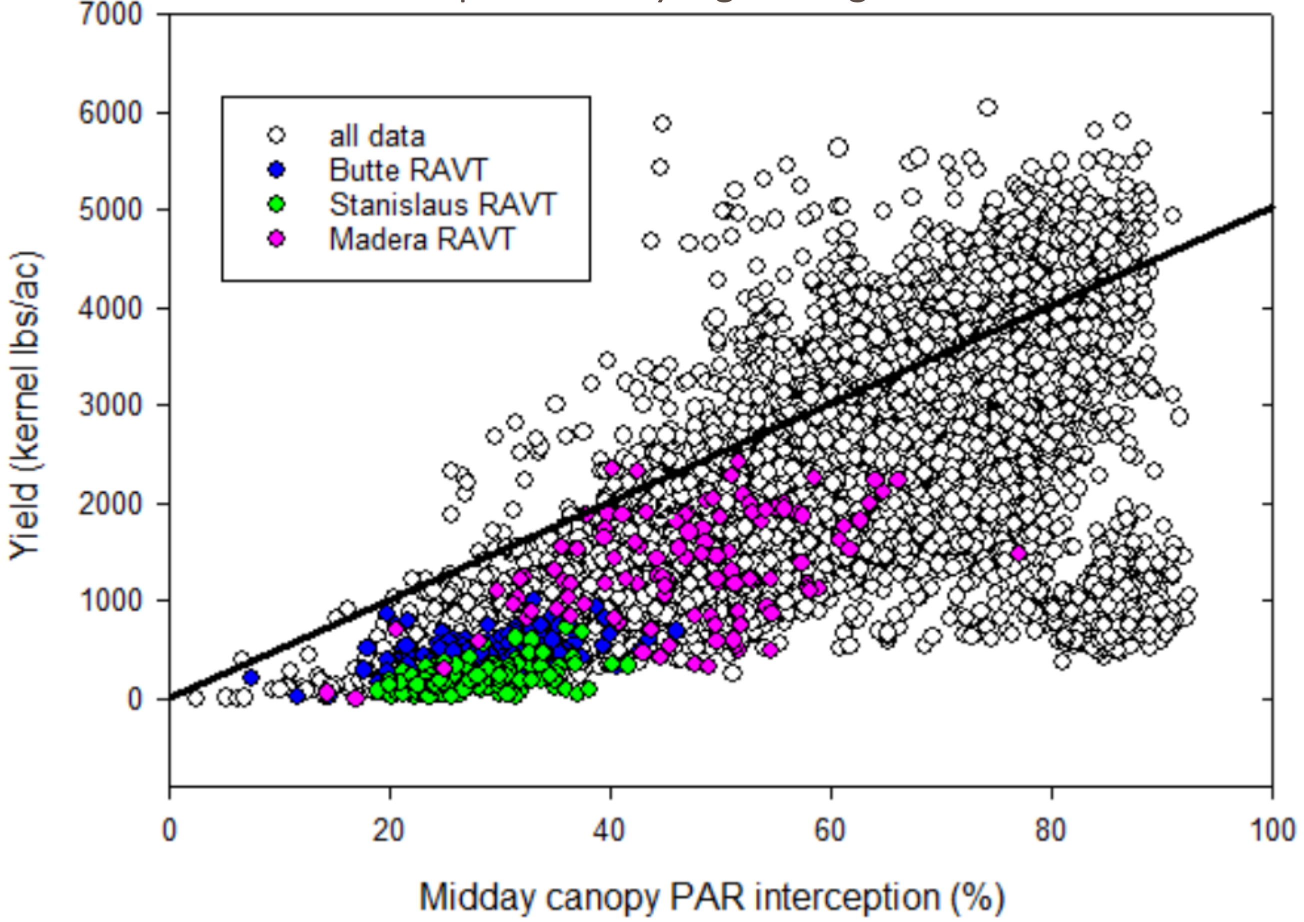
Site	Trees per acre	Yield range (kernel lb/ac)
Butte	110	159-796
Stanislaus	130	40-460
Madera	173	410-1999





Up to 70% PAR interception and 2500 kernel pounds per acre in 3rd leaf

PAR interception is very high for age at Madera site



Data to be collected in 2018

- Bloom timing
- Hullsplit timing
- Midday canopy PAR interception
- Yield
- Nut quality
- Harvestability
- Disease incidence
- Tree loss

INTEGRATED CONVENTIONAL AND GENOMIC APPROACHES TO ALMOND ROOTSTOCK DEVELOPMENT

MALLI ARADHYA, CRAIG LEDBETTER, DAN KLUEPFEL AND GREG BROWNE, USDA-ARS; ANDREAS WESTPHAL, KAC, UC RIVERSIDE

USDA ARS Agricultural Research Service

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.

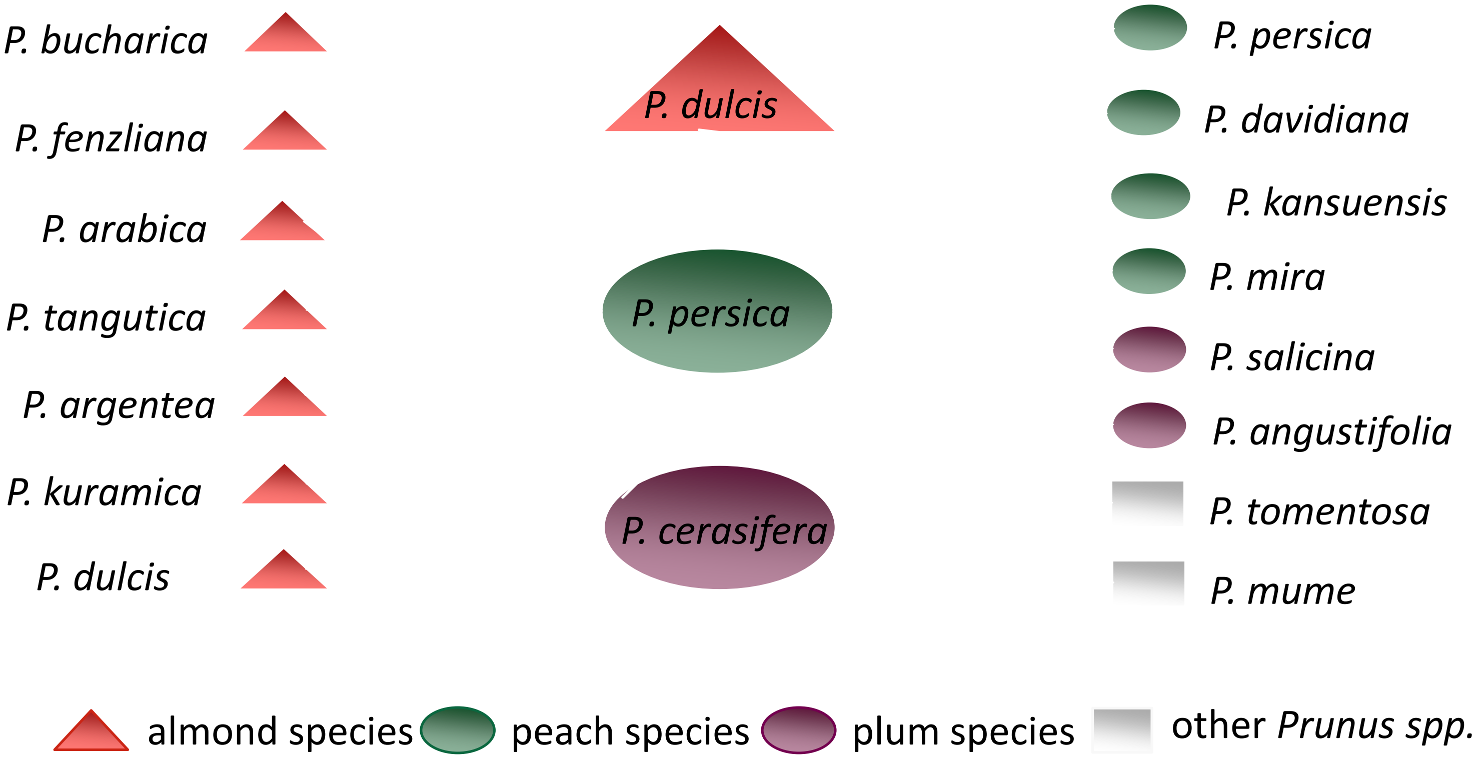
- Develop and use effective marker assisted selection strategies for rapid development of improved rootstocks.

USDA ars Agricultural Research Service

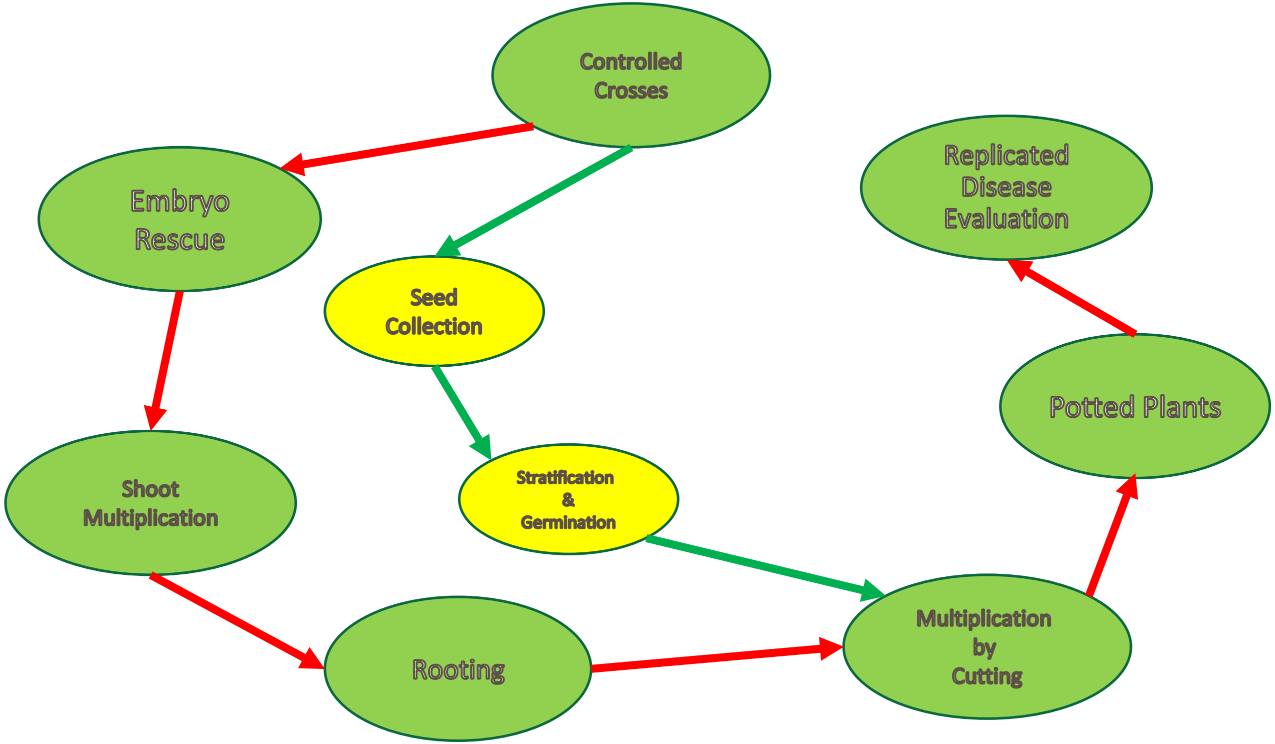
STEP 1

PRODUCTION OF INTERSPECIFIC HYBRID ROOTSTOCKS

Hybrid Combinations 2017



Rootstock - Production Cycle



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Rootstock - Embryo rescue & Propagation

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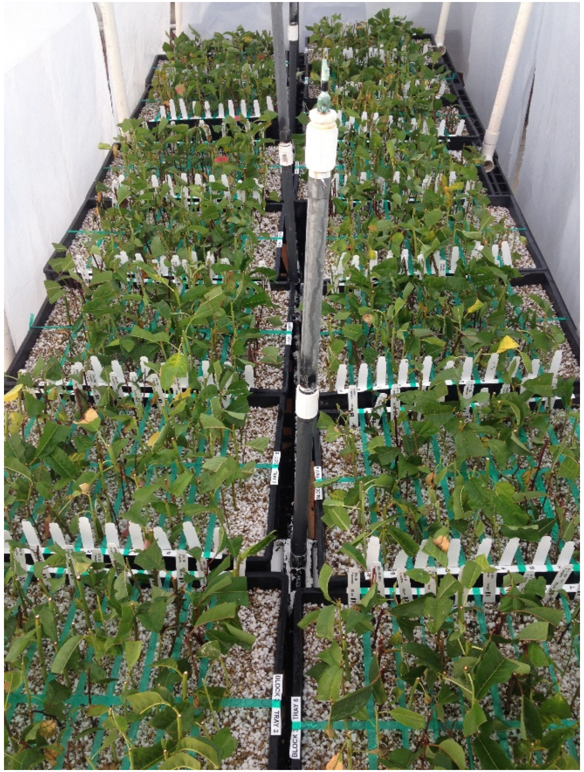
Seed Propagation of Hybrids

USDA ARS Agricultural Research Service

ROOTABILITY OF SPP. USED IN ROOTSTOCK PRODUCTION, 2017

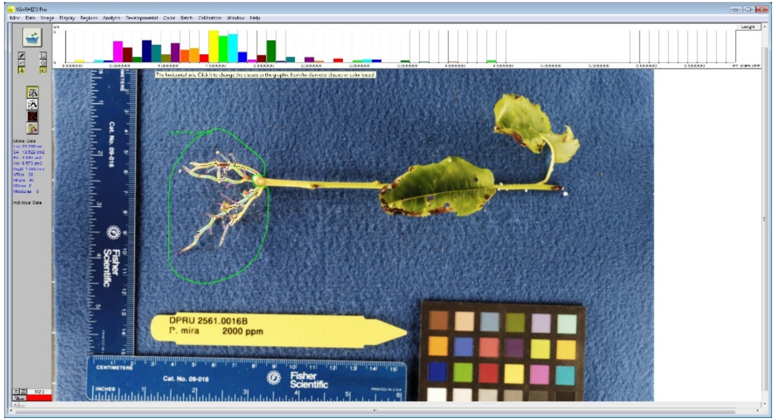


9 Species

5 Rooting hormone KIBA

Conc. (0, 500, 1000, 2000, 4000 mg/L KIBA)

RCBD/5blocks/4 cuttings/treat



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STEP 2

DISEASE TESTING OF HYBRIDS (PHY/CG/NEM)

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PRUNUS HYBRIDS – PHYTOPHTHORA EVALUATION

USDA Agricultural Research Service

CG Inoculation

1

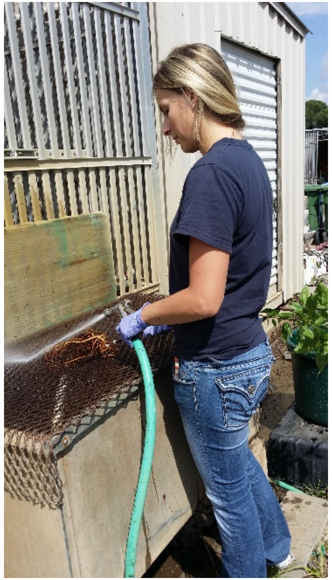
2 Root wash.

3 Stab inoculation

4 Spray-inoculate with Agro.

5 Re-potting of plant

PRUNUS HYBRIDS – CROWN GALL EVALUATION



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PRUNUS HYBRIDS – NEMATODE (RN/LESION) EVALUATION

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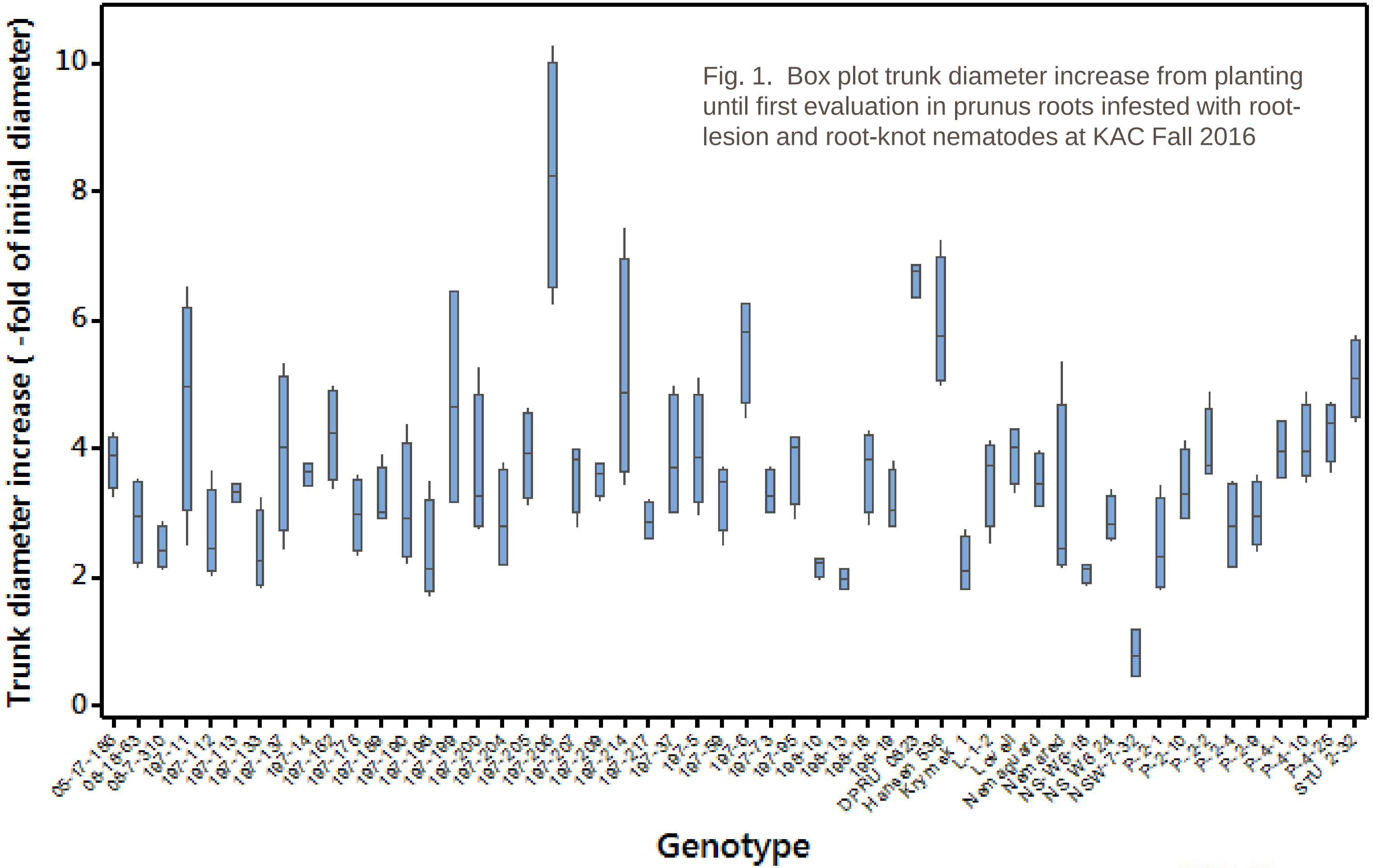

Fig. 1. Box plot trunk diameter increase from planting until first evaluation in prunus roots infested with root-lesion and root-knot nematodes at KAC Fall 2016

