

UNIVERSITY of CALIFORNIA COOPERATIVE EXTENSION

2012 Annual Statewide Pistachio Day

January 18, 2012 Visalia, CA



***Research update: Planting
pistachios in saline soils***

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This isn't morning frost!





***This doesn't look too salty...
or is it?***



Just a little “black alkali”...

Really?



**Some spots
are just too
hot!**

*Research update: Planting
pistachios in saline soils*

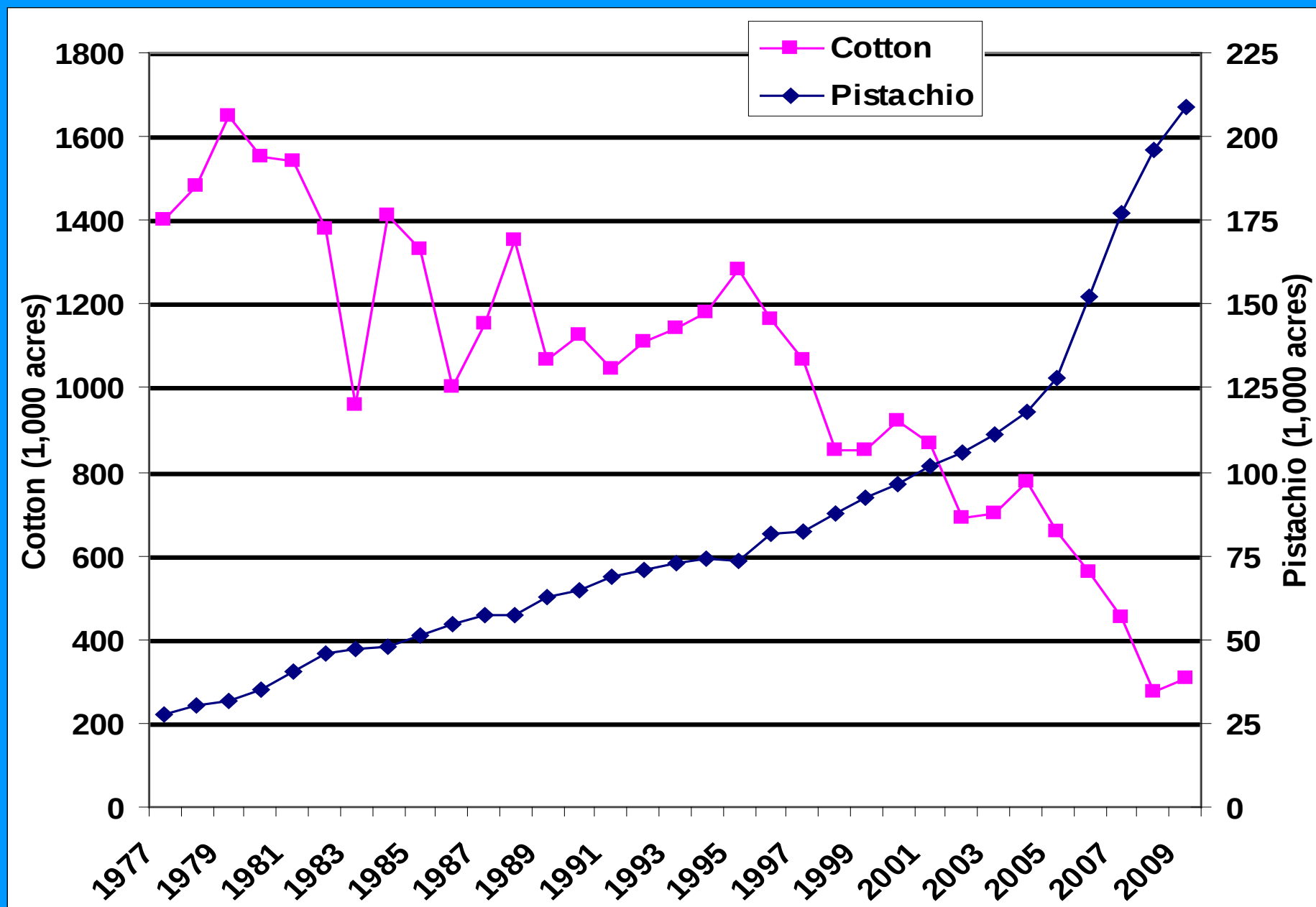
DON'T DO IT!!

Thank you.

Acknowledgements & thanks:

- **Starrh & Starrh Farms
(8 years of cooperation)**
- **Beau Antongiovanni**
- **Paramount Farming Company
– harvest 2011**
- **Rain for Rent Irrigation**
- **Belridge Water District**

Pistachio acreage has doubled in last 10 years



More than ½ million more acres are free of “perched water” but have poor surface soils with excessive silt and sodicity, resulting in “sealing” and poor structure not conducive to optimal root development.



However, much of this land is less expensive than the I-99 corridor, has Panoche-type clay loam soils with high-yield potential and good canal water supplies.



...with large areas that can “drown out” and salinize under surface irrigation. Well managed micro-irrigation systems can reduce or eliminate much of the drainage problem, but when salts become this bad some leaching and reclamation is essential.





The results in some areas of the Westside have been spectacular.

An aerial photograph of a dense orchard. The trees are closely packed, with their green foliage filling most of the frame. Between the trees, there are lighter-colored patches of ground, likely dirt or grass, which form a network of paths or clearings. The overall pattern is a complex, organic grid of green and light tones.

But no orchard is perfect

No marginal burn
on 0.7 dS/m UCB
Rep 1 (9/16/02)



Marginal burn on
0.7 dS/m UCB
Rep 2 (9/16/02)



Boron, chloride and sodium accumulation
killing marginal leaf areas at end of season.



STUDY SITE – NW KERN COUNTY (Aerial 9/19/02)

40 acre pistachio orchard planted 1989

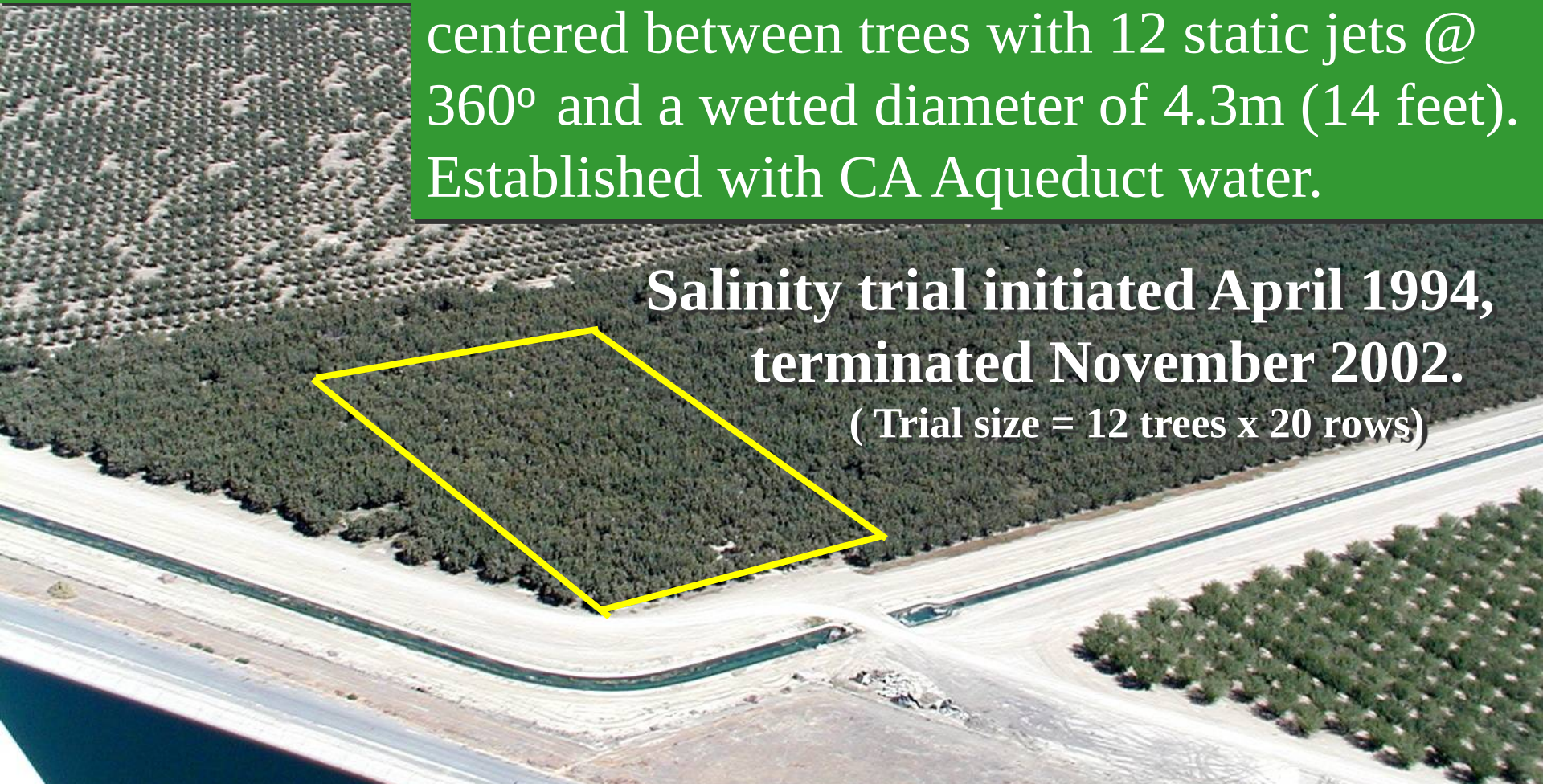
Soil: calcareous Twisselman silty clay

Spacing: 5.2 x 6.1m (17 x 20 feet)

Irrigation: One 55 lph (14.5 gph) microsprinkler/tree centered between trees with 12 static jets @ 360° and a wetted diameter of 4.3m (14 feet). Established with CA Aqueduct water.

**Salinity trial initiated April 1994,
terminated November 2002.**

(Trial size = 12 trees x 20 rows)



0.5-0.7 dS/m



4 dS/m



8 dS/m



12 dS/m



Plot Layout in Orchard

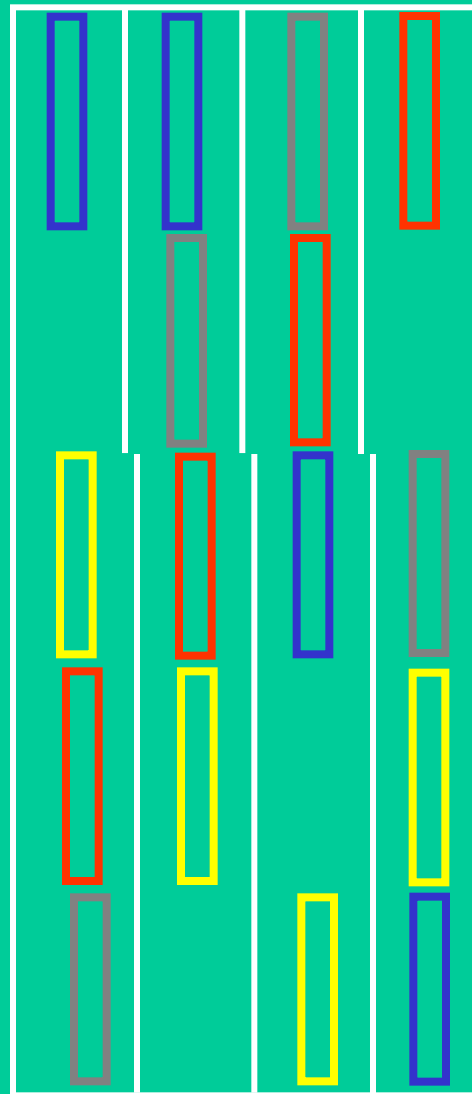
BLOCKS

1

2

3

4



Precipitated salts on soil surface in
12 dS/m plot (10/13/00)



SALINITY TRIAL IRR. WATER @ 8 dS/m

Na:	60 meq/l	Cl:	40 meq/l	B:	1 ppm
	1,380 ppm		1,400 ppm		

Cumulative Yields by Salinity

Cumulative and (Average Annual) Yield per tree; 1997 - 2002

Yield (kg/tree)	Irrigation Water / Root Zone Salinity*				12 dS/m yield as a % of control yield
	0.75 / 4.7*	4.0 / 8.7*	8.0 / 11.3*	12.0+ / 13.2*	
Rootstock					
Atlantica	46.3 (7.7)	47.3 (7.8)	42.4 (7.1)	38.0 (6.3)	82%
PGI	57.3 (9.6)	52.1 (8.7)	51.6 (8.6)	51.8 (8.6)	90%
PGII	50.3 (8.4)	51.8 (8.6)	54.6 (9.1)	42.9 (7.2)	85%
UCB1	56.0 (9.3)	62.0 (10.3)	53.6 (9.4)	36.2 (6.0)	65%

*Soil salinities are end of season 2002 values.

+12 dS/m irrigation was only applied for 1997 through 2002 seasons.

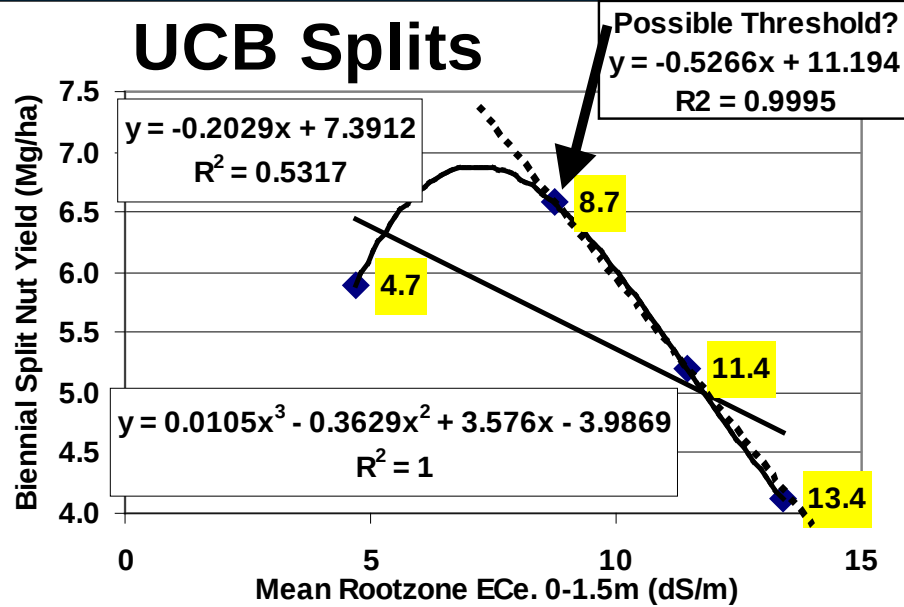
**8th-13th Leaf Average
Annual Yield for 0.75 to
8 dS/m water (lb/ac):**

**PG1
2,531**

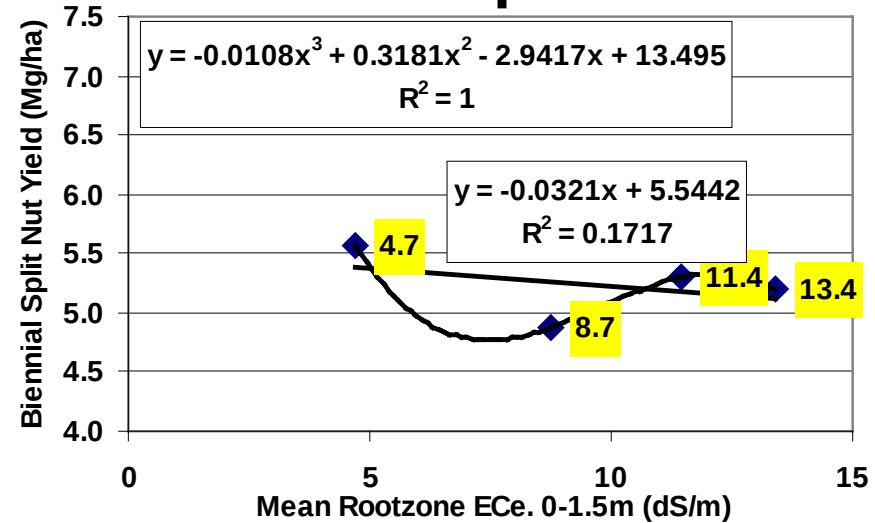
**UCB1
2,727**

Westside Salinity Trial 2001/2002 Biennial Split Nut Yields for all Varieties as a Function of Rootzone Salinity

