Managing Almond Rust

James E. Adaskaveg
Professor
University of California Riverside

Management of Almond Leaf Rust

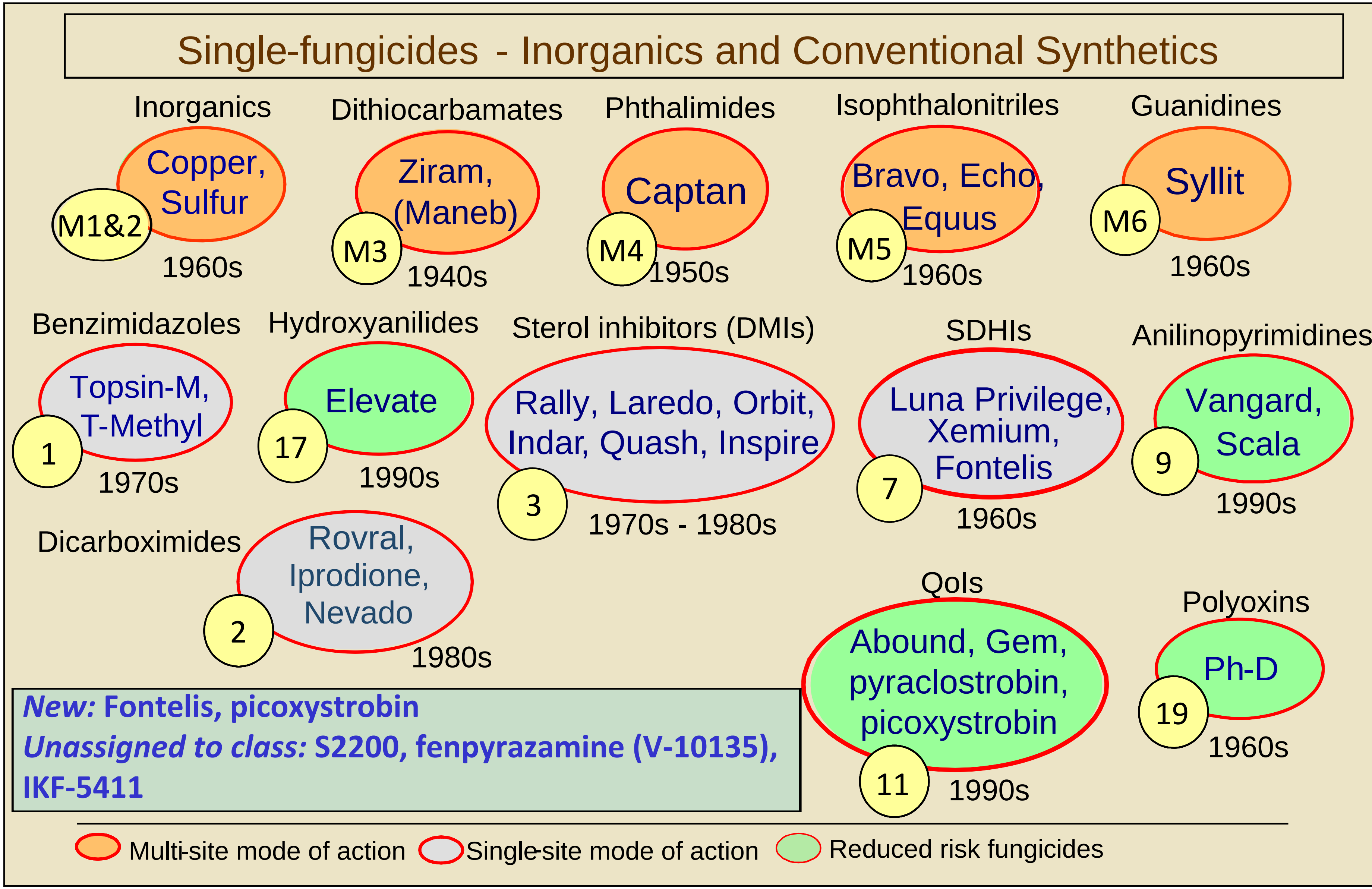
- **Planting: Varietal Susceptibility**
  - *Most varieties are susceptible*
  - *Varieties that hold their leaves carry inoculum from one season to the next (e.g., Sonora)*
- **Horticultural**
  - *Remove leaves in the fall season (Oct. 30) using 30-40 lb zinc sulfate*

Practice	Goal
Planting Design	Allow air circulation
Tree Pruning	Increase air movement and reduce RH
Irrigation Management	Reduce orchard RH
Clean Cultivation	Reduce orchard RH
Avoid heavy late-summer/fall fertilization with N	Reduce production of highly susceptible host tissues

Management of Almond Leaf Rust

- Maneb (e.g., Manex) was canceled in 2009 leaving the almond industry without the traditional treatment (i.e., PF application to shift occurrence to late summer and fall).
- Currently in the process of registering: the EBDC fungicide Mancozeb to replace maneb (e.g., Manex).
- Research was done to evaluate current arsenal –
  - First goal: find a multi-site material with long residual including:
    - Chlorothalonil
    - Mancozeb
  - Second goal: Evaluate QoI and DMI fungicides shown by Adaskaveg et al. to be excellent springtime treatments for rust fungi on peach
  - Third goal: Evaluate new chemistry and pre-mixtures available that can be applied in the spring petal fall to May timings.

Fungicides for Managing Almond Diseases



Fungicides for Managing Almond Diseases

Conventional Synthetic Fungicides – Pre-mixtures

- Inspire XT (3+3)
- Inspire Super (3+9)
- Adament, Quadris Top, Quilt Xcel (3+11)
- Pristine, Luna Sensation, Merivon, Q8Y78 (7+11)

3	DMIs
7	SDHIs
9	Anilinopyrimidines
11	QoIs

Natural Products and Biocontrols

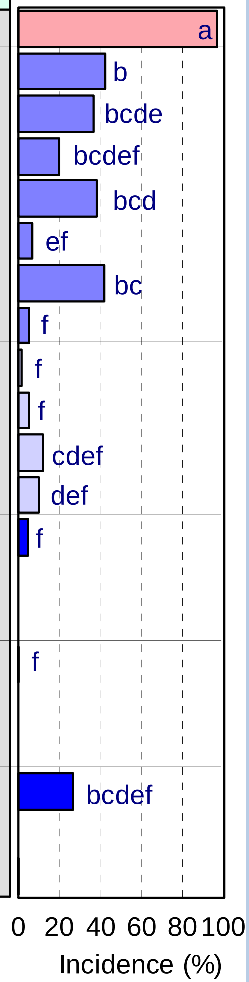
Regalia, Cerebrocide, Ph-D organic, Actinovate

Natural products and a biocontrol that already are or potentially will be OMRI approved were evaluated for organic farming of almonds.

Management of Almond Leaf Rust

- 2010 -

	Treatment	4-29	5-18	6-15
	Control	---	---	---
Single treatments	Ph-D 11.2DF 6.2 oz	---	@	@
	Tilt 3.6EC 8 fl oz	---	@	@
	Quash 50WG 3.5 oz	---	@	@
	Inspire EC 7 fl oz	---	@	@
	Abound 2F 12.5 fl oz	---	@	@
	Gem 500SC 3 fl oz	---	@	@
	Bravo 96 fl oz	---	@	@
Pre-mixtures	Adament 50WG 6 oz	---	@	@
	Quadris Top 20 fl oz	---	@	@
	Quilt Excel 14 fl oz	---	@	@
	Pristine 38WG 14.5 oz	---	@	@
Rotations	Manzate Pro-Stick 76.8 oz	@	---	---
	Ph-D 11.2 DF 6.2 oz	---	@	---
	Adament 50WG 6 oz	---	---	@
	Bravo 96 fl oz	@	---	---
	Quilt Excel 14 oz	---	@	---
	Quadris Top 20 oz	---	---	@
	Ph-D 11.2DF 6.2 oz	@	---	---
	Quash 50WG 3.5 oz	---	@	---
	Ph-D 6.2 oz + Quash 2.5 oz	---	---	@



cv. Carmel, Colusa Co.

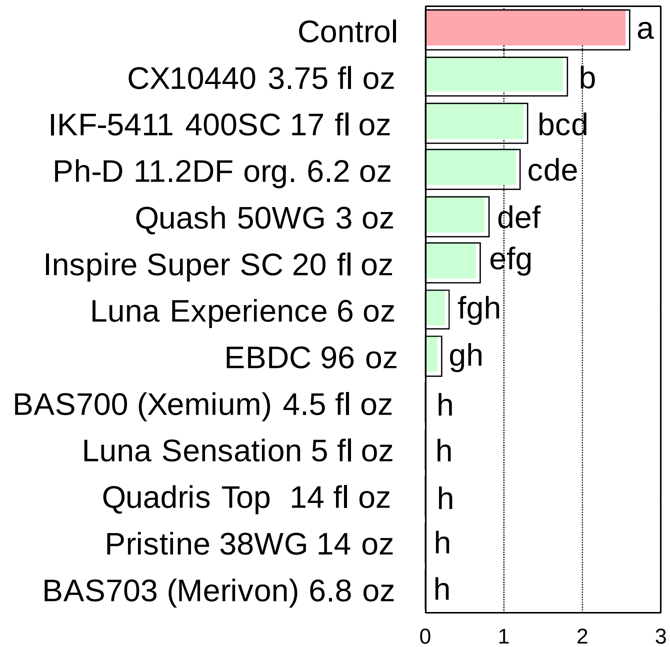
- **Most effective new fungicides:**
- Materials that included a QoI compound (e.g., Abound, Adament, Quadris Top, Quilt Excel, Pristine) were among the most effective fungicides.
- The DMIs (Quash, Tilt, Inspire) and Ph-D also significantly reduced the incidence of disease.
- Chlorothalonil (e.g., Bravo) was also highly effective, but this fungicide is currently only registered for use up to150 days of harvest (changes pending).

Management of Almond Leaf Rust

- 2011 -

Almond Rust

Pathogen:
Tranzschelia discolor



cv. Fritz, Kern Co.

Applications on May13, June 21, and June23 (as part of an Alternaria leaf spot management program). Severity rating from 0 to 4.

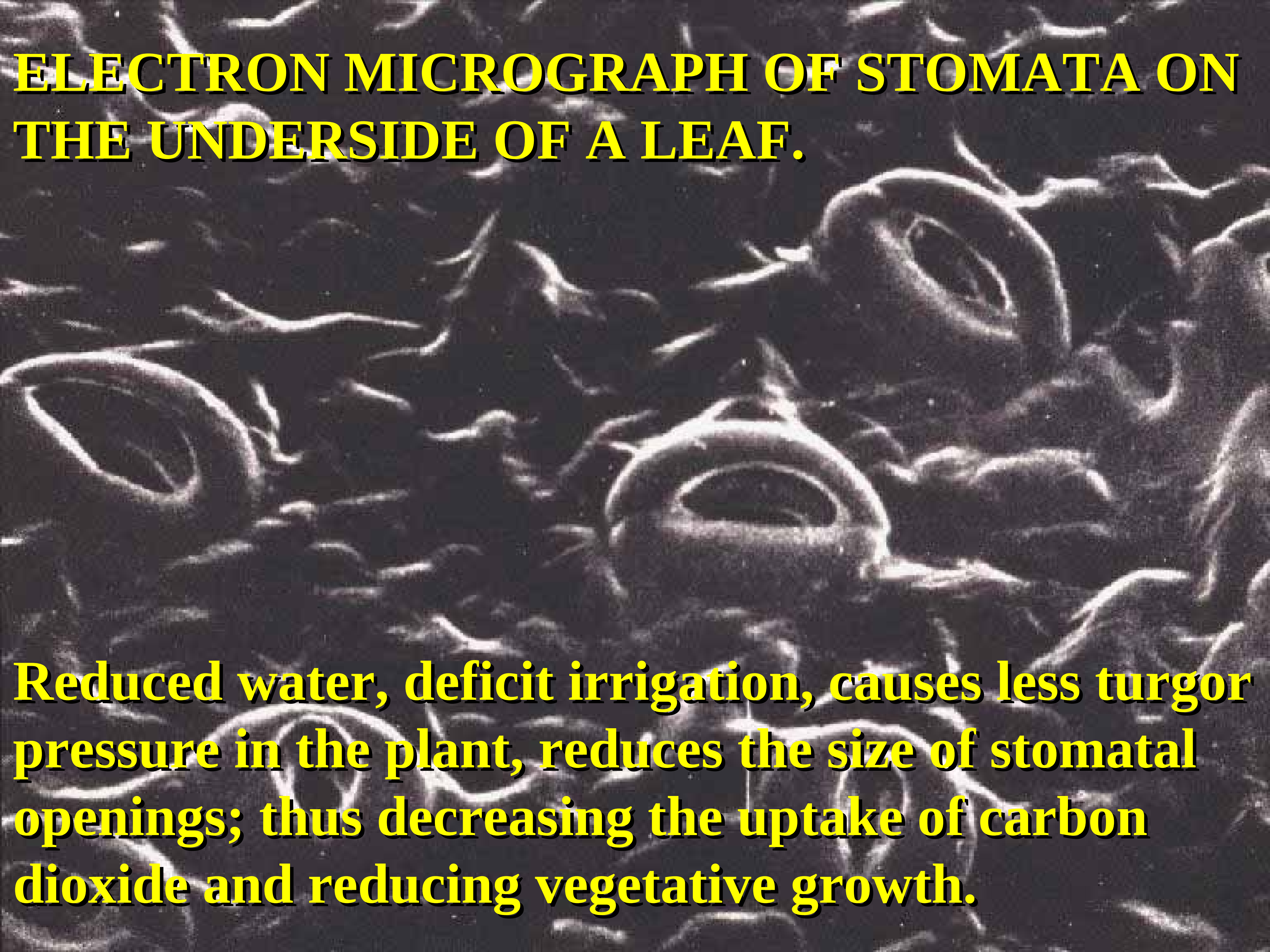
- Materials that included a QoI and/or a SDHI compound (e.g., Luna Experience, Luna Sensation, Quadris Top, Pristine, Merivon) were among the most effective fungicides.
- The DMIs (Quash, Inspire Super), Ph-D, as well as numbered compounds also significantly reduced the incidence of disease.
- The EBDC material was also highly effective, but this fungicide class is currently not registered for late-season applications.
- The first fungicide application should be done at the very first occurrence of disease symptoms (1% of leaf sample) in a spring (April-June) monitoring program if the disease occurred in the previous season.

Water Demand & Fertigation Options for Almonds in the SJV

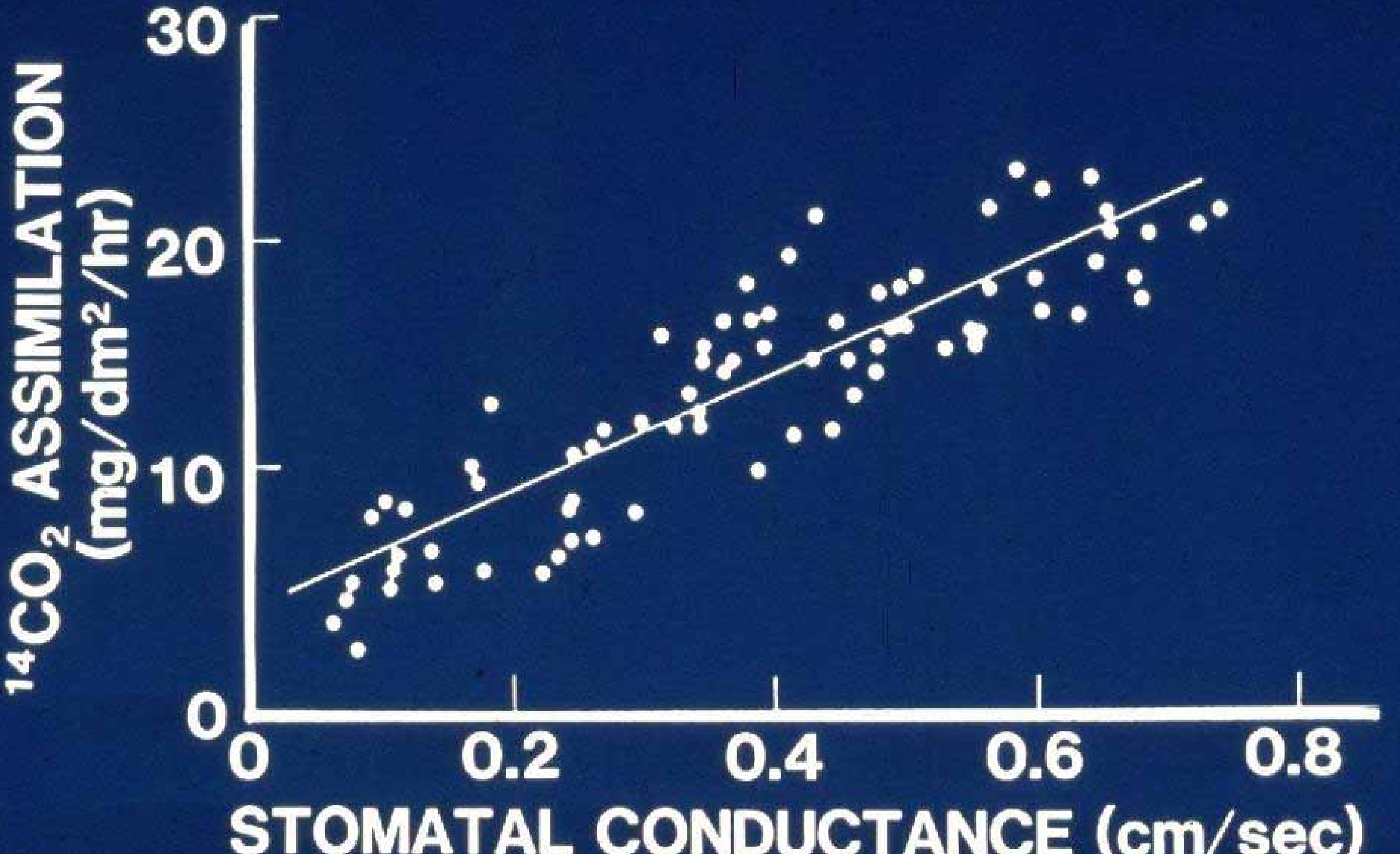
Kern Almond & Irrigation Workshop March 28, 2012
UCCE 1031 S. Mt. Vernon Ave, Bakersfield CA 93307

Blake Sanden – Irrigation Advisor, Kern County
http://cekern.ucdavis.edu/Irrigation_Management/

ELECTRON MICROGRAPH OF STOMATA ON THE UNDERSIDE OF A LEAF.

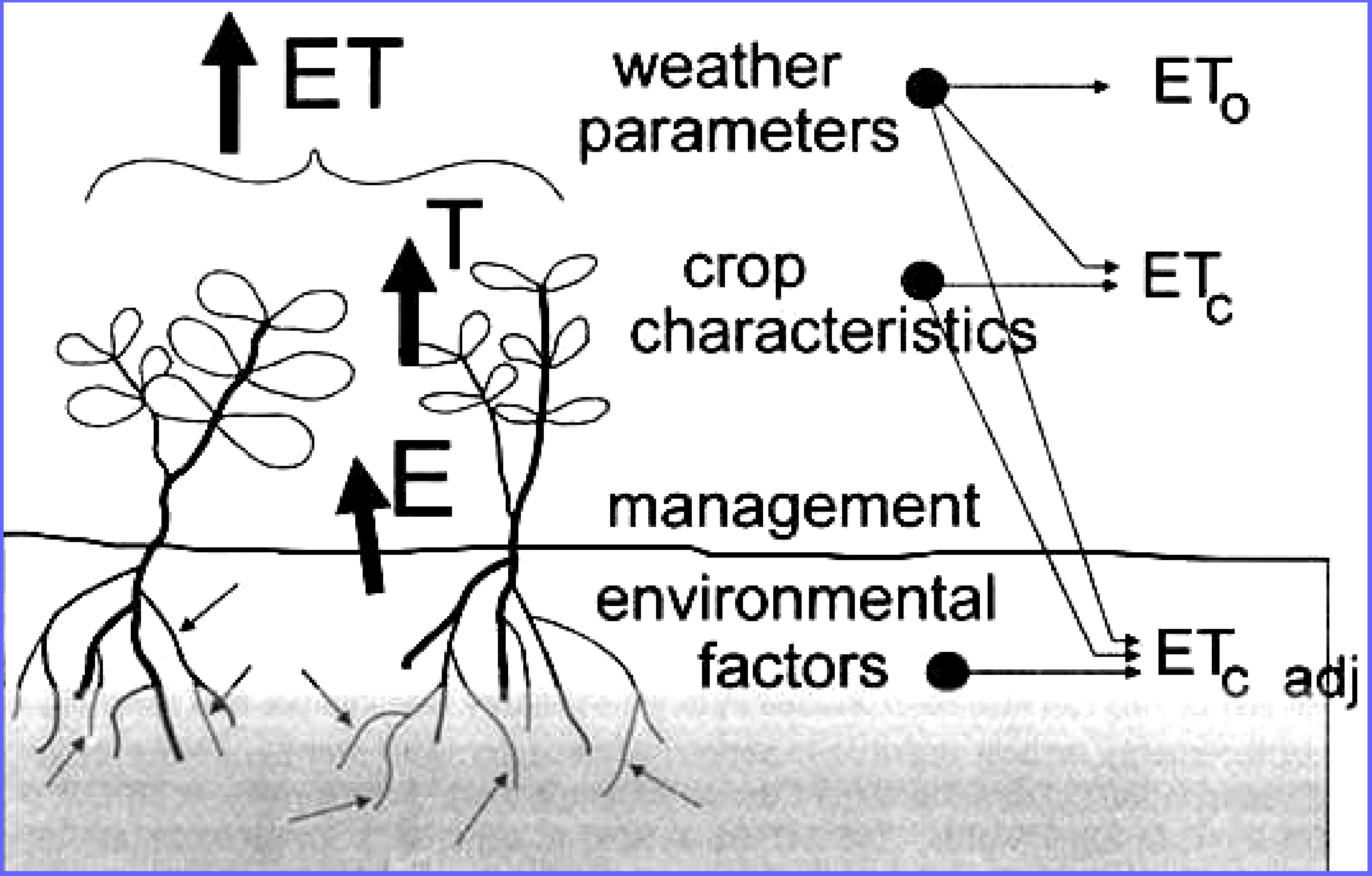


Reduced water, deficit irrigation, causes less turgor pressure in the plant, reduces the size of stomatal openings; thus decreasing the uptake of carbon dioxide and reducing vegetative growth.



30
20
10
0
$^{14}CO_2$ ASSIMILATION
(mg/dm^2/hr)
0
0.2
0.4
0.6
0.8
STOMATAL CONDUCTANCE (cm/sec)

Crop water use is made up of EVAPORATION (E) from the wet soil and leaves and TRANSPIRATION (T), hence ET



Calculating ET for crops:

$$ET_{crop} = ET_o * K_c * E_f$$

ET_o = **reference crop** (tall grass) ET

K_c = **crop coefficient** for a given stage of growth as a ratio of grass water use. May be 0 to 1.3, standard values are good starting point.

E_f = an "**environmental factor**" that can account for immature permanent crops and/or impact of salinity. May be 0.1 to 1.1, determined by site.

CIMIS – CA Irrigation Management Information Service

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variablity between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

The whole Central Valley covers Zones 12 to 16: for an "normal year" ETo of 53.3 to 62.5 in/yr, with most area @ 53 to 58 inches.

The "dirt" is the thing. Know your soil!

IDEAL: deep, well drained, non-alkali sandy to sandy clay loam

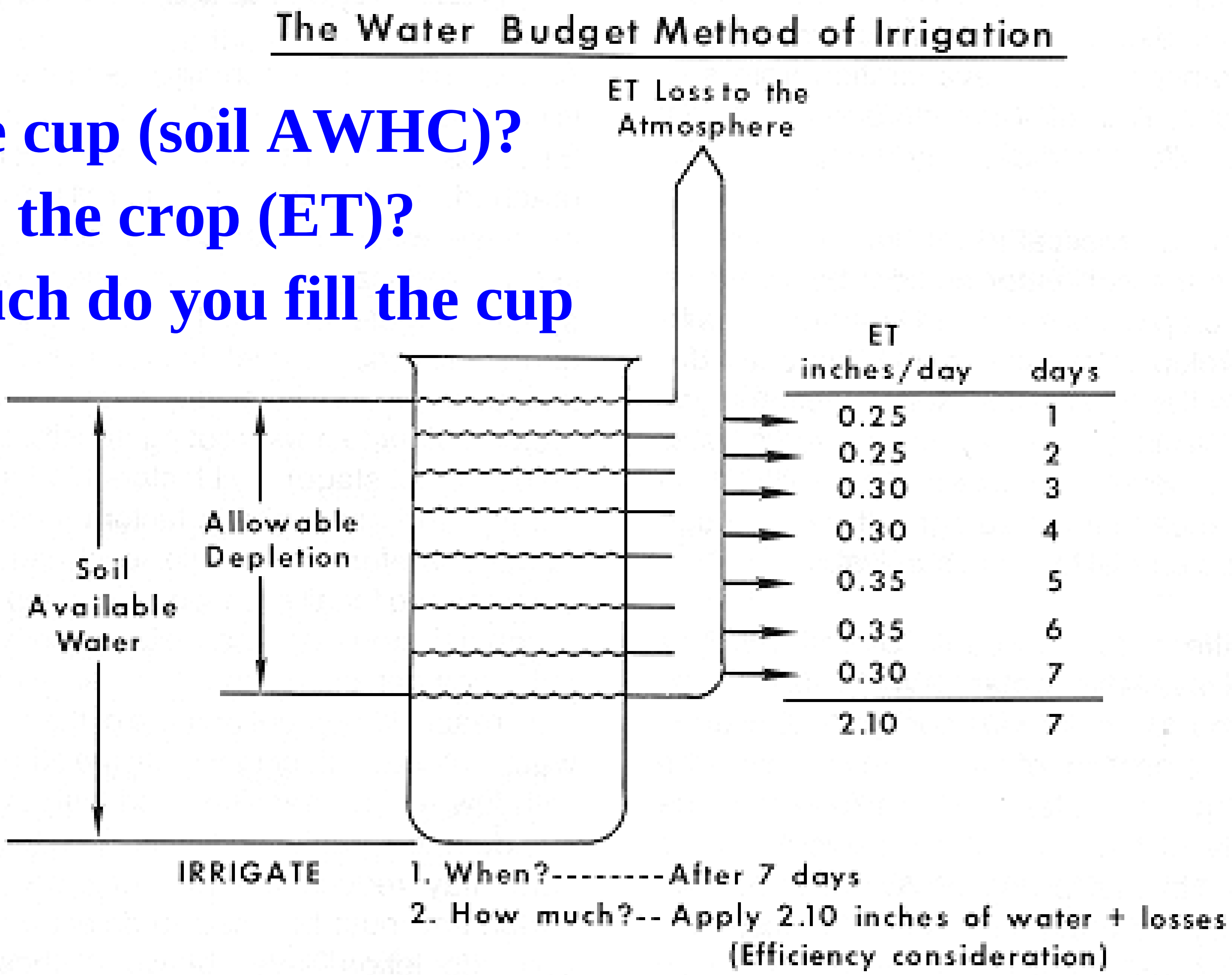
SOIL TEXTURE DETERMINES AVAILABLE WATER HOLDING CAPACITY

SOIL TEXTURE "FEEL METHOD"

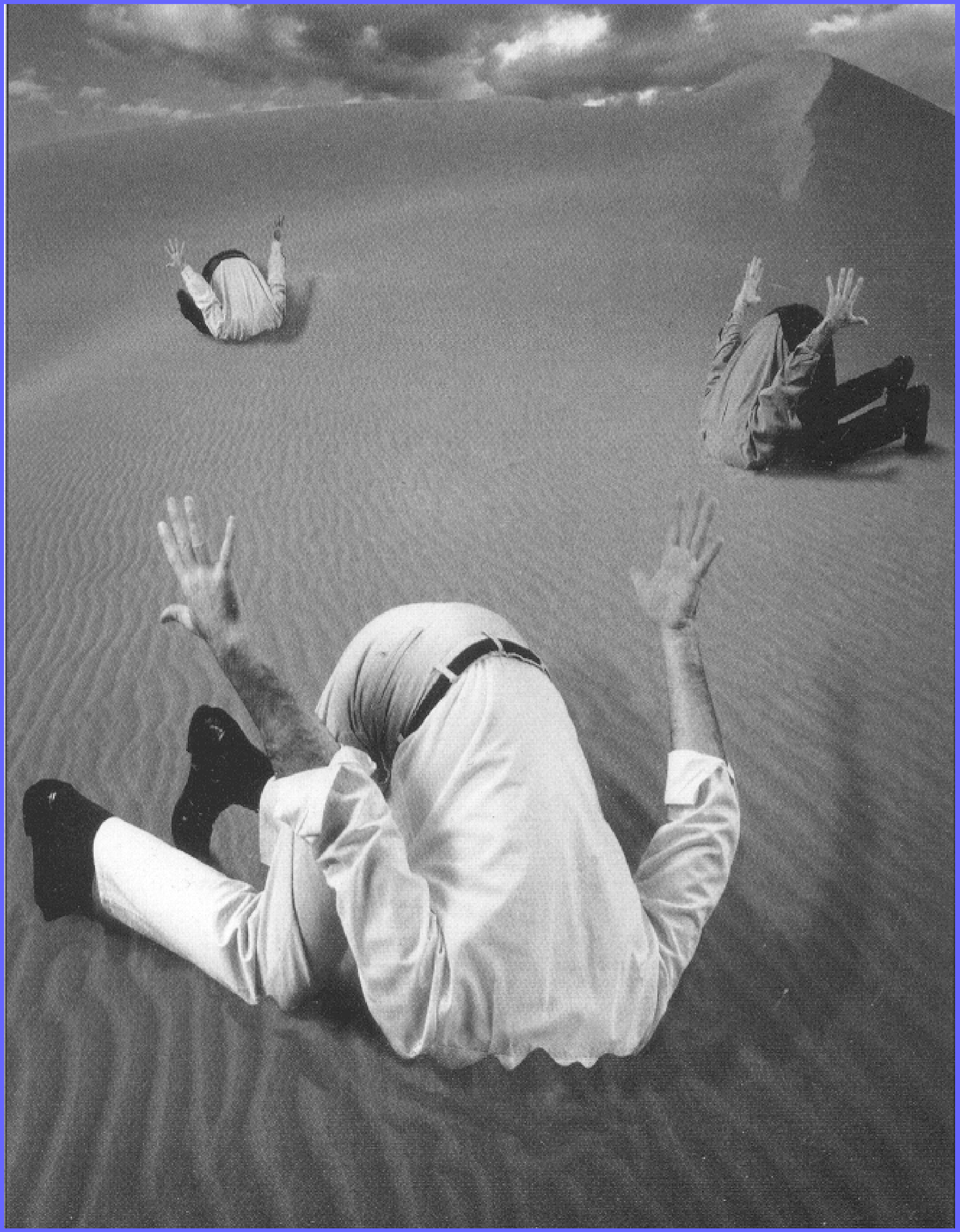
$$\text{AWHC} = \%\text{Volume} = \frac{\text{inch depth of water}}{\text{1 foot depth of soil}}$$

Creating the efficient field water balance – your soil moisture checking account!

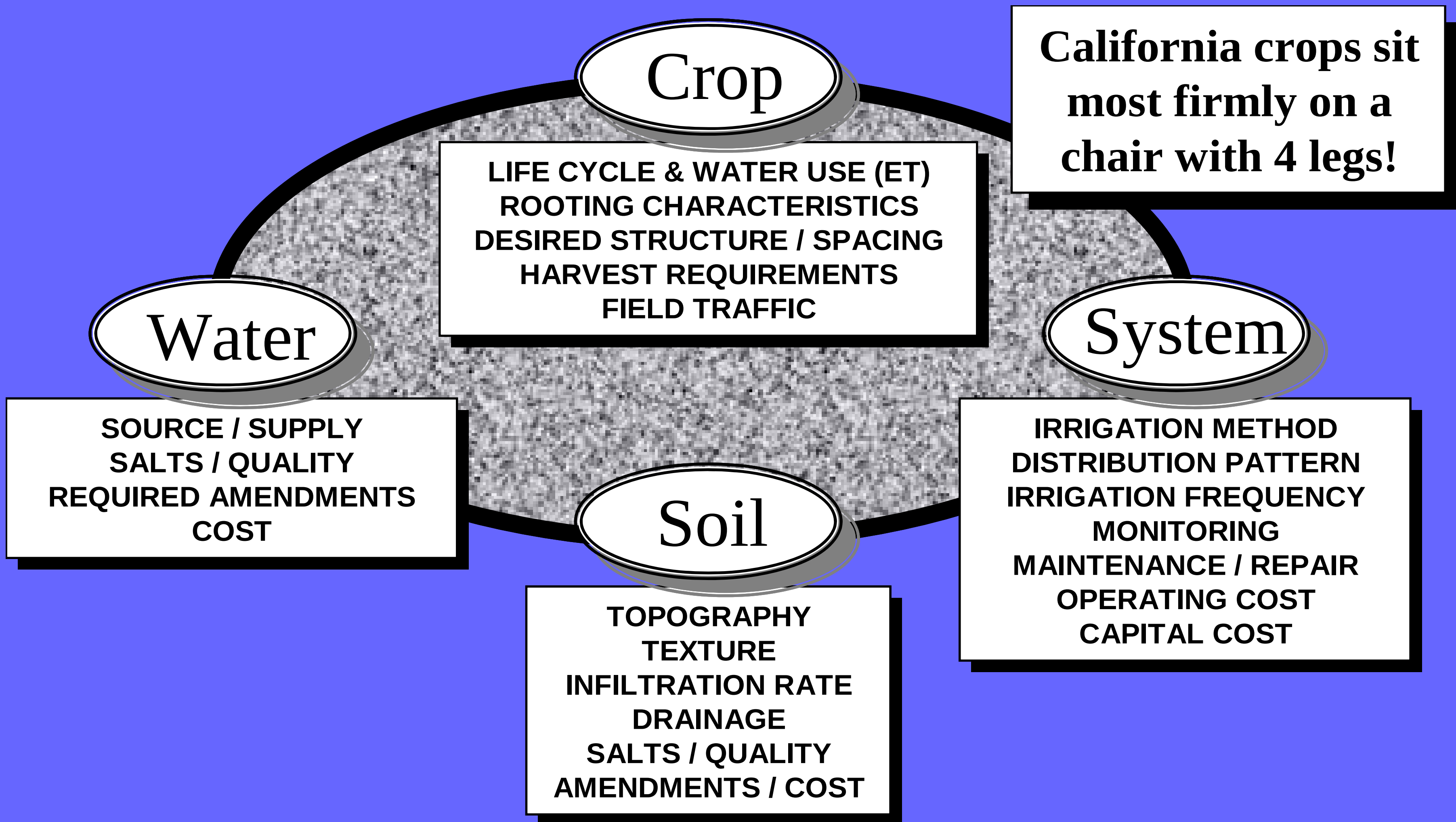
- **How big is the cup (soil AWHC)?**
- **How thirsty is the crop (ET)?**
- **How often/much do you fill the cup (Scheduling)?**



So how do I look into the crop rootzone to optimize my field water & fertilizer budget?



The soil & irrigation system are the "ESSENTIAL" integrating factors for creating an optimal water balance.




"Essential" is just the basics, right?
So can flood irrigation with 8 inch
alfalfa valves @ 200 gpm be optimal?


What about 18 inch
valves @ 2000 gpm?

Micro-irrigation system capable of injecting fertilizer and applying 0.6 to 1.5 inches/day

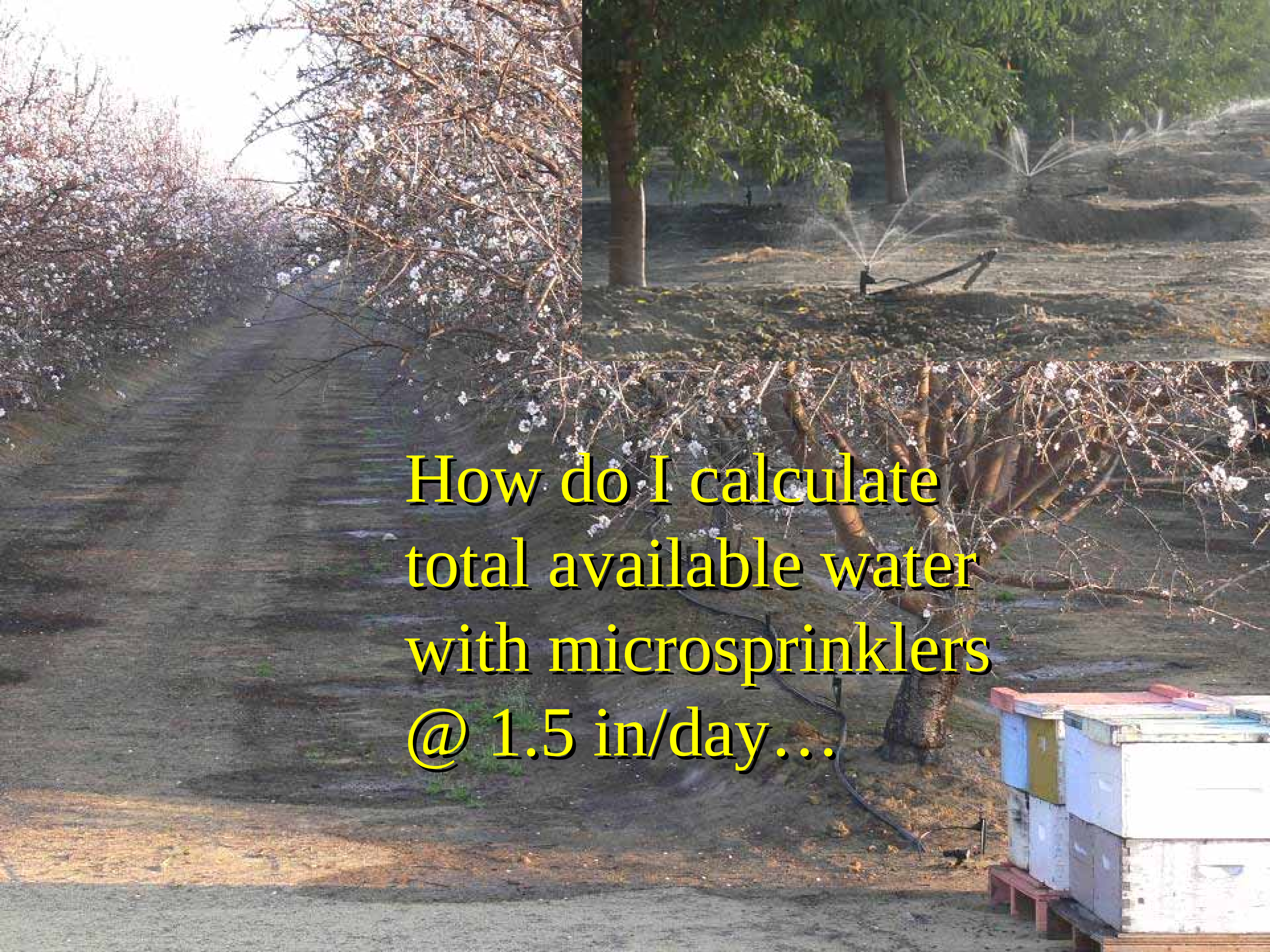

… or do you need this
kind of system …

… and this much technology?

YES …

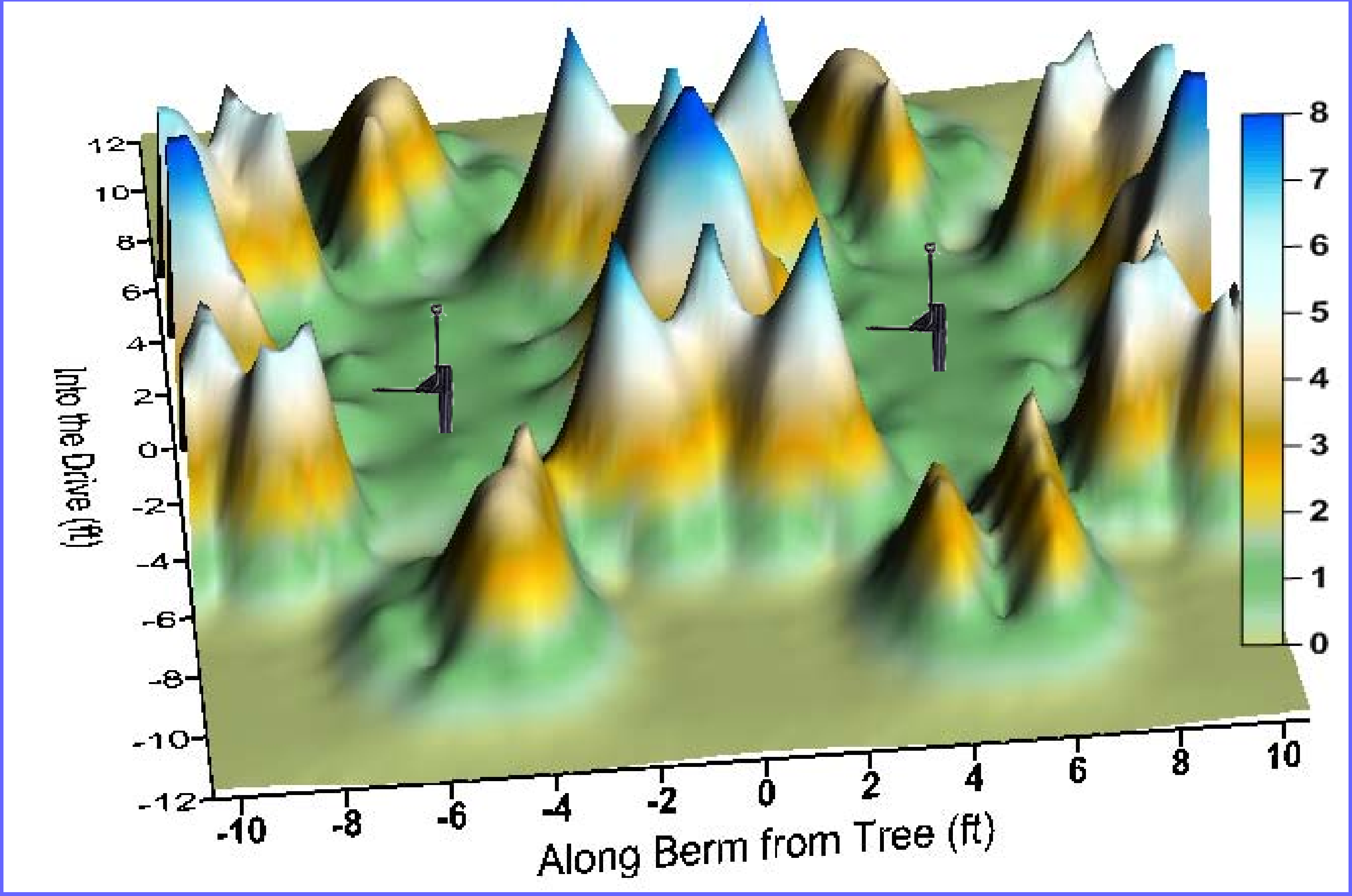
NO …

DEPENDS.

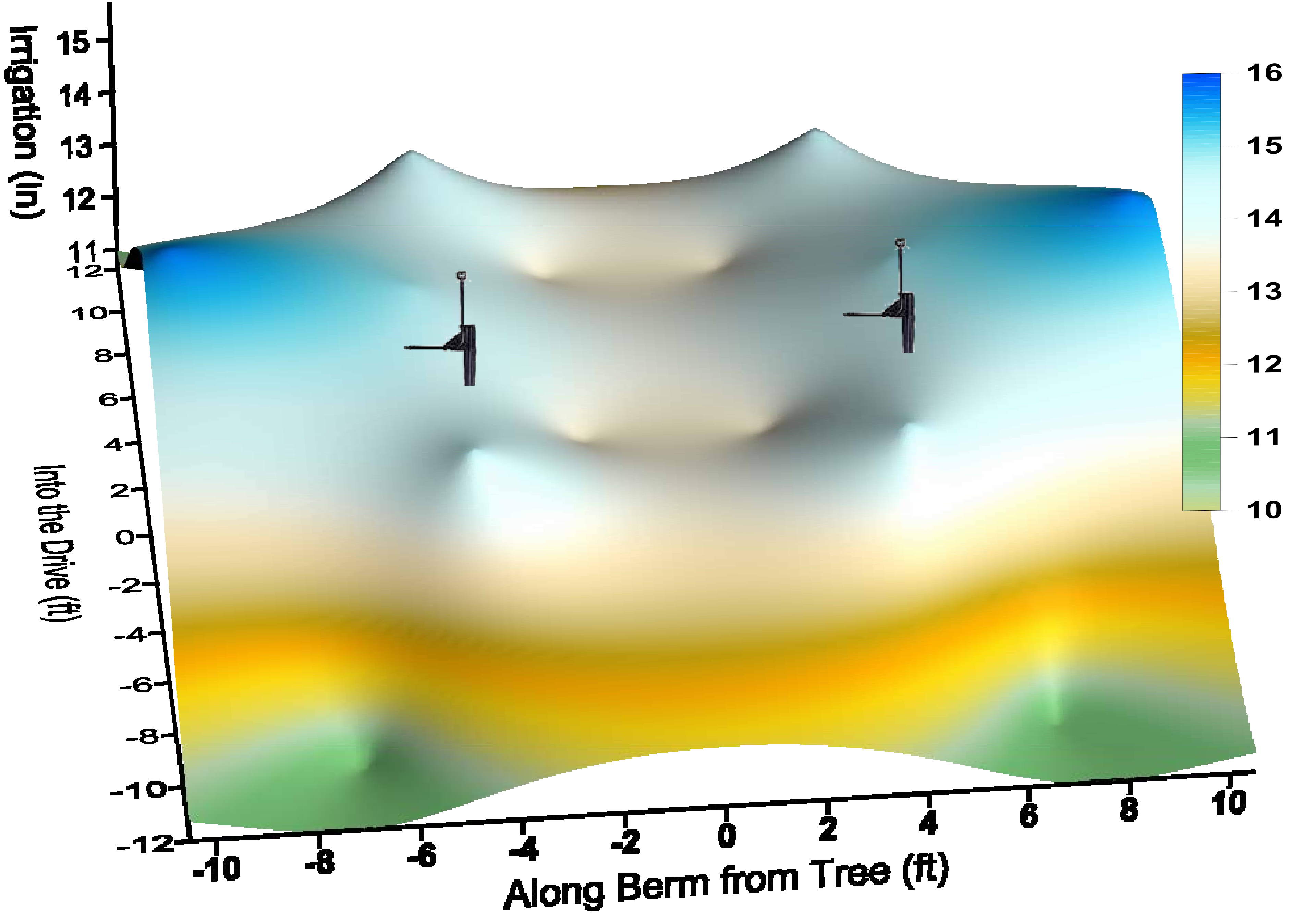

How do I calculate
total available water
with microsprinklers
@ 1.5 in/day…


Irrigation evaluation for
application patterns &
rootzone subbing 4/23/09
Bowsmith A-40
microsprinkler

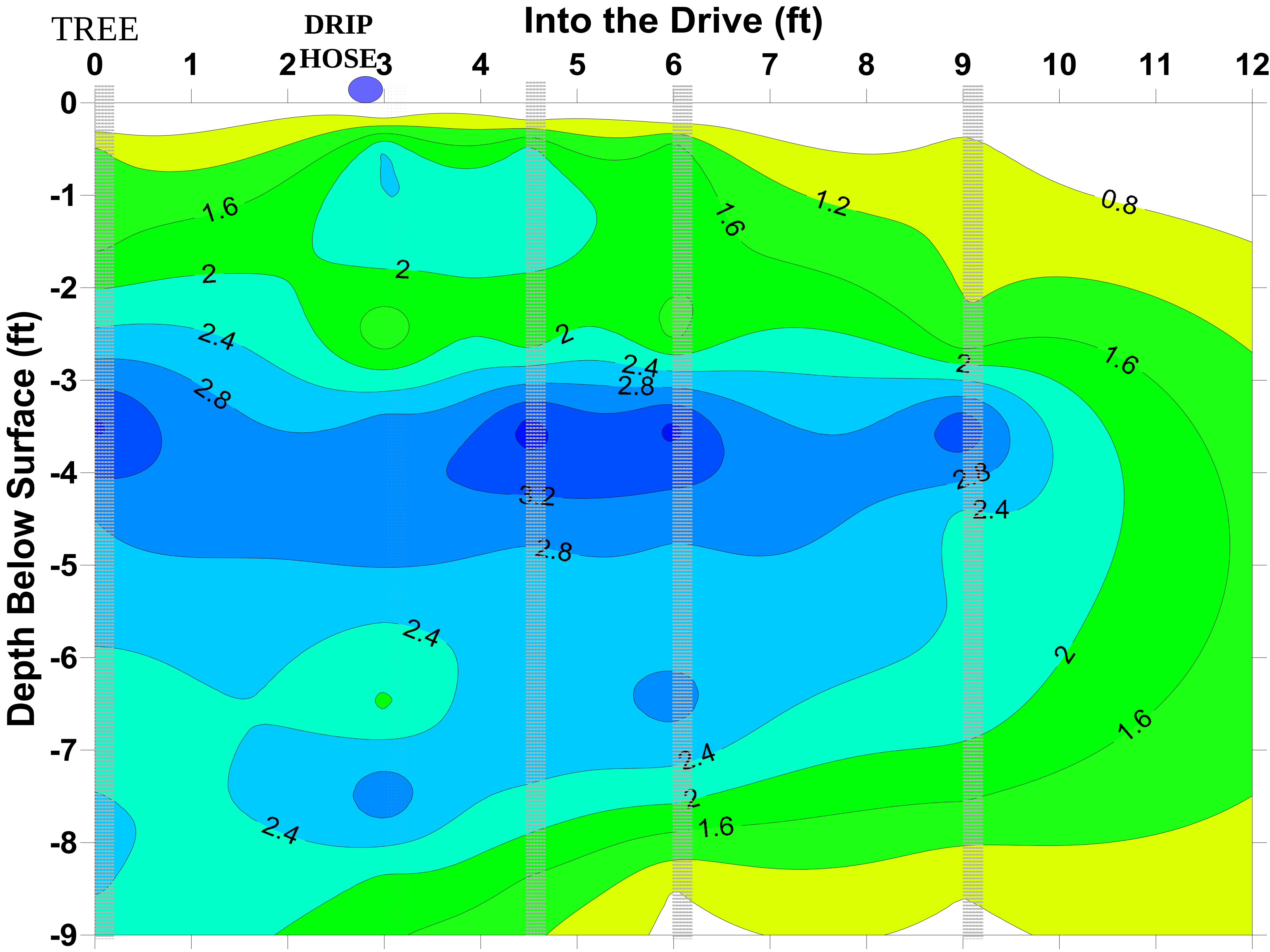
Interpolated pattern of applied water from 2 Fanjets/tree



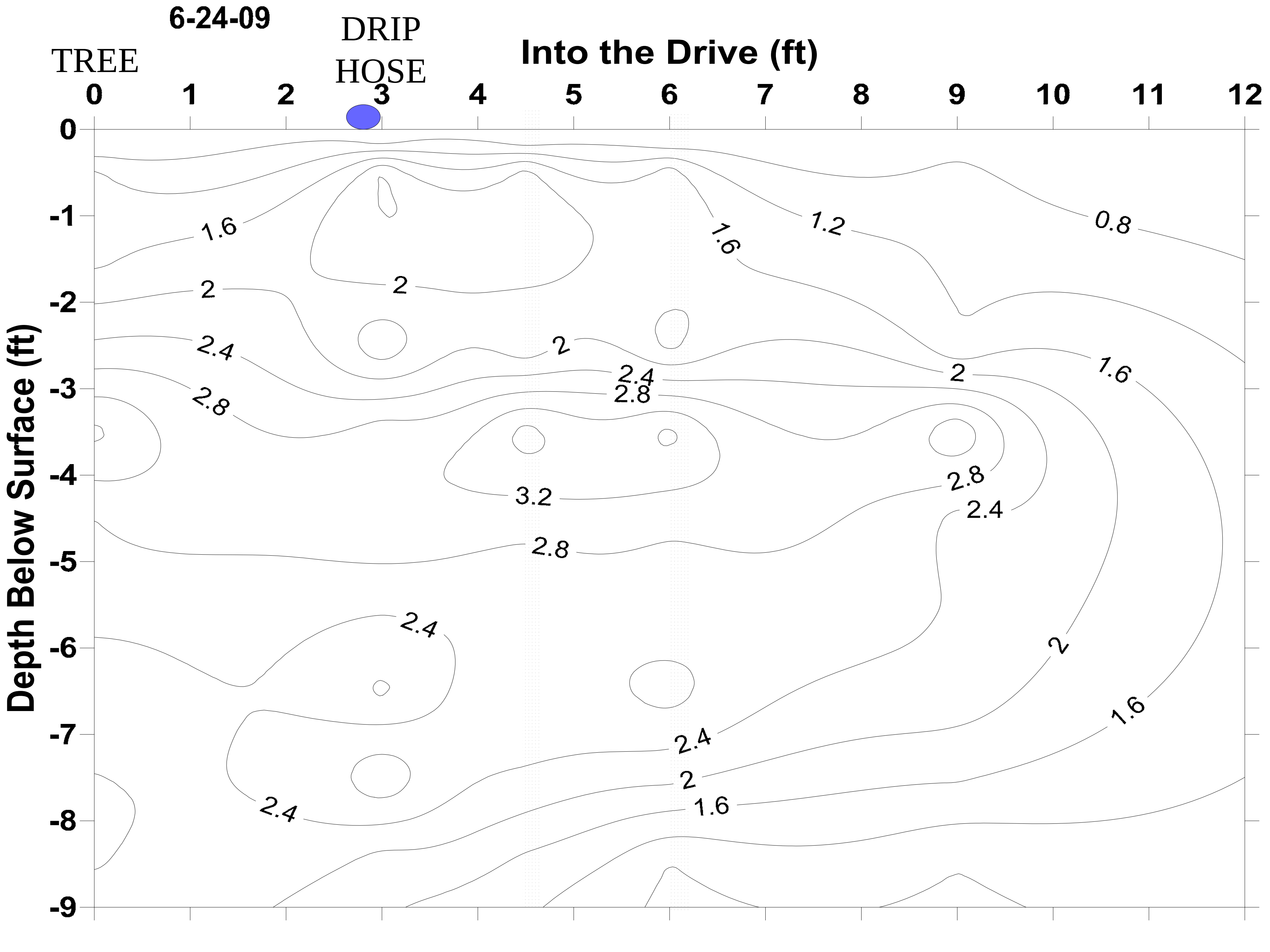
Summed 0-6 ft water content 6/24/09 after 24 hour irrigation




… or account for
"subbing" in a double-
line drip?



TREE
DRIP HOSE
Into the Drive (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
Depth Below Surface (ft)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
1.6
1.2
0.8
2
2.4
2.8
3.2


6-24-09
TREE
DRIP
HOSE
Into the Drive (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
Depth Below Surface (ft)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
1.6
1.6
1.2
0.8
2
2
2
2
2.4
2.4
2.8
2.8
1.6
3.2
2.8
2.4
2.8
2.4
2
1.6
2.4
2.4
2
1.6
2.4

Estimating Water Holding Capacity & Microirrigation Set Times for Orchards

Refill Times for Different Soil Textures and Micro Systems

[1]Irrigation Time to Refill & Moisture Reserve of 4 Foot Wetted Rootzone @ 50% to 100% Available

ALMONDS 0.28 inch/day ET

Soil Texture	Available Soil Moisture (in/ft)	Avg Drip Subbing Diameter from 1 to 4' Depth (ft)	Dble-Line Drip 1-gph, 10 per tree (irrig hrs)	Moisture Reserve @ 0.28"/day (days)	10 gph Fanjet, 1 per tree (irrig hrs)	Moisture Reserve @ 0.28"/day (days)	14 gph Fanjet, 1 per tree (irrig hrs)	Moisture Reserve @ 0.28"/day (days)
Sand	0.7	2	2.2	0.3	11.6	1.6	12.5	2.4
Loamy Sand	1.1	3	7.8	1.0	19.6	2.7	20.9	4.0
Sandy Loam	1.4	4	17.5	2.4	26.9	3.6	28.3	5.4
Loam	1.8	5	35.9	4.9	37.1	5.0	38.6	7.3
Silt Loam	1.8	6	43.1	5.8	39.7	5.4	40.8	7.7
Sandy Clay Loam	1.3	6	31.1	4.2	28.6	3.9	29.5	5.6
Sandy Clay	1.6	7	44.7	6.0	37.6	5.1	38.3	7.2
Clay Loam	1.7	8	54.3	7.3	42.6	5.8	42.9	8.1
Silty Clay Loam	1.9	9	68.2	9.2	50.6	6.8	50.5	9.6
Silty Clay	2.4	9	86.2	11.6	64.0	8.6	63.8	12.1
Clay	2.2	10	87.8	11.9	62.3	8.4	61.5	11.6

[1]Based on a tree spacing of 20 x 22'. Drip hoses 6' apart. 10 gph fanjet wets 12' diameter. 14 gph fanjet @ 15' diameter

Note: Peak water use @ 0.28"/day and 20 x 22' spacing = 74 gallons/day/tree. 0.20"/day = 55 gallons/day/tree.

Table takes into account merging water patterns below soil surface for drip irrigation.

So Point 1: If I understand my soil water holding capacity and schedule accordingly, then can flood irrigation be as "effective" as micro/drip?

