



Water management in deciduous orchard crops

Allan Fulton

UC Irrigation and Water Resources Farm Advisor,
Tehama, Glenn, Colusa, and Shasta Counties

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aefulton@ucanr.edu

(530)-527-3101

Topics

- Review irrigation research
 - Walnut
 - Almond
 - Prune
- BREAK
- On-farm water management experiences
 - Irrigation scheduling tools
 - Irrigation system

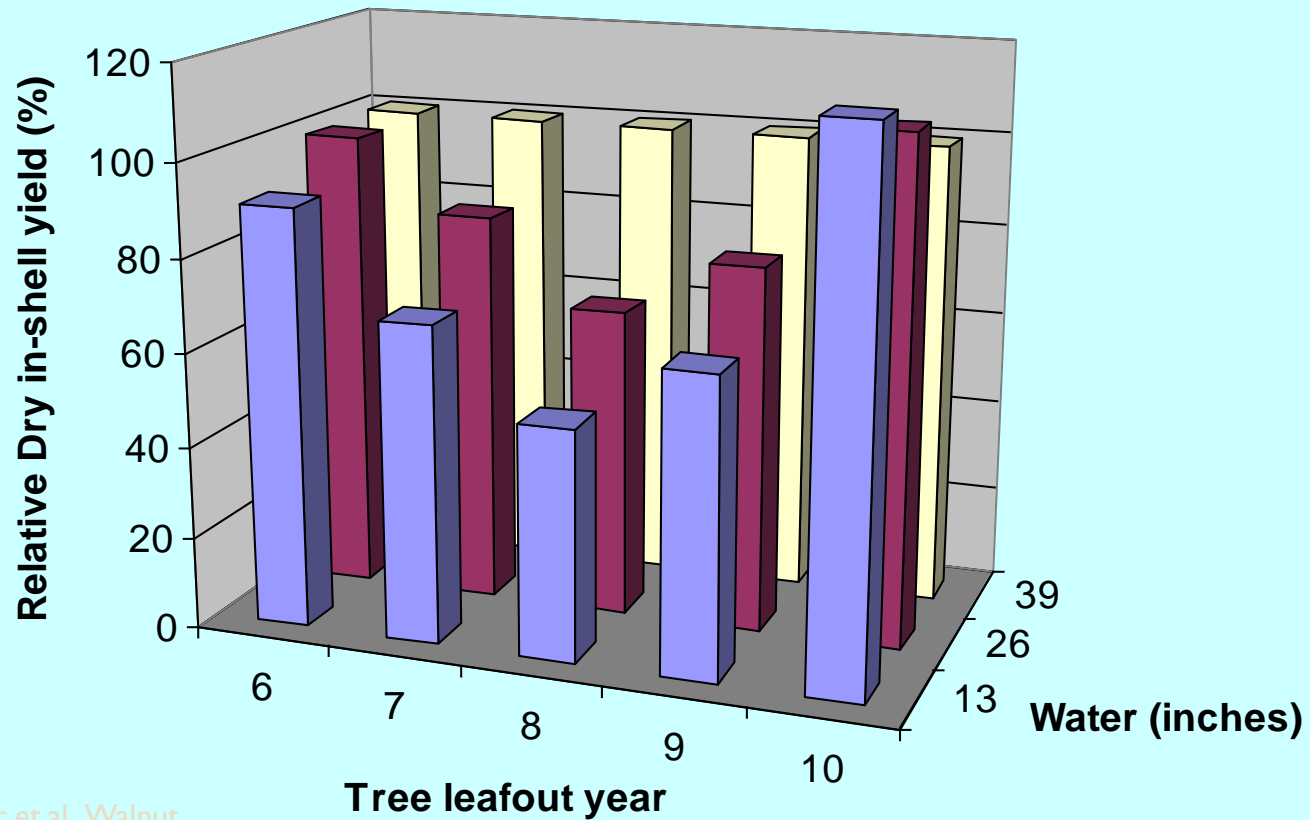
Walnut responses to irrigation

◦ Goldhamer, et.al., 1991-1996

- Parlier, CA
- Hedgerow planting, Chico cultivar
- Evaluated three levels of irrigation
- Strategy: 33, 67, and 100 % ET_c (39 inches) evenly allocated over season
- Supported by walnut research board



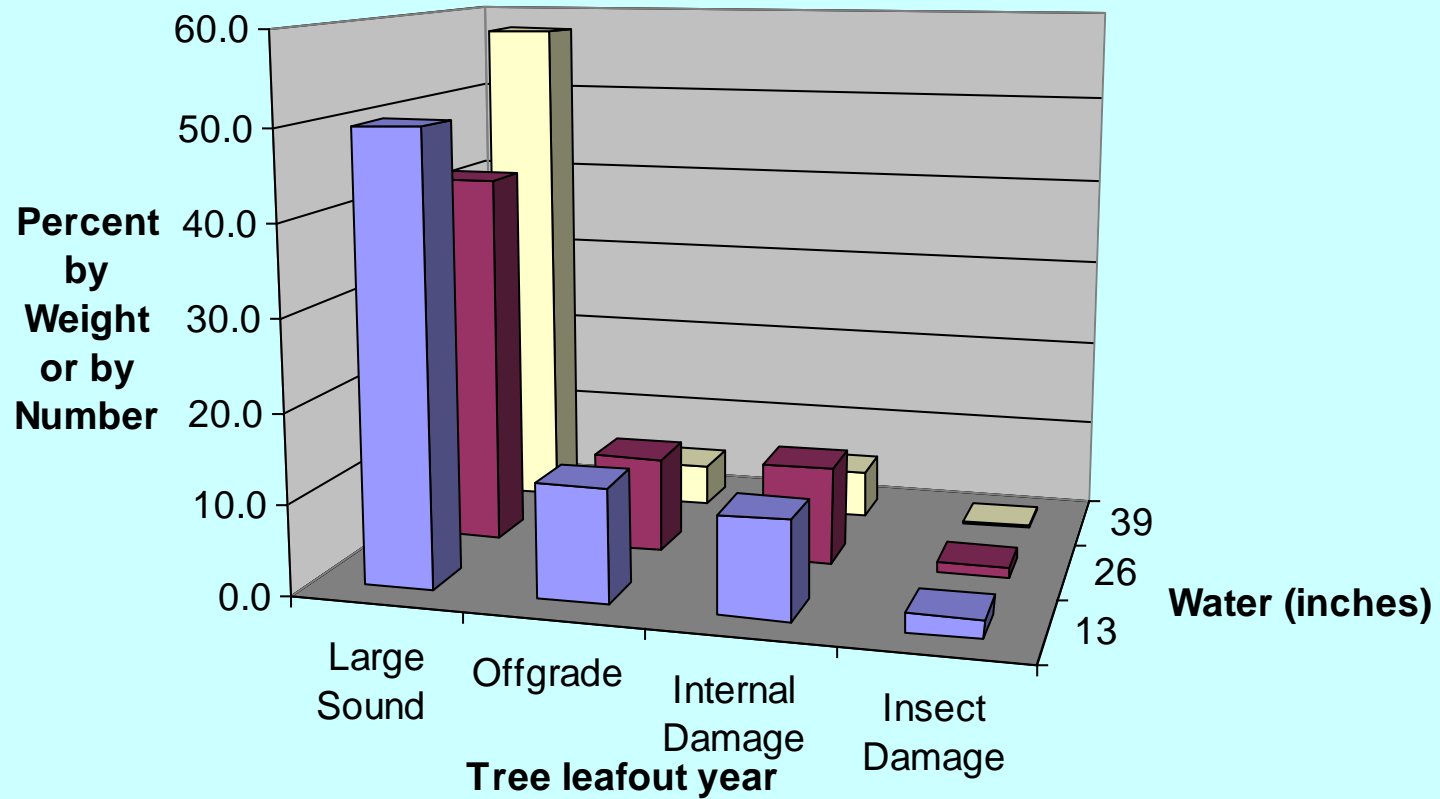
Relative walnut yield response to 3 years of water stress followed by 2 years of improved irrigation (Hedgerow, Chico Variety).



Goldhamer et.al., Walnut

Marketing Reports, 1991-96

Walnut quality responses to 3 consecutive years of water stress (Hedgerow, Chico variety)



Walnut summary points (Goldhamer, et. al.)

- Walnut sensitive to water stress
- Yield is more responsive than nut quality
- Unable to identify crop stages or irrigation strategy allowing some water stress without large impacts on yield
- Possible to recover a walnut orchard from water stress within 2 years

Walnut responses to irrigation

Fulton, Buchner, Grant, Prichard, Lampinen, et.al., 2002-2006

- Chandler variety
- Tehama County
 - Young (8th – 13th leaf)
 - mechanically hedged planting (81 trees/acre),
 - shallow terrace soils
 - Paradox and northern California Black rootstock
- San Joaquin County
 - Mature (20+ years old)
 - un-pruned, conventional planting (49 tree/acre)
 - deep alluvial soils
 - Paradox rootstock
- Evaluated effects of low, mild to moderate, and high crop stress on walnuts
- Supported by walnut research board from 2002 - 2004

Defining the irrigation treatments

- Strategy: increased water stress as season progressed
- Driven by SWP measurements with pressure chamber

Average Seasonal SWP (bars)	Seasonal Range in SWP (bars)	Average Applied Irrigation Water (inches / acre)
-4.0 to -5.5	-3.0 to -7.0	36 to 42
-6.2 to -7.0	-3.0 to -10	22 to 28
-7.5 to -8.6	-3.0 to -14	18 to 23

Effect of water stress on shoot growth in young mechanically hedged Chandler orchard

Average Seasonal SWP (bars)	Average Seasonal Shoot Growth (feet)
-3.6	3.5a
-6.2	3.4a
-7.5	2.4b
Average of 64 shoots per irrigation treatment	



Effect of water stress on Chandler/Paradox walnut yield

Location	Three-year Average SWP (bars)	2002 Yield (tons/ac)	2003 Yield (tons/ac)	2004 Yield (tons/ac)	2004 Yield Reduction (%)
Tehama County CA	-3.6	1.98a	2.82a	2.24a	0
	-6.2	1.84a	2.33b	1.65b	-26
	-7.5	1.74a	2.07b	1.31b	-42
San Joaquin County CA	-5.5	3.55a	4.43a	3.77	0
	-7.0	3.26a	3.94a	2.98	-21
	-8.6	3.29a	3.80a	3.08	-18

Effect of water stress on bud fruitfulness in walnut

Location	Three-year Average SWP (bars)	Change in buds that opened (%)	Change in floral buds (%)	Change in flowers per floral bud (%)	Change in Nut Load (%)
Tehama County CA	-3.6	0	0	0	0
	-6.2	-1	-18	-3	-24
	-7.5	-12	-12	-9	-31
San Joaquin Ca	-5.5	0	0	0	0
	-7.0	-3	-15	-1	-16



Remember
Shoot
Growth

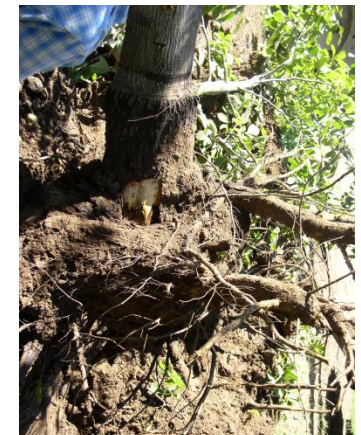
Effect of water stress on edible nuts, Tehama County experiment