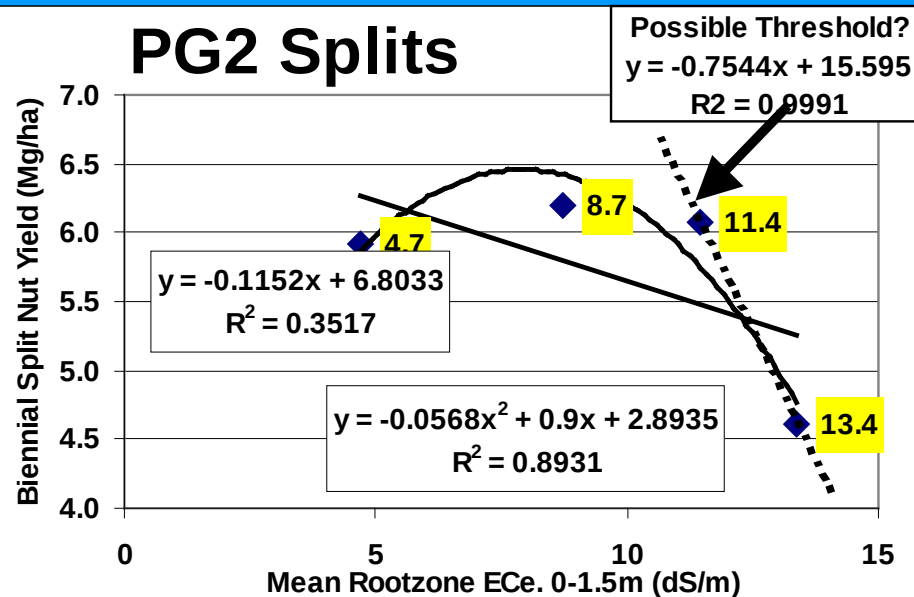
UCB Splits



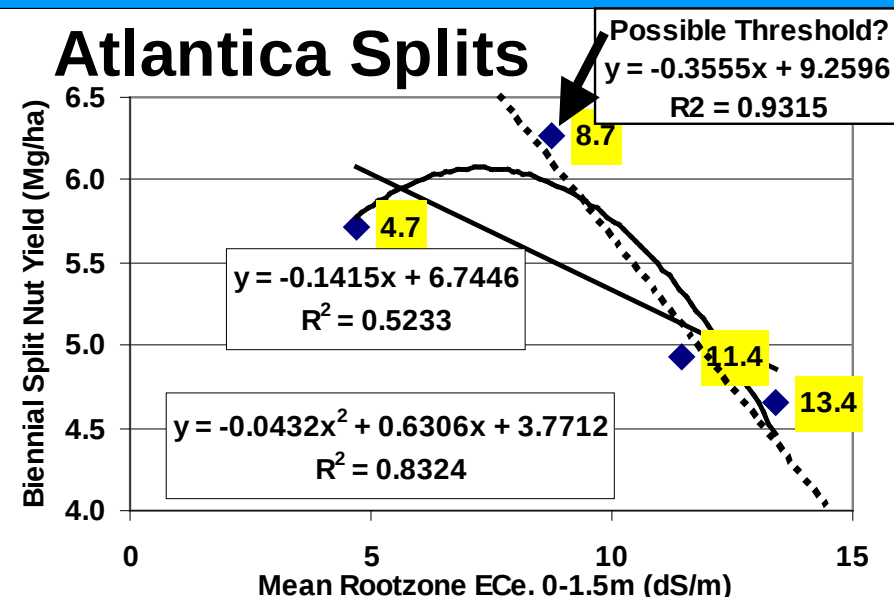
PG1 Splits



PG2 Splits

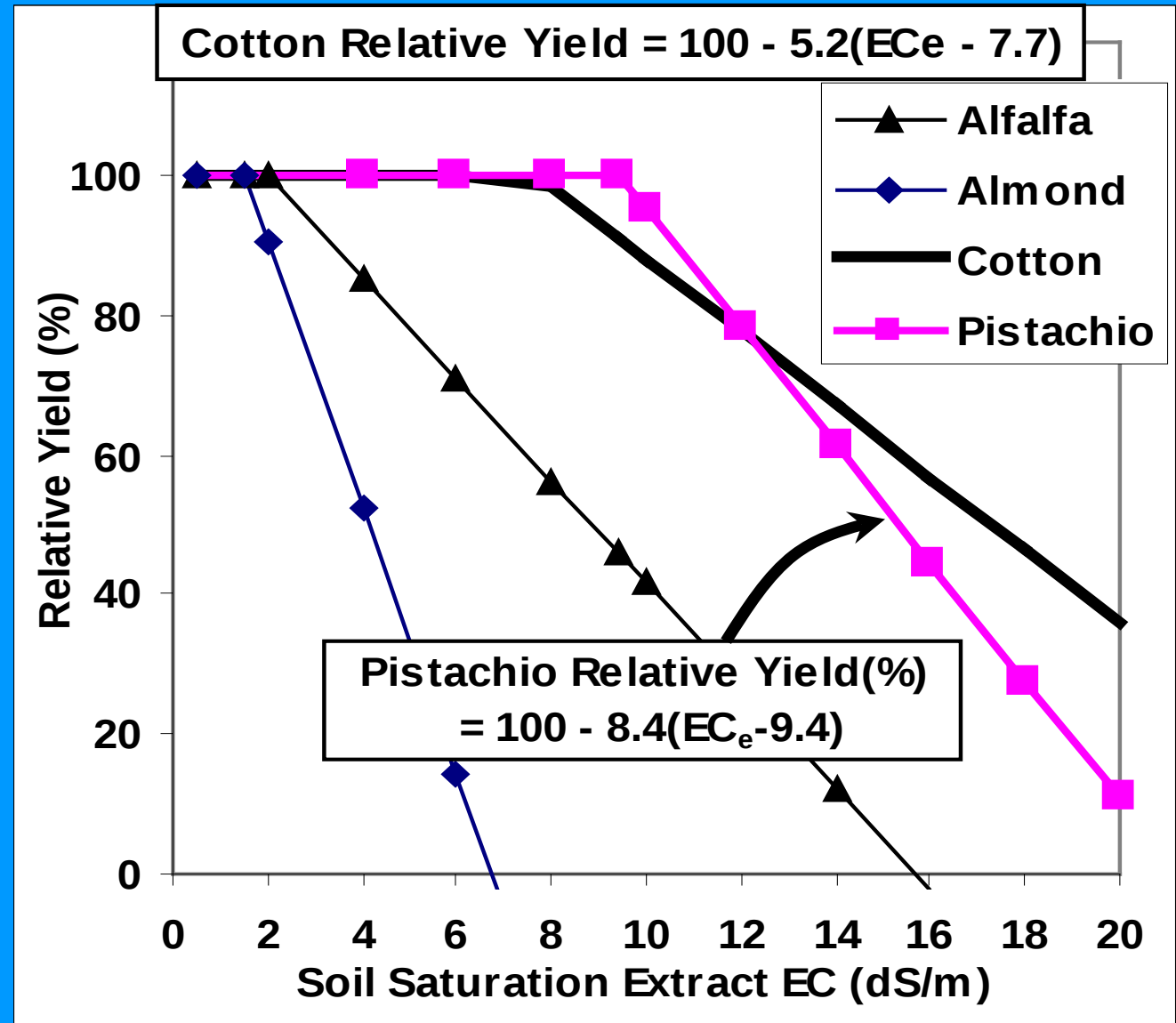


Atlantica Splits



Relative yield of as a function of soil ECe

**Current
salinity
thresholds
for
pistachios**

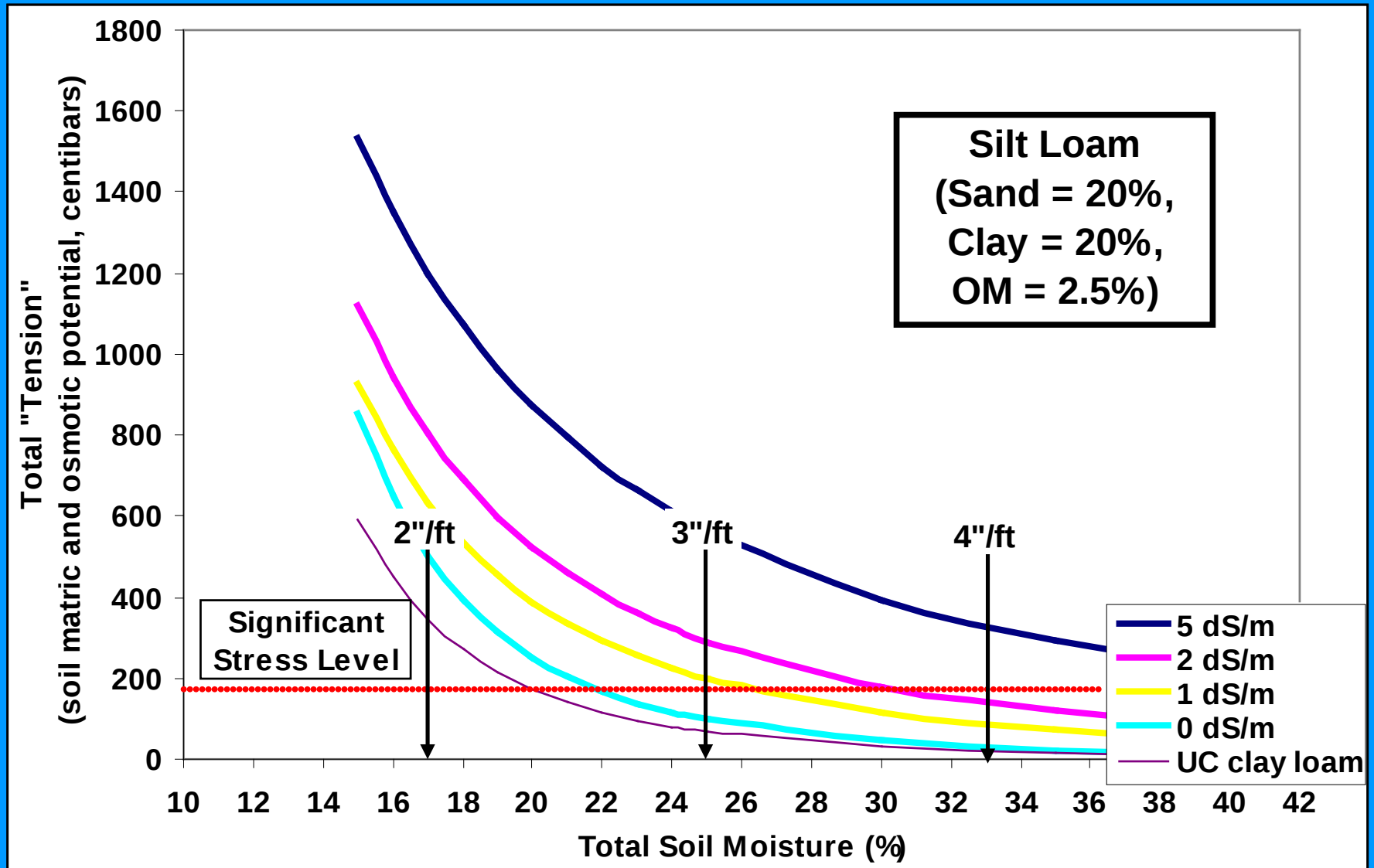


Sanden, B.L., L. Ferguson, H.C. Reyes, and S.C. Grattan. 2004. Effect of salinity on evapotranspiration and yield of San Joaquin Valley pistachios. *Proceedings of the IVth International Symposium on Irrigation of Horticultural Crops, Acta Horticulturae* 664:583-589.

**WHAT ABOUT
DEVELOPING NEW
PISTACHIO
PLANTINGS USING
SALINE WATER?**

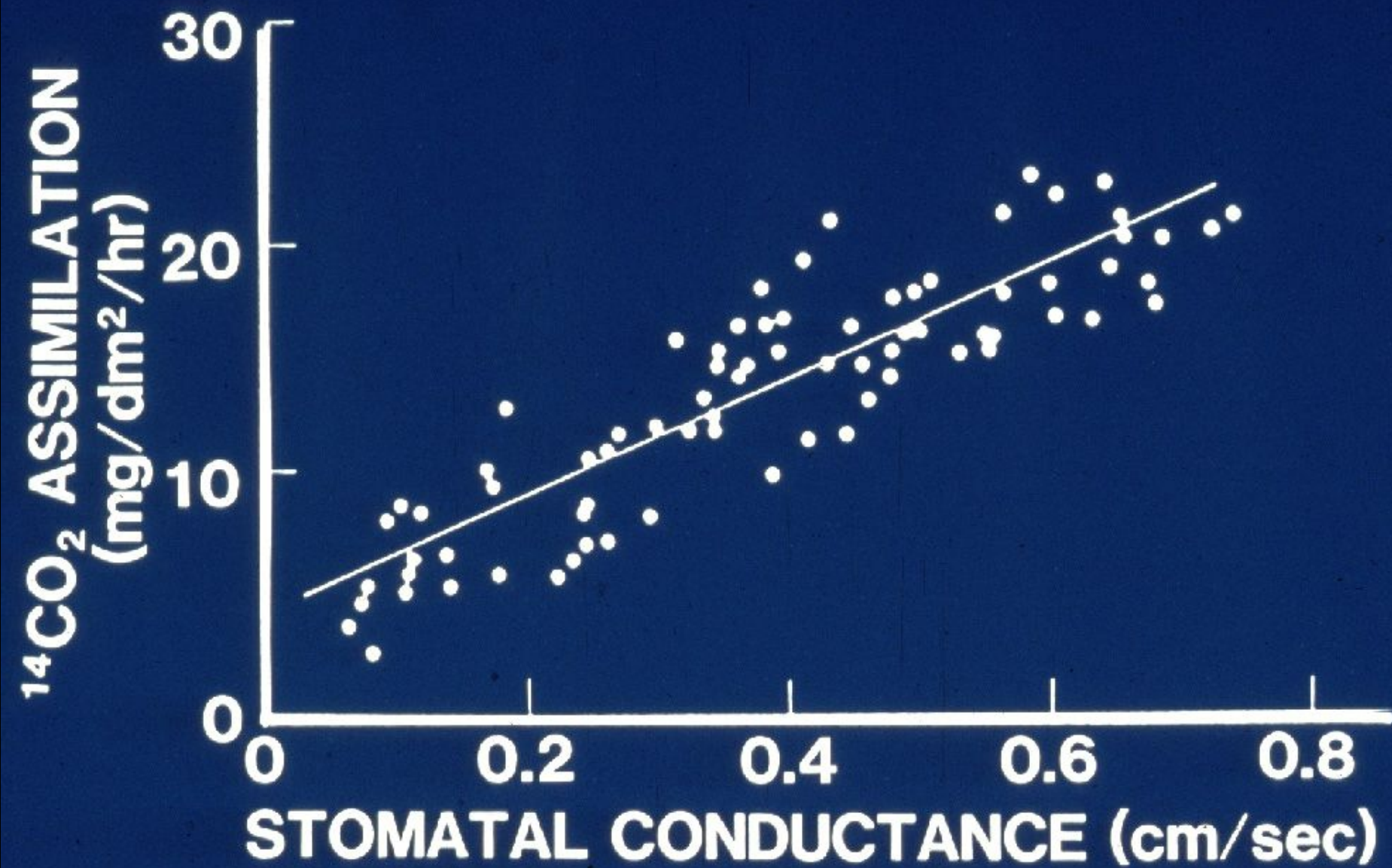
Plant stress can be high even with wet soil