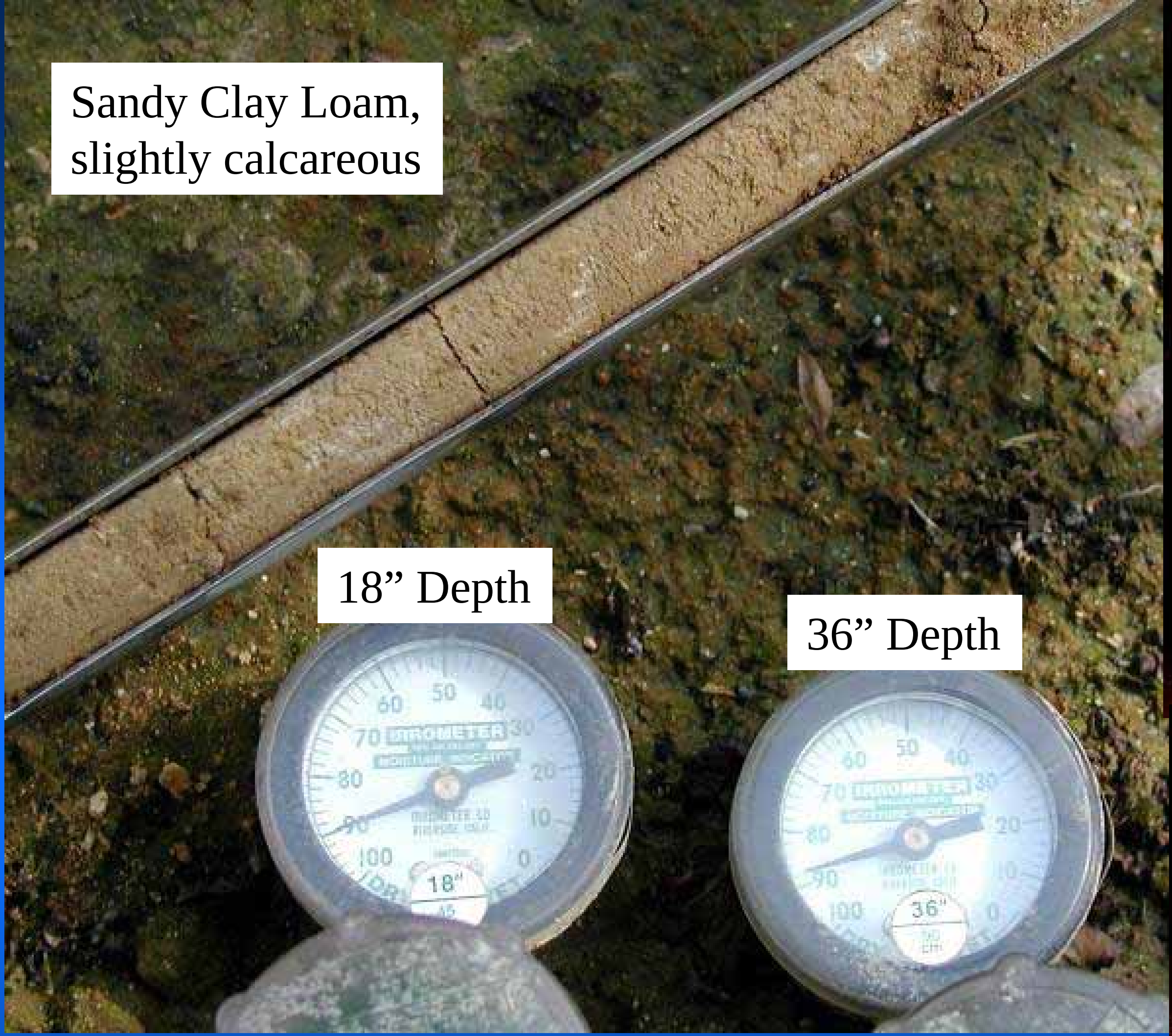
(1st leaf almonds needing to grow as much vegetative matter as possible)

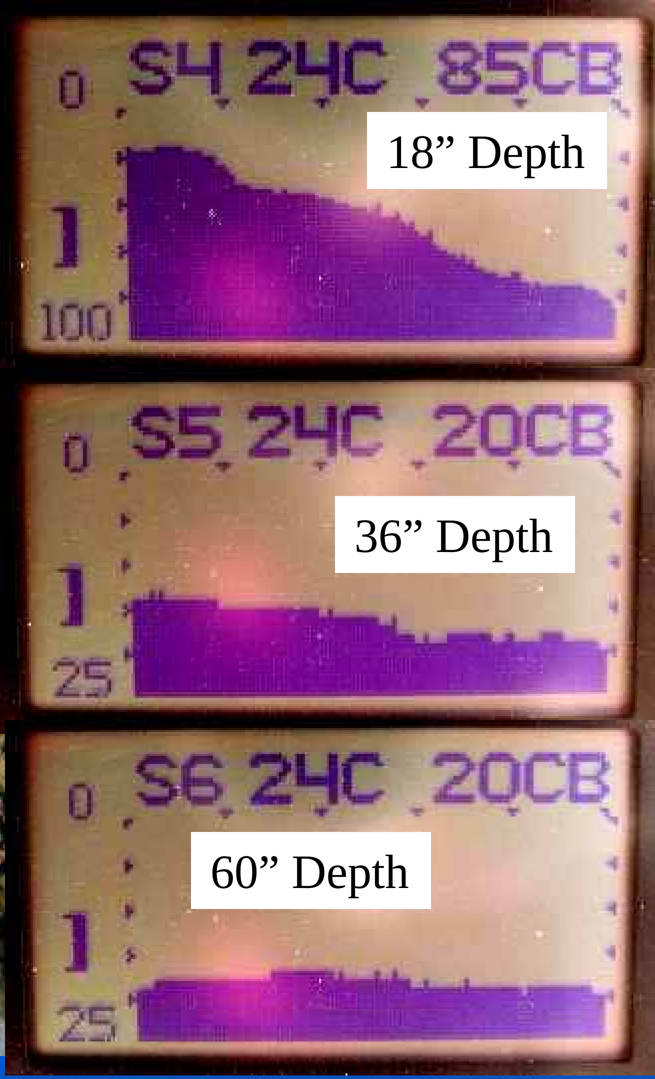
Irrigation non-uniformity can have severe impacts on water use and yields

Hand-powered twist augers

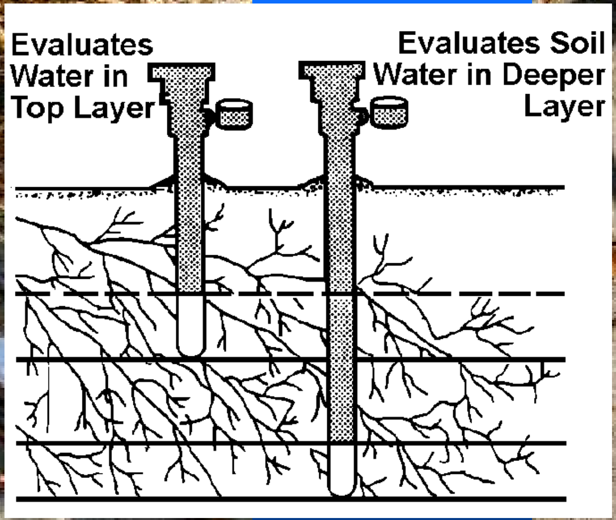
3 foot push or slide hammer-type probe.

A device using low levels of radiation, the neutron probe, was developed in the 1960's for checking soil moisture. Used mostly by researchers and irrigation consultants, it is often the standard check for the accuracy of other instruments. Largest sample "volume" to estimate moisture.





Checking reliability of dry readings on tensiometers with a soil core obtained with a 3 foot hammer probe.

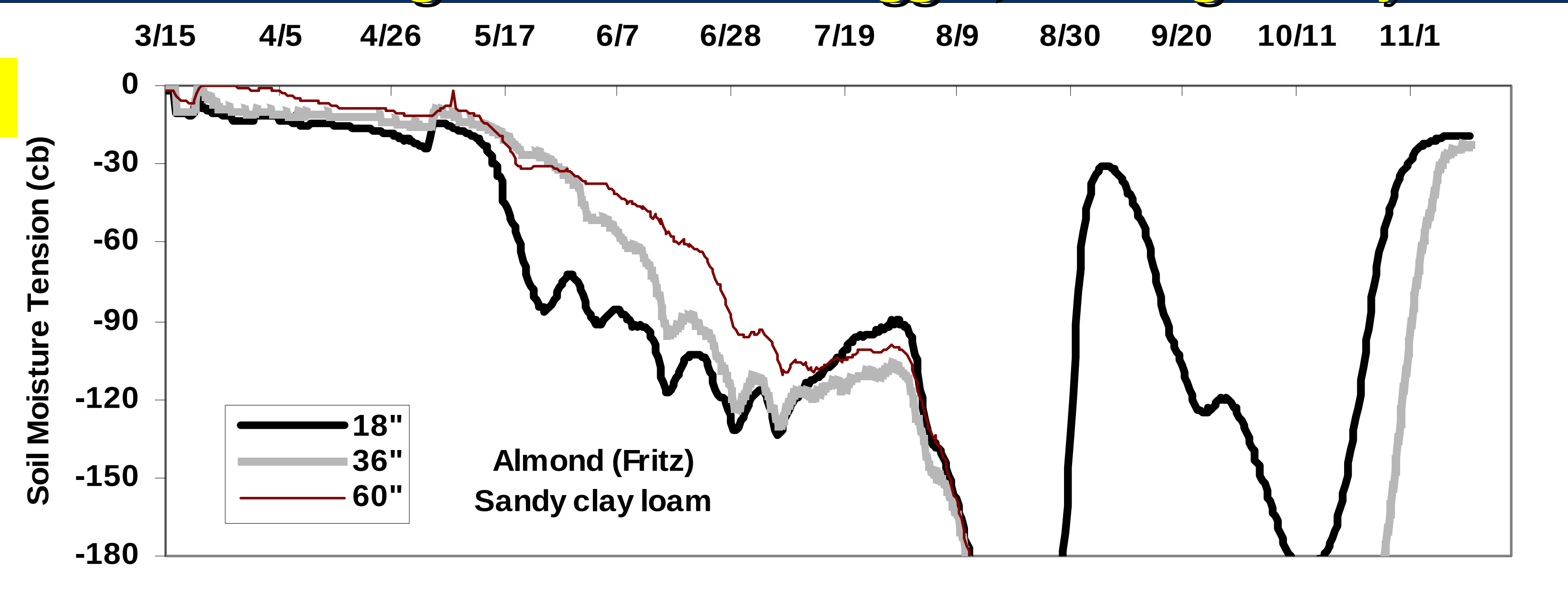


Tensiometers, Watermarks for Soil Moisture Tension (matric potential)

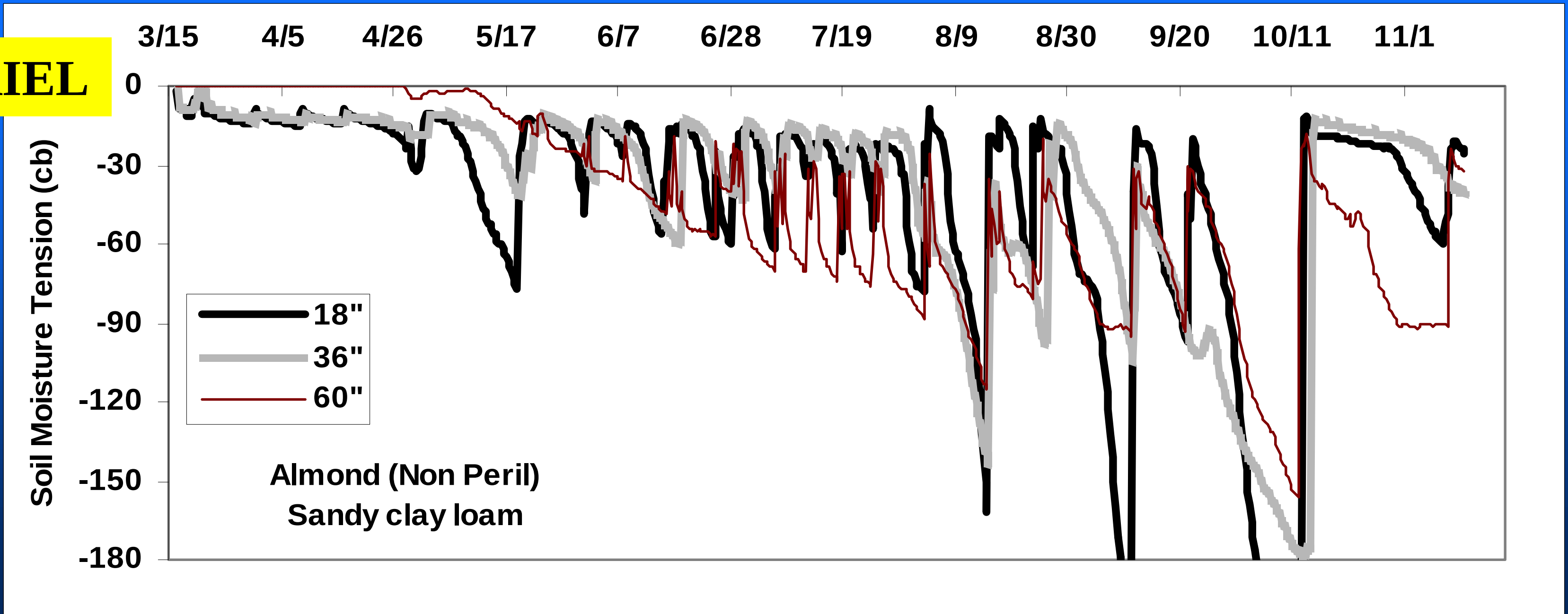
A variety of loggers can be used for various sensors: Costs from $100 (Hobo) to $5,000 (Campbell)

Watermark Readings from AM400 logger, reading 3x/day

FRITZ

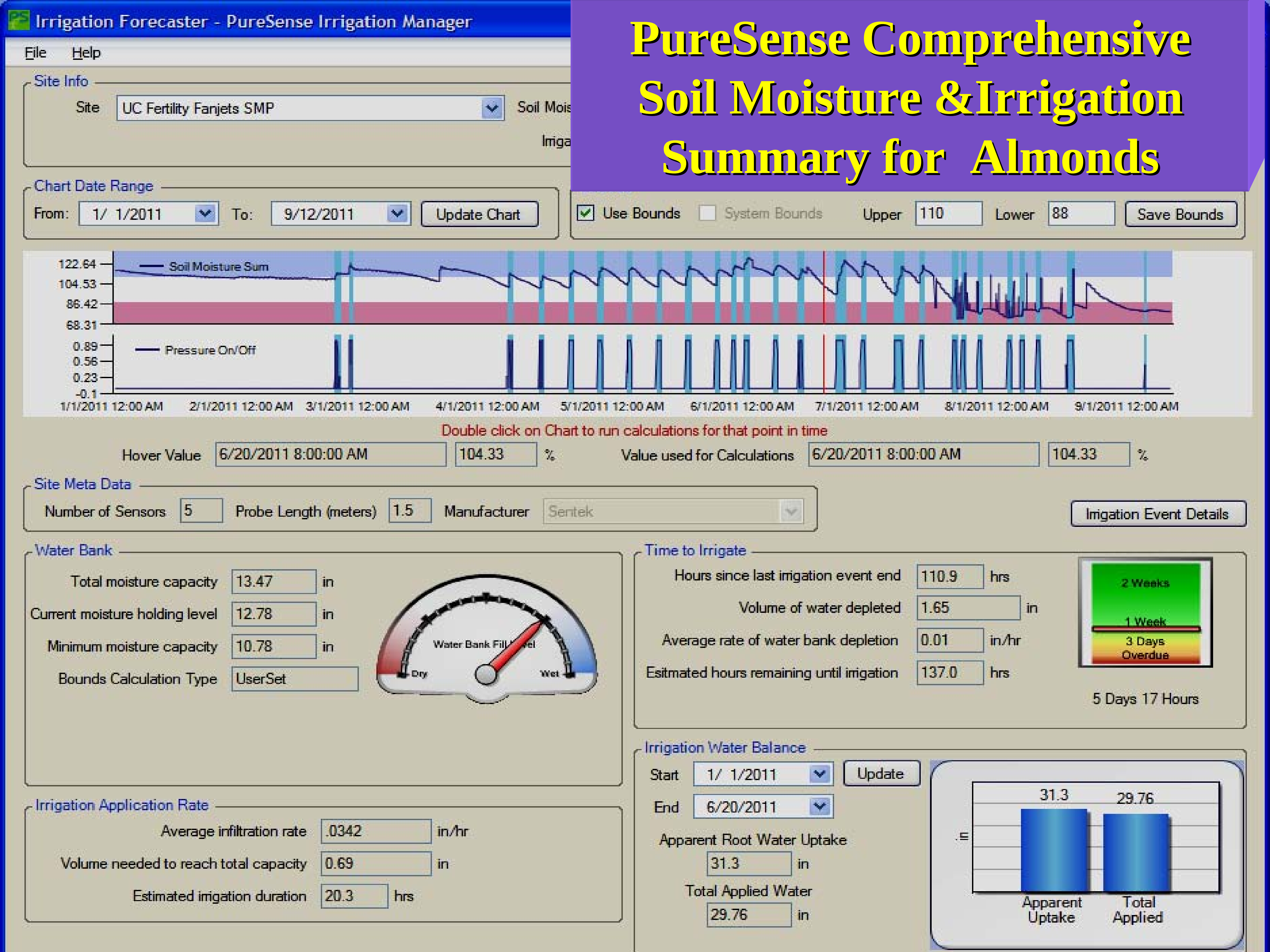


NONPARIEL



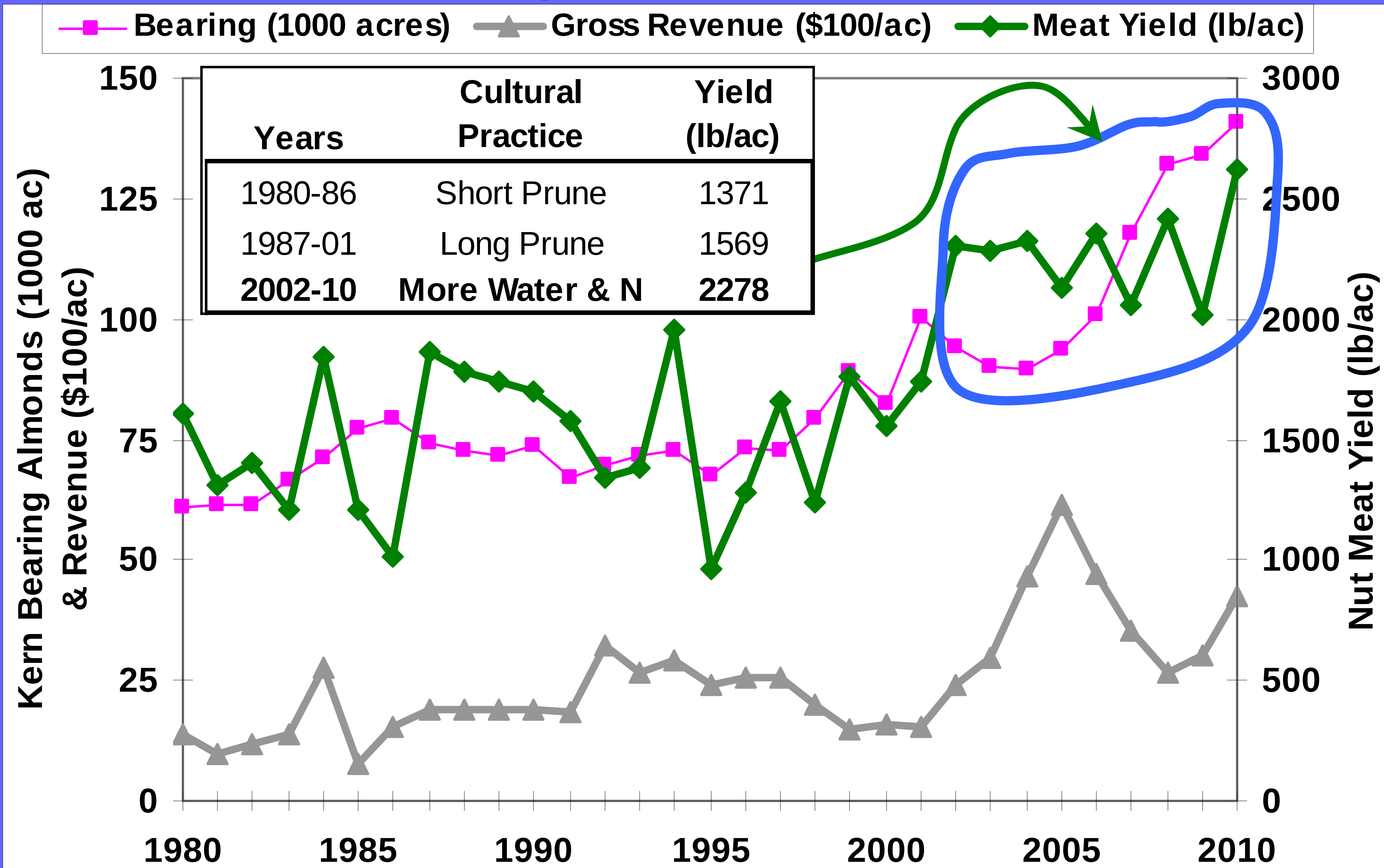
Electronics, data loggers, weather stations and multi-stage sensors can increase the cost rapidly up to $5,000 to $10,000. Does this degree of sophistication payoff?

PureSense Comprehensive Soil Moisture &Irrigation Summary for Almonds



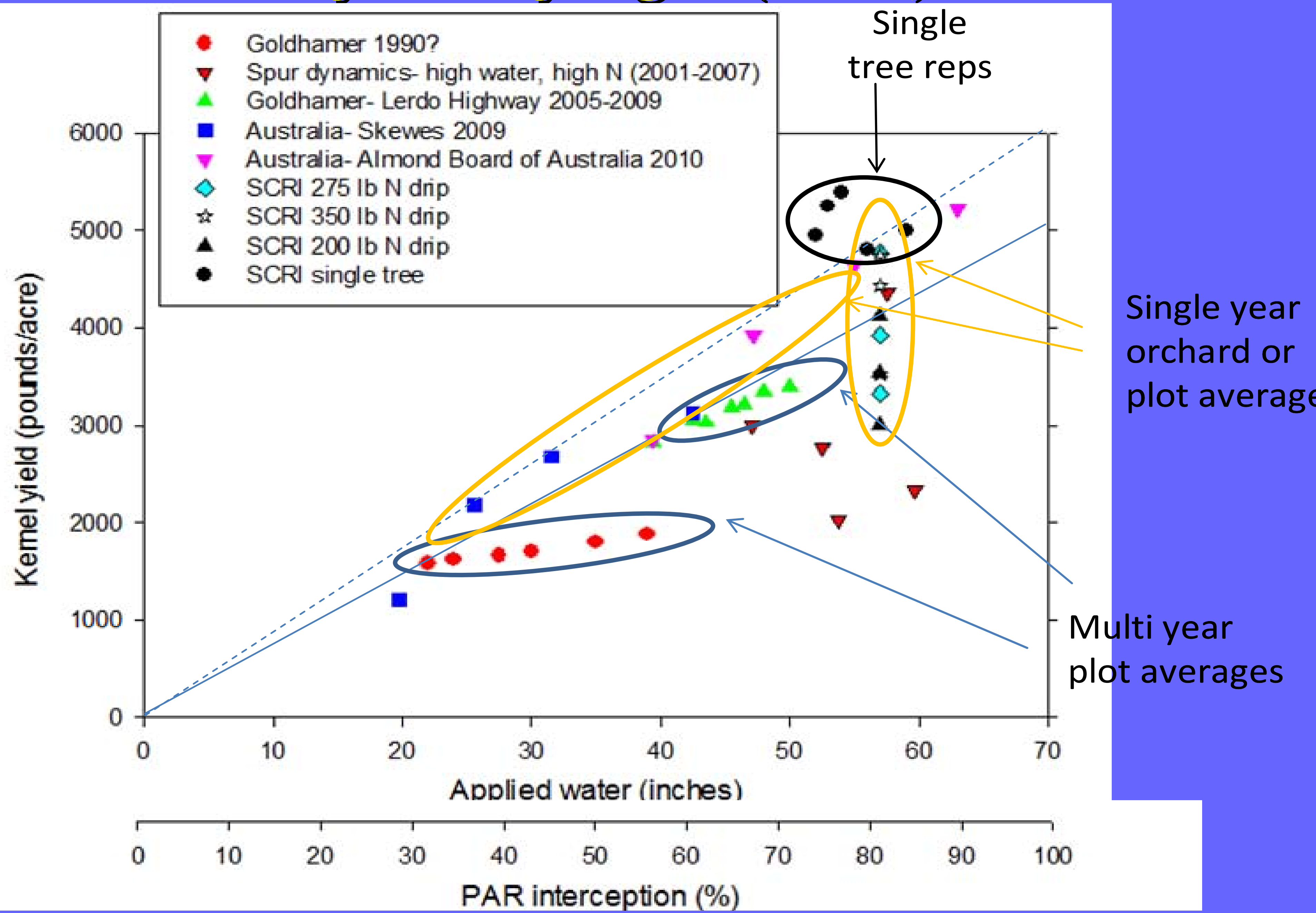
So what do we actually know about water and almonds?

Changes in Kern County almond yield and acreage from 1980-2010

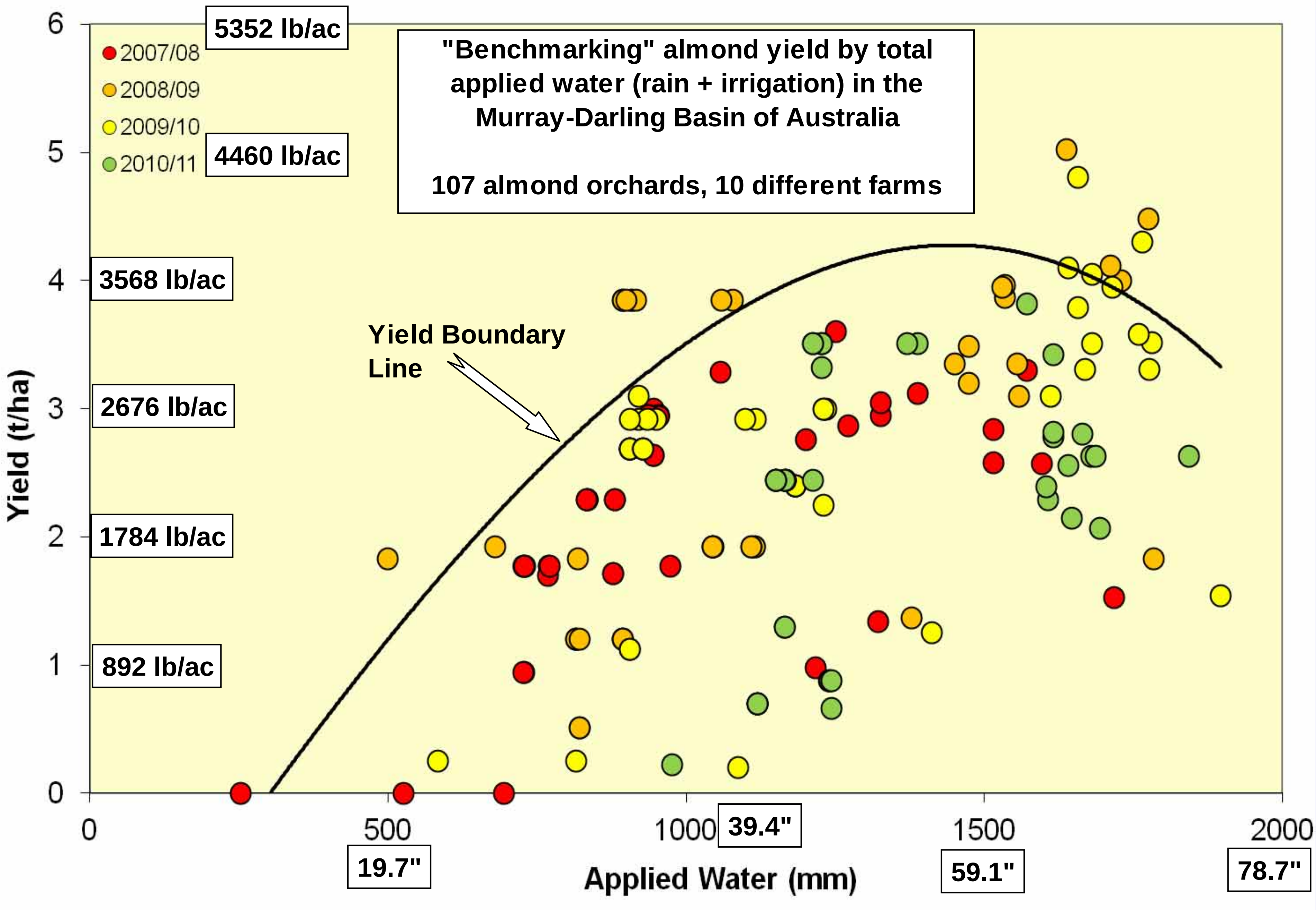


Years	Cultural Practice	Yield (lb/ac)
1980-86	Short Prune	1371
1987-01	Long Prune	1569
2002-10	**More Water & N**	**2278**

Almond yield by light (PAR) & water



Yield by applied water, Murray-Darling R. Valley Australia



Do almonds really need as much water as alfalfa – 52 to 56 inches? The old recommendation was 42-45 inches?

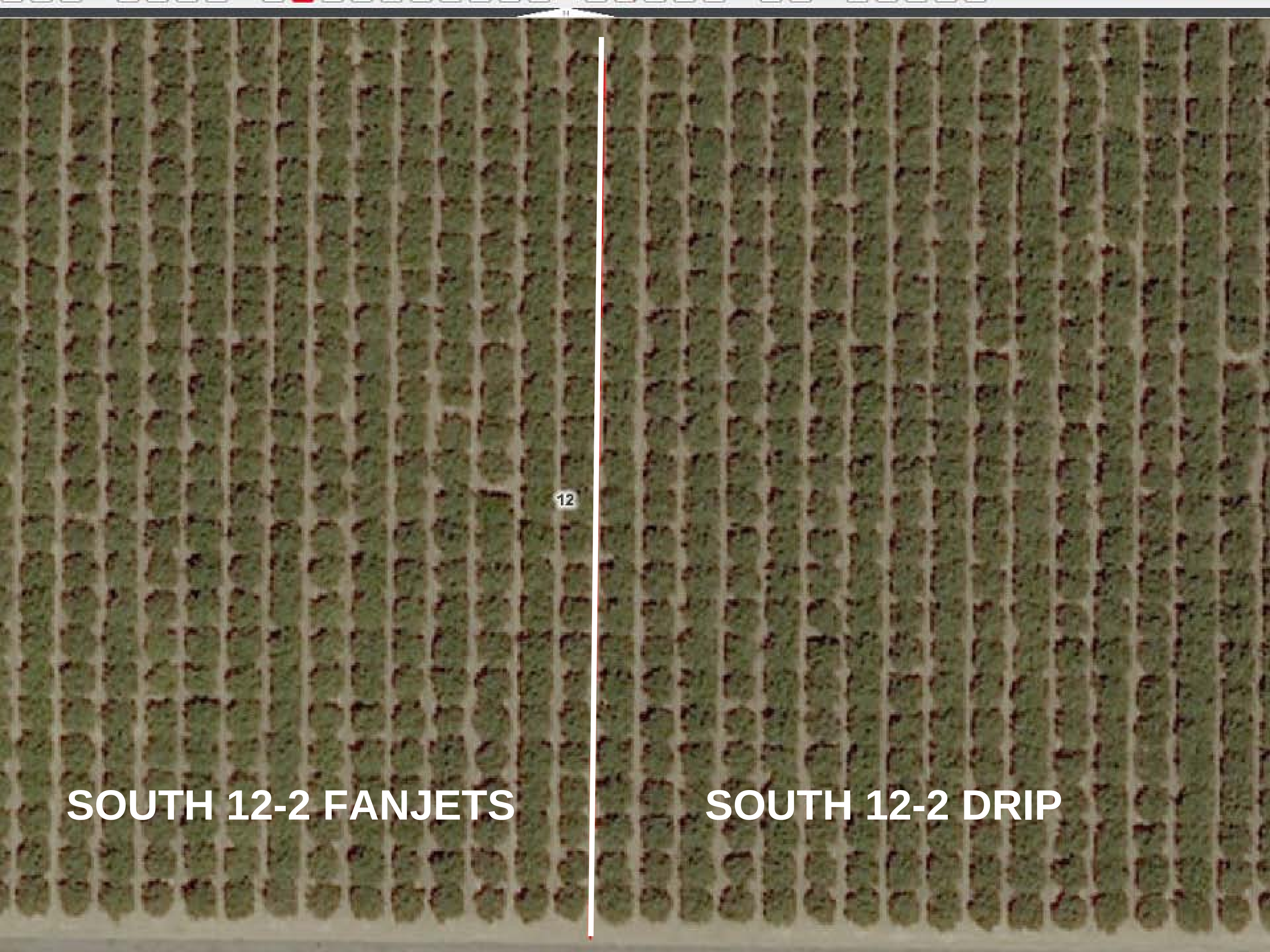
What’s the right ET?

UNIVERSITY of CALIFORNIA
COOPERATIVE EXTENSION

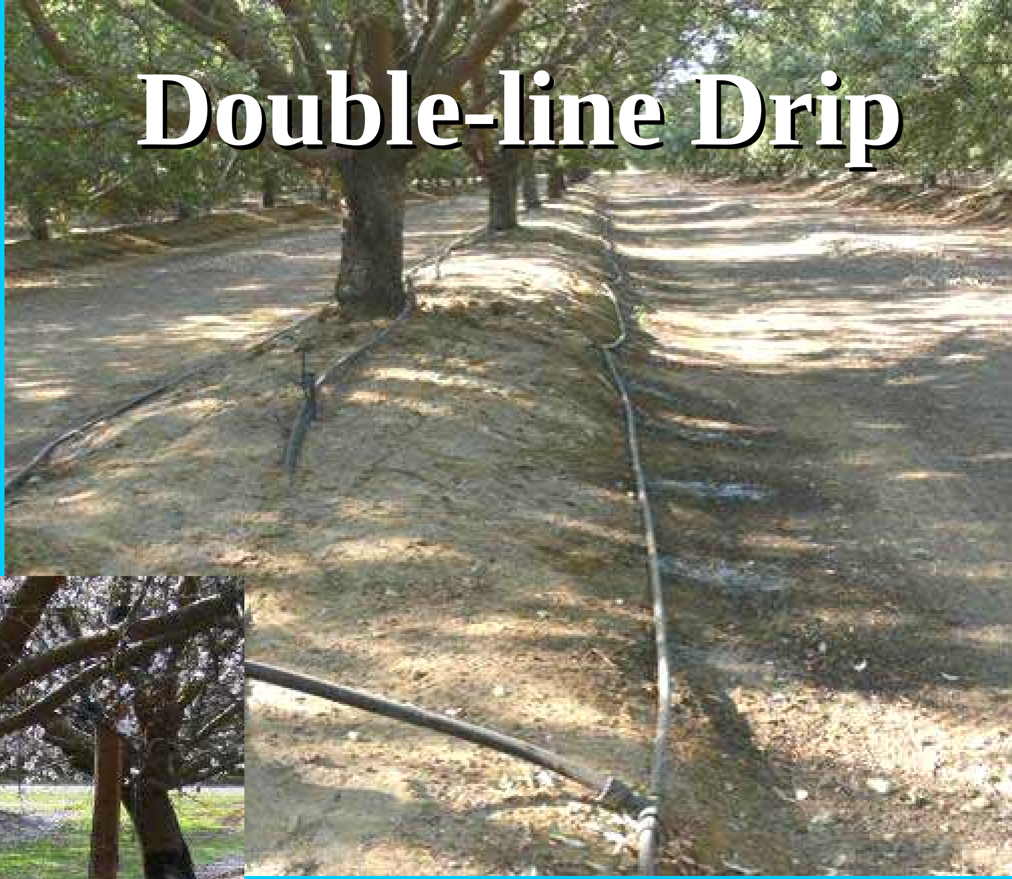
Fertigation: Case study of interaction of water and nutrient management in almonds: 2008-2012

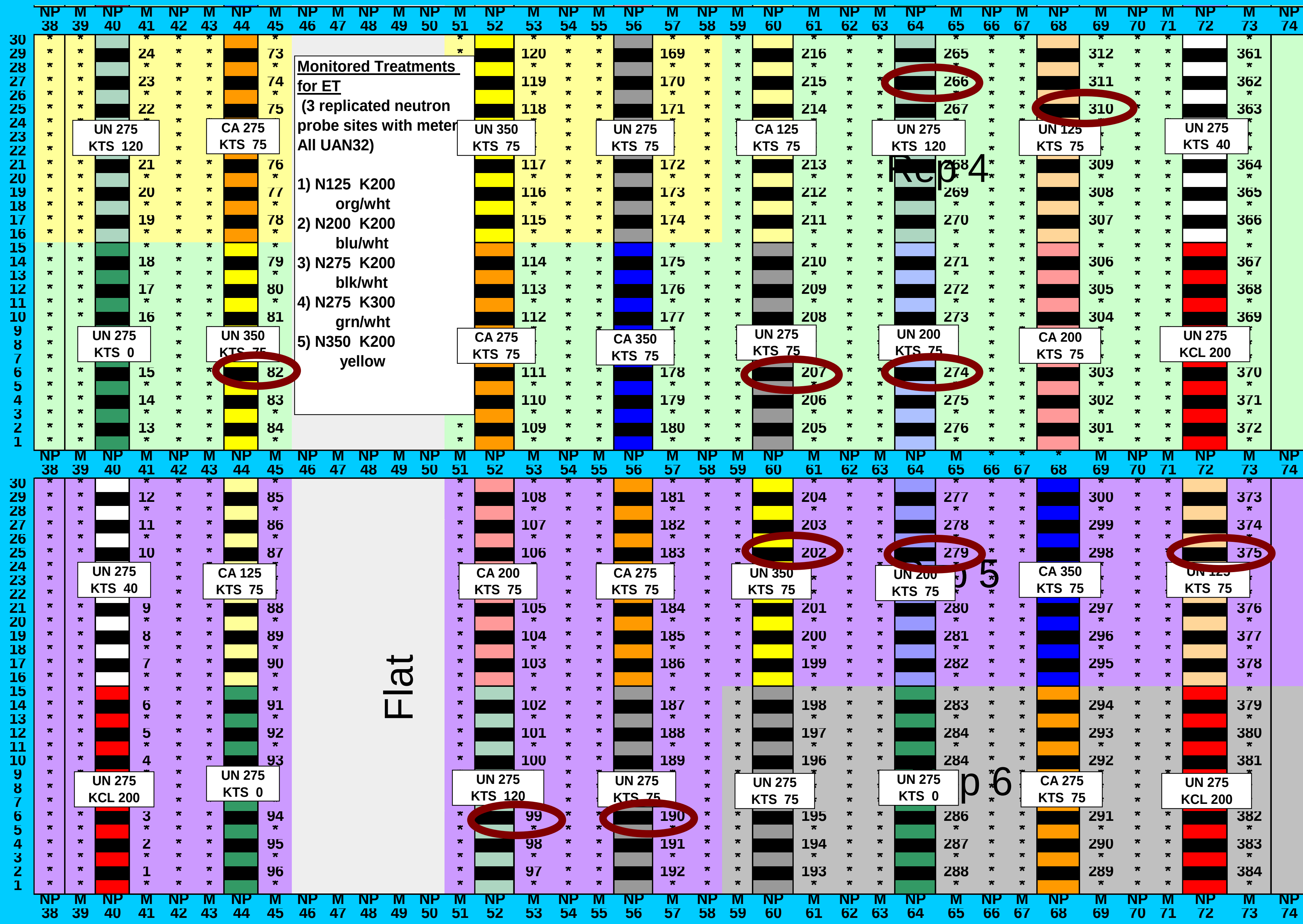
Blake Sanden – Irrigation & Agronomy, Kern County

Collaborative USDA Specialty Crops and California Almond Board Project


12
SOUTH 12-2 FANJETS
SOUTH 12-2 DRIP

Measuring nutrient and irrigation response under …

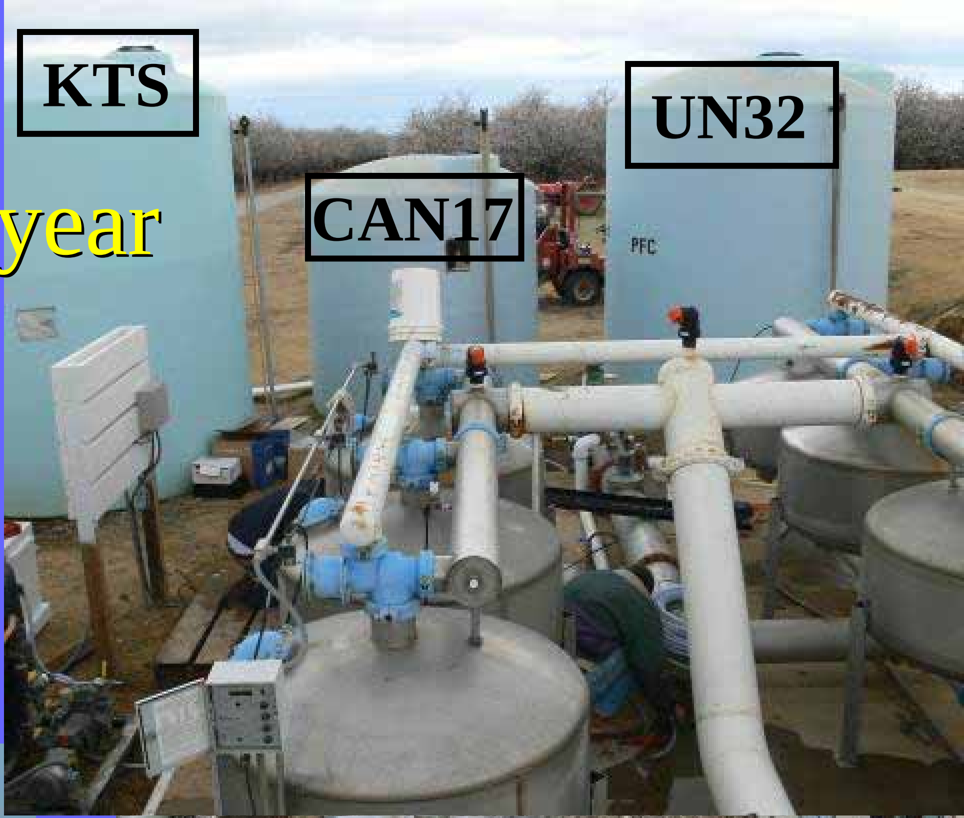



Monitored Treatments for ET
(3 replicated neutron probe sites with meter All UAN32)
1) N125 K200 org/wht
2) N200 K200 blu/wht
3) N275 K200 blk/wht
4) N275 K300 grn/wht
5) N350 K200 yellow
UN 275 KTS 120
CA 275 KTS 75
UN 350 KTS 75
UN 275 KTS 75
CA 125 KTS 75
UN 275 KTS 120
UN 125 KTS 75
UN 275 KTS 40
UN 275 KTS 0
UN 350 KTS 75
CA 275 KTS 75
CA 350 KTS 75
UN 275 KTS 75
UN 200 KTS 75
CA 200 KTS 75
UN 275 KCL 200
Rep 4
UN 275 KTS 40
CA 125 KTS 75
CA 200 KTS 75
CA 275 KTS 75
UN 350 KTS 75
UN 200 KTS 75
CA 350 KTS 75
UN 125 KTS 75
Flat
UN 275 KCL 200
UN 275 KTS 0
UN 275 KTS 120
UN 275 KTS 75
UN 275 KTS 75
UN 275 KTS 0
CA 275 KTS 75
UN 275 KCL 200

Main fertility trial:

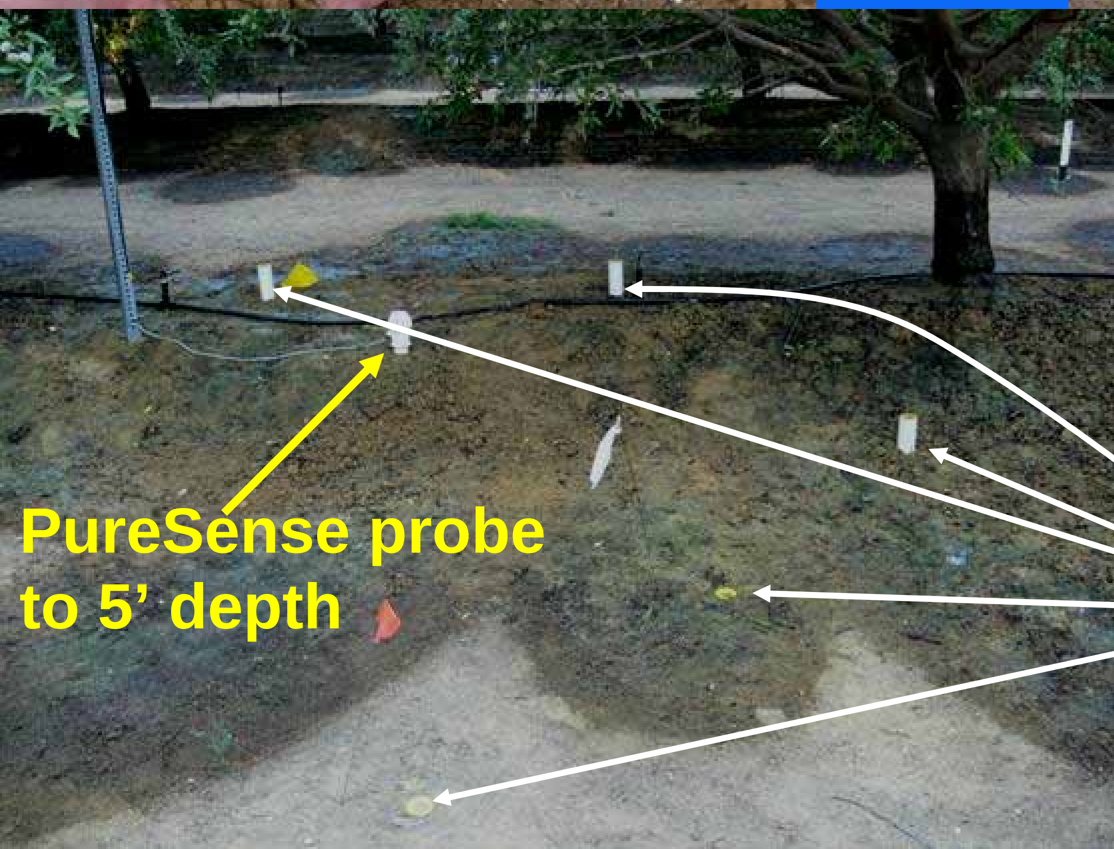
Direct injection 4 times/year

Bloom	20%
April	30%
June	30%
Post Harvest	20%

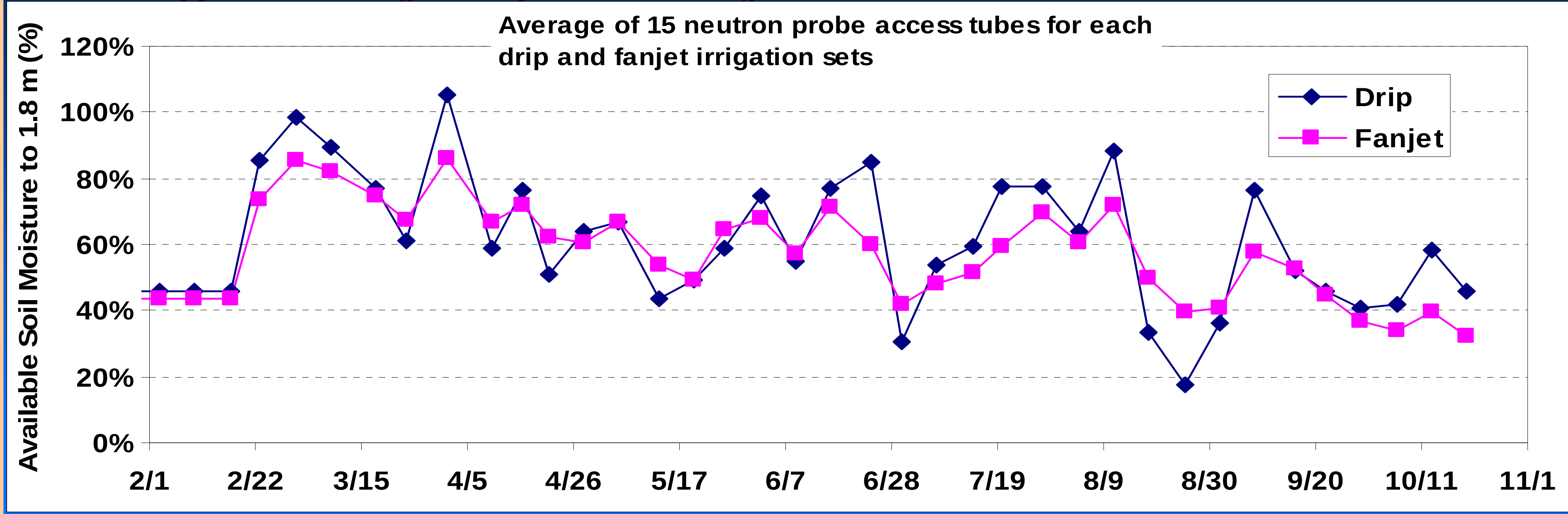


Data collection

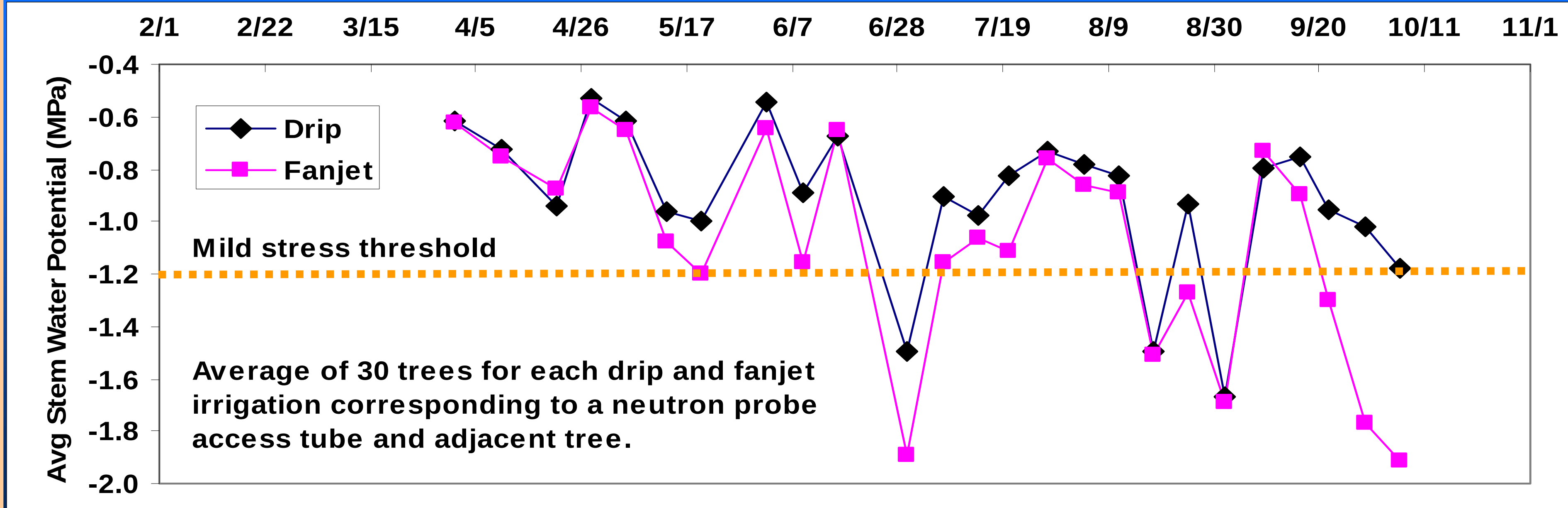
- Eddy covariance & surface renewal estimates of LE / ET, continuous
- 48 neutron probe sites to 2.7m depth (0.3m readings) and site applied irrigation, weekly. Soil salinity/ fer-tility yearly.
- 68 stem water potential (SWP) measurements, weekly
- 759 tree nut yields, tissue samples (4x), trunk circumference yearly.
- Satellite and low elevation high-resolution multi-spectral analysis and additional ground data
- Dinitrification / NOx blow off from fertilizer


PureSense probe to 5' depth
5 neutron probe access tubes installed to 9 ft depth, intensive site

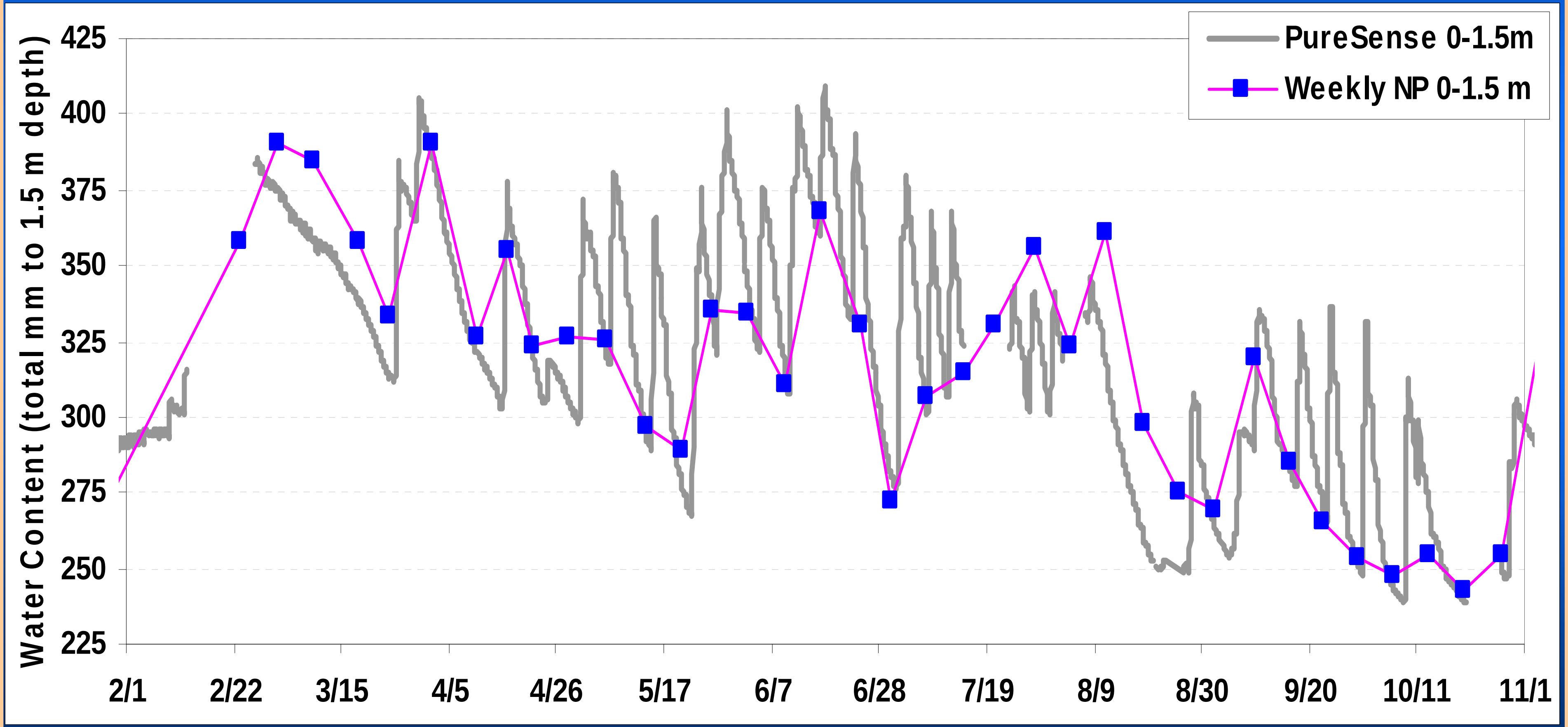
Average weekly drip and fanjet soil water content to 1.8 m



Average weekly drip and fanjet stem water potential

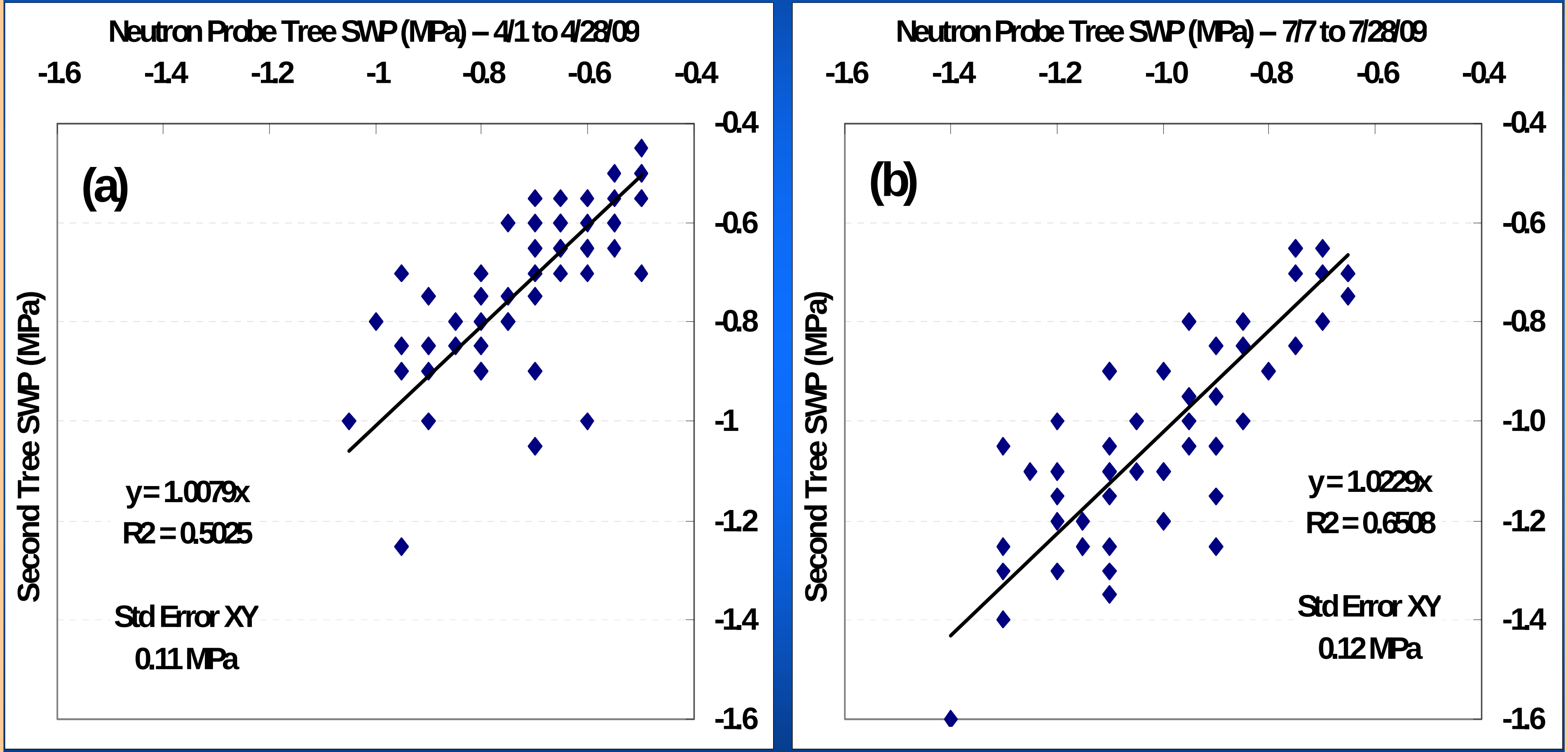


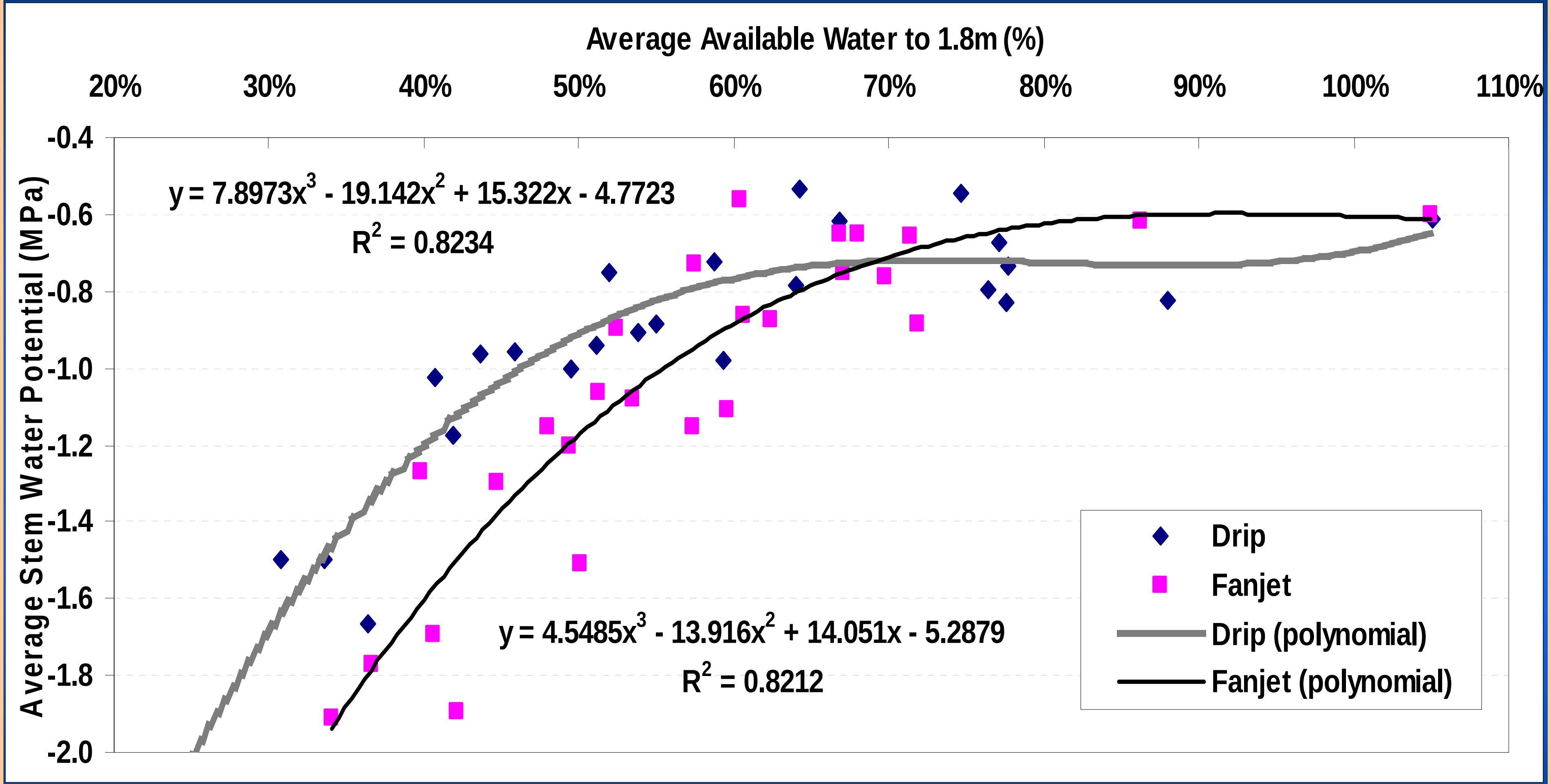
Weekly neutron probe water content just before irrigation compared to PureSense continuous capacitance probe readings



So maybe I should just use the pressure "bomb" to schedule my irrigations?