Rootstock	Four Year Average SWP (bars)	2002 Edible Walnuts (%)	2003 Edible Walnuts (%)	2004 Edible Walnuts (%)	2005 Edible Walnuts (%)
Paradox	-4.0	49.3	53.7 ^a	47.3	46.2
	-6.2	49.0	51.3 ^b	48.3	46.3
	-7.5	49.8	49.4 ^c	47.8	46.3
Northern California Black	-4.0	48.4	52.5 ^a	48.8	45.4 ^a
	-6.2	47.8	50.7 ^b	48.5	44.2 ^b
	-7.5	47.9	49.6 ^c	48.8	42.8 ^c

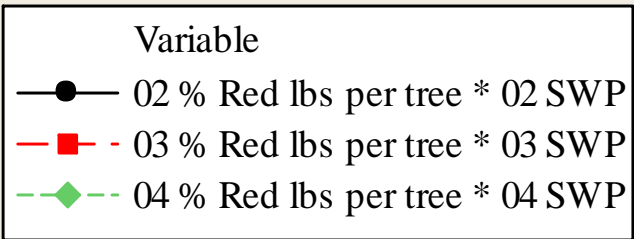
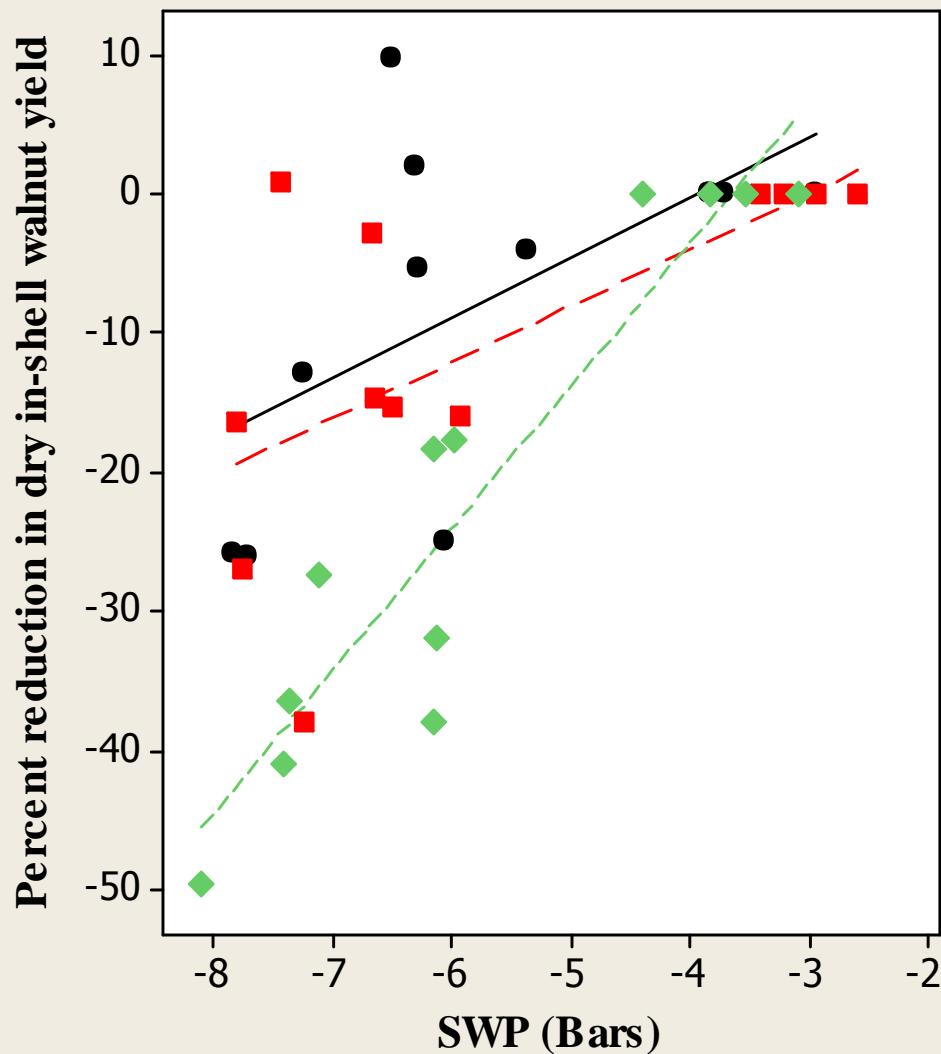
Note: water stress did not significantly affect edible yield during any of the three years (2002-2004) of evaluation at the San Joaquin County experiment

Effect of water stress on tree health of Chandler walnut grown on Paradox and northern California Black rootstock.

Walnut Rootstock	Four-year Seasonal Average SWP (bars)	Average Applied Water (inches)	Trees in mild or moderate decline (%)	Tree death or trees in severe decline (%)
Paradox	-4.0	42	0.0	0.0
	-6.2	28	2.7	1.3
	-7.2	23	1.3	1.3
Northern California Black	-4.0	42	10.3 ^a	24.2 ^a
	-6.2	28	6.3 ^b	3.0 ^b
	-7.2	23	3.1 ^c	0.0 ^b



Effect of irrigation as indicated by average seasonal midday SWP on dry in-shell yield of Chandler walnut grown on Paradox rootstock



Statistical Summary:

02 – slope = 4.35
 $R^2 = 35.8$
 $p = 0.04$, Significant

03 – slope = 4.03,
 $R^2 = 41.9$
 $p = 0.02$, Significant

04 - slope = 10.2
 $R^2 = 87.2$
 $p < 0.01$, Highly Significant

Walnut summary points (Fulton, et. al.)

- Chandler walnut sensitive to water stress
- 38-42 inches of seasonal ET_c reasonable estimate of seasonal water use but the irrigation requirement is site specific
- Young orchards nearing full production potential was more responsive to irrigation than established orchards
- Bud fruitfulness and yield is more responsive than shoot growth and nut quality
- Postponing water stress until mid to late season tree and crop development stages did not prevent significant impacts on yield
- Long term tree health is influenced by irrigation management and root stock selection
- Limited experimentation (data not shown) with Howard walnut suggests they respond similarly to water stress.

Irrigating Prunes: What is known and unknown

Richard Buchner
UCCE Tehama



Since 1986 we have information for five
irrigation research projects in California
(*Prune Research Reports*)



Project #1

The Effects of Four Years of Variable Preharvest Irrigation Cutoff Periods on Prune Tree Performance

Dave Goldhamer, Steve Sibbett and Don Katayama

1986-1989 • Tulare Co.

- Preharvest Fruit Drop
- Fruit Load and Development
- Yield



Project #2

Sensitivity of French Prune Seasonal Growth Stages to Water Deprivation

Dave Goldhamer, Steve Southwick, Ken Shackel, Bill Olson and Bruce Lampinen – 1989-1992

Water deprivation at different seasonal prune growth stages.

Description of Irrigation Treatments

Treatment	Growth stage of water deprivation	Dates of Cutoff
1	None (control)	
2	1 (early growth phase)	Through May 4
3	1 st half II (lag phase)	May 5 – Jun 6
4	2 nd half II (lag phase)	Jun 7 – Jul 18
5	Entire II (lag phase)	May 5 – Jul 18
6	III (late growth phase)	Jul 19 – harvest
7	Post harvest	Harvest – season end

FRUIT DIAMETER SEASONAL PATTERNS

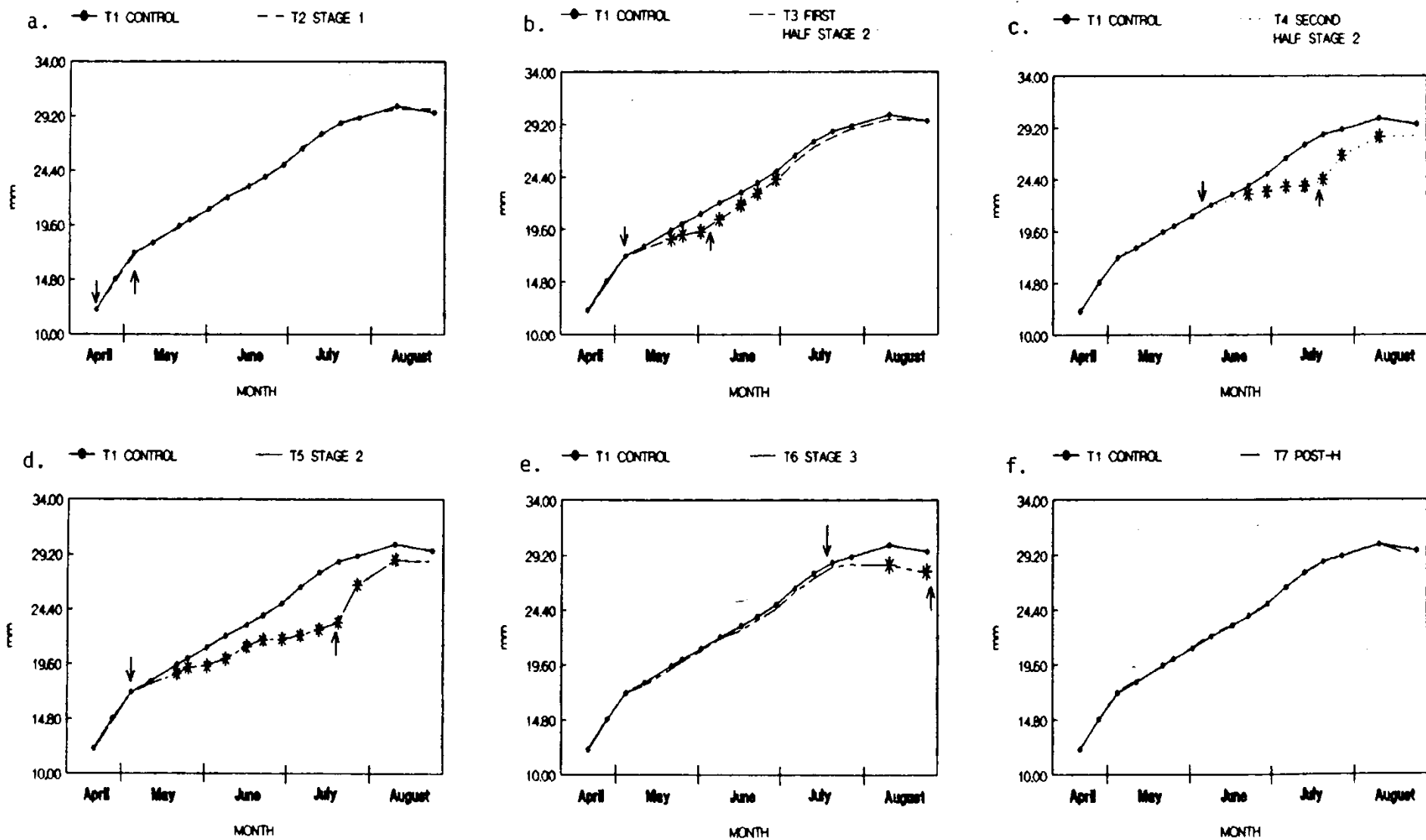


Figure 1. Fruit growth with time over the season.



Project #3a

Plant-based Prune Tree Water Stress Measurement

Ken Shackel – 1989

Could leaf water potential detect
irrigation treatment differences?