(Effective soil moisture tension for a silt loam soil)

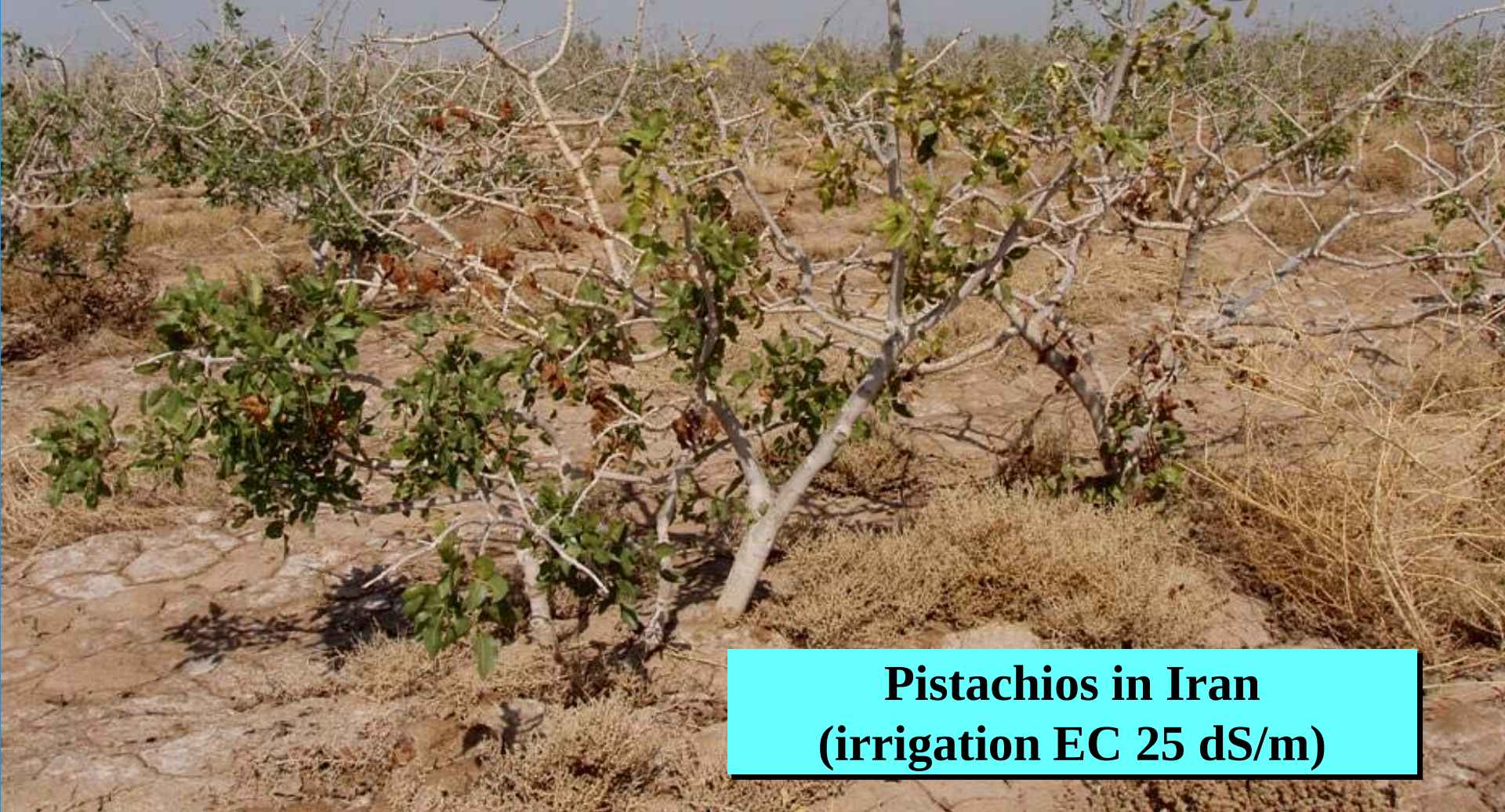


ELECTRON MICROGRAPH OF STOMATA ON THE UNDERSIDE OF A LEAF.

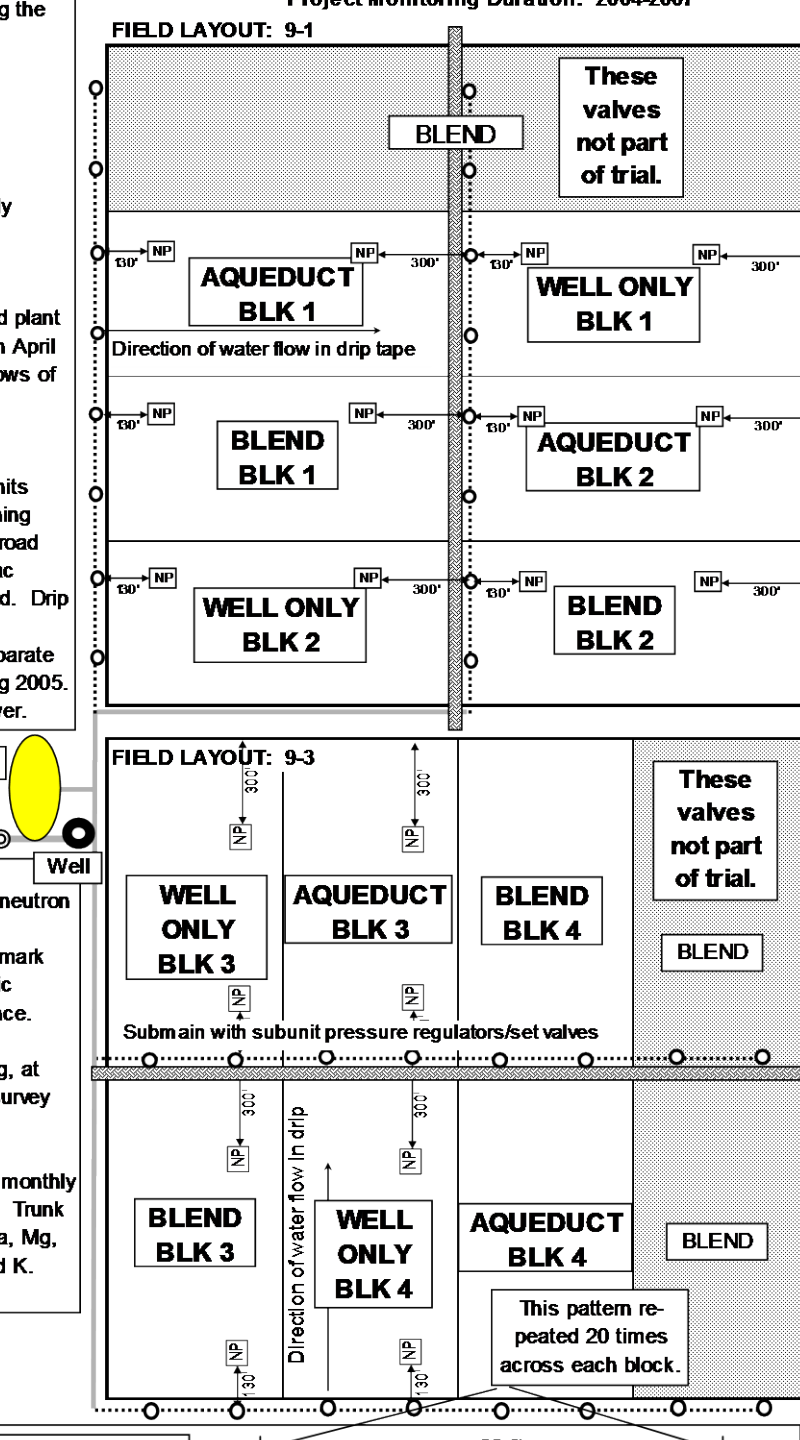
Reduced water, deficit irrigation, causes less turgor pressure in the plant, reduces the size of stomatal openings; thus decreasing the uptake of carbon dioxide and reducing vegetative growth.



Salt increases osmotic potential, costing the plant energy and interferes with water uptake and limits critical processes like cell expansion for germination and shoot growth.



**Pistachios in Iran
(irrigation EC 25 dS/m)**



Belridge Salinity Trial

-- 2, 155 acre fields

-- 12, 19.5 acre testplots





- **Tape: TSX 12-220 @ 0.875 in diameter**
- **Emitters: spaced @ 12 inches**
- **Depth: 9 to 10 inches below bed.**
- **Run: 1280 to 1300 feet**
- **Cotton rows: 38 inches**
- **Irrigation depth: 1.97 in/day**

**SDI tape
system
installed
January
2004**

Objectives

1. Assess the viability of large-scale cotton production and pistachio interplanting using saline groundwater (EC 5 dS/m and B @ 10 ppm) and optimal irrigation scheduling with SDI.
2. Determine crop ET as a function of salinity using simple water and chloride balance.
3. Maintain acceptable soil salinity levels for cotton stand establishment/production and maximum growth of young pistachios.
4. Compare total project profitability under SDI using 3 different levels of salinity: saline water, non-saline CA Aqueduct water and a 50/50 blend.

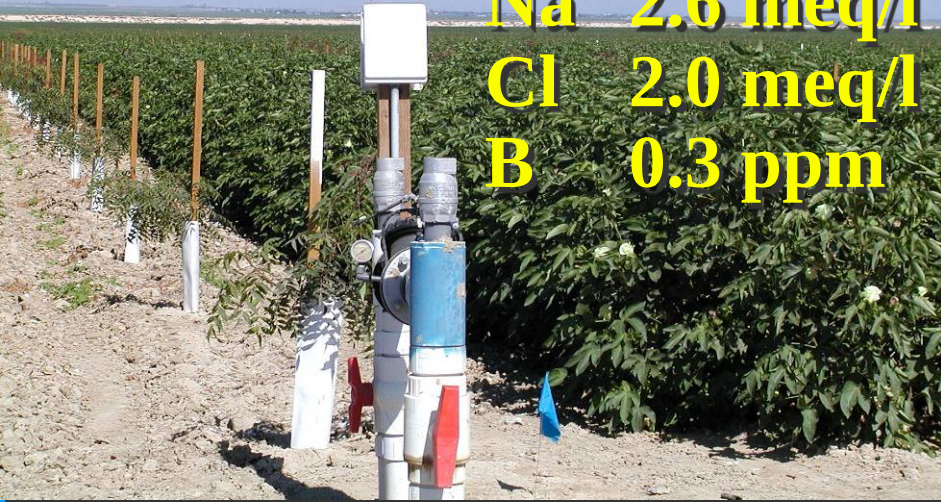
Aqueduct

EC 0.5 dS/m

Na 2.6 meq/l

Cl 2.0 meq/l

B 0.3 ppm



Establishing pistachios
interplanted in Pima
cotton using drip tape
and saline water.

(1st leaf, 8/2/05)

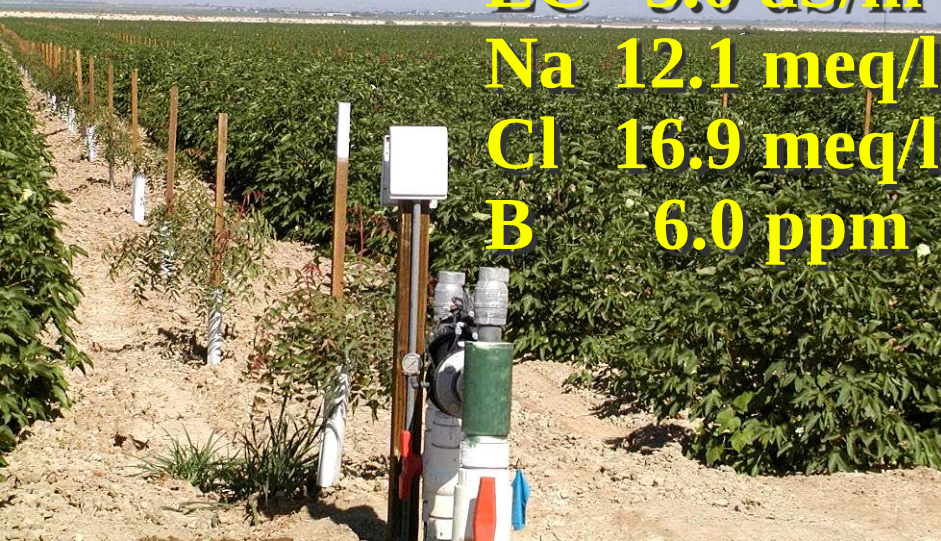
Blend (50/50)