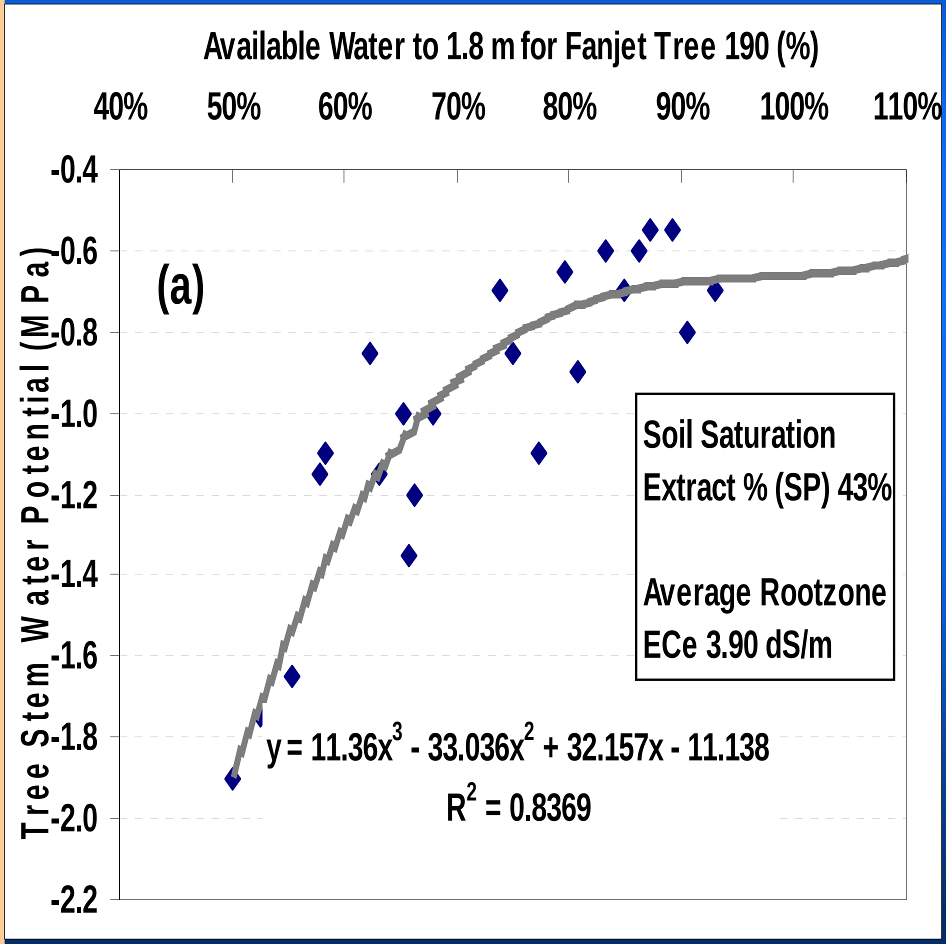
Variation in tree to tree SWP

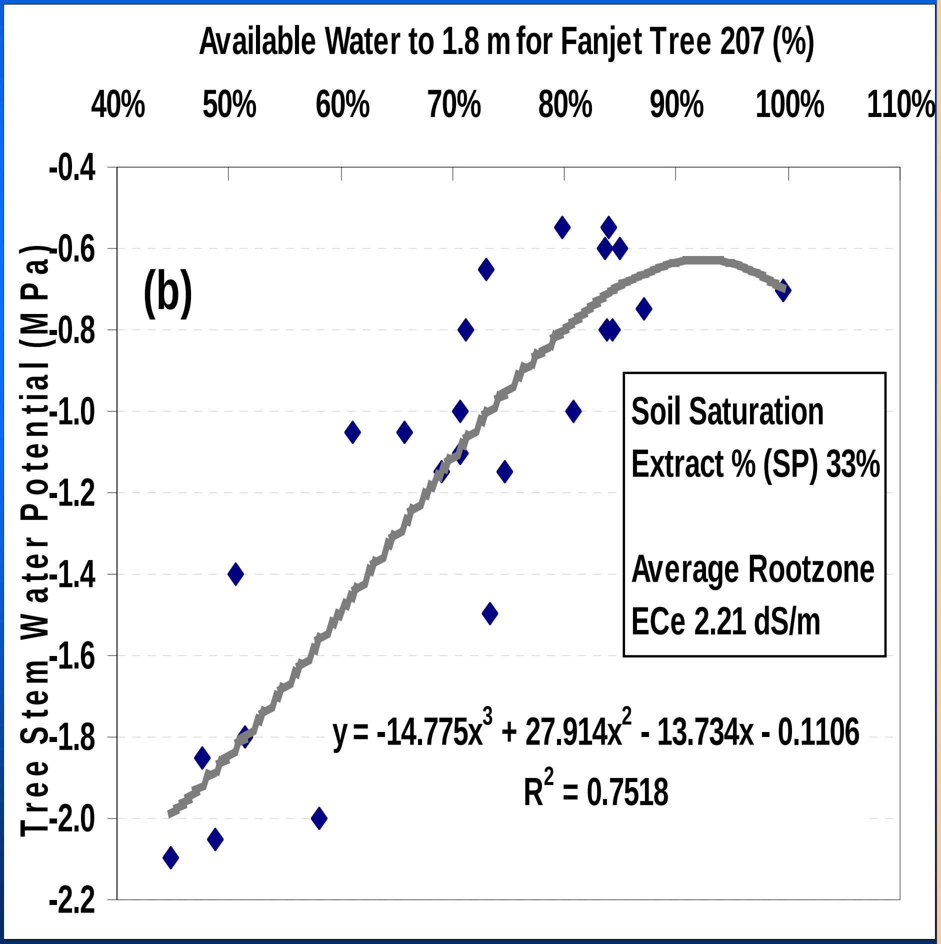




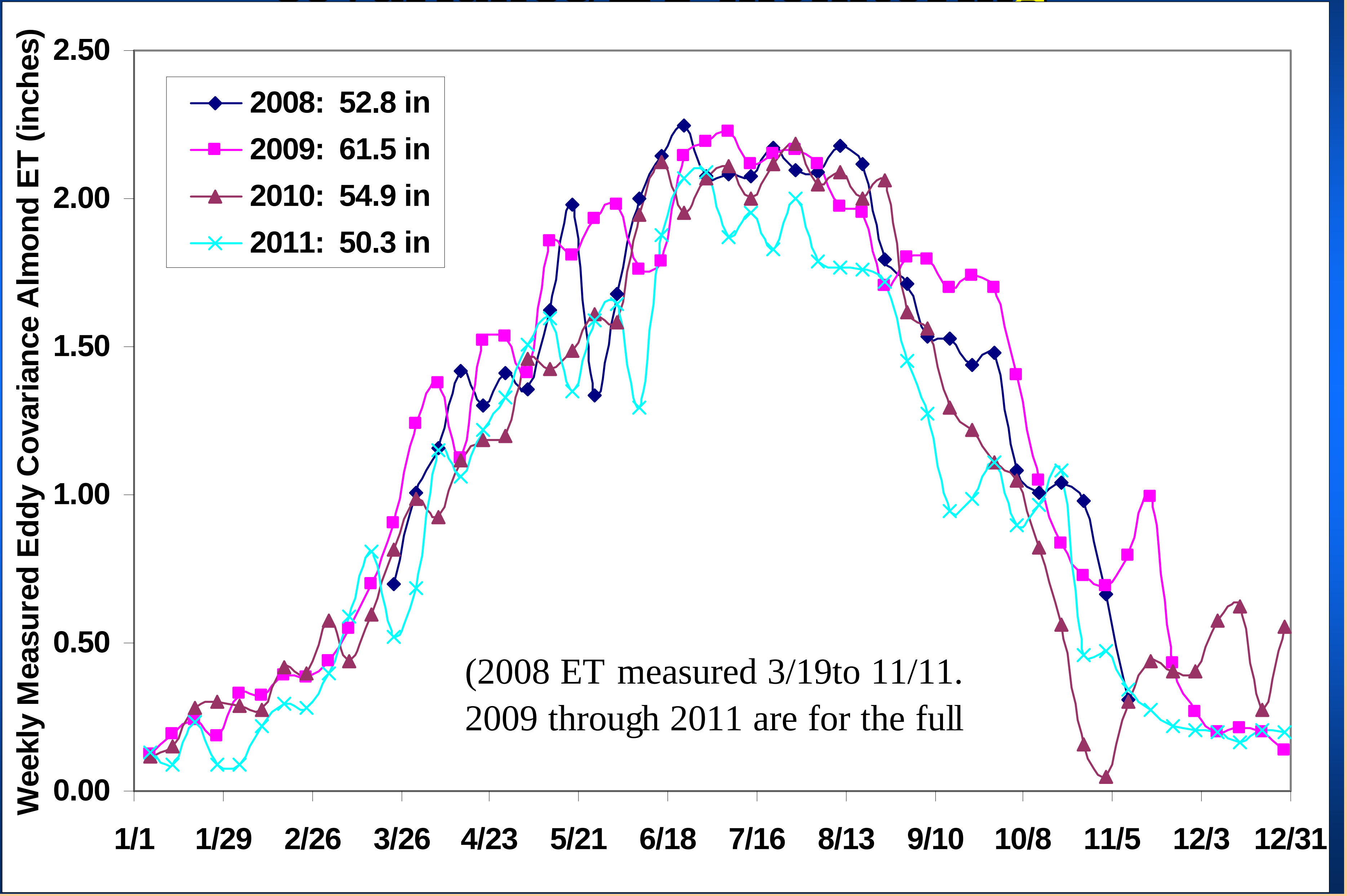
Average Available Water to 1.8m (%)
20%
30%
40%
50%
60%
70%
80%
90%
100%
110%
Average Stem Water Potential (MPa)
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
y = 7.8973x3 - 19.142x2 + 15.322x - 4.7723
R2 = 0.8234
y = 4.5485x3 - 13.916x2 + 14.051x - 5.2879
R2 = 0.8212
Drip
Fanjet
Drip (polynomial)
Fanjet (polynomial)

Variation in tree specific SWP decline with declining soil moisture – doesn't always match classic soil physics

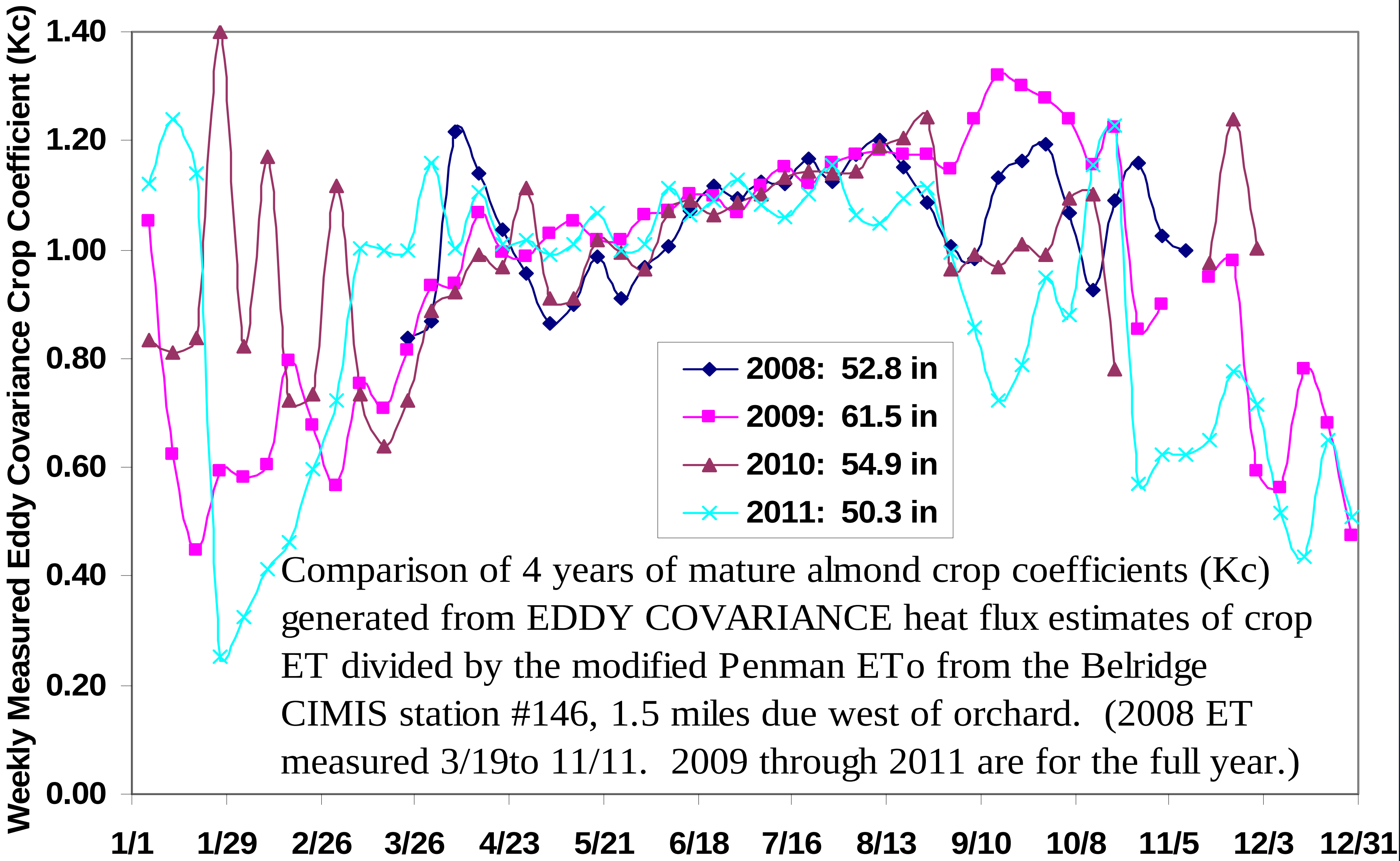




4 years of almond Kc values from eddy covariance/ET monitoring

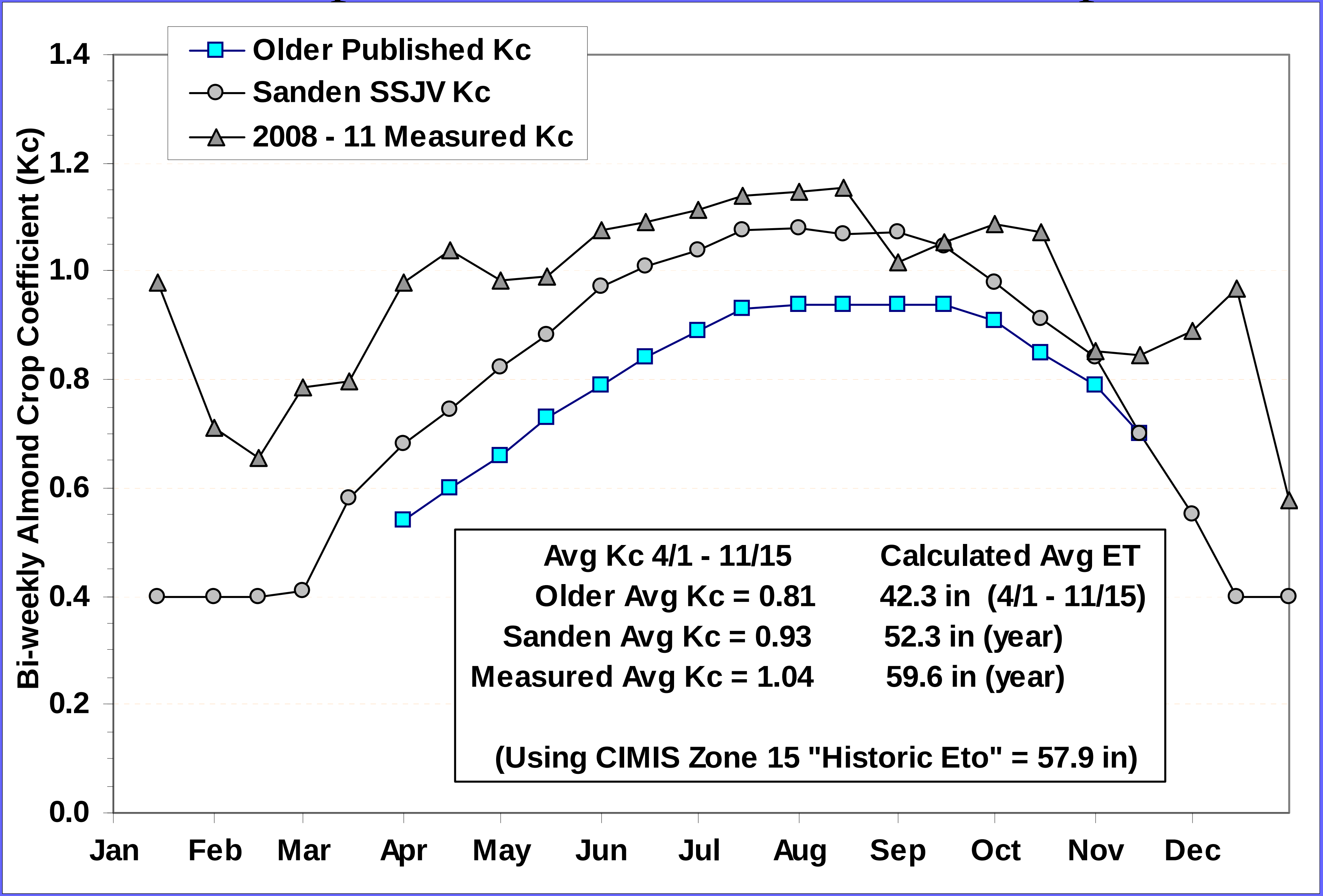


4 years of almond Kc values from eddy covariance/ET monitoring

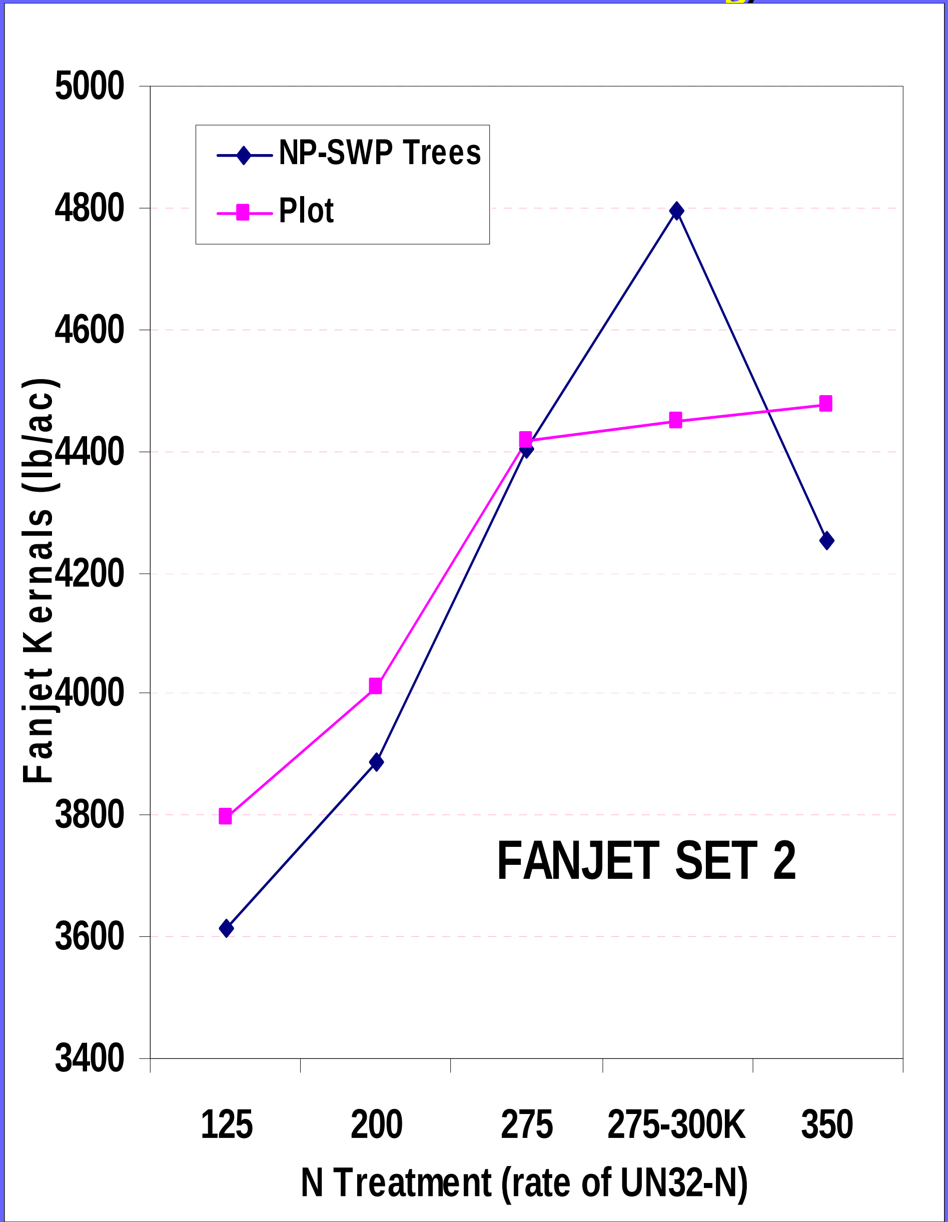


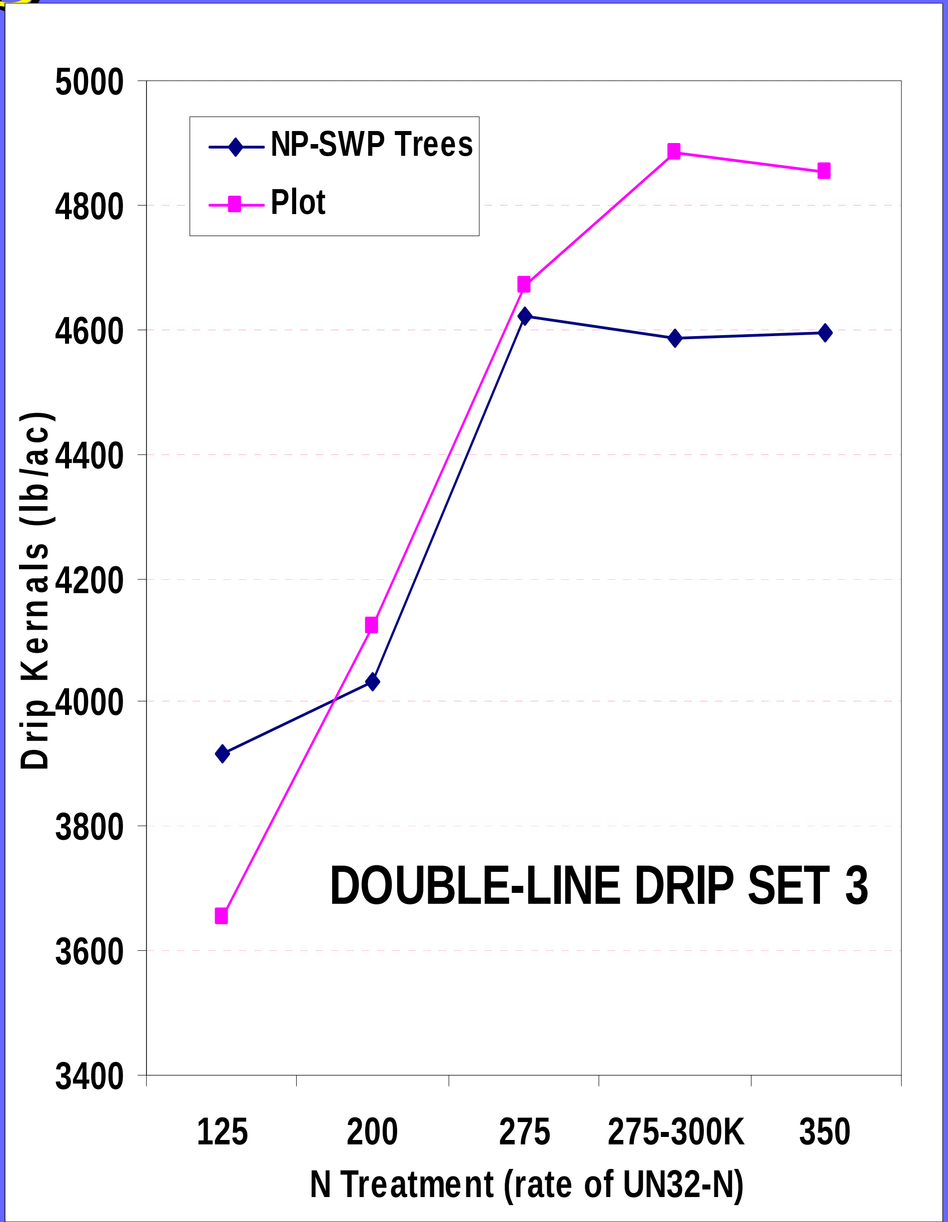
Comparison of 4 years of mature almond crop coefficients (Kc) generated from EDDY COVARIANCE heat flux estimates of crop ET divided by the modified Penman ETo from the Belridge CIMIS station #146, 1.5 miles due west of orchard. (2008 ET measured 3/19to 11/11. 2009 through 2011 are for the full year.)

What are optimal almond Kc's and crop ET?



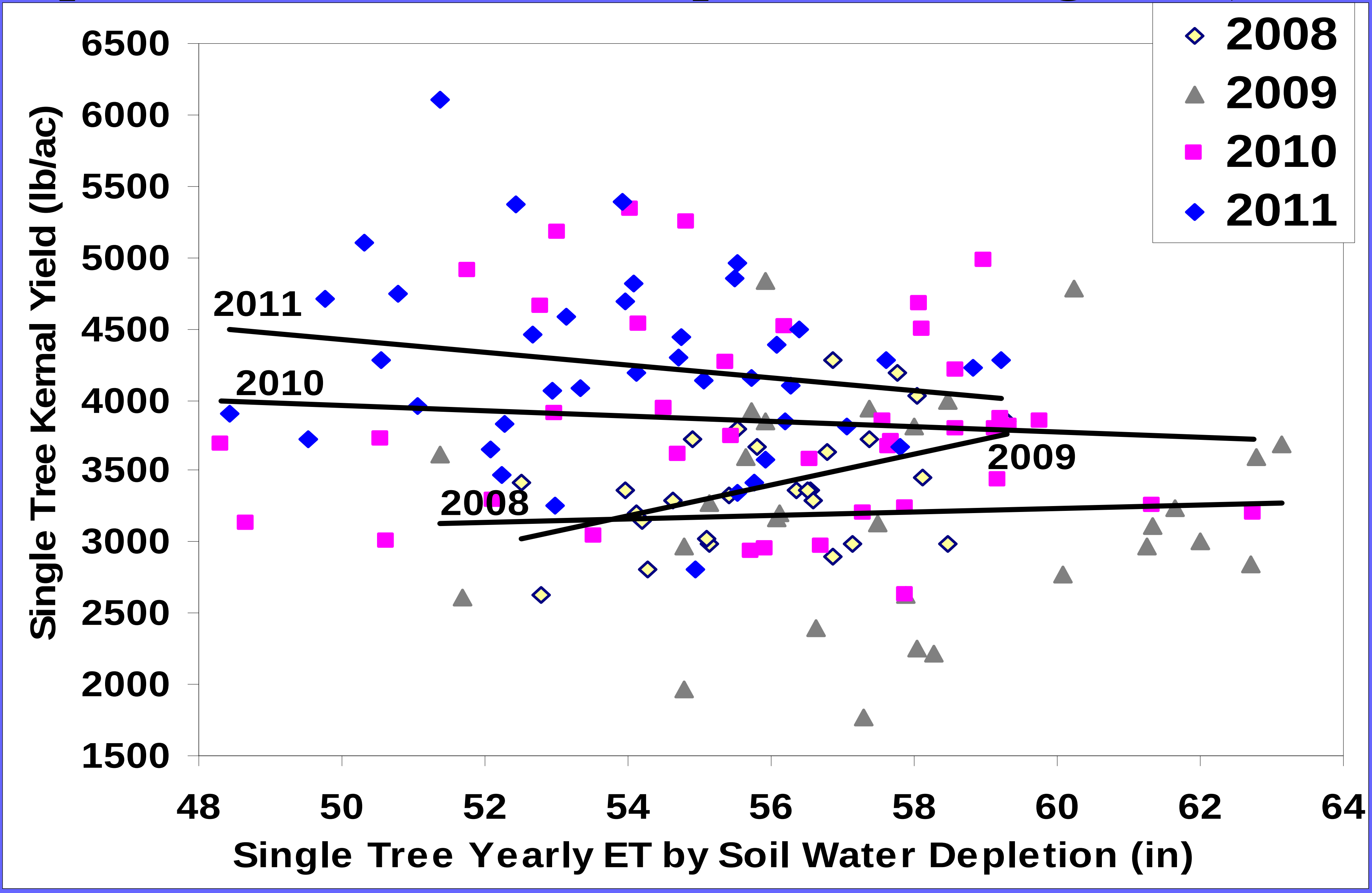
2011 Nonpareil Yields – Fertility/Irrigation Trial





So, if I give the tree 60 inches of water do I get more yield?

Single Tree Yield by ET (estimated by neutron probe soil moisture depletion + irrigation)



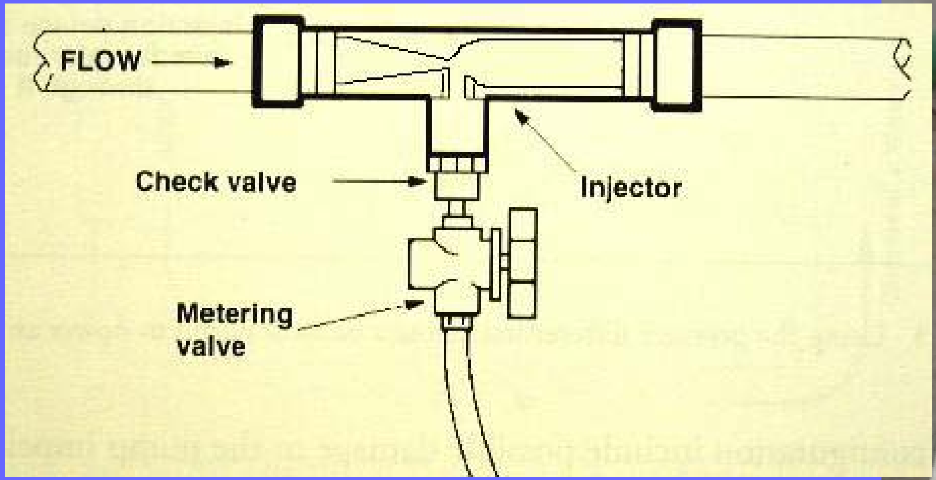
<u>Problem:</u> High production orchards virtually all have fungal disease problems – hull rot, alternaria, etc

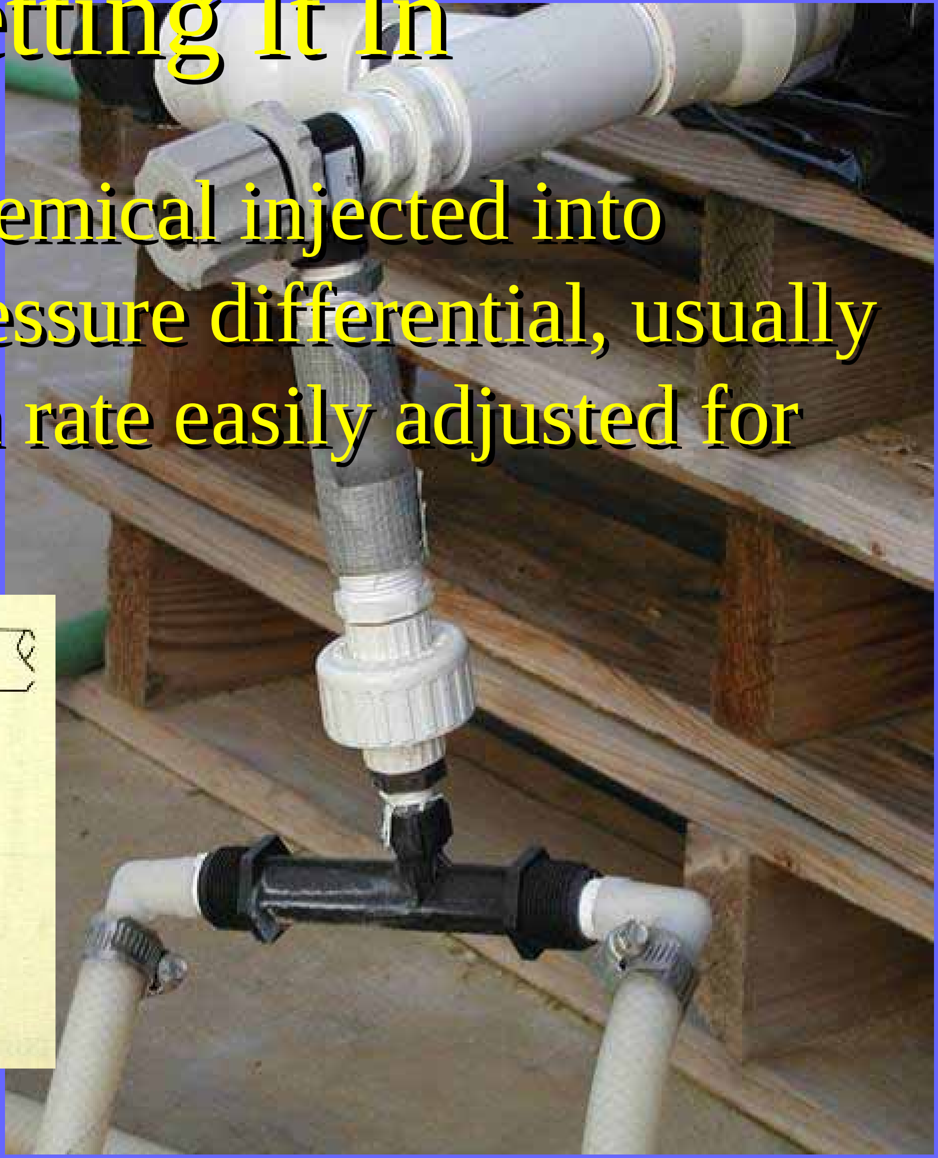
Fertigation options


Winter banding of sulphate of potash
(K_2SO_4, or simply SOP, @ 125 lb/ac K)

Chemigation: Getting It In

- **<u>Venturi (Mazzei)</u>:** chemical injected into vacumn created by pressure differential, usually fertilizer, but injection rate easily adjusted for small volume





Chemigation: Getting It In

- **Multi-stage diaphragm**

Chemigation: Getting It In

- **<u>Single-stage diaphragm pump on roll-up nurse tank</u>**


CHLORINE


RAIN BIRD

Injection nipple on well casing dribbling chemicals directly into groundwater.

Chemigation Initiative

REQUIRED CHEMIGATION SAFETY DEVICES

Equipment Required on the Irrigation Pipeline

(A) Check Valve

(B) Low Pressure Drain

(C) Air/Vacuum Relief Valve

Alternative for (A), (B), and (C): Gooseneck Pipe Loop

(D) Pressure Switch

Required Power and System Interlocks

(E) Interlocking System Controls

Equipment Required on the Injection Line

(F) Solenoid Operated Valve

Alternatives:

a. 10-psi Check Valve*

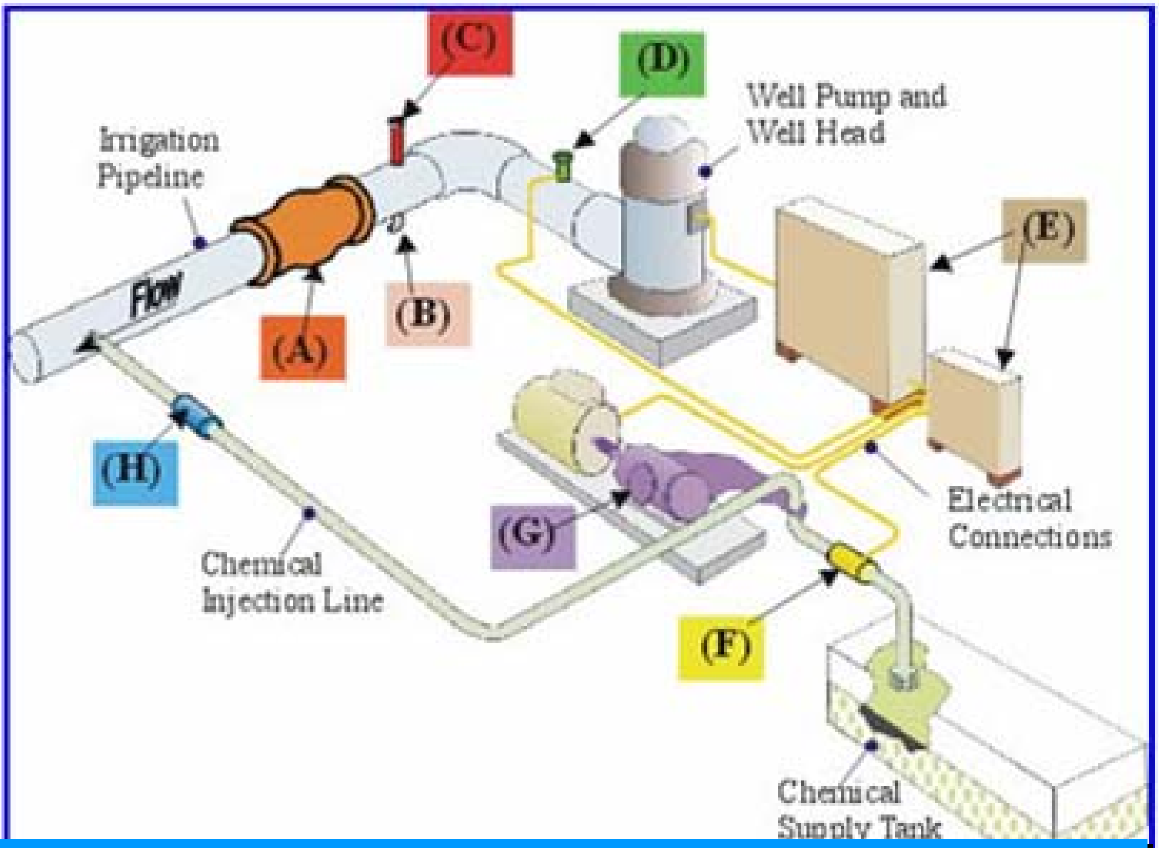
b. Hydraulically Operated Valve

c. Vacuum Relief Valve*

(G) Chemical Injection Pump

Alternative: Venturi Injector

(H) Injection Line Check Valve**



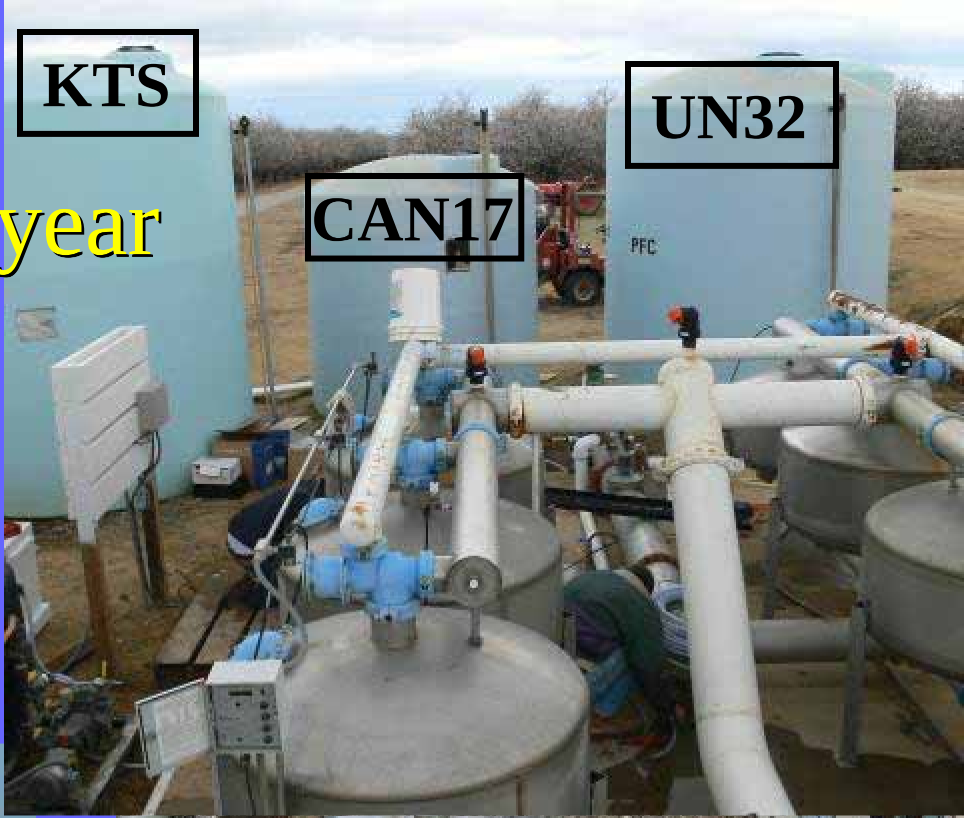
Chemigation/Backflow Prevention

http://www.cdpr.ca.gov/docs/gwp/chem/chemdevices.htm

Main fertility trial:

Direct injection 4 times/year

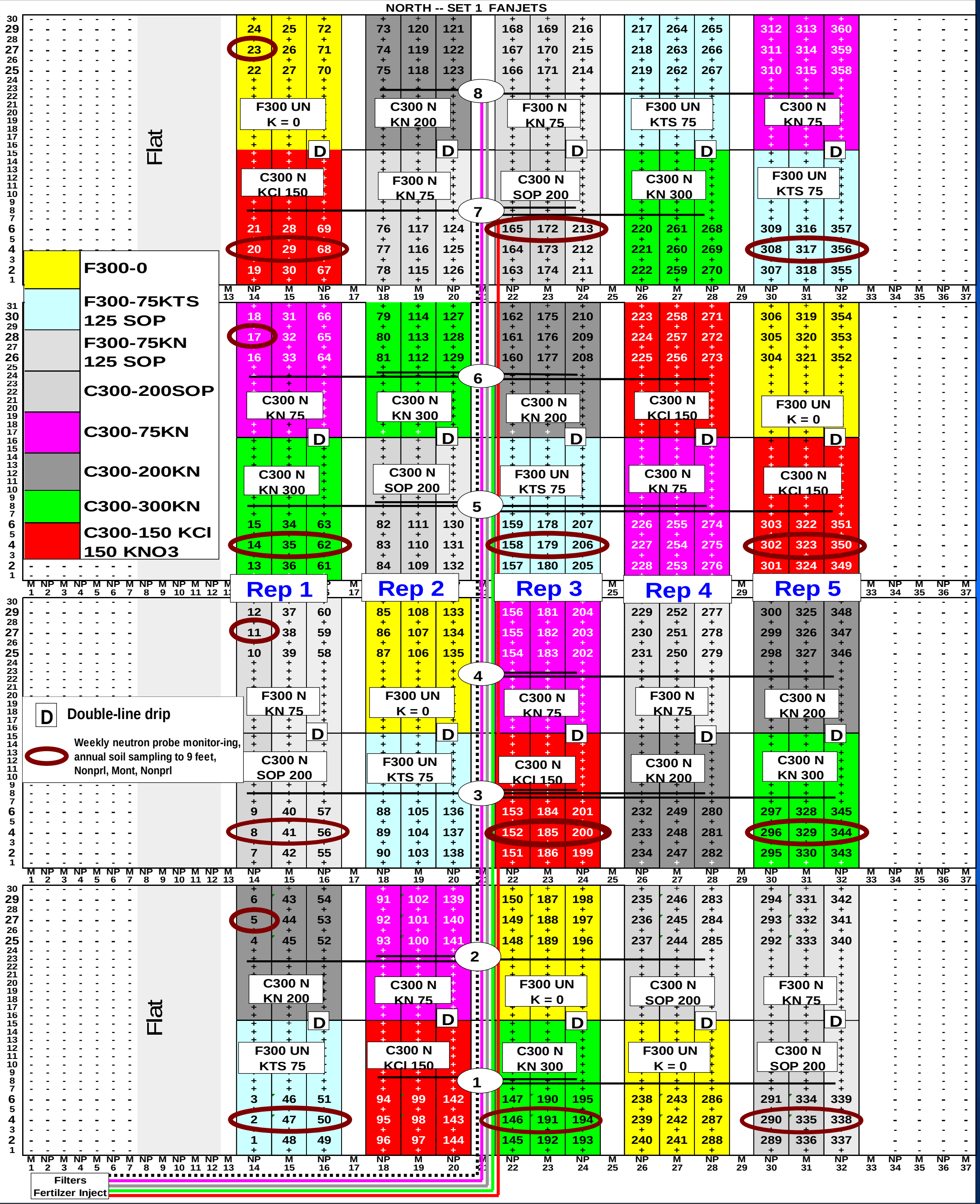
Bloom	20%
April	30%
June	30%
Post Harvest	20%



So what about “spoon-feed” continuous fertigation – smaller doses more often? Shouldn’t this help fertilizer use efficiency and yield?

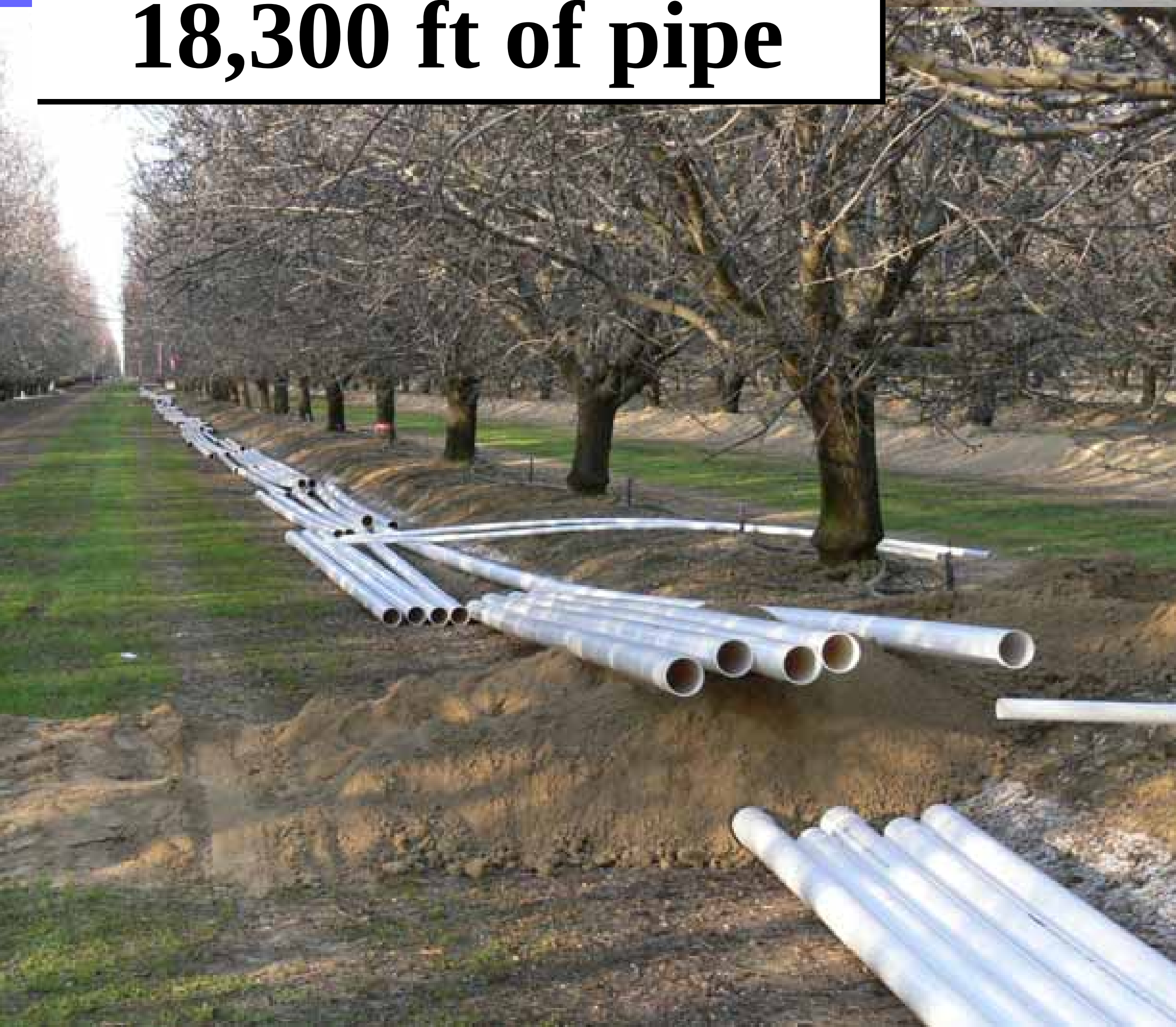
Suitability of alternative potassium sources and continuous fertigation under drip and microsprinkler irrigation to optimize California almond productivity

	F300-0	T1: No K, 300 lbs N as UAN
	F300-75KTS 125 SOP	T2: 200 lb K = 125 SOP band + 75 KTS, 300 lb UAN (Grower Standard)
	F300-75KN 125 SOP	T3: 200 lb K = 125 SOP band + 75 KNO3, 273 UAN + 27 KNO3
	C300-200SOP	T4: 200 lb K = SOP dissolved in mix tank, 300 lb UAN (Manifold 1)
	C300-75KN	T5: 200 lb K = 125 SOP band + 75 KNO3, 273 UAN + 27 KNO3 (Manifold 2)
	C300-200KN	T6: 200 lb K = KNO3, 193 UAN + 107 KNO3 (Manifold 3)
	C300-300KN	T7: 300 lb K = KNO3, 128 N UAN + 172 KNO3 (Manifold 4)
	C300-150 KCl 150 KNO3	T8: 300 lb K = 150 KCL + 150 KNO3, 248 UAN + 52 KNO3 (Manifold 5)

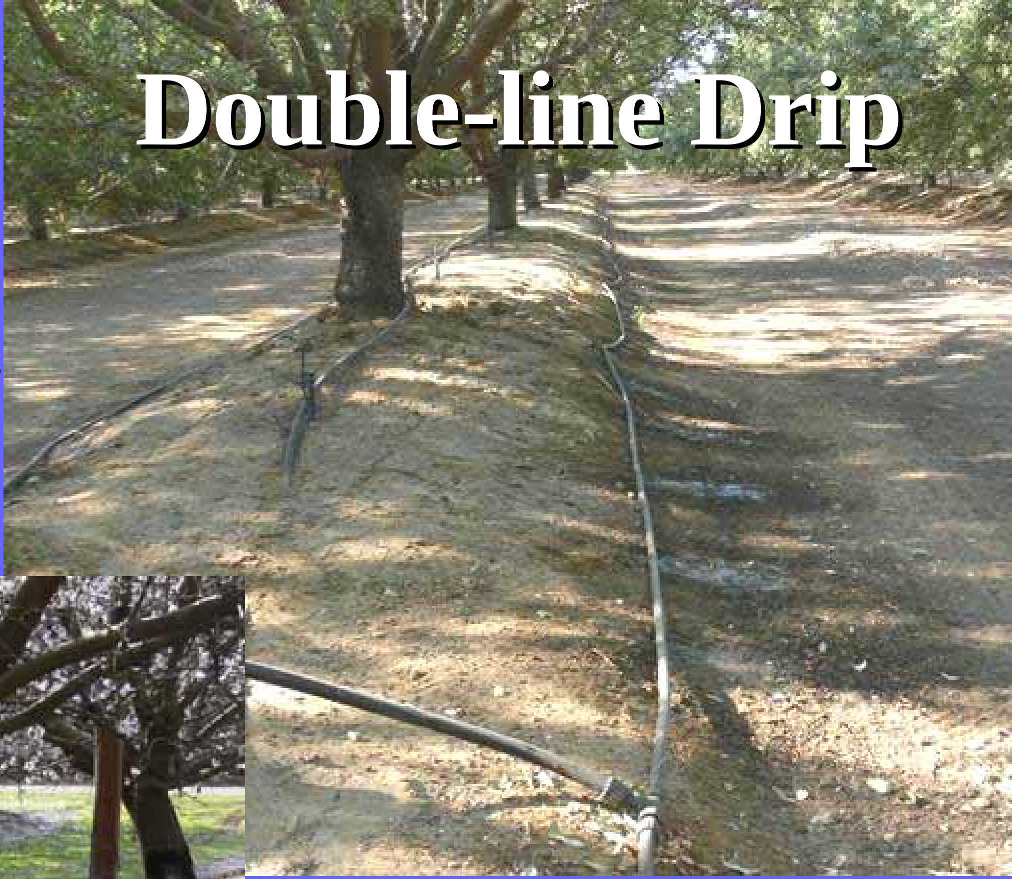


Field map of "spoon feed" variable K source trial

New submains: 1 for each "spoon-feed" treatment. 18,300 ft of pipe

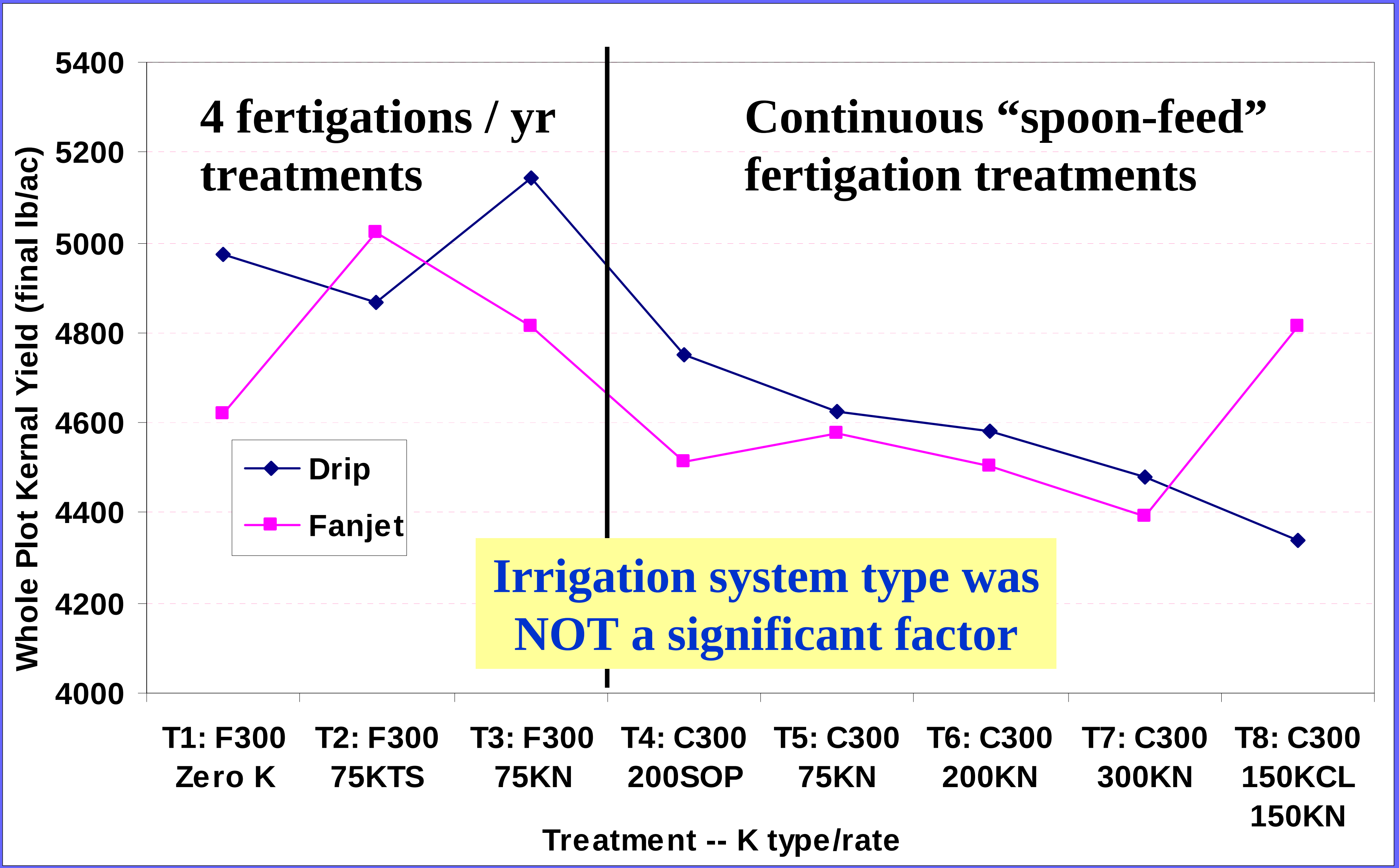


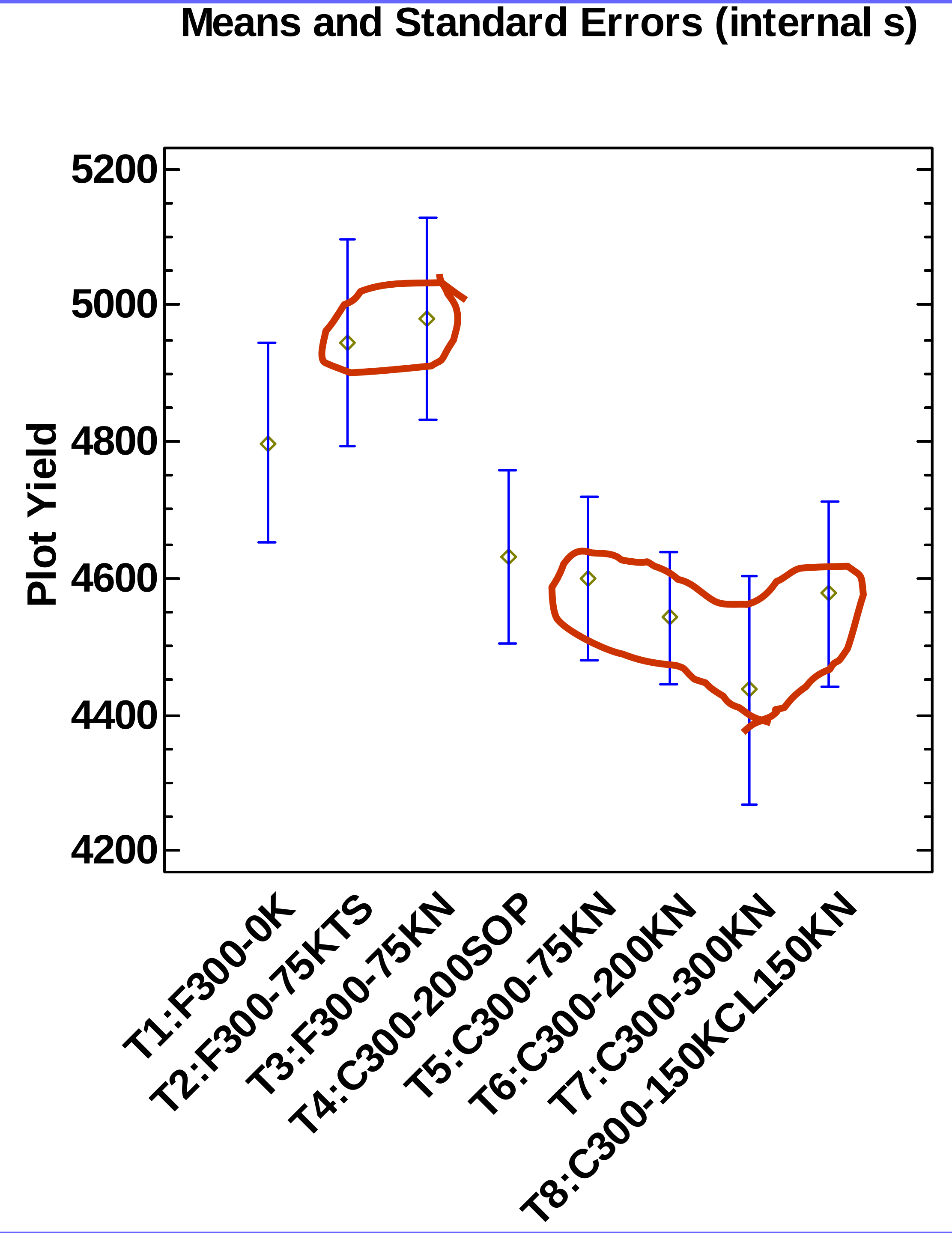
Also a replicated comparison of microsprinkler and double-line drip



2011 installation of 5 Grundfos dosing pumps for “spoon-feed” fertigation trial

2011 Nonpareil yields for episodic vs. continuous fertigation





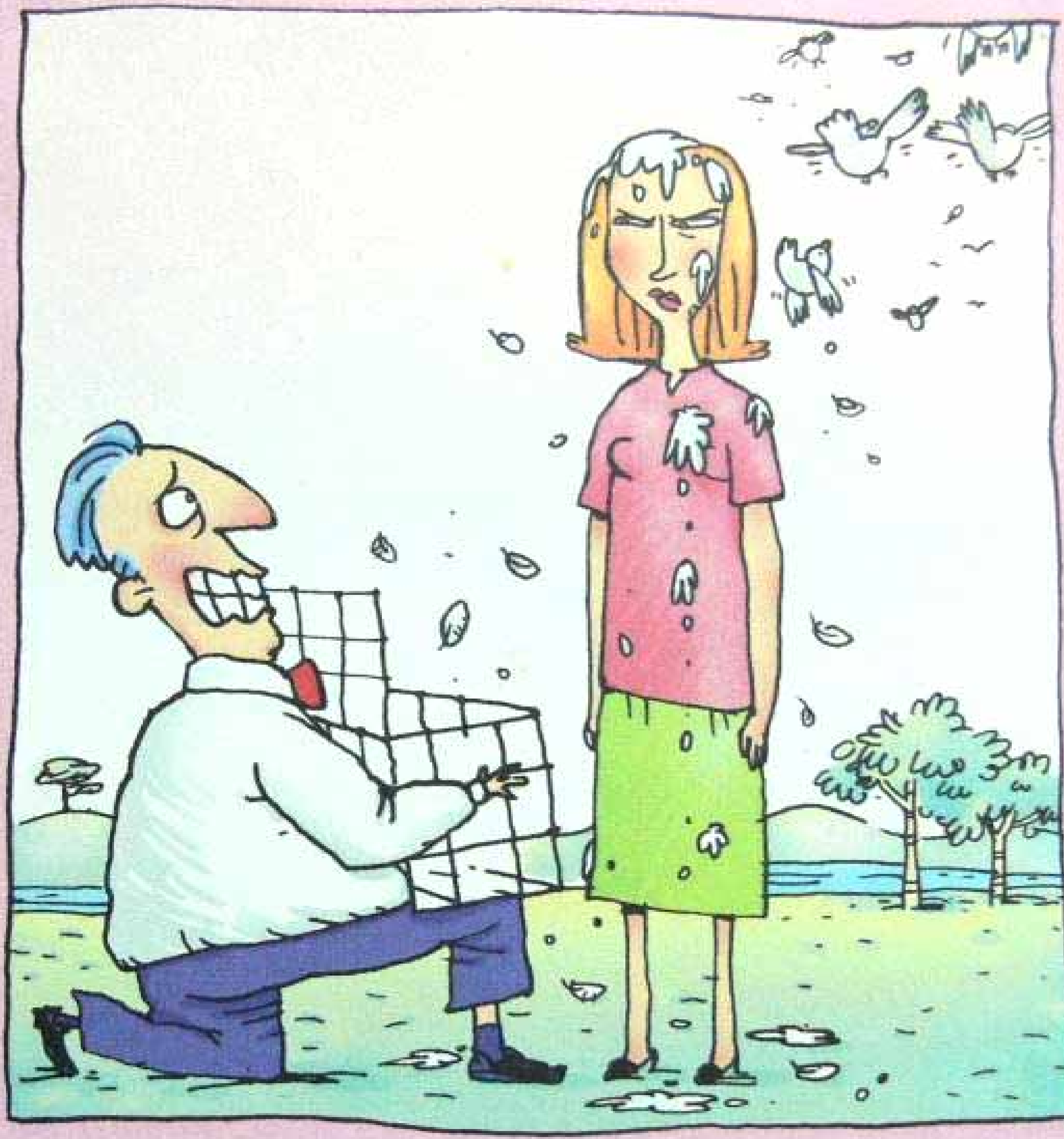
With no significant drip vs fanjet effect, kernal yield for the 4 injections per year of KTS and KNO3 were significantly greater than the 4 KNO3 spoon-feed treatments

CONCLUSION (THE END): Use a better tool than this one -- seat of the pants still most common method


Technology is helpful, but the
most valuable thing you can put
in the field is your shadow …

…because pigeons happen despite our best plans!!