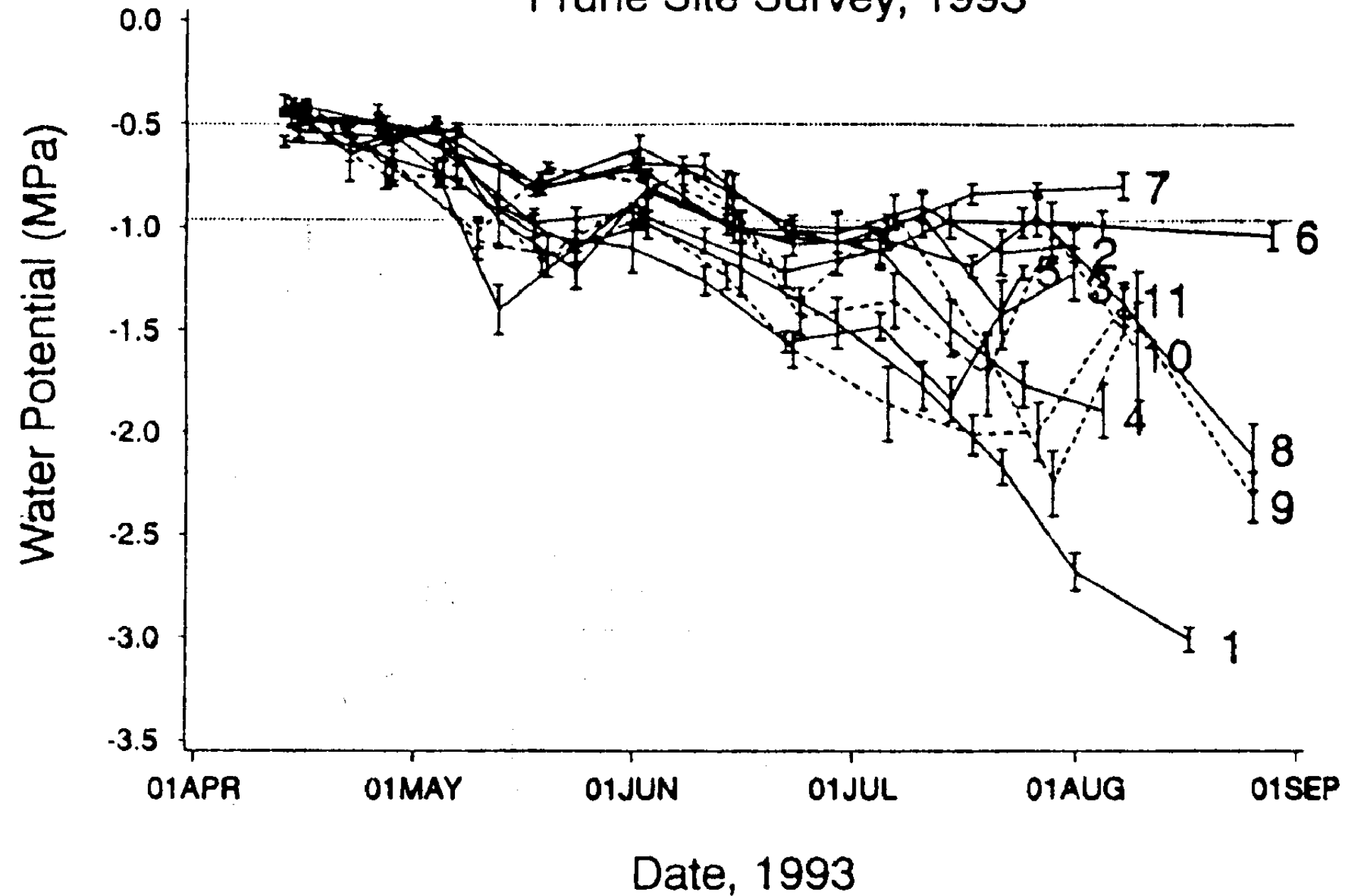
Project 3b

Prune Orchard Water Status in Contrasting Prune Growing Areas of California

Bruce Lampinen, Ken Shackel, Steve Southwick, Dave Goldhamer, Jim Yeager, Rick Buchner, Bill Krueger, Bill Olson, Steve Sibbett, Frank Yoshikawa – 1993

Assess the range of midday stem water potentials.

Prune Site Survey, 1993



Project 4

Physiological Responses of Prune Trees to Moderate and Severe Water Stress: Three Year Summary

Bruce Lampinen, Ken Shackel, Steve Southwick, Dave Goldhamer, Steve Sibbett, Bill Olson, Jim Yeager – 1994-1996

Tried to impose gradual tree and crop stress and evaluate effects prune trees.

Yield characteristics, relative money return, applied water and seasonal average stem water potential for Tulare County site 1996

Range in SWP (bars)	No. of Fruit at Harvest/ acre (x1000)	No. of Fruit Dropped/ ac (x1000)	Dry Fruit Yield (tons/acre)	Dry Fruit Count (count/lb)	Fruit Drying Ratio	Growth in Trunk cross-sectional area (cm ²)
-10 to -12	5020	700	6.07	61	2.99	10.53 ^a
-12 to -15	5090	560	6.03	62	2.90	9.68 ^a
-14 to -20	4940	490	5.73	68	2.83	8.86 ^b
LSD (5%)	680	100	0.54	3	0.07	1.30



Project #5a

Cracking in 'French' Prune in 1999: Field Trial and Definition of Defects

Steve Southwick, Bill Olson, Jim Yeager, Nadeem Shawareb, Kitren Glozer – 1999

Evaluated effects of irrigation and fruit load on fruit defects.



Project 5b

Effect of Irrigation on Fruit Cracking for French Prune

*Richard Buchner and Cyndi Gilles –
Tehama 2000*

Attempted to induce fruit cracking in French prune to demonstrate cause and effect relationships with irrigation.

Prune summary

- Limited experimental information for prune irrigation
- Prune response to water stress is not completely understood
- Midday stem water potential can indicate tree stress
- Irrigation deficit does not appear to affect fruit drop
- Irrigation deficit appears to affect fruit size
- Irrigation deficit appears to affect dry ratio
- Early season stress plus irrigation appears to aggravate end cracks
- Late season stress plus irrigation may not affect fruit cracking

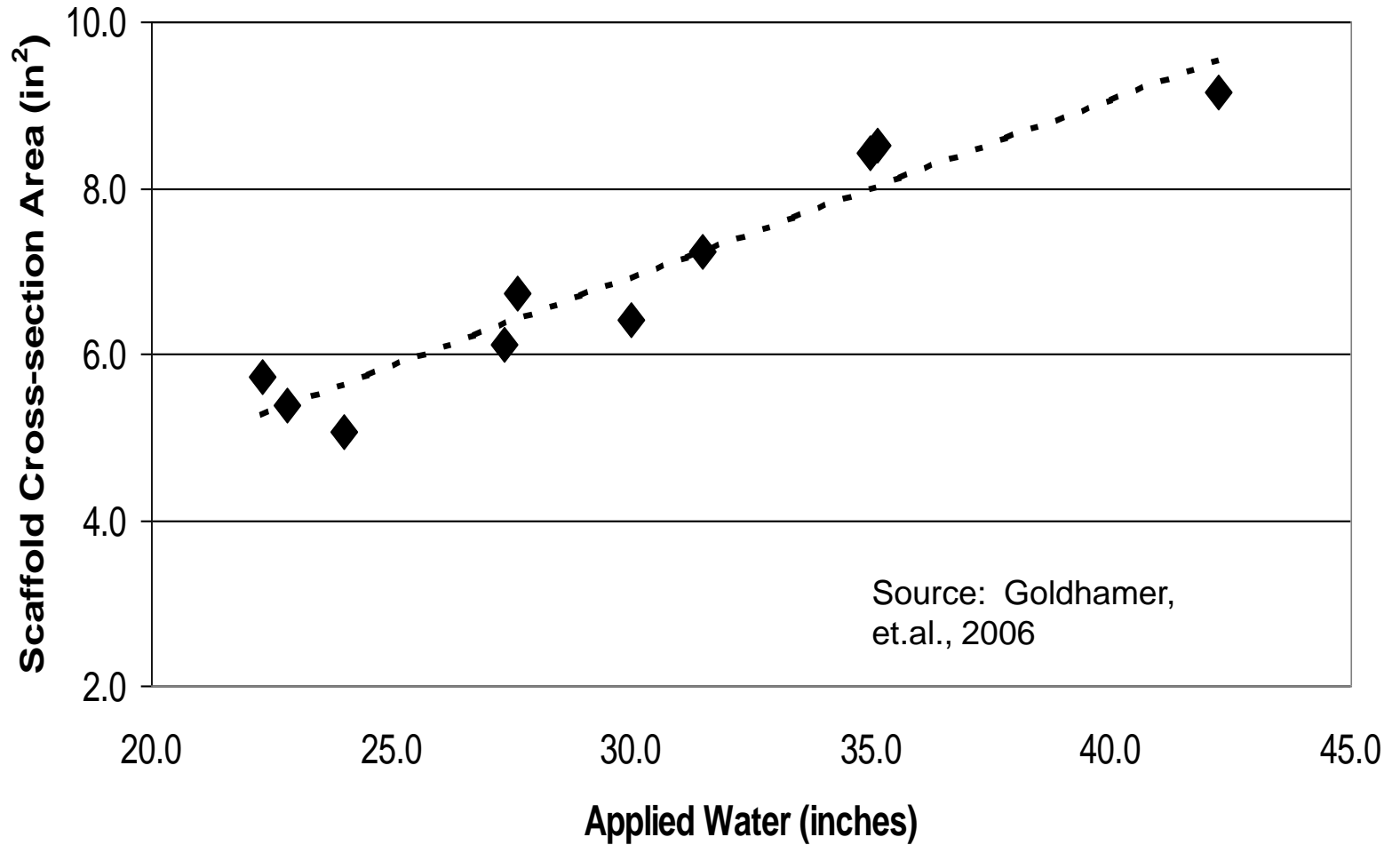
Almond responses to irrigation



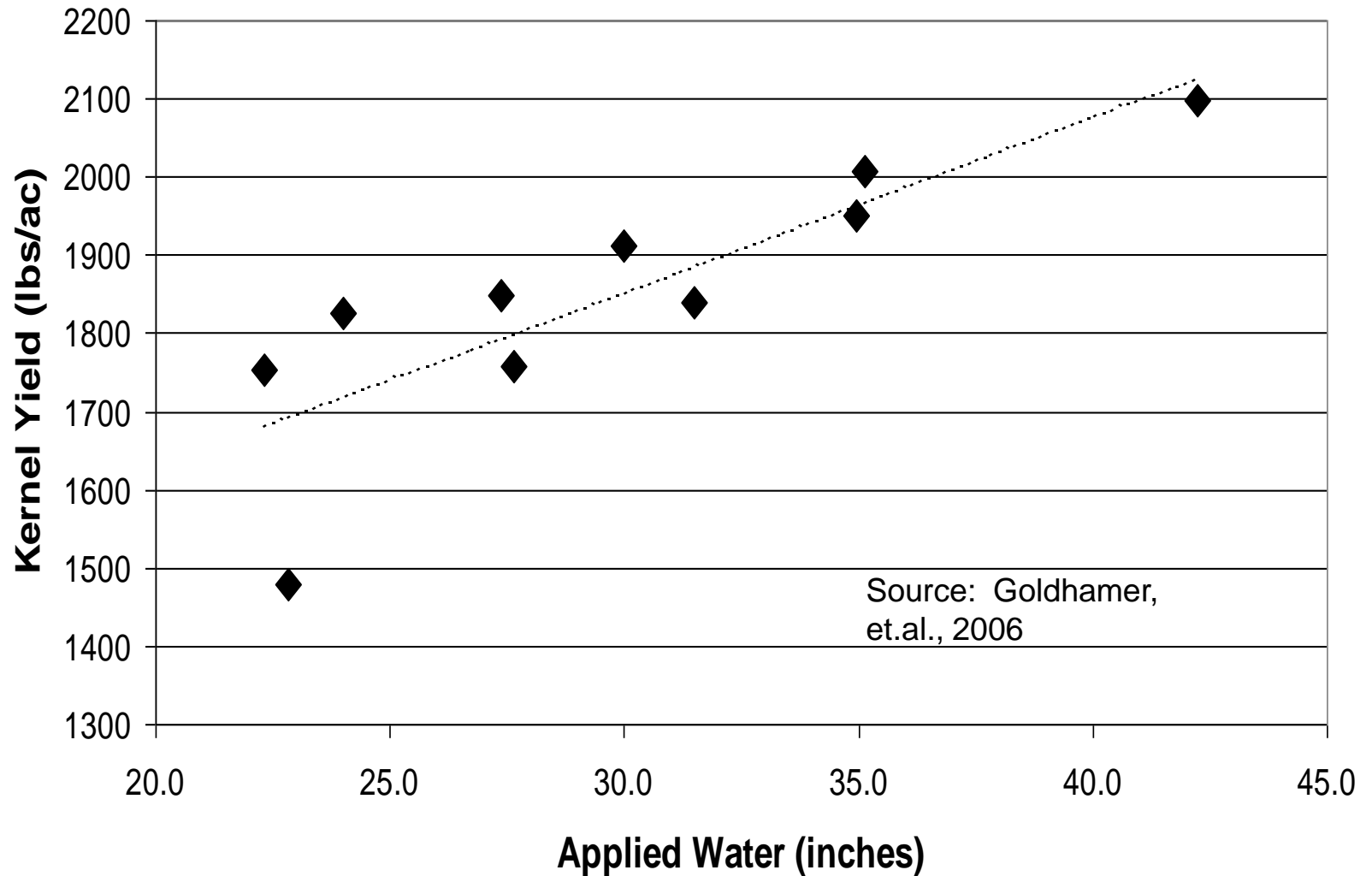
Suggested almond irrigation references:

- Goldhamer et. al., Irrig Sci, (2006) 24:101-114, RDI in almonds: the effects of variations in timing of applied water and crop stress
- Lampinen et. al., Annual Almond Industry Proceedings, 2001 – 2007, Spur dynamics and almond productivity
- Shackel et. al., Annual Almond Industry Proceedings, 2001-2004, Regulated Deficit Irrigation during hull split
- Stewart, et.al. 2010. Regulated deficit irrigation reduces water use of almonds without affecting almond yield. California Agriculture. 65(2):90-95.
- Brown et.al., June 2011. Almond irrigation, nutrition for high yield and stewardship. Report for Kern County Field Day. University of California Cooperative Extension, Kern County.
http://cekern.ucanr.edu/Irrigation_Management/Irrigation-Fertility_Almond_Field_Day_Handout_6-16-11/

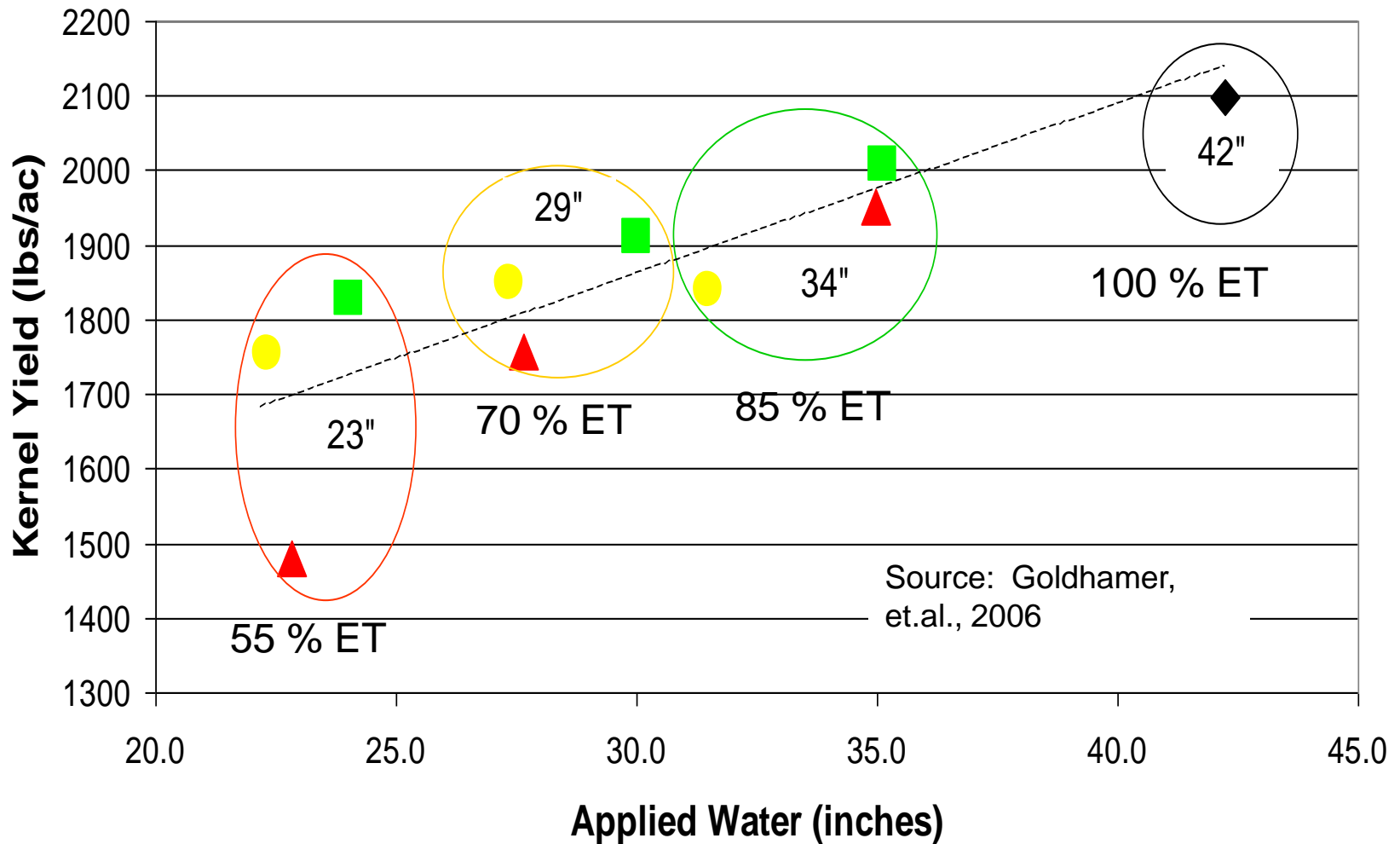
Almond Response - Tree Growth



Almond response – kernel yield



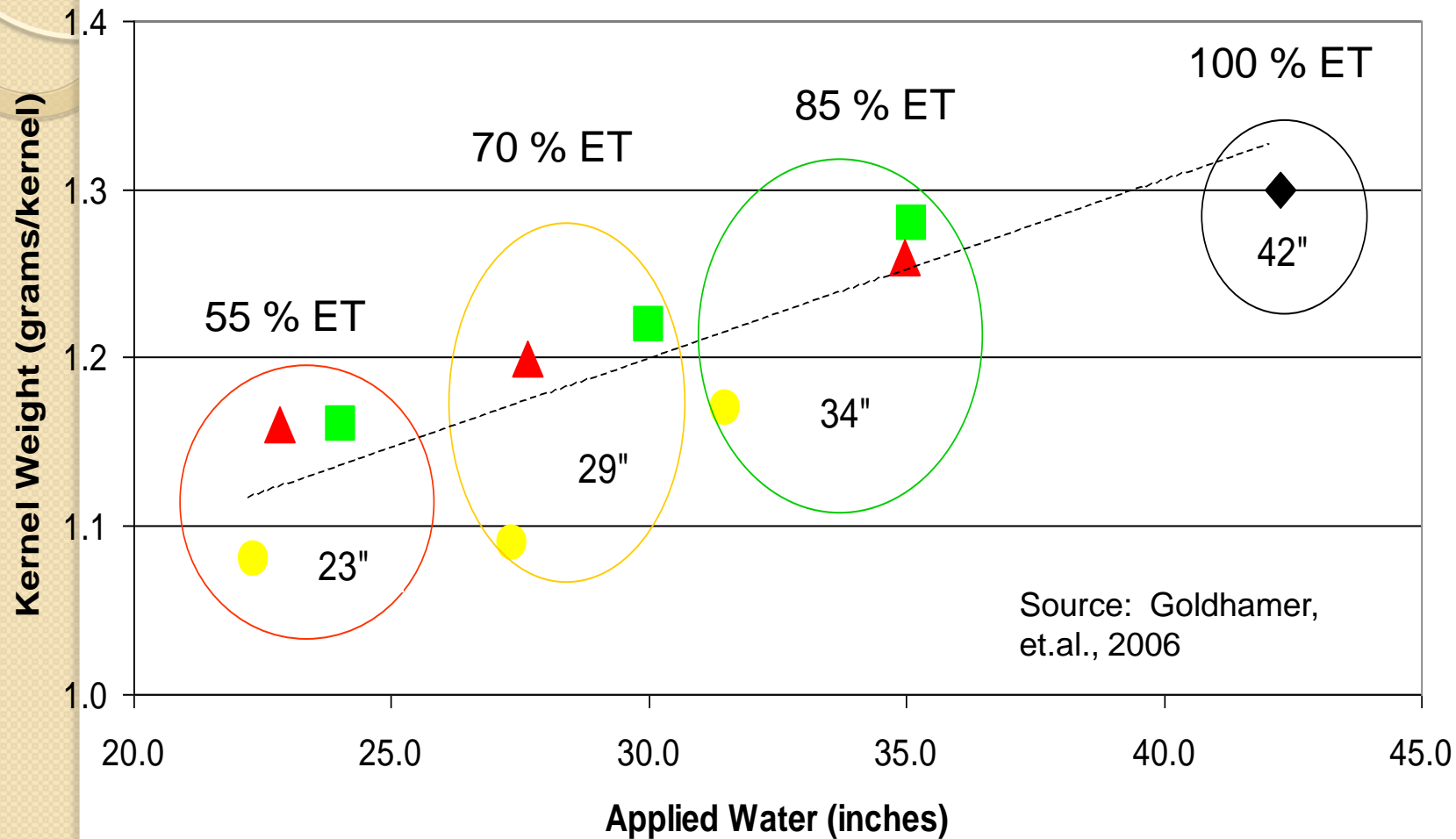
Effects of Variations in Timing of Applied Water and Crop Stress on Almond Yield



Source: Goldhamer, et.al., 2006

- ◆ Control
- Sustained deficit
- Pre-harvest deficit bias
- ▲ Post-harvest deficit bias

Effects of Variations in Timing of Applied Water and Crop Stress on Kernel Weight



Source: Goldhamer, et.al., 2006

- ◆ Control
- Sustained deficit
- Pre-harvest deficit bias
- ▲ Post-harvest deficit bias