EC 3.0 dS/m

Na 12.1 meq/l

Cl 16.9 meq/l

B 6.0 ppm



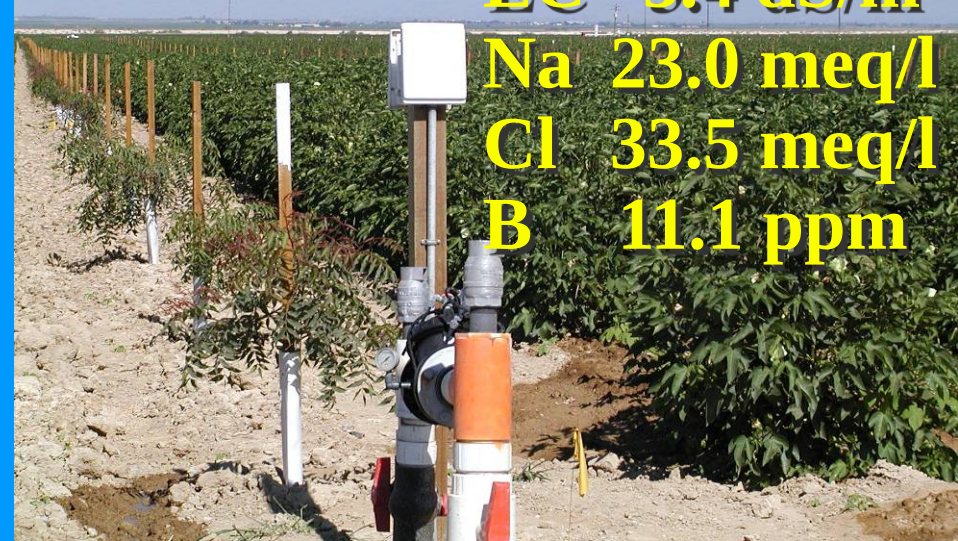
Belridge Well

EC 5.4 dS/m

Na 23.0 meq/l

Cl 33.5 meq/l

B 11.1 ppm



IRRIGATION SCHEDULING REPORT -- Pistachio: SDI, Aqueduct

Adjustment factor (% of Mature Water Use): 15%

CIMIS ET Estimates

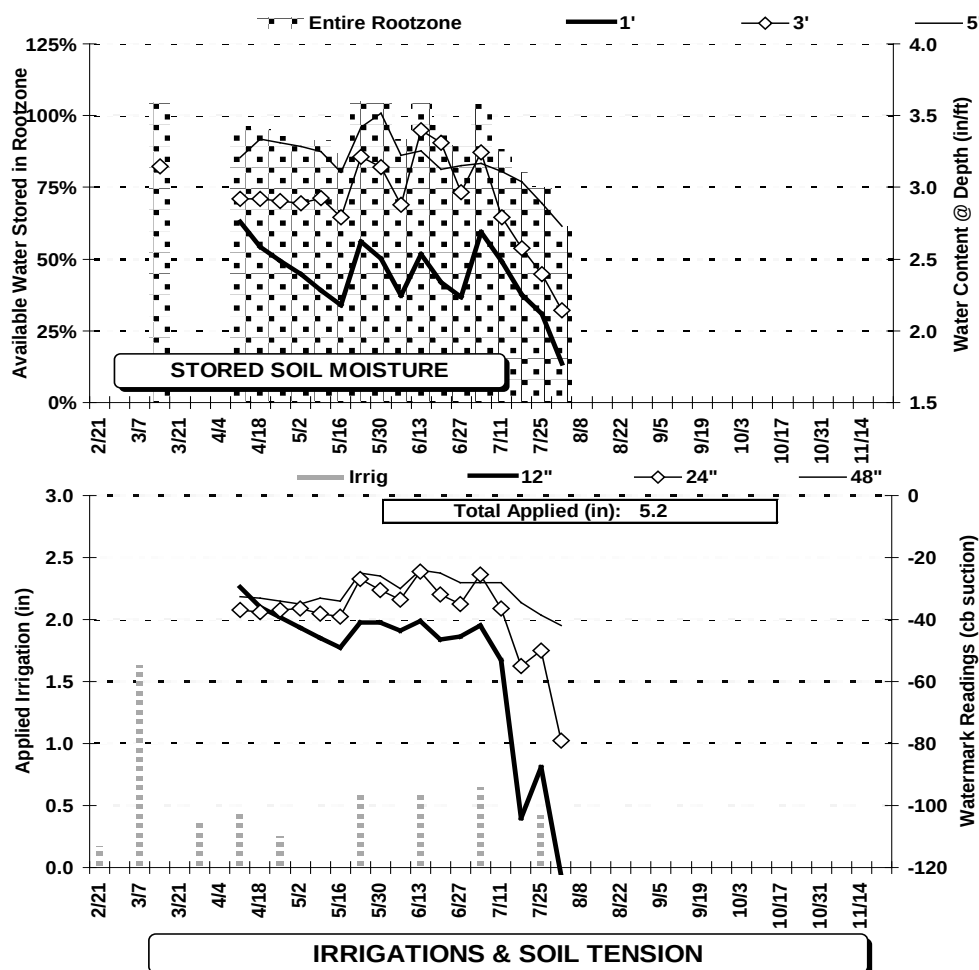
Week	Avg ET	2006 ET	Meas Use & Drainage
1/3	0.00	0.00	
1/10	0.00	0.00	
1/17	0.00	0.00	
1/24	0.00	0.00	
1/31	0.00	0.00	
2/7	0.00	0.00	
2/14	0.00	0.00	
2/21	0.00	0.00	
2/28	0.00	0.00	
3/7	0.01	0.01	0.01
3/14	0.01	0.01	0.01
3/21	0.01	0.03	
3/28	0.01	0.05	
4/4	0.01	0.07	
4/11	0.01	0.10	0.10
4/18	0.01	0.10	0.04
4/25	0.01	0.11	0.36
5/2	0.21	0.17	0.11
5/9	0.24	0.23	-0.06
5/16	0.28	0.28	0.18
5/23	0.30	0.23	-0.15
5/30	0.32	0.28	0.03
6/6	0.32	0.30	0.52
6/13	0.33	0.31	0.10
6/20	0.34	0.32	0.33
6/27	0.34	0.32	0.29
7/4	0.34	0.33	0.05
7/11	0.34	0.33	0.65
7/18	0.32	0.32	0.33
7/25	0.32	0.32	0.65
8/1	0.31	0.31	0.57
8/8	0.29		
8/15	0.28		
8/22	0.24		
8/29	0.22		
9/5	0.21		
9/12	0.18		
9/19	0.17		
9/26	0.14		
10/3	0.12		
10/10	0.10		
10/17	0.09		
10/24	0.05		
10/31	0.04		
11/7	0.03		
11/14	0.00		
11/21	0.00		
11/28	0.00		
12/5	0.00		
12/12	0.00		
12/19	0.00		
12/26	0.00		
Total	6.5	4.5	4.1

CURRENT DATE: 8/4/2006

LAST READING DATE: 8/3/2006

SOIL TYPE:	sandy clay loam		
FIELD CAPACITY (in/ft):	3.1		
REFILL POINT (in/ft):	1.1	Total Avail @ 100%(in):	12
ROOTING DEPTH (ft):	6	Tree Row Area (sq ft):	28,160
TREE ROW SPACING:	18' x 22'	FLOW (gpm):	7.00
IRRIGATION SYSTEM:	TSX 220-12 SDI		
NORMAL RUN TIME (hrs):	24	WET AREA APPLIC (in):	1.64
WETTED VOLUME (%):	35%	NUMBER OF SETS:	4
		NET APPLIC (in):	0.57

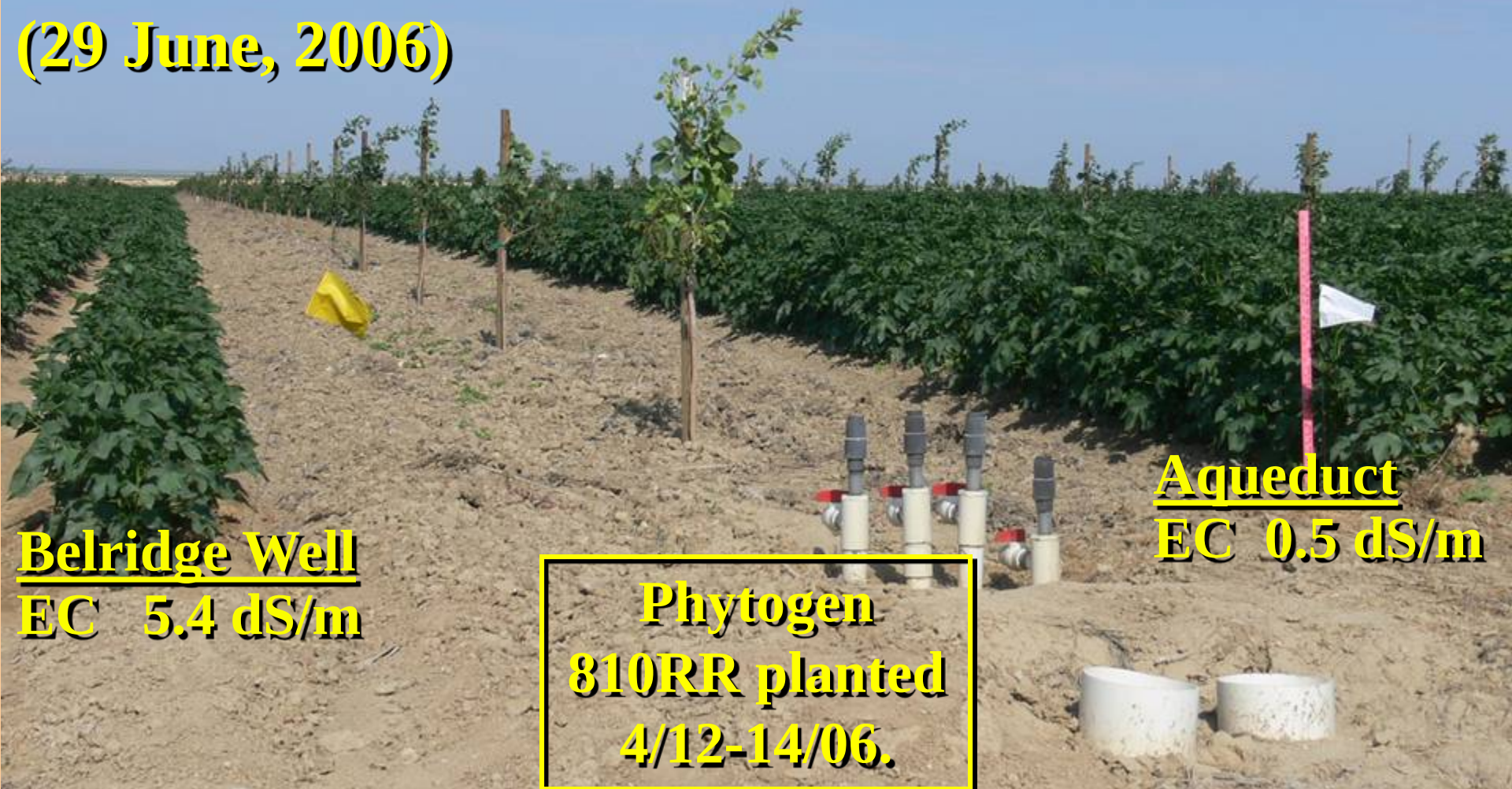
CURRENT DEPLETION	PROJECTED IRRIGATIONS		
4.73 (in)	8/5	8/9	8/13



Recommended irrigation schedules are provided to the grower on a weekly basis for both cotton and pistachios for all treatments. In practice, all treatments are irrigated to supply the ET demand for the 0.5 dS/m treatment.

Following stand establishment problems from a cool spring, the saline Well and Blend treatments showed reduced cotton plant height compared to the Aqueduct treatment.

(29 June, 2006)



Belridge Well
EC 5.4 dS/m

Phytogen
810RR planted
4/12-14/06.

Aqueduct
EC 0.5 dS/m

Aqueduct
EC 0.5 dS/m



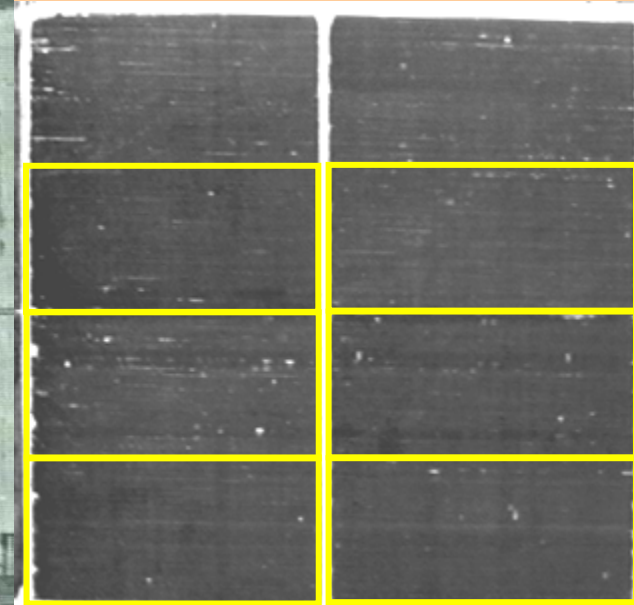
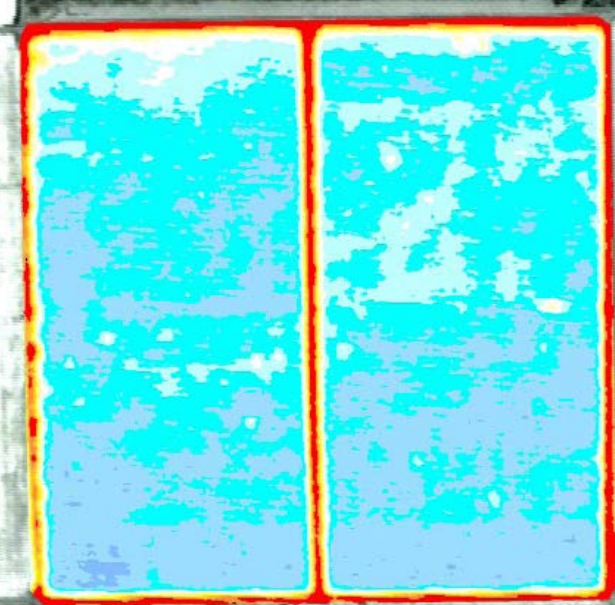
**By mid August, vigor
in all treatments
appeared equal.
(17 August, 2006)**

Blend (50/50)
EC 3.0 dS/m



Belridge Well
EC 5.4 dS/m





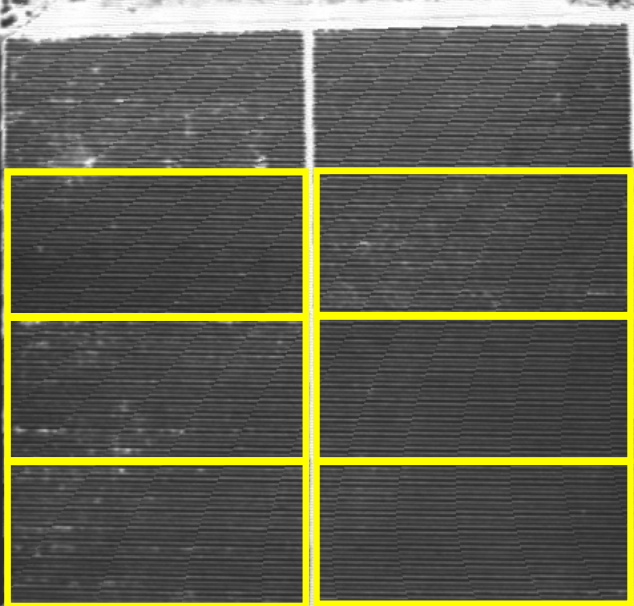
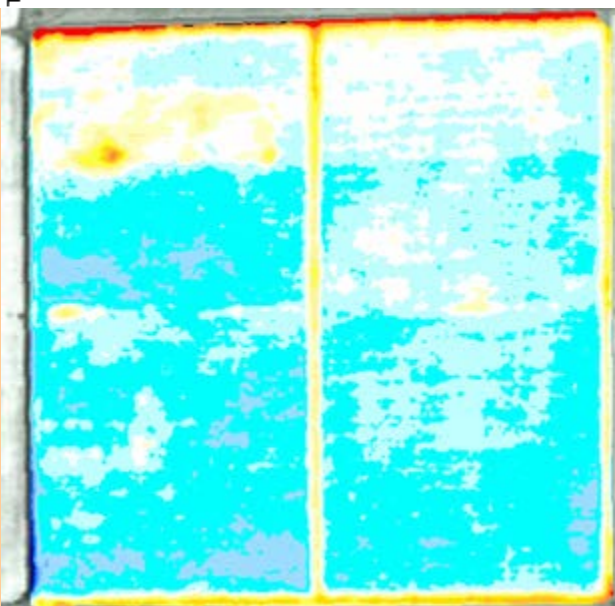
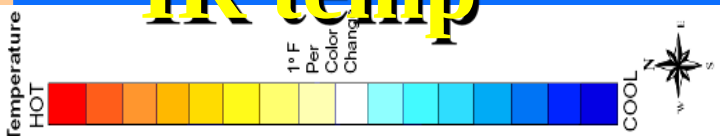
9-1