Happy Valentines Day



Paul's plan to deliver his Valentine via carrier pigeon goes horribly wrong.

UNIVERSITY of CALIFORNIA COOPERATIVE EXTENSION

Balancing Efficiency & Salinity Control in the Field

Blake Sanden - Irrigation/Agronomy Advisor, Kern County

Kern Almond & Irrigation Workshop March 28, 2012

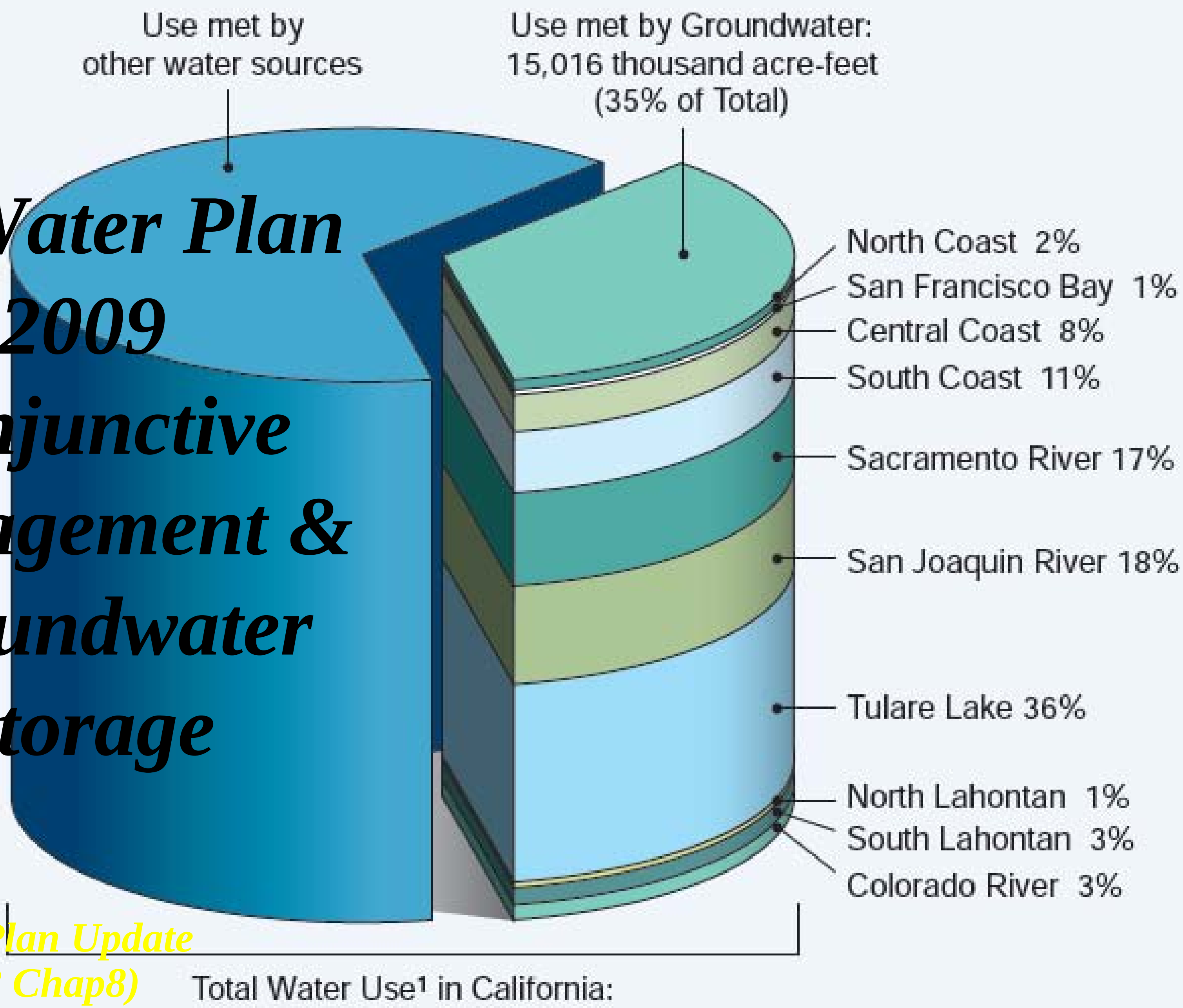
The Global Perspective: Paul Ehrlich's "Population Bomb" has not disappeared

- Global food production will need to increase by 38% by 2025 and 57% by 2050.
- It is estimated that about 15% of the total land area of the world has been degraded by soil erosion and physical and chemical degradation, including soil salinization.

(Wild A. 2003. Soils, land and food: managing the land during the twenty-first century. Cambridge, UK: Cambridge University Press.)

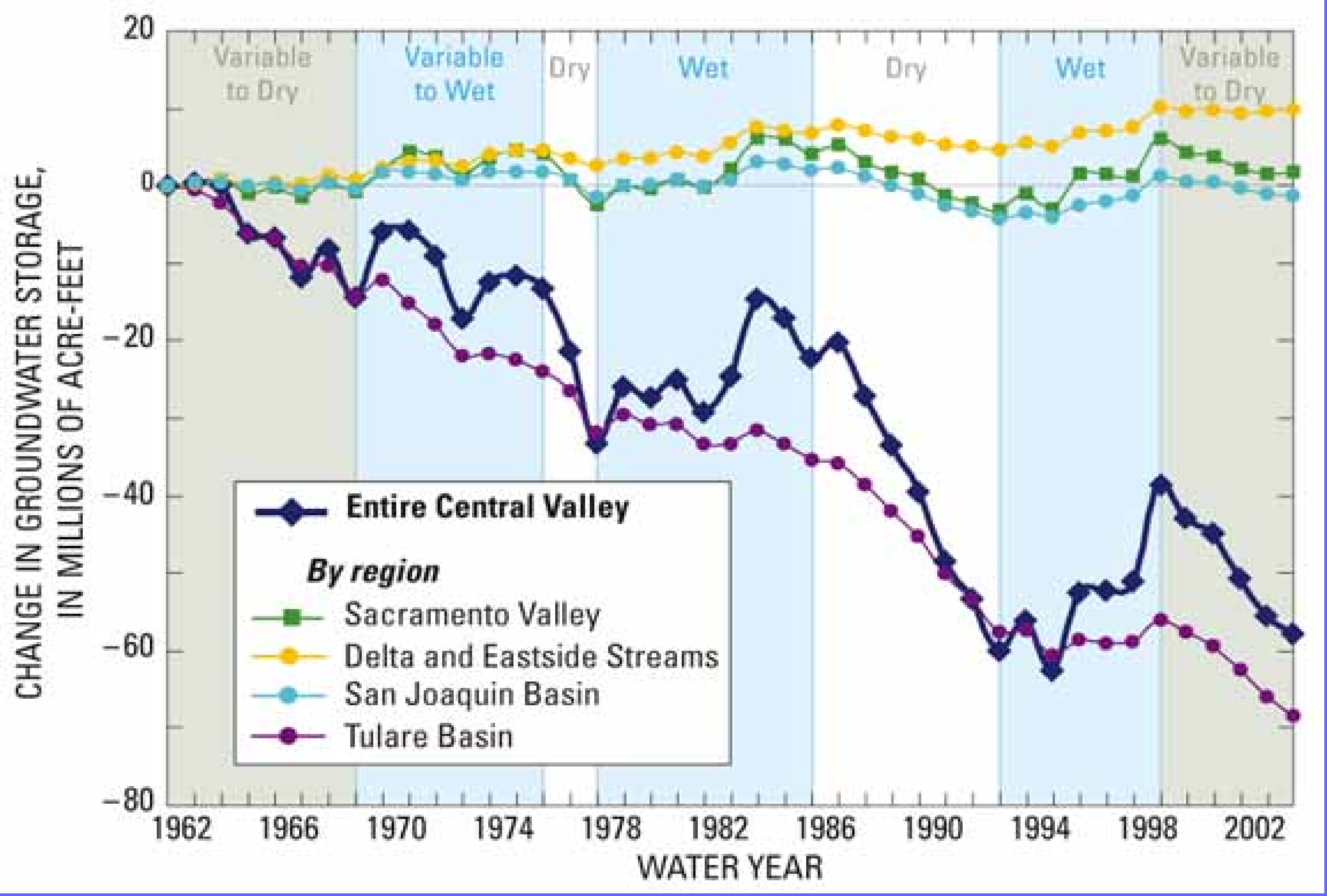
Figure A Percentage of groundwater extraction in California, statewide and by hydrologic region (1998-2005 average annual data)

CA Water Plan 2009 Conjunctive Management & Groundwater Storage



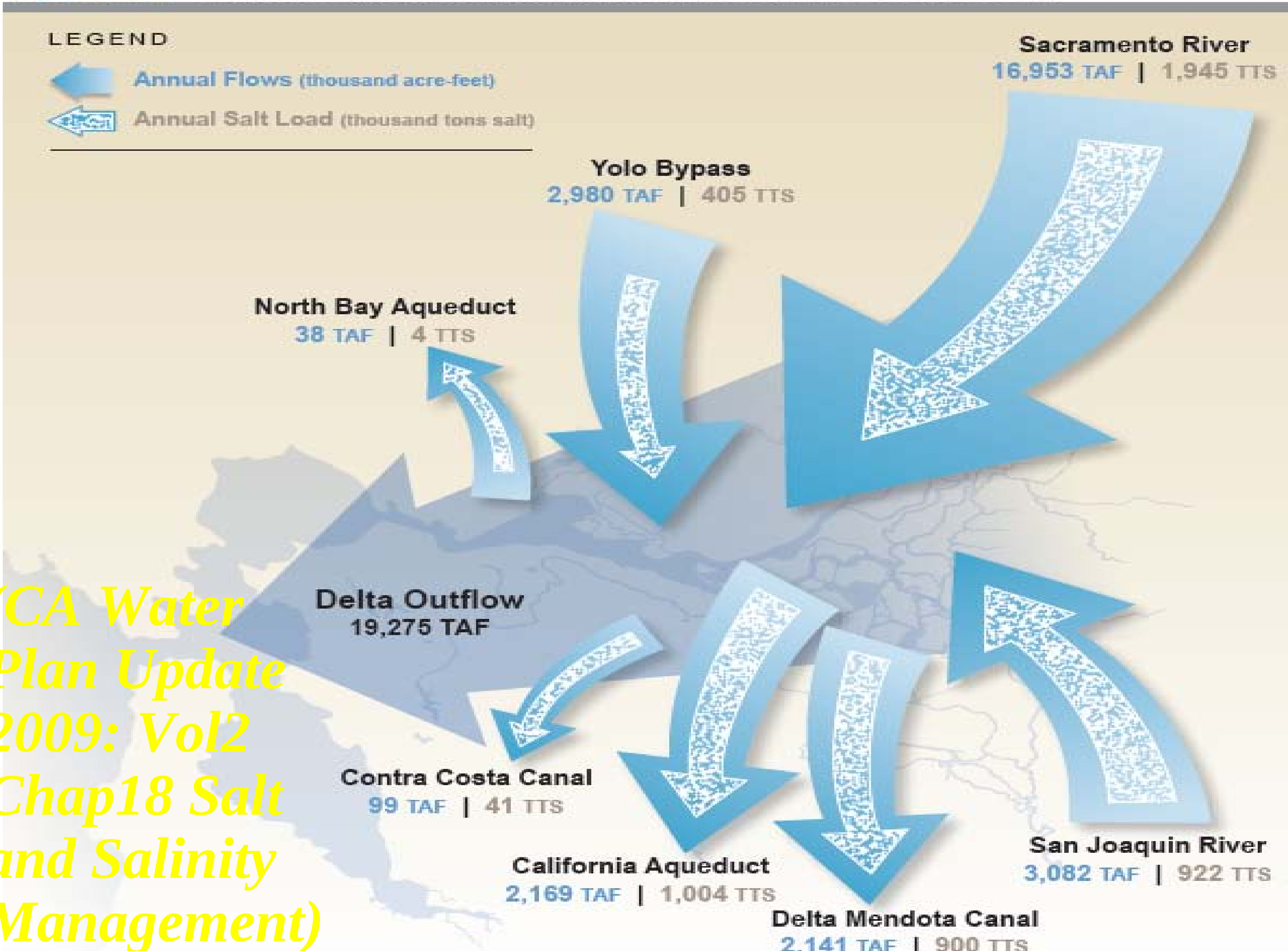
(CA Water Plan Update 2009: Vol2 Chap8)

CA groundwater depletion: 1962-2003



Faunt, C.C. ed., 2009, Groundwater Availability of the Central Valley Aquifer: U.S. Geological Survey Professional Paper 1766, 225 p. http://pubs.usgs.gov/pp/1766/

Figure 18-1 Salt load (mean of annual averages from 1959 to 2004)



(CA Water Plan Update 2009: Vol2 Chap18 Salt and Salinity Management)

CA Water Plan 2009
Salt and Salinity Management

Sacramento River water salinity = 0.11 ton / ac-ft

CA Aqueduct water salinity = 0.46 ton / ac-ft

(CA Water Plan Update 2009: Vol2 Chap18: Salt and Salinity Management)

CA Water Plan 2009: MONITORING (really 'funding') for salinity management

Monitoring

8. Federal, State, Tribal, local, non-government and private stakeholders should work collaboratively to fund, develop and operate a monitoring network or an array of compatible networks capable of identifying emerging salinity problems and tracking the success of ongoing salinity management efforts where such networks do not already exist. Using the model of the Pesticide Use Reporting program, continuous funding for operation and maintenance of these networks might be made possible through a mil tax (1 mil = $0.0001) on salt–containing products sold in the state (fertilizers, detergents, personal care products, water softener salts, processed foods, etc.), since many of these salts may end up in our wastewater treatment plants, ultimately discharged to groundwater or surface streams. New or expanded networks should build off of and remain compatible with existing relevant statewide monitoring programs such as the Surface Water Ambient Monitoring Program (SWAMP) and Groundwater Ambient Monitoring and Assessment (GAMA) program. Data should be made available to the public through a web-based user interface such as the Integrated Water Resources Information System (IWRIS). (See also Recommendations 2, 3, 11 and 12.)

(CA Water Plan Update 2009: Vol2 Chap18: Salt and Salinity Management)

CA Water Plan 2009: RESEARCH for salinity management

Salt storage and other research and implementation

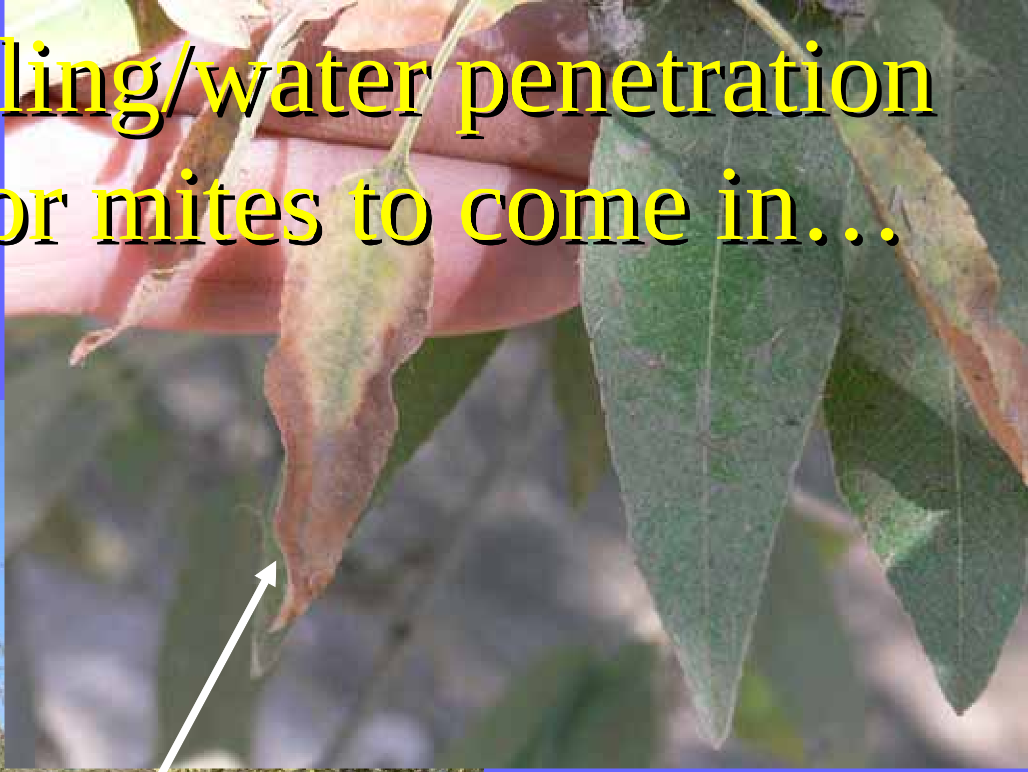
10. Additional options for salt collection, salt treatment, salt disposal and long-term storage of salt should be developed. University researchers should work with regulatory agencies and stakeholders to identify environmentally acceptable and economically feasible methods of closing the loop on salt for areas of the state that do not currently have sustainable salt management options. Funding for this sort of research should be prioritized to ensure that areas with the greatest needs (i.e. high salt and few or no feasible management options) are targeted first. (See also Recommendations 2 through 7, 11 and 12.)

What happened to the UC Salinity-Drainage taskforce?

(CA Water Plan Update 2009: Vol2 Chap18: Salt and Salinity Management)

Excessive Na and Cl can desicate almonds.

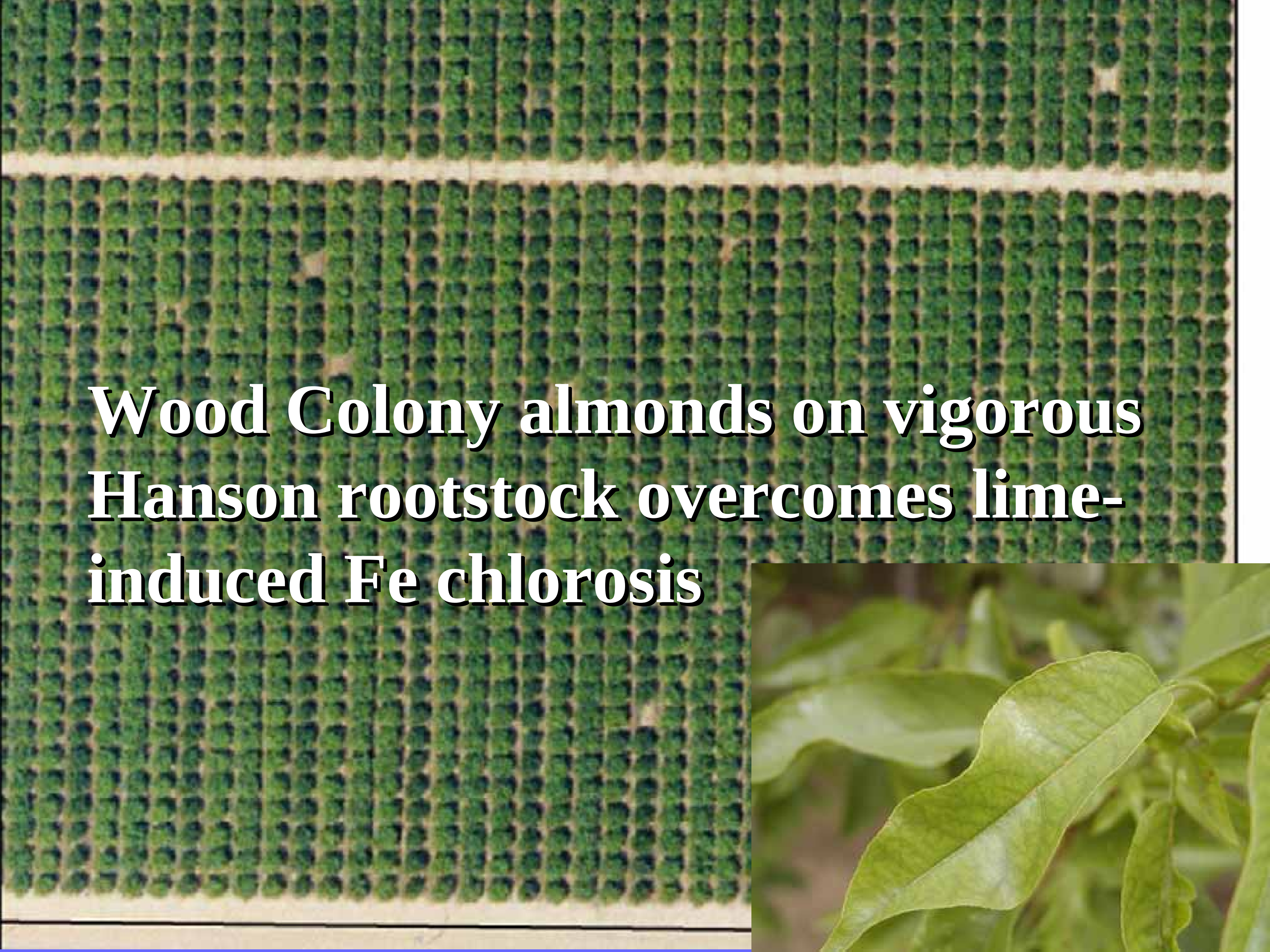
At best poor scheduling/water penetration creates conditions for mites to come in…



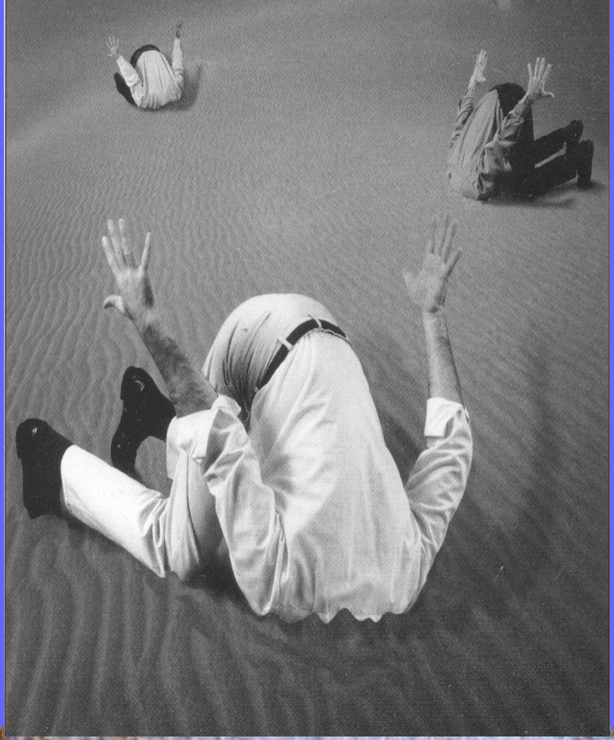
At worst, individual leaves show marginal burn and can lead to severe defoliation

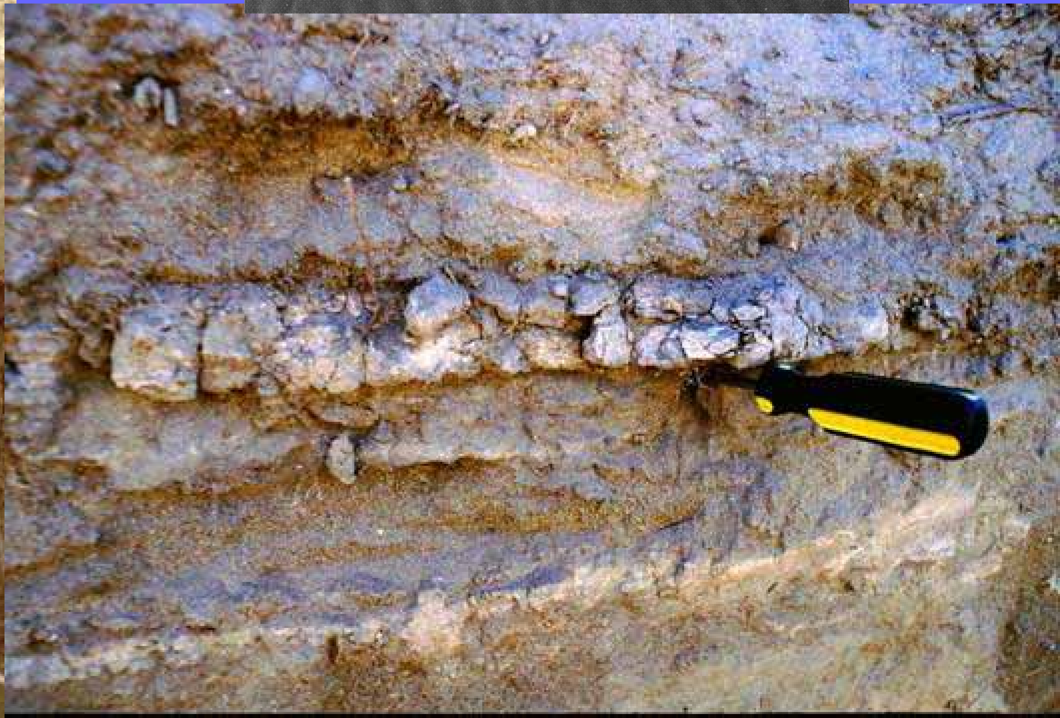
"Head" end of same rows – more on time, more leaching

Wood Colony almonds on vigorous Hanson rootstock overcomes lime-induced Fe chlorosis



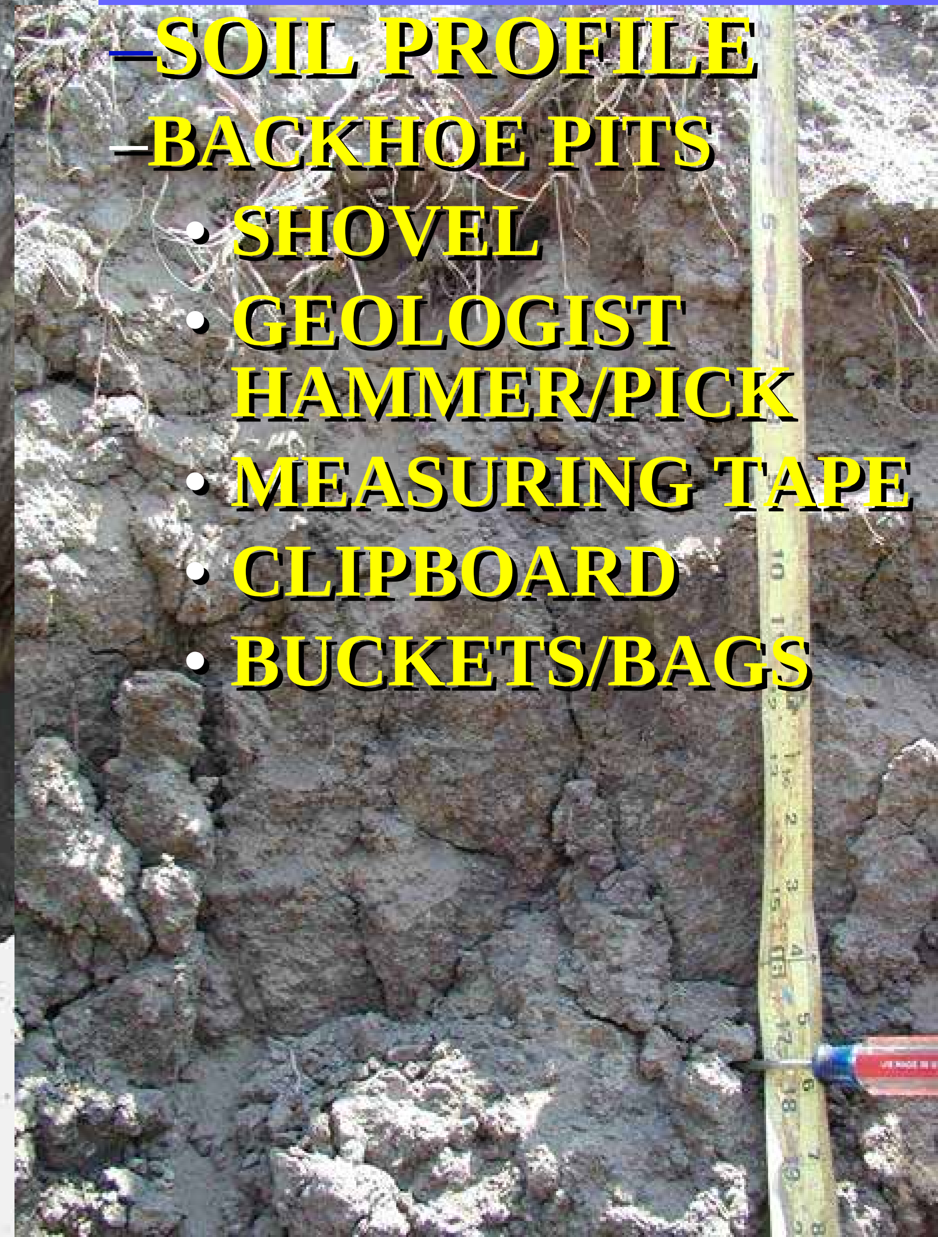
Check your dirt! It has more secrets than the CIA.





How to do it

- SOIL PROFILE
- BACKHOE PITS
  - SHOVEL
  - GEOLOGIST HAMMER/PICK
  - MEASURING TAPE
  - CLIPBOARD
  - BUCKETS/BAGS



How to do it

– SOIL TEXTURE

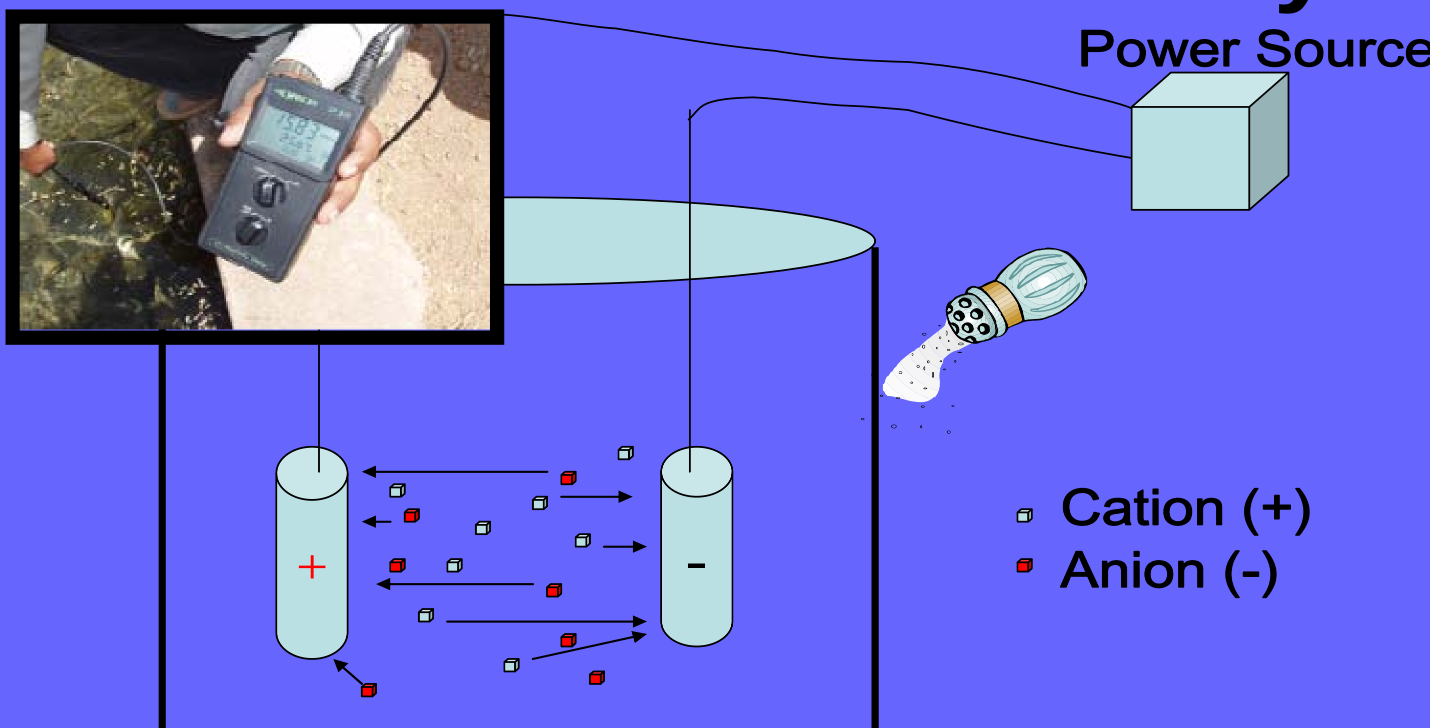
Making a soil "ribbon" test from a moistened ball. Sandy Clay Loam – Westside Kern County


HSC

How do we measure salinity?

- **ECw (water) or ECe (soil water extract)**
  - **<u>mmhos/cm = dS/m = 640 ppm TDS</u>**
    - **Water – Ion concentration, temperature (25°C)**
    - **Soil – distilled water extract –> underestimates the actual pore water salinity**

Electrical Conductivity

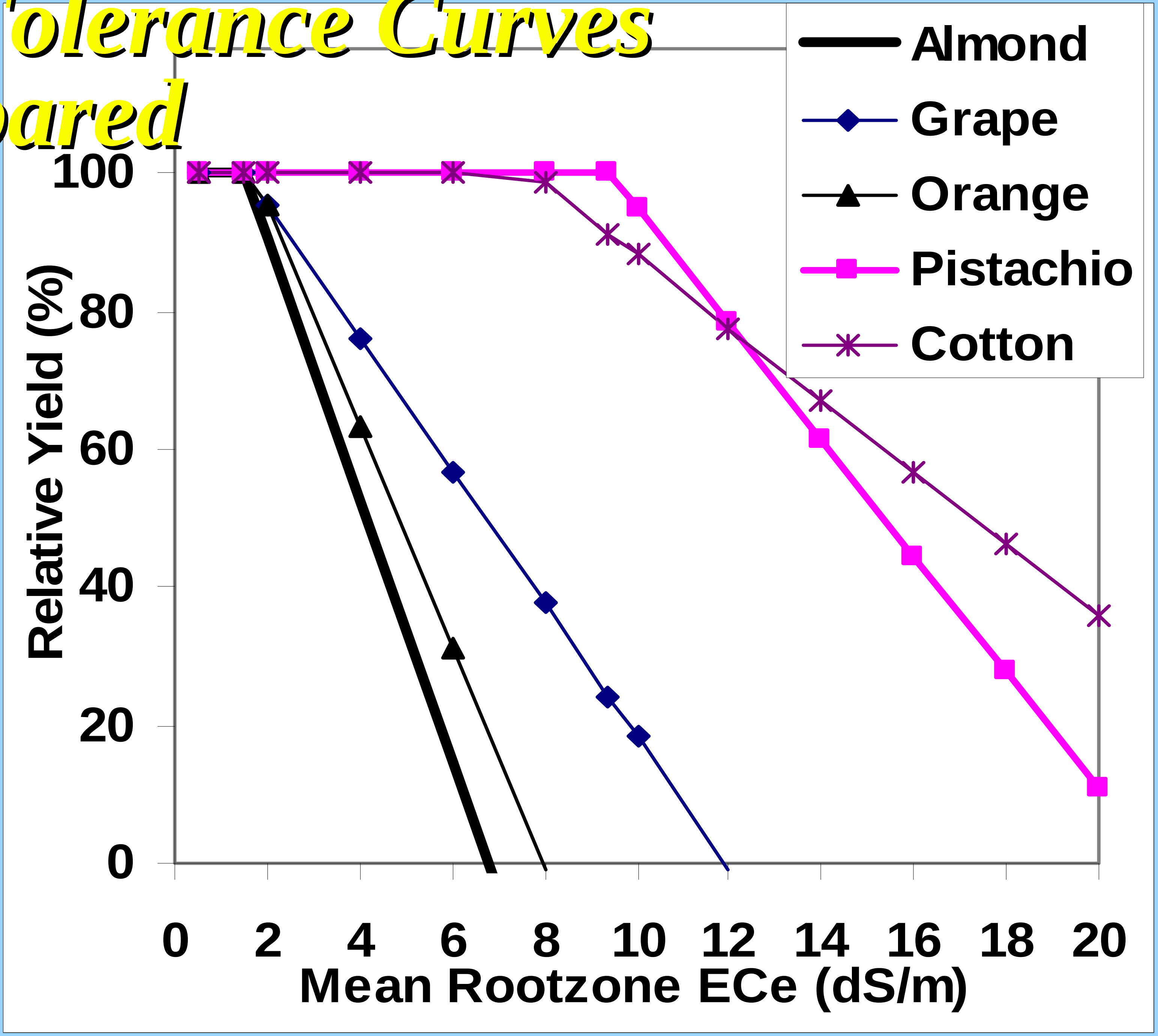


SOIL SALINITY & SPECIFIC ION TOXICITY THRESHOLDS

S = sensitive, <5-10 meq/l. MT=moderately tolerant, <20-30 meq/l

Crop	EC_{thresh} (dS/m)	Slope (%)	Sodium (meq/l)	Chloride (meq/l)	Boron (ppm)
Almond	1.5	19	S	S	0.5-1.0
Apricot	1.6	24	S	S	0.5-0.75
Avocado			S	5.0	0.5-0.75
Date palm	4.0	3.6	MT	MT	
Grape	1.5	9.6		10-30	0.5-1.0
Orange	1.7	16	S	10-15	0.5-0.75
Peach	1.7	21	S	10-25	0.5-0.75
Pistachio	**9.4**	**8.4**	**20-50**	**20-40**	**3-6**
Plum	1.5	18	S	10-25	0.5-0.75
Walnut			S		0.5-1.0

Salt Tolerance Curves Compared



Salt Affected Relative Yield(%) =

$100 - Slope*(Soil\ EC_e - EC_{threshold})$

Almond Relative Yield(%) =

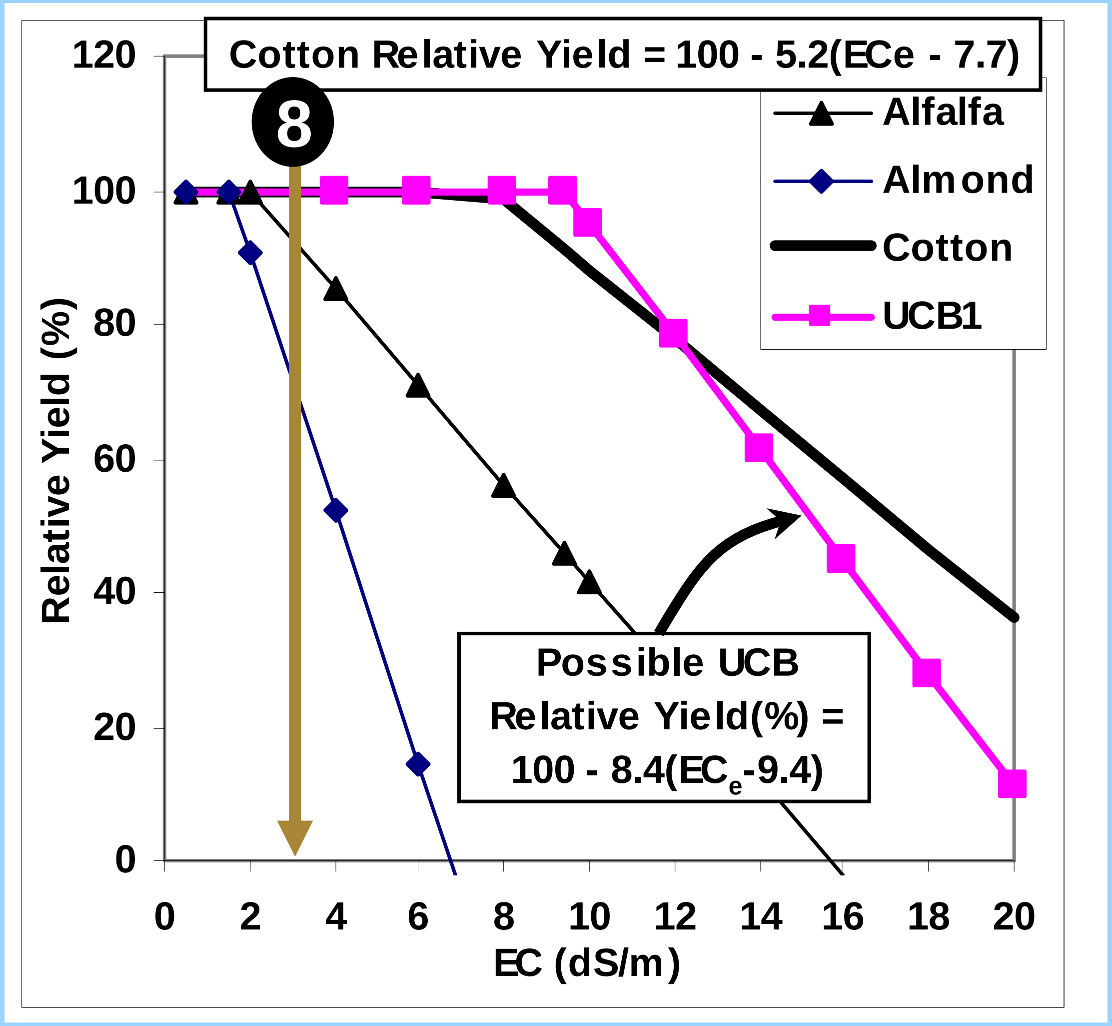
$100 - 19*(Soil\ EC_e - 1.5)$

How to do it   How to fix it *(pg 134-5)*

- **WATER QUALITY**

Analysis:

pH	8.4
EC_w	1.0 dS/m
Ca	0.5 meq/l
Mg	0.1 meq/l
Na	9.6 meq/l
HCO_3	4.2 meq/l
CO_3	1.0meq/l
Cl	4.6meq/l
SO_4	0.1meq/l
B	0.7 mg/l
NO_3	5.2 mg/l
SAR	17.5
SAR_{adj}	16.6



<u>FIX</u>: Pistachio: none needed – normal irrigation.

Almond: increase leaching fraction to 20%.

Almond Relative Yield =

$$100 - \text{slope}(EC_{thresh} - EC_e)$$

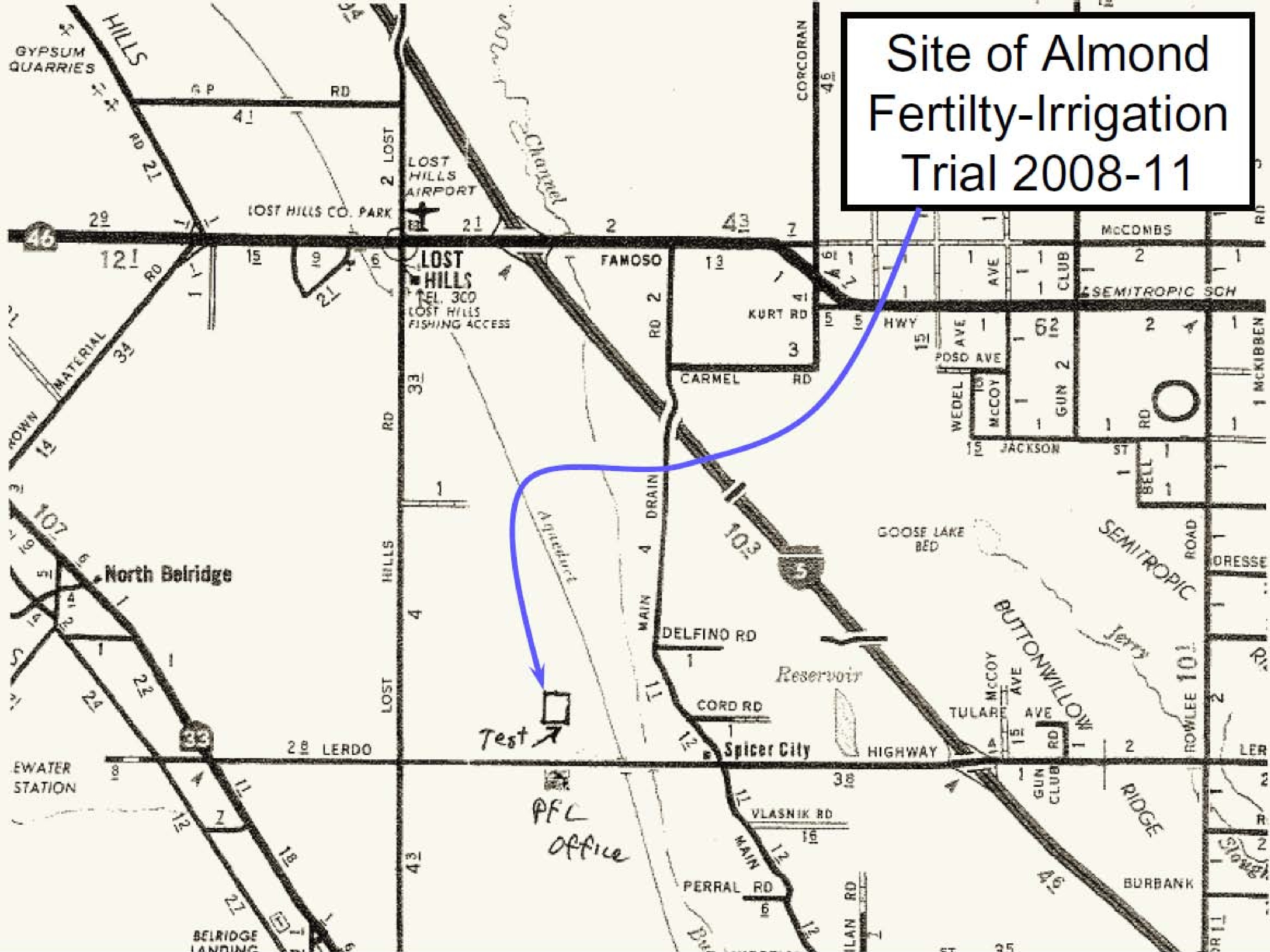
10%LF = 100-19(3-1.5) = 71.5%

15%LF = 100-19(2-1.5) = 90.5%

Rule of Thumb:

Long-term $EC_{rootzone} \sim 3 * EC_{irr\ water}$ @ 10% LF

Long-term $EC_{rootzone} \sim 2 * EC_{irr\ water}$ @ 15% LF


Site of Almond Fertilty-Irrigation Trial 2008-11
GYPSUM QUARRIES
HILLS
G P RD
LOST HILLS AIRPORT
LOST HILLS CO. PARK
LOST HILLS
LOST HILLS FISHING ACCESS
Channel
FAMOSO
KURT RD
CARMEL RD
CORCORAN
McCOMBS
SEMITROPIC SCH
HWY
POSO AVE
WEDEL
McCOY
GUN
CLUB
JACKSON ST
BELL
MCKIBBEN
MATERIAL
North Belridge
Aqueduct
MAIN DRAIN RD
DELFINO RD
CORD RD
Reservoir
GOOSE LAKE BED
SEMITROPIC
ROAD
BUTTONWILLOW
Jerry
ROWLEE
TULARE AVE
Spicer City
HIGHWAY
LERDO
LOST HILLS RD
EWATER STATION
Test
PFL Office
VLASNIK RD
PERRAL RD
RIDGE
BURBANK
BELRIDGE LANDING
DRESSE

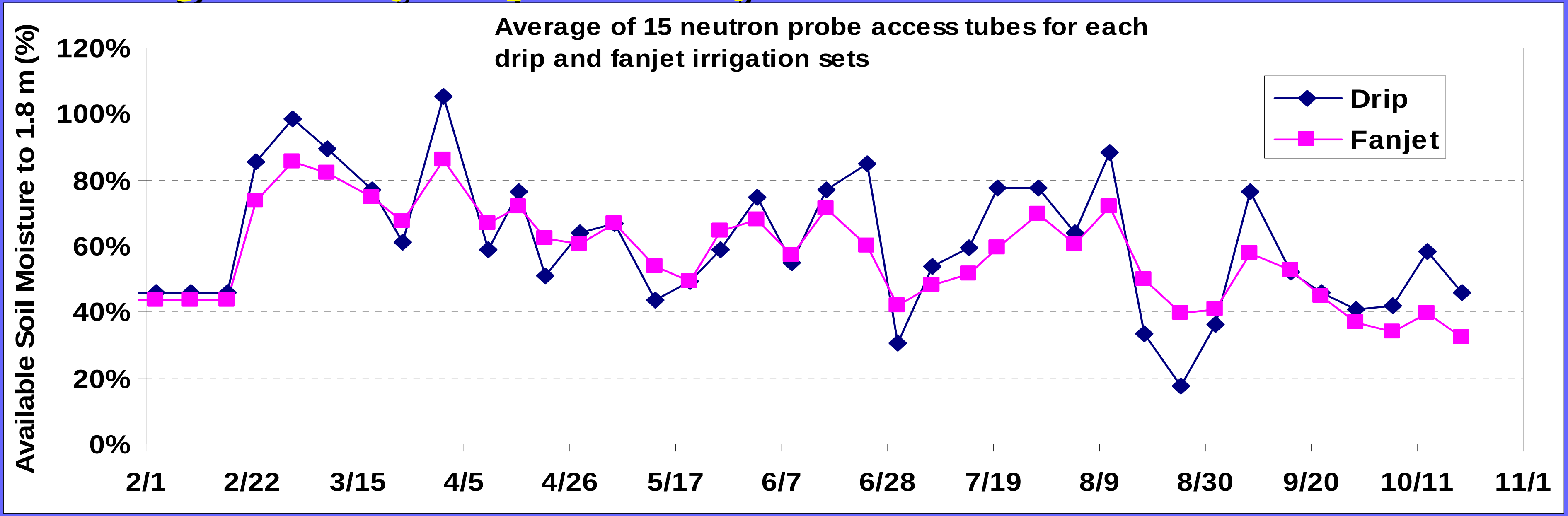
Intensive monitoring site with 5 neutron probe access tubes, Watermark/Irrometer logger, Surface Renewal and Sonic Anemometer heat flux estimates of ET.