Key variable – the effect of canopy size and light interception on ETC



Tehama 38%



Tehama 68%

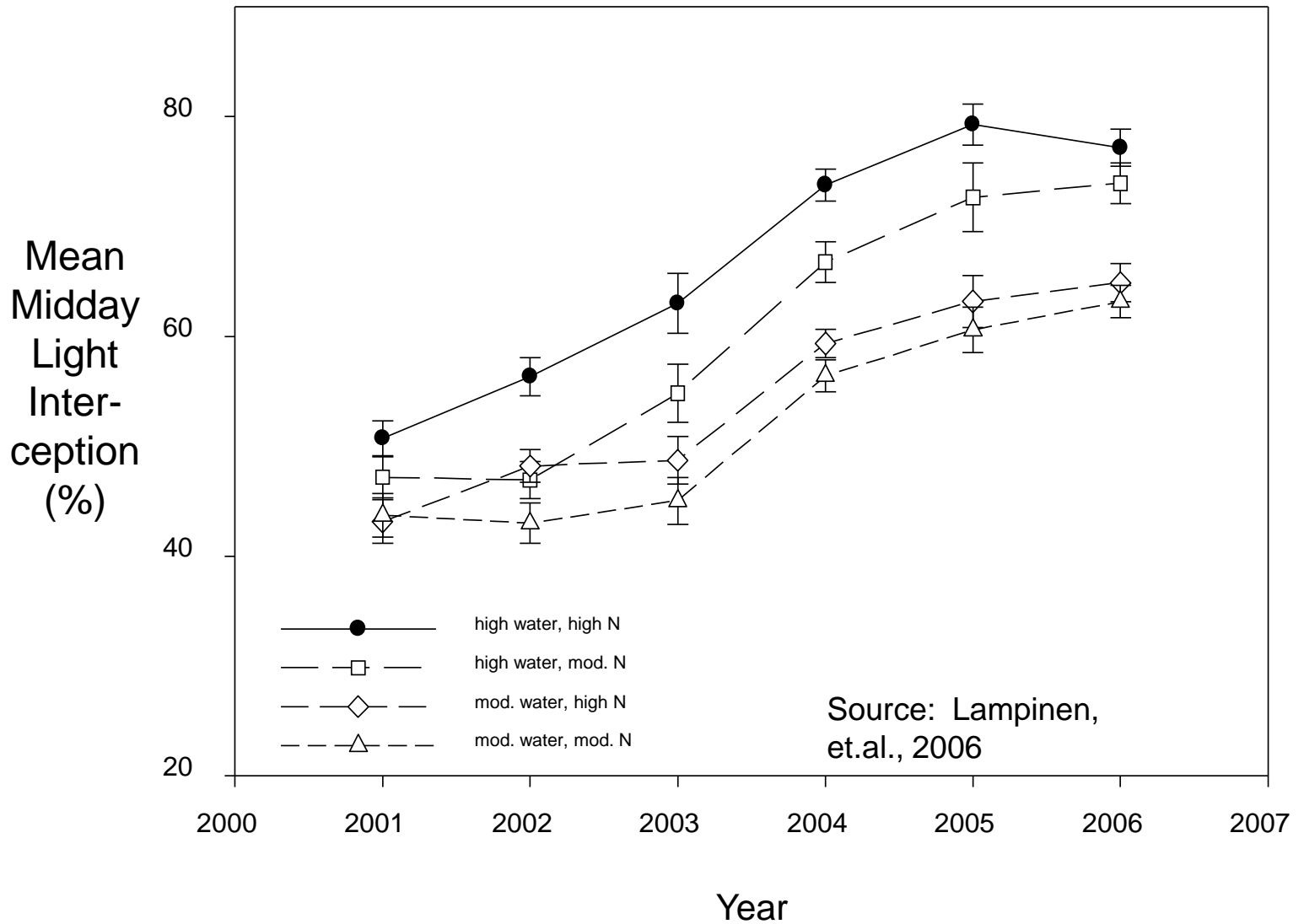


Merced 50%



Merced 73%

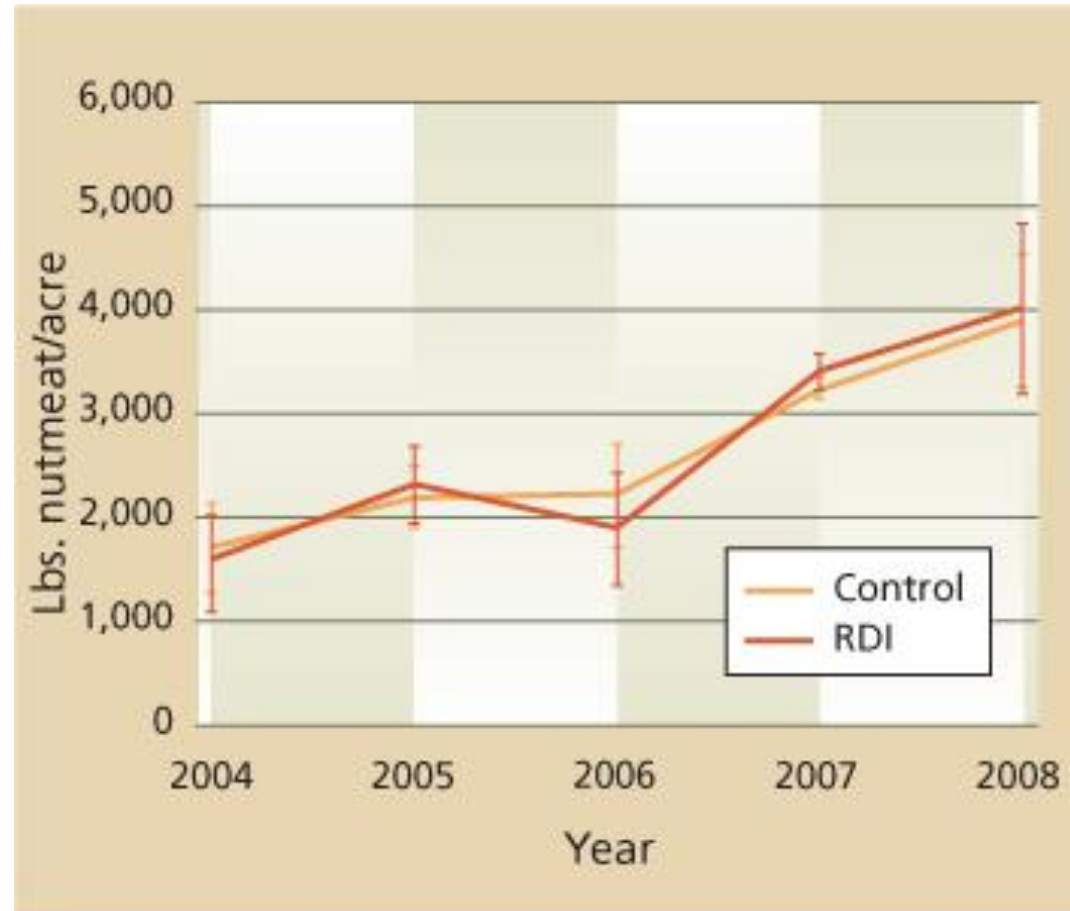
Almond Response – Canopy and Light Interception



Almond kernel yields achieved under intensive drip irrigation and fertilizer management in Kern County (Brown, et.al. 2011)

N-K fertilizer Rates (lbs/ac)	2008 Average SWP (bars)	2008 Kernel Yield (lbs/ac)	2009 Average SWP (bars)	2009 Kernel Yield (lbs/ac)	2010 Average SWP (bars)	2010 Kernel Yield (lbs/ac)
125-200	NA	NA	-9.6a	2722a	-9.8	3565a
200-200	-9.6	3260a	-9.3ab	2642a	-9.7	3779ab
275-200	-8.5	3997ab	-8.9b	3524b	-10.1	4266bc
275-300	-8.4	3839ab	-8.3c	3572b	-10.1	4069cd
350-200	-9.5	3518ab	-9.7a	3727b	-9.7	4717d
Average	-9.0	3653	-9.2	3237	-9.8	4079
LSD 0.05	1.1	715	0.6	752	0.5	457
Average ET _c Supplied (inches)	55.9		58.2		56.9	

Annual pattern of nutmeat yield from 2004-2008 in Glenn County orchard with and without RDI.



Five year average nutmeat yield was 2640 lbs/ac in both control and RDI treatments.

Five year average seasonal SWP patterns and ET_c estimates in 9th – 14th leaf almonds that were and were not deficit irrigated in Glenn County, CA

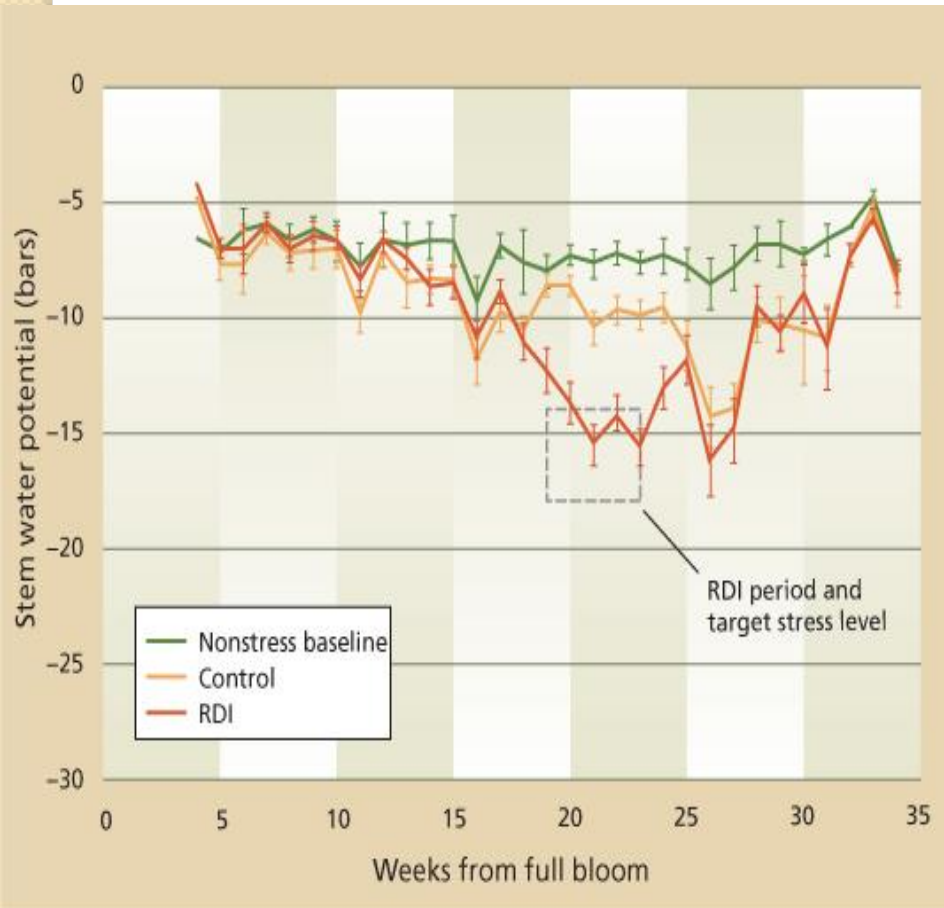


TABLE 2. Consumptive water use and overall percentage savings, 2005–2008

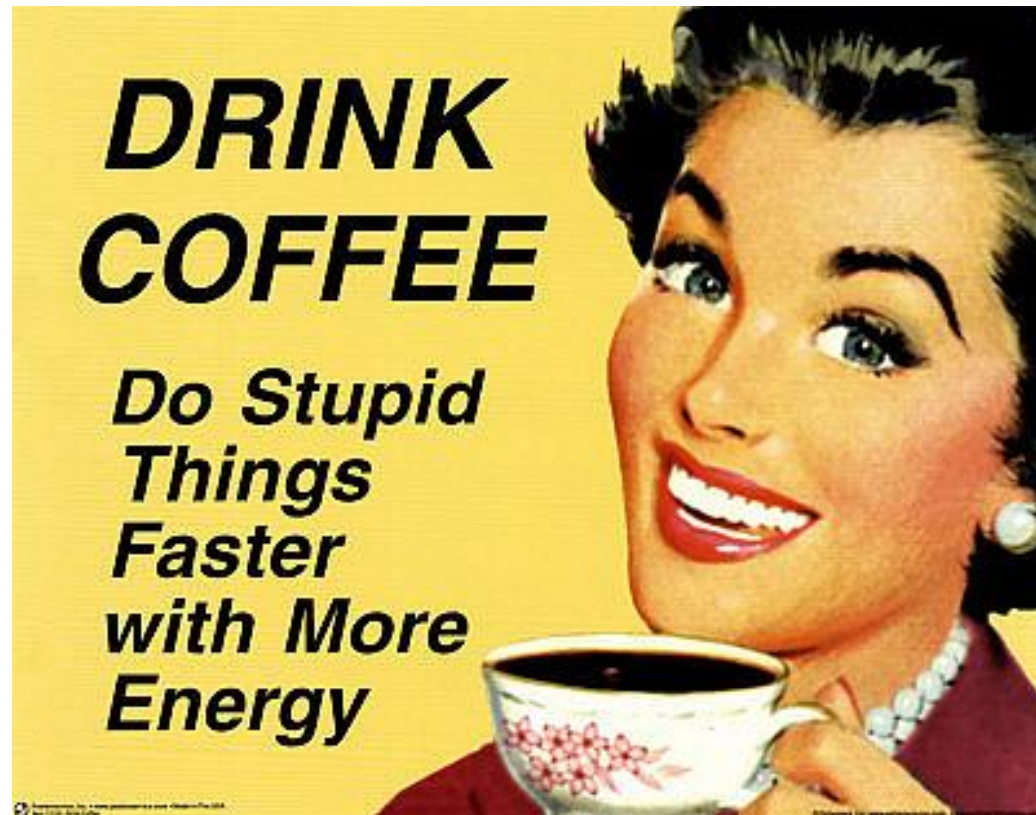
Year	Treatment	Consumptive use	Savings
		<i>inches (cm)</i>	<i>%</i>
2005	RDI*	34.6 (87.9)	15
	Control	40.2 (102.1)	
2006	RDI	36.0 (91.4)	13
	Control	41.6 (105.7)	
2007	RDI	47.1 (119.6)	10
	Control	52.3 (132.8)	
2008	RDI	42.6 (108.2)	13
	Control	48.7 (123.7)	

* Regulated deficit irrigation.