7/29/04

IR temp

Colored
NDVI

Grayscale
NDVI



8/14/06

9-1: 8/14/06 NDVI

Aqueduct
EC 0.5 dS/m

Belridge Well
EC 5.4 dS/m

Blend (50/50)
EC 3.0 dS/m

Aqueduct
EC 0.5 dS/m

Belridge Well
EC 5.4 dS/m

Blend (50/50)
EC 3.0 dS/m

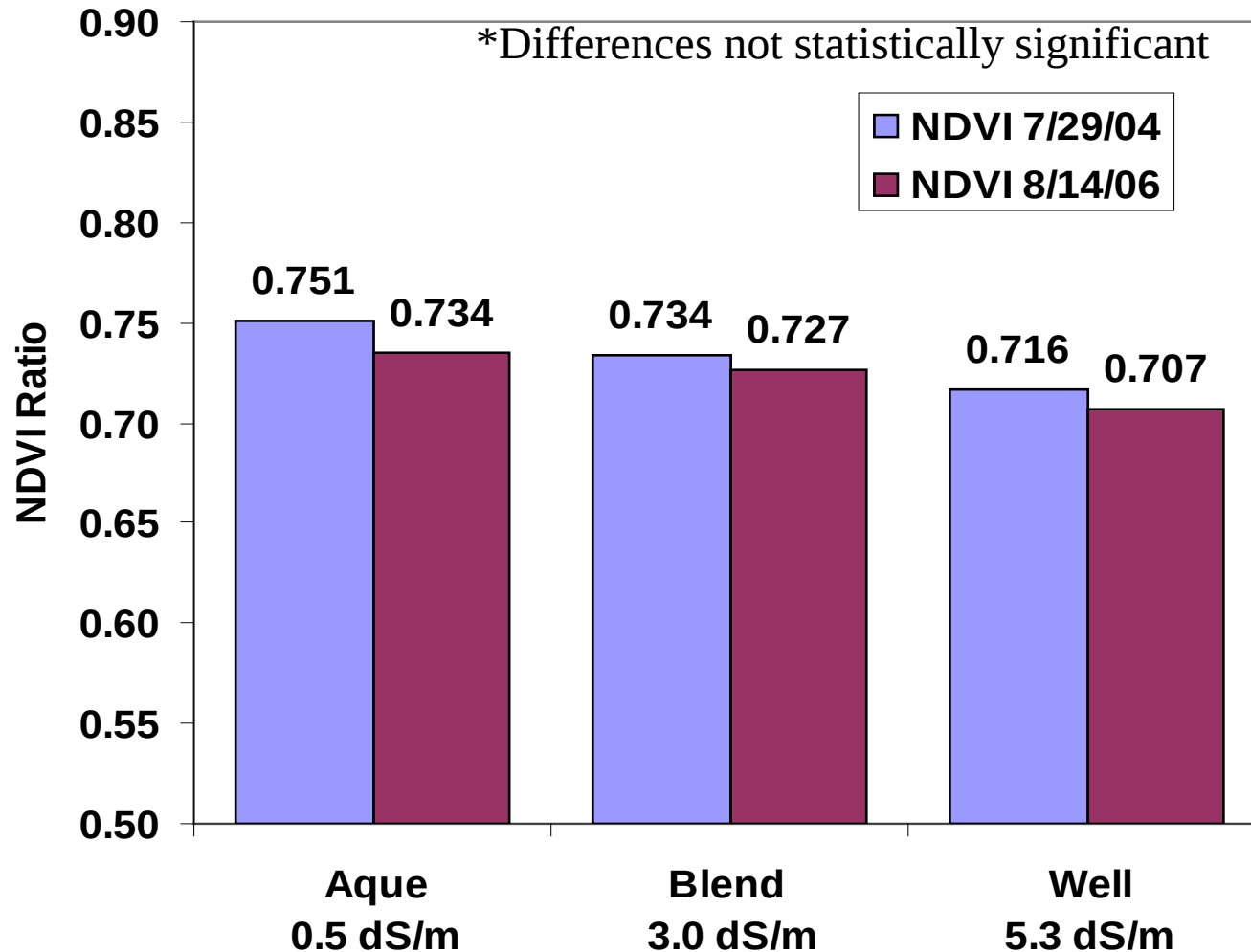
Normalized Difference Vegetation Index

Indicates plant biomass and possibly vigor by the following ratio:

$$\text{NDVI} = (\text{NIR} - \text{R}) / (\text{NIR} + \text{R})$$

NIR = near infrared reflectance @ 800nm

IR = infrared reflectance @ 675nm



**NDVI
comparison
after 3
seasons of
irrigation
treatments**

9-1 East

10/3/07 3rd Leaf

V6E Well

1,156,326 pix
83.94 grn mean



**Photoshop pixel
counts of
pistachio foliage**



V4E Aque

1,266,033 pix
81.79 grn mean



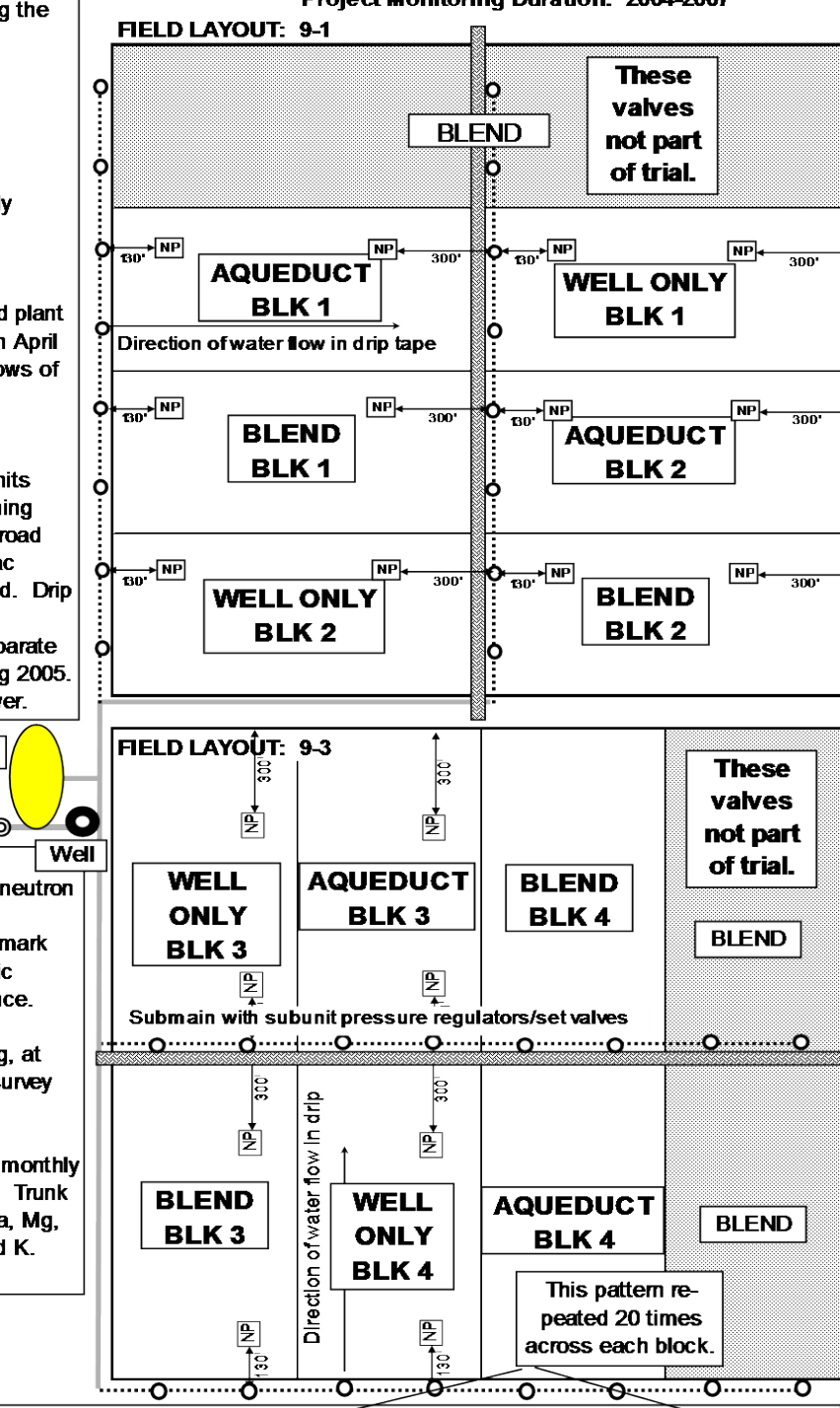
V2E Blend

1,137,636 pix
72.89 grn mean

9-1 WELL
5/15/09

Well (60% Well,
40% Aque)
EC 4.7 dS/m





2009 PROBLEMS:

- 1) **NO WATER!** Surplus water to Belridge WD \$400-500/ac-ft. 2 ft fresh water cost for 80 acres = **\$80,000**
- 2) Former well for **WELL** treatment too saline (8 dS/m). To maintain 5 dS/m irrigation treatment requires blending with new well (3.4 dS/m), boron levels maybe excessive. Grower unwilling to commit 80 acres to long-term damage.
- 3) Small plot **AQUEDUCT** control currently maintained. Grower maybe willing for small plot 5 dS/m irrigation, but replumbing system required.

**WHAT
HAPPENED IN
2010?**

COLOR KEY FOR SET VALVES & IRRIGATION WATER:

BLUE (Set 1) --

AQUEDUCT

EC 0.5 dS/m

GREEN (Set 2) --

50/50 BLEND (low well)

EC 3.2 dS/m

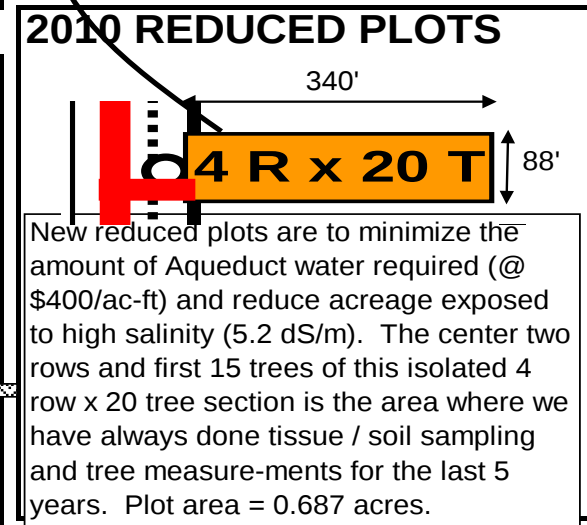
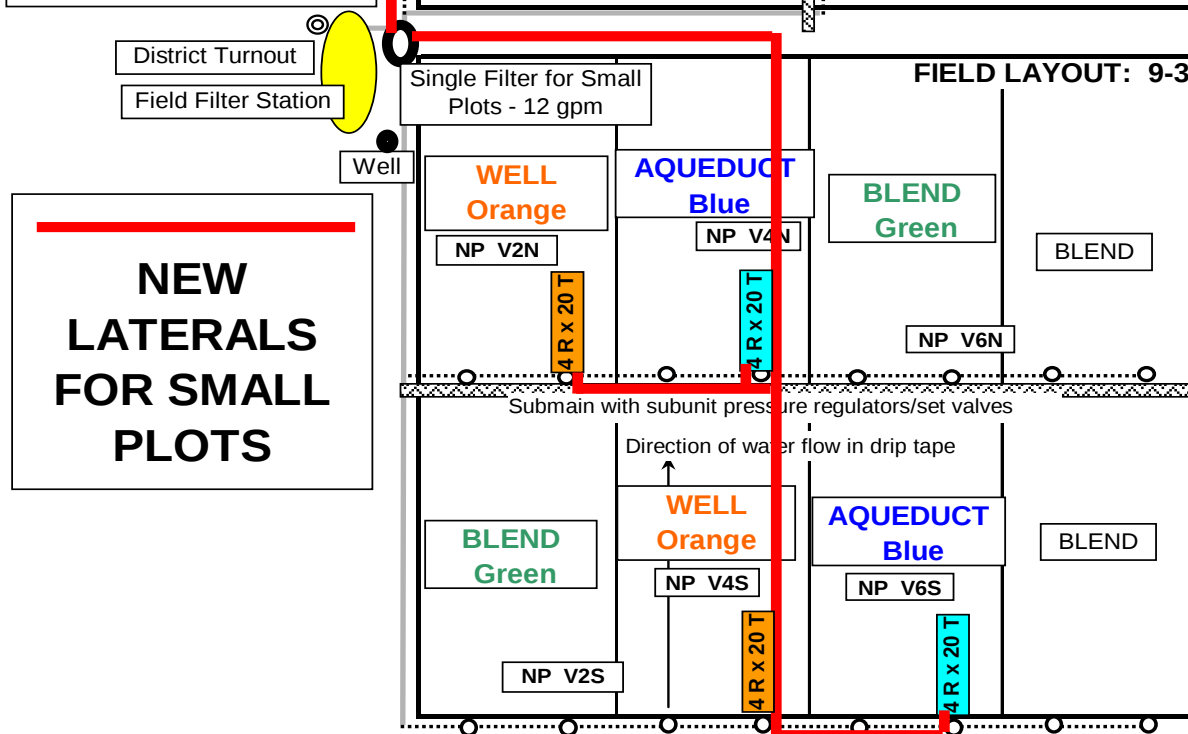
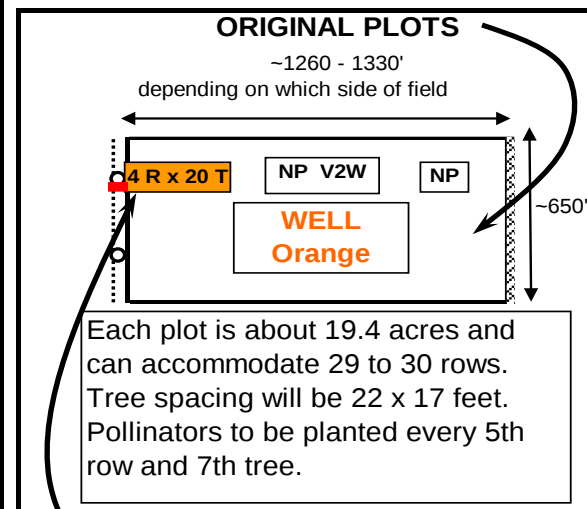
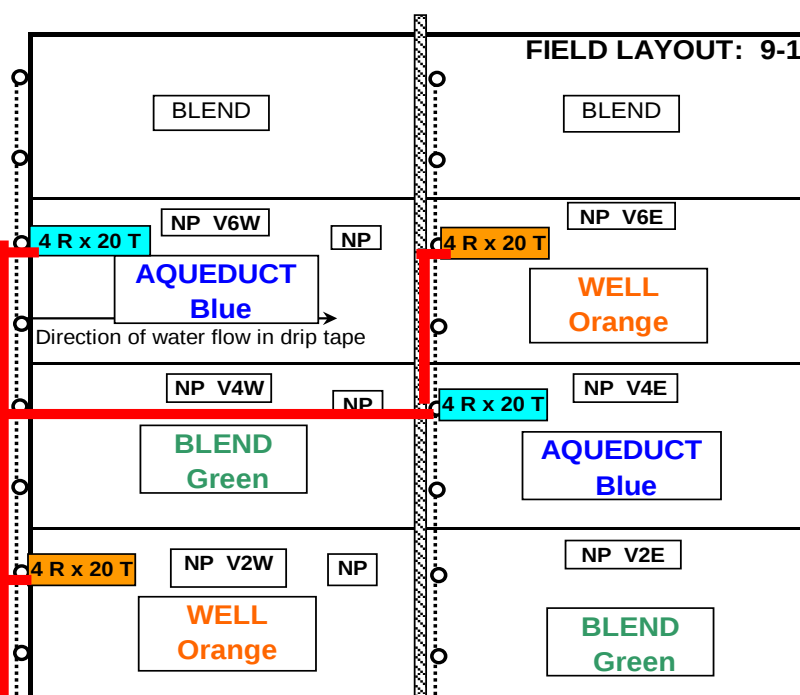
RED (Set 3) --

BLEND (same as above but not part of test area)