Possible PureSense Probe

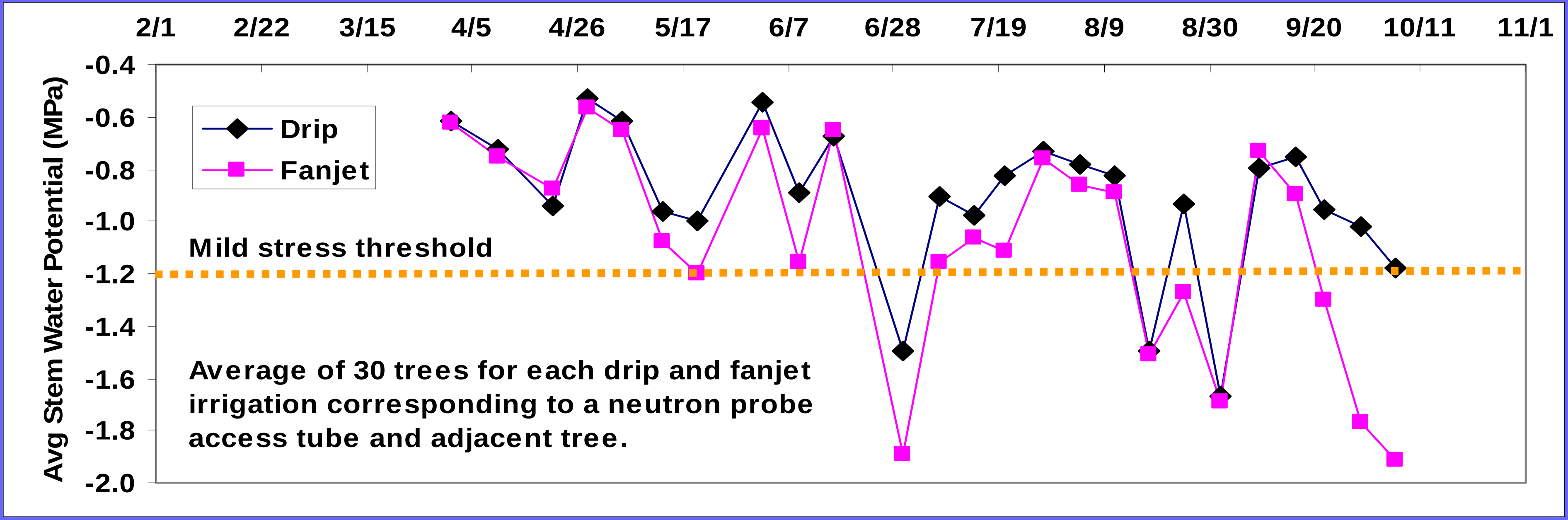
Aerial late March 2006

Planted 1999

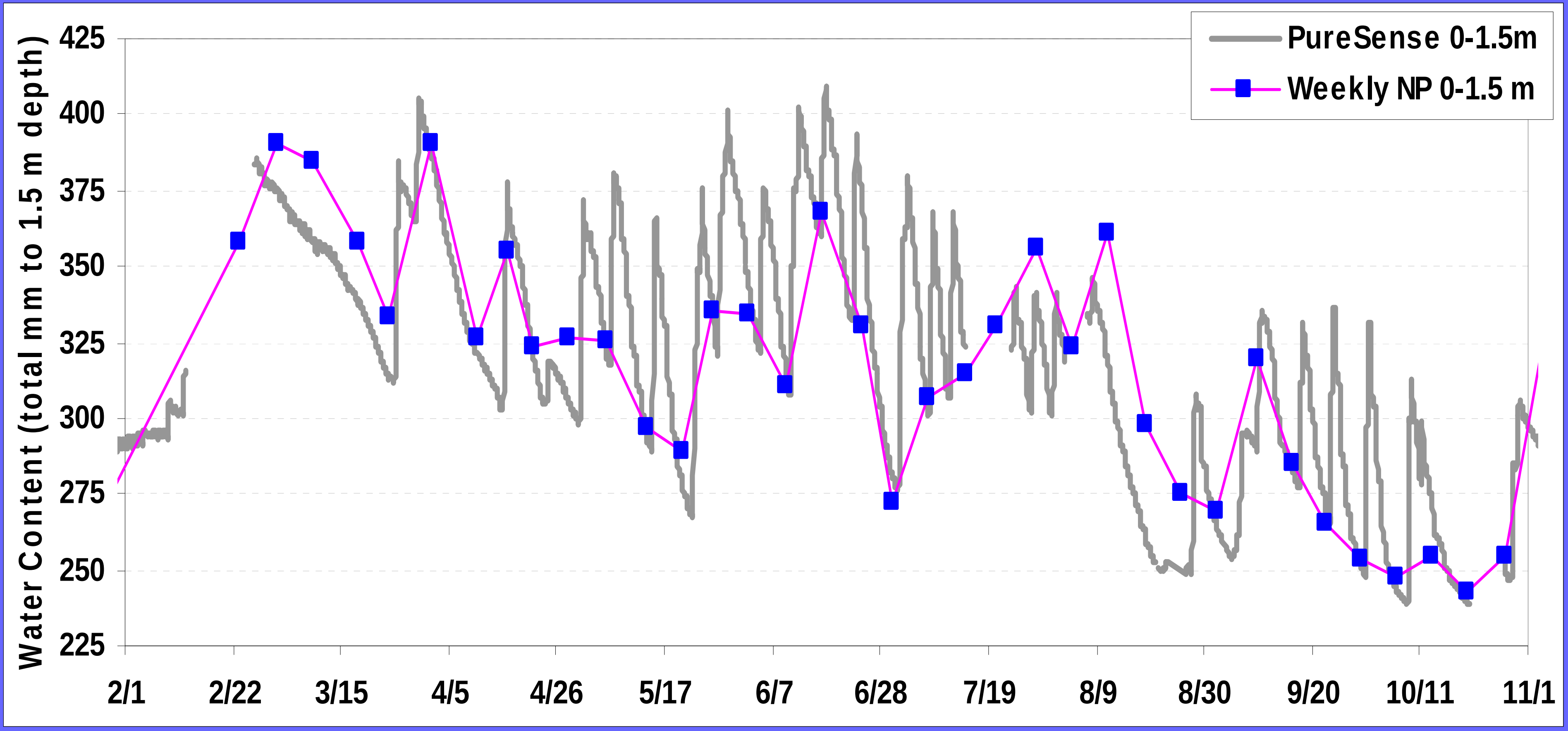
Average weekly drip and fanjet soil water content to 1.8 m

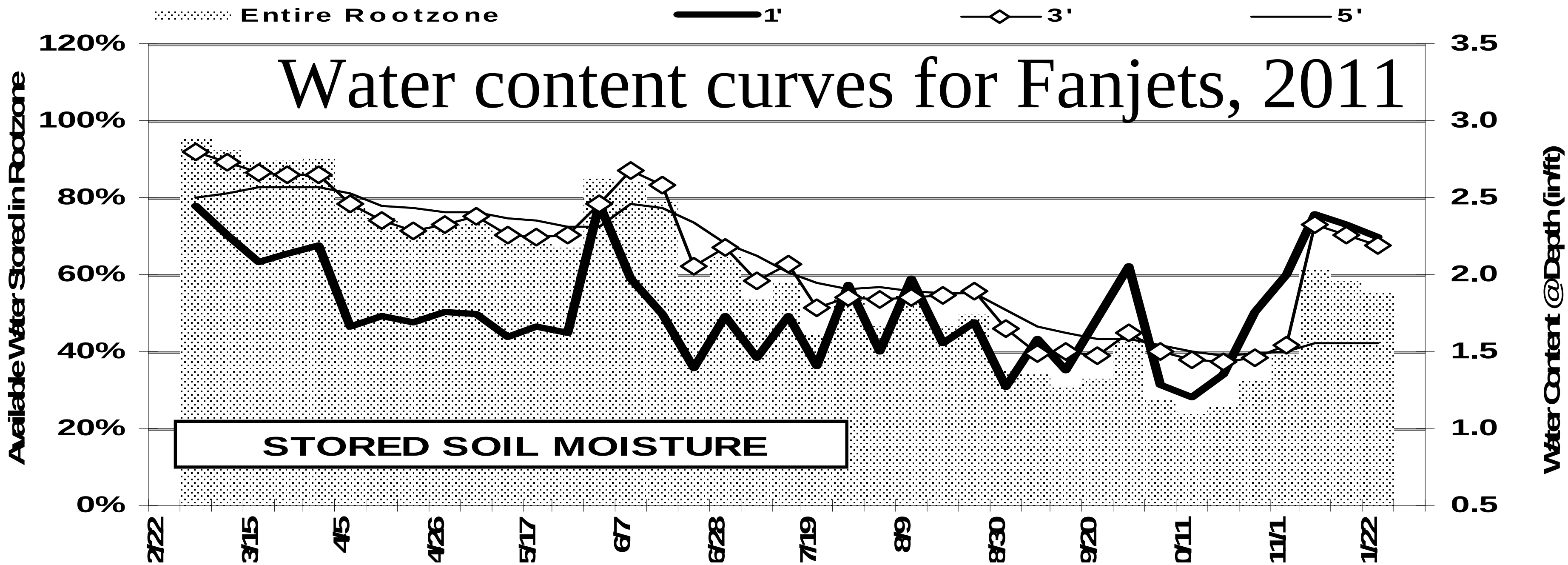


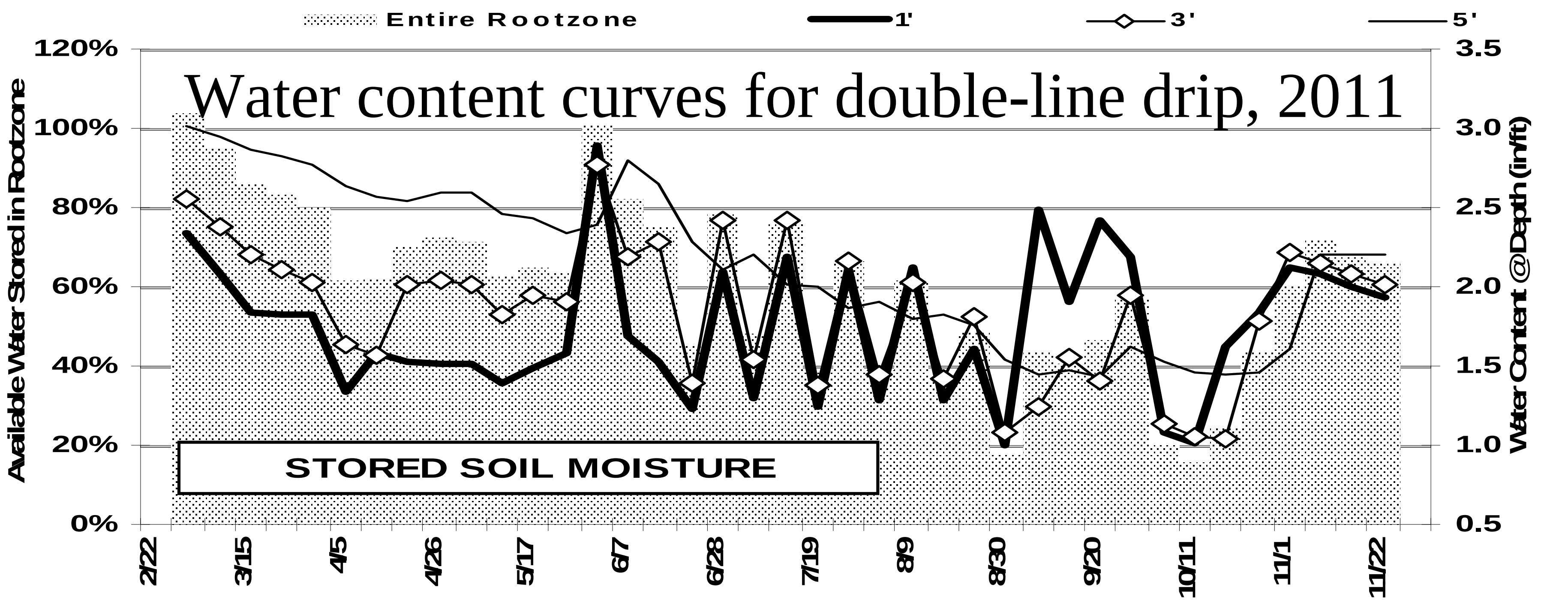
Average weekly drip and fanjet stem water potential



Weekly neutron probe water content just before irrigation compared to PureSense continuous capacitance probe readings

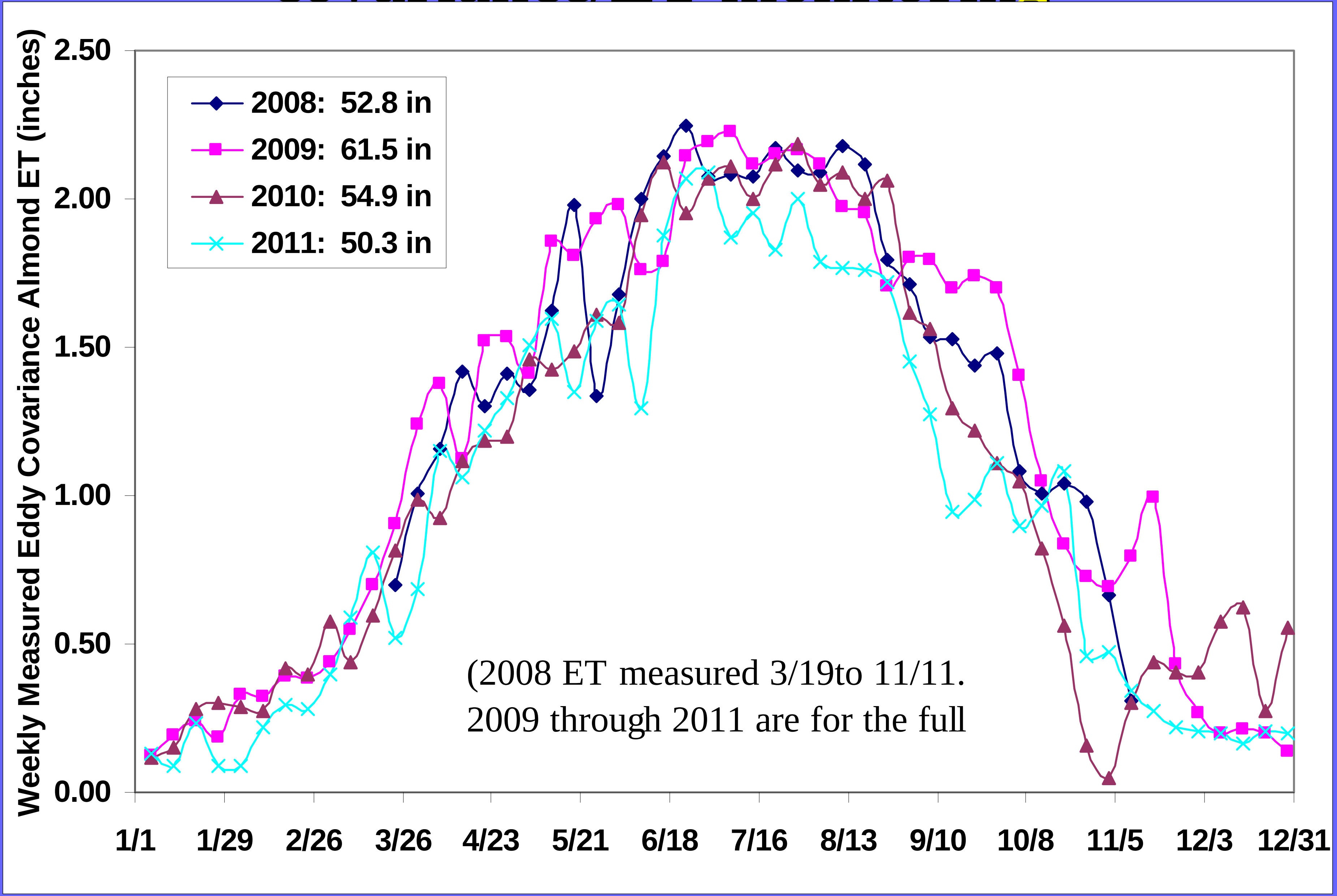



Water content curves for Fanjets, 2011
Entire Rootzone
1'
3'
5'
STORED SOIL MOISTURE
Available Water Stored in Rootzone
Water Content @Depth (in/ft)
120%
100%
80%
60%
40%
20%
0%
3.5
3.0
2.5
2.0
1.5
1.0
0.5
2/22
3/15
4/5
4/26
5/17
6/7
6/28
7/19
8/9
8/30
9/20
0/11
11/1
1/22


Water content curves for double-line drip, 2011
Entire Rootzone
1'
3'
5'
STORED SOIL MOISTURE
Available Water Stored in Rootzone
Water Content @Depth (in/ft)
120%
100%
80%
60%
40%
20%
0%
3.5
3.0
2.5
2.0
1.5
1.0
0.5
2/22
3/15
4/5
4/26
5/17
6/7
6/28
7/19
8/9
8/30
9/20
10/11
11/1
11/22

<u>Problem:</u> **You can be too efficient. Chloride and salt accumulation contributing to chlorosis and early leaf senescence after harvest cutoff.**

4 years of almond Kc values from eddy covariance/ET monitoring



In its simplest form, the leaching fraction (LF) or water percolating below the rootzone can be reduced to a simple mass balance of salt in, salt out:

$$\frac{D_{dw}}{D_{iw}} = \frac{EC_{iw}}{EC_{dw}}$$

Where:

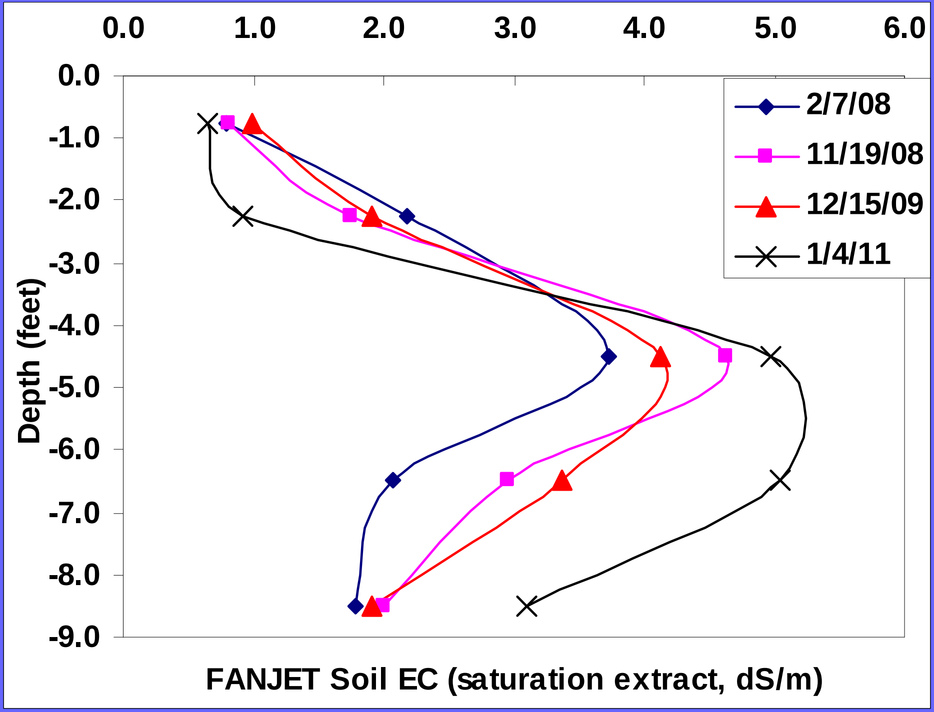
D_{dw} = depth of drain water below rootzone

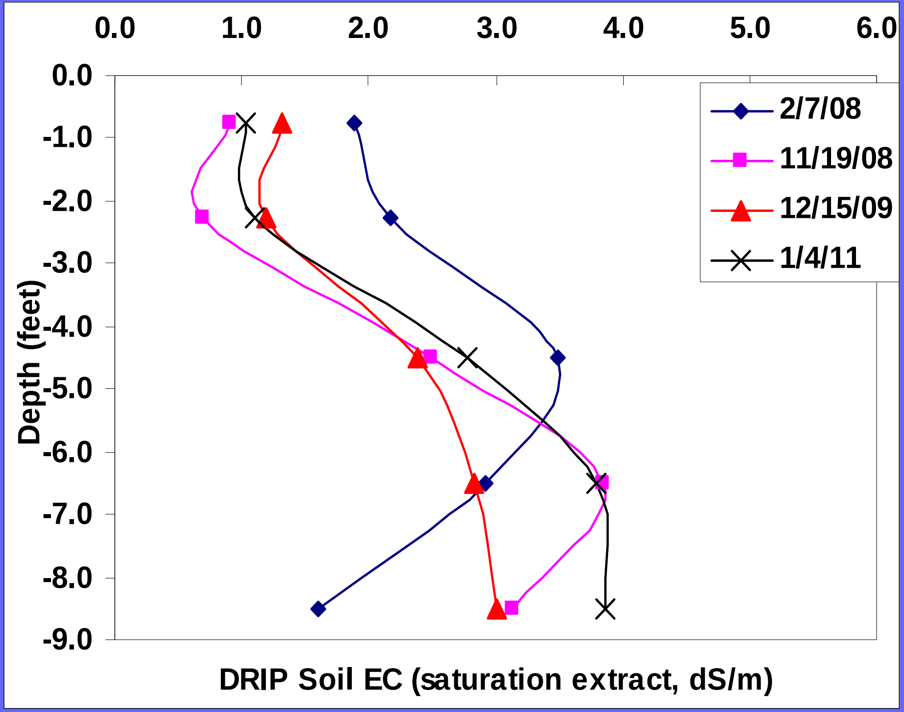
D_{iw} = depth of irrigation water

EC_{iw} = electroconductivity (or chloride concentration) of irrigation water

EC_{dw} = electroconductivity (or chloride concentration) of drain water

Problem: **Salts concentrate in the lower rootzone and eventually have to be leached. A Cl mass balance can also be used to estimate WUE.**


0.0
1.0
2.0
3.0
4.0
5.0
6.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
Depth (feet)
2/7/08
11/19/08
12/15/09
1/4/11
FANJET Soil EC (saturation extract, dS/m)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0.0
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-2.0
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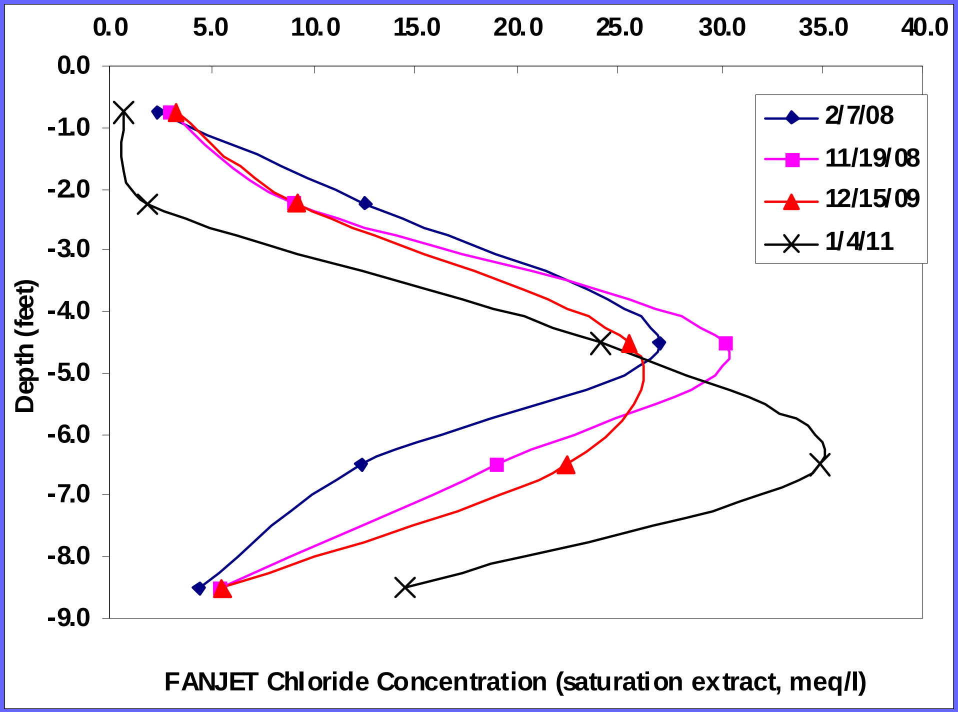
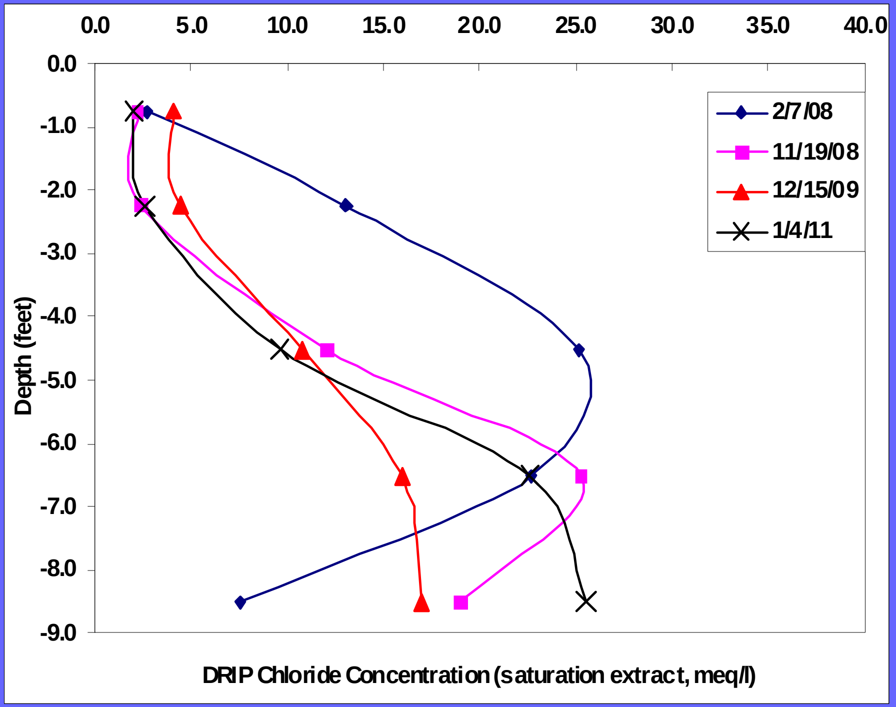
-5.0
-6.0
-7.0
-8.0
-9.0
Depth (feet)
2/7/08
11/19/08
12/15/09
1/4/11
DRIP Soil EC (saturation extract, dS/m)


0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
Depth (feet)
2/7/08
11/19/08
12/15/09
1/4/11
FANJET Chloride Concentration (saturation extract, meq/l)


0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
Depth (feet)
2/7/08
11/19/08
12/15/09
1/4/11
DRIP Chloride Concentration (saturation extract, meq/l)

MICROSPRINKLER -- Cl (soil saturation extract, meq/l)					LEACHING FRACTION ESTIMATE				WATER USE EFFICIENCY			
Sample Depth (ft)	2/7/08	11/19/08	12/15/09	1/4/11	2/7/08	11/19/08	12/15/09	1/4/11	2/7/08	11/19/08	12/15/09	1/4/11
-0.75	2.3	3.0	3.33	0.7	0.48	0.42	0.40	0.77	0.67	0.70	0.72	0.57
-2.25	12.6	9.1	9.17	1.9	0.15	0.19	0.19	0.54	0.87	0.84	0.84	0.65
-4.50	27.0	30.2	25.50	24.1	**0.08**	**0.07**	**0.08**	0.08	**0.93**	**0.94**	**0.93**	0.92
-6.50	12.4	19.1	22.44	34.9	0.15	0.10	0.09	**0.06**	0.87	0.91	0.92	**0.94**
-8.50	4.4	5.5	5.56	14.6	0.33	0.29	0.28	0.13	0.75	0.78	0.78	0.88
Avg 0-6.5 feet	**13.6**	**15.4**	**15.1**	**15.4**								

(Average Cl_{irrig} concentration = 2.2 meq/l)

$$FieldWUE = 1 - LR$$

MICROSPRINKLER -- *Cl mass (lb/ac-ft soil @ 29.1 SP)					LF as Cl MASS ESTIMATE				WUE - Cl mass estimate			
Sample Depth (ft)	2/7/08	11/19/08	12/15/09	1/4/11	2/7/08	11/19/08	12/15/09	1/4/11	2/7/08	11/19/08	12/15/09	1/4/11
-0.75	97	126	137	28	0.73	0.56	0.52	2.57	0.58	0.64	0.66	0.28
-2.25	519	375	378	78	0.14	0.19	0.19	0.91	0.88	0.84	0.84	0.52
-4.50	1114	1244	1051	994	**0.06**	**0.06**	**0.07**	0.07	**0.94**	**0.95**	**0.94**	0.93
-6.50	509	786	925	1440	0.14	0.09	0.08	**0.05**	0.88	0.92	0.93	**0.95**
-8.50	181	225	229	601	0.39	0.32	0.31	0.12	0.72	0.76	0.76	0.89

(*Cl irrig mass = 70.8 lb/ million lbs water. Applied irrig = 54" = 12.20 million lbs. Total applied Cl = 950 lbs/year.)

DOUBLE-LINE DRIP -- Cl (soil saturation extract, meq/l)					LEACHING FRACTION ESTIMATE				WATER USE EFFICIENCY			
Sample Depth (ft)	2/7/08	11/19/08	12/15/09	1/4/11	2/7/08	11/19/08	12/15/09	1/4/11	2/7/08	11/19/08	12/15/09	1/4/11
-0.75	2.7	2.2	4.12	2.0	0.45	0.50	0.35	0.52	0.69	0.67	0.74	0.66
-2.25	13.1	2.4	4.44	2.6	0.14	0.48	0.33	0.46	0.87	0.68	0.75	0.69
-4.50	25.2	12.1	10.73	9.6	**0.08**	0.15	0.17	0.19	**0.93**	0.87	0.85	0.84
-6.50	22.7	25.3	15.99	22.6	0.09	**0.08**	0.121	0.09	0.92	**0.93**	0.892	0.92
-8.50	7.6	19.0	16.91	25.5	0.22	0.10	**0.115**	**0.08**	0.82	0.91	**0.897**	**0.93**
Avg 0-6.5 feet	**15.9**	**10.5**	**8.8**	**9.2**								

SUMMARY

- **Water supply quality and quantity is paramount, EC<0.7 dS/m for almonds with a 10% LF minimum**
- **Soil profile/texture preferably uniform to 5 feet, no "perching" clay layer, ECe < 2 dS/m**
- **Lab should be certified and analyses familiar to you or your consultant**
- **Salinity impacts reduced when Calcium dominates over Na. For almonds want Ca > 0.3Na**
- **Old salt tolerance curves not accurate for all soils and waters**

Brian Hockett

District Manager

North West Kern
Resource Conservation District

Irrigation Mobile Laboratory

Irrigation Systems

- Furrows – cotton, corn, tomatoes...
- Border Strip (flood) – alfalfa, almonds...
- Solid Set Sprinkler – carrots, onions…
- Hand Move Sprinkler – alfalfa, cotton…
- Linear Move Sprinkler – alfalfa, carrots…
- Center Pivot – carrots, turf…
- Micro Drip – almonds, pistachios, vines…
- Micro Sprinkler – trees & vines

Distribution Uniformity (DU)

What does that mean?

$$DU = \frac{\text{Ave. low } 1/4}{\text{Ave. of the whole}}$$

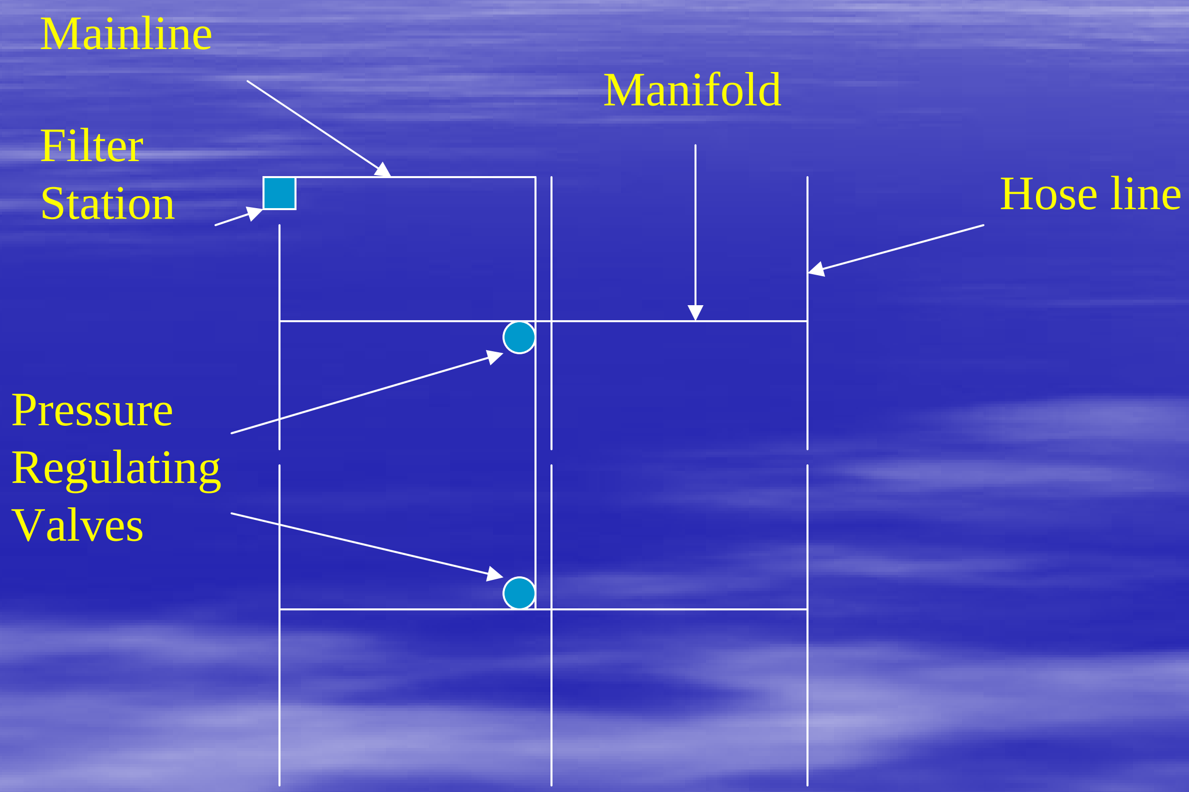
Sand Media & Screen filters

Disc filters


Overflow screen

Check pressure

System layout




Catch water

Irrigation System Uniformities

System	County Average (1988 – 2008)
Border Strip	81
Furrow	80
Solid Set Sprinkler	66
Hand Move Sprinkler	65
Linear Sprinkler	76
Center Pivot Sprinkler	87 (*) Only one test conducted
Undertree Sprinkler	86
Micro Drip	83
Micro Sprinkler	82
Landscape Water Audit	63

Maintenance

Maintenance issues

- Plugged emitters

- <u>Pressure Differences</u>
- Improperly set regulating valves
- Plugged hose screens
- Dirty manifolds


Observations
Hose screen plugged
With organic matter

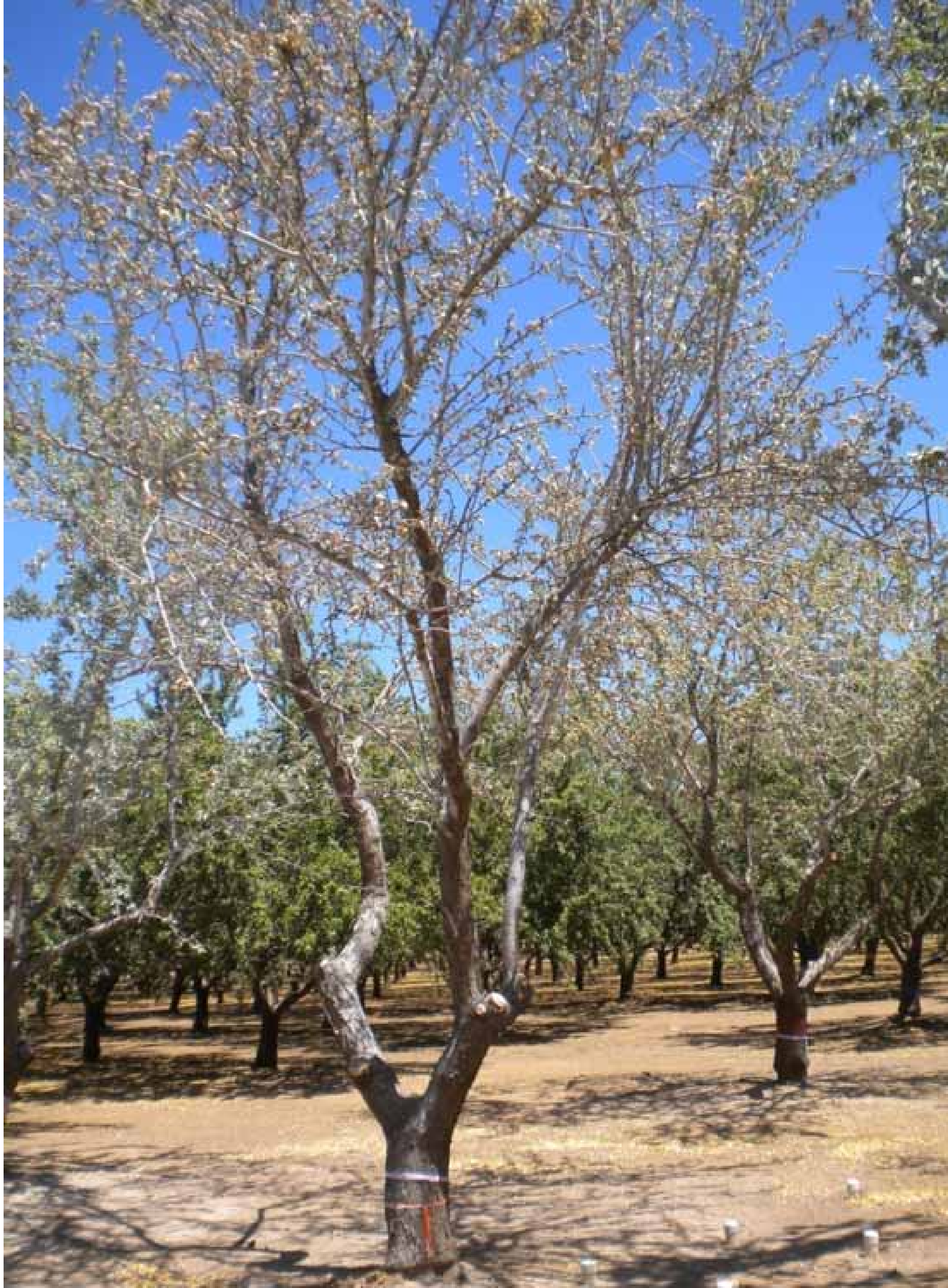

Slime or algae
20 PSI


Plastic shavings in ball valve


More problems
Buried flush valve

- For an evaluation
- Contact me at: (661) 336-0967, ext. 138

Plant stress and drought management: current year effects and “hangover” effects.



2009 Drought Study

Questions/Objectives:

1) How much water does it take for an almond tree to survive?

2) Under non-irrigated (rain and stored soil moisture only) conditions, will survival be improved by 50% canopy reduction and/or kaolin (surround) spray?

3) Will application of small amounts of water (5”, 10”) over the season help?

4) Is there a critical level of tree water stress that is necessary to cause tree death or dieback?

Treatments applied, 2009 (19 year old trees)

Irrigation Treatment	Canopy modification
0 (rainfed)	None
	50% reduction once SWP reaches -15 bars
	50% reduction + Kaolin spray
5" in-season	None
	Kaolin spray
10" in-season	None
	Kaolin spray
Control (100% ETc, 40”?)	None

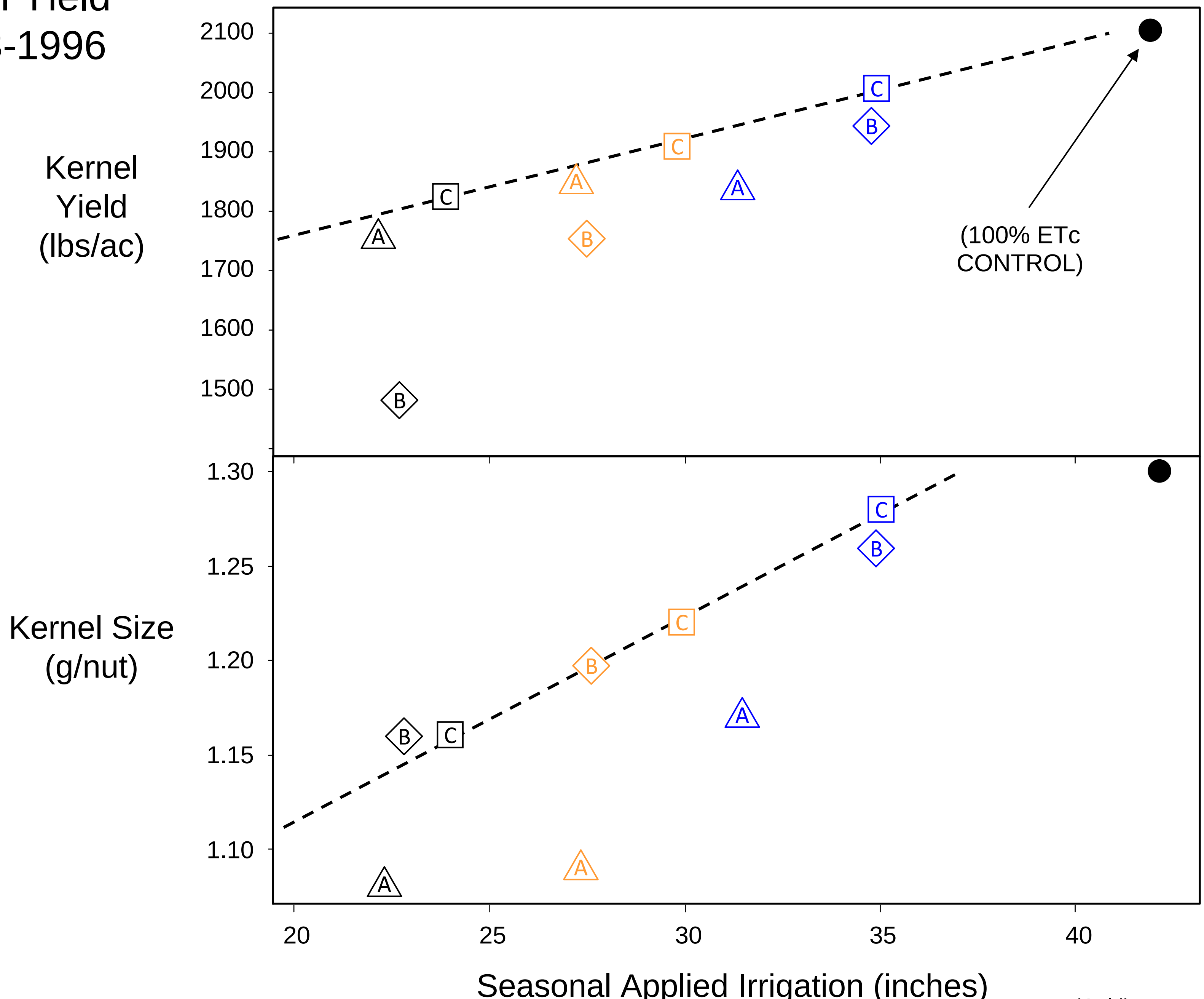
Drought irrigation approach based on Goldhamer 1993 – 1996 almond study.

Goldhamer tested 3 levels of irrigation deficit:

1) Irrigation deficit early (A)
2) Irrigation deficit late (B)
3) Even irrigation deficit throughout (C)

Conclusion: **Even** deficit throughout (%ET) is best.

Mean Yield 1993-1996



(Goldhamer et al., 2006)

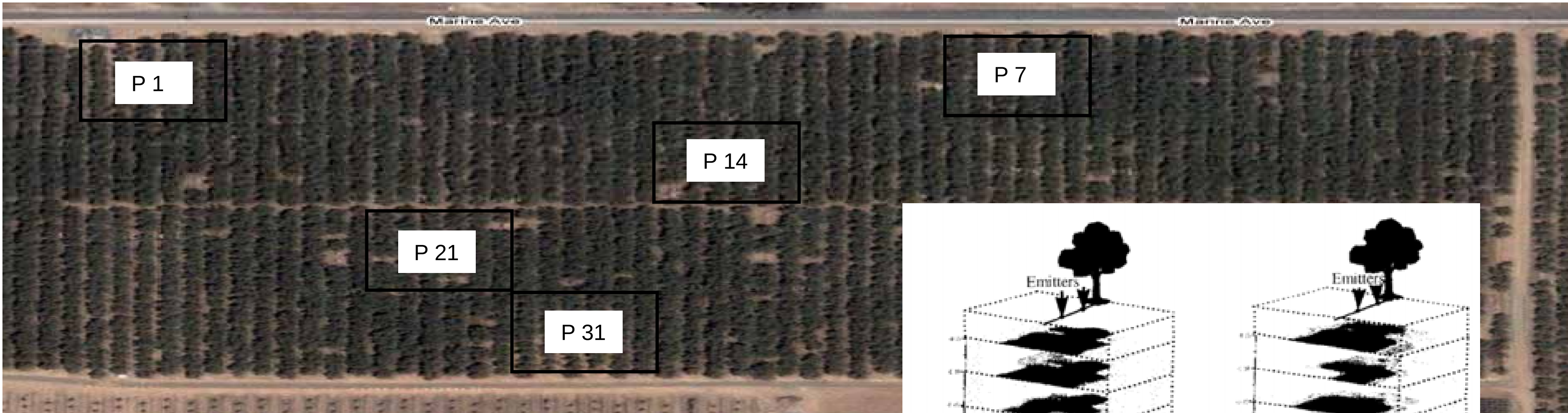
2009 Drought study: Nickels soils lab, Arbuckle, CA

1) Single line drip irrigation system (restricted root zone expected)

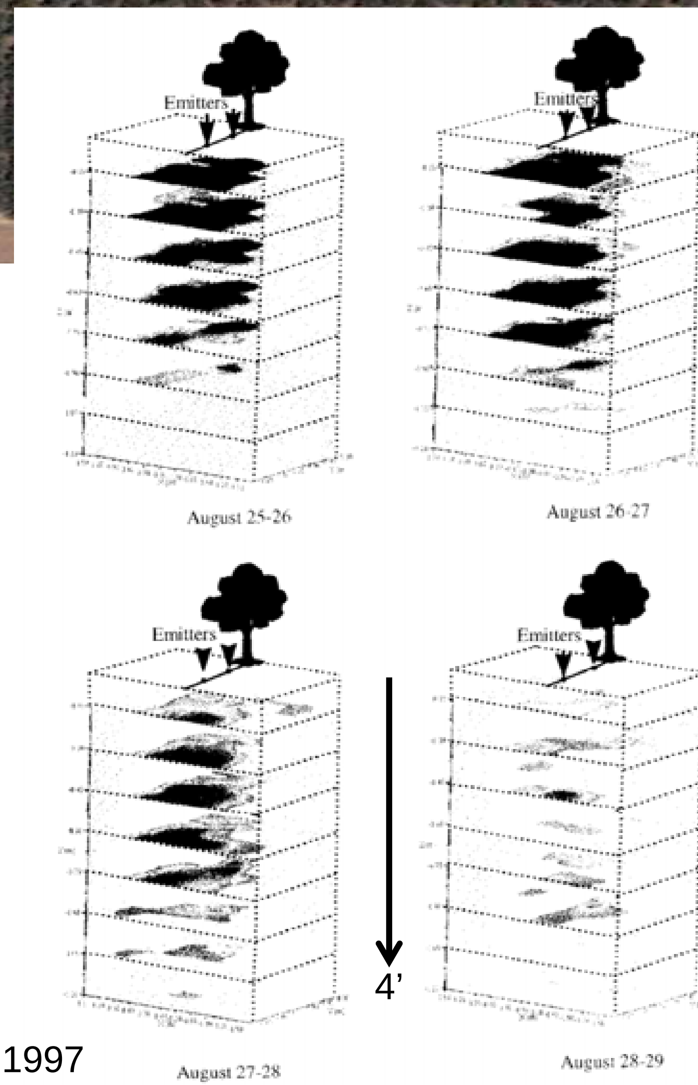
2) Gravel soil, WHC about 1”/foot (90 mm/m)

3) Demonstrated root water uptake only to about 3’ when trees were 6 years old

2009 Drought study: Nickels soils lab, Arbuckle, CA

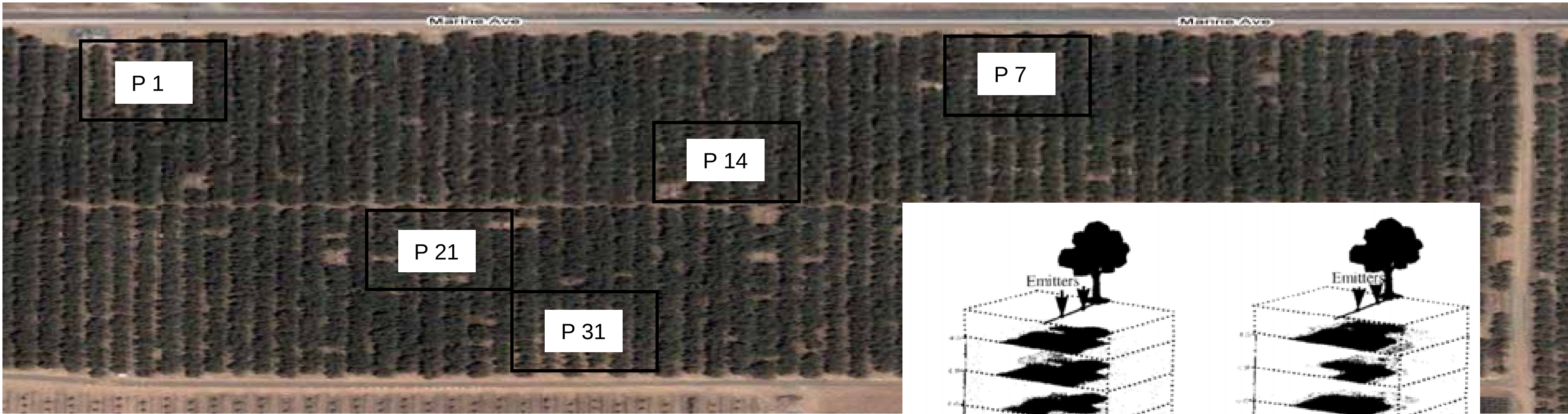


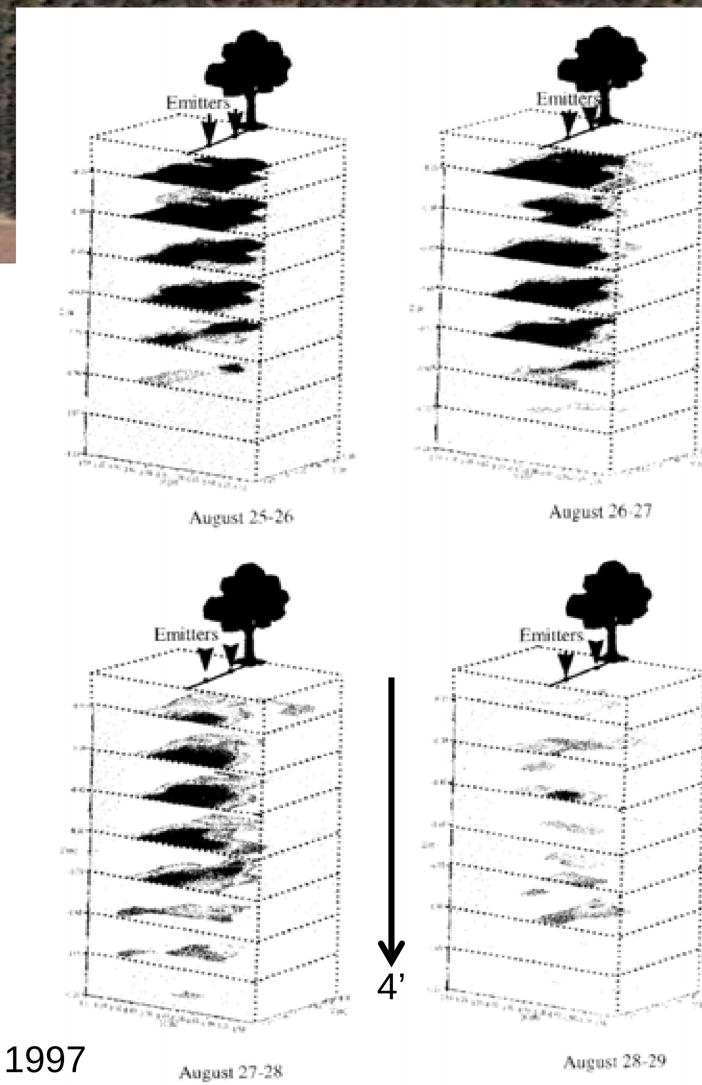
1) Single line drip irrigation system (restricted root zone expected)
2) Gravel soil, WHC about 1”/foot (90 mm/m)
3) Demonstrated root water uptake only to about 3’ when trees were 6 years old



Andreu et al, 1997

2009 Drought study: Nickels soils lab, Arbuckle, CA





1) Single line drip irrigation system (restricted root zone expected)

2) Gravel soil, WHC about 1"/foot (90 mm/m)

3) Demonstrated root water uptake only to about 3' when trees were 6 years old

Should be a good place to cause water stress!

Andreu et al, 1997

Q: How much water does it take to survive?

An extensive system of neutron soil moisture monitoring sites were installed to track soil water depletion. Nine sites per tree (1/4 of root zone), eight to a depth of 6’, one to a depth of 10’.

Water uptake at 10’ was detected in all deficit treatments!

Contribution of irrigation, rain, and stored soil water to observed tree water use

Treatment	Irrigation	Rain	Soil	Total	%ETc
0”	0”	2.1”	5.5”	7.6”	21%
5”	3.6”	2.1”	6.7”	12.4”	35%
10”	7.2”	2.1”	5.9”	15.2”	42%
Control	30.8”	2.1”	(?)	(32.9”)	(92%)

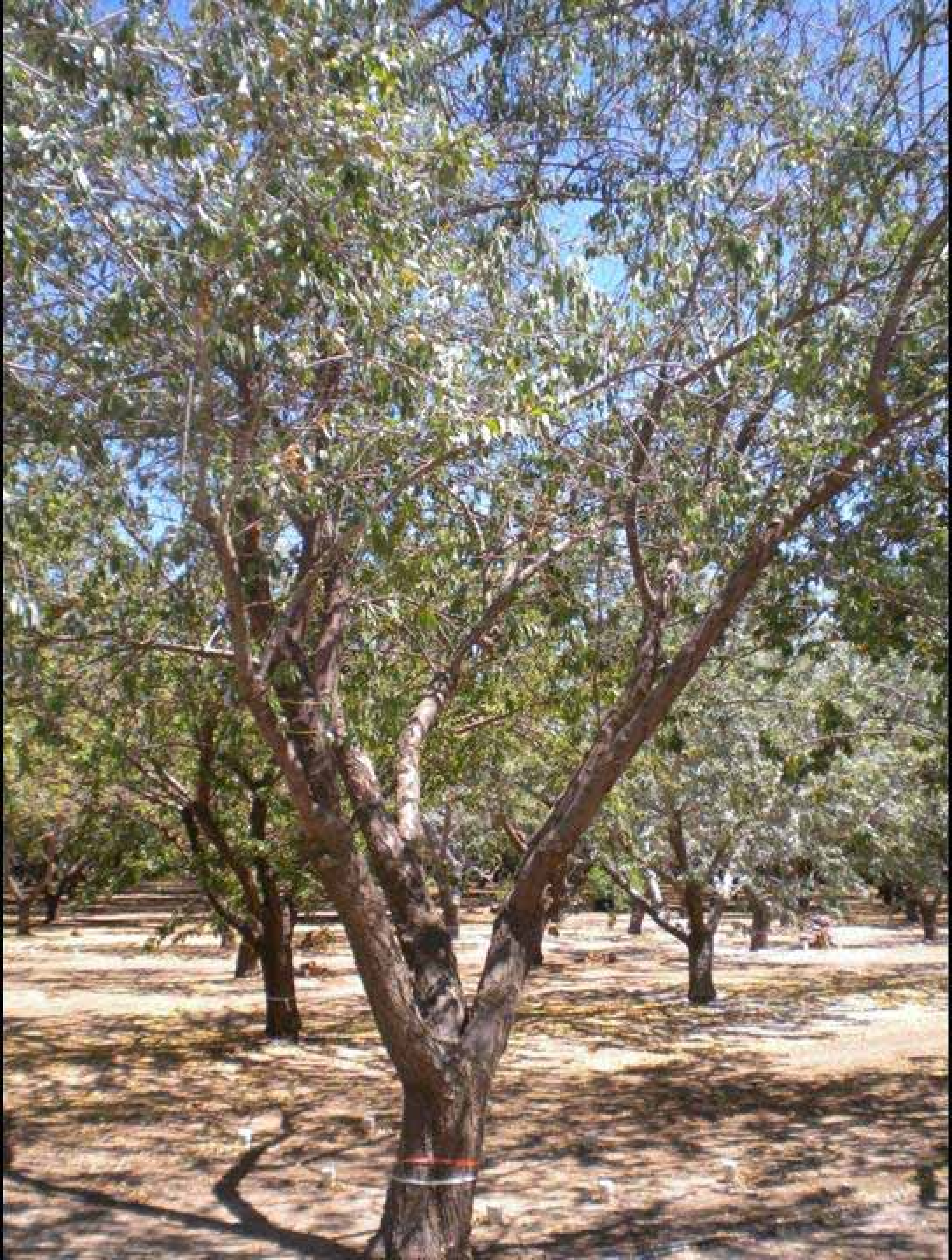
Q #1: How much water to stay alive?
(hint: none of the study trees died)

A: Non Pareil almond trees may be able to survive on 7.6”

July 21, 2009

Control tree

- 9.8 bars SWP



July 21, 2009

10” tree

- 25 bars SWP

July 21, 2009

0” tree

- 39 bars SWP

July 21, 2009

0” tree

- 54 bars SWP


S10
CHEVROLET
CORNING
California

This tree had reached -63 bars on July 14, 2009, and by July 28 was completely defoliated

TENTATIVE GUIDELINES FOR INTERPRETING PRESSURE CHAMBER READINGS (MIDDAY STEM WATER POTENTIAL-SWP) IN WALNUT, ALMOND, AND DRIED PLUM. UPDATED MAY 2007.

Allan Fulton and Richard Buchner, UCCE Farm Advisors, Tehama County, Joe Grant, Farm Advisor, San Joaquin County, Terry Prichard, Bruce Lampinen, Larry Schwankl, Extension Specialists, UC Davis, and Ken Shackel, Professor UC Davis.

Pressure Chamber Reading (- bars)	WALNUT	ALMOND	PRUNES
0 to –2.0	Not commonly observed	Not commonly observed	Not commonly observed
-2.0 to –4.0	Fully irrigated, low stress, commonly observed when orchards are irrigated according to estimates of real-time evapotranspiration (ETc), long term root and tree health may be a concern, especially on California Black rootstock.	↓	↓
-4.0 to –6.0	Low to mild stress, high rate of shoot growth visible, suggested level from leaf-out until mid June when nut sizing is completed.	↓	↓
-6.0 to –8.0	Mild to moderate stress, shoot growth in non-bearing and bearing trees has been observed to decline. These levels do not appear to affect kernel development.	Low stress, indicator of fully irrigated conditions, ideal conditions for shoot growth. Suggest maintaining these levels from leaf-out through mid June.	Low stress, common from March to mid April under fully irrigated conditions. Ideal for maximum shoot growth.
-8.0 to –10.0	Moderate to high stress, shoot growth in non-bearing trees may stop, nut sizing may be reduced in bearing trees and bud development for next season may be negatively affected.	↓	Suggested levels in late April through mid June. Low stress levels enabling shoot growth and fruit sizing.
-10.0 to –12.0	High stress, temporary wilting of leaves has been observed. New shoot growth may be sparse or absent and some defoliation may be evident. Nut size likely to be reduced.	Mild to moderate stress, these levels of stress may be appropriate during the phase of growth just before the onset of hull split (late June).	Suggested mild levels of stress during late June and July. Shoot growth slowed but fruit sizing unaffected.
-12.0 to –14.0	Relative high levels of stress, moderate to severe defoliation, should be avoided.	↓	Mild to moderate stress suggested for August to achieve desirable sugar content in fruit and to reduce "dry-away" (drying costs).
-14.0 to –18.0	Severe defoliation, trees are likely dying.	Moderate stress in almond. Suggested stress level during hull split, Help control diseases such as hull rot and alternaria, if diseases are present. Hull split occurs more rapidly	Moderate stress acceptable in September.
-18.0 to –20.0	Crop stress levels in English walnut not observed at these levels.	Transitioning from moderate to higher crop stress levels	Moderate to high stress levels. Most commonly observed after harvest. Generally undesirable during any stage of tree or fruit growth. Most appropriately managed with post-harvest irrigation
-20 to -30	↓	High stress, wilting observed, some defoliation	
Less than – 30		Extensive defoliation has been observed	High stress, extensive defoliation

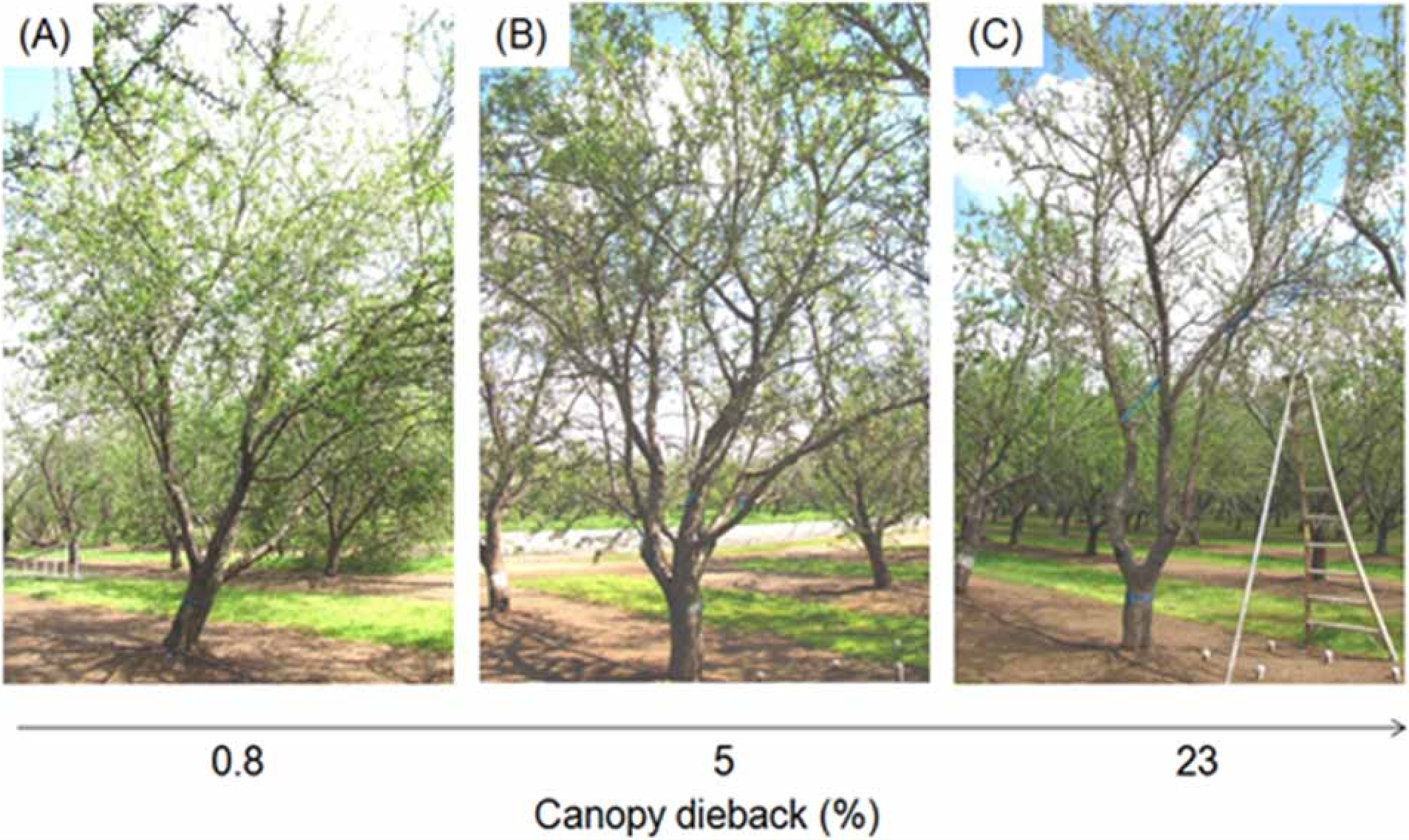
* These guidelines are tentative and subject to change as research and development with the pressure chamber and midday stem water potential progress. This table should not be duplicated without prior consent by the authors.