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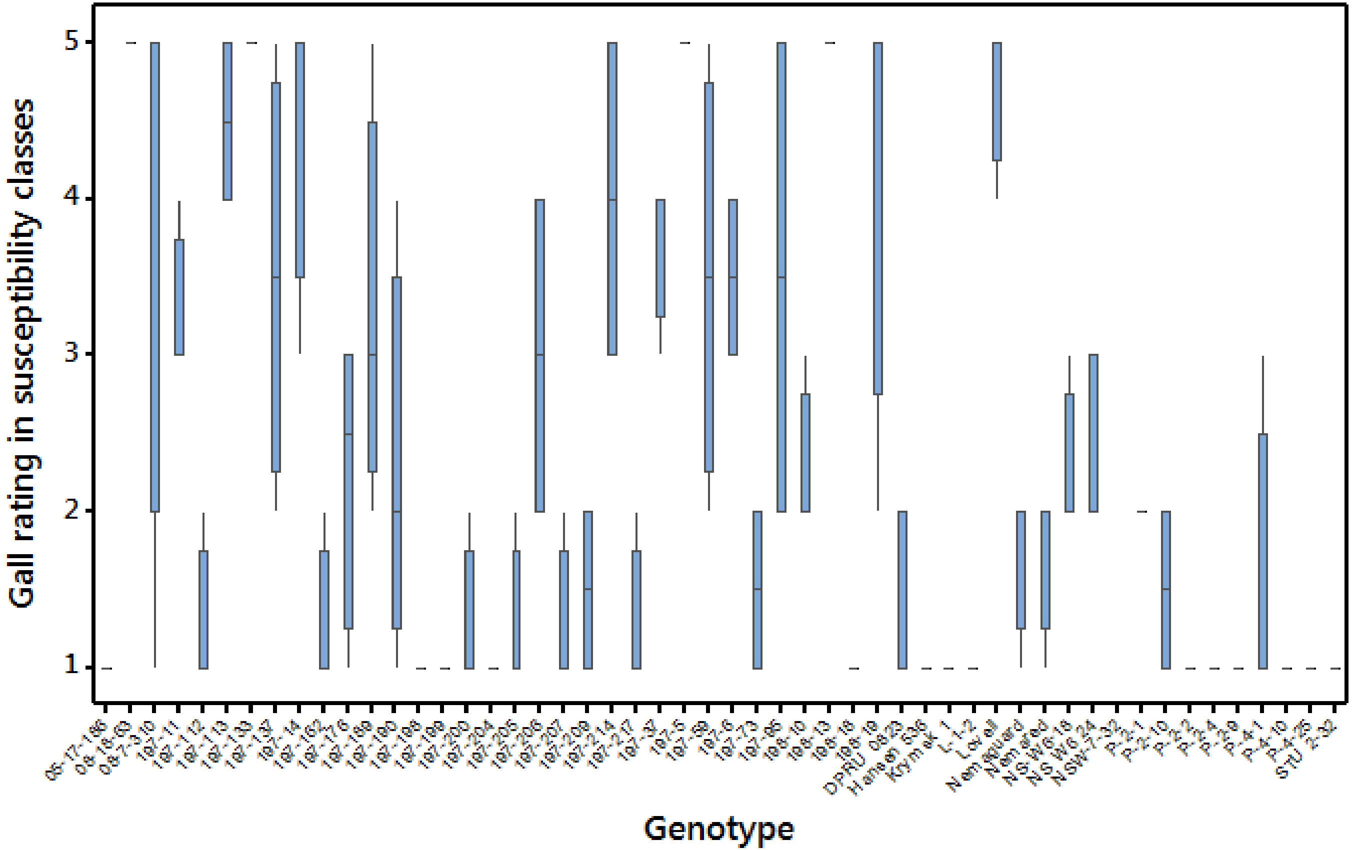
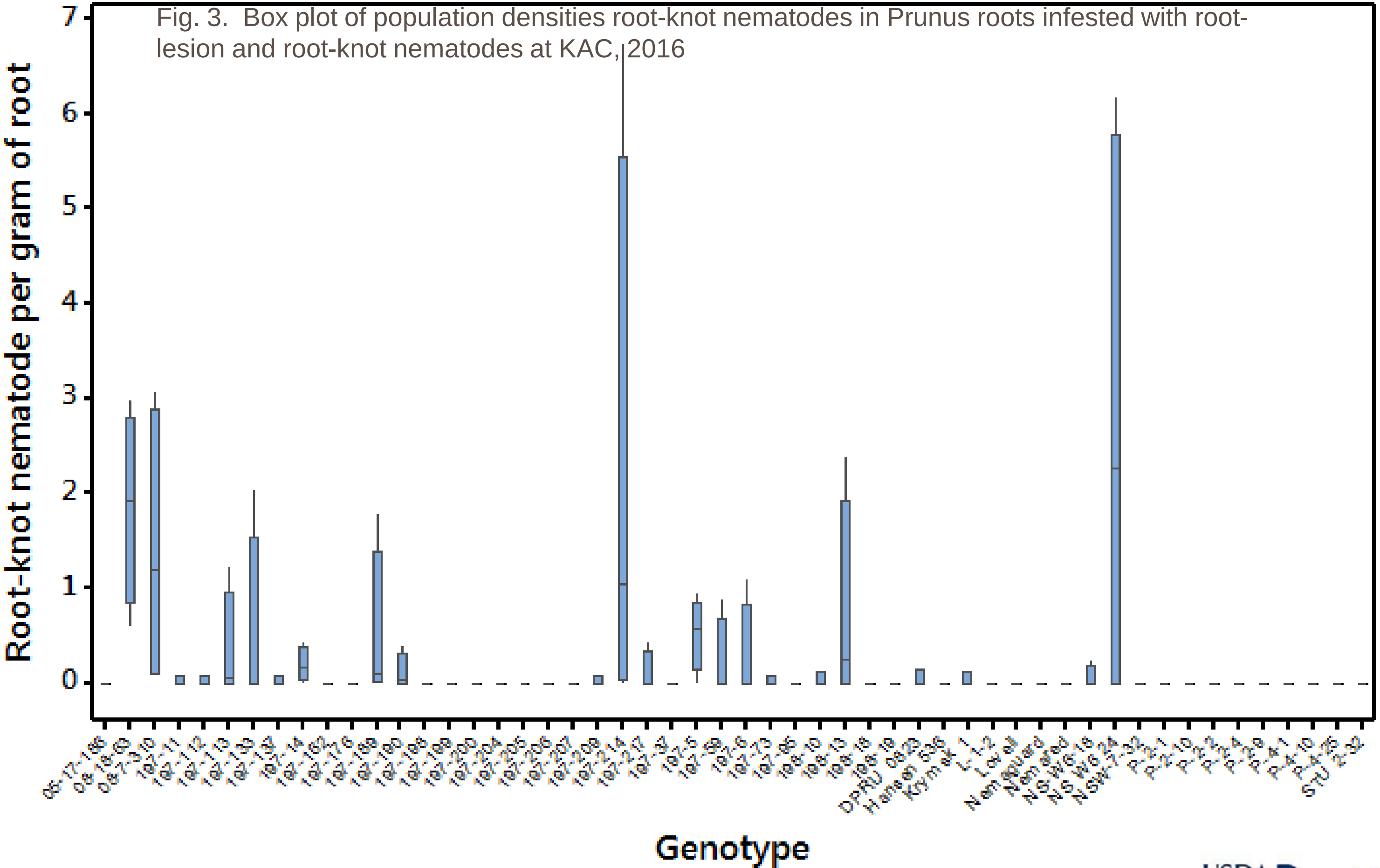


Fig. 2. Box plot of galling induced by root-knot nematodes (1: no visible galls, 2: 1-4 galls, 3: 5-10 galls, 4: 10-20 galls; 5: >21 galls) in Prunus roots at KAC, 2016

Fig. 3. Box plot of population densities root-knot nematodes in Prunus roots infested with root-lesion and root-knot nematodes at KAC, 2016



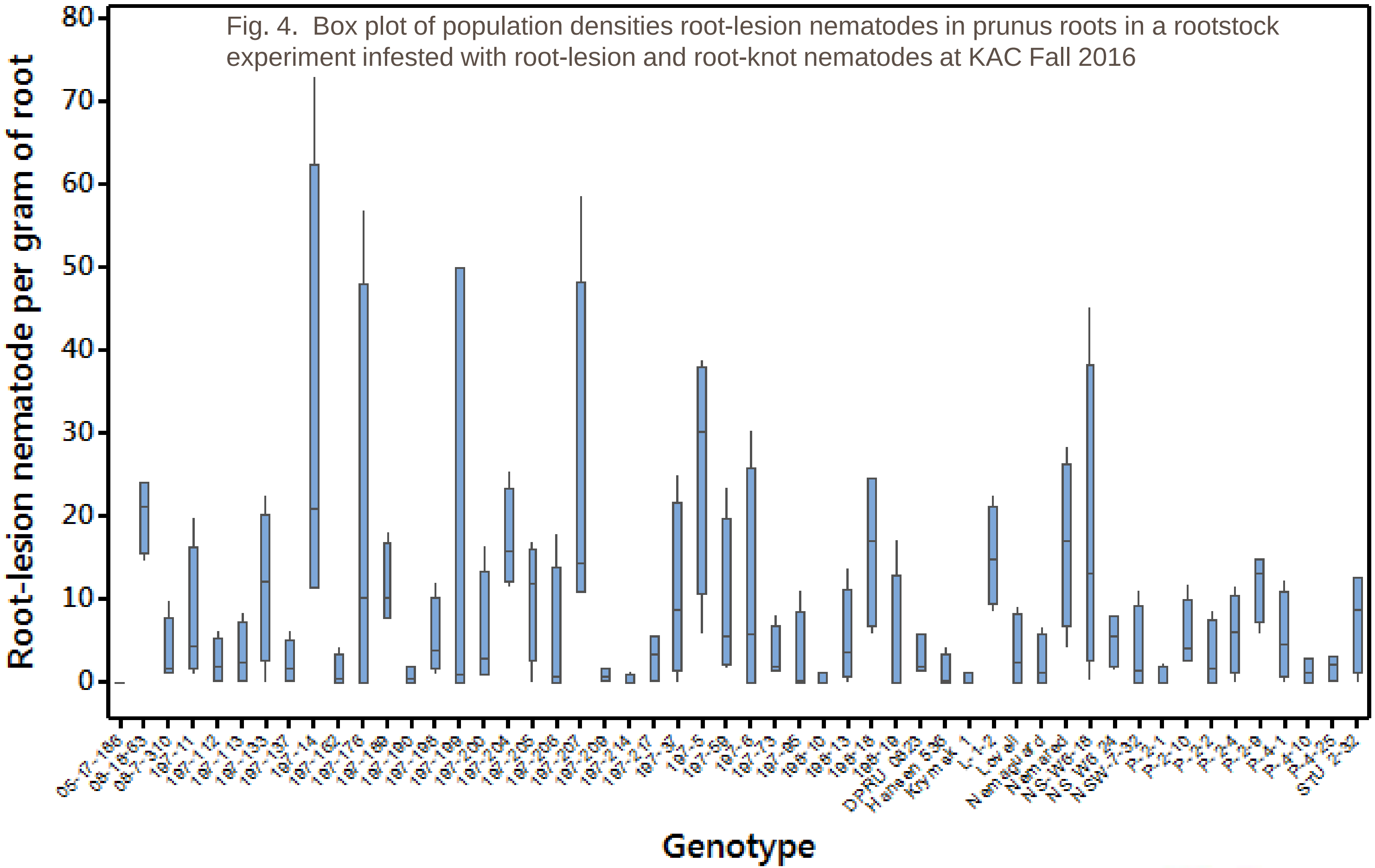


Fig. 4. Box plot of population densities root-lesion nematodes in prunus roots in a rootstock experiment infested with root-lesion and root-knot nematodes at KAC Fall 2016

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New Rootstocks Showing High Levels of Resistance to CG/PHY/NEM

* CG = Two year results

Hybrid	Parentage	CG*	PHY	RK_NEM	RL_NEM
P2-1	Nemared x P. argentea	X			
P2-2	Nemared x P. argentea			X	
P2-4	Nemared x P. argentea			X	
P2-9	Nemared x P. argentea	X		X	
P4-1	Nemared x P. argentea		X		
P4-10	Nemared x P. argentea			X	X
P4-25	Nemared x P. argentea	X	X	X	X
L1-2	P. cerasifera (OP)		X	X	
197-190	P. persica x P. dulcis		NT		X
197-198	P. persica x P. davidiana	X	NT	X	
197-199	P. persica x P. davidiana	X	NT	X	
197-204	P. persica x P. kansuensis	X	NT	X	
197-209	P. persica x P. kuramica		NT		X
197-214	P. persica x P. bucharica		NT		X
198-10	P. argentea x P. dulcis		NT		X
198-18	Nemaguard x Kansunsis		NT	X	
197-112	P. persica x P. tangutica		NT		X
197-113	P. persica x P. tangutica	X	NT		X
197-133	P. persica x P. tangutica	X	NT		
197-137	P. persica x P. tangutica		NT		X
197-162	P. persica x P. tangutica		NT		X
197-214	P. persica x P. bucharica	X	NT		
197-217	P. persica x P. kuramica	X	NT		X

USDA ARS Agricultural Research Service

Cooperators

John Preece	Research Leader, NCGR, USDA-ARS
Carolyn DeBuse	*Prunus* Horticulturist, USDA-ARS
Ali McClean	CPGRU, USDA-ARS
Tom Gradziel	Professor, Plant Sciences, UCD
Chuck Fleck	Sierra Gold Nurseries
Emily Johnson	Grad Student (Plant Sciences, UCD)
Dianne Velasco	Doctoral Student (Genetics, UCD)
Holly Forbes	Grad Student, Plant Pathology, UCD

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Roger Duncan, UCCE Stanislaus County

ROOTSTOCK FIELD EVALUATION

BUTTE COUNTY EVALUATION OF SIX ROOTSTOCKS FOR ALMOND

Joseph Connell
Farm Advisor Emeritus, UCCE Butte Co.
Sam Richardson
Deseret Farms of California - Durham
Fowler Nursery

University of California
Agriculture and Natural Resources

BUTTE COUNTY ROOTSTOCK TRIAL

- Orchard planted March 2010, 24’x16’ on Farwell Loam Soil
- Compares tree size, yield, and field performance of ‘Nonpareil’ on six rootstocks

- ✓ ‘Lovell’
- ✓ ‘Krymsk 86’
- ✓ ‘Atlas’
- ✓ ‘Empyrean 1’
- ✓ ‘Nickels’
- ✓ ‘Rootpac-R’

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BUTTE COUNTY ROOTSTOCK TRIAL

Tree size, Kernel size, and Yield of 'Nonpareil' almond

2017, 8th Leaf

Rootstock	Trunk Circ. (cm)	Kernel wt. in Grams	Lbs. Kernel per tree	Lbs. Kernel per Acre
'Empyrean 1'	80.8 a	1.33 a	37.4 a	4,231 a
'Nickels'	77.9 b	1.35 a	35.6 a	4,019 a
'Atlas'	68.6 c	1.32 a	36.4 a	4,111 a
'Krymsk 86'	66.3 c	1.27 b	29.0 b	3,279 b
'Lovell'	67.8 c	1.27 b	28.4 b	3,211 b
'Rootpac-R'	61.9 d	1.22 c	21.5 c	2,434 c

Values followed by the same letters are not significantly different from one another at $P < 0.05$ using Fisher's least significant difference (LSD) procedure.

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BUTTE COUNTY ROOTSTOCK TRIAL

- Trees on vigorous rootstocks produce larger nuts
- Yield is heaviest on ‘Empyrean 1’, ‘Atlas’, and ‘Nickels’
- Yield on ‘Krymsk 86’ and ‘Lovell’ is intermediate
- ‘Rootpac-R’ produces the smallest trees, the smallest nuts, and the lightest yield
- Since yield is related to rootstock vigor and tree canopy size, planting at the optimum tree density for each rootstock is essential for good production

SEVENTH YEAR EVALUATION OF 13 ALMOND ROOTSTOCKS IN A SANDY LOCATION WITH NEMATODES

David Doll, UCCE Merced

Arnold Farms, Atwater, CA

Cameron Zuber, UCCE Merced

MERCED COUNTY ROOTSTOCK TRIAL

Background:

- Planted in January 2011,
- Spacing 22’ x 18’
- 13 rootstocks tested on ‘Nonpareil.’
- 7 rootstocks tested on varieties ‘Monterrey,’ and ‘Fritz.’

Challenges:

- Sandy soil near Atwater, CA,
- low cation exchange capacity,
- Irrigated with groundwater with high nitrates and moderate sodium

- Currently following nematode populations

‘Nonpareil,’ ‘Monterey,’ and ‘Fritz’	‘Nonpareil’ only
Atlas	BB106
BH5	Cadaman*
Empyrean-1	Cornerstone*
Hansen 536	Floridaguard x Alnem
Nemaguard	Krymsk-86
Viking	RootPacR
	TemproPac

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Merced County Rootstock Trial

- Causes severe stunting and loss of productivity;
- Krymsk-86 is susceptible and should not be planted in Rootknot infested soils;
- FxA, could be due to weed populations;

Rootknot Nematode (*Meloidogyne* sp.)

Rootstock	2011	2012	2013	2014	2015	2016	2017
Atlas	0	0	0	0	0	0	0
BB106	0	0	0	0	0	0	0
BH5	0	0	0	0	0	0	0
Cadaman	0	0	0	0	0	0	0
Cornerstone	0	0	0	0	0	0	0
Empyrean-1	0	0	0	0	0	0	0
Floridaguard x Alnem	0	0	0	0	0	0	15
Hansen 536	0	0	0	0	0	0	0
Krymsk-86	0	0	1	131	88	13	312
Nemaguard	0	0	0	0	0	0	0
RootpacR	0	0	0	0	0	0	0
TemproPac	0	0	0	0	0	0	0
Viking	0	0	0	0	0	0	0

Merced County Rootstock Trial

- Causes stunting of almond trees, especially when in the presence of Ring
- Most rootstocks are susceptible in the trial
- Numbers are low due to extraction method.

Root Lesion Nematode (*Pratylenchus vulnus)*

	Lesion nematodes per 500 grams of soil						
Rootstock	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Atlas	0	0	0	0	0	0	16
BB106	0	0	0	0	0	12	0
BH5	0	0	0	38	6	46	0
Cadaman	0	0	0	0	0	0	0
Cornerstone	0	311	31	0	2	13	51
Empyrean-1	0	0	0	0	0	0	29
Floridaguard x Alnem	0	0	0	0	0	0	0
Hansen 536	0	0	0	0	131	34	0
Krymsk-86	0	0	33	547	160	0	47
Nemaguard	0	0	0	0	0	0	0
RootpacR	0	0	0	9	33	2	25
TemproPac	0	0	0	34	26	0	0
Viking	0	0	0	0	41	55	26

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Merced County Rootstock Trial

Ring Nematode (*Mesocriconema xenoplax*)

- Predisposing factor of bacterial canker
- Peach almond hybrids are highly susceptible;
- All rootstocks in the trial are susceptible

	Ring nematodes per 500 grams of soil[1]						
Rootstock	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Atlas	0	0	0	0	75	418	290
BB106	0	0	0	46	1	122	978
BH5	0	0	0	123	282	934	824
Cadaman	0	0	0	1	624	510	702
Cornerstone	0	0	0	0	150	610	861
Empyrean-1	0	0	0	0	229	91	630
Floridaguard x Alnem	0	0	0	12	656	774	2506
Hansen 536	0	0	1	1832	1066	470	1367
Krymsk-86	0	0	8	247	319	730	926
Nemaguard	0	0	0	0	8	230	265
RootpacR	0	0	0	0	530	1586	909
TemproPac	0	0	0	0	86	188	811
Viking	0	0	0	0	6	11	923

MERCED COUNTY ROOTSTOCK TRIAL

- Prior to planting, soil had no detectable levels of Rootknot, Ring, or Root Lesion (*P. vulnus)* and grower strip fumigated with Telone-II. Rootstocks are the best management tool;

- Populations have been increasing taking 2-3 years before consistent populations begin to appear;

- Sugar-sieve method is effective in isolating ring nematode, not so good with root lesion or rootknot.