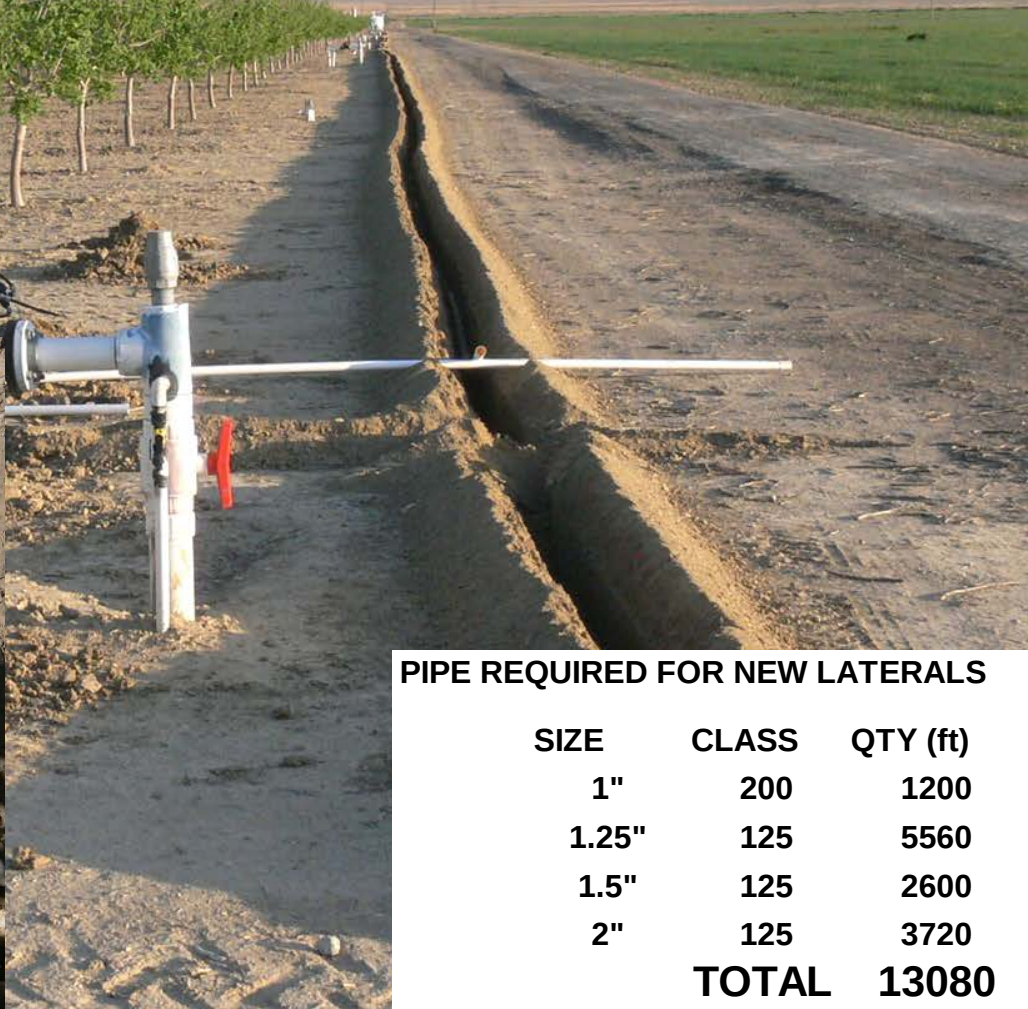
ORANGE (Set 4) --

WELL ONLY

EC 5.1 dS/m



Installing isolation mainlines, valves, manifolds and meters for 4 row x 20 tree plots, late April



PIPE REQUIRED FOR NEW LATERALS

SIZE	CLASS	QTY (ft)
1"	200	1200
1.25"	125	5560
1.5"	125	2600
2"	125	3720
TOTAL		13080

A single drip hose with 4, 2 gph emitters per tree was plumbed into the row manifold to quickly apply sufficient water from 9 dS/m well to achieve an equivalent 5.2 dS/m irrigation EC to trees during irrigation.

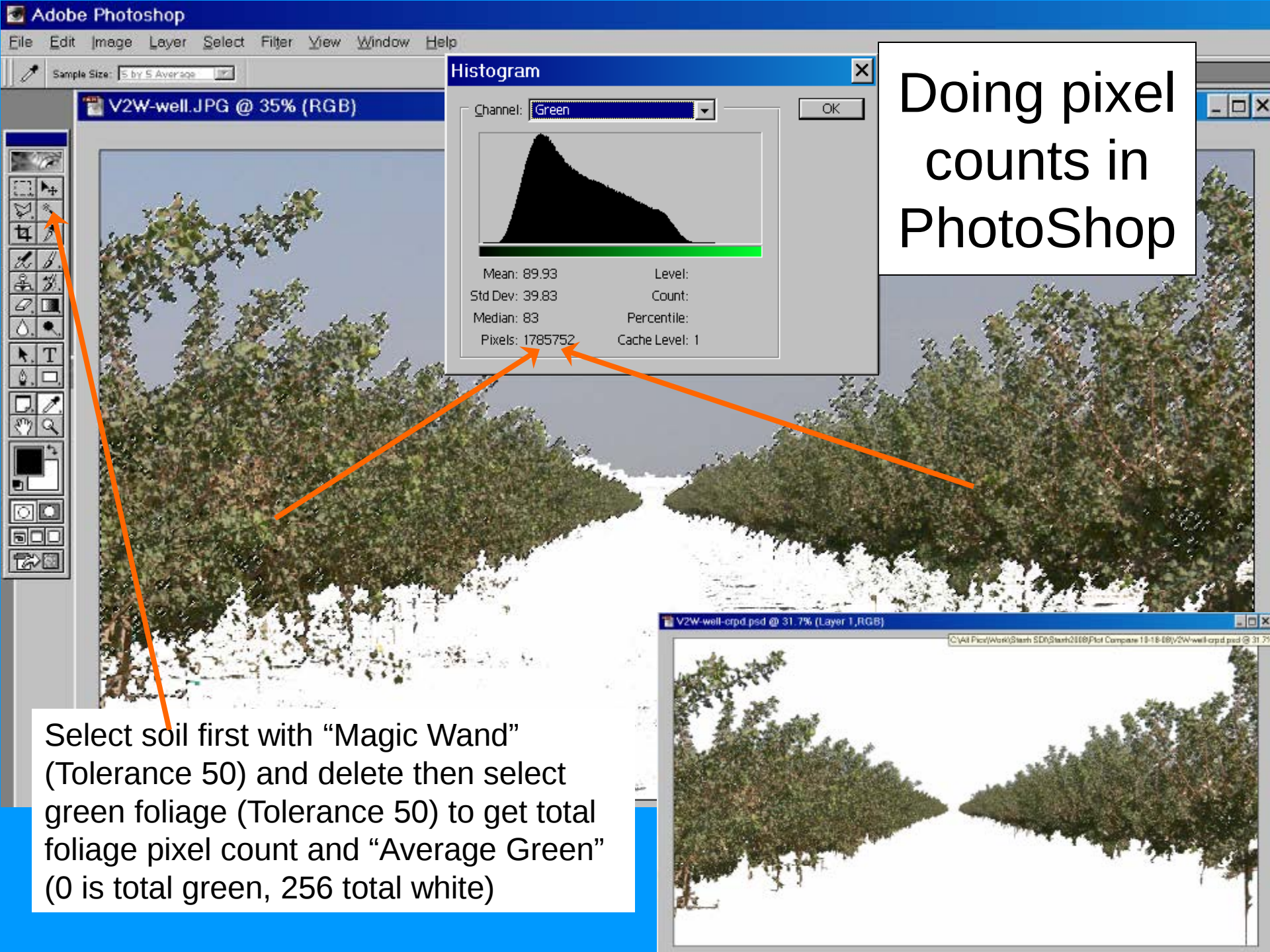


10 PG1 trees

10 UCB trees

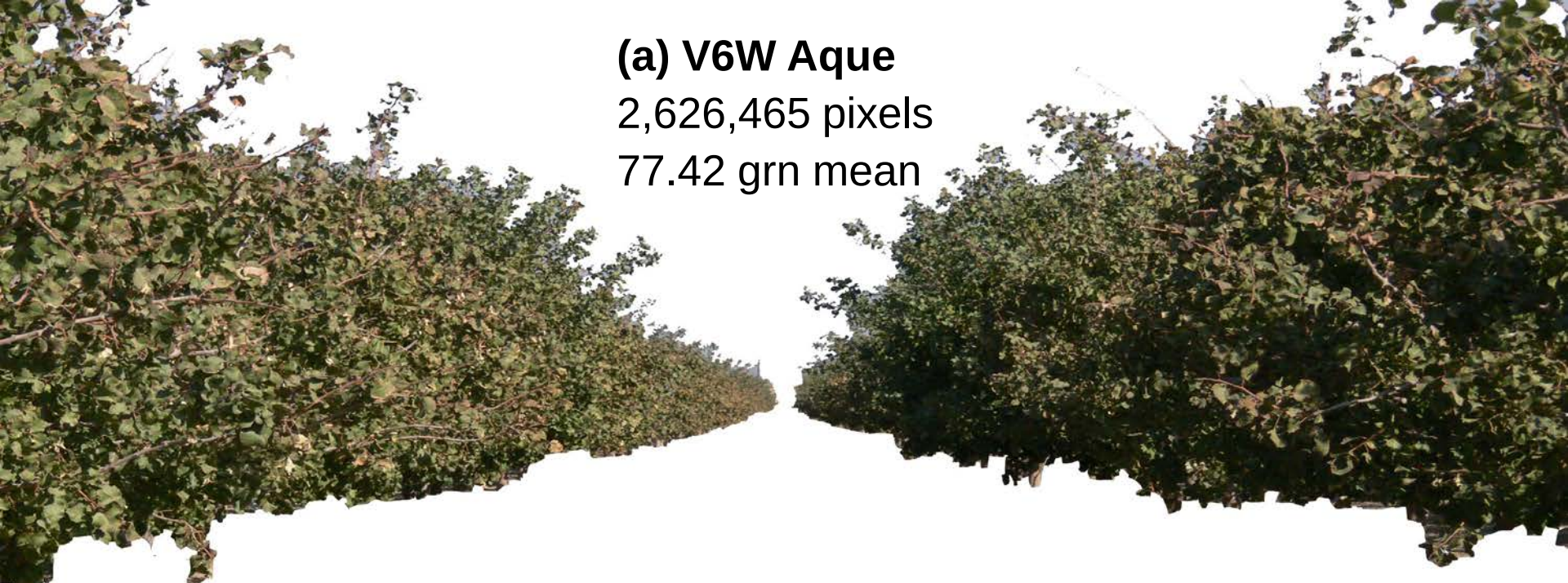


V2West
WELL
treatment
sample rows



Doing pixel
counts in
PhotoShop

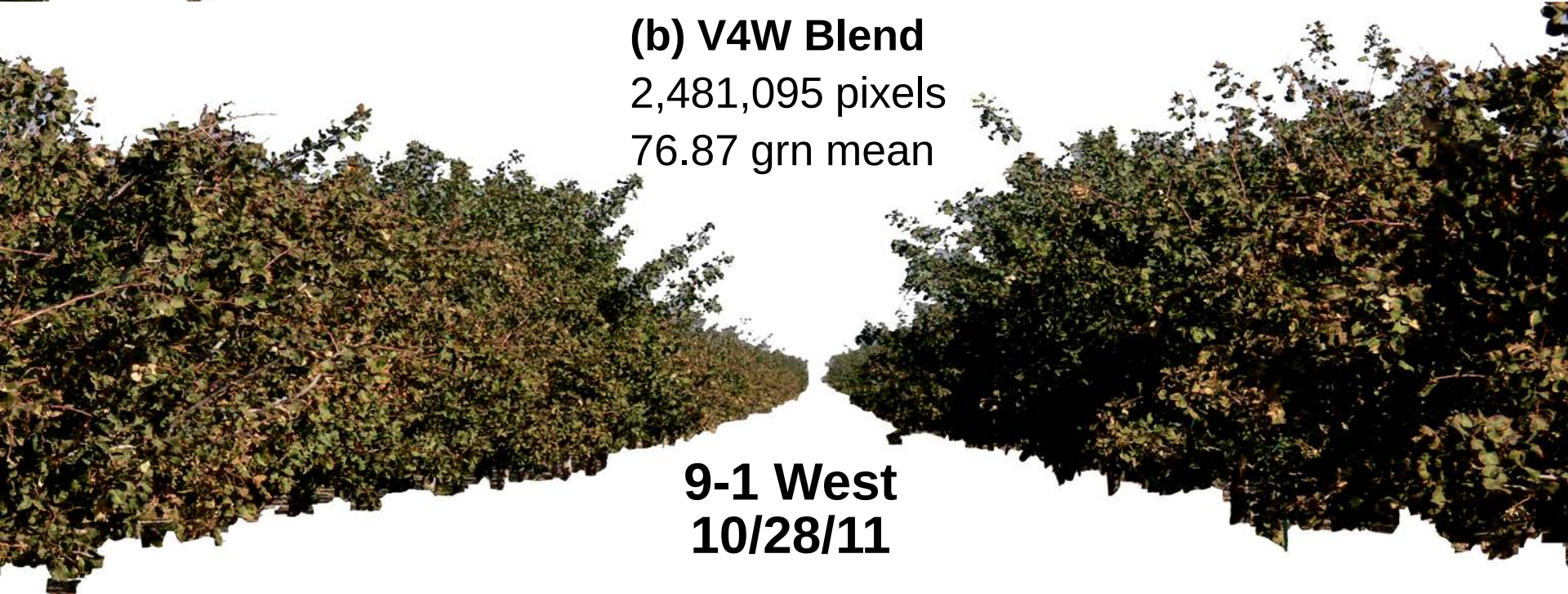
Select soil first with "Magic Wand"
(Tolerance 50) and delete then select
green foliage (Tolerance 50) to get total
foliage pixel count and "Average Green"
(0 is total green, 256 total white)