↓ Around -60

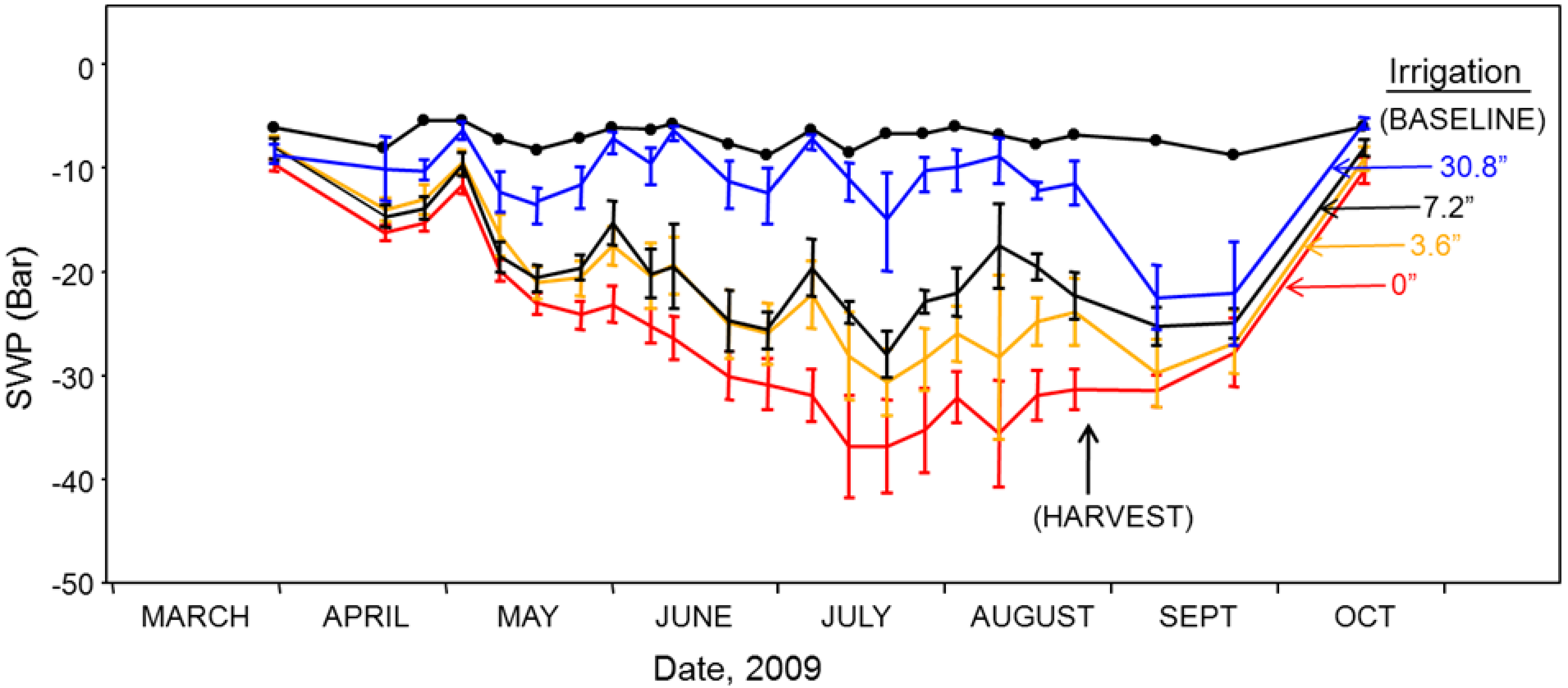
↓ Complete defoliation


August, 2009
Defoliated and wood is dead/dry
Wood still alive

Spring, 2011

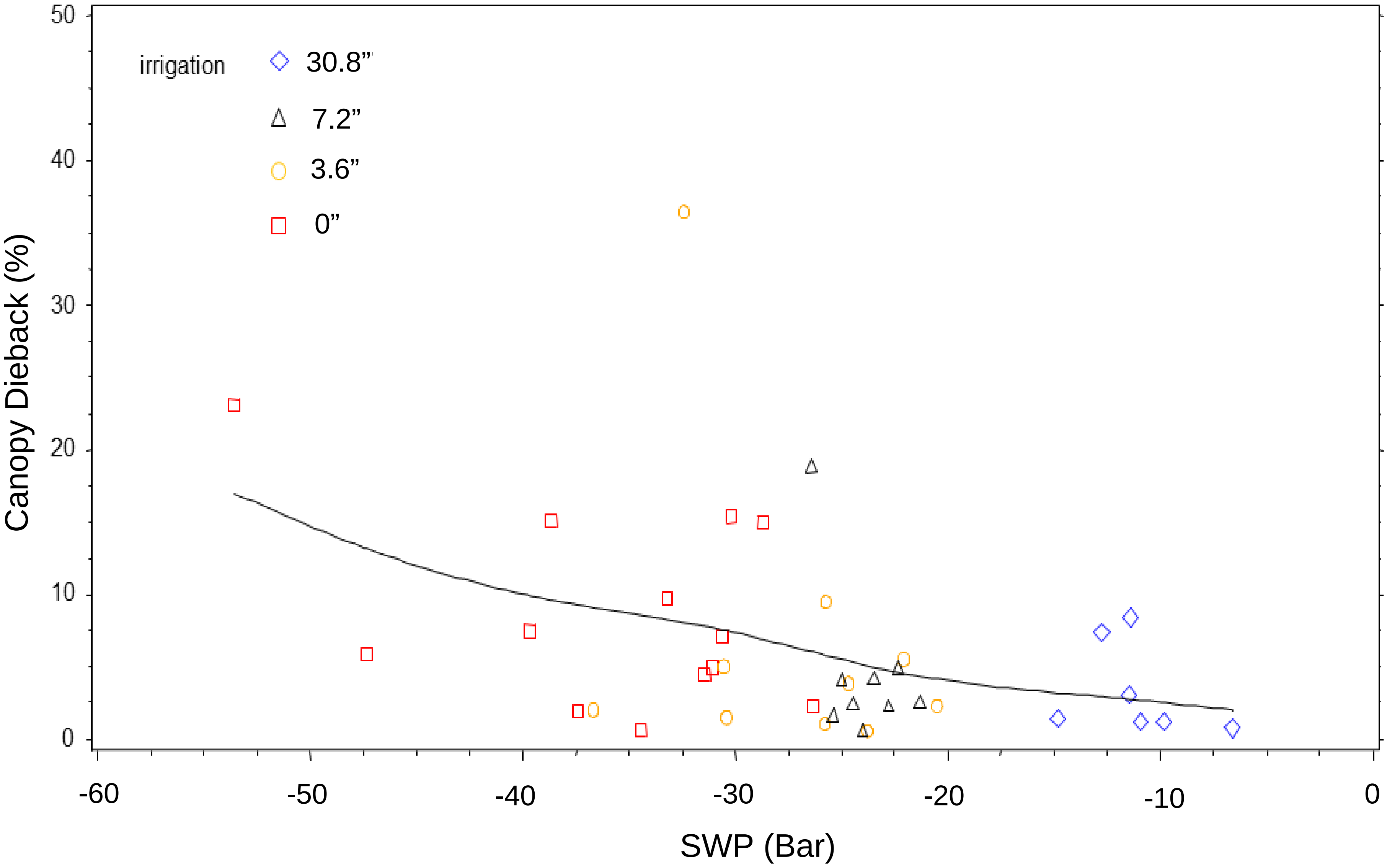


Midday stem water potential (SWP) during the drought year

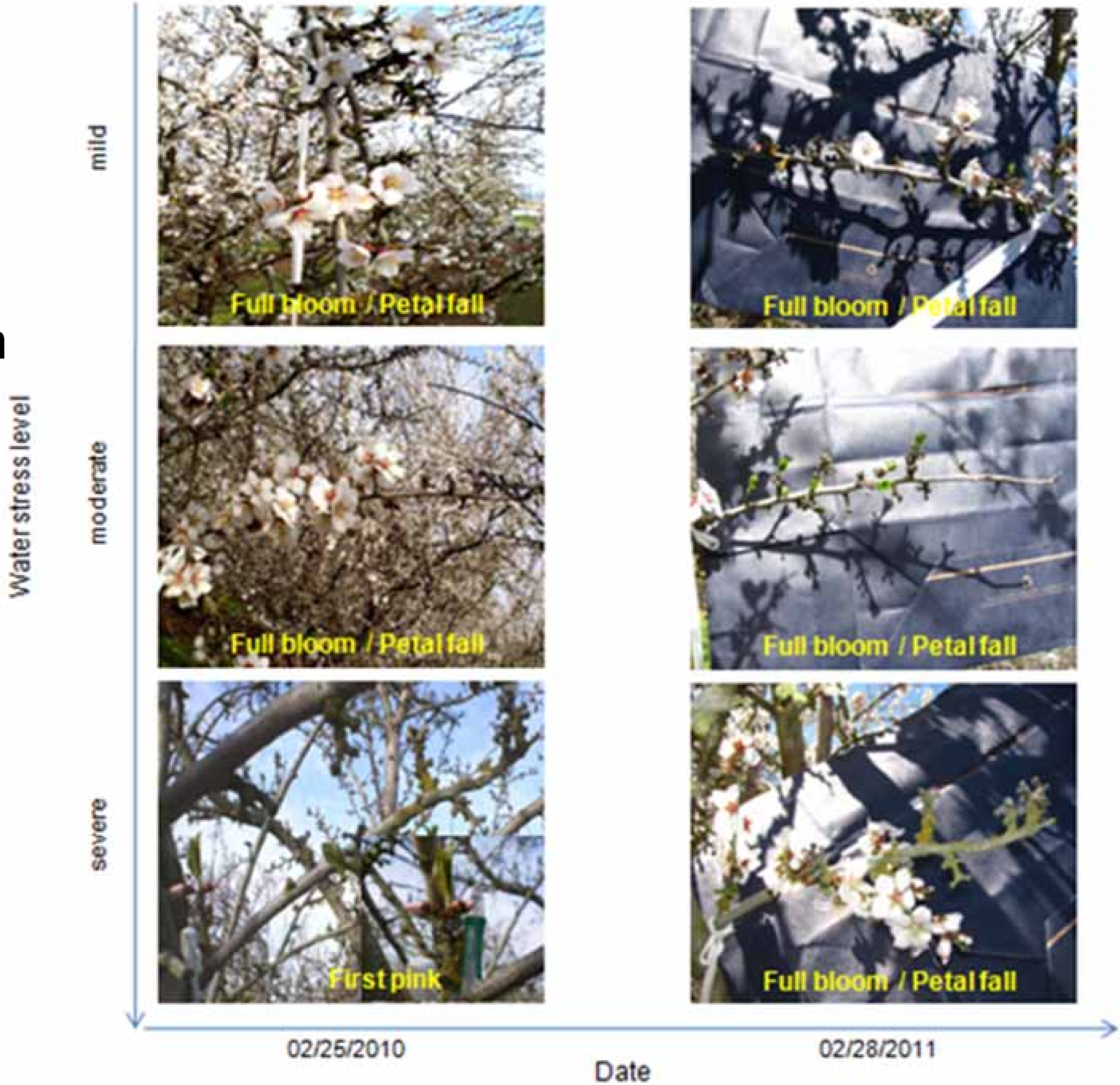


Spring 2011canopy dieback and July 2009 SWP:

About 2.5% dieback for every 10 bars of SWP



Some (3 day) delay in flowering in 2010 for the most severely stressed trees in 2009

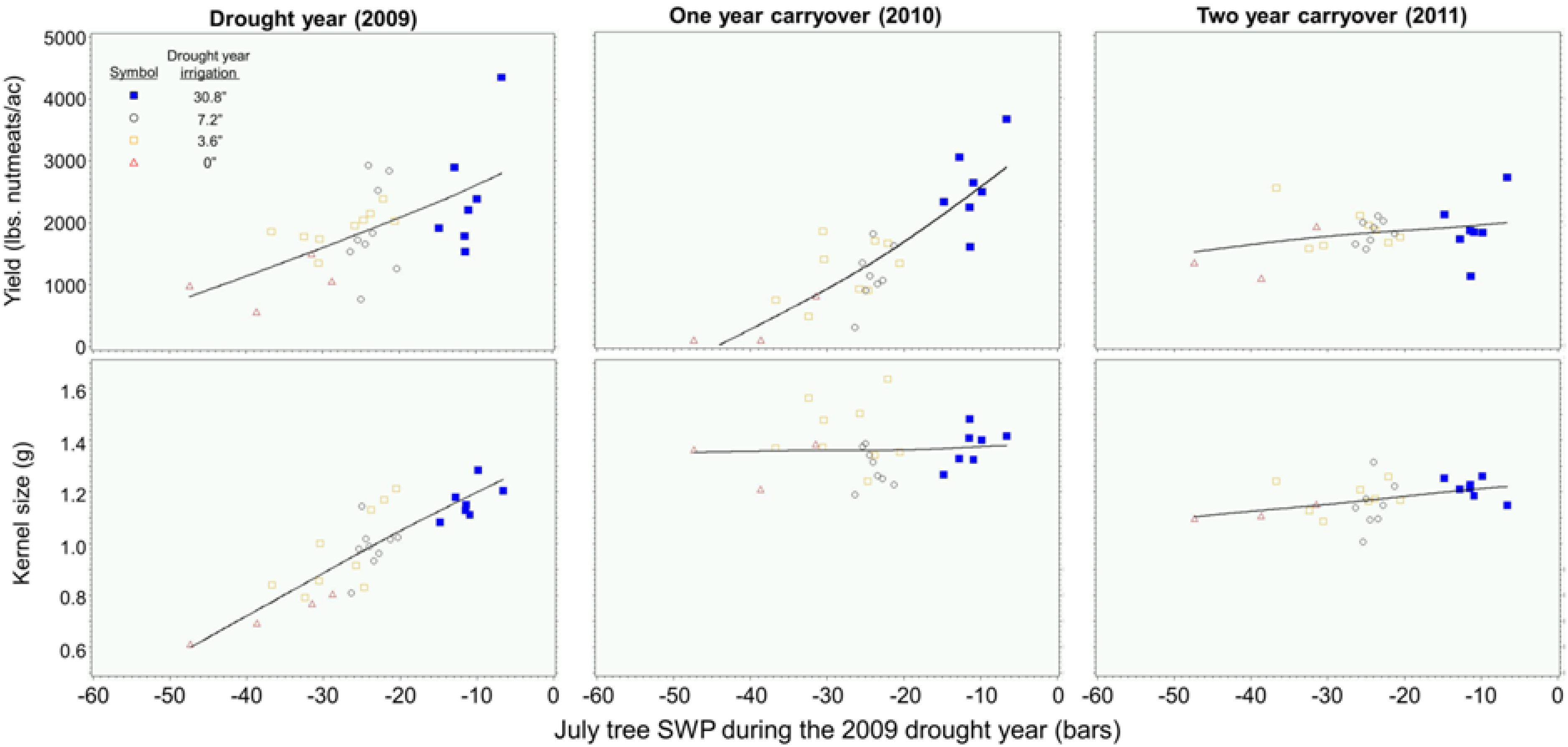


Yield (top) and Kernel weight (bottom) 2009 – 2011 for all treatments: overall small effect of Kaolin spray, big reduction in nut size in 2009 (not 2010), big reduction in yield in 2010 (not 2009).

Canopy Modification Treatment	Irrigation Treatment	Year						3 Year Cumulative
		2009 Yield		2010 Yield		2011 Yield		
		Lbs./ac	% control	Lbs./ac	% control	Lbs./ac	% control	% control
(None)	30.8”	2440	100	**2260 a**	100	1880	100	100
(None)	7.2”	1890	78	**1350 ab**	53	1740	93	76
(None)	3.6”	2020	83	**1010 b**	39	1890	100	75
(None)	0”	1030	42	**320 b**	12	1440	76	42
Kaolin spray	7.2”	1910	78	910	34	1930	103	72
Kaolin spray	3.6”	1800	74	1450	55	1860	99	78
50% pruning	0”	860	35	770	29	1360	72	45
50% pruning + spray	0”	590	24	430	16	980	52	31

Canopy Modification Treatment	Irrigation Treatment	Year					
		2009 Kernel Size		2010 Kernel Size		2011 Kernel Size	
		g/kernel	% control	g/kernel	% control	g/kernel	% control
(None)	30.8”	**1.16 a**	100	1.38	100	1.21	100
(None)	7.2”	**1.03 a**	90	1.32	96	1.20	99
(None)	3.6”	**0.96 a**	84	1.43	104	1.19	98
(None)	0”	**0.71 b**	62	1.32	96	1.12	93
Kaolin spray	7.2”	0.90	78	1.2	87	1.10	91
Kaolin spray	3.6”	0.97	83	1.4	101	1.16	96
50% pruning	0”	0.79	68	1.39	101	1.21	100
50% pruning + spray	0”	0.77	66	1.39	101	1.20	99

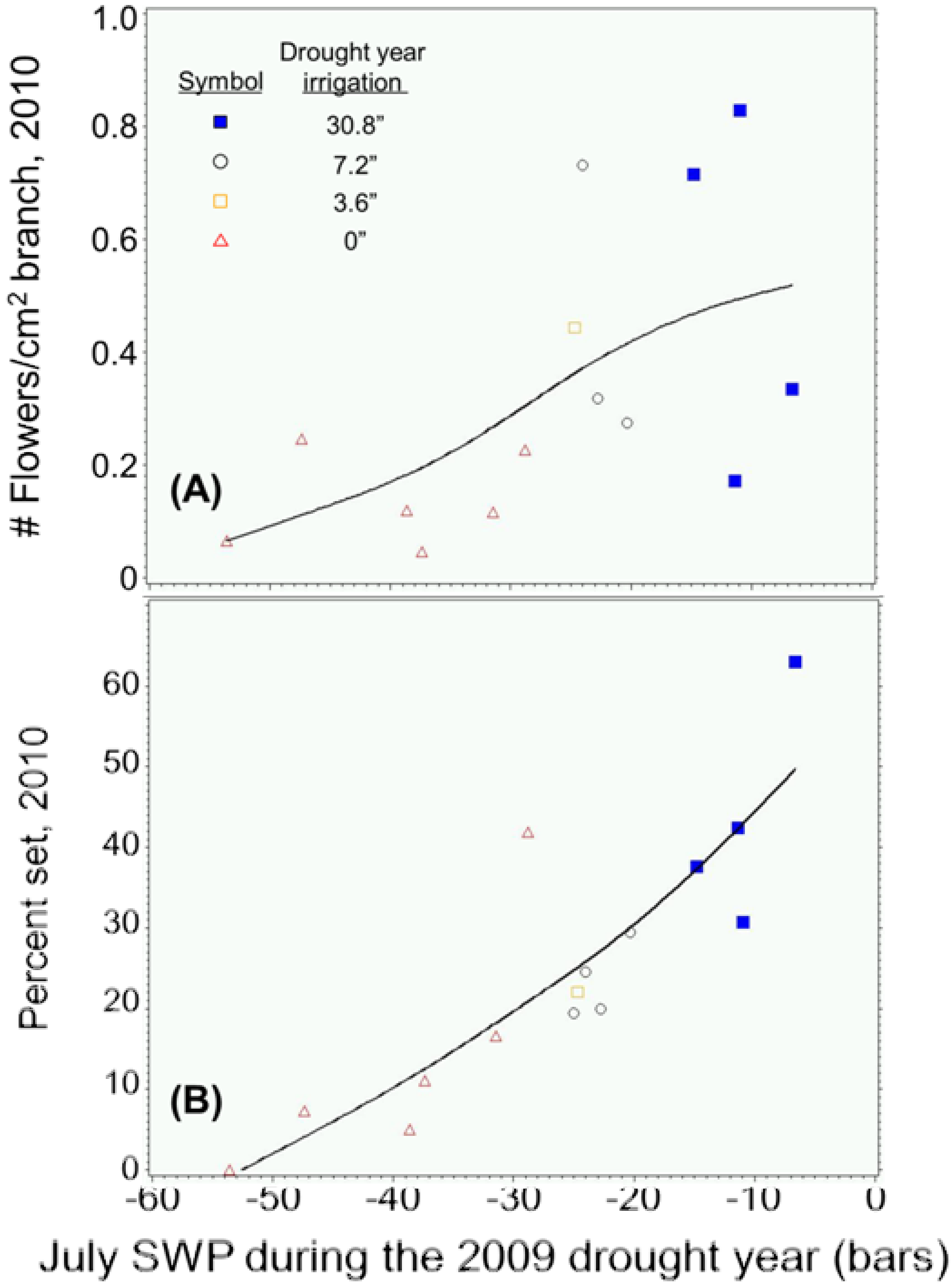
Yield (top) and Kernel weight (bottom) 2009 – 2011 as a function of July 2009 SWP



Branch level carry-over effects on selected trees:

# of flowers/branch area
(more stress, less flowering)

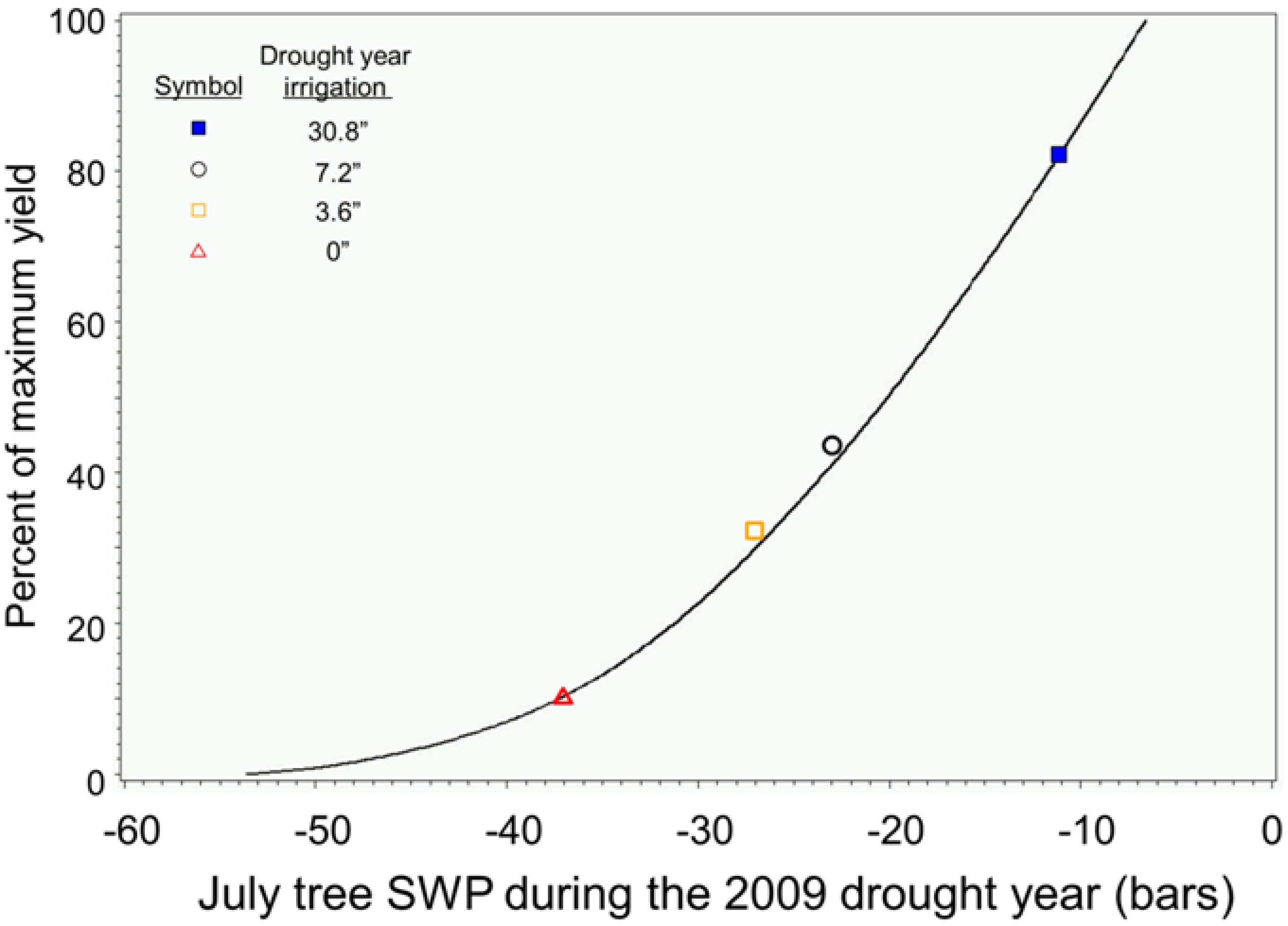
% set
(more stress, less % set)



Predicting specific treatment carry-over effects from branch-level measurements

Irrigation treatment	Observed 2009 July SWP (Bars)	Branch-level observations corresponding to July SWP values (from figure 2)				Predicted carryover yield (% of control)	Observed 2010 yield (% of control)
		Flowering		Fruit set			
		#/bxsa	% control	%	% control		
30.8”	-11	0.518	100	34.5	100	100	100
7.2”	-23	0.445	86	22.1	64	55	53
3.6”	-27	0.370	71	20.0	58	41	39
0”	-37	0.185	36	12.8	37	13	12

Predicting the entire range of carry-over effects from branch-level measurements



Drought recommendations: saving water

1) Control weeds.
2) Expect to see differences where soils are different – manage irrigation differently if at all possible.
3) Hull split period is a good time for saving water.
4) Use a pressure bomb to manage irrigation.

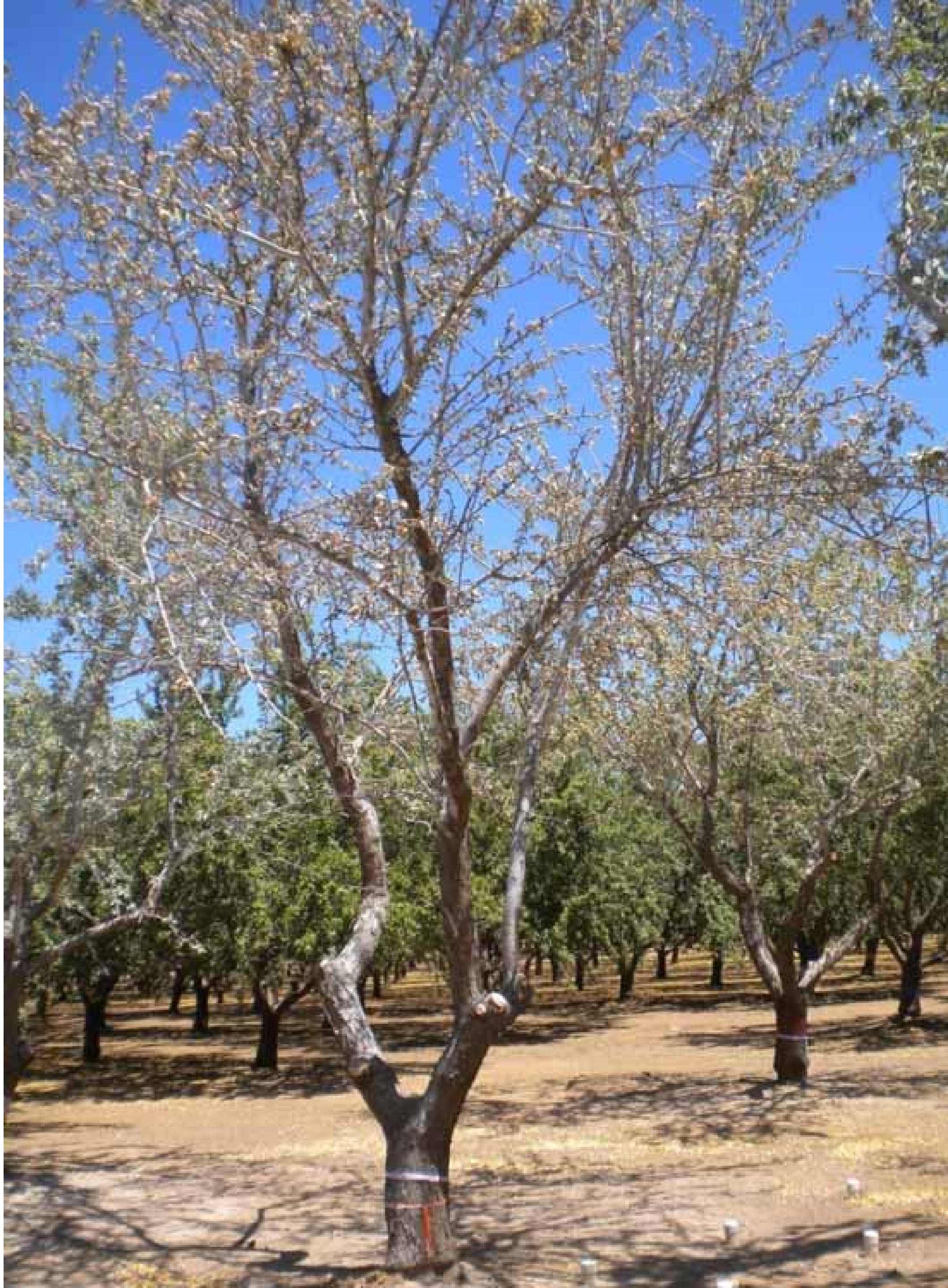

Deficit irrigation can magnify the effect of local soil conditions on tree stress.

Drought recommendations: Triage situation

1) Control weeds.
2) Expect to see differences where soils are different – manage irrigation differently if at all possible.
3) If water is available, use a pressure bomb or look for visual symptoms to determine the areas that need water the most. Interior leaf yellowing means mild/moderate stress (around -15 bars). Wait for mild stress to start irrigating, and spread water evenly over the season after that.
4) If no water is available and stress is severe, pruning <u>may</u> improve tree survival.

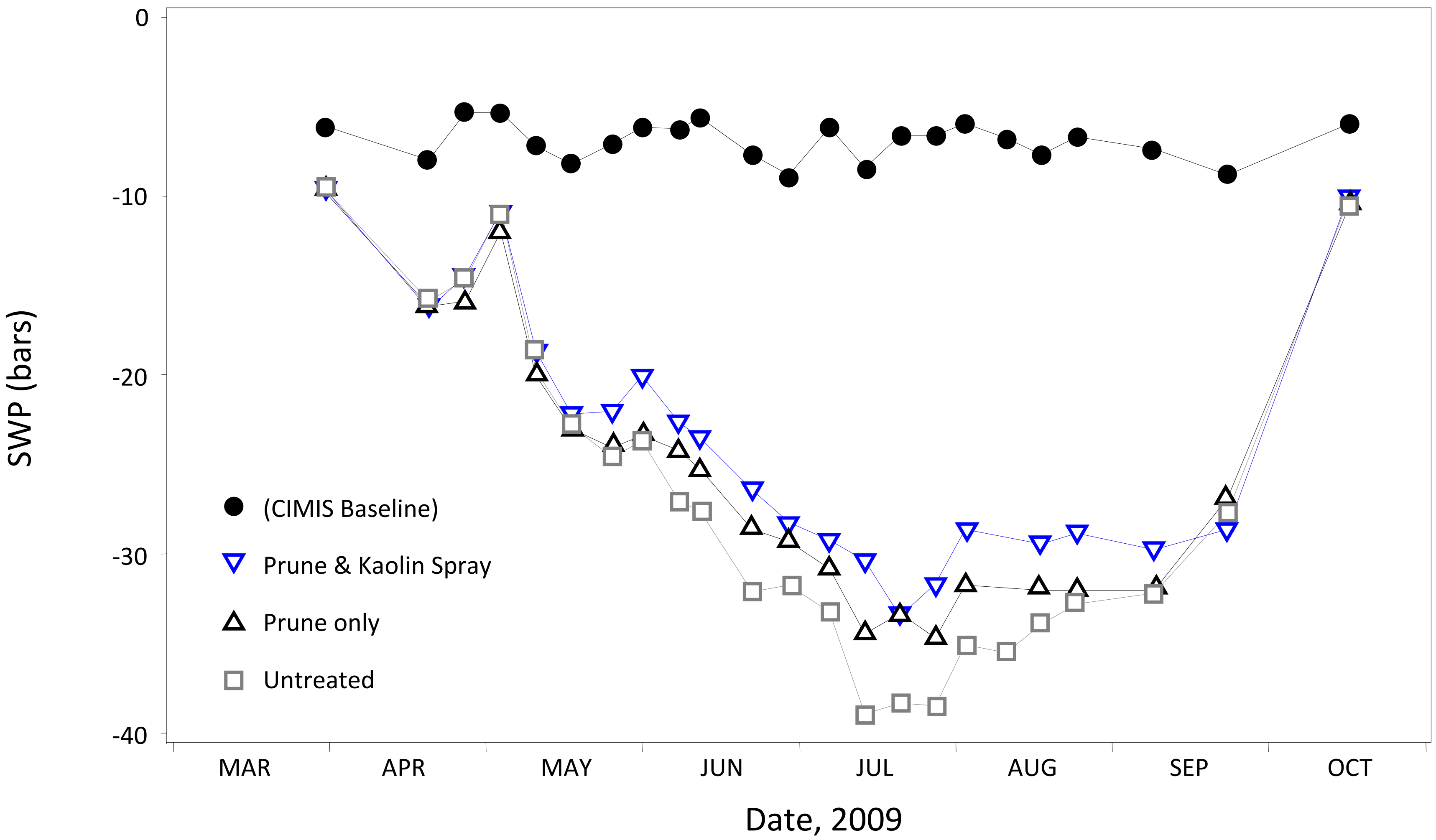
Thanks for your attention.

Questions?

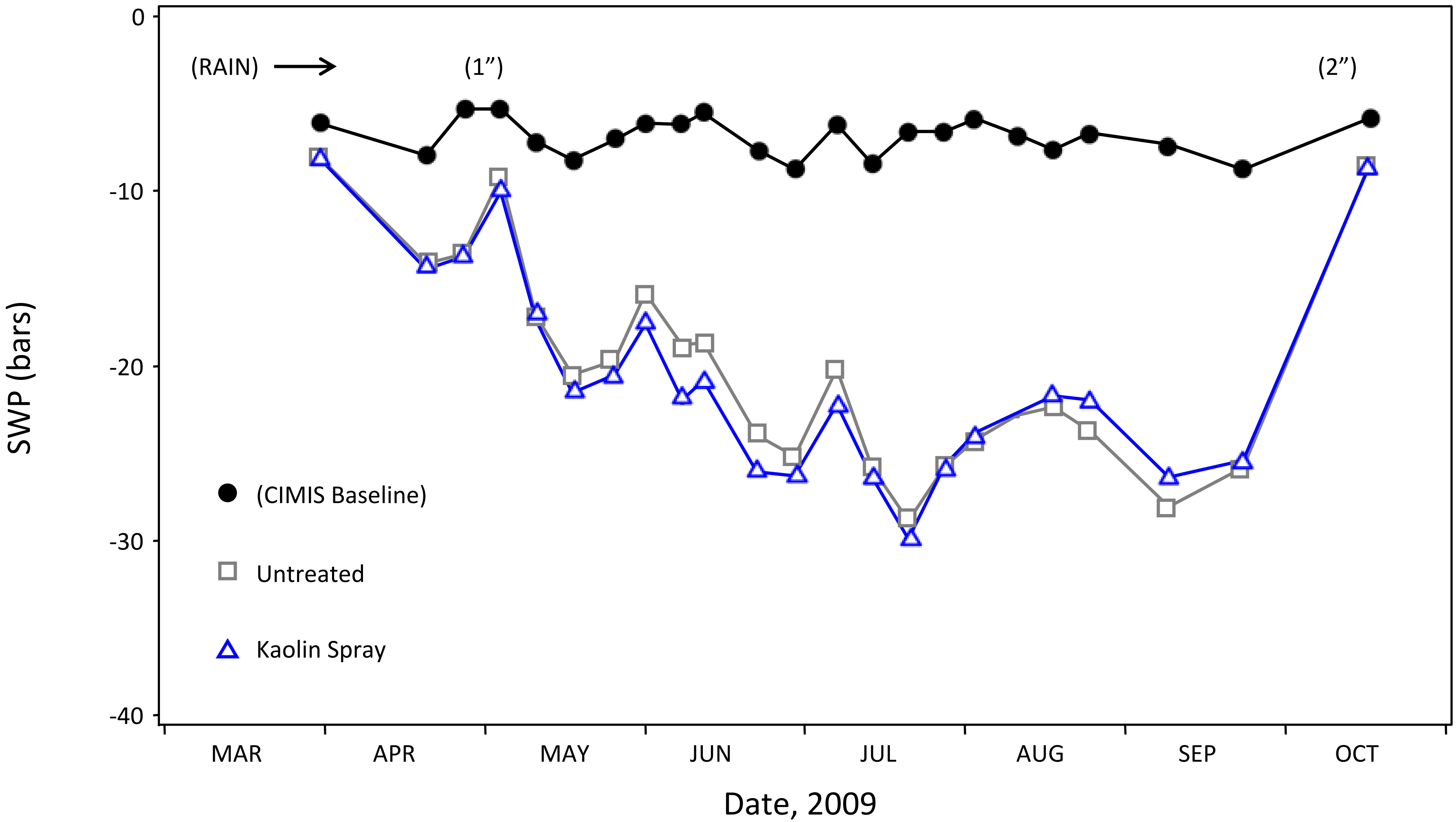


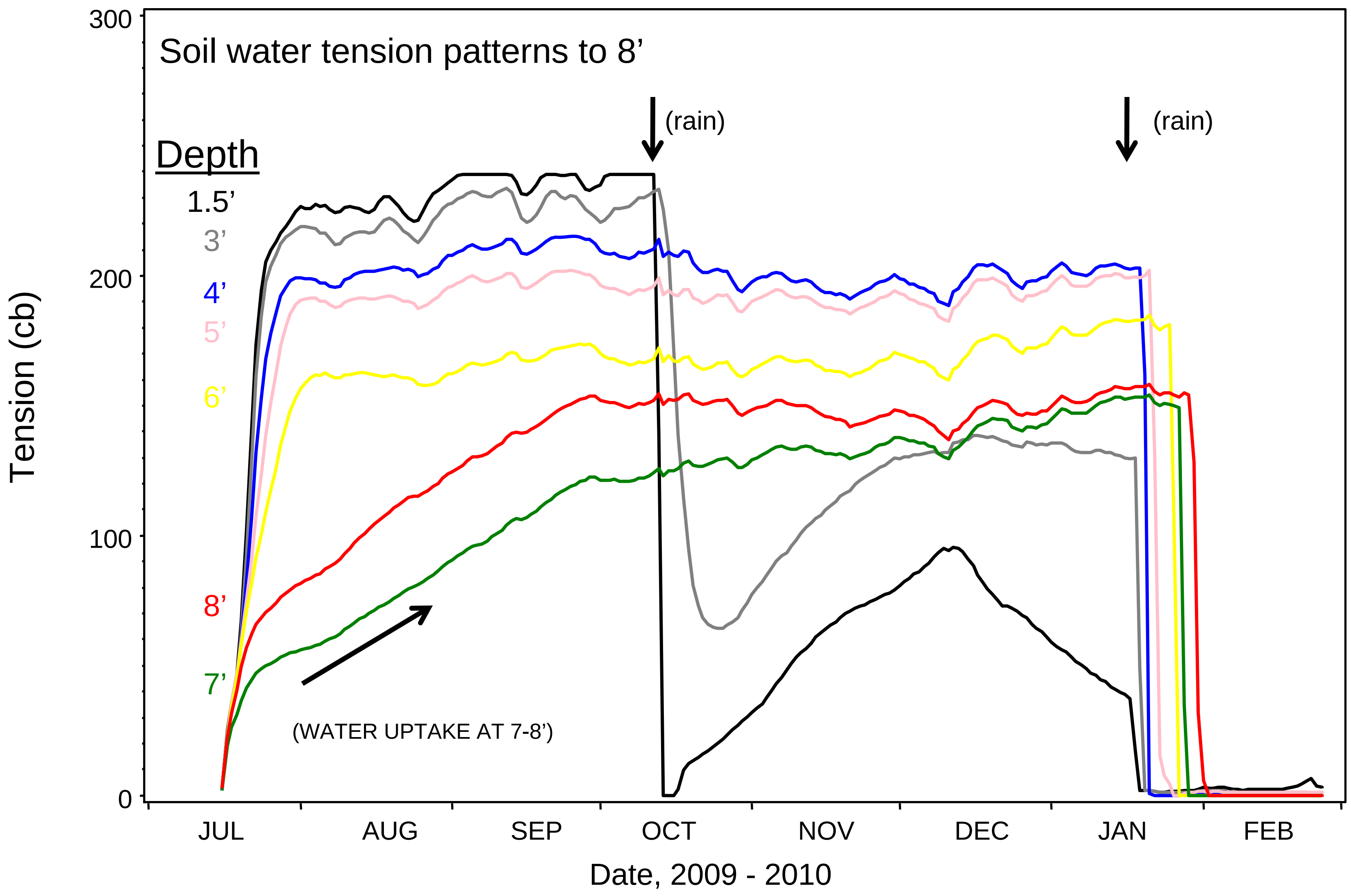
Resprouting (but not flowering) of defoliated tree when given some postharvest irrigation.

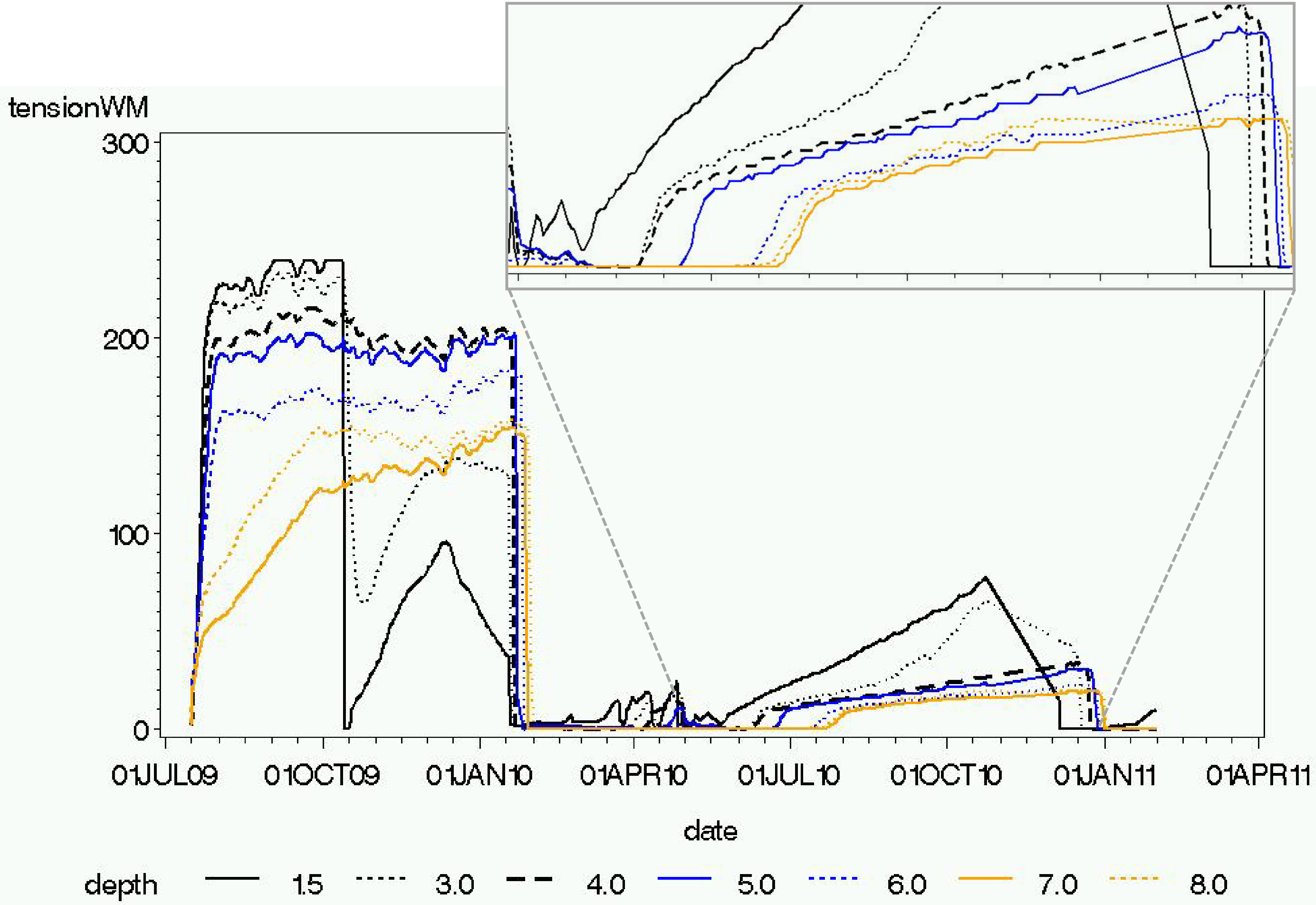
Midday stem water potential (SWP) of **Untreated**, **Pruned** (50% canopy reduction), and **Pruned & Sprayed** trees in the 0” (rainfed) treatment showing **some reduction** in stress due to pruning and spraying



Midday stem water potential (SWP) of **Untreated** and **Kaolin Sprayed** trees in the 5” and 10” irrigation treatments showing **no reduction** in stress due to spraying

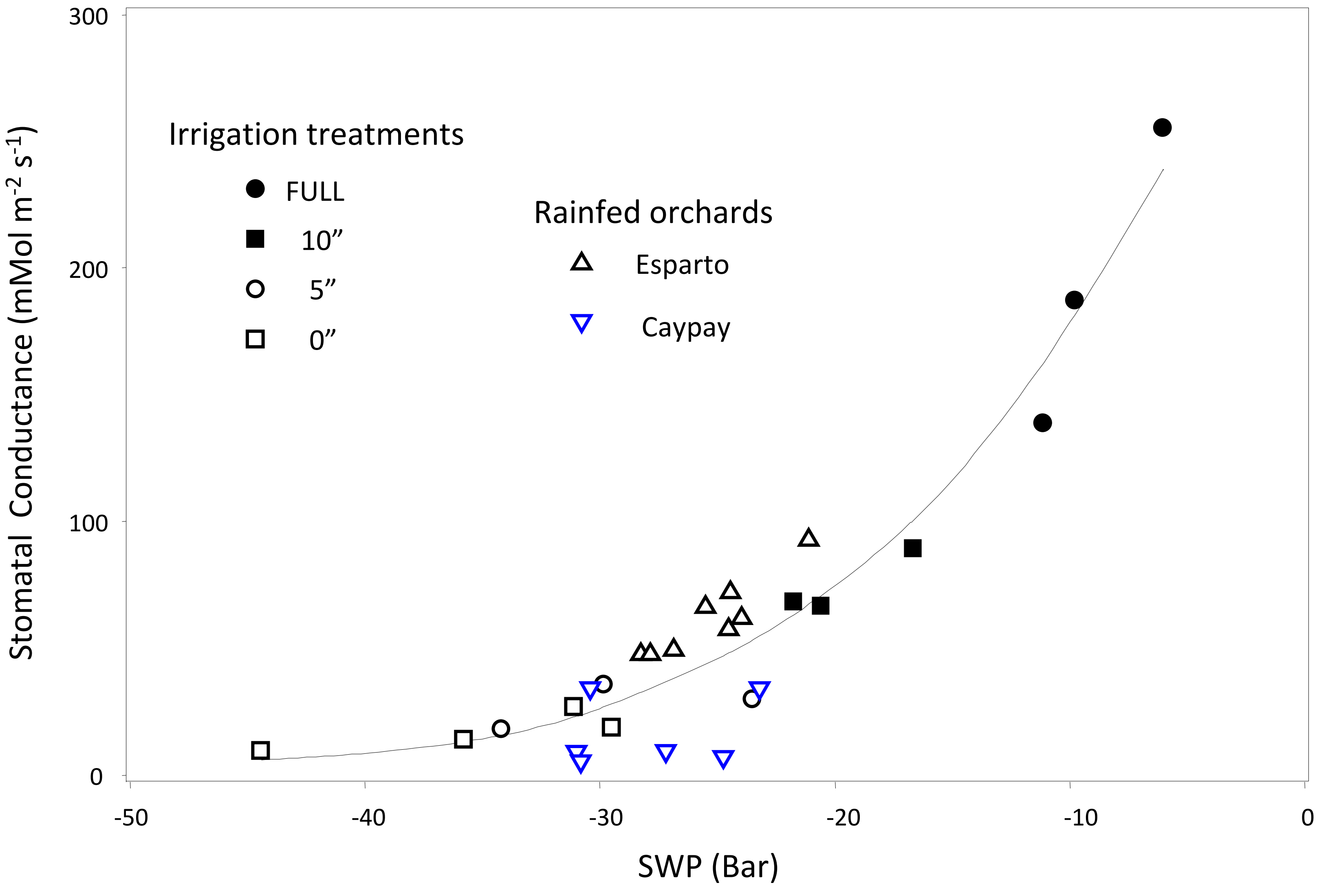


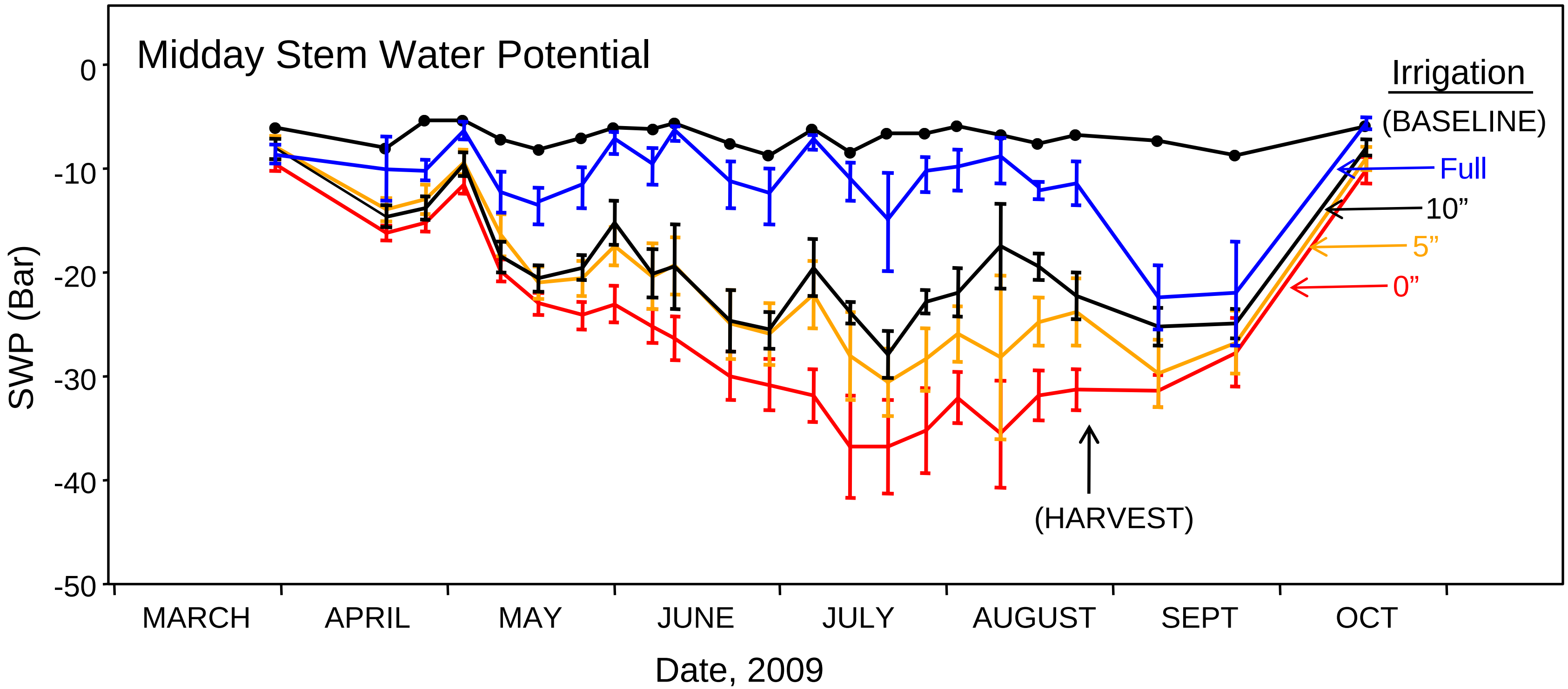

Soil water tension patterns to 8'
(rain)
(rain)
Depth
1.5'
3'
4'
5'
6'
8'
7'
(WATER UPTAKE AT 7-8')
Tension (cb)
300
200
100
0
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
Date, 2009 - 2010



tensionWM
300
200
100
0
01JUL09
01OCT09
01JAN10
01APR10
01JUL10
01OCT10
01JAN11
01APR11
date
depth
1.5
3.0
4.0
5.0
6.0
7.0
8.0

Rainfed orchards: similar relation, but some evidence that better looking trees may be associated with more closed stomata (more conservative water use)





Midday Stem Water Potential
Irrigation
(BASELINE)
Full
10”
5”
0”
(HARVEST)
0
-10
-20
-30
-40
-50
SWP (Bar)
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPT
OCT
Date, 2009

New Approaches to Almond Nutrient Management

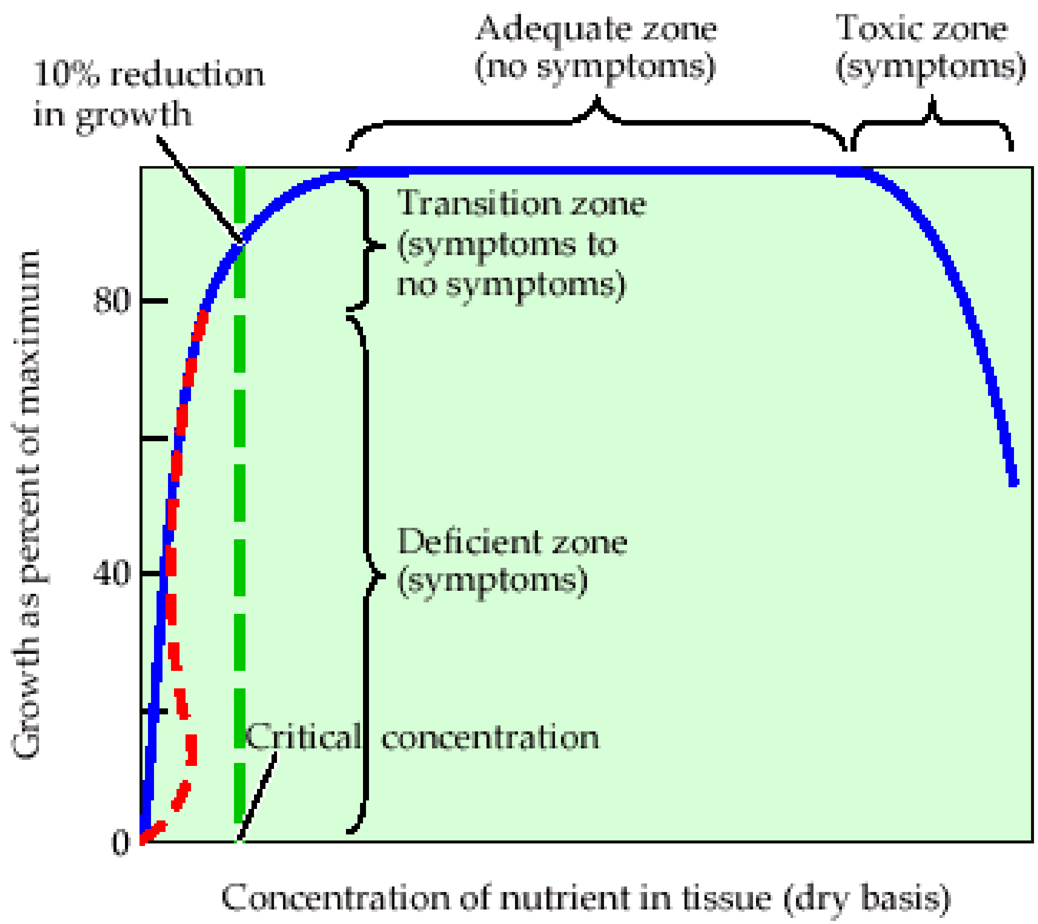
Sebastian Saa-Silva, Saiful Muhammad, Patrick Brown

UC-Davis

New Approaches to Almond Nutrient Management

Part 1: Leaf Sampling And Interpretation Methods.

What do we know and how do we manage? Leaf Sampling and Critical Value Analysis



*Critical values for boron deficiency and toxicity are currently being revised. Hull boron >300 ppm is excessive. Leaf sampling is not effective to determine excess boron.

:ols are well defined

;pur leaves

quadrant at 6'.

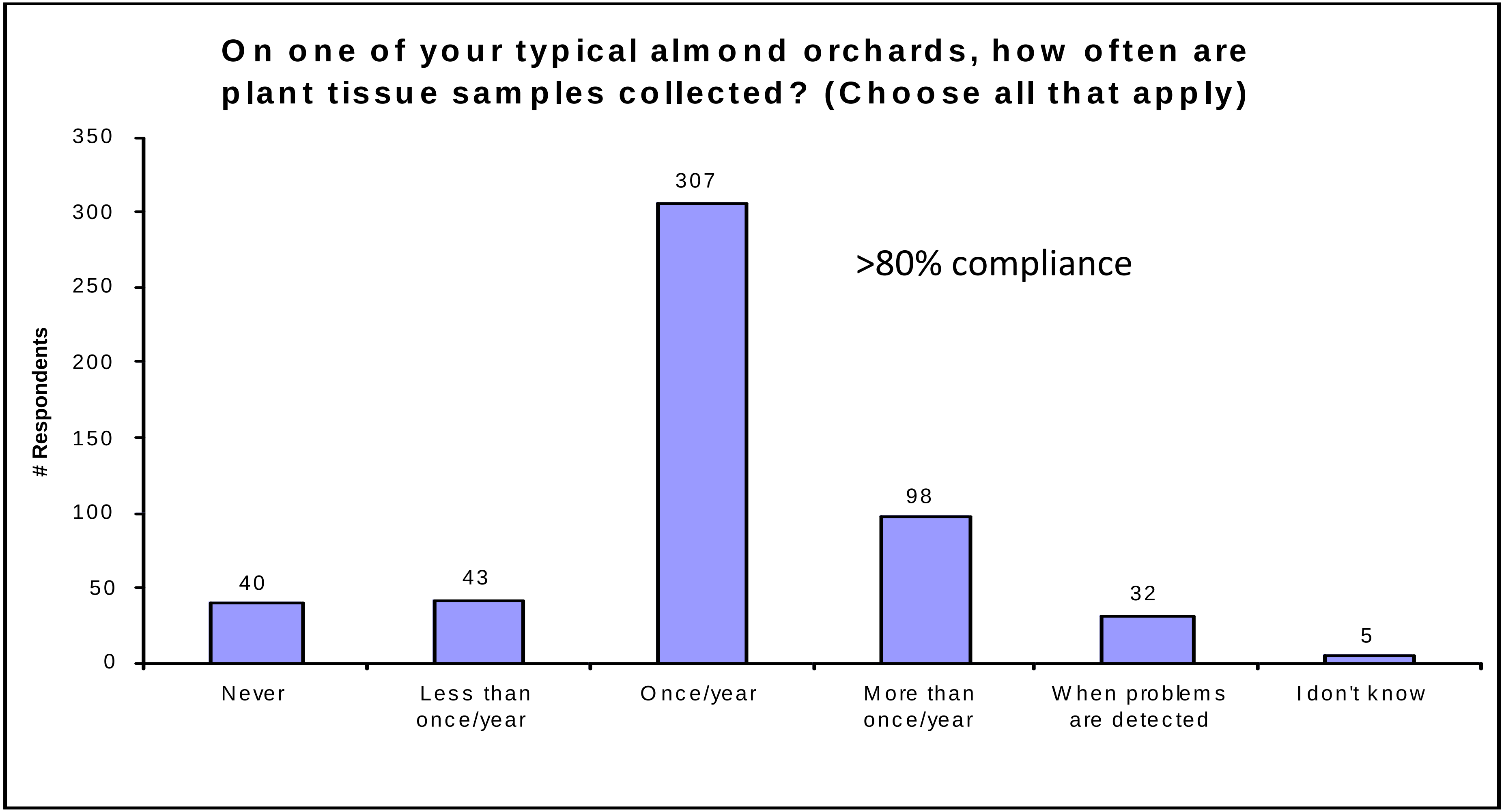
f analysis with standard Critical
ıed in Almond Production Manual

ʻials (N, K, B)

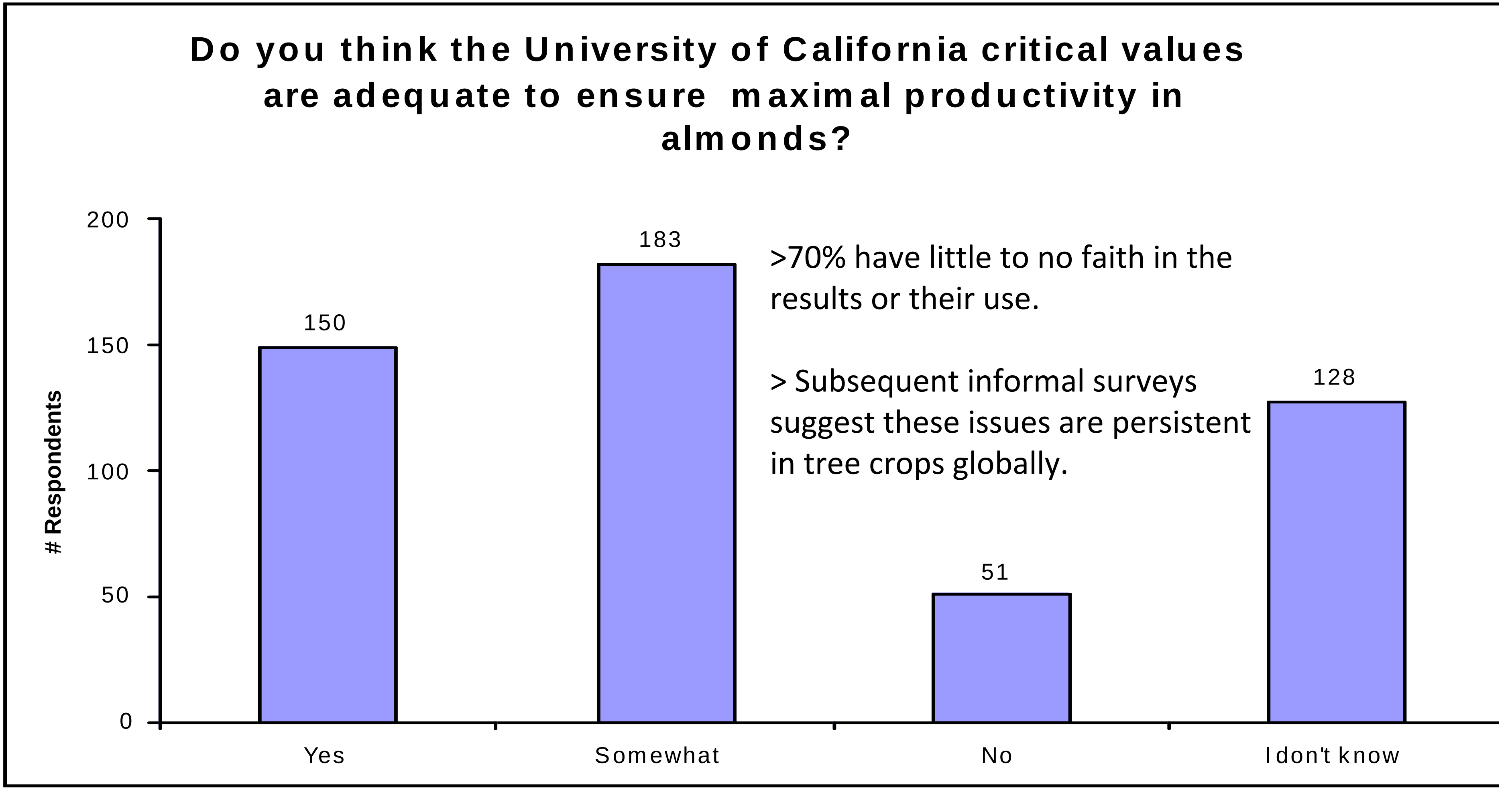
/mptoms (P, S, Mg, Ca, Mn, Zn,

wn (Ni, Cl, Mo)

Are tissue samples collected and if so how often?