Almond summary points

- Amidst a changing paradigm in irrigation management of almonds
- Microsprinkler/drip irrigation, fertigation, non-pruning systems and other cultural practices are resulting in higher larger orchard canopies and more light interception.
- A trend is developing towards higher production potential and water consumption (ET_c)
- Questions exist about sustainability
 - Excessive shading causing orchards to go vegetative with substantial drop off in yield that is difficult to correct
 - Higher incidence of alternaria and hull rot diseases
 - Higher incidence of root diseases and shorter life span of orchards
- Information concerning RDI strategies still valuable in instances of water shortages

Break (5-10 minutes)





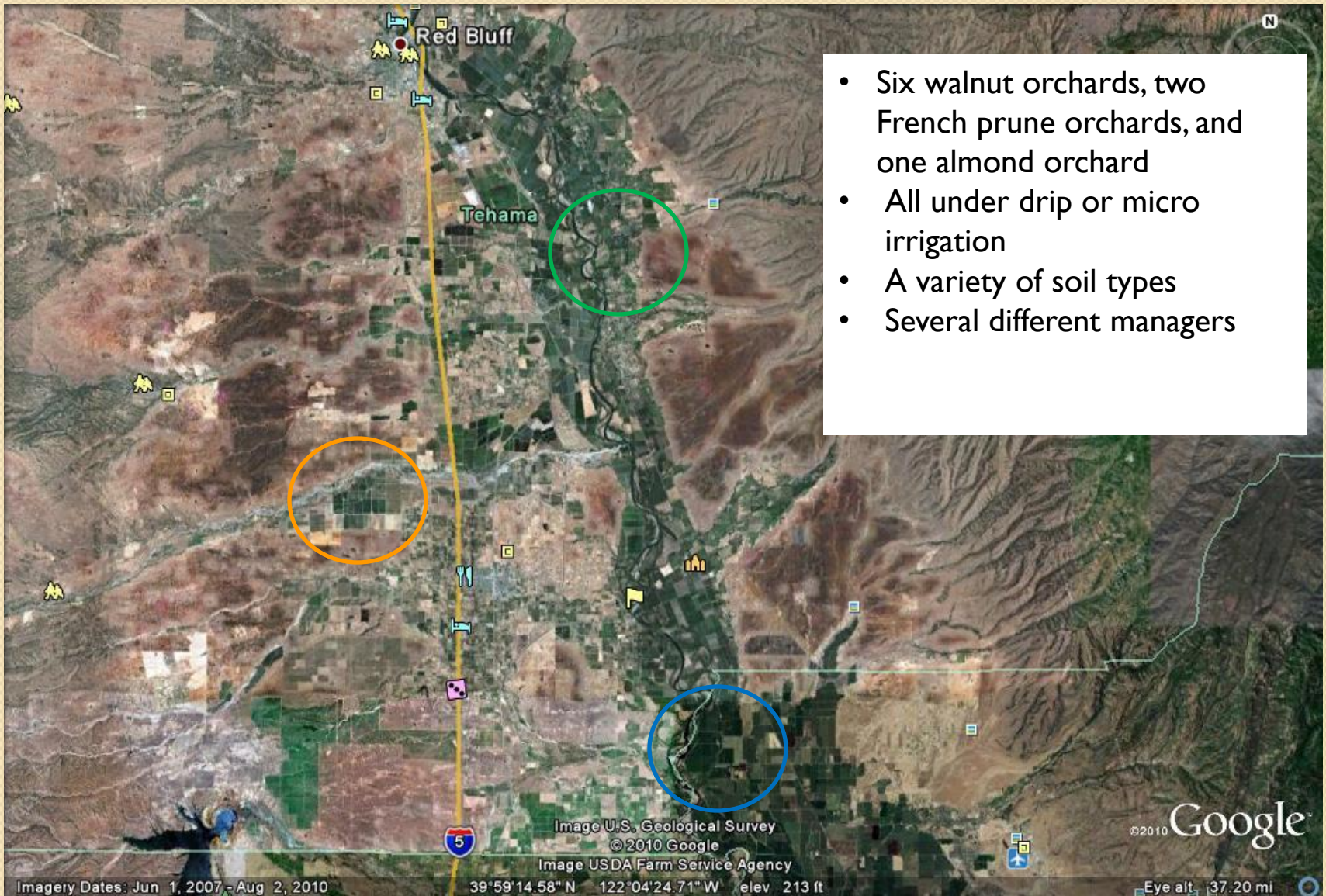
Experience with Irrigation Scheduling Tools in Walnuts, Almonds, and Prune

- 2 walnut case studies
- 1 almond case study
- 1 prune case study

Types of irrigation scheduling tools

Method	Scientific Discipline
Soil moisture depletion	Soil science, agronomy
Orchard water status (pressure chamber and midday stem water potential)	Horticulture, plant physiology
Water budget (Compare ET _c to applied water, in-season rain, and soil storage)	Biometeorology, engineering

Note: Research and development of each of these irrigation scheduling methods dates back to 1960 or earlier. All three methods are linked together by the “soil-plant-atmospheric continuum”



Field Study Areas, 2008-2011

Water budget (compared applied water, in-season rainfall, stored soil moisture to ETC)

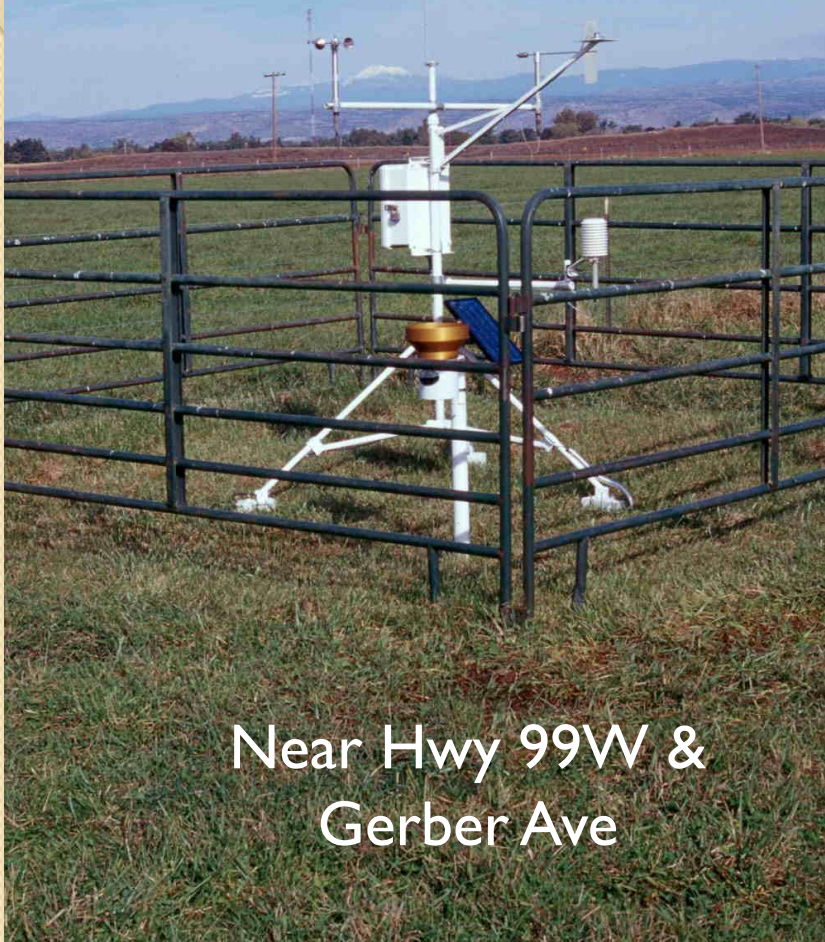


Measure applied water



Mobile Irrigation Lab

Grass reference
evapotranspiration
 ET_0



Near Hwy 99W &
Gerber Ave

DATE	WALNUT K_c^1	ALMOND K_c^2
Mar 1-15	NA	0.57
Mar 15-31	NA	0.69
Apr 1-15	0.12	0.81
Apr 16-30	0.53	0.91
May 1-15	0.68	0.95
May 16-31	0.79	0.96
June 1-15	0.86	0.96
June 16-30	0.93	0.96
July 1-15	1.00	0.96
July 16-31	1.14	0.96
Aug 1-15	1.14	0.95
Aug 16-31	1.14	0.93
Sept 1-15	1.08	0.84
Sept 16-30	0.97	0.86
Oct 1-15	0.88	0.68
Oct 16-31	0.51	0.58
Nov 1-15	0.28	0.53

¹ Goldhamer, et.al., 1996,

² Snyder and Pruitt, 1989

What is a Kc? $Kc = (ETc/Eto)$, assumes soil moisture is not limiting



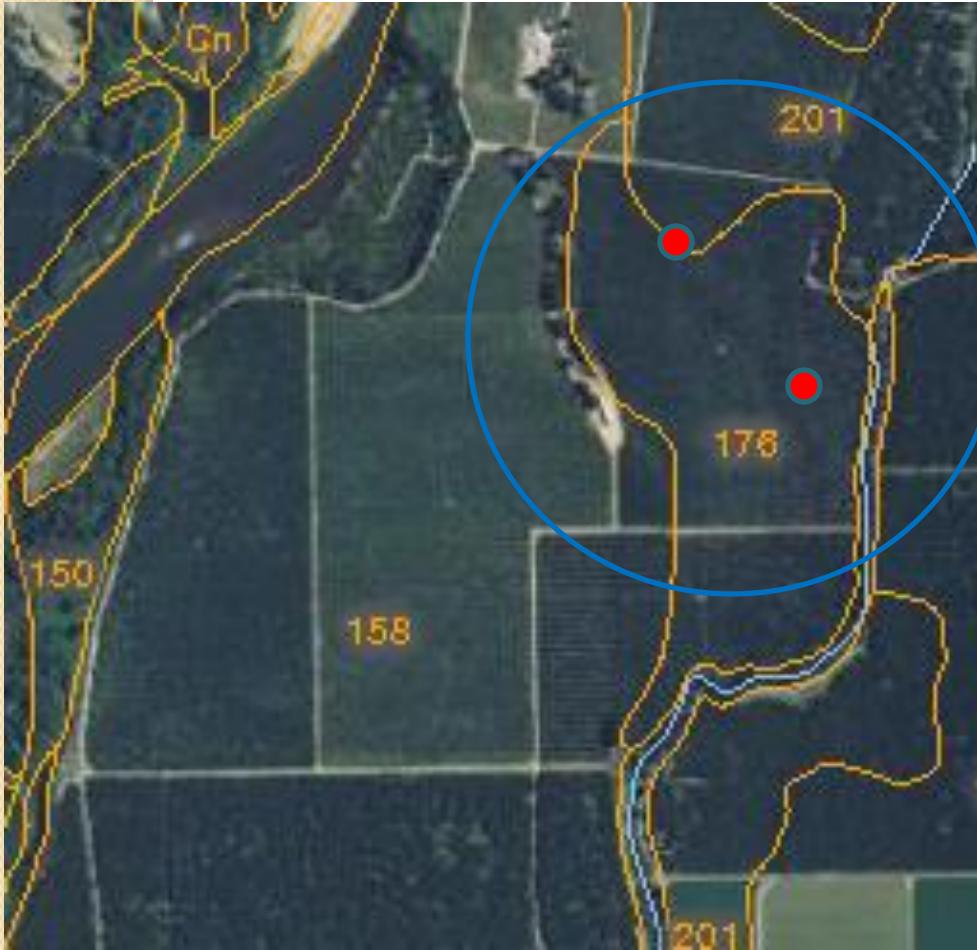
Monitor soil moisture depletion, one-foot increments, six foot composite