- Results suggest Krymsk-86 is susceptible to all plant parasitic nematodes, most (all?) P/A hybrids susceptible to ring

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EFFECTS OF ROOTSTOCKS ON MARGINAL, HIGH BORON SOIL

Katherine Jarvis-Shean, *UCCE Sac-Solano-Yolo;*

Dave Scheuring*, Gold Oak Ranch;*

Lampinen Lab*, UC Davis;*

Carolyn DeBuse, *USDA*

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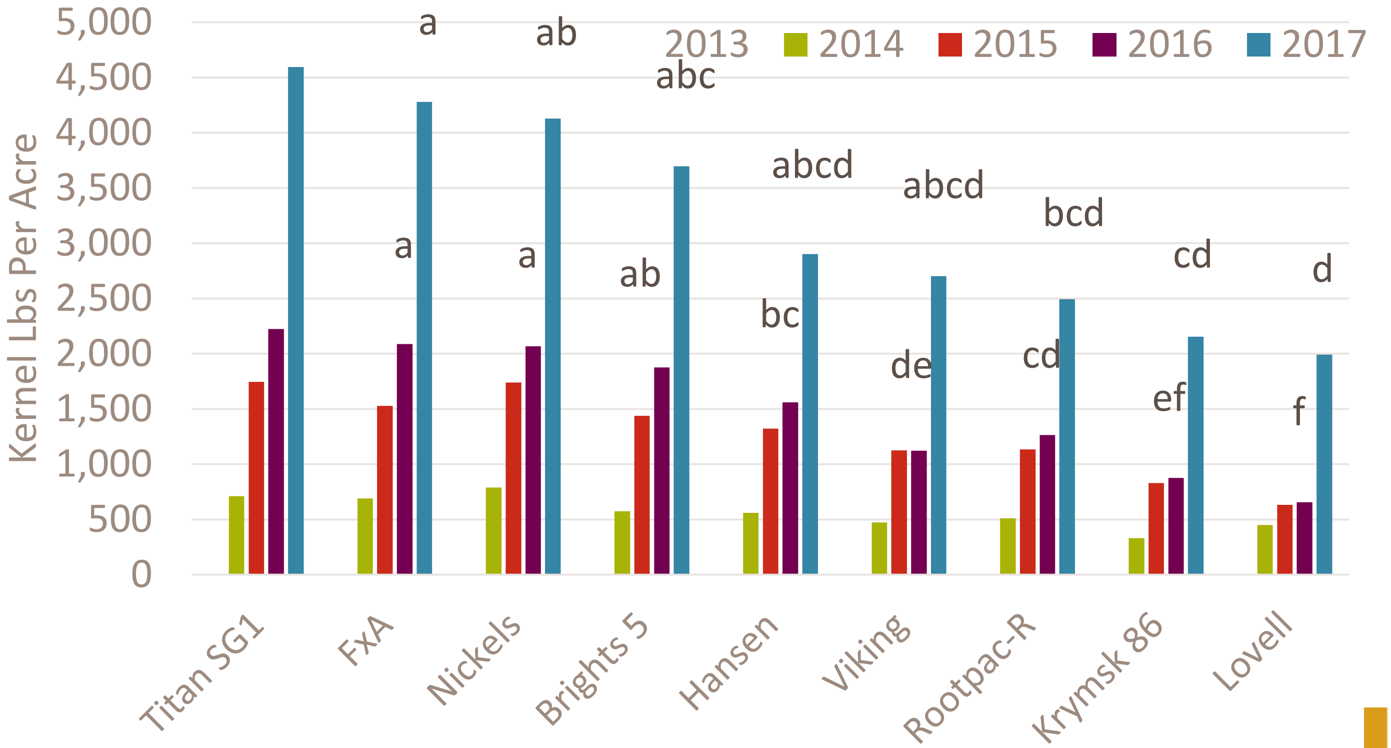
BORON ROOTSTOCK TRIAL – YIELD HIGHLY CORRELATED WITH ROOTSTOCK



Marvin silty clay loam
Water: <1 - 3.1 mg/l B
Soil: 1.3-2.2 mg/l B

cv. Nonpareil

Planted: Feb, 2011
(Titan Apr 2011 not rep'd)
Spacing: 22' x 18'

Different letters indicate statistical diff. values when compared in same year.

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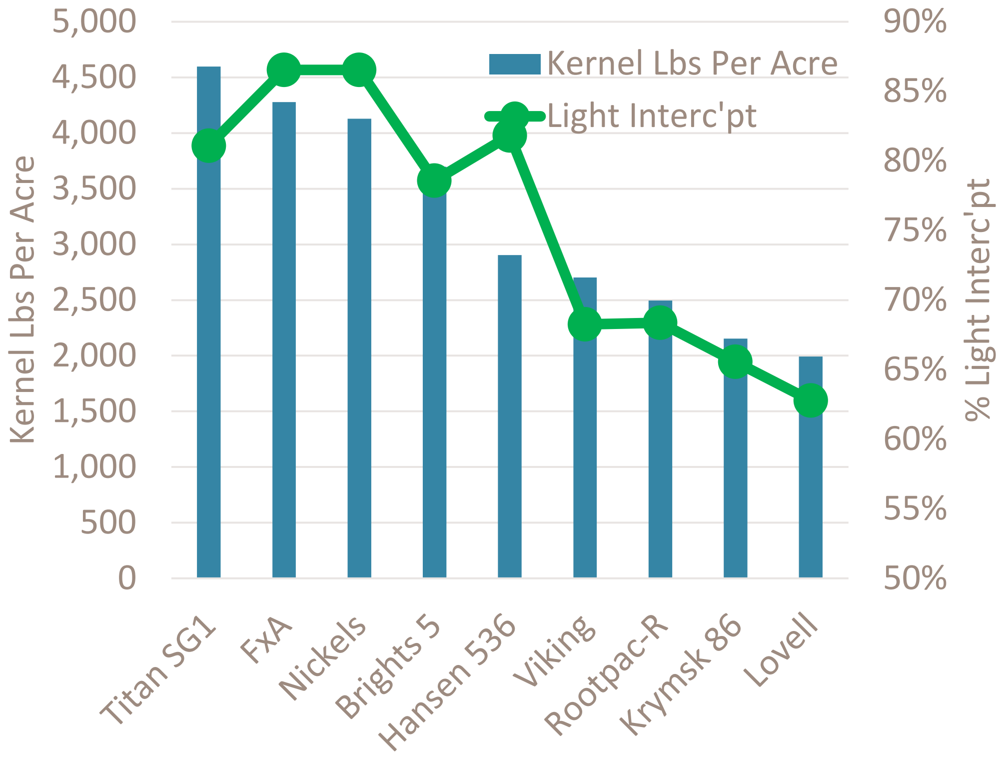
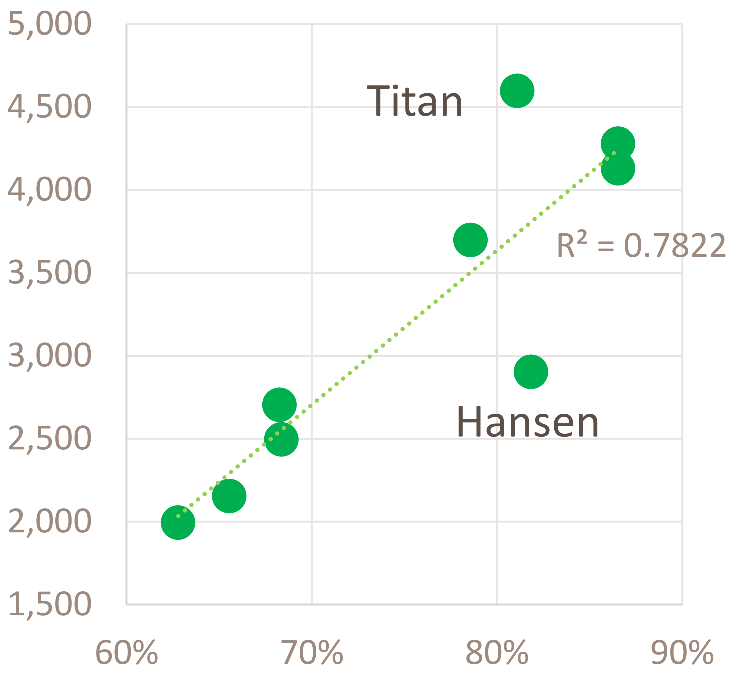
YIELD CORRELATES WITH TREE SIZE.
> HANSEN UNDER-PERFORMING FOR IT'S SIZE.
> TITAN HIGH YIELDING FOR IT'S SIZE.





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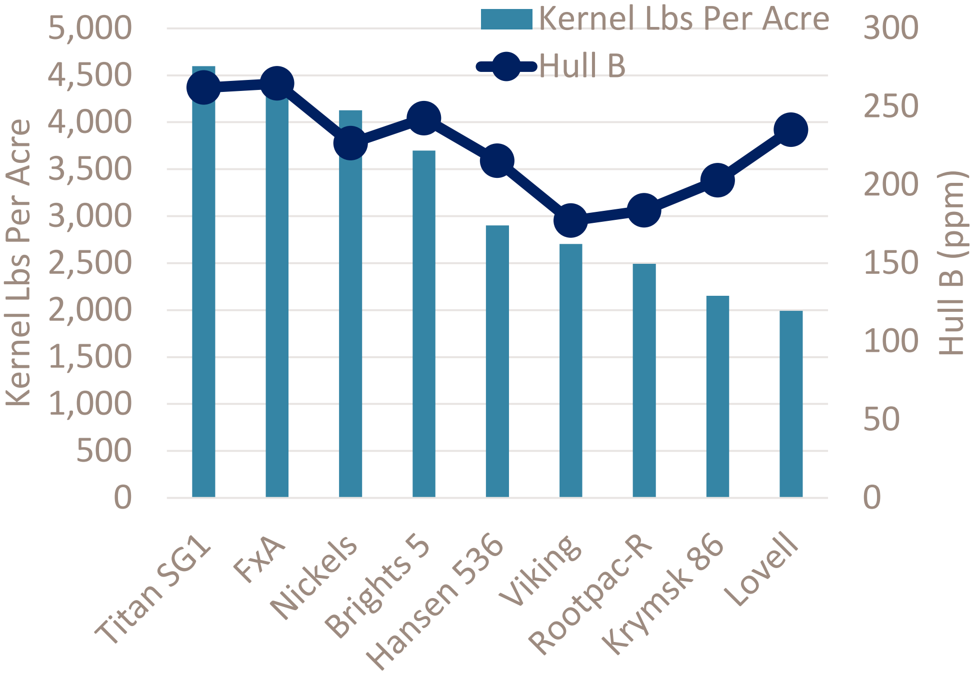
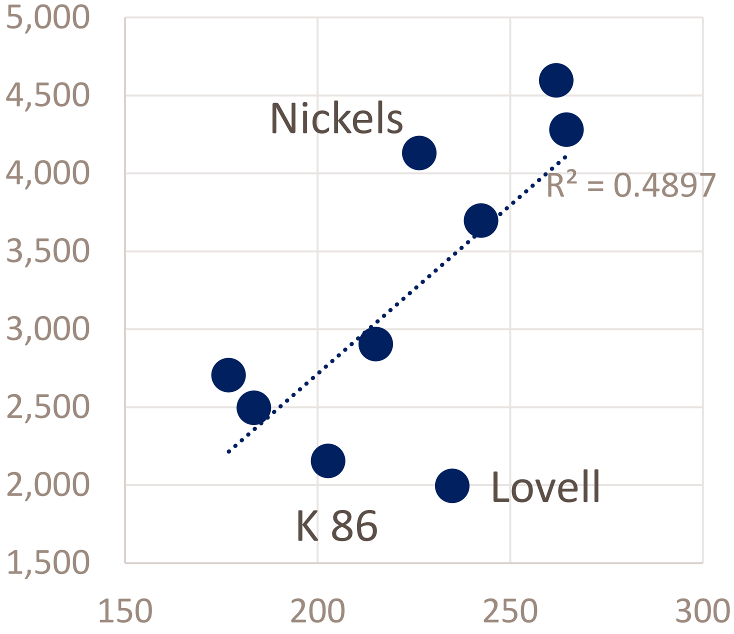
YIELD CORRELATES WITH HULL B.
> ALL TREES BELOW TOXICITY (300 PPM) AFTER WET, LEACHING WINTER.
> HIGHER YIELDS WITH HIGHER B MAY BE RELATED TO LARGER TREES HAVING LARGER ROOT ZONES. DID NOT SEE HIGHER B → HIGHER YIELD IN NON-LEACHING YEARS.





BORON ROOTSTOCK TRIAL – SUMMARY (SO FAR)

- **Poor Yield** related to **Canopy Size**, **Hull Boron in *previous* years**. Points to two potential rootstock effects:
  - Vigorous rootstocks → Larger Trees
  - Boron tolerant rootstocks decrease B to scion → Decrease B at growing points (flowers, nuts) where it can do damage.
- **Titan, FxA & Nickels** continue to perform **better** than other rootstocks under high boron conditions
- **Lovell, Krymsk 86** continue to perform **poorly** under high boron conditions
- Looks like Lovell combines worst combination: Low vigor with high B

FIELD EVALUATION OF ROOTSTOCKS FOR THE WESTSIDE OF THE SAN JOAQUIN VALLEY

- Roger Duncan, UC Cooperative Extension, Stanislaus County
- Brent Holtz, UC Cooperative Extension, San Joaquin County

- In cooperation with Lee Del Don, Westley CA

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- Zacharias clay loam soil
- Soil and irrigation water alkaline, moderately high in Cl and/or boron, depending on year / water source
- Following decades of row crops (tomatoes & melons)

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List of Rootstocks. Planted Dec. 2012

Lovell	*P. persica*
Nemaguard	*P. persica*
Empyrean 1 (a.k.a. Barrier 1)	*P. persica x P. davidiana*
Avimag (a.k.a. Cadaman)	*P. persica x P. davidiana*
HBOK 50	*Harrow blood x Okinawa peach*
Hansen	*P. dulcis x P. persica*
Brights 5	*P. dulcis x P. persica*
BB 106	*P. dulcis x P. persica*
Paramount (a.k.a. GF 677)	*P. dulcis x P. persica*
Flordaguard x Alnem a.k.a. Y119-109-98.	*P. persica x* Israeli bitter almond
PAC9908-02	*(P. dulcis x P. persica) x P. persica*
Hansen x Monegro (HM2)	*(P. dulcis x P. persica) x (P. dulcis x P. persica)*
Viking	*P. Persica x (P. dulcis)x [(P. cerasifera x P. armeniaca)]*
Atlas	*P. Persica x (P. dulcis)x [(P. cerasifera x P. armeniaca)]*
Krymsk 86	*P. cerasifera x P. persica*
Rootpac R	*P. cerasifera x P. dulcis*

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Rootstock Effect on Chloride Accumulation in Leaf Tissue

Cl critical level = 0.3%

	% Cl
Krymsk 86	0.89 a*
Lovell	0.72 b
Nemaguard	0.57 c
PAC9908-02	0.45 d
Atlas	0.42 de
Cadaman	0.38 def
Empyrean 1	0.33 ef
HBOK 50	0.31 ef
Viking	0.30 f
F x A	0.19 g
BB 106	0.19 g
Brights 5	0.18 g
GF 677	0.18 g
Rootpac R	0.17 g
HM2	0.16 g
Hansen	0.15 g

*$P \leq 0.05$

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Rootstock Effect on Boron Accumulation in Hull Tissue

B critical level = 300 ppm

	B (ppm)
Lovell	180 a*
Cadaman	170 ab
Atlas	158 ab
HBOK 50	158 ab
Nemaguard	153 bc
Krymsk 86	152 bc
Empyrean 1	133 cd
Rootpac R	132 cd
Hansen	126 de
GF 677	120 de
HM2	116 de
Viking	109 e
PAC9908-02	108 e
Brights 5	106 e
F x A	104 e
BB 106	102 e

*P ≤ 0.05

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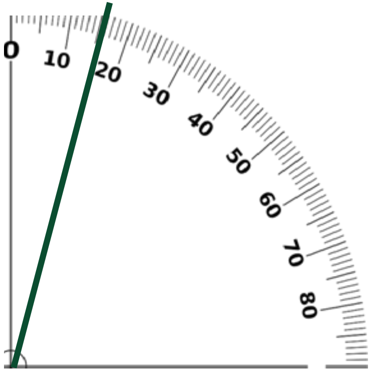
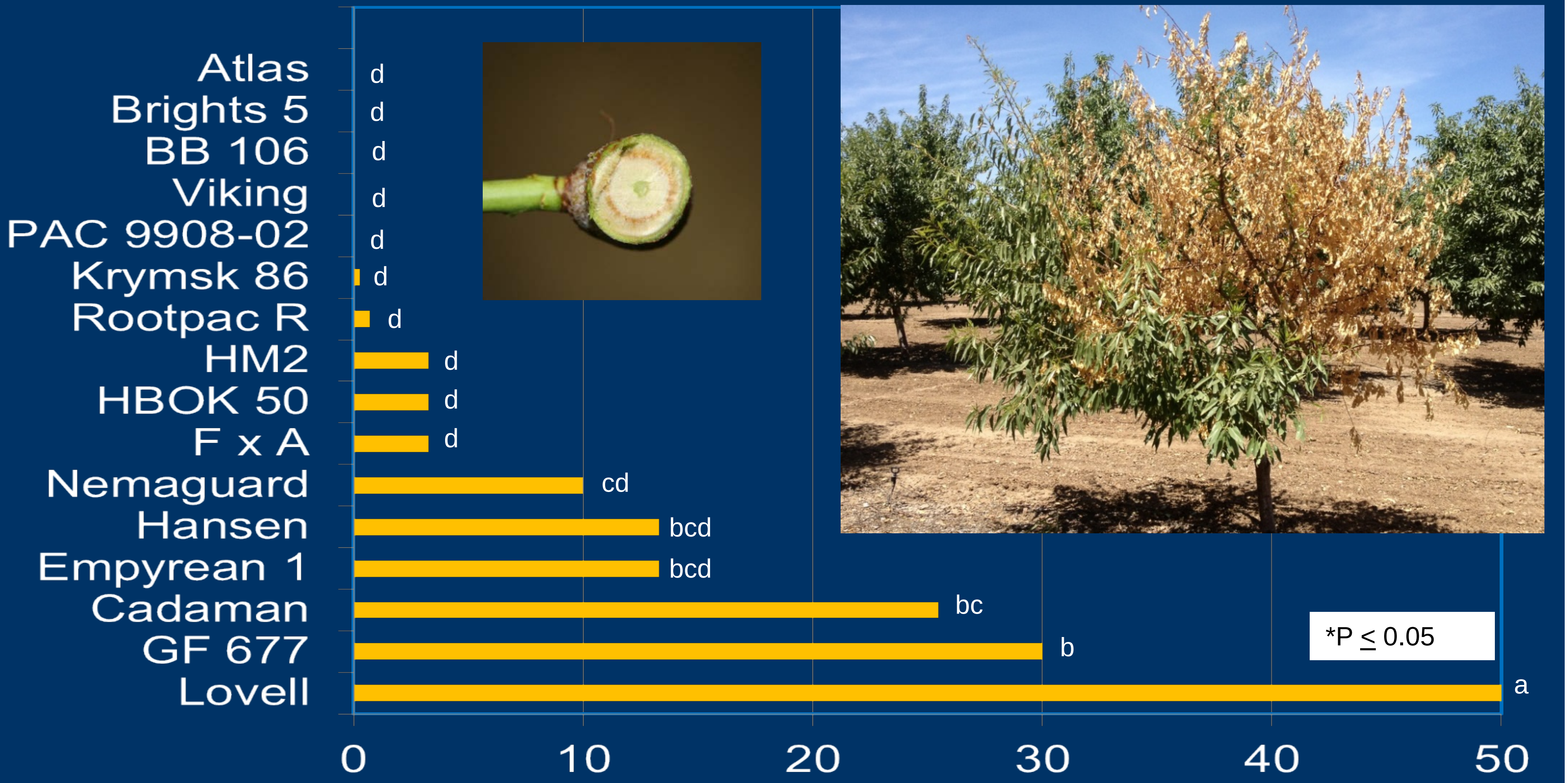
Anchorage



	Trunk Lean (degrees)	% of Trees > 15^0 Lean
Krymsk 86	5 a*	0
PAC 9908-02	5 a	6.7
Viking	6 a	6.7
Hansen	6 a	0
Flordaguard x A	8 ab	6.7
Nemaguard	8 ab	16.7
Rootpac R	9 abc	20.0
Brights 5	9 abc	13.3
Lovell	9 abc	33.3
Atlas	10 bcd	20.0
GF 677	11 bcd	24.1
BB106	14 bcd	20.0
Empyrean 1	15 cde	40.0
HBOK 50	16 cde	40.0
Cadaman	17 de	25.0
Hansen x Monegro	21 e	66.7