(a) V6W Aque

2,626,465 pixels

77.42 grn mean



(b) V4W Blend

2,481,095 pixels

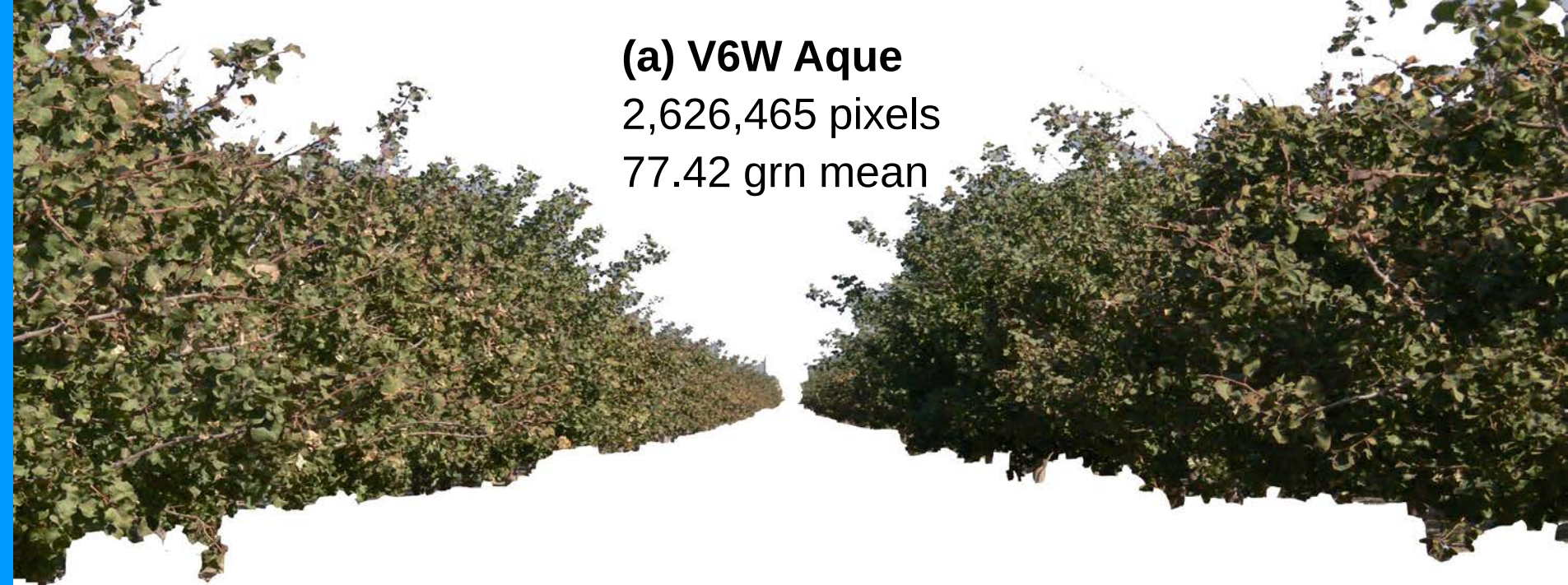
76.87 grn mean

**9-1 West
10/28/11**

(a) V6W Aque

2,626,465 pixels

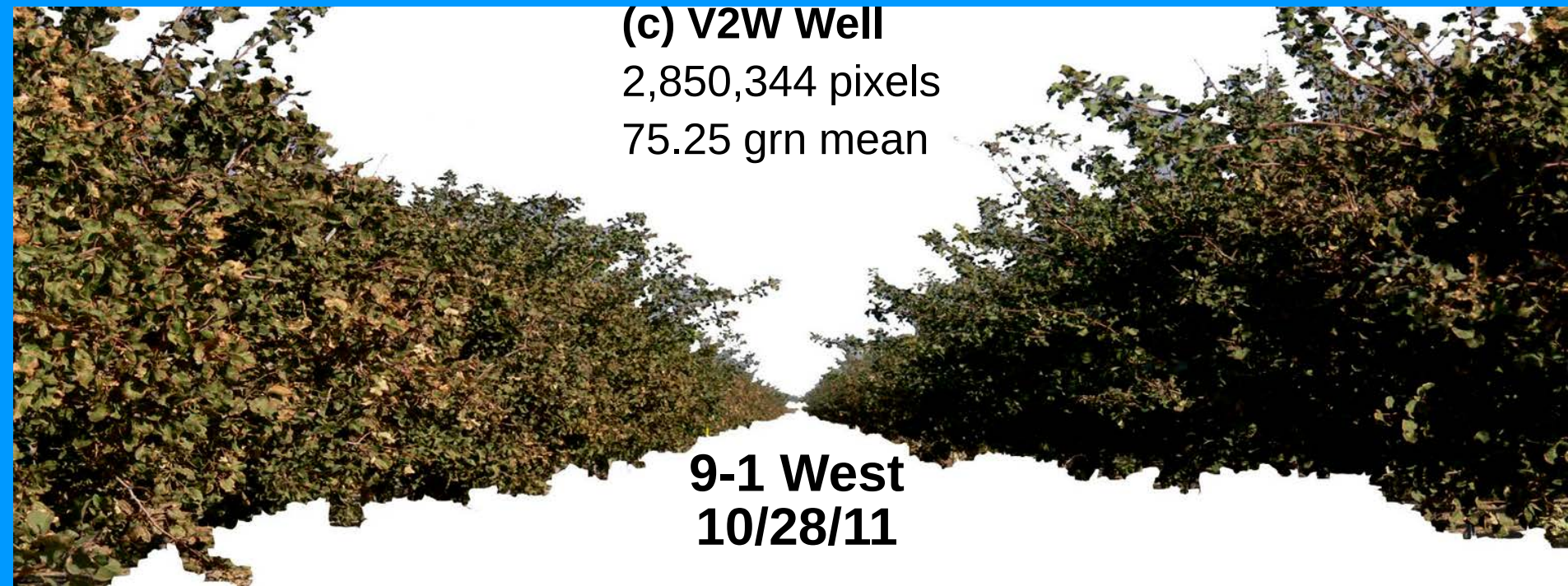
77.42 grn mean



(c) V2W Well

2,850,344 pixels

75.25 grn mean



**9-1 West
10/28/11**

Marginal burn
was seen on most
leaves

9-1 West Compare



Aqueduct
EC 0.5 dS/m



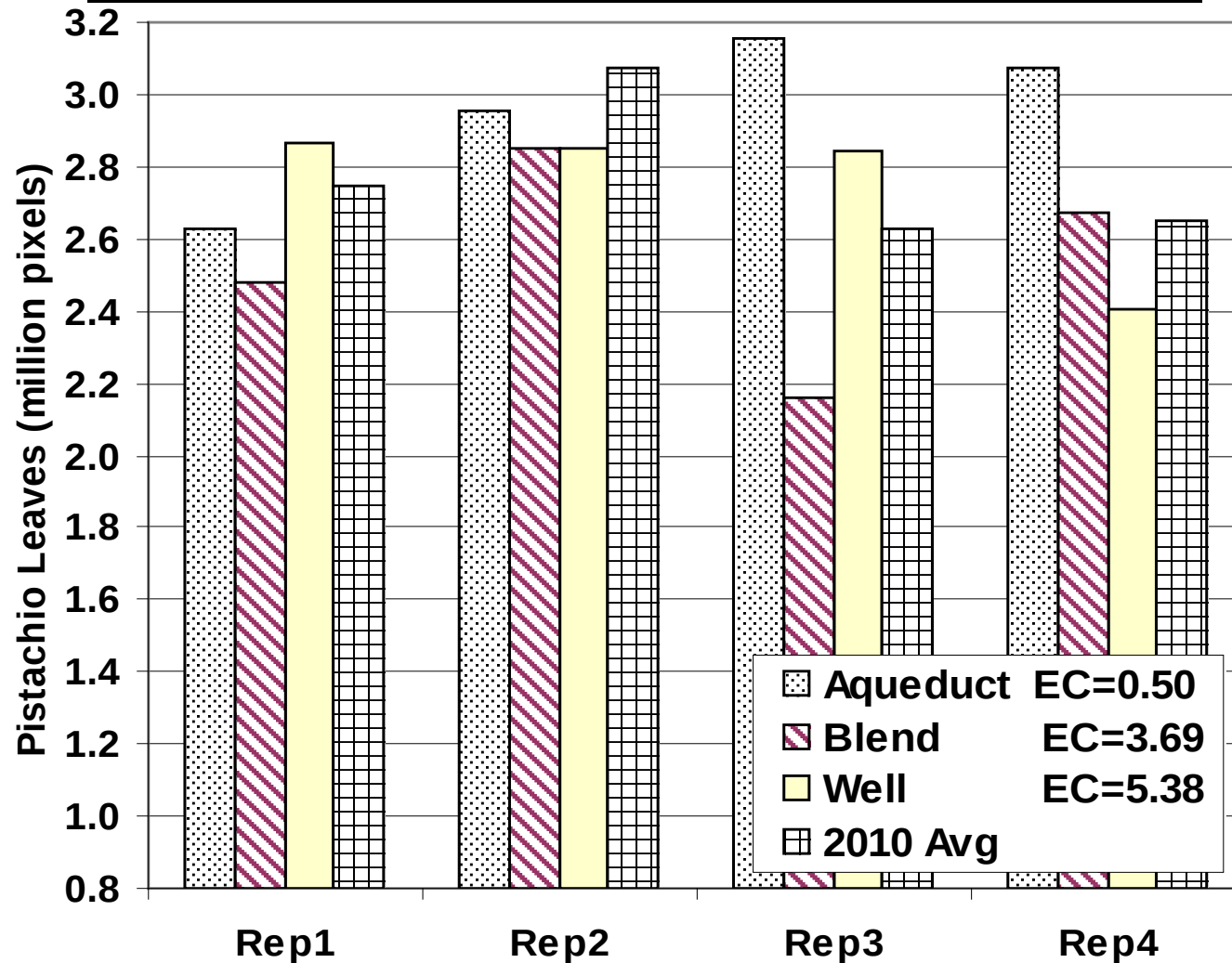
Blend (30% Well,
70% Aque)
EC 3.2 dS/m



Well (60% Well,
40% Aque)
EC 5.2 dS/m

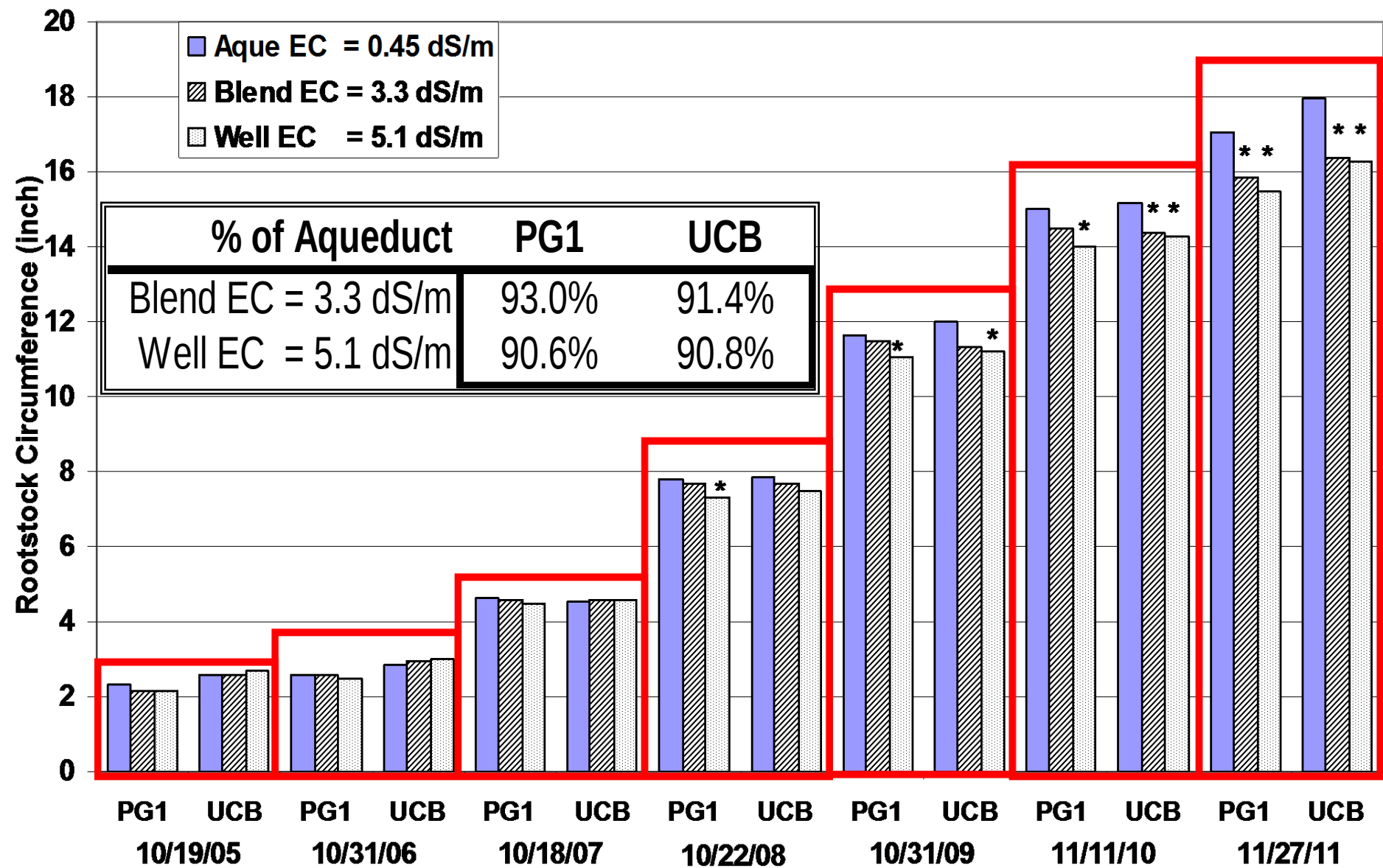
AVERAGE LEAF PIXEL TOTALS

	Leaf Pixels	% of Aque	Mean Green
AQUEDUCT	2,951,458	100.0%	78.23
BLEND	2,539,943	86.1%	78.00
WELL	2,740,930	92.9%	72.11



Pistachio
foliage
pixel
counts
10/28/11
(no
statistically
significant
difference)

2009-11 rootstock growth decreased 7 to 9% from well water



Trees planted March 5-11, 2005. *Irrigation salinity impact statistically significant ($P < 0.05$)

Change in tissues and soil salinity

Kerman Leaves 10/31/06			Pistachio 2006		Rootzone ECe to 5'			
	N (%)	P (%)	K (%)	Na(ppm)	Cl (%)	B(ppm)	10/30/06	Circum (in)
Aque	1.19	0.08	2.67	171	0.52	531	2.65	2.58
Blend	1.36	0.08	2.83	140	*0.58	**954	4.34	2.55
Well	*1.55	0.09	2.99	201	*0.62	**1096	*4.61	2.49
Kerman Leaves 7/21/10 (PG1)				Pistachio 2010		7/21/10	11/11/10	
Aque	2.30	0.12	2.09	115	0.24	274	5.62	15.0
Blend	2.34	0.12	2.32	106	0.25	**563	*8.55	14.5
Well	2.33	0.12	2.21	132	0.27	**610	*7.82	*14.0
Kerman Leaves 7/21/10 (UCB1)				Pistachio 2010			11/11/10	
Aque	2.41	0.13	1.75	99	0.16	248		15.2
Blend	2.44	0.13	1.89	92	0.16	**479		*14.4
Well	2.53	0.13	1.84	99	0.18	**516		*14.3
Kerman Leaves 7/29/11 (PG1)				Pistachio 2011		7/21/11	11/27/11	PG1 (lb/ac)
Aque	2.41	0.13	2.21	159	0.29	455	6.96	2159
Blend	2.54	0.12	2.32	151	0.28	**845	*12.68	1983
Well	2.55	0.13	2.30	113	0.27	**818	8.49	1902
Kerman Leaves 7/29/11 (UCB1)				Pistachio 2011			11/27/11	UCB (lb/ac)
Aque	2.51	0.13	2.00	161	0.25	328		1949
Blend	2.52	0.13	2.23	160	0.24	**724	*16.4	1901
Well	2.66	0.13	2.03	109	0.24	**637	*16.3	1808

*Significantly different from Aqueduct @ 0.05, **Significant @ 0.01

¹Cotton height @ irrigation cutoff.

²Cotton cover = 12.7 feet/tree row

Pistachio drip subbin

Salt added to crop rootzone from start of project

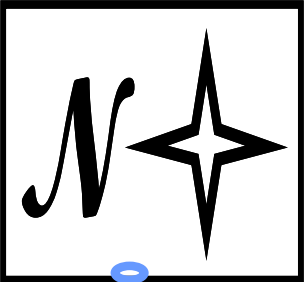
	2005		2007		2009		2011		TOTAL		² EC+ Max (dS/m)
Irrigation Treatment	Irrig (in)	Salt ¹ (lb/ac)	Irrig (in)	Salt (lb/ac)	Irrig (in)	Salt (lb/ac)	Irrig (in)	Salt (lb/ac)	Irrig (in)	Salt (lb/ac)	
Aque	10.4	1742	12.0	1390	17.5	7022	33.3	3387	115.9	18192	1.4
50/50	10.4	8570	10.8	7571	15.6	14399	41.0	40838	111.1	78900	6.2
Well	11.8	14782	10.7	13197	16.6	18444	35.3	48596	117.7	129915	10.1

¹Irrigation inches for total tree spacing, salt totals (lb/ac) calculated for a 9.5 foot wide subbing area centered on the tree row. Assumes 640 ppm soluble salt = 1 dS/m and a 5 ac-ft depth of soil = 20 million lbs.

²Maximum increase in soil saturated paste EC for a 5 foot rootzone with no precipitation of salts and no leaching past the 5 foot depth.