Weekly measurement of Orchard Stress (pressure chamber, midday SWP)



Vina Area Case Study

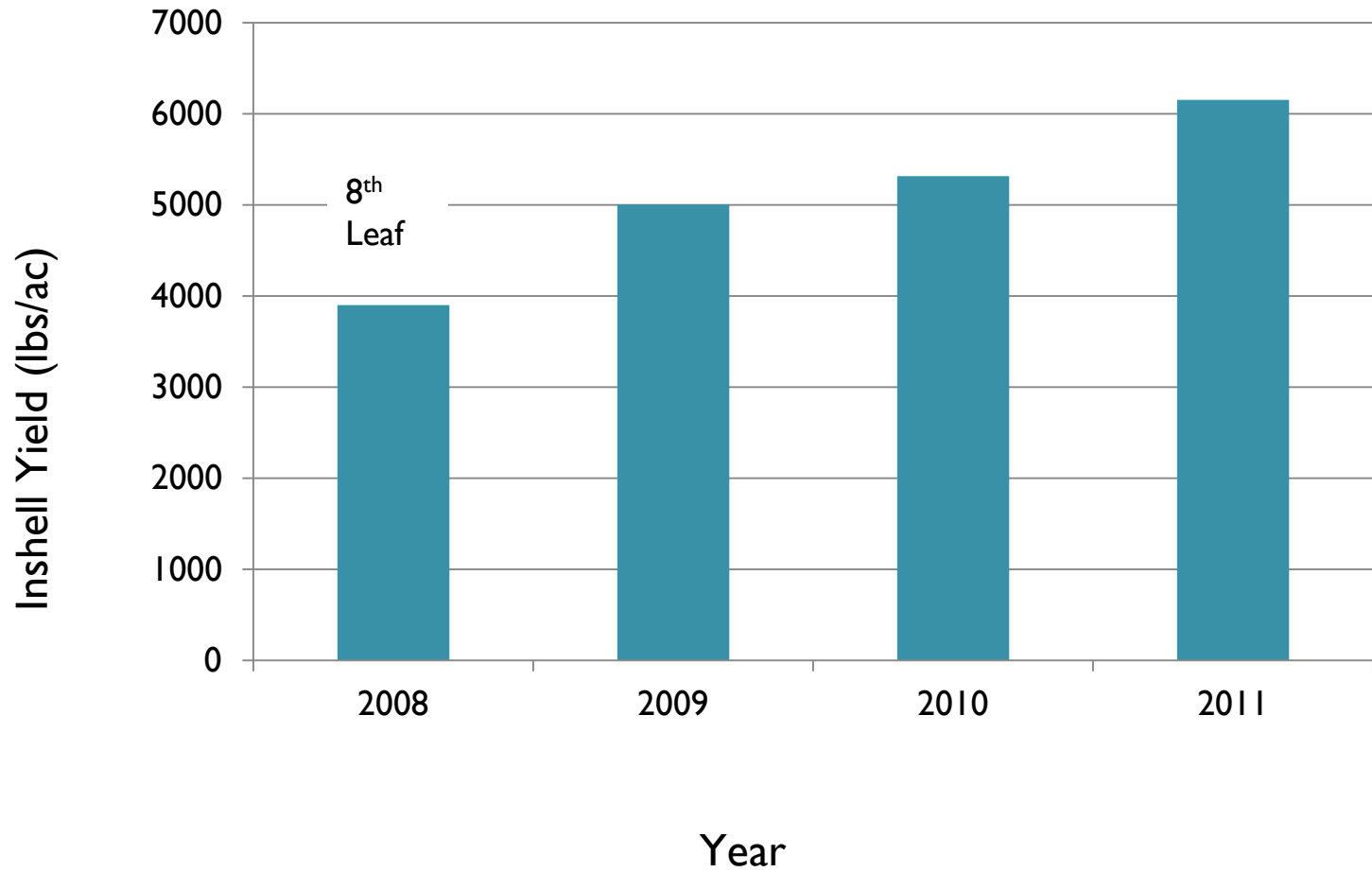


Background

- Howard variety, 122 acres
- Planted in 2001
- 80 % Farwell loam
- Gianella fine sandy loam
- Nelson R-5 minisprinkler
- Irrigated approximately one time per week mid summer

Production Background

Inshell Yield (lbs/ac)

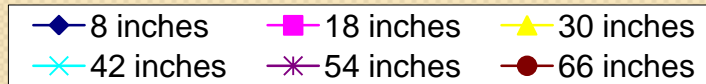
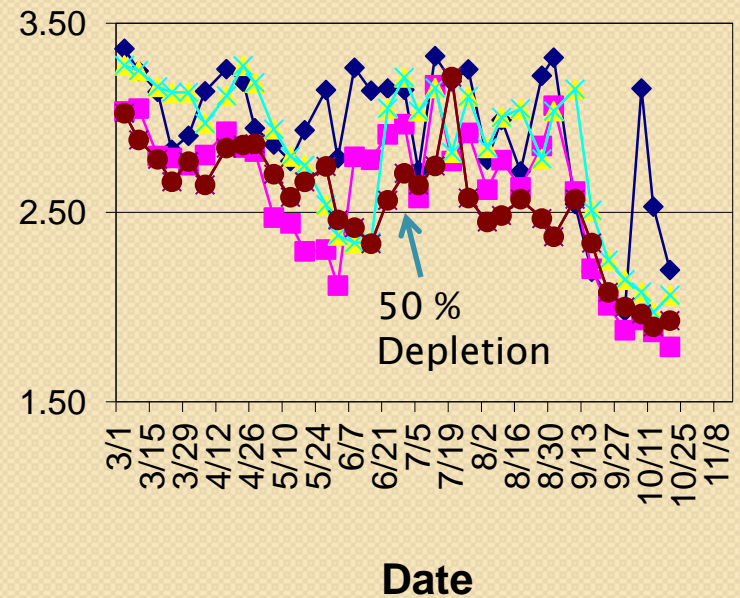
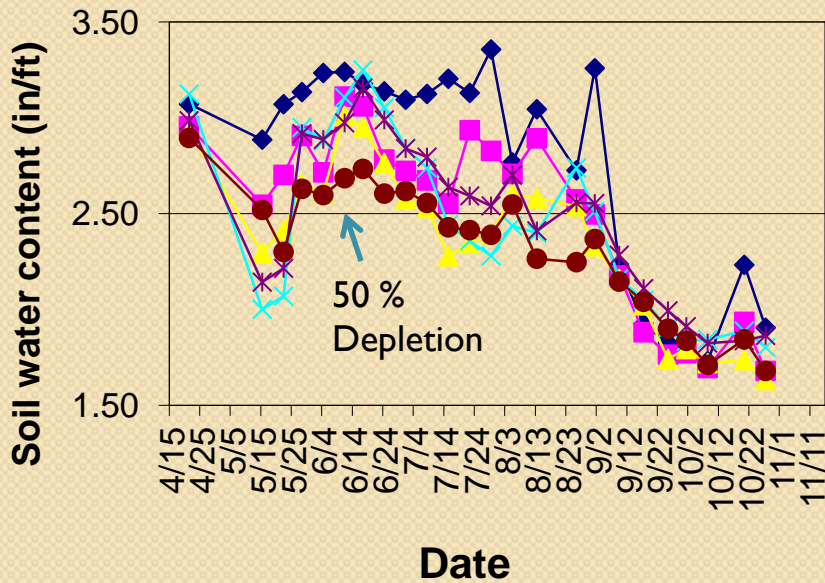


Water Budget Summary for Vina Site

Year	Cumulative Walnut ETc	Measured Cumulative Applied Water	Effective In-season rainfall ¹	Needed soil storage contribution	Cumulative ETc Supplied
	----- INCHES -----				
2009	41.9	33.4	2.5	6.0	100
2010	39.4	31.1	4.5	3.8	100

¹ Assumed 60 percent of total in-season rainfall to effectively contribute to ETc.