*$P \leq 0.05$

Expression of Verticillium Wilt 2nd Leaf



ROOTSTOCK EFFECT ON TREE SIZE, YIELD & YIELD EFFICIENCY

	Trunk Circum.	2017 Yield	Cum Yield (4^{th} – 6^{th})	Yield Efficiency
BB 106	57.5 c	4209 a	8327 a	0.50 bc
Flordaguard x Alnem	60.9 a*	4112 ab	8311 ab	0.45 cd
Empyrean 1	59.3 abc	3775 abc	7974 ab	0.45 cd
Brights 5	52.0 def	3604 bcde	7863 ab	0.58 a
HM2	58.4 abc	3686 bcd	7789 ab	0.45 cd
Hansen	58.3 bc	3881 abc	7690 bc	0.45 cd
PAC9908-02	60.3 ab	3537 cdef	7554 bc	0.41 d
Rootpac R	58.1 bc	3192 defgh	7111 cd	0.42 cd
Atlas	52.8 de	3104 efgh	7049 cd	0.50 bc
Viking	51.9 def	3085 efgh	6463 de	0.48 bcd
GF 677	51.6 ef	3239 defg	6385 de	0.48 bcd
HBOK 50	54.4 d	3026 fgh	6141 de	0.41 d
Nemaguard	52.7 def	2965 gh	6031 de	0.43 cd
Krymsk 86	48.6 g	2846 gh	5862 ef	0.49 bc
Lovell	50.2 fg	2696 h	5289 f	0.42 cd

BOTTOM LINE

Trees on Lovell rootstock:

- are small
- have the highest boron
- have toxic levels of chloride
- had the highest incidence of Verticillium wilt disease
- have the lowest yields and low yield efficiency

DON'T PLANT ON LOVELL ROOTSTOCK ON THE WESTSIDE OF THE SAN JOAQUIN VALLEY

Thank you for your Attention

See you at the posters 3:00 – 5:00

Roger Duncan
209-525-6800

raduncan@ucdavis.edu

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SUBCELLULAR CHARACTERIZATION OF SALINITY TOLERANCE IN ALMONDS

Georgia Drakakaki

Department of Plant Sciences,

University of California, Davis

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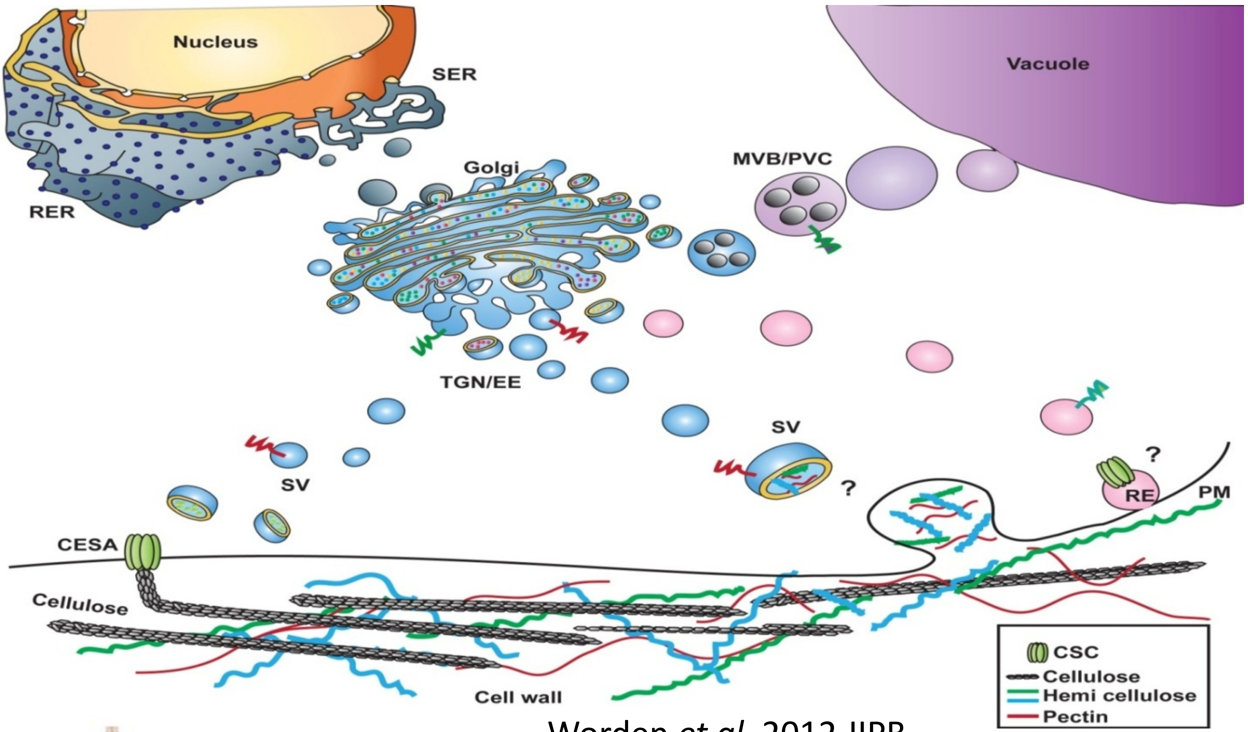
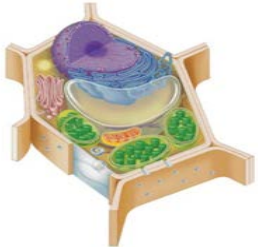
Questions in my Research Group:



Worden *et al*. 2012 JIPB



- ❑ **How does this membrane network controls respons to biotic an abiotic stress?**

- ❑ **How do cell walls contribute to stress response?**

Motivation

Almond plants are relatively sensitive to salinity stress

NEED A COMPREHENSIVE UNDERSTANDING OF SALINITY TOLERANCE

Physiology: traits associated with salinity tolerance

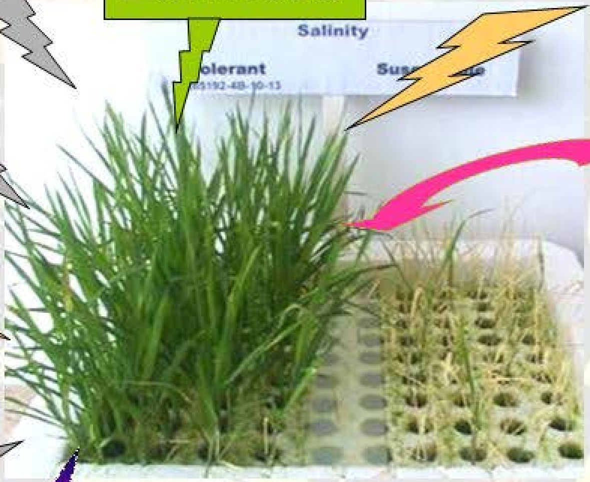
Regulation of uptake

Earliness

Responsive stomata

Compartmentation In old tissue

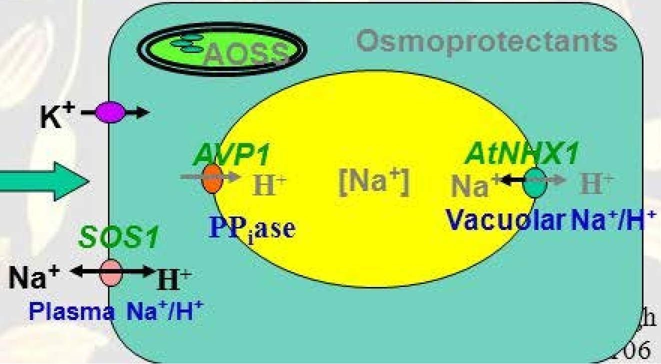
Upregualtion of antioxidants



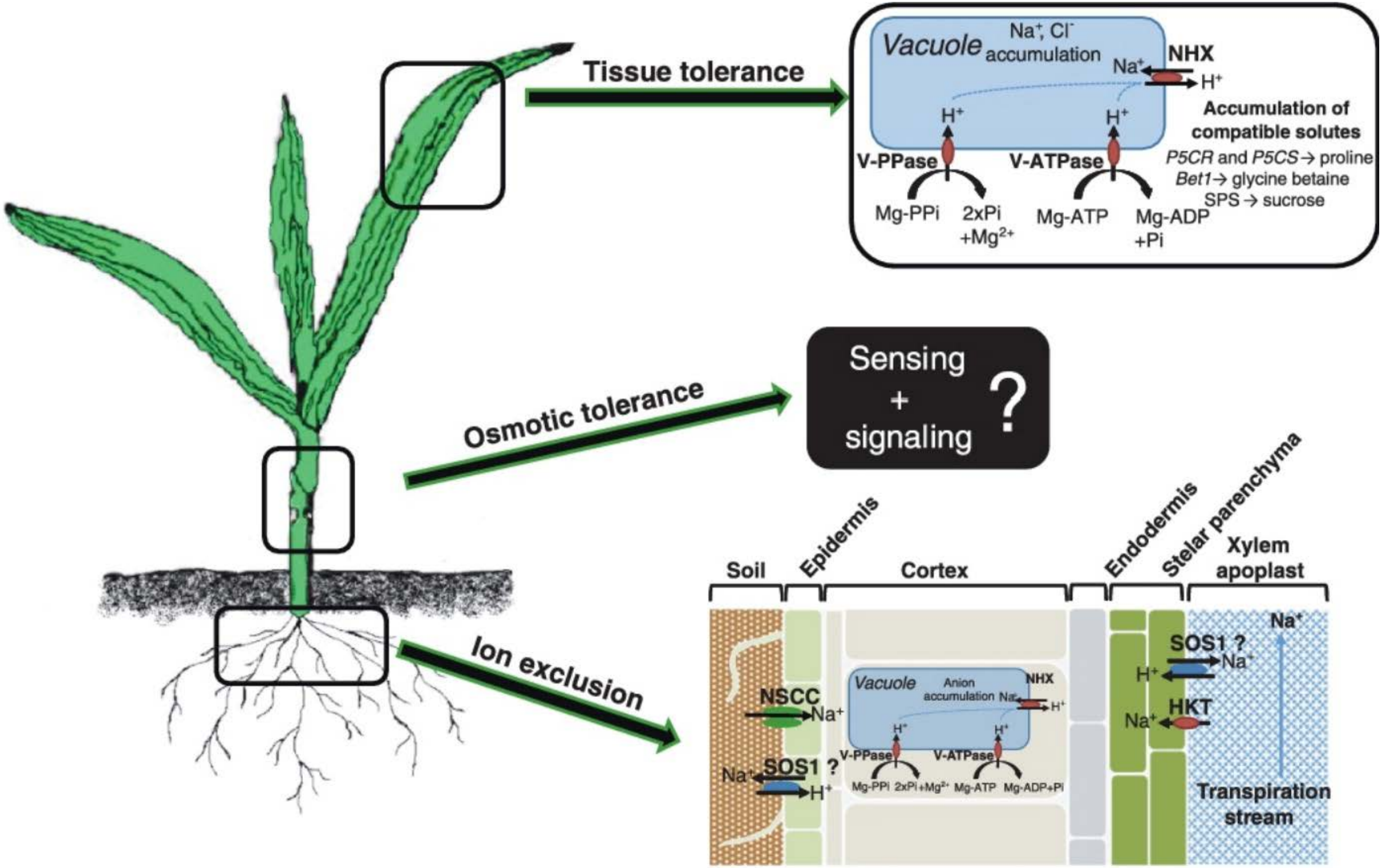
Protective metabolites
Polyamines, dehydrins, glyoxalates

Vigorous growth

Compartmentation within tissue (tissue tolerance)



Salt resistant crop plants



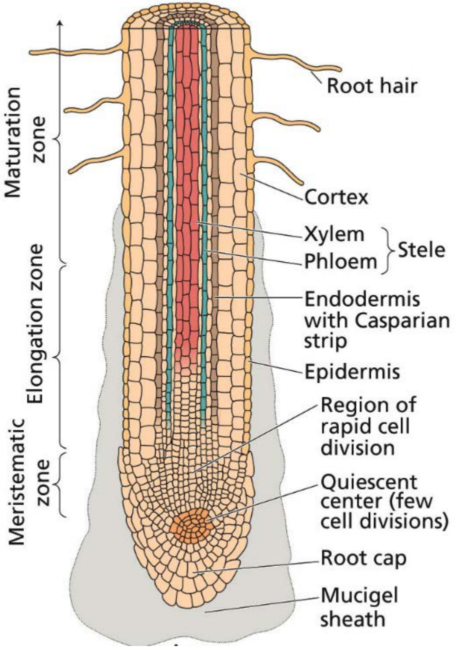
Current Opinion in Biotechnology, Volume 26, 2014, 115–124

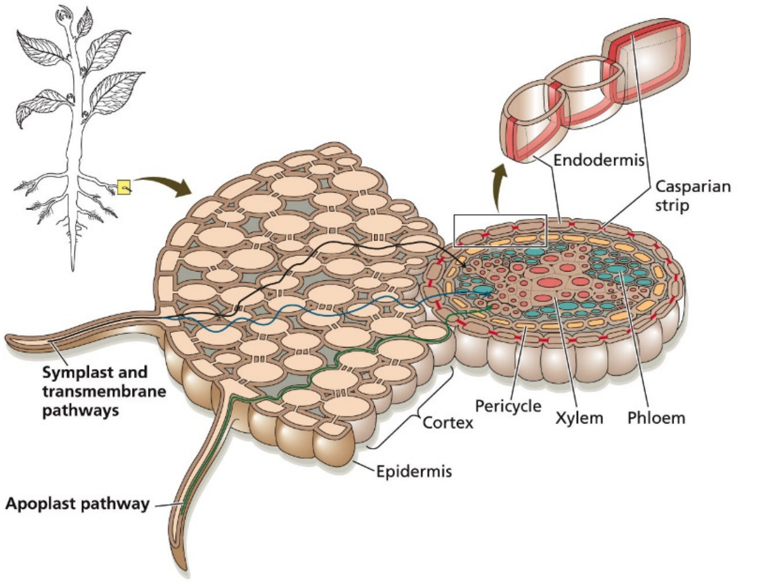
Stuart J Roy, Sónia Negrão, Mark Tester

How different rootstocks respond to salinity?