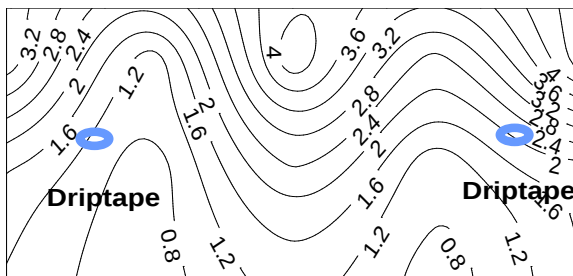
Average change in soil salinity over 8 years

PISTACHIO AVERAGE SOIL SALINITY FROM PREPLANT TO 7/21/11										Nitric Acid Total B (ppm)
	SP %	pH	EC dS/m	Ca (SP) meq/l	Mg (SP) meq/l	Na (SP) meq/l	Cl (SP) meq/l	HCO3 meq/l	B (SP) ppm	
WEIGHTED AVERAGES TO 5 FEET Soil sampled 3/23/04										
Aque	44	7.8	2.07	11.7	2.1	9.1	5.7	1.9	1.1	17.6
Blend	47	7.8	2.53	13.0	2.3	11.4	7.0	1.9	1.1	
Well	46	7.7	2.10	14.2	1.9	9.3	4.9	1.9	0.8	20.7
WEIGHTED AVERAGES TO 5 FEET Soil sampled 7/21/11										(ppm)
Aque	41	7.8	6.96	45.5	10.0	23.9	35.2	1.7	1.7	24.8
Blend	42	7.6	12.68	85.3	18.4	47.6	86.7	1.7	4.7	32.3
Well	41	7.7	8.49	50.9	12.1	36.5	53.2	1.3	5.7	34.9
% Change over 8 years										(ppm)
Aque	---	---	336%	388%	471%	262%	617%	92%	158%	141%
Blend	---	---	502%	654%	809%	419%	1247%	93%	431%	
Well	---	---	405%	359%	623%	390%	1081%	72%	754%	168%



Driptape

Driptape



Driptape

Driptape

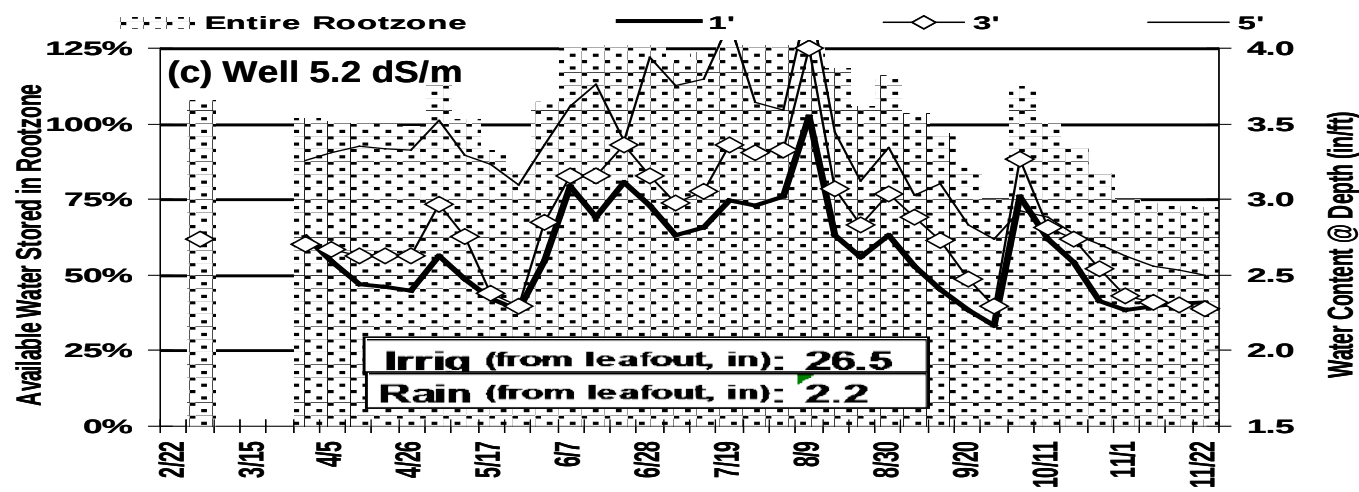
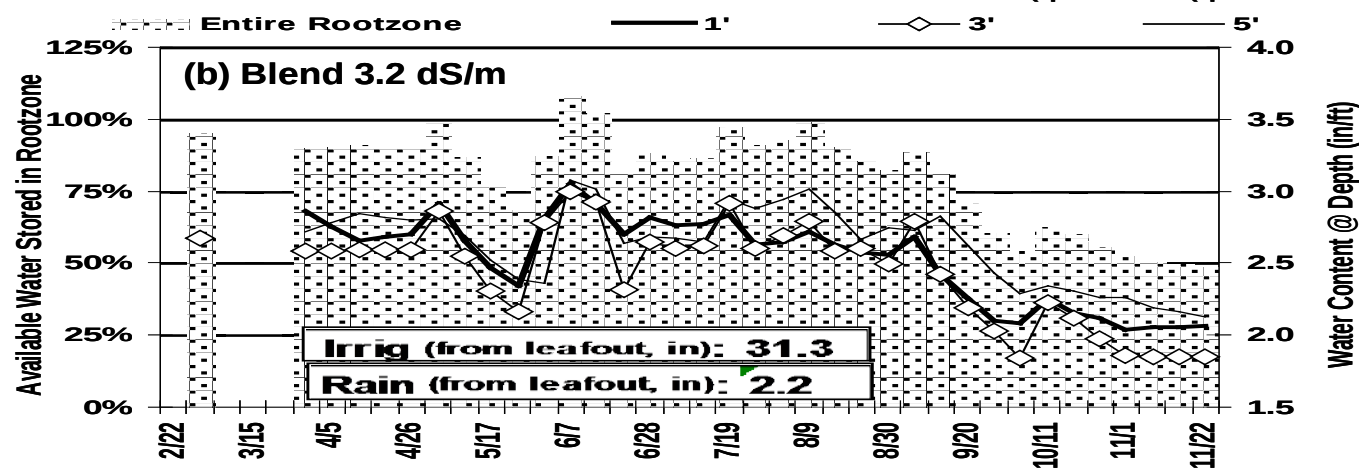
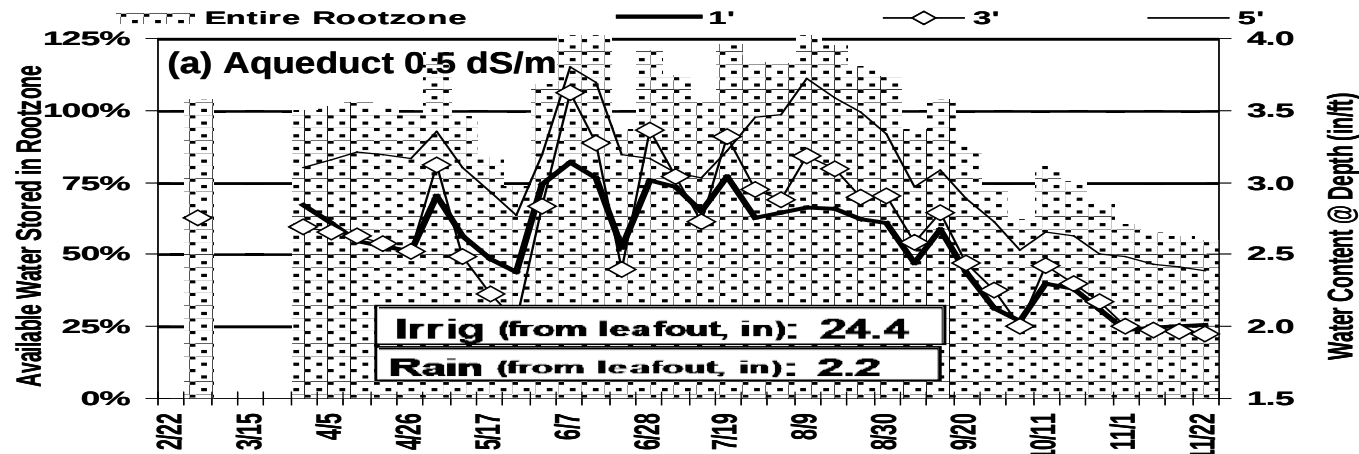


Driptape

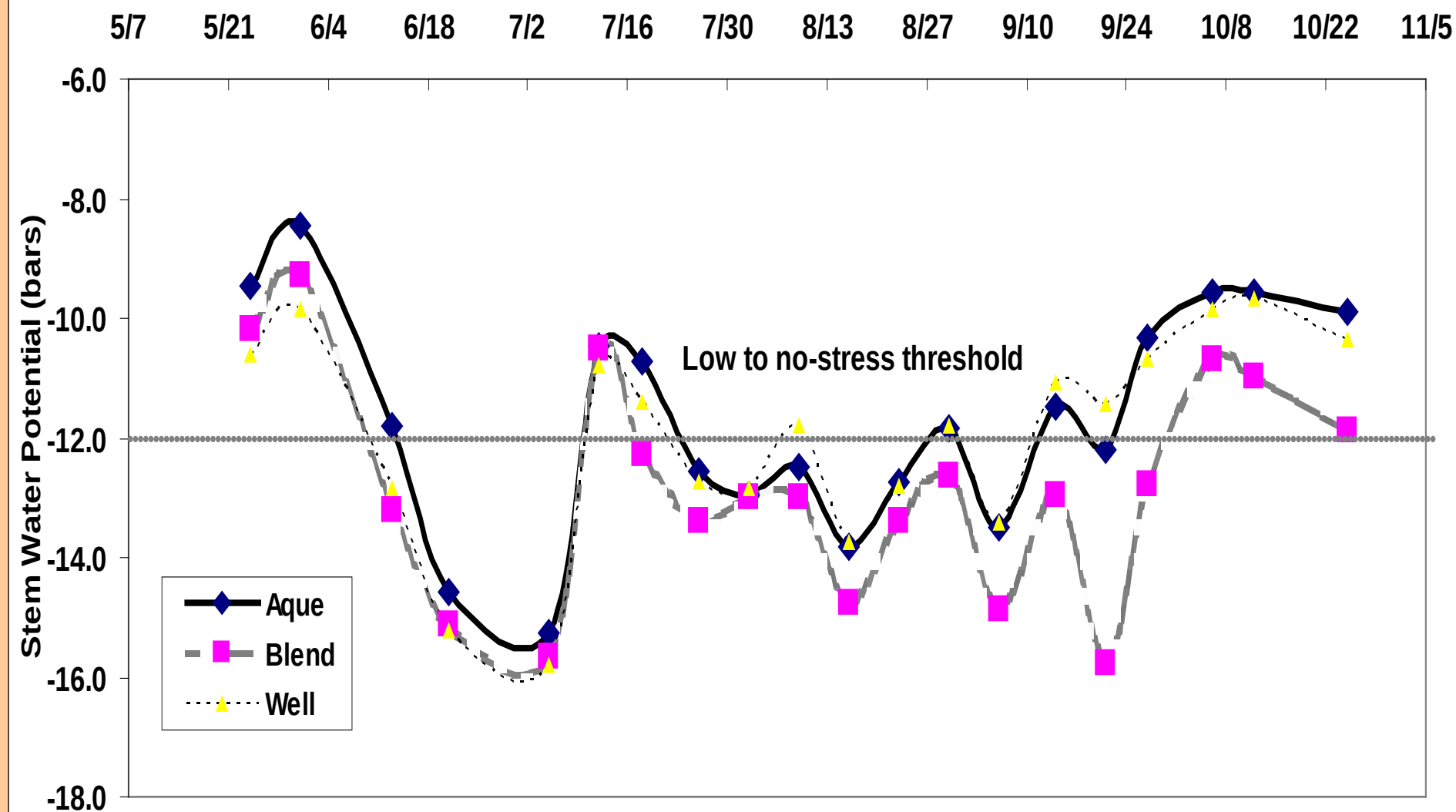
Driptape

Contours of soil salinity (ECe, dS/m) in pistachio rows, 2007-2011

2011
neutron
probe soil
moisture
readings
showed
significant
leaching for
the WELL
treatment



2011 Bi-weekly Stem Water Potential

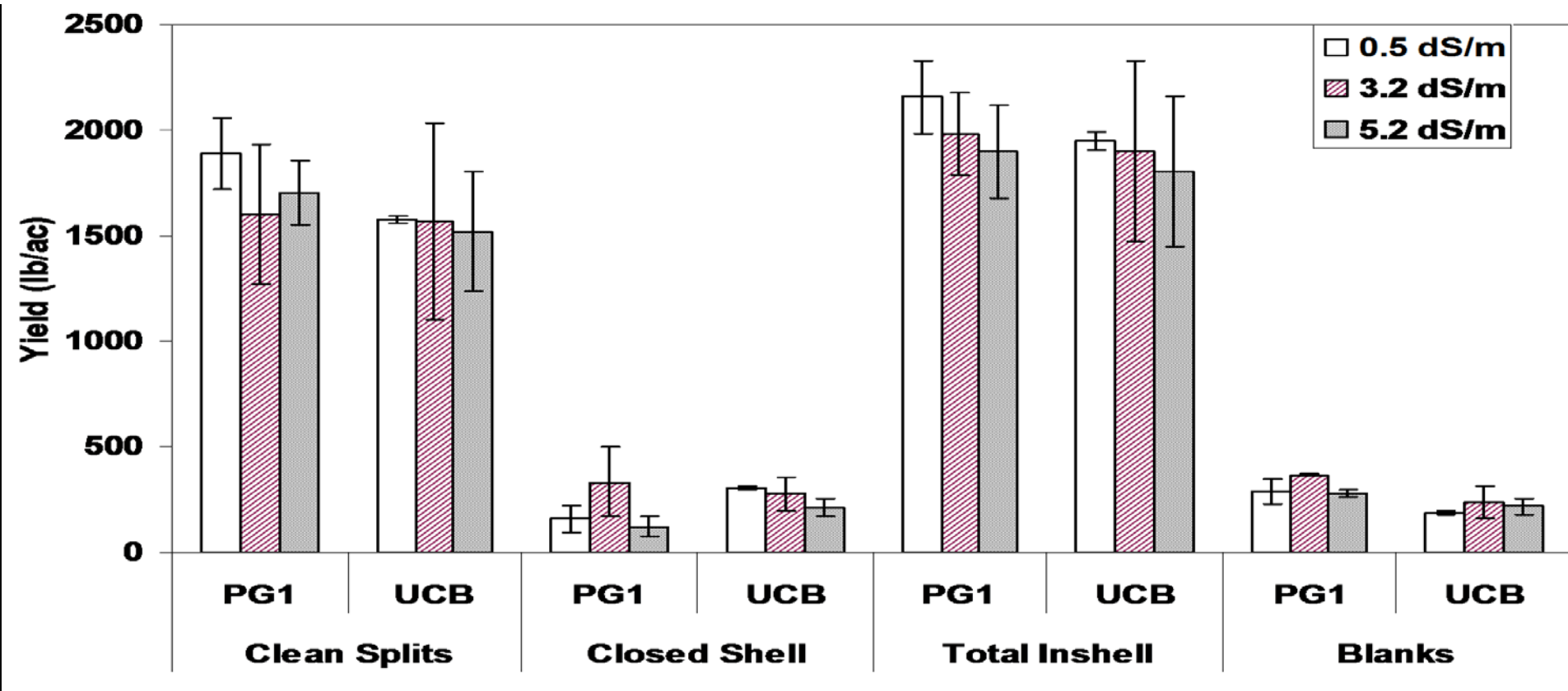




1st Harvest
9/23/11



	Clean Splits		Closed Shell		Total Inshell		Blanks	
	PG1	UCB	PG1	UCB	PG1	UCB	PG1	UCB
0.5 dS/m	1891	1575	157	303	2159	1949	290	184
3.2 dS/m	1602	1568	334	278	1983	1901	367	238
5.2 dS/m	1702	1520	121	212	1902	1808	279	216



FINAL TURNOUTS (with standard error bars) FOR VARIOUS PISTACHIO YIELD CATEGORIES -- NO STATISTICAL DIFFERENCE BETWEEN 0.5 dS/m and 5.2 dS/m treatments

Conclusions

- Without effective winter rainfall/fresh-water irrigation > 6 inches every couple years, excessive salt buildup will reduce young pistachio growth and eventually yield.
- High Na/Ca ratios can make this problem worse and even lead to frost susceptibility (topic for another talk)
- Presently adsorbed boron could have a time bomb affect
- Use of saline water could save \$2,000 - 10,000/ac over 20 years if appropriate leaching can be maintained