Are tissue samples being used to guide fertilizer management?



Apparently tissue sampling is not trusted- Why?

- It was designed to detect deficiency.
- It is not designed to determine how much fertilizer to apply.
- The complexity of tissue sampling was recognized, but not adequately optimized for trees.
- Samples collected do not always represent the true nutrient status of the orchard as a whole.
- Current Sampling Protocol is too late in year to make in season adjustments.
- Our current CV’s may not apply in all cases or may be wrong.

Objectives:

- Develop methods to sample in April and relate that number to July critical value.
- Develop method for grower to sample his field (recognizing that typical practice is only 1 sample per field is generally collected).
- Reevaluate the current CV's.

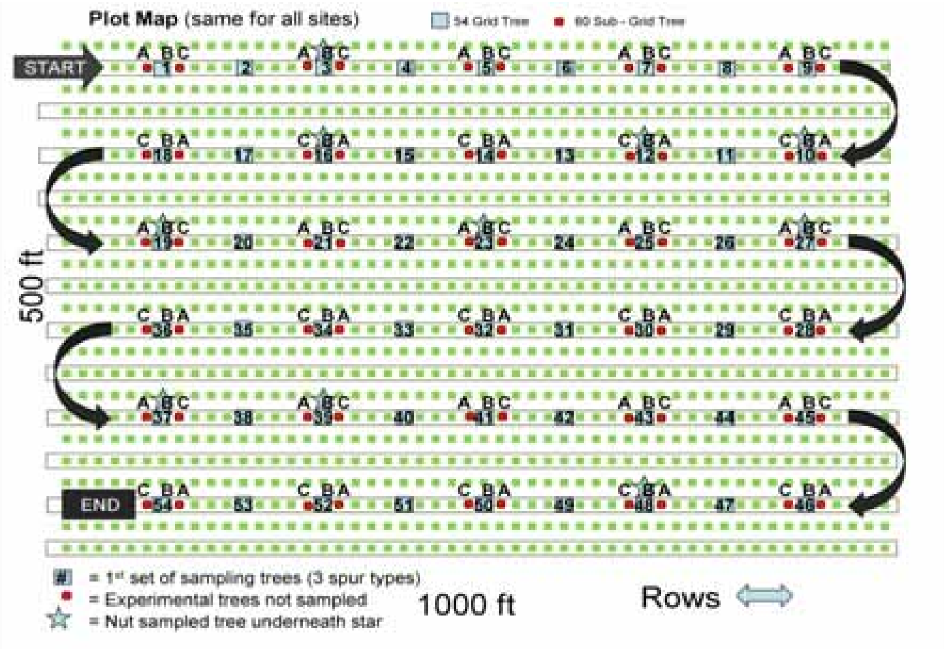
Solve Late Season Sampling And True Nutrient Status Problem

Orchard Selection

- Four sites from California's major almond producing regions (2009-12)
  - Arbuckle
  - Modesto
  - Madera
  - Belridge

Location	Arbuckle	Salida	Madera	Belridge
Tree Age	1998	1998	2000	1999
Varieties	NP – 50% B – 25% A – 12.5% C – 12.5%	NP – 50% A – 25% WC – 25%	NP - 50% C – 25% M – 25%	NP – 50% M – 50%
Spacing	22' x 18' (110 trees/ac)	21' x 21' (99 trees/ac)	21' x 17' (122 trees/ac)	24' x 21' (86 trees/ac)
Irrigation	Drip	Microsprinkler	Microsprinkler	Microsprinkler

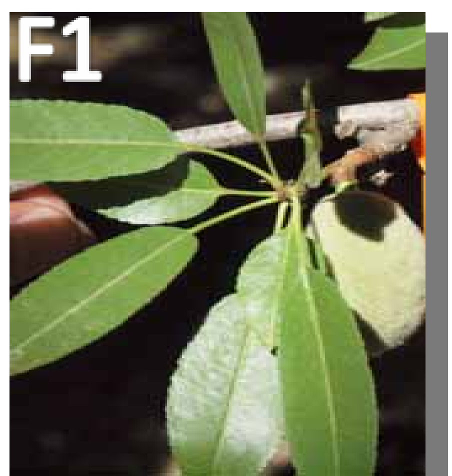
Design and Sampling



- 114 trees x 4 Sites x 3 years.

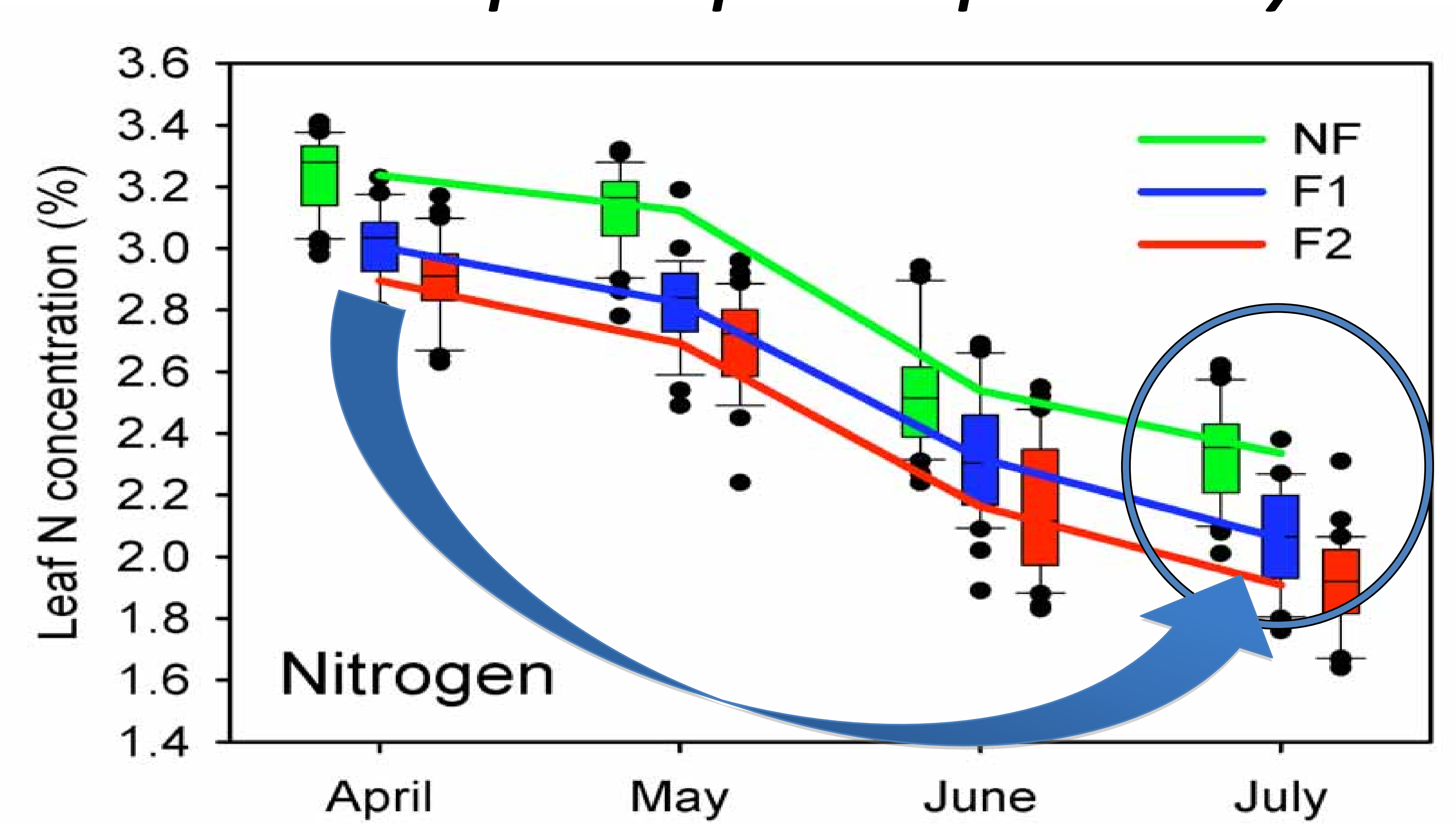
- Yield.
  (About 1,130 data points)

- 5 in-season nutrient samples.
  (8,500 x 11 = 93,500 data points)



Early Sampling.

Can we sample in April and predict July?



Approach: Multi site, multi year, multi tissue and multi element analysis.

Two Models have been Developed to Answer the same Q.

- Model one uses all the April information from F2 spurs to predict the July nitrogen value.
- Model two uses the nitrogen NF information from April to predict the July nitrogen value.
- Both models also predict what percentage of the trees will be above or below the current July nitrogen critical value.
- Both models work well with additional validation in 2012.

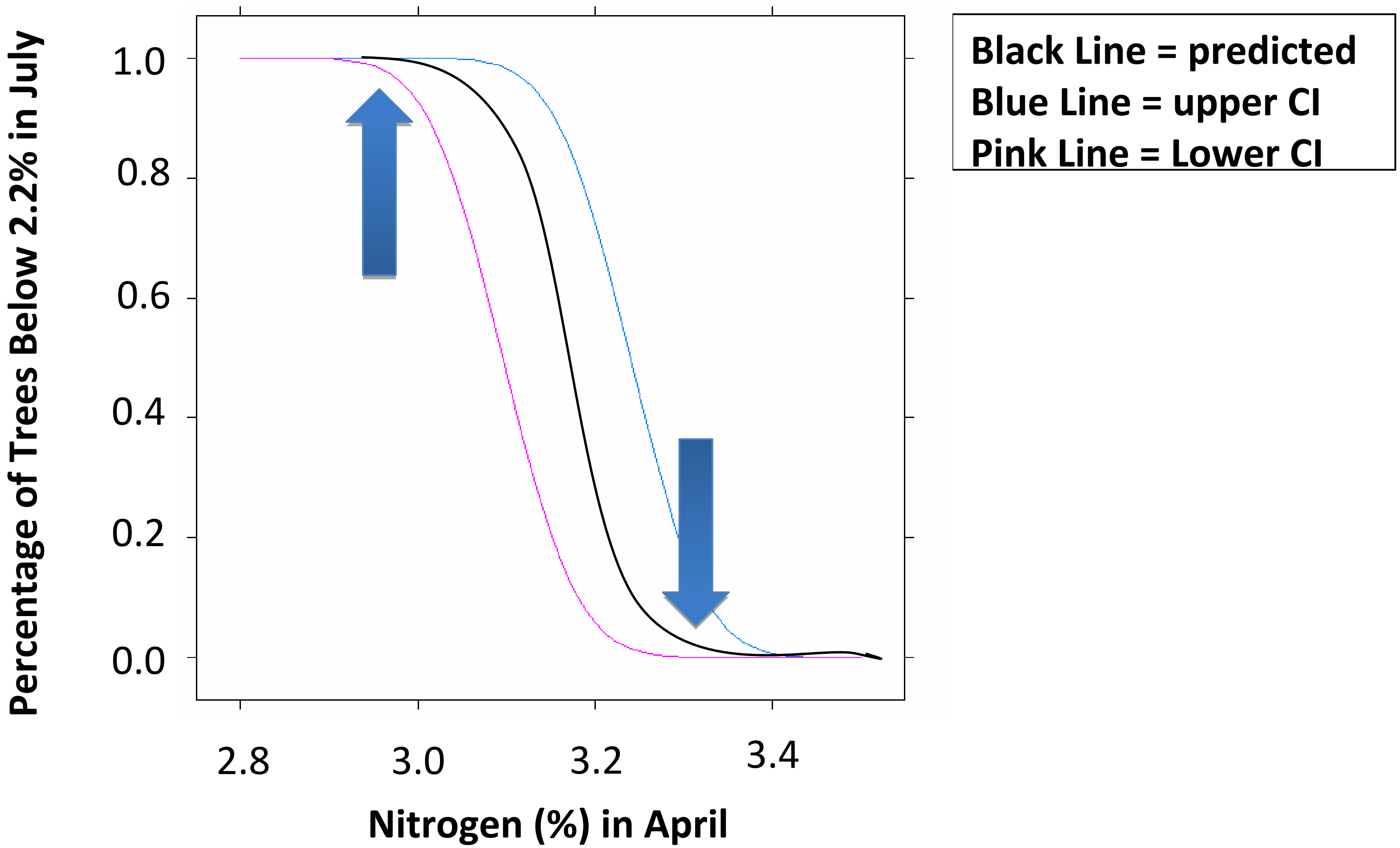
Results Cross-Validation Model 1

How well does our model of April sampled leaves predict the actual July values?

Site	Year	July Nitrogen Predicted	July Nitrogen Observed
Arbuckle	8	2.4	2.3
Belridge	8	2.4	2.4
Madera	8	2.5	2.4
Modesto	8	2.4	2.4
Arbuckle	9	2.4	2.6
Belridge	9	2.4	2.4
Madera	9	2.6	2.4
Modesto	9	2.6	2.7
Arbuckle	10	2.4	2.5
Belridge	10	2.3	2.7
Madera	10	2.3	2.3
Modesto	10	2.4	2.5

Results: Model 2

Expected % of trees below 2.2% in July



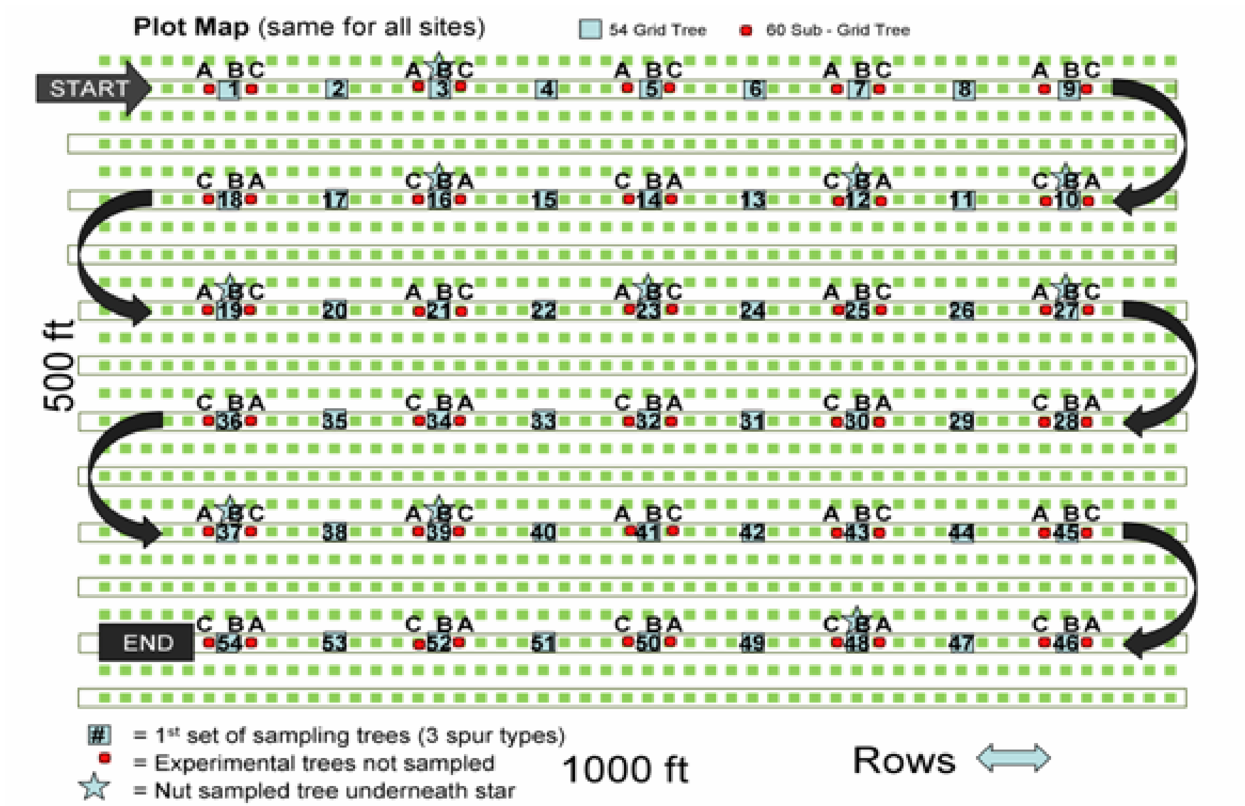
Q? How Do we make best use of these new approaches and make April sampling effective?

A: Make sure sampling is done properly.

Distance from Tree to Tree

Number of Trees/ Sampling Criteria

Distance From Tree to Tree



- Analysis of Spatial Correlation: Samples Collected at least 30 yards away.

Number of trees needed in April to Estimate the true mean of Nitrogen

Number of Acres	Trees needed at 95% Confidence	Trees needed at 90% Confidence
2	25	18
5	27	19
10	28	19
50	28	20
100	28	20
Note: 1 acre is assumed to be 100 trees		

Pooled trees = Number of trees from which leaves must be collected and pooled into a single bag for a single nutrient analysis

Sampling Criteria

- Collect leaves from 18 to 28 trees in one bag.
- Each tree sampled at least 30 yards apart.
- In each tree collect leaves around the canopy from at least 8 well exposed spurs located between 5-7 feet from the ground.
- In April, collect samples at 8121 GDH +/- 1403 (43 days after full bloom (DAFB) +/- 6 days).
- If you would like to collect samples in July, then collect samples at 143 DAFB +/- 4 days. SAME RULES!

New Approaches to Almond Nutrient Management

Part 2: Nutrient Budget Approach

- Applying the Right Rate
  - Match demand with supply (all inputs- fertilizer, organic N, water, soil).
- At Right Time
  - Maximize uptake minimize loss potential.
- In the Right Place
  - Ensure delivery to the active roots.
- Using the Right Source
  - Maximize uptake minimize loss potential.

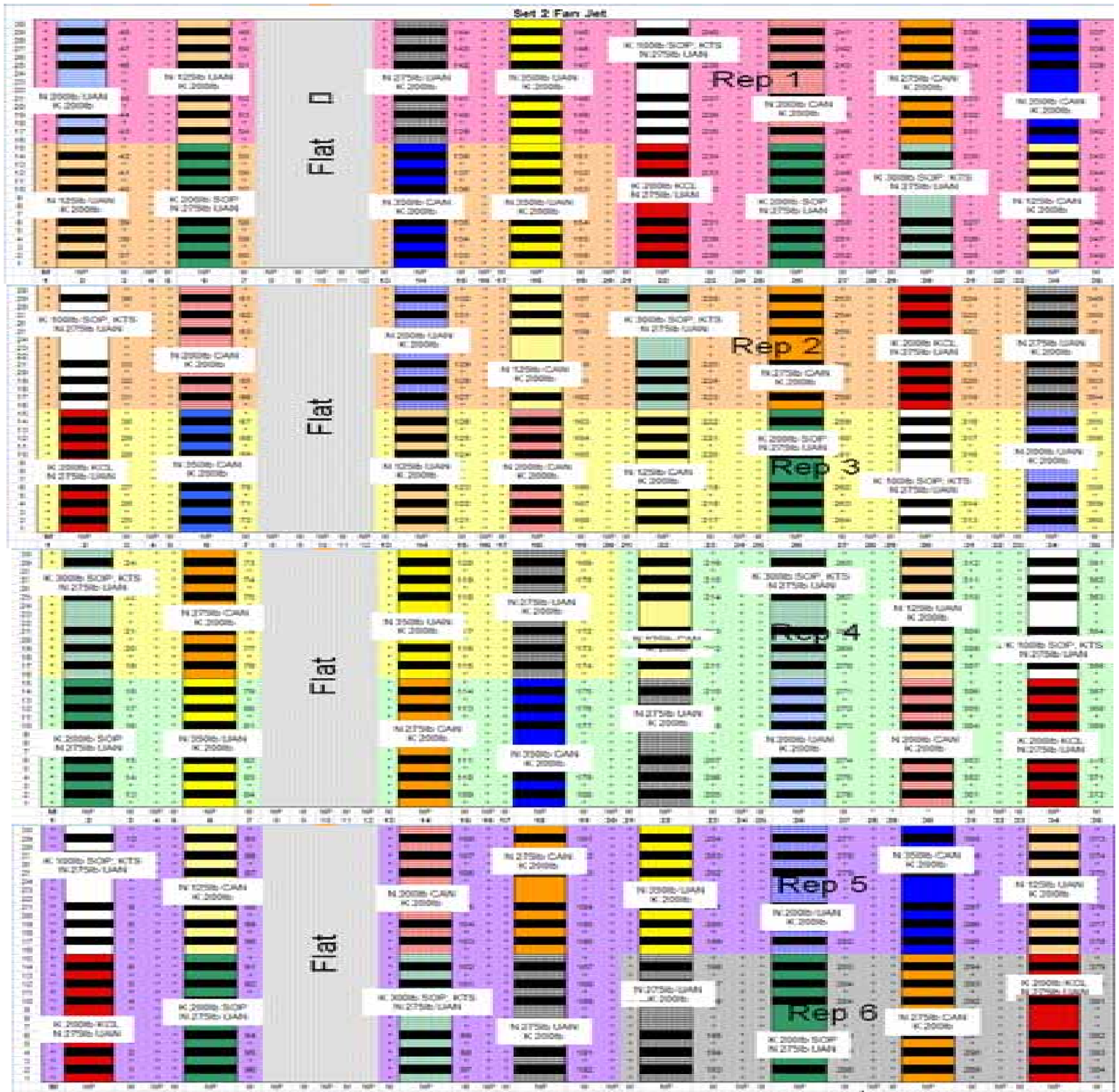
Fertility Experiment

- Treatments
- 4 Nitrogen rates – 125, 200, 275 and 350lb/ac
- 2 Nitrogen Sources- UAN 32 and CAN 17
- 3 Potassium Rates- 100, 200 and 300lb/ac
- 3 Potassium Sources- SOP, SOP+KTS and KCl @200lb/ac
- Irrigation Types
- Fan Jet and Drip

Fertigation

- 4 times during the season
    - 20, 30, 30 and 20% in February, April, June and October
- Samples Collection
- Leaf and Nut samples collected from 768 individual trees five time in season
- All trees individually harvested

Experimental Layout



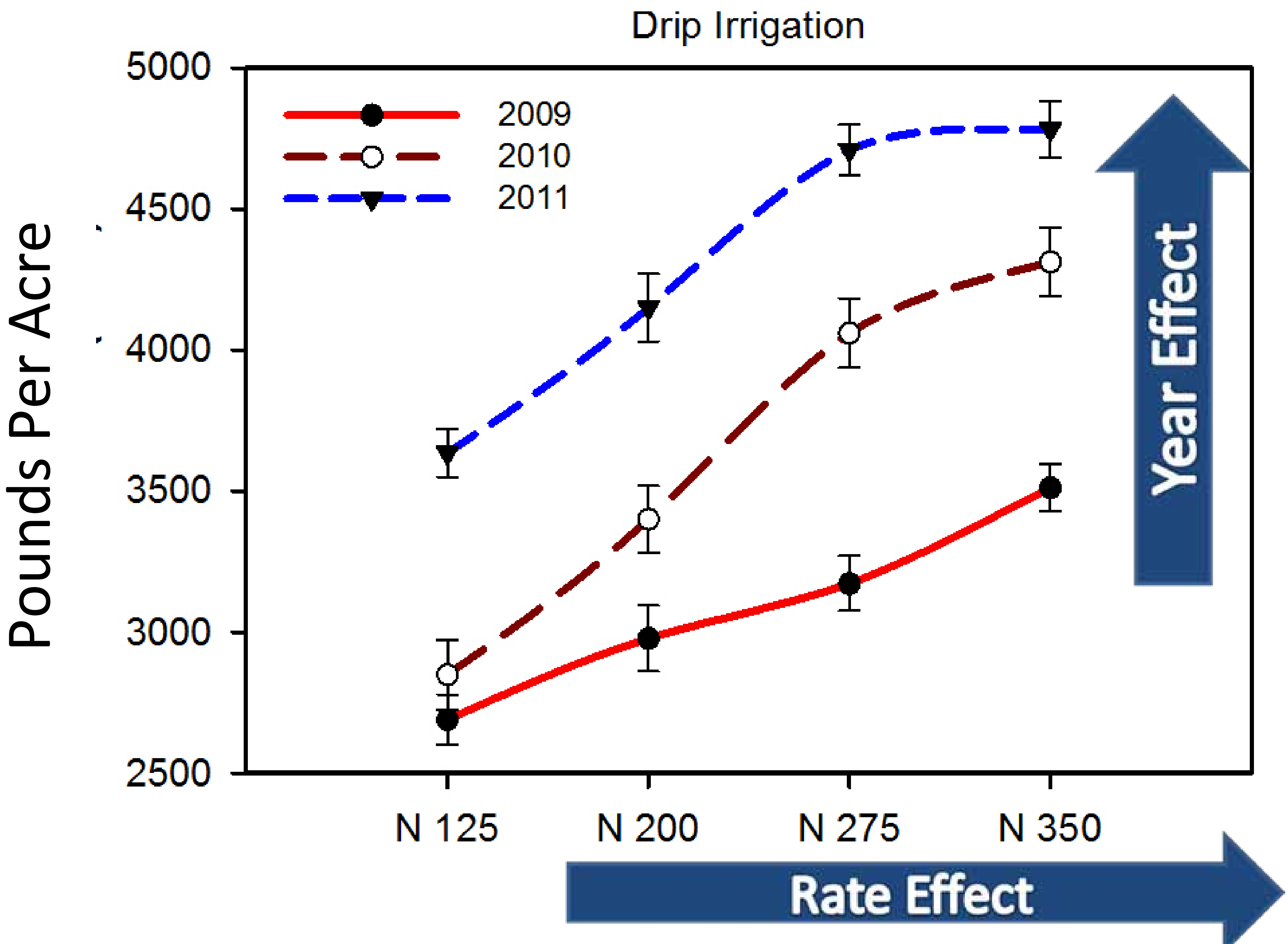
Large experiment covering approximately 100 acres.

768 trees individually monitored for nutrients, yield, light interception, disease, water.

Trees were 9 leaf in 2008.

Nonpareil - Monterey

Yield Response to Nitrogen



Cumulative Kernel Yield 2009-11

Cumulative Kernel Yield 2009-2011 (lb/ac)

Irrigation	N UAN 32				N CAN 17			
	125	200	275	350	125	200	275	350
Drip	9,328	10,642	11,667	12,356	8,796	10,298	11,844	12,139
	d	c	b	a	c	b	a	a
Fan Jet	9,156	10,245	11,201	11,314	9,563	10,345	11,539	11,109
	c	b	a	a	c	b	a	a

Means not followed by the same letter are significantly different at 10%.
Statistics are only within irrigation type.

In the long Term:
275 pounds and 350 pounds of N result in a 3 year average yield of approx. 4,000 pounds per year. 125 pounds and 200 lbs N resulted in significant yield reductions.

NPK Export by 1000lb Kernel at Harvest 2009-10 Added Together

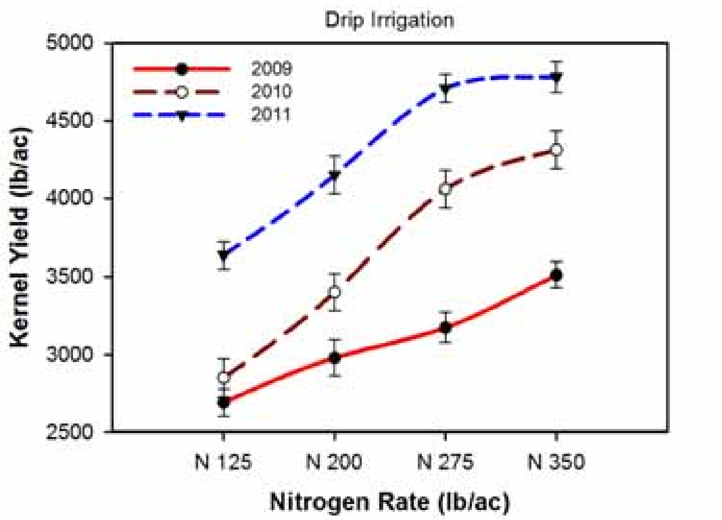
NPK Export by 1000lb Kernel in 2009-10 (lb)

Average of 2009 and 2010				
Nutrient	**Nitrogen Rate (lb/ac)**			
	125	**200**	**275**	**350**
N	**57**	**59**	**66**	**65**
	b	ab	a	a
P	**8.1**	**7.8**	**8.1**	**6.7**
	a	a	ab	b
K	**82**	**77**	**77**	**77**
	ab	b	b	b

Means not followed by the same letter are significantly different at 10%.

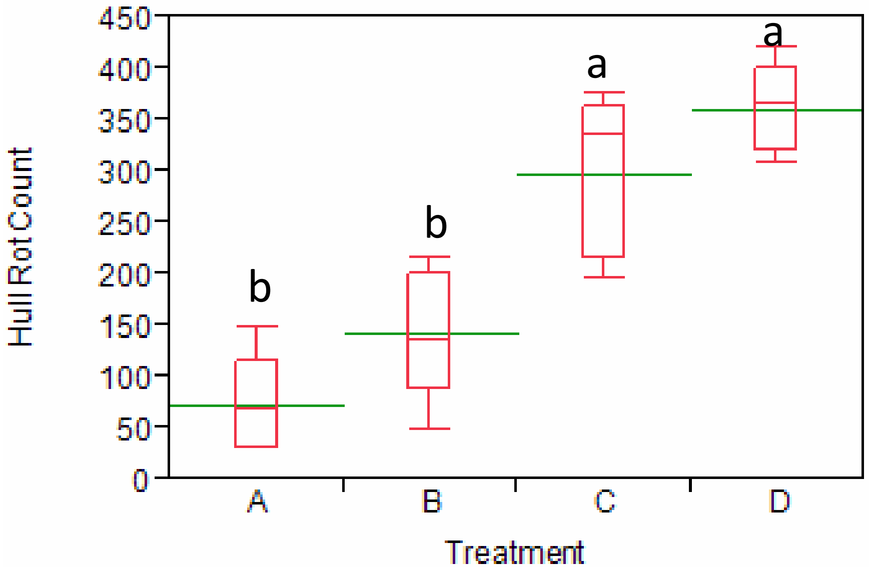
If you produce around 2,000 pounds , then you export: around 130 lb of N; 16 lb of P; and 154 lb of K.

Effect of N fertilization on Hull Rot

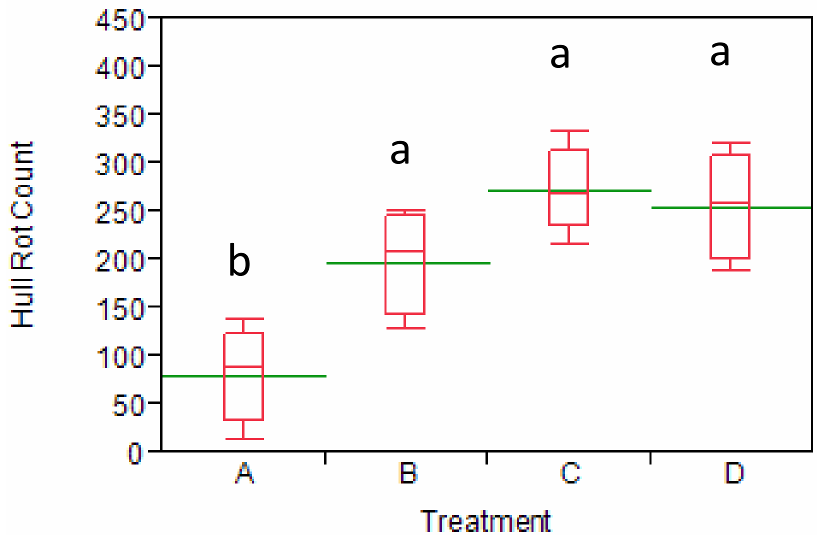


Treatments
A= N 125lb/ac
B= N 200lb/ac
C= N 275lb/ac
D= N 350lb/ac

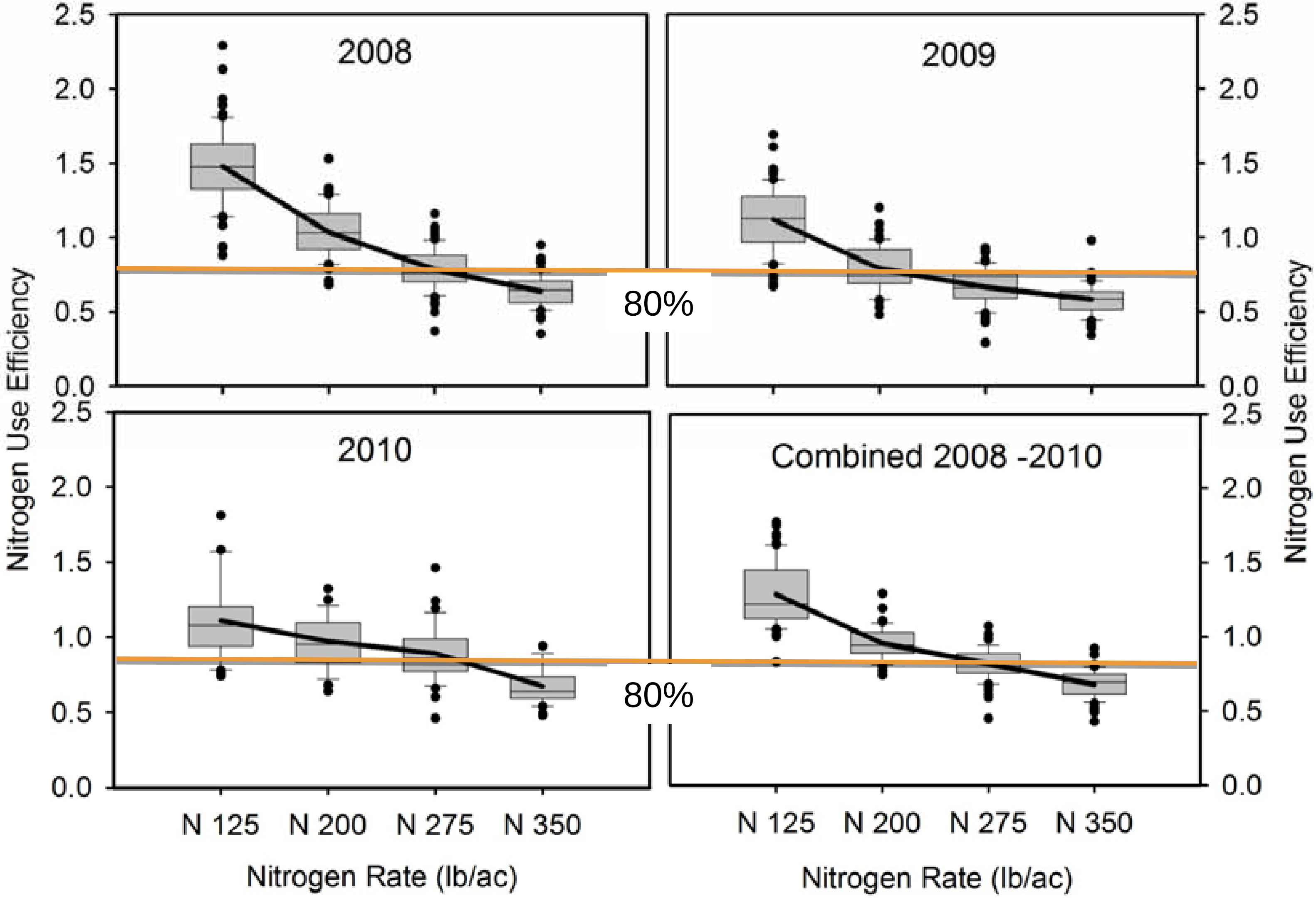
DRIP



Fan Jet



Nitrogen Use efficiency 2008 - 2010



NUE = N Export in Fruit/N Applied

Why is this Orchard so Efficient?

In this orchard we have attempted to satisfy the 4 R's

Applying the Right Rate

- Match demand with supply (all inputs- fertilizer, organic N, water, soil).

At Right Time

- Fertigate coincident with demand.

In the Right Place

- Ensure delivery to the active roots.

Using the Right Source

- Soluble, compatible and balanced.

Conclusions

- 1000lb kernel removes from 55 - 70lb N (at a leaf N of 2.0 to 2.4% in July), 8lb P and 80lb K.

- 80% of N, 75% of P and K accumulates in the fruit before 120 DAFB (mid June in 2010).

- In this trial a N rate of 275lb/ac maximized yield (4,700 lb acre) and there was no benefit from N application in excess of this value.

- A Nutrient Use Efficiency (N removed in harvest/N applied) of 75-85% was observed for N rate 275lb/ac rate.

An NUE of 65-75% is among the highest ever measured in agriculture – is that good enough?

75% efficiency = 50 lbs N/acre/yr (x 500,000^{+} acres)

= 25,000,000 lbs N/yr

However small changes make a big impact.

- A 25 lb reduction in N application or 15% increase in efficiency reduces loss by 50%.

Secrets to High Efficiency:

Adapt fertilization to real yield potential (next step)

Apply N coincident with tree demand

Keep fertilizer N in the root zone

Manage variability (next step)

Monitor for soil and plant N accumulation

Conclusions: Managing Nitrogen

Base your Fertilization Rate on Realistic, Orchard Specific Yield

- Estimate your current yield and try to get as close to 'replacement' as possible.
- 1000lb kernel removes from 55-70 lb N (July leaf N 2.0 – 2.4%) , 8lb P and 80lb K.
- Apply 70-80% from bloom to mid-June.
- Apply 20-30% post harvest but only if trees are healthy.
- Every field is a unique decision
- Include all inputs (fertilizer, water, manures etc)

Nitrogen Demand by 20 acre block

Whole Field Average N demand = 150 lbs N

Conclusions: Managing Nitrogen

Leaf analysis is useful to monitor orchards but it is NOT adequate to make fertilizer decisions.

Follow the sampling rules!

- 18 trees/one bag/each two trees apart. You can sample in April to estimate July. (Labs will have guidelines by April)
- Use leaf analysis in conjunction with yield estimate to adjust in-season fertilization.
- Keep good records and sample consistently (right) over the years.

Estimate yield, measure leaf nutrients in April, adjust accordingly.

Take Home Message

- Adjust for yield.
- Manage each orchard as an individual - do not just give everything 250 lbs.
- Estimate yield (your best fair guess)
- Analyze leaves in April, estimate yield in April - Adjust accordingly.

Thanks!

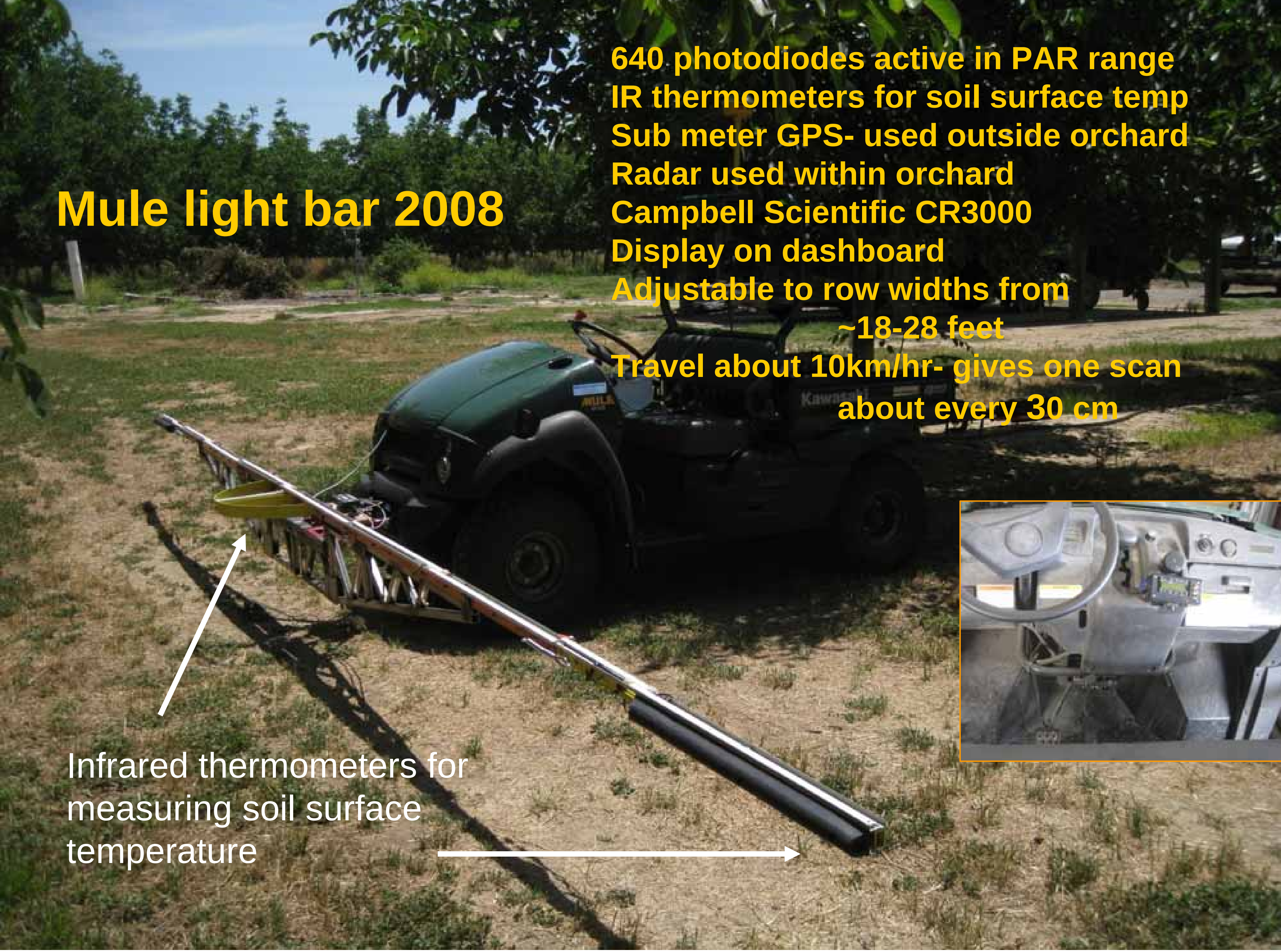
- Sebastian Saa
- Saiful Muhammad
- Blake Sanden
- Roger Duncan
- John Edstrom
- David Doll
- Bruce Lampinen
- Ken Shackel
- Emilio Laca

- Art Bowman
- Lagoisty Farms
- Paramount Farming
- Lots more…….

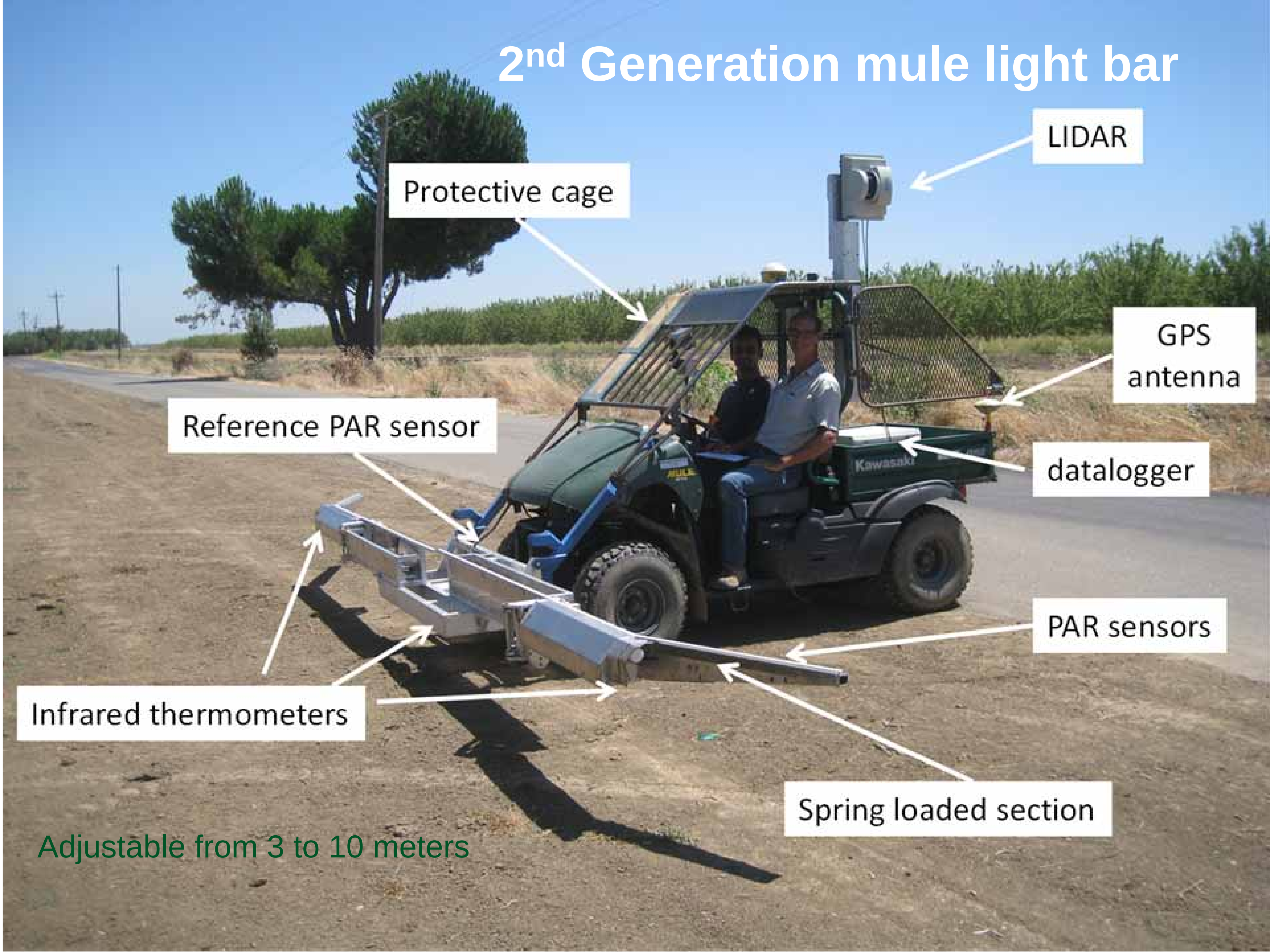
Interactions of Disease, Canopy Size and Yield in Almond

Bruce Lampinen
UC Davis Plant Sciences

Maximum potential productivity is limited by the percentage of the total incoming photosynthetically active radiation a canopy can intercept


Mule light bar 2008
640 photodiodes active in PAR range
IR thermometers for soil surface temp
Sub meter GPS- used outside orchard
Radar used within orchard
Campbell Scientific CR3000
Display on dashboard
Adjustable to row widths from ~18-28 feet
Travel about 10km/hr- gives one scan about every 30 cm
Infrared thermometers for measuring soil surface temperature

2nd Generation mule light bar



Adjustable from 3 to 10 meters

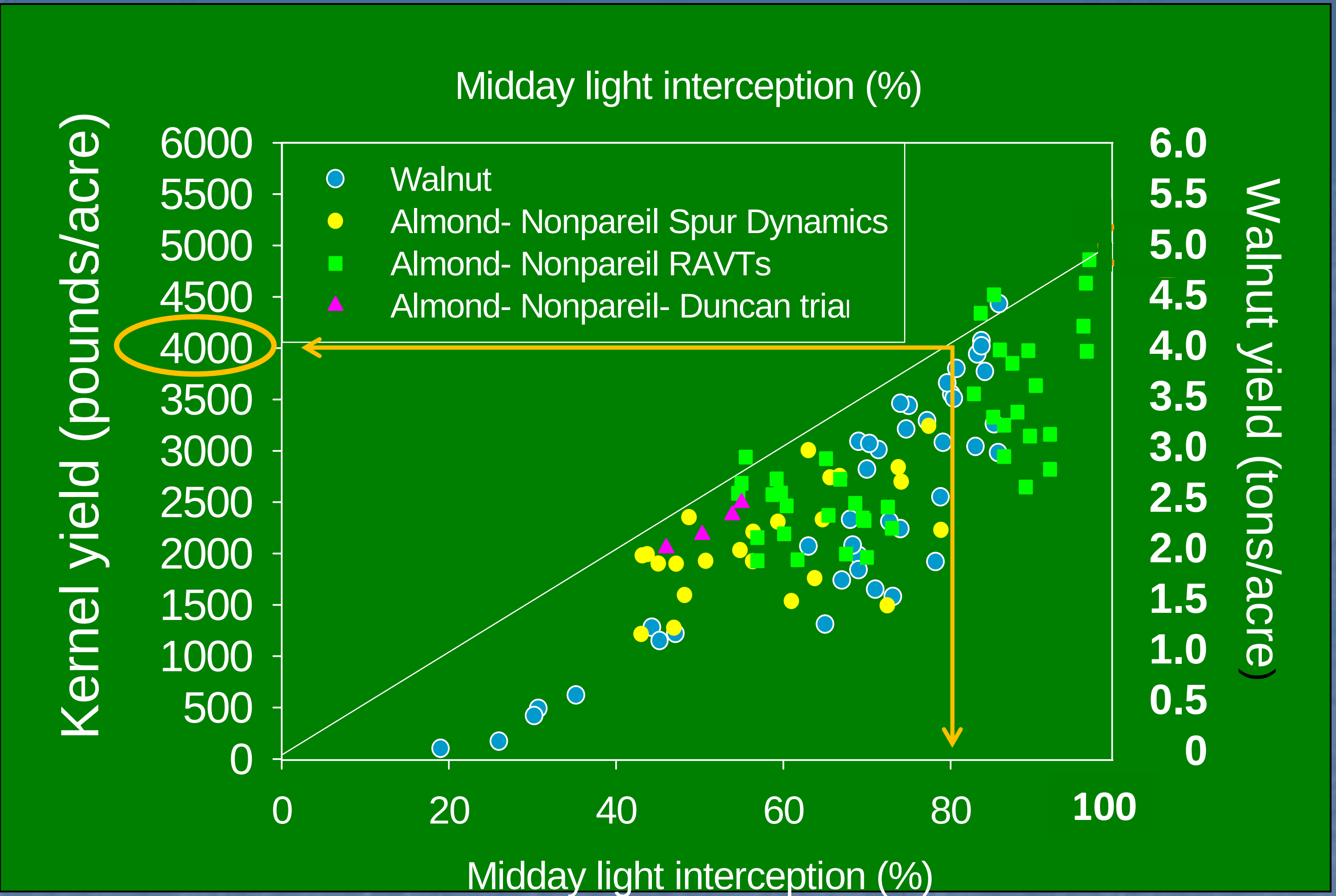
Mid-summer, drive down rows with Mule light bar

At harvest, pick up and weigh all nuts from same area driven down with light bar


Honda motor and hydraulic pump
Fuel tank


Scale display
Trimble GPS unit
elevator


Hydraulically driven auger to deliver samples to rear
Samples are delivered to 5 gallon bucket at rear (much safer than old method of getting samples by hand)



The white line is the maximum potential yield. Any number of factors can decrease your orchard yield relative to it's potential including water stress (excess or deficit), disease pressure, poor bloom weather, poor nutrient management etc.