- **What happens under different environments?**

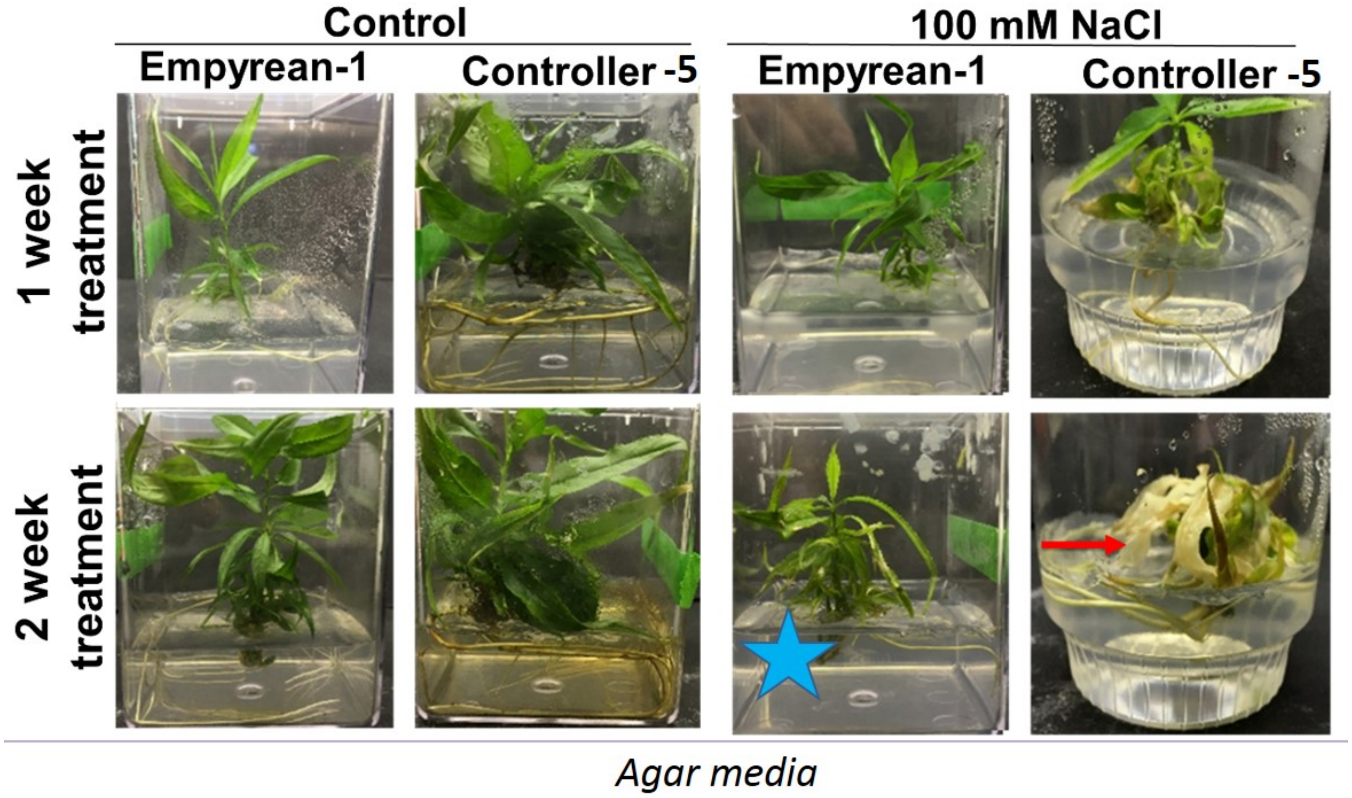
- **Where is sodium localized?**



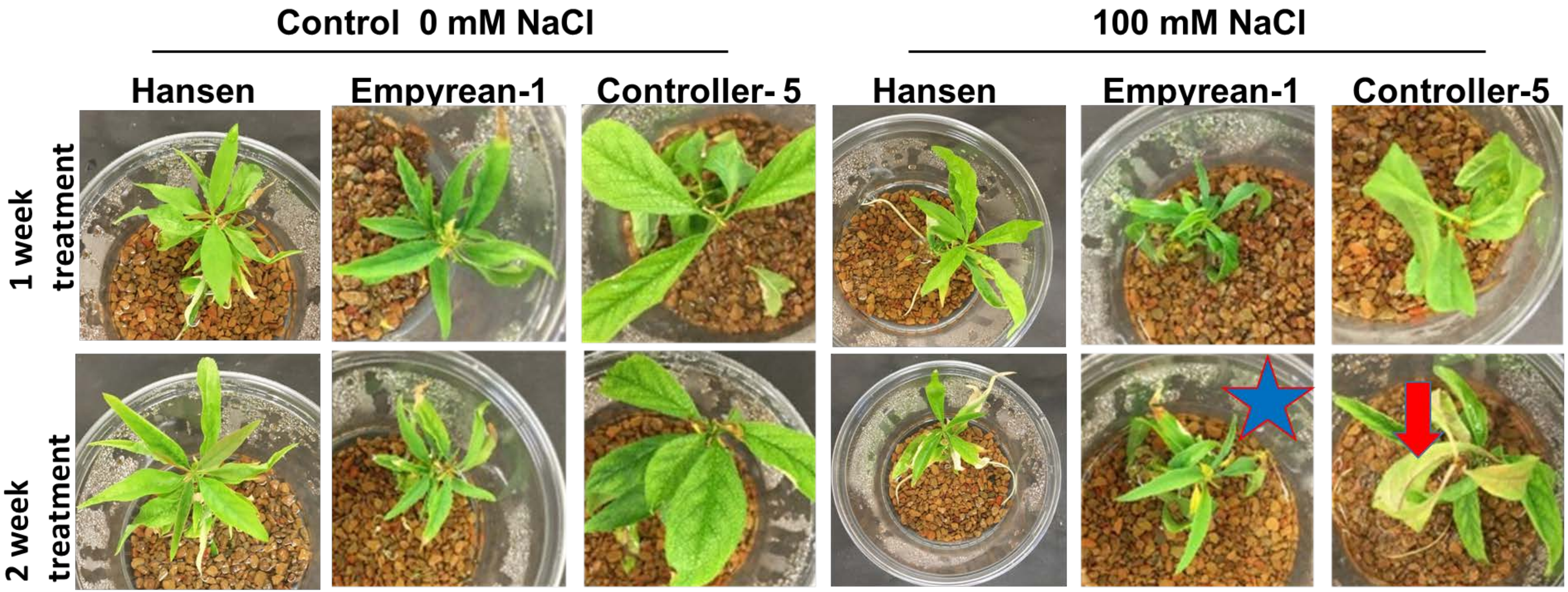


PLANT PHYSIOLOGY, 5e, Figure 4.4

Phenotypic characterization of rootstocks

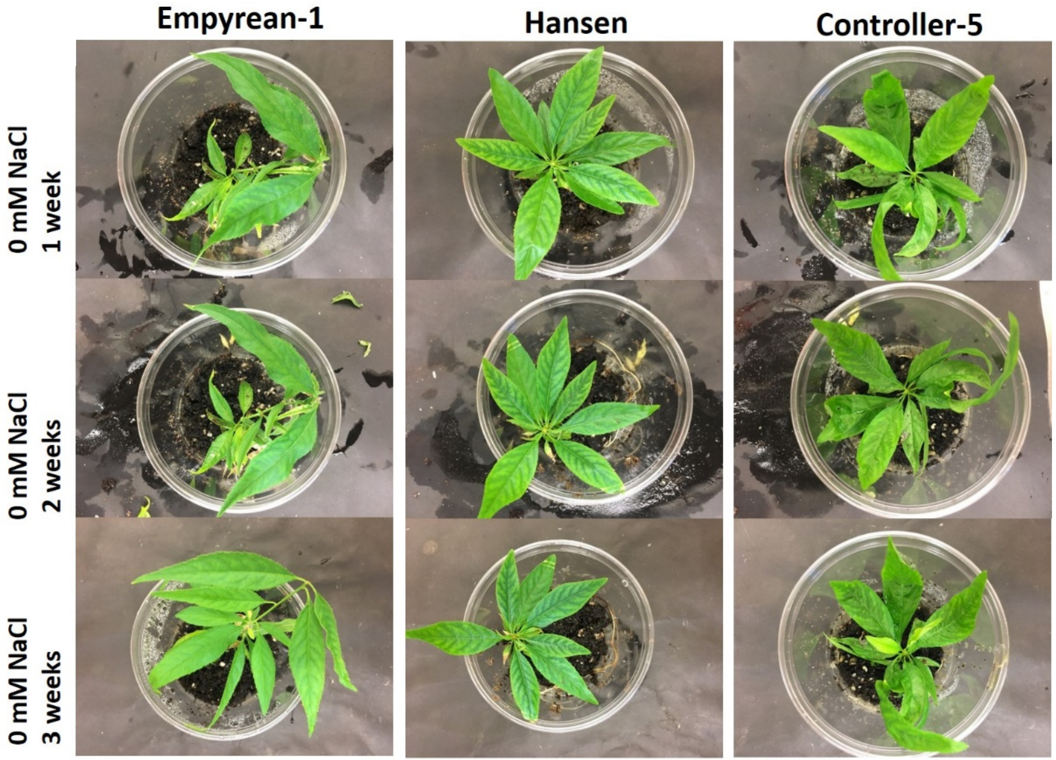


Phenotypic characterization of rootstocks

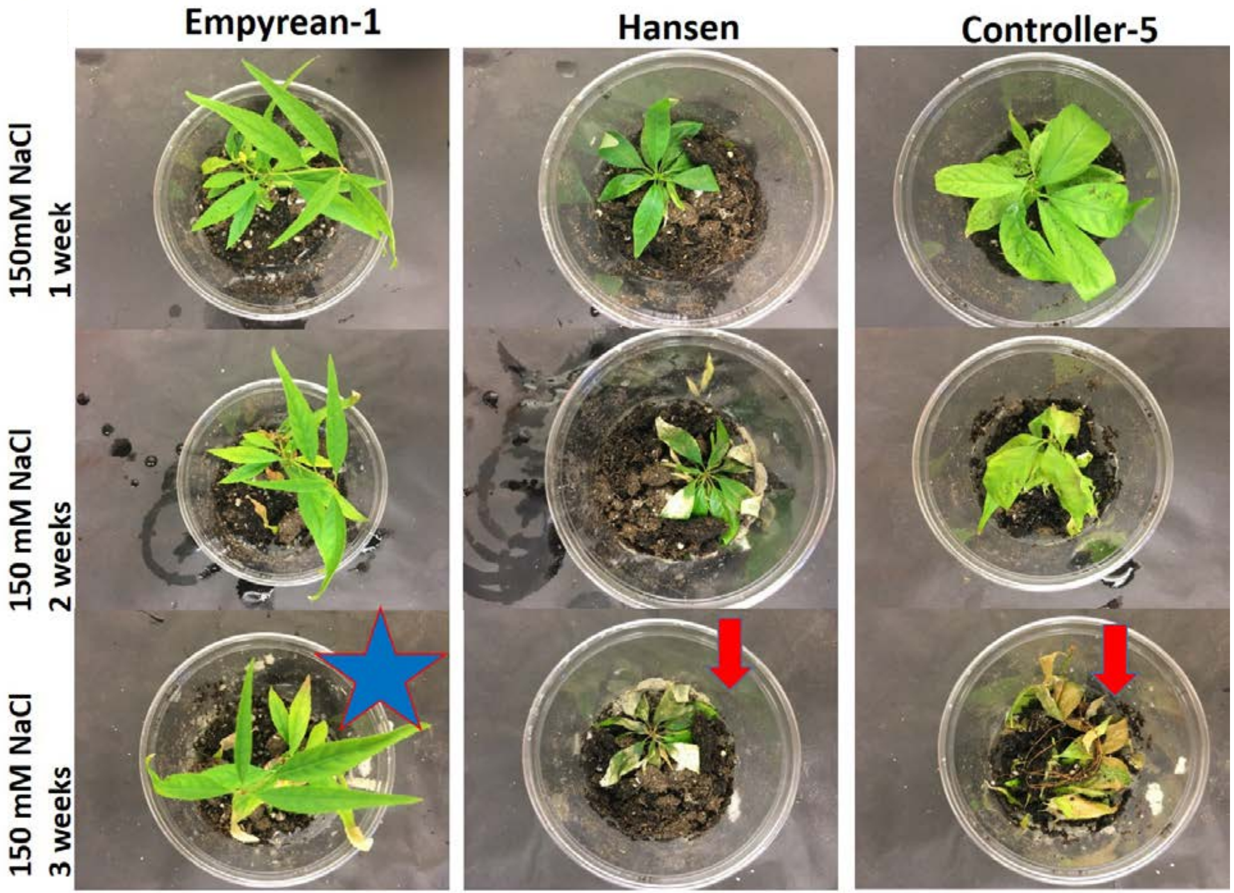


Turface based support

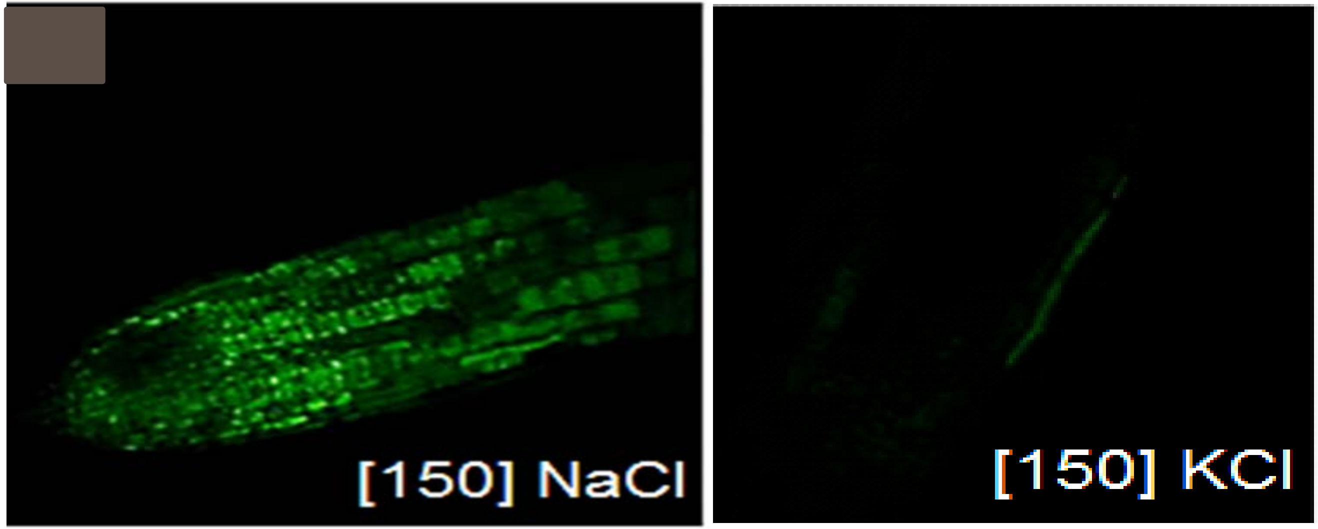
Phenotypic characterization of rootstocks

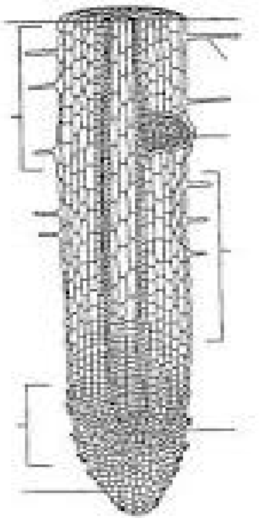


Phenotypic characterization of rootstocks



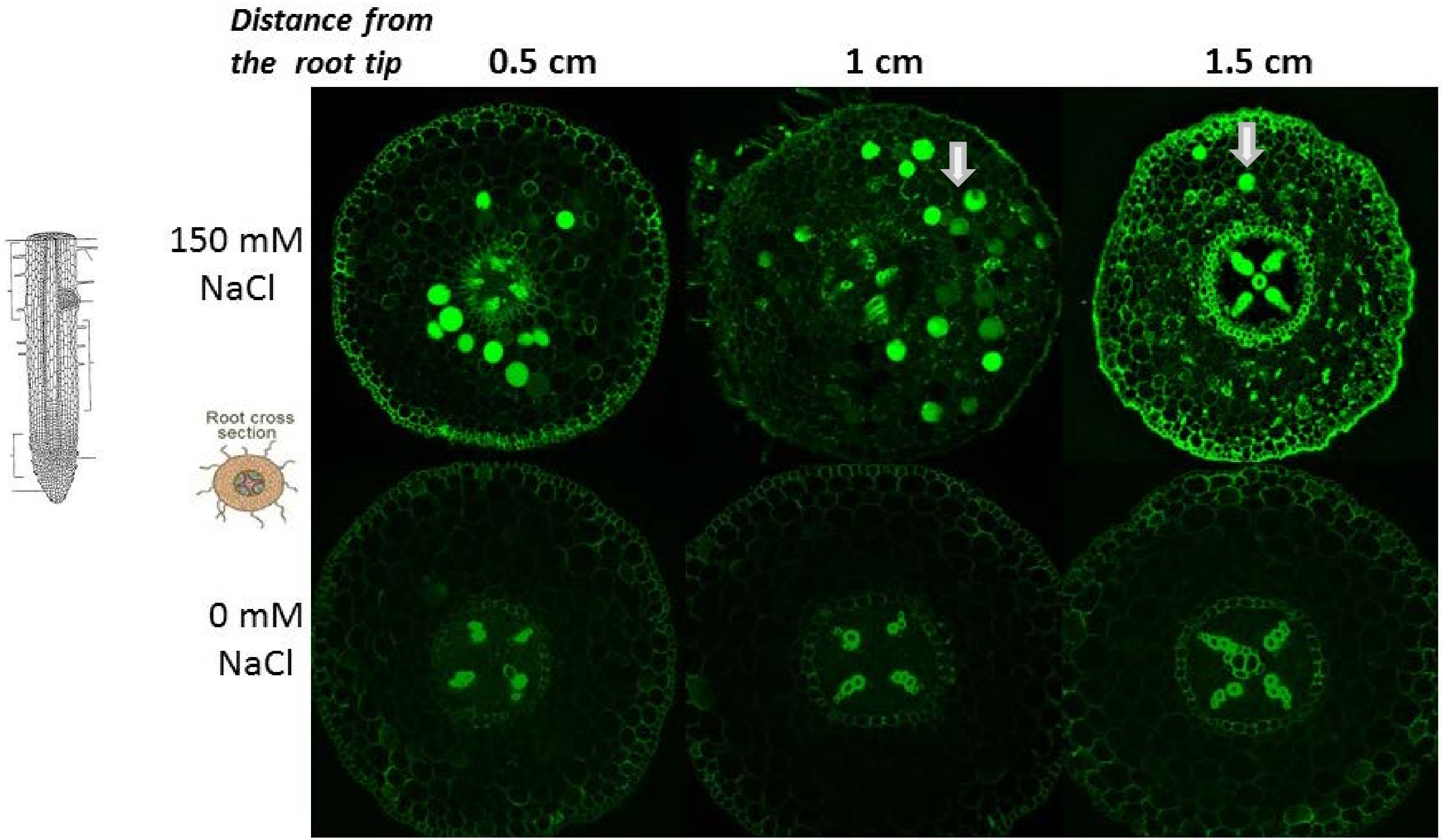
SELECTIVITY OF CORONA-GREEN WITH SODIUM



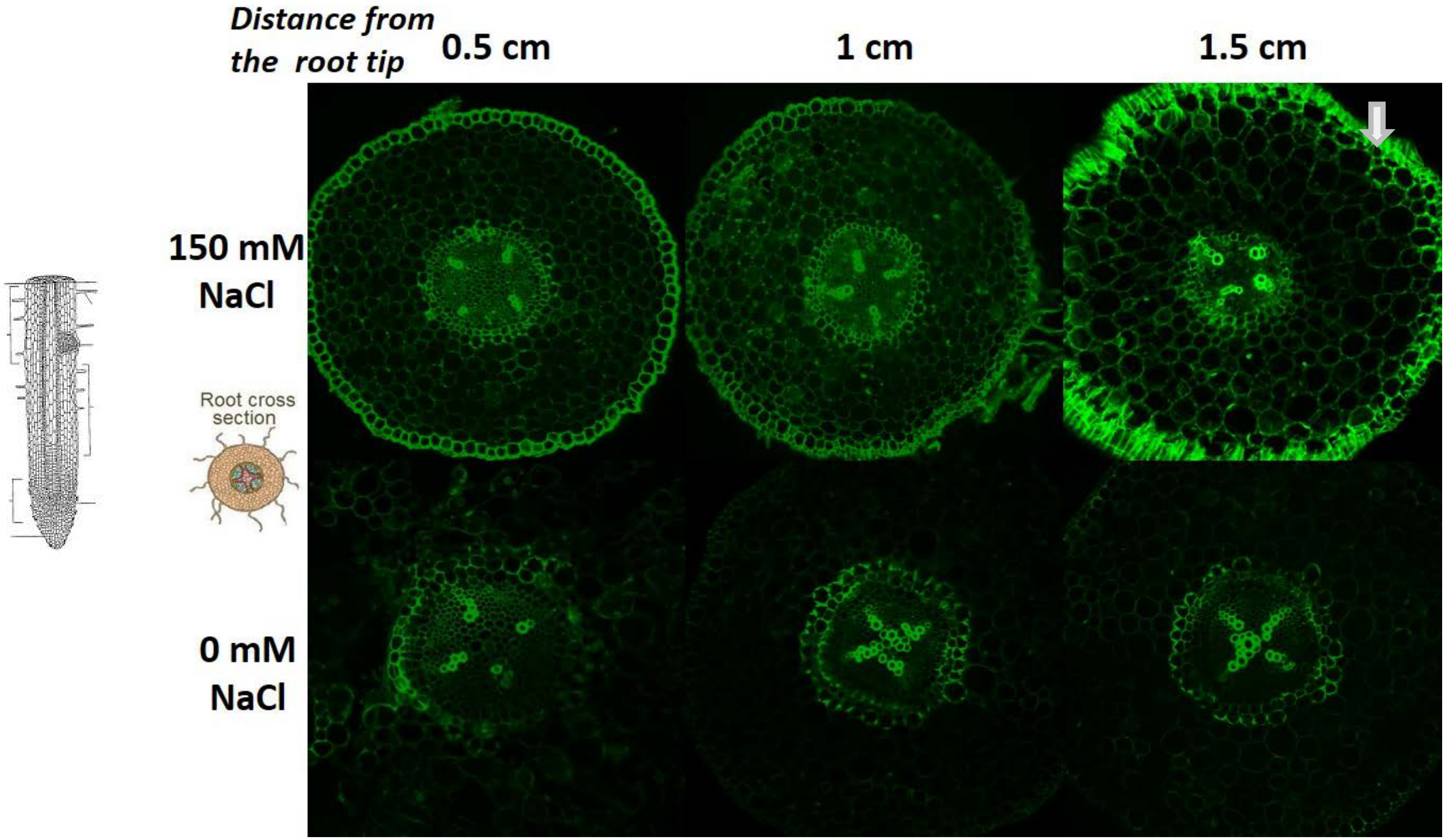


We established methods for sodium, potassium and chloride localization.

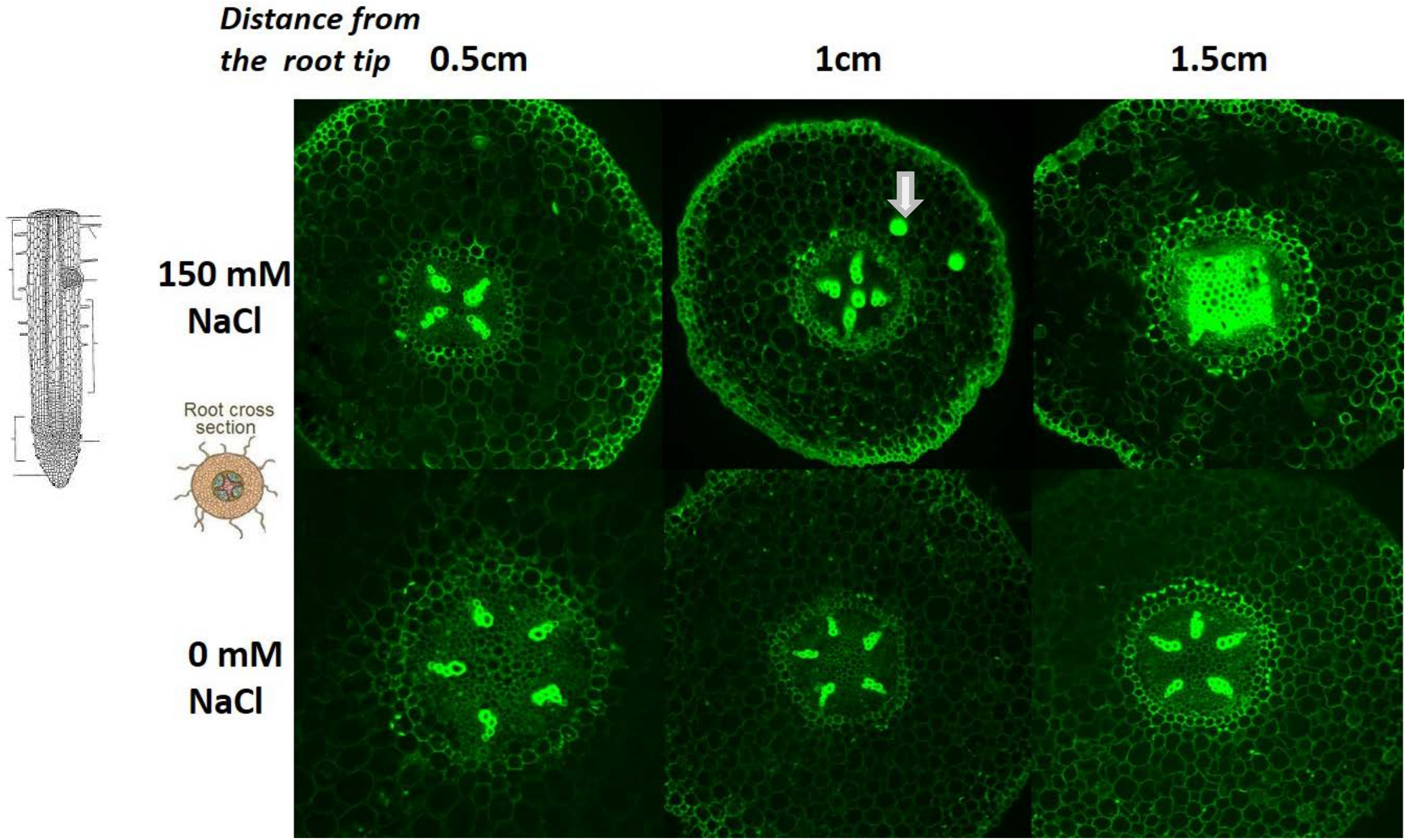
Sodium localization in Controller-5 under salinity treatment



Sodium localization in Empyrean-1 under salinity treatment



Sodium localization in Hansen under salinity treatment



Summary

- Methods for sodium and potassium and chloride have been established

- **Unique subcellular distribution patterns of sodium were observed in the evaluated rootstocks**

- **The results suggest that an exclusion mechanism of sodium transport takes place in Empyrean-1 compared to Controller-5**

Acknowledgements

Yukun Cheng

Thomas Wilkop

Collaborators:

Judy Jernstedt

Hank Dorsey

UCDAVIS PLANT SCIENCES

Sierra Gold Nurseries

Understanding Genetic and Physiological Bases of Salt Tolerance in Almond Rootstocks

Devinder Sandhu, Research Geneticist

Jorge Ferreira, Plant Physiologist

Donald L. Suarez, Soil Scientist

USDA US Salinity Laboratory
Riverside, CA

OBJECTIVES

- Evaluate diverse rootstocks for tolerance to salinity of solutions of mixed salt composition.
- Characterize physiological and biochemical markers associated with salt tolerance and salt composition of irrigation water in almond rootstocks.
- Identify and characterize the genes involved in salinity tolerance in almond rootstocks.

EXPERIMENTAL SET UP:

- Experiment was set up in a randomized complete block design
- Non-grafted plants of 16 different rootstocks
- 3 replications
- 3 plants per replication (one plant per pot)
- 5 treatments of water (irrigation water composition) with total 720 trees.
- 15 blocks, each containing combinations of genotypes and replications were created.

SALT TREATMENTS:

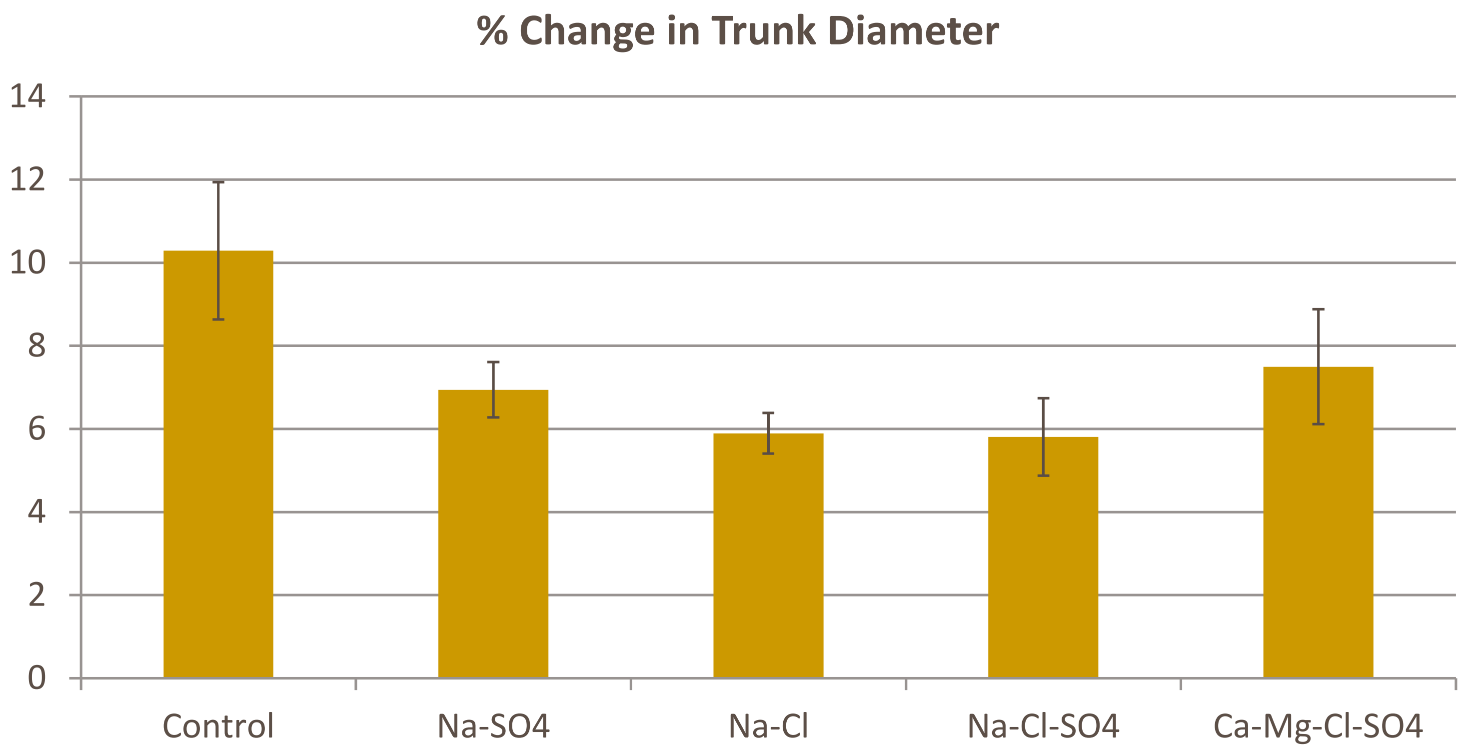
- *Treatment 1* ***(Control)*** *(:* Non saline control {Na^+ 1.65 meq L^{-1}, K^+ 6.5 meq L^{-1}, PO_4^{3-} 1.5 meq L^{-1}, Mg^{2+} 1.3 meq L^{-1}, SO_4^{2-} 1.5 meq L^{-1}, Cl^- 1.5 meq L^{-1}, NO_3^- 5 meq L^{-1} and micronutrients}
- *Treatment 2* ***(Na-SO$_4$)*** *:* mixed cations (Ca^{2+} = 1.25Mg^{2+} = .25 Na^+) with predominantly sulfate (Cl^- = 0.2 $SO^{2-}{}_4$) {Na^+ 18 meq L^{-1}, Ca^{2+} 4.5 meq L^{-1}, K^+ 6.5 meq L^{-1}, PO_4^{3-} 1.5 meq L^{-1}, Mg^{2+} 3.6 meq L^{-1}, SO_4^{2-} 22 meq L^{-1}, Cl^- 4.4 meq L^{-1}, NO_3^- 5 meq L^{-1} and micronutrients}
- *Treatment 3* ***(Na-Cl)*** *:* mixed cations (Ca^{2+} = 1.25Mg^{2+} = .25 Na^+) with predominantly chloride ($SO^{2-}{}_4$ = 0.2 Cl^-) {Na^+ 15.5 meq L^{-1}, Ca^{2+} 3.8 meq L^{-1}, K^+ 6.5 meq L^{-1}, PO_4^{3-} 1.5 meq L^{-1}, Mg^{2+} 3.1 meq L^{-1}, SO_4^{2-} 3.8 meq L^{-1}, Cl^- 19 meq L^{-1}, NO_3^- 5 meq L^{-1} and micronutrients}
- *Treatment 4* ***(Na-Cl-SO$_4$)*** *:* mixed anions SO_4-Cl ($SO^{2-}{}_4$=Cl^-), predominantly Sodium (Ca^{2+} = 1.25Mg^{2+} = .25 Na^+) {Na^+ 17 meq L^{-1}, Ca^{2+} 4.25 meq L^{-1}, K^+ 6.5 meq L^{-1}, PO_4^{3-} 1.5 meq L^{-1}, Mg^{2+} 3.4 meq L^{-1}, SO_4^{2-} 12.32 meq L^{-1}, Cl^- 12.32 meq L^{-1}, NO_3^- 5 meq L^{-1} and micronutrients}
- *Treatment 5* ***(Ca-Mg-Cl-SO$_4$)*** *:* mixed anions $SO^{2-}{}_4$-Cl^- ($SO^{2-}{}_4$=Cl^-), predominantly Ca^{2+} and Mg^{2+}. (Ca^{2+} = 1.25 Mg^{2+} = 5 Na^+) {Na^+ 2.75 meq L^{-1}, Ca^{2+} 13.5 meq L^{-1}, K^+ 6.5 meq L^{-1}, PO_4^{3-} 1.5 meq L^{-1}, Mg^{2+} 10.8 meq L^{-1}, SO_4^{2-} 13.5 meq L^{-1}, Cl^- 13.5 meq L^{-1}, NO_3^- 5 meq L^{-1} and micronutrients}

Treatments 2-5 all had EC = 3.0 dS/m.

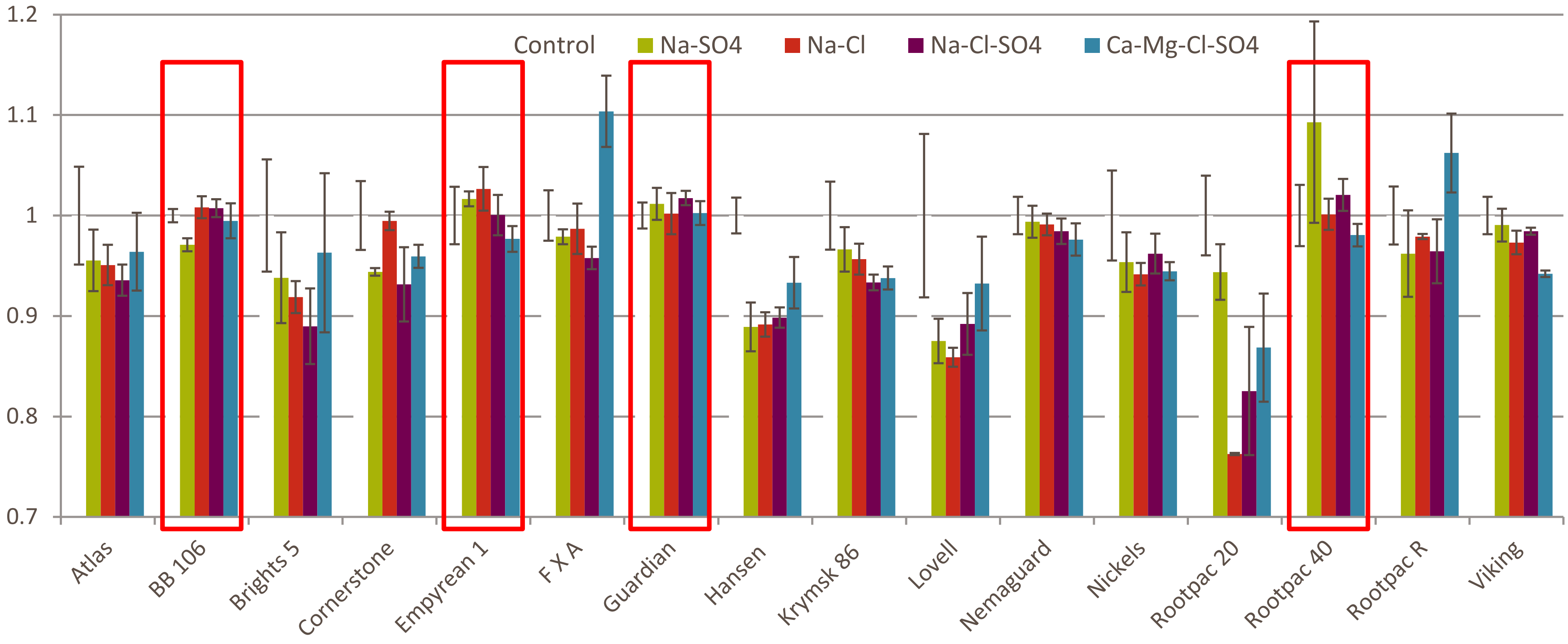
DIFFERENT ROOTSTOCKS USED IN THE STUDY

S.No.	Rootstock	Nursery
1	Atlas	Dave Wilson Nursery
2	BB 106	Sierra Gold Nursery
3	Brights 5	Sierra Gold Nursery
4	Cornerstone	Burchell Nursery
5	Empyrean 1	Sierra Gold Nursery
6	F x A	Sierra Gold Nursery
7	Guardian	Burchell Nursery
8	Hansen	Sierra Gold Nursery, Dave Wilson Nursery
9	Krymsk 86	Sierra Gold Nursery, Fowler Nursery
10	Lovell	Sierra Gold Nursery
11	Nemaguard	Burchell Nursery
12	Nickels	Sierra Gold Nursery
13	Rootpac 20	Agromillora Nursery
14	Rootpac 40	Agromillora Nursery
15	Rootpac R	Agromillora Nursery
16	Viking	Sierra Gold Nursery, Dave Wilson Nursery

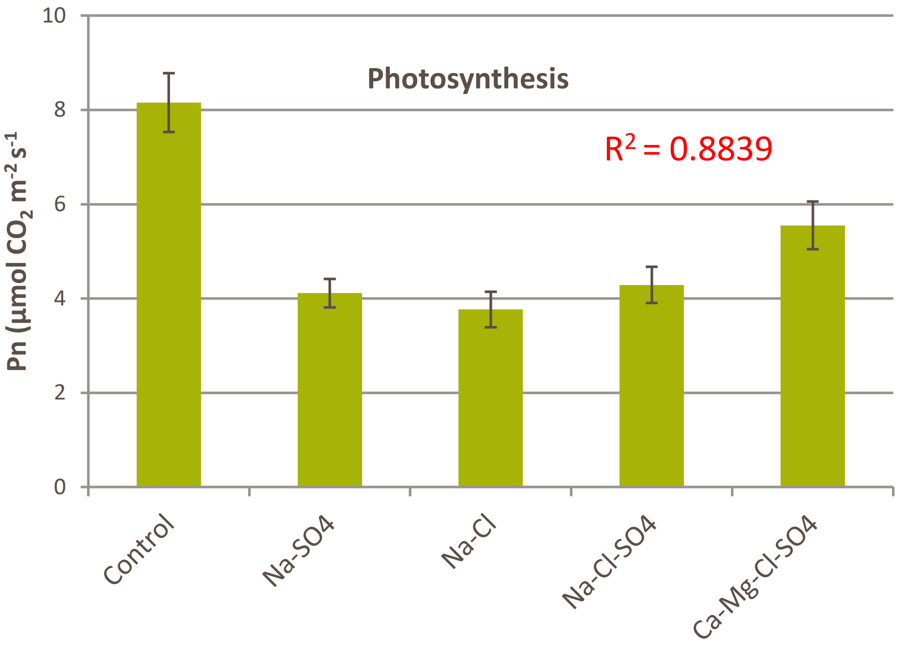
PERCENT CHANGE IN TRUNK DIAMETER IN DIFFERENT SALT TREATMENTS

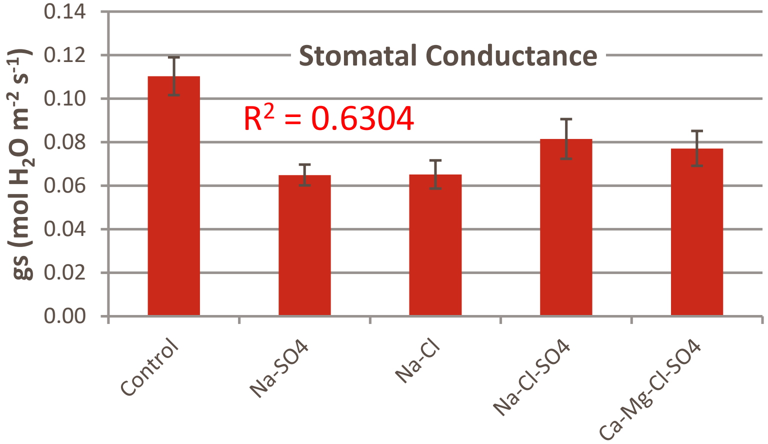


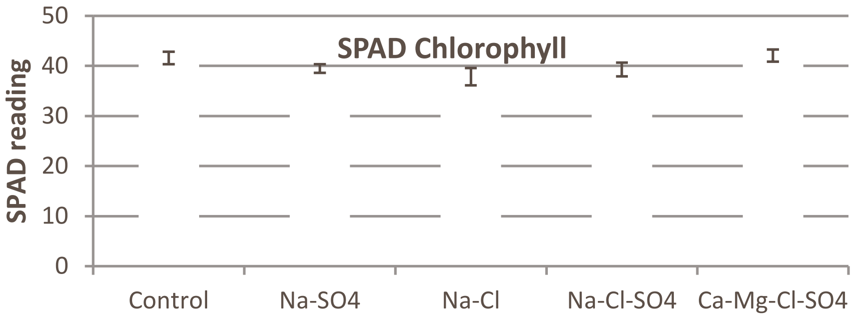
RELATIVE CHANGE IN TRUNK DIAMETER IN 16 ALMOND ROOTSTOCKS UNDER DIFFERENT SALT TREATMENTS