Production potential is about 50 kernel pounds/ac of almond for every 1% of incoming light intercepted- so to produce 4000 kernel pounds per acre you need to intercept ~80% of the incoming PAR

27% PAR interception

37% PAR interception

39% PAR interception

50% PAR interception

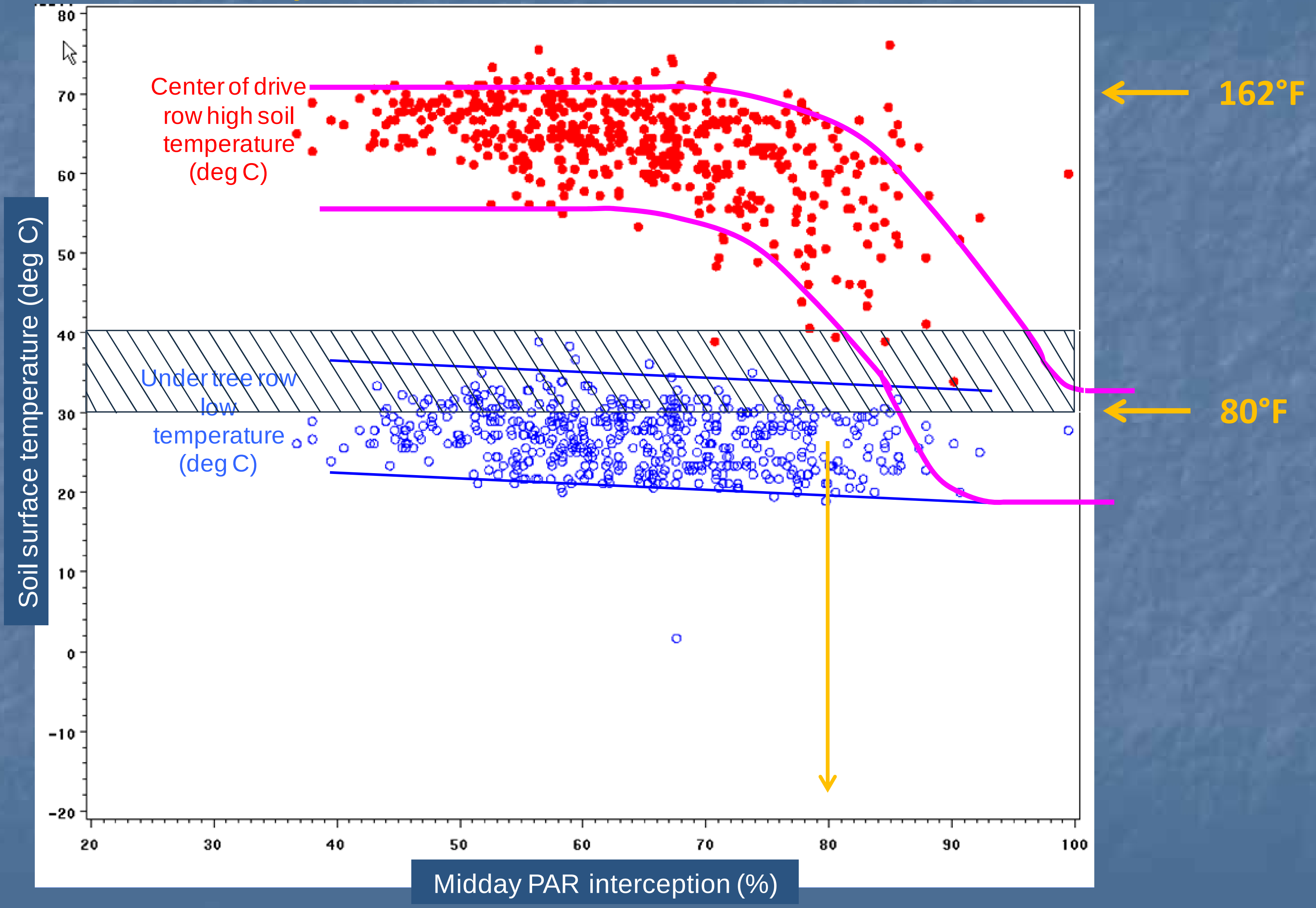
76% PAR interception

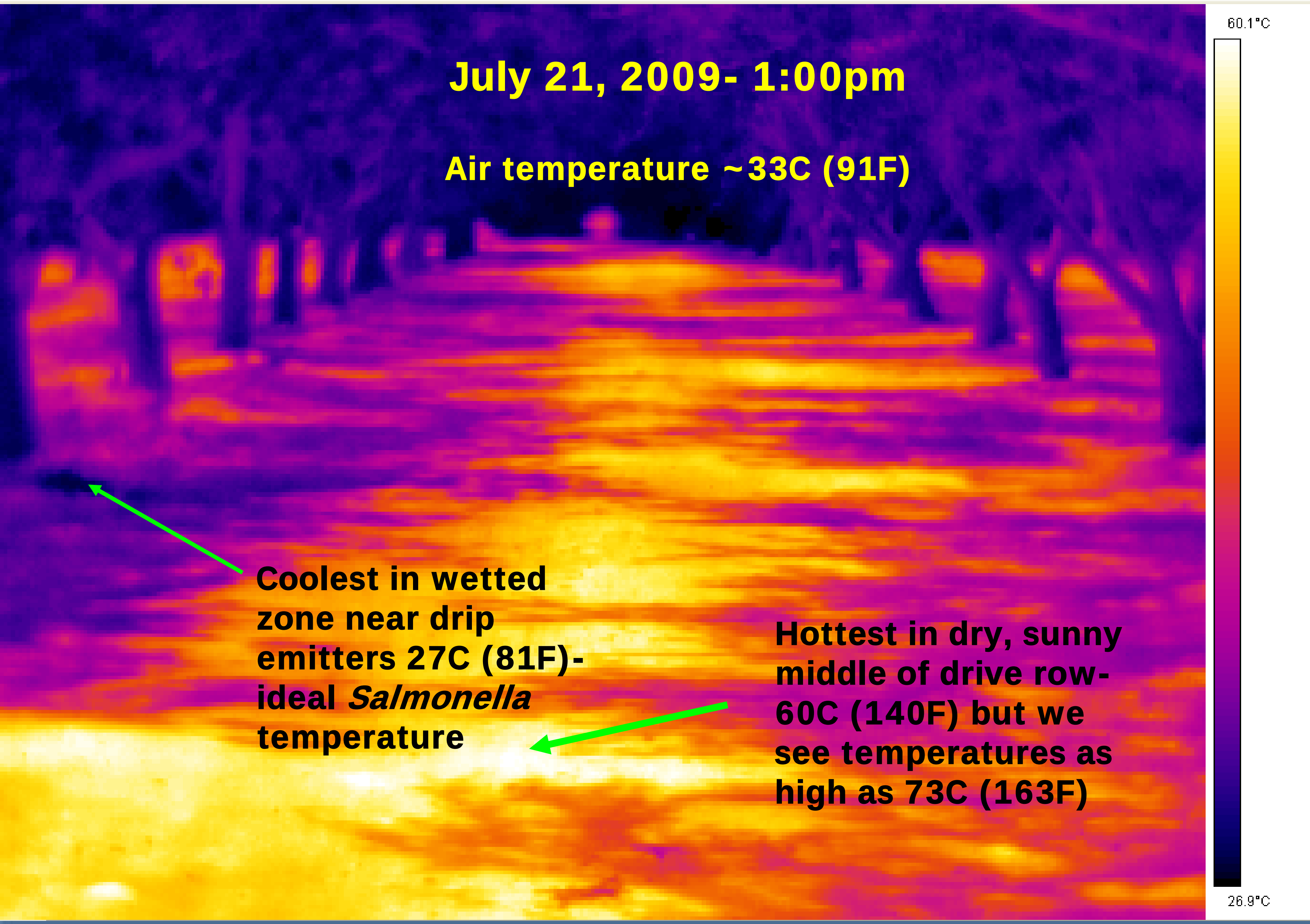
80% PAR interception

85% PAR interception

90% PAR interception

We have been looking at how other orchard management practices can influence food safety risk in almond




July 21, 2009- 1:00pm
Air temperature ~33C (91F)
Coolest in wetted zone near drip emitters 27C (81F)- ideal *Salmonella* temperature
Hottest in dry, sunny middle of drive row- 60C (140F) but we see temperatures as high as 73C (163F)
60.1°C
26.9°C

Salmonella outbreaks tied to raw almonds from California

- 2000-2001 ← **Traced to high PAR interception orchard**
  - 168 cases Canada and the U.S.
- 2003-2004
  - 47 cases in the U.S. and Canada
  - Handler (processor) unrelated to previous outbreak
    - 18 million pounds of raw almonds were recalled- no positives were found in any recalled almonds
- 2005-2006 (raw almond-link suspected)
  - 15 cases in Sweden

- Since 2007, all almonds sold in the U.S. have been required to be pasteurized as outcome of *Salmonella* outbreaks

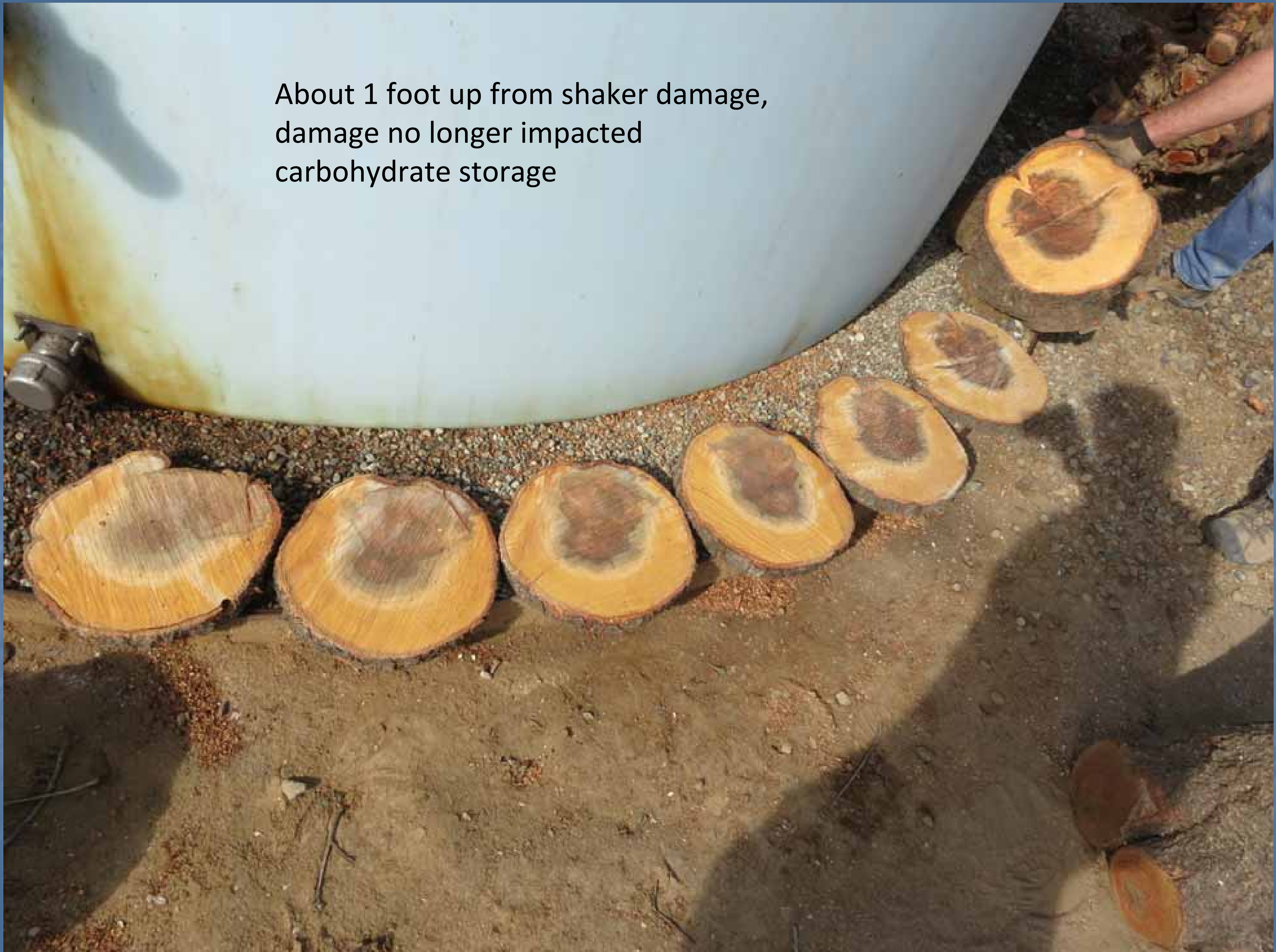
Pasteurization Options

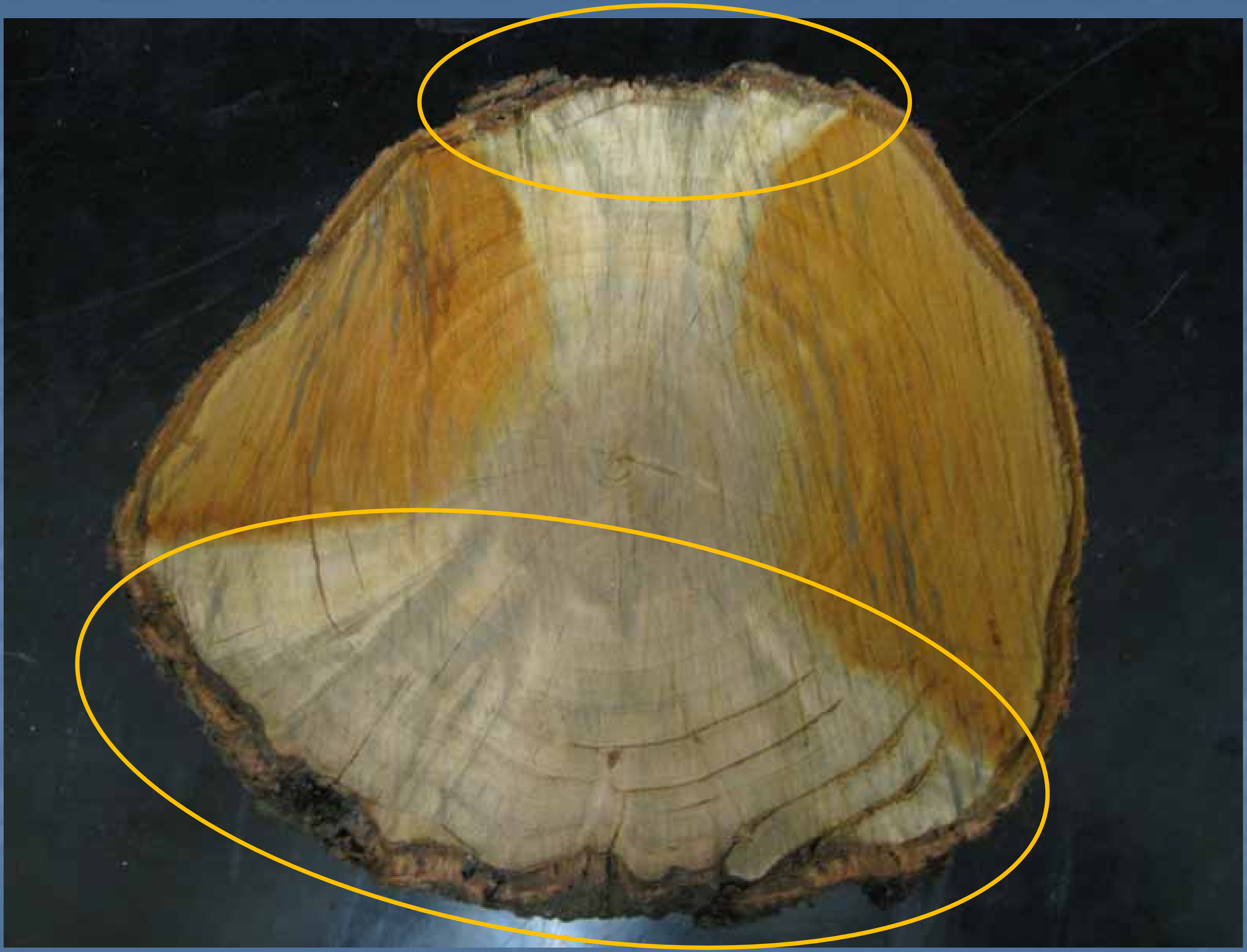
- Oil Roasting:
  - Minimum of 260°F (127°C) 2 min
- Water Blanching (removes skin):
  - Minimum of 190°F (88°C) 2 min
- Propylene Oxide Gas:
  - Temperature, time, concentration
- Two different Steam Treatments
- One FMC oven with steam

Danyluk, Uesugi and Harris. 2005. JFP 68:1613- 1622

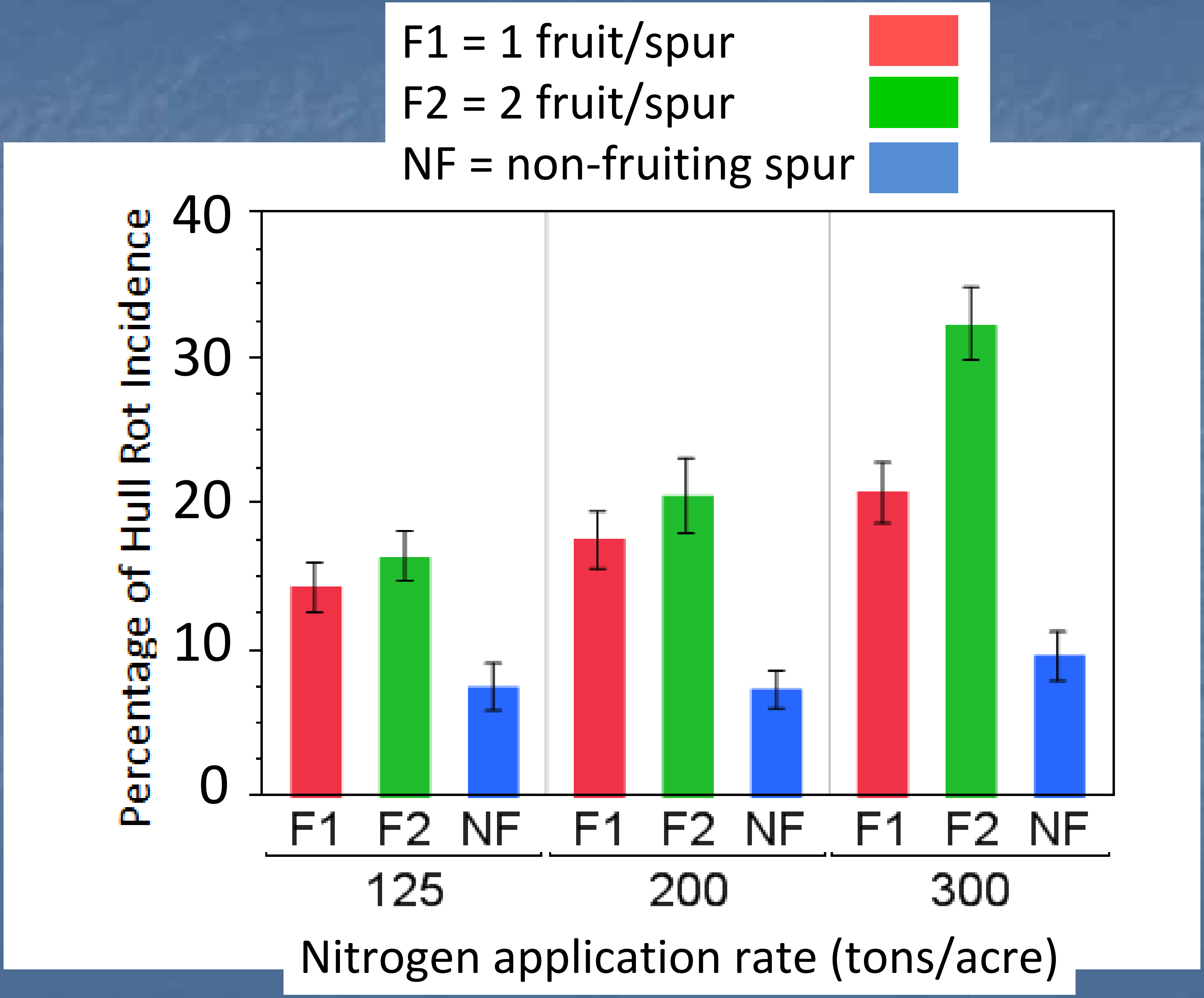
Does this mean that almond growers do not need to concern themselves with food safety?

- No- Pasteurization is designed for log 4 reduction which should be adequate based on historic levels of contamination
- If level of organisms is higher, log 4 reduction will not be adequate
- Only nuts sold in North America are required to be pasteurized


About 1 foot up from shaker damage,
damage no longer impacted
carbohydrate storage



Belridge SCRI trial 2011



Western Fresno County

July 2004
(4300+ lbs/ac)

May 2011 (2000 lbs/ac?)

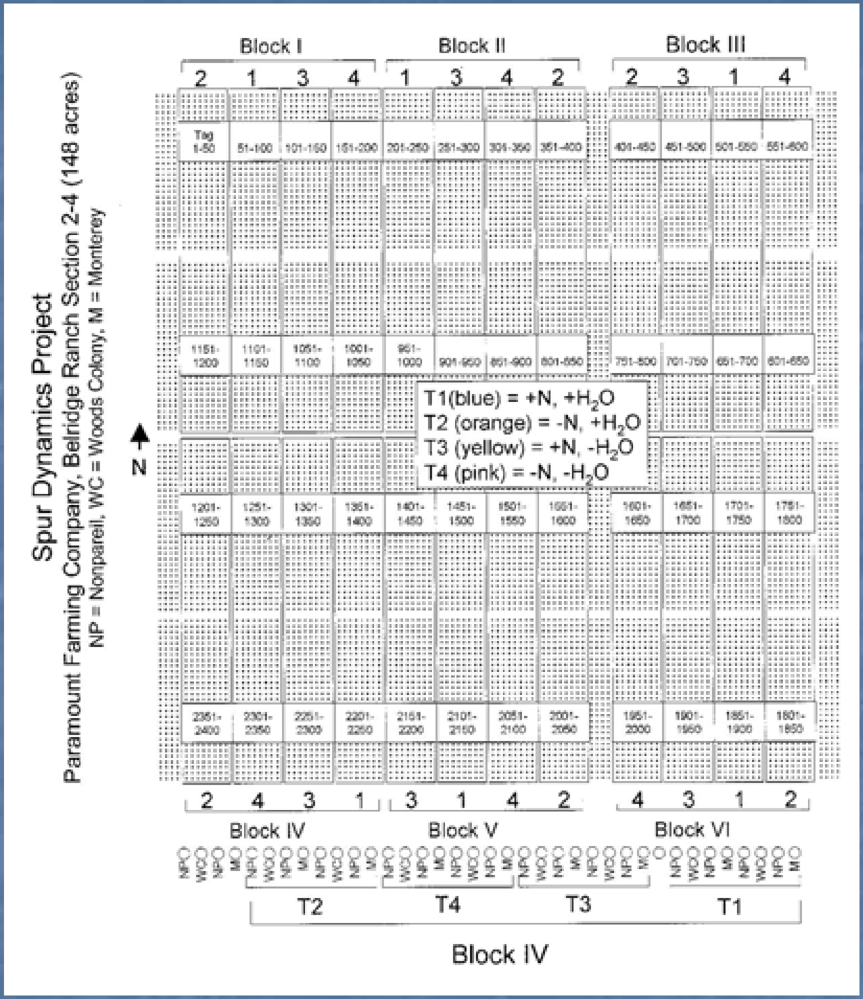
Evaluation of tree health in Spur Dynamics Orchard Lost Hills- June 2011

Sam Metcalf and Bruce Lampinen

In June 2011, we evaluated the tree health of the Spur Dynamics orchard in Lost Hills. Deficit irrigation and nitrogen treatments were imposed from 2001 to 2007. In the spring of 2008, all treatments were returned to normal, grower levels of water and nitrogen.

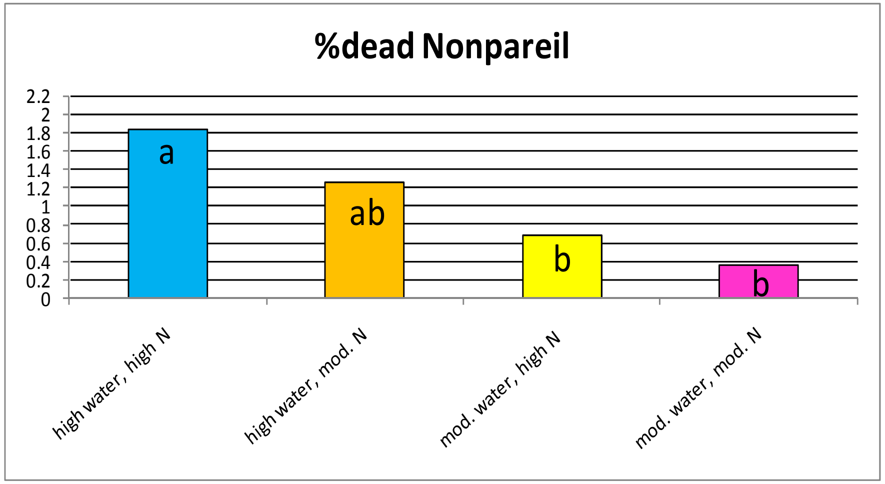
Plans and Procedures

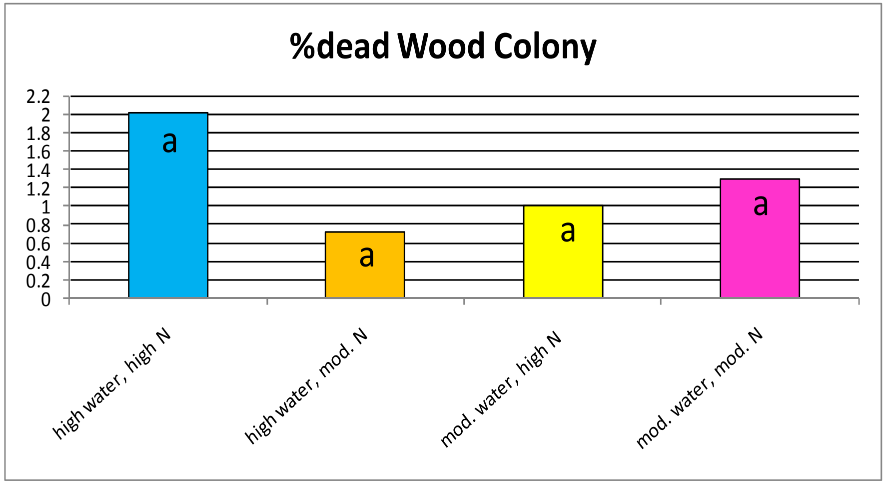
- 5 year old orchard in 2001
  146 acres (treatments applied from 2001-2007)
  37 acres per treatment
- Nonpareil, Monterey
  and Wood Colony
- Spacing
  24’ between rows
  21’ within row

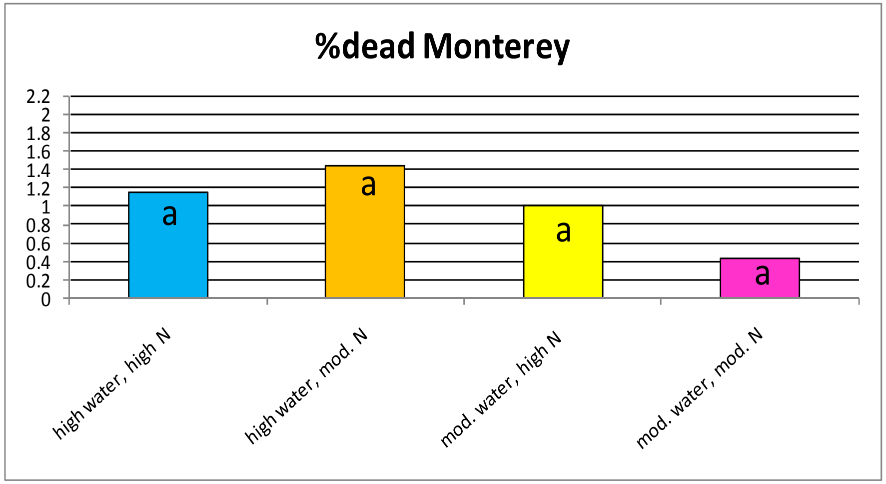


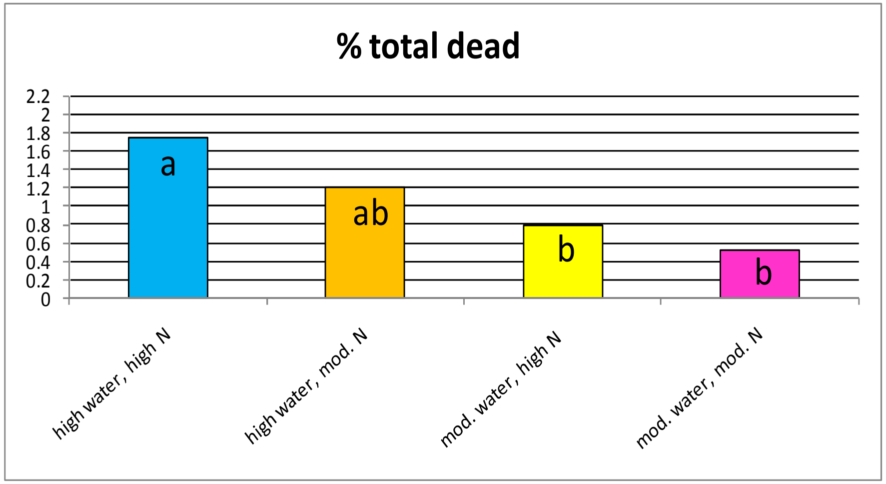
- Treatments
  - T1 = + N, + water
  - T2 = moderate N, + water
  - T3 = +N, moderate water
  - T4 = mod. N, mod. water
- Moderate nitrogen- fertilize when leaf N level falls below 2.2%
- Moderate water- irrigate when midday stem water potential reaches –1.2 MPa (mild stress)

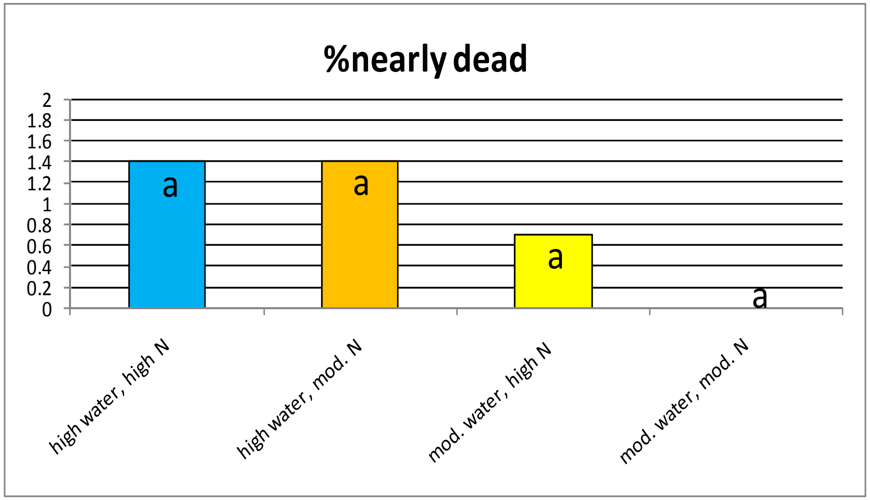
- Severe trunk damage occurred in all treatments in 2006
- We surveyed across orchard in summer of 2011 to see how recovery varied by treatment

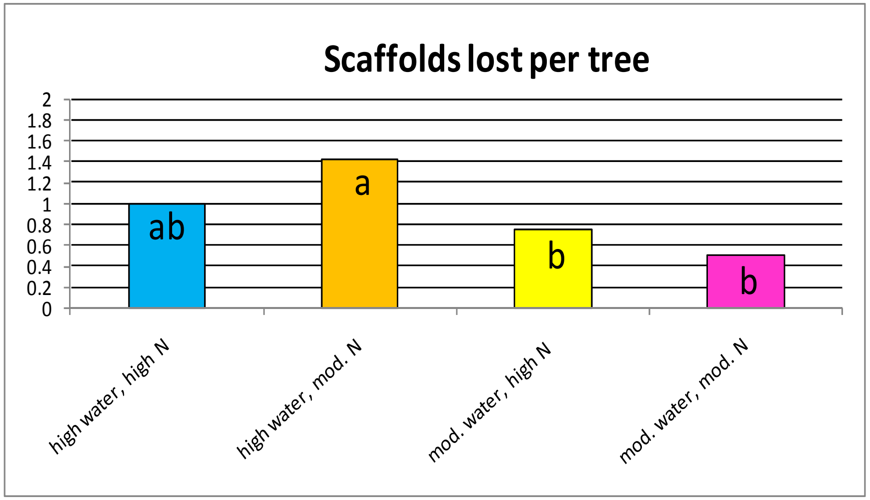

%dead Nonpareil
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
a
ab
b
b
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

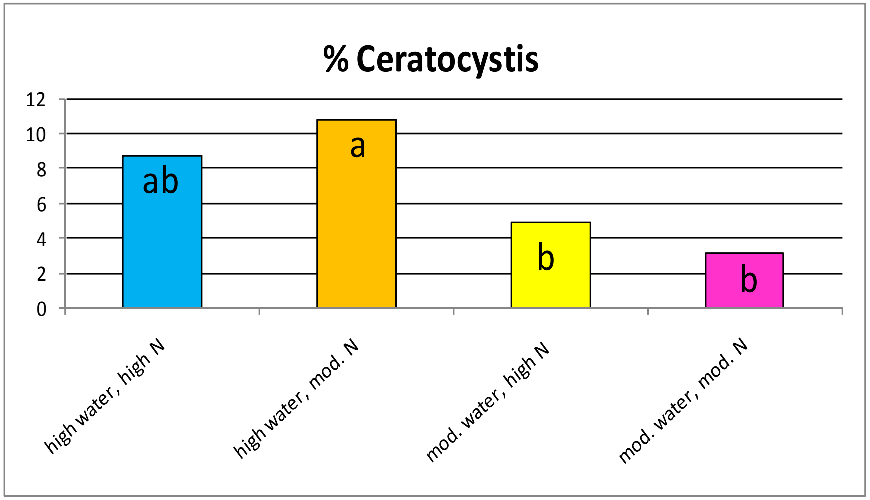

%dead Wood Colony
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
a
a
a
a
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

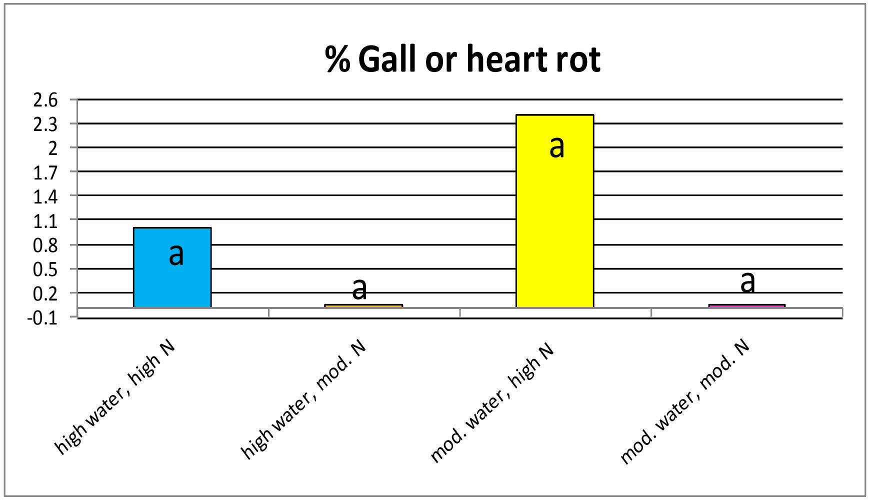

%dead Monterey
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
a
a
a
a
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

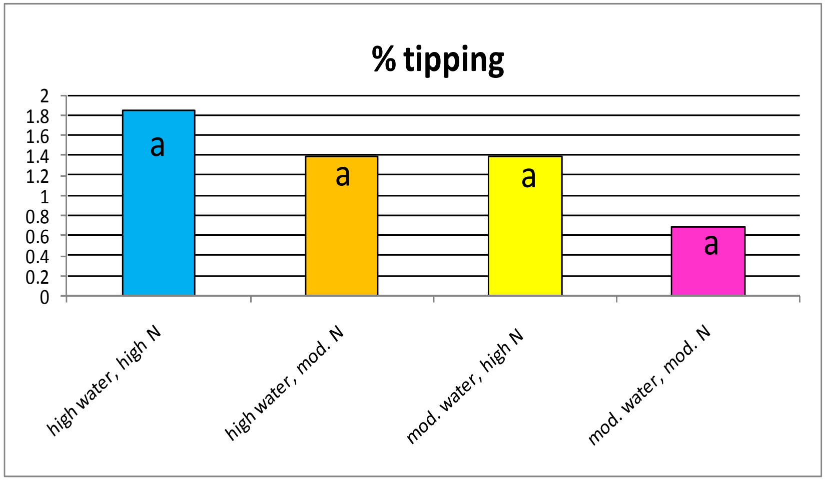

% total dead
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
a
ab
b
b
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

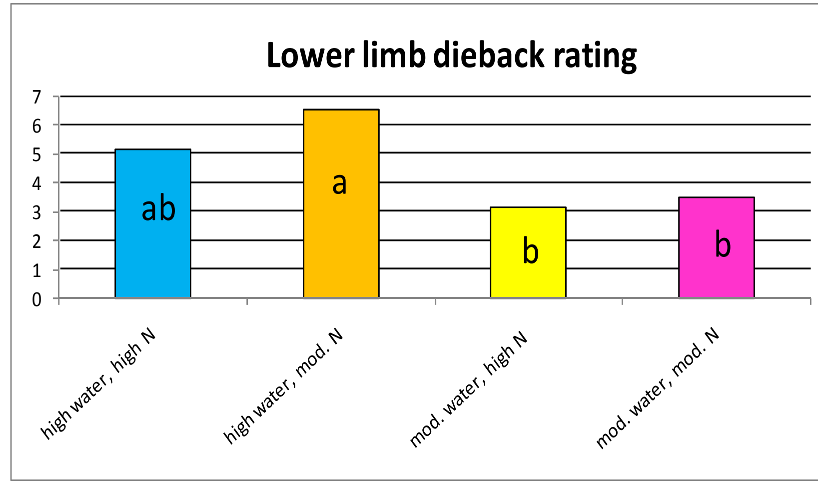

%nearly dead
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
a
a
a
a
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

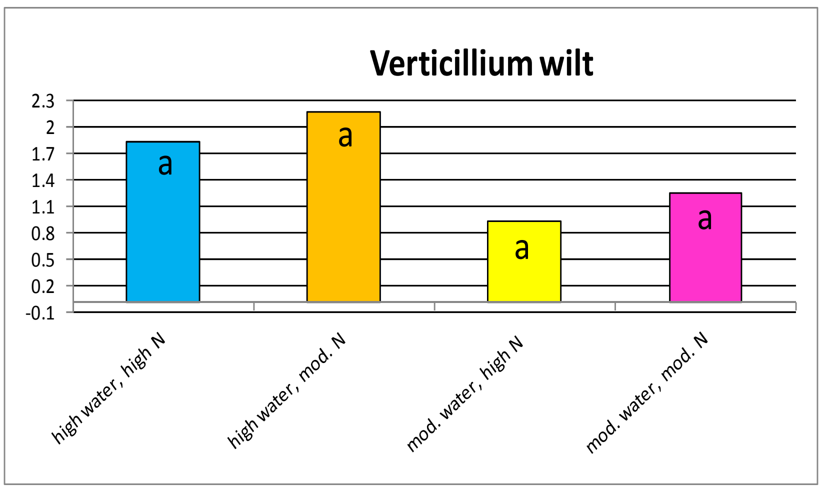

Scaffolds lost per tree
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
ab
a
b
b
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

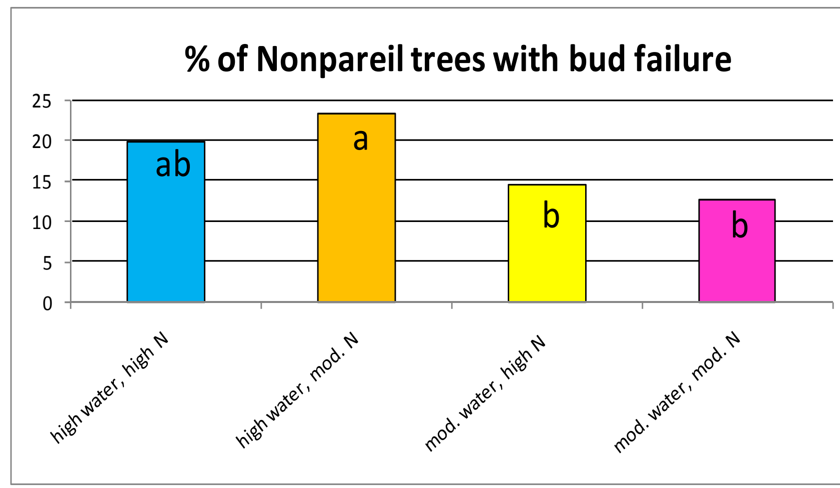

% Ceratocystis
12
10
8
6
4
2
0
ab
a
b
b
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

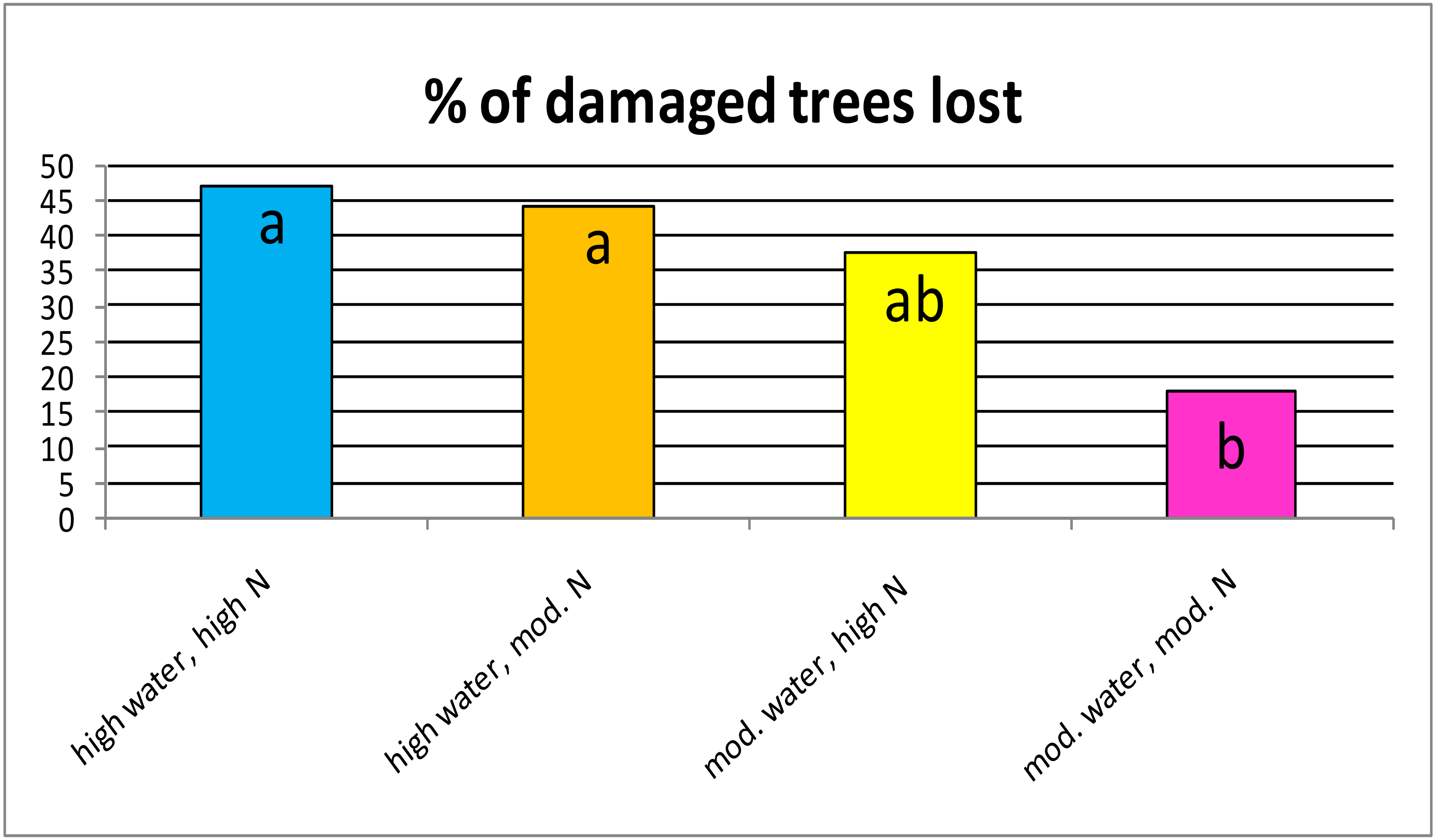

% Gall or heart rot
2.6
2.3
2
1.7
1.4
1.1
0.8
0.5
0.2
-0.1
a
a
a
a
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N


% tipping
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
a
a
a
a
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N


Lower limb dieback rating
7
6
5
4
3
2
1
0
ab
a
b
b
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

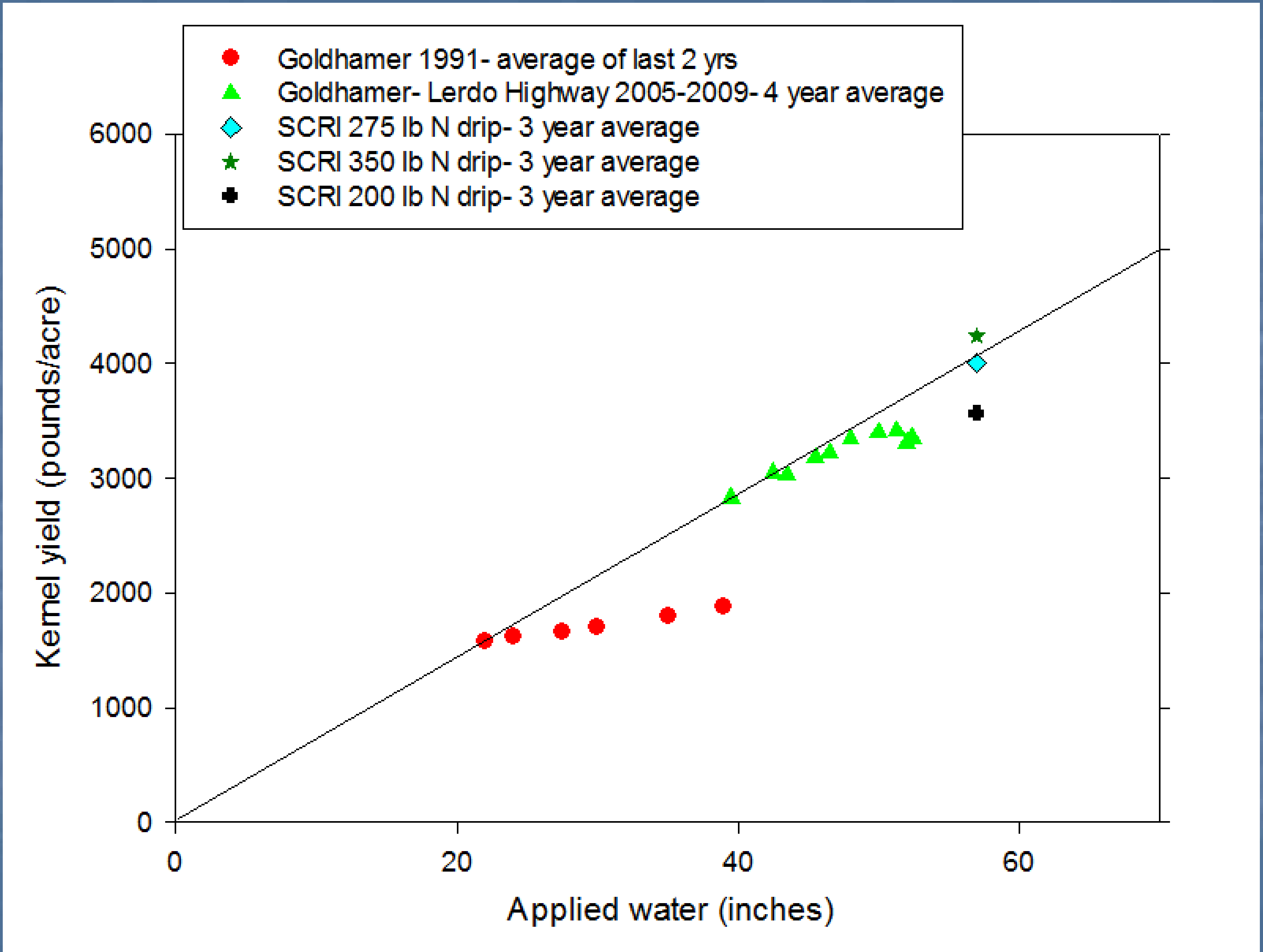

Verticillium wilt
2.3
2
1.7
1.4
1.1
0.8
0.5
0.2
-0.1
a
a
a
a
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N


% of Nonpareil trees with bud failure
25
20
15
10
5
0
ab
a
b
b
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

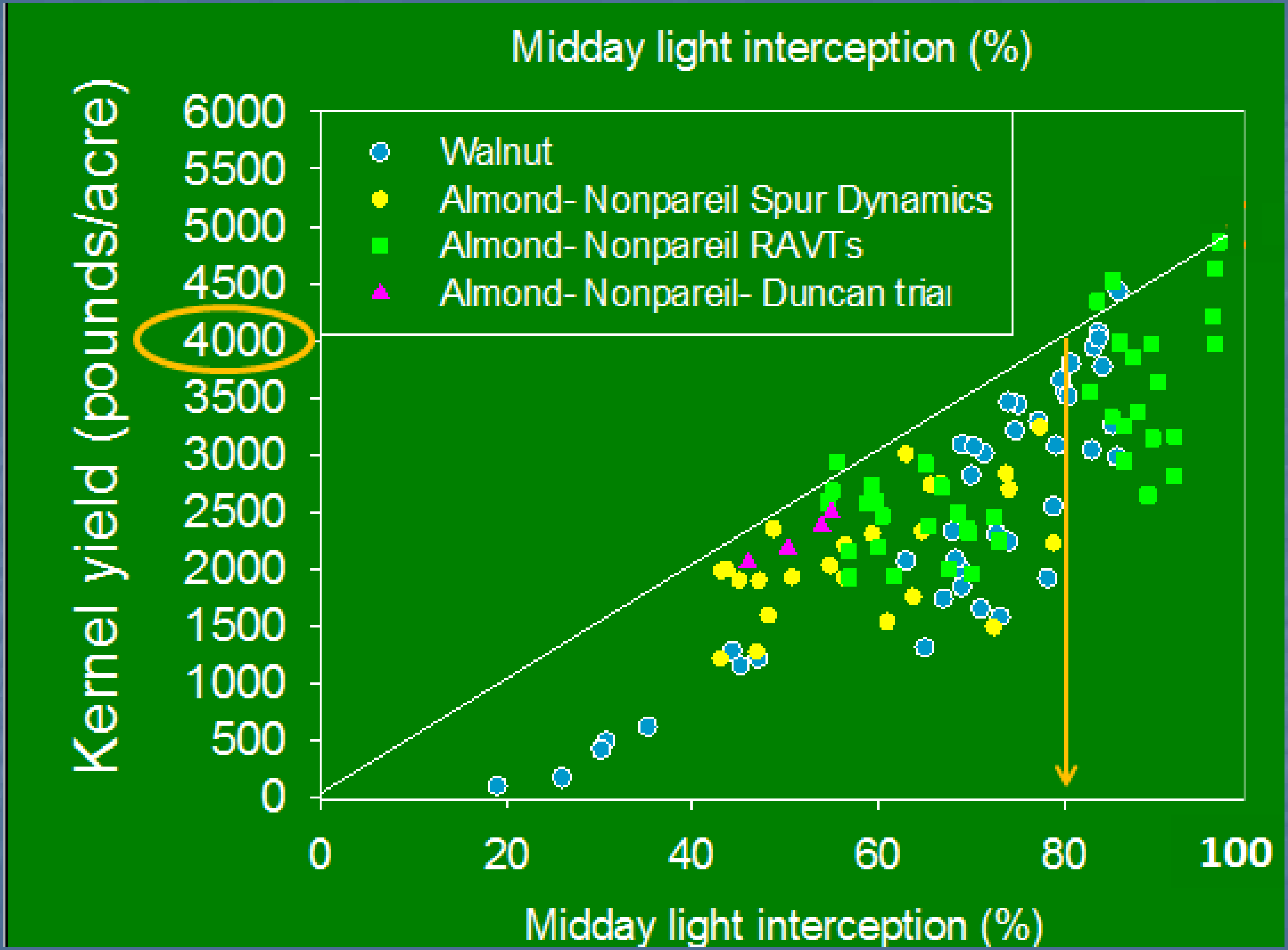

% of damaged trees lost
50
45
40
35
30
25
20
15
10
5
0
a
a
ab
b
high water, high N
high water, mod. N
mod. water, high N
mod. water, mod. N

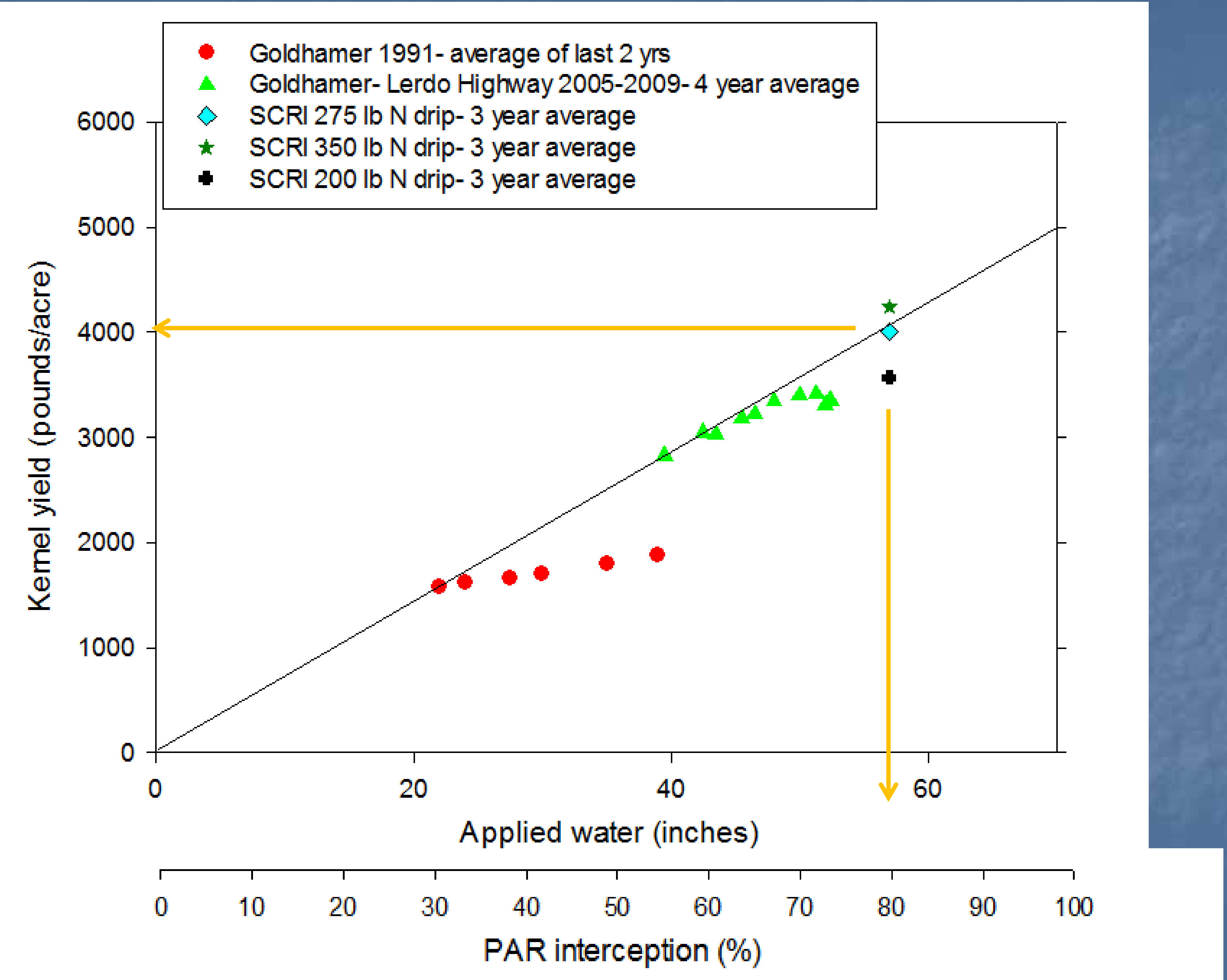
- So how do you know how much water you should apply to your orchard?

If we consider three trials that have 2-4 year average data



This begins to look awfully familiar

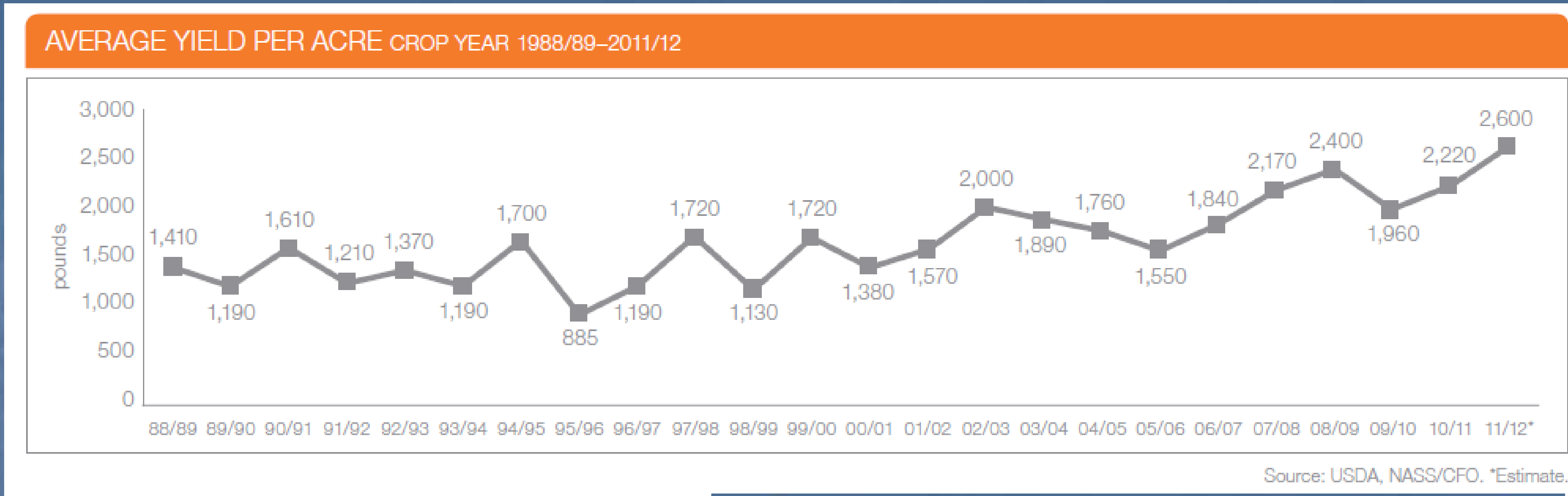



Goldhamer 1991- average of last 2 yrs
Goldhamer- Lerdo Highway 2005-2009- 4 year average
SCRI 275 lb N drip- 3 year average
SCRI 350 lb N drip- 3 year average
SCRI 200 lb N drip- 3 year average
Kernel yield (pounds/acre)
6000
5000
4000
3000
2000
1000
0
0
20
40
60
Applied water (inches)
0
10
20
30
40
50
60
70
80
90
100
PAR interception (%)

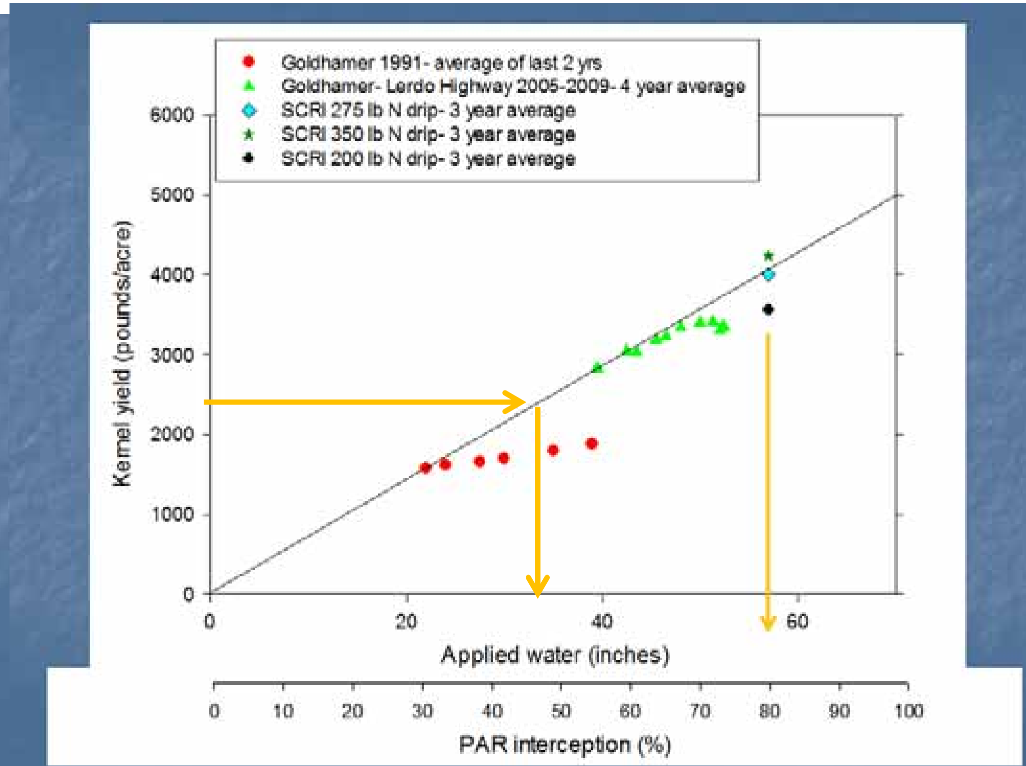
This suggests that water should be applied as below (not considering efficiency or stored soil water)

Midday PAR interception	Applied water (inches)	Yield potential (kernel lbs/acre)
10	7	500
20	14	1000
30	21	1500
40	28	2000
50	35	2500
60	42	3000
70	49	3500
80	56	4000
90	63	4500

Canopy cover above 80% will likely lead to increased food safety risk, increased foliar diseases and decreased tree life



Average per acre production in California in 2011 was 2220 kernel lbs/acre which should require about 31 inches of water



There are tradeoffs when maximum yields are pursued in almond

- Disease incidence/tree loss tends to increase with increasing canopy cover (especially above 75-85%)
- Food safety risk also increases above 75-85% canopy cover
- Water application rates need to be proportional to amount of canopy cover
  - If you have 60% PAR interception, 57 inches of applied water is not going to produce 4000 kernel pounds per acre- at most you will get 3000 kernel pounds per acre and likely large amount of disease and tree loss
- Recovery from trunk damage is lower under high water/high nitrogen conditions


Questions?

Almond Varieties
Mario Viveros
UC Farm Advisor Emeritus

Billings Test Plot

Project leader: Bruce Lampinen (Dep. Plant Science UCD)

Cooperators: Tom Gradziel, Sam Metcalf, Mario Viveros, Peggy Schrader,

Minerva González, Billing Ranches.

- Objective 1. Determine bud failure in 8 Nonpareil cones.
- Objective 2. Demonstrate yield differences among 8 clones and among 8 different varieties.

Orchard Characteristics

- Planted: 2004
- Density: 121 trees/acre
- Planting distance: 20x18 ft
- Ratio: (1:1)
- Soil: McFarland loam & Wasco sandy loam

Nonpareil Clones

- Nico
- Newell
- 3-8-16-90
- 3-8-13-8
- 3-8-2-70
- 3-8-5-72
- 3-8-6-72
- 3-8-7-72

Origin of Nonpareil Clones

- Fowler Nursery

  -Nico

  -Newell

  -Driver Nursery

  -(3-8-16-90)

Origin of Nonpareil Clones

- Jones (3-8-13-8)
- McEnepsy (1880)

  -(3-8-5-72) or 5

  -(3-8-6-72) or 6

  -(3-8-7-72) or 7
- IR-2, Prosser, WA

  -(3-8-2-70)

Clonal Yields Non-Replicated plots

Clone	Observations	Ave. lbs/acre
5	8	2511
2-72	8	2384
12	8	2368
IR-2	8	2178
13-8	-	------
16-90	-	------

Varieties of Interest

- Kochi
  -High production
  -High quality kernel
  -Susceptible to “Hull Rot” disease
- Kahl
  -High production
  -Susceptible to Altenaria
  -Double kernels
- Price (Solano)
  -High production?
  -Poor turn out
  -Harvest after Nonpareil
- Chips
  -High production in early years
  -Poor production in mature years

Variety of interest cont.

- UCD 2-19E

  -Highest production (1993 test plot)

  -Strong alternate- bearing habit

  -High kernel quality

  -Harvest after price but before Sonora

  -Blooms at the tail end of Nonpareil

Variety of Interest cont.

- Marcona

  -World's highest quality variety

  -Blooms ahead of Nonpareil

  -Early production

  -Late maturing

  -Hard Shell

  -Crack out 20-30%

Variety of interest cont.

- Winters

  -High producer in Sacramento Valley

  -Late and uneven maturity

  -Susceptible to NOW

  -Bud failure in Fresno County

  -Some level of self-compatibility

  -Susceptible to Altenaria

  -High kernel quality

Variety of interest cont.

- Sweetheart

  -Small Marcona

  -Heart shape kernel

  -Resistant to NOW

  -Takes long to come into production

  -Yield aren't great

  -Blooms ahead of Nonpareil

  -Vigorous tree

Top 10 Almond producing varieties (2011)

- Nonpareil
- Monterey
- Carmel
- Butte/Padre
- Butte
- Fritz
- Padre
- Aldrich
- Sonora
- Price

Nonpareil clone yields (meat lbs/acre)

Source	Clone	2006	2007	2008	2009
McEnepsy	5	1110	2251	3692	3476
	6	1075	2103	3300	3661
	7	940	2332	3763	3571
Fowler	Nico	1232	2279	4056	3977
	Newell	1086	2536	3456	4004
	Driver	1103	2370	3611	3977
Jones	3-8-13-8	1066	2152	3224	3513
Prosser, WA	IR-2	1101	2291	3714	3798

Nonpareil clone yields (meat lbs/acre)

Source	Clone	2010	Cumulative Yields
McEnepsy	5	3130	13579 abc
	6	3081	13219 bc
	7	3282	13510 abc
Fowler	Nico	3141	14558 a
	Newell	2931	14099 ab
	Driver	2841	13910 abc
Jones	3-8-13-8	1945	12691 c
Prosser, WA	IR-2	3011	13915 abc

Variety yields (meat lbs / acre)

Variety	2006	2007	2008	2009	2010	accumulative
2-19E	1718	2156	3321	3285	2020	13100 bc
Winter	1540	2634	2670	2415	1945	11203 d
Chips	985	1780	2956	2422	2789	19933 d
Sweetheart	588	1588	2893	2906	2803	10768 de
Kahl	965	2332	2733	2559	2048	10561 de
Marcona	1258	1995	1748	2562	1745	9307 fg
Kochi	965	1729	2002	2259	1466	8421 g

Independence

- Self fertile
- Blooms with Nonpareil
- Harvest 2-3 days before Nonpareil
- Large kernel
- High quality kernel
- Prolific bloomer
- Bears on clusters
- Second leaf 300 lbs/Acre

Conclusion

- The Nico clone is the most productive but it has shown “Bud failure” in commercial orchards
- IR-2 is not far behind Nico in yields

- 2-19E is the most productive variety in the Billings test plot. It's due to be release in the near future.

It is my opinion that this variety can reach 5,000 meat lbs/acre. However, it should be planted on hybrid rootstock and hedged during the winter. In addition, it should not be subject to water stress