PHYSIOLOGICAL MEASUREMENTS IN ALMOND ROOTSTOCKS UNDER DIFFERENT SALT TREATMENTS

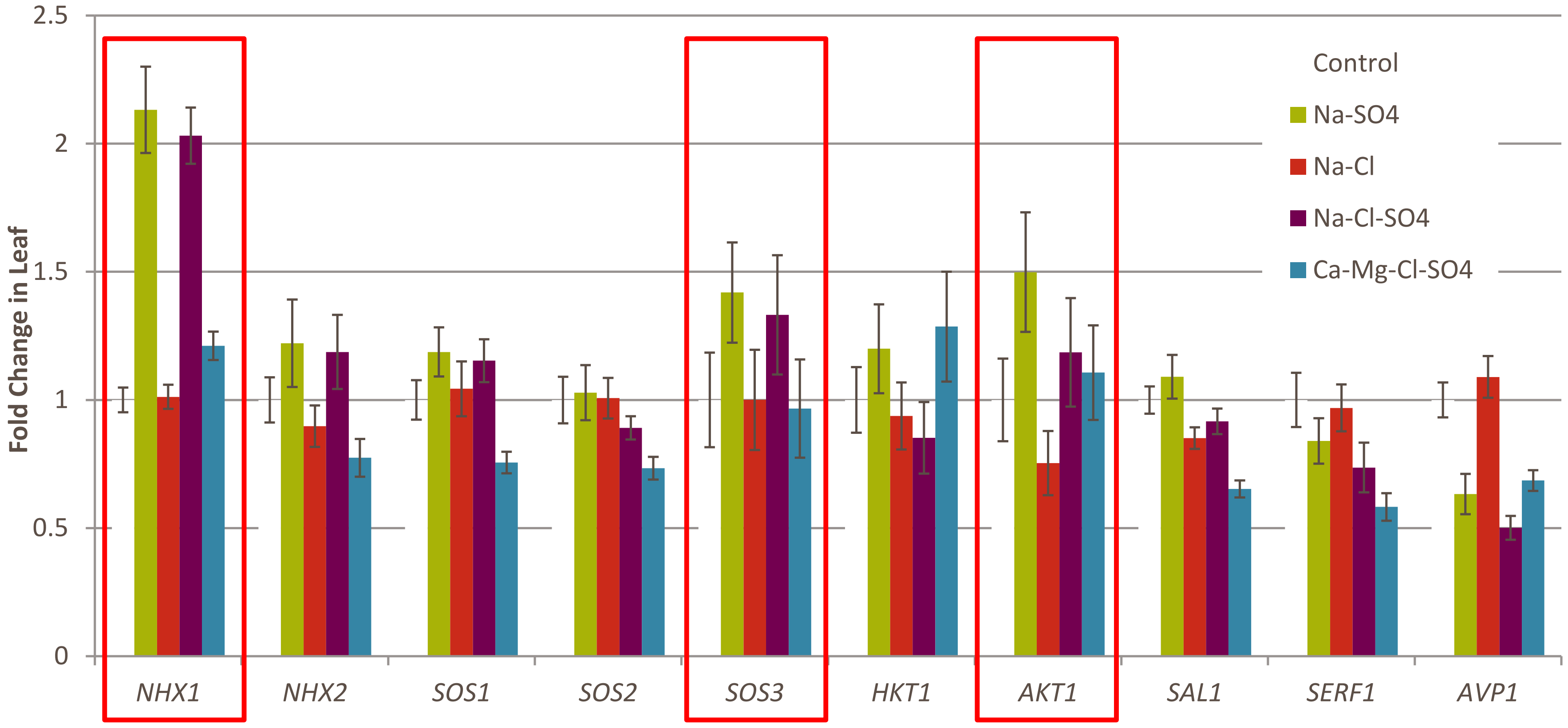




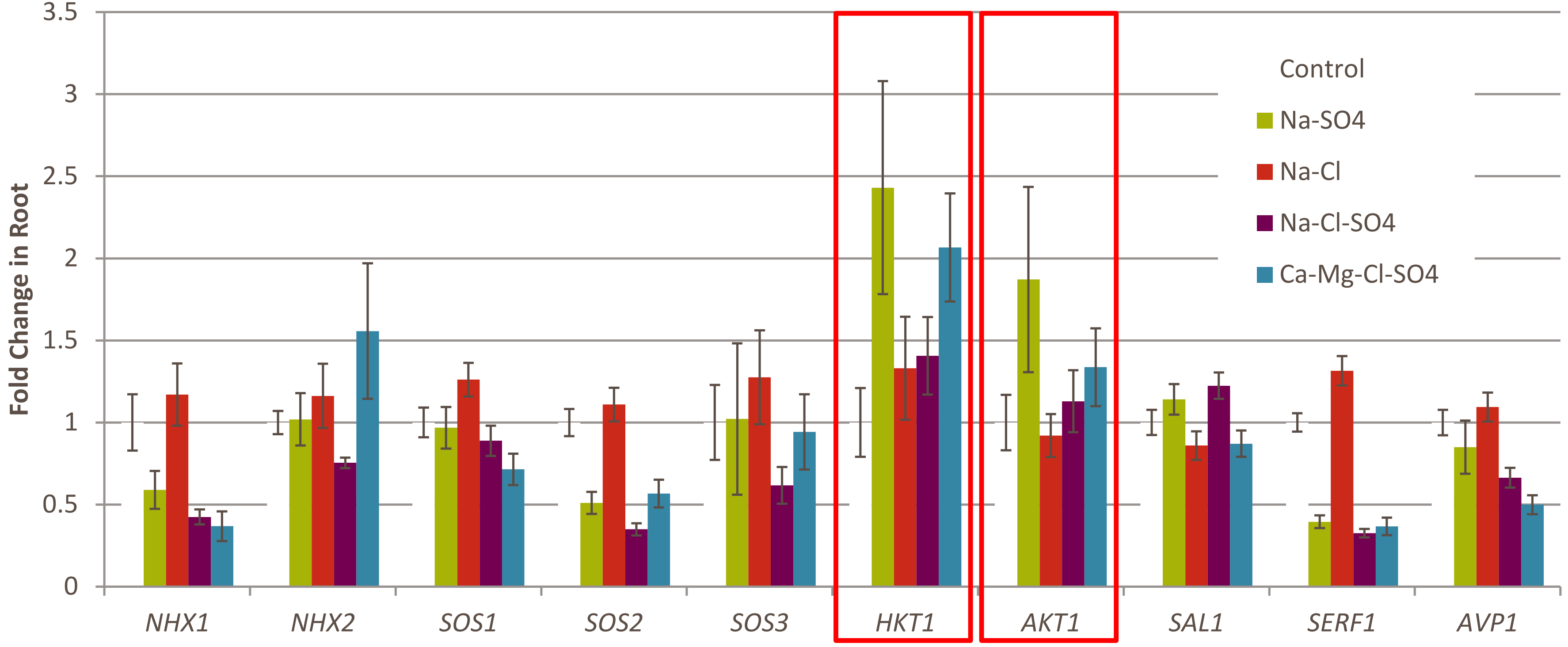


$R^2 = 0.5258$

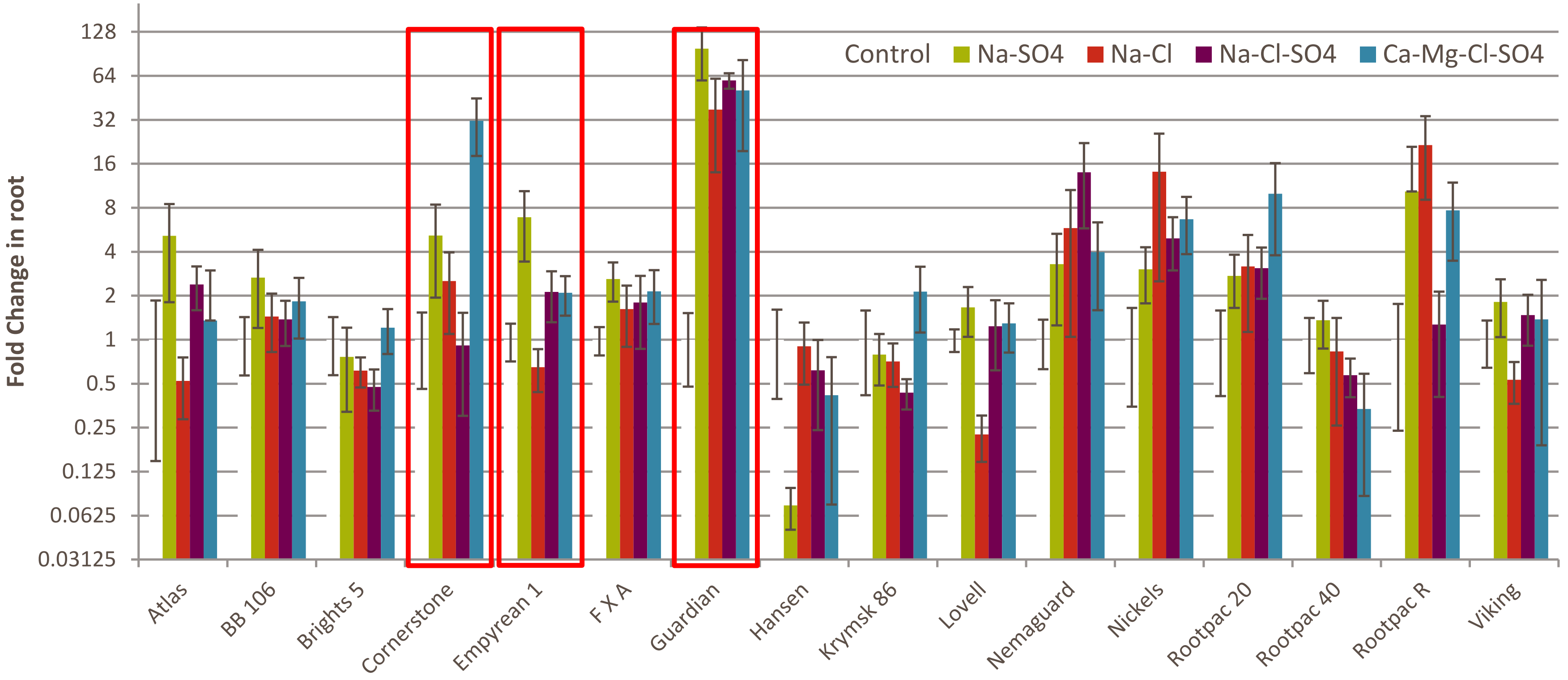
Expression analysis of salt related genes in almond leaves



EXPRESSION ANALYSIS OF SALT RELATED GENES IN ALMOND ROOTS



EXPRESSION ANALYSIS OF *HKT1* IN THE ROOTS OF 16 ALMOND ROOTSTOCKS UNDER 5 SALT TREATMENTS



CONCLUSIONS

- There was maximum reduction in trunk diameter when irrigation water was high in Na and Cl suggesting that mostly Na and to a lesser extent Cl concentrations in irrigation water are the most critical ion toxicities for almond rootstocks

- Photosynthesis showed the highest correlation with change in trunk diameter followed by correlations with stomatal conductance and chlorophyll content.

- NHX1, SOS3 and AKT1 were highly upregulated in salinity treatments in leaves

- HKT1 and AKT1 showed the highest upregulation (expression) in salinity treatments in roots

FUTURE PLANS

- Evaluation of almond rootstocks to determine their tolerance response to a range of salt concentrations.

- Characterizing different almond genotypes based on different components of salt tolerance mechanism.

- Study global changes in the gene expression profiles under normal versus salt stress conditions in almond rootstocks.

Acknowledgements

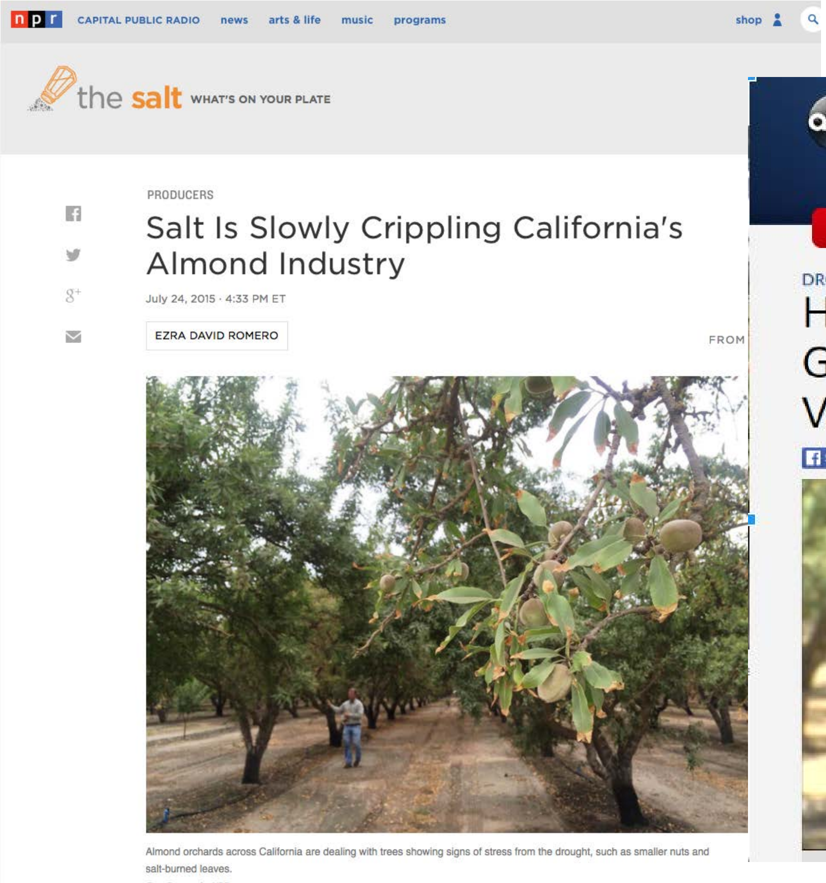
- **Almond Board of California**
- Dr. Manju Pudussery
- Dr. Amita Kaundal
- Dr. Xuan Liu
- Student helpers- Jason, Noah, Sumedha, Diane, Jeffery, Steven, Taylor
- Roger Duncan and Dr. Patrick Brown
- Robert Curtis and Debye Hunter

Nurseries: Sierra Gold, Dave Wilson, Agromillora, Burchell, Fowler

RESEARCH UPDATE: VARIETY AND ROOTSTOCK STUDIES

Francisco Valenzuela, Umit Baris Kutman, Daniela Reineke,
Douglas Carvalho, Mary Aldrich, Saiful Muhammad,
Maziar Kandelous, Patrick Brown
UC Davis

Why salinity?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the salt WHAT'S ON YOUR PLATE

PRODUCERS

Salt Is Slowly Crippling California's Almond Industry

July 24, 2015 · 4:33 PM ET

EZRA DAVID ROMERO

FROM

Almond orchards across California are dealing with trees showing signs of stress from the drought, such as smaller nuts and salt-burned leaves.


abc30 ACTION NEWS KFSN-TV • FRESNO

47°

SECTIONS TRAFFIC WATCH Fresno County North Valley South Valley Foothills-Sier

BREAKING NEWS Car crashes into big rig on a foggy Fresno C

DROUGHT

HIGH SALINITY IN GROUNDWATER IMPACTING VALLEY ALMOND CROP

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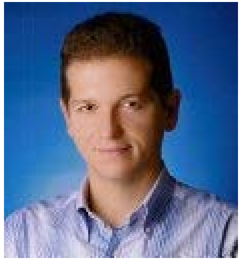
Why salinity?

- Part 1: Understand salinity on almond

- Part 2: Rootstock screening

- Part 3: Micro-irrigation management challenges

Part 1: Understand salinity on almond



Baris Kutman

- Salt levels?
- Salt types?
- Rootstocks?
- Cultivars?

- All those question were answered with several experiments.
  - 7 gal pots.
  - Calcined clay was use (high water-holding capacity and a high cation exchange capacity)
  - Trees were irrigated with complete nutrient solution containing different amounts and types of salinizing agents, depending on the treatment.
  - Irrigation time and frequency were adjusted as needed to meet the demand of the trees and to provide some extra water for leaching.
  - - A leaching fraction of about 25% was used to avoid salt accumulation in pots.

Part 2: Rootstock screening

Mary Aldrich +

Saiful Muhammad

- A rootstock screening for salt tolerance was performed.

- During the second season of trial grafted plants of Nonpareil on different rootstocks were transplanted to 10 gallon pots having Calcined clay (Turface).

- Plants were irrigated with nutrient solution having all essential nutrients with an EC_w of ~0.6 dS/m and saline treatment consisted on a mix of 2 NaCl and 1 Na_2SO_4 to represent Na dominant salinity with an EC_w ~4.5 dS/m.

- Leaves were analyzed for Na^+ and Cl^- concentration.

- Plant canopy size was estimated by taking pictures and analyzing images.

Part 3: Micro-irrigation management challenges

Francisco Valenzuela

+

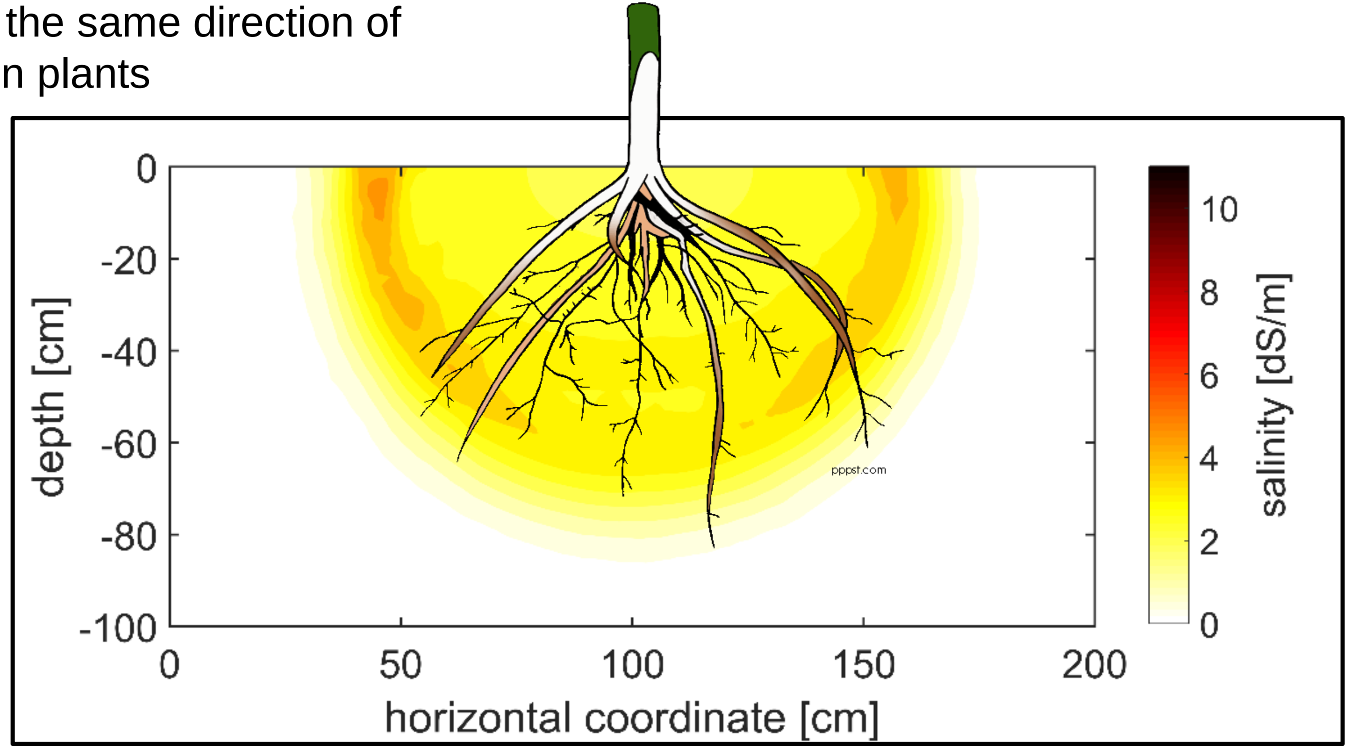
Daniela Reineke

- Experiment to understand physiology of trees under heterogeneous saline conditions
    - Split-root experiment approach.
    - Solution culture allow us to answer key questions to understand tree response.

- Once obtained all the physiological questions (small picture), we can address the field problem (big picture)
    - Lysimeters using mass balance approach.
    - Different soils and irrigation used to measure key parameters for computer simulations.

Part 3: Micro-irrigation management challenge

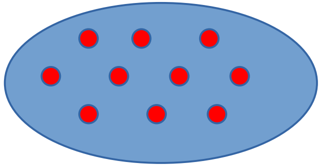
Transversal "cutting" of the row.
Drips placed in the same direction of the row between plants

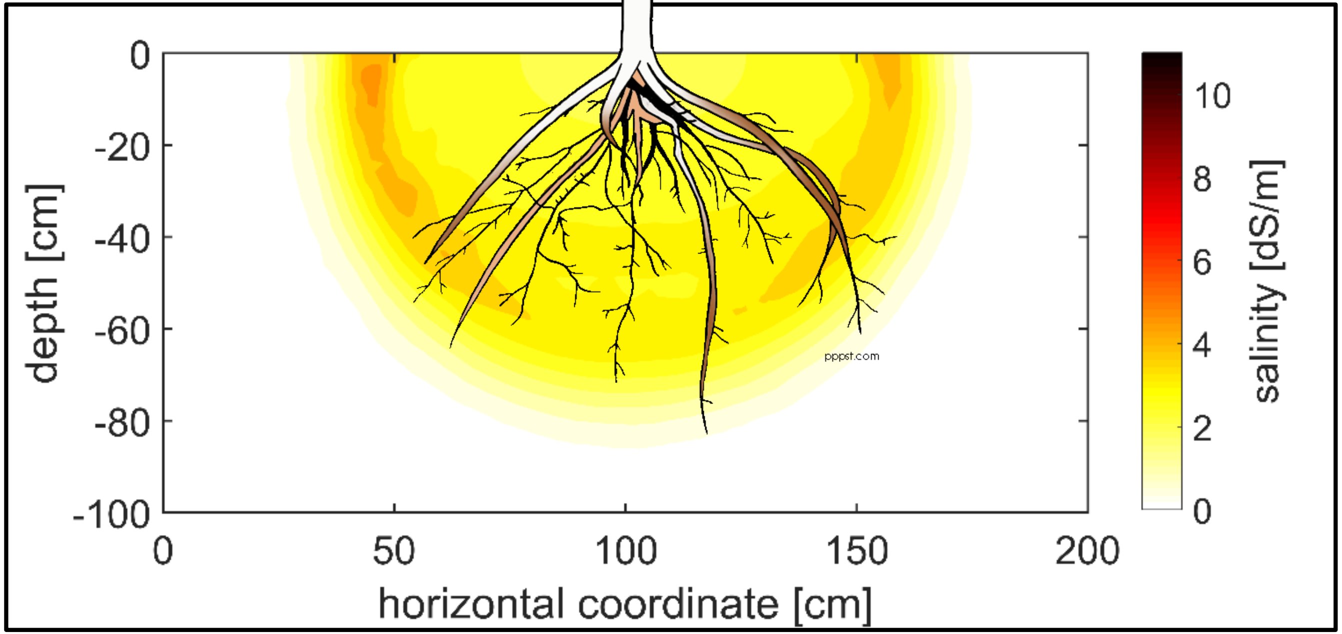


(Reineke and Brown, 2016 unpublished simulation)

Part 3: Micro-irrigation management challenge

Irrigation water added to the roots (just 1 dS/m ~ 10 mM of NaCl)

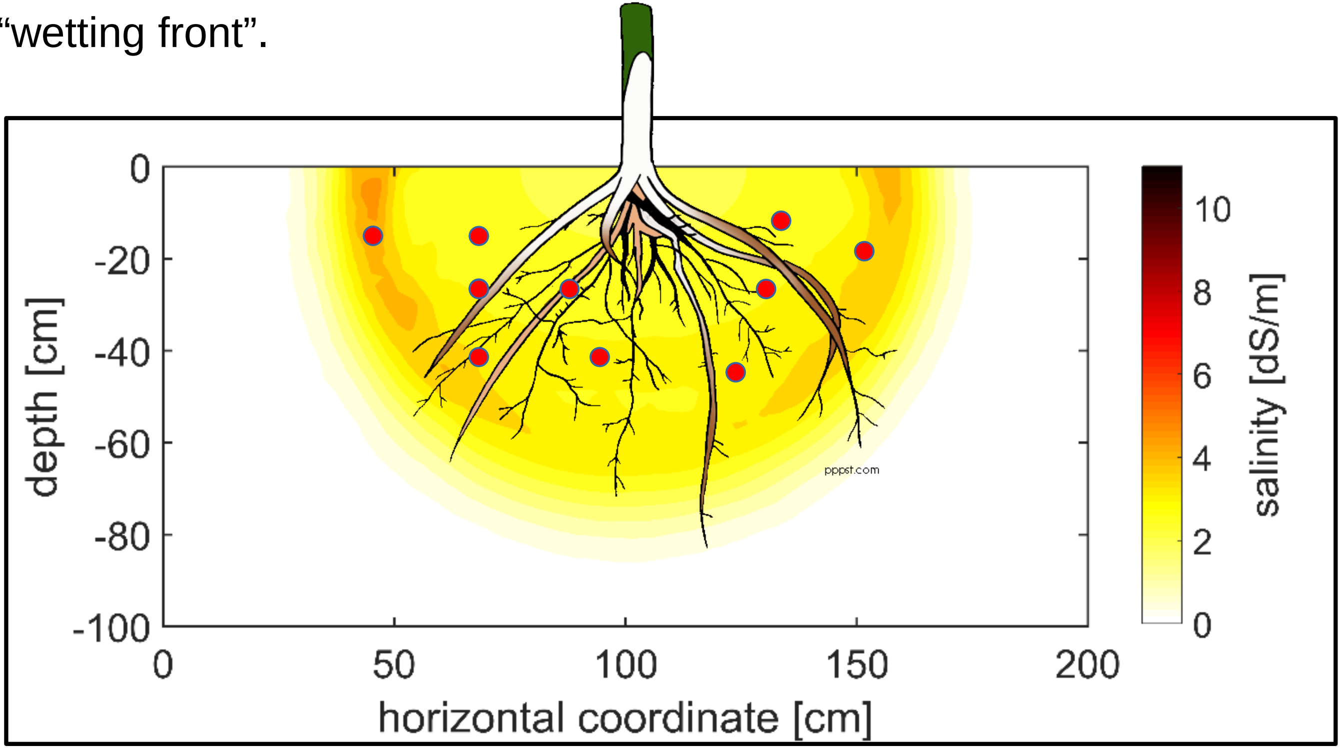




(Reineke and Brown, 2016 unpublished simulation)

Part 3: Micro-irrigation management challenge

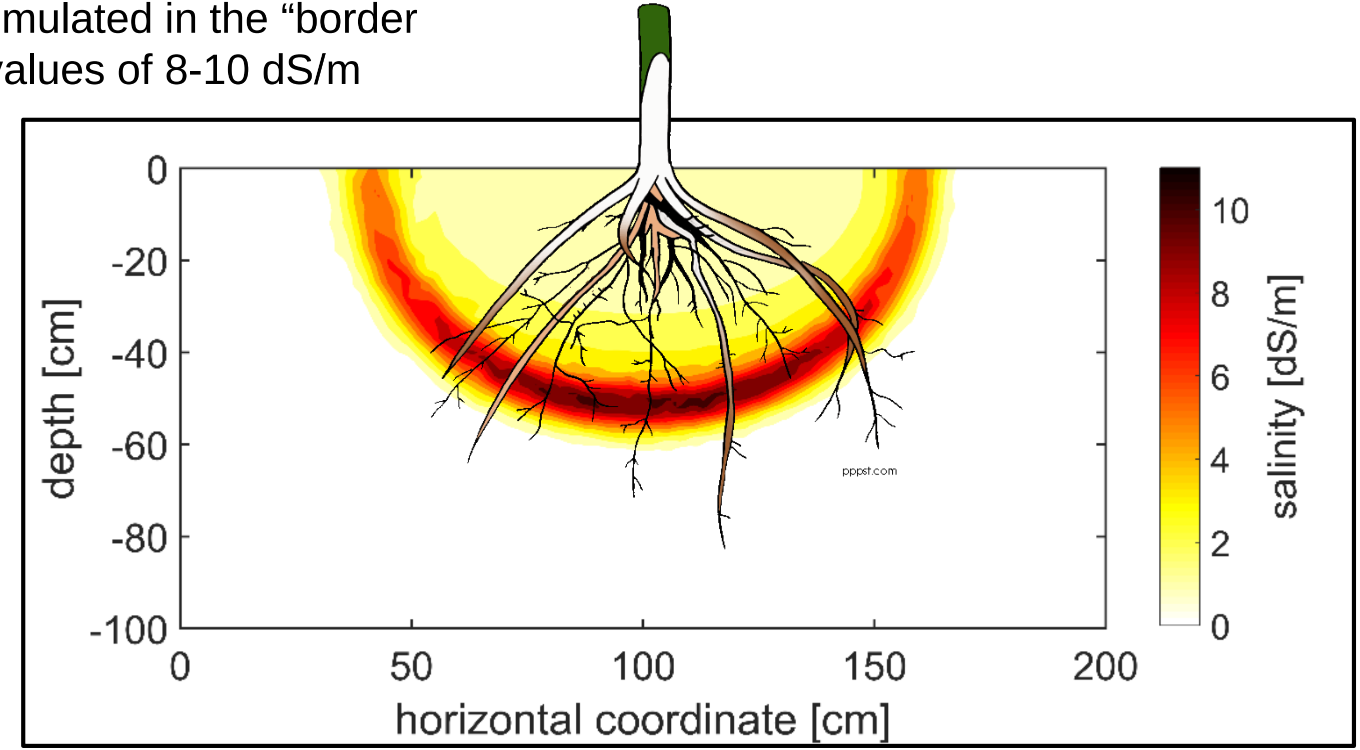
Salts are going to be washed out of the root zone by the “wetting front”.



(Reineke and Brown, 2016 unpublished simulation)

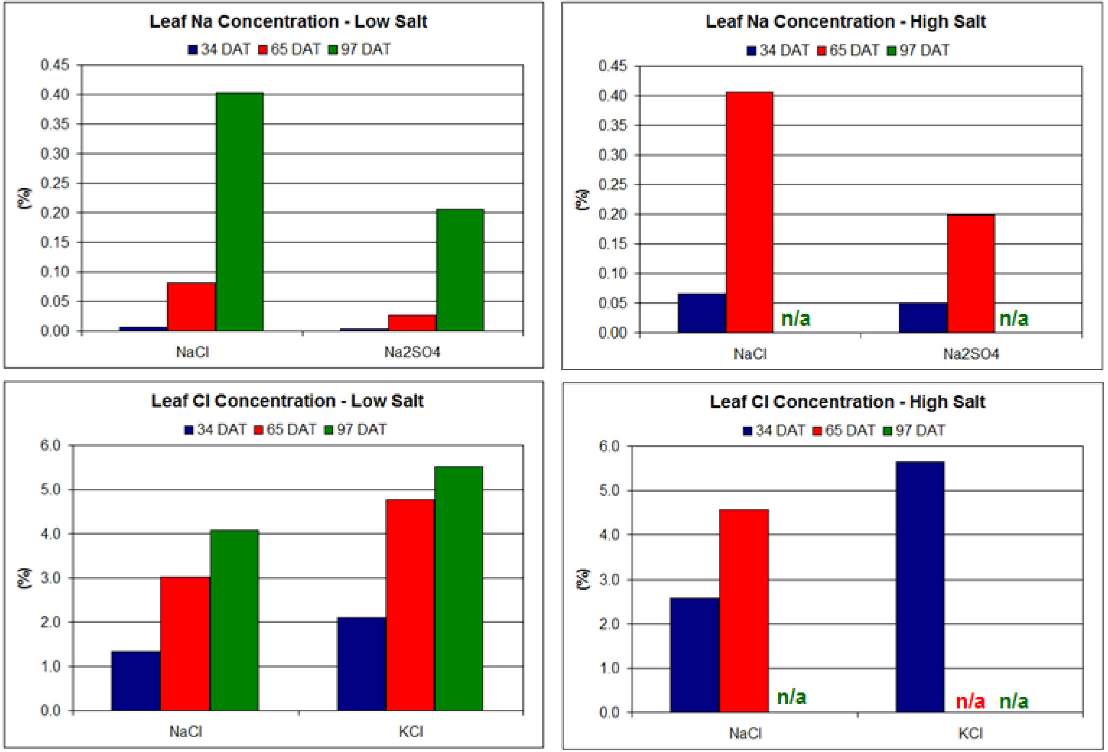
Part 3: Micro-irrigation management challenge

After several irrigation events. Salts are going to be accumulated in the “border zone” reaching values of 8-10 dS/m



(Reineke and Brown, 2016 unpublished simulation)

Results: Part 1: Understanding salinity on almond

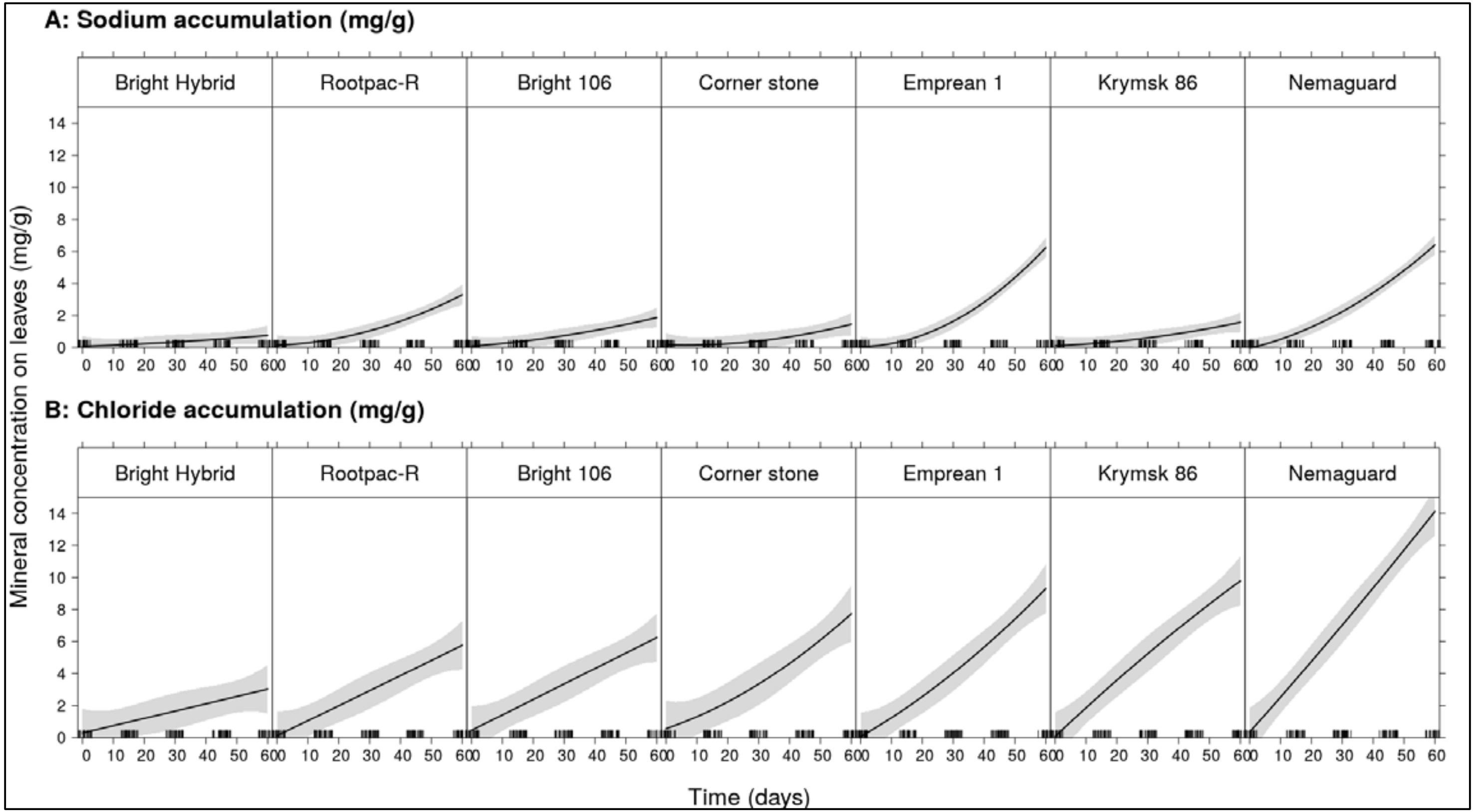


Take home message:

- Toxicity observed on leaves is dominated by Cl^- accumulation
- Sulfate does not contribute to specific ionic toxicity.
- Fertilizing almond with KCl is a bad idea.
- Some cultivars present of Na^+ remobilization from leaves to woody tissue.

(Kutman and Brown, 2015 unpublished data)

Results: Part 2: Rootstock screening (Update 2017)



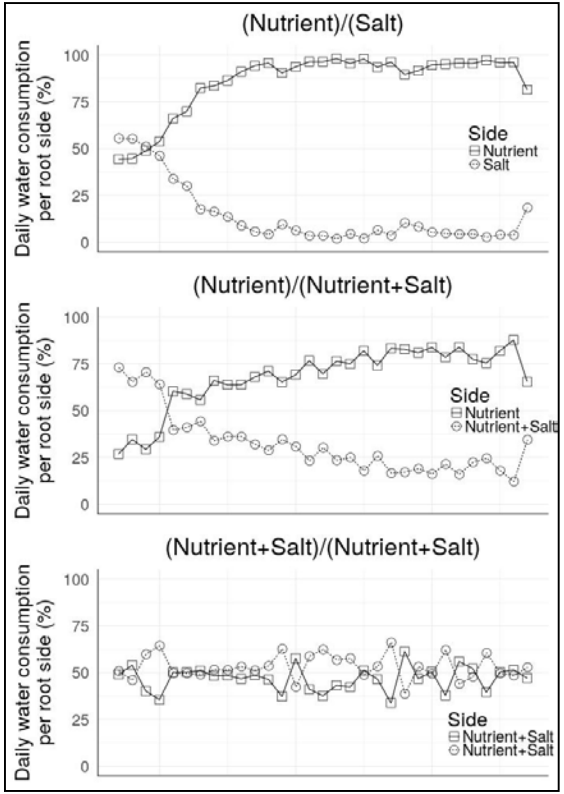
Take home message:

- If you have salinity risk in your filed, use a tolerant rootstock. Bright Hybrid and Viking are good alternatives.

Ask Farm Advisors and Nurseries!!!

(Aldrich, Muhammad and Brown, 2017 unpublished data)

Results: Part 3: Micro-irrigation management challenge (Update 2017)



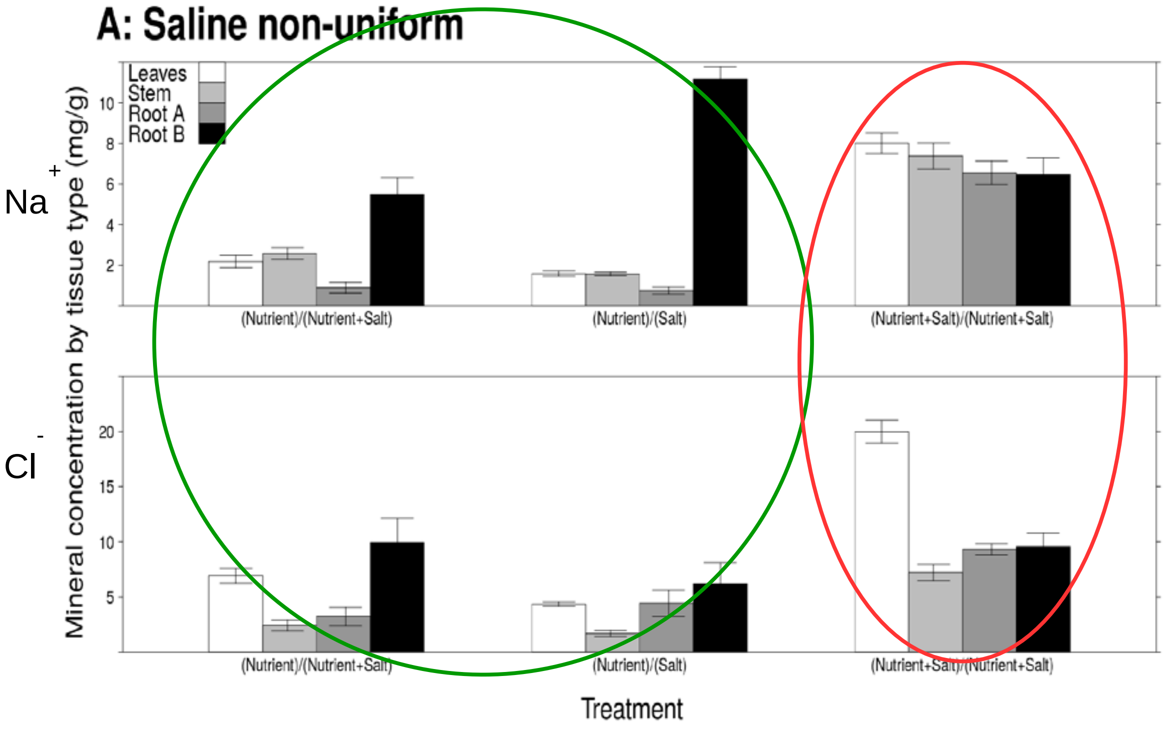
- Results shows us that almond roots are remarkably ‘plastic’, nearly complete shut-down of water consumption from saline root half, if a non-saline root zone was present.
- However, if the saline root-zone contains needed nutrients then uptake from saline root-zone will occur.

Questions:

- Which nutrient was responsible for this response?
- These responses are likely a result of both pure thermodynamic principles but also demonstrate a clear biological adaptability of roots.

(Valenzuela, Kutman and Brown, 2017 unpublished data)

Results: Part 3: Micro-irrigation management challenge (Update 2017)



- A significant decrease on salt accumulation was observed on salt tissue concentration under non uniform saline conditions was observed.
- Lack of nutrients ‘push’ roots to uptake increase uptake of nutrient from saline treated roots, increasing salt accumulation of DI Water/Nutrient+Salts (Check this on the poster session)
- Plants can regulate root hydraulic conductivity based on the presence/absence of nutrients.

(Valenzuela, Kutman and Brown, 2017 unpublished data)

What is next for 2018:

To start with the lysimeter experiment. Measurement/Simulation/Validation must be performed to modeling and represent in a better manner soil/nutrient/plant dynamics.

Answer key questions:

- Can nutrients in the high salinity ‘boundary zone be accessed by the plant?
- How do roots respond to non-uniform and changing root zone ECe?.
- Can roots in high salinity ‘shut-down’?
- How ‘small’ and heterogeneous can this zone be and still support growth?
- Where do you measure soil salinity and how do you interpret results?
- How will the various ions distribute and how will this impact plant performance?
- What are the physiological mechanisms underlying response to heterogeneous salt distribution?

CEUs – New Process

Certified Crop Advisor (CCA)

- Sign in and out of each session you attend.
- Pickup verification sheet at conclusion of each session.
- *Sign in sheets are located at the back of each session room.*

Pest Control Advisor (PCA), Qualified Applicator (QA), Private Applicator (PA)

- Pickup scantron at the start of the day at first session you attend; complete form.
- Sign in and out of each session you attend.
- Pickup verification sheet at conclusion of each session.
- Turn in your scantron at the end of the day at the last session you attend.

Sign in sheets and verification sheets are located at the back of each session room.

What’s Next

Wednesday, December 6 at 11:10 a.m.

- Research Update: Growing and Harvesting – Room 312-313
- Sensory and Analytical: Where Science Meets Art – Room 314
- Going Nuts for Beauty: From California to China – Room 306-307
- Tools for Better Irrigation – Room 308-309