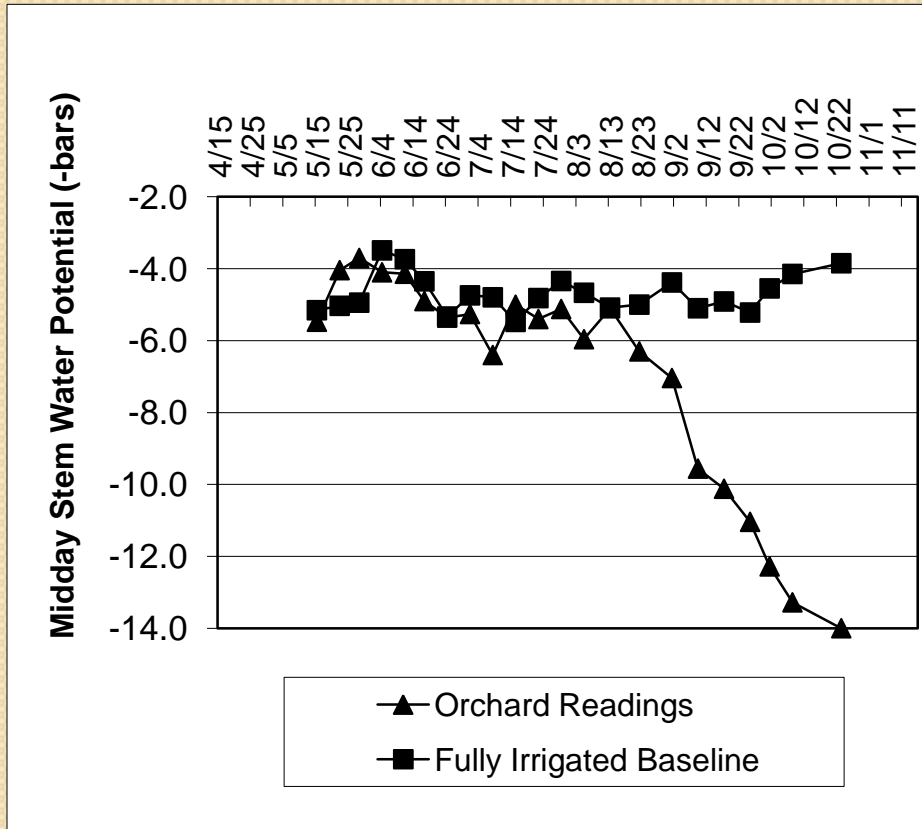
Summary of Soil Moisture Depletion



2009

2010

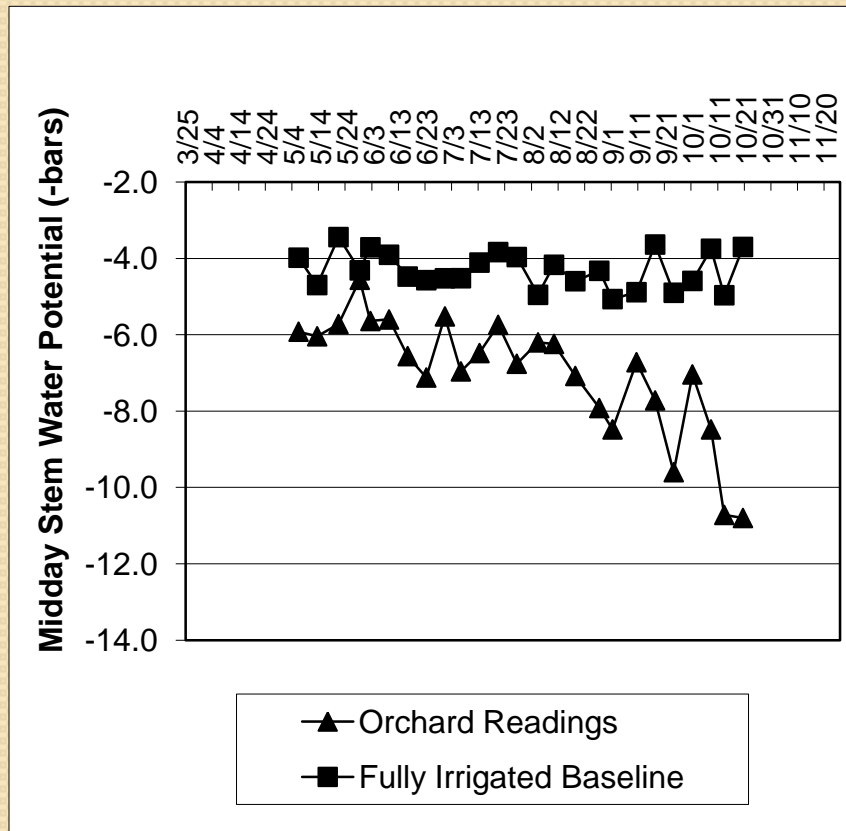
Summary of orchard water status (pressure chamber)



2009

Pressure Chamber Reading (- bars)	WALNUT
0 to -2.0	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 (ET _c), 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.
-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.

Summary of orchard water status (pressure chamber)



2010

Pressure Chamber Reading (- bars)	WALNUT
0 to -2.0	Not commonly observed
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-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.

Los Molinos Case Study

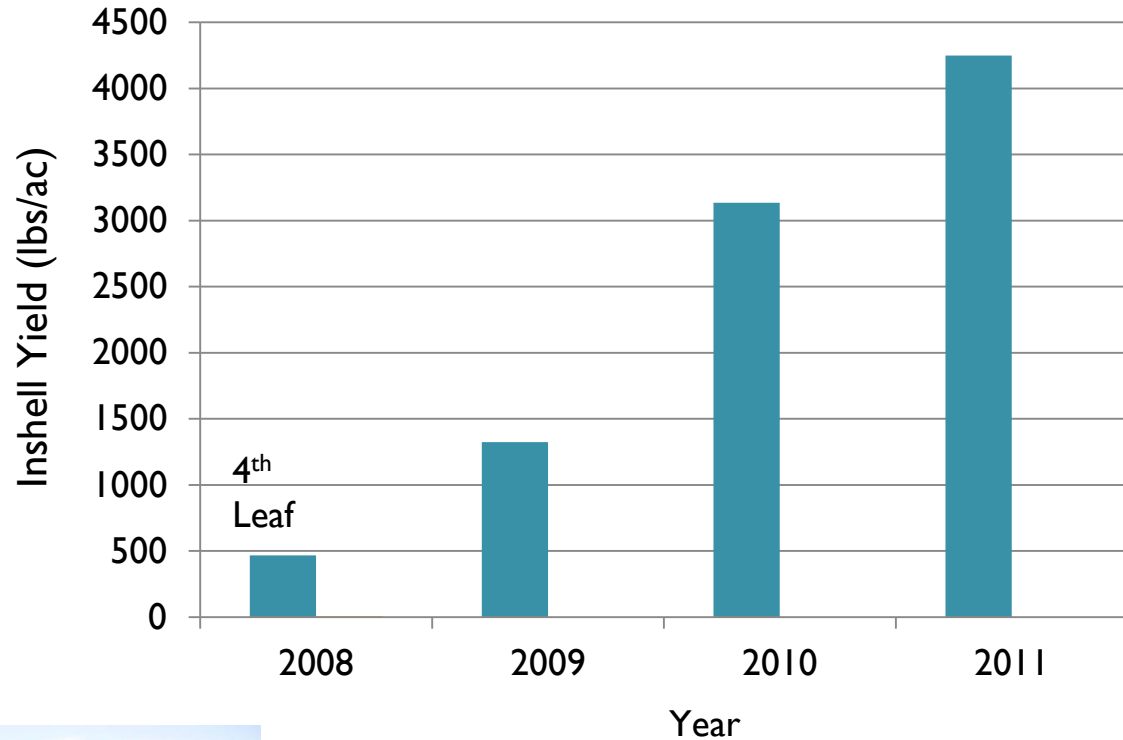


Background

- Chandler variety, 18 acres
- Planted in 2005
- 95 % Vina loam
- Nelson R-5 minisprinklers
- Relatively, delayed when beginning the irrigation season except for frost protection
- Irrigate approximately every 7 to 9 days during mid summer
- Concerned with root health and tree loss

Production Background

Los Molinos Area Walnut Case Study, 4th through 7th
leaf - Inshell Yield (lbs/ac)

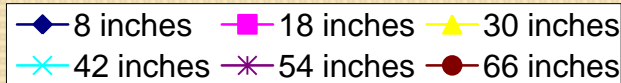
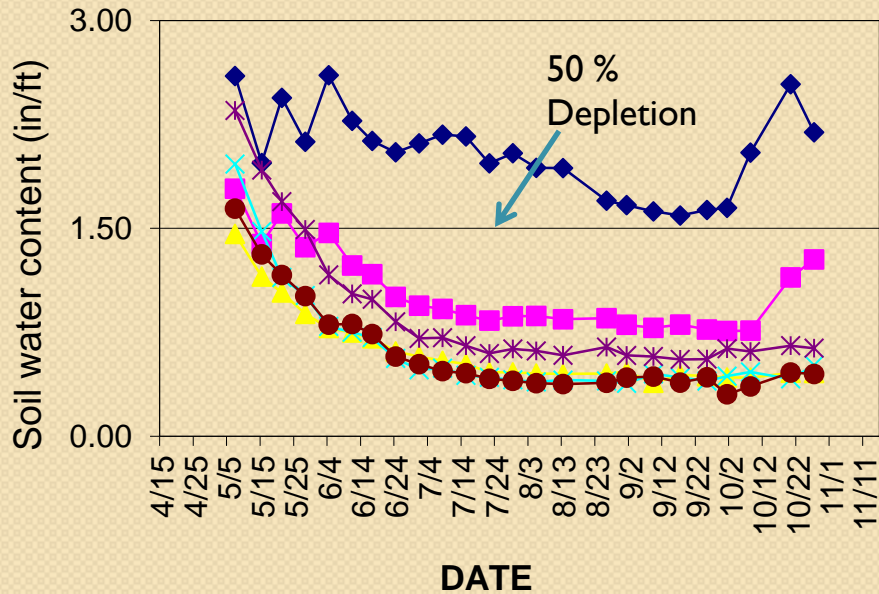


Water Budget Summary for Los Molinos Site

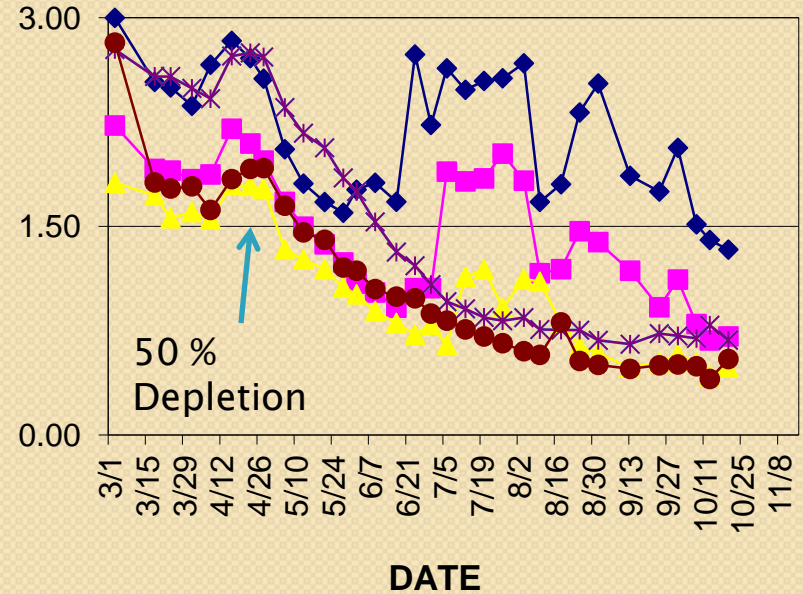
Year	Cumulative Walnut ETc	Measured Cumulative Applied Water	Effective In-season rainfall ¹	Needed soil storage contribution	Cumulative ETc Supplied
	INCHES				
2009	41.9	28.2	2.5	11.2	100
2010	39.4	20.1	4.5	14.8	100
2011	39.0	22.6	3.9	12.5	100

¹ Assumed 60 percent of total in-season rainfall to effectively contribute to ETc.

Summary of Soil Moisture Depletion

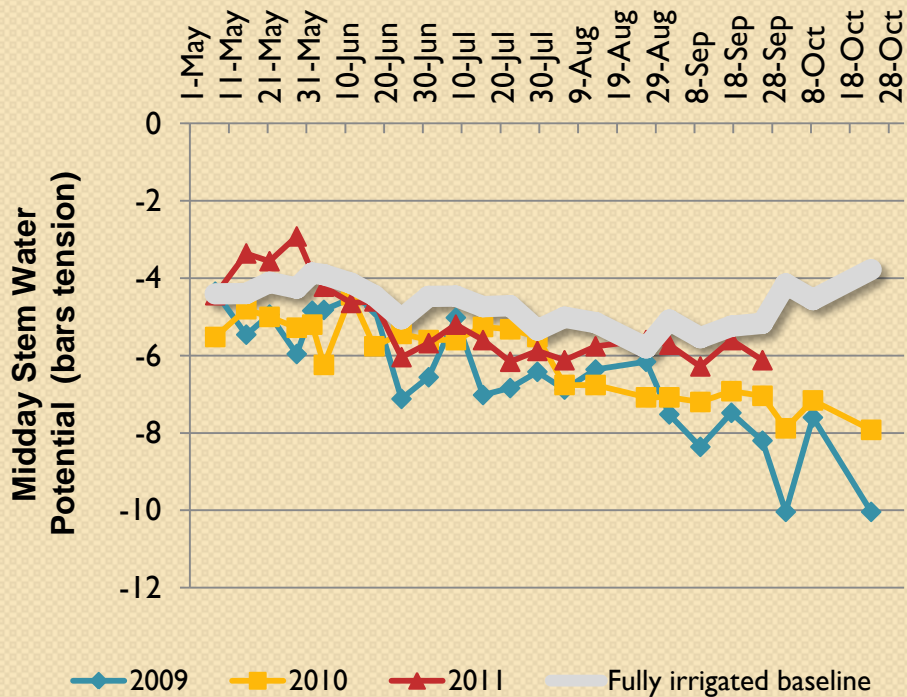


2009



2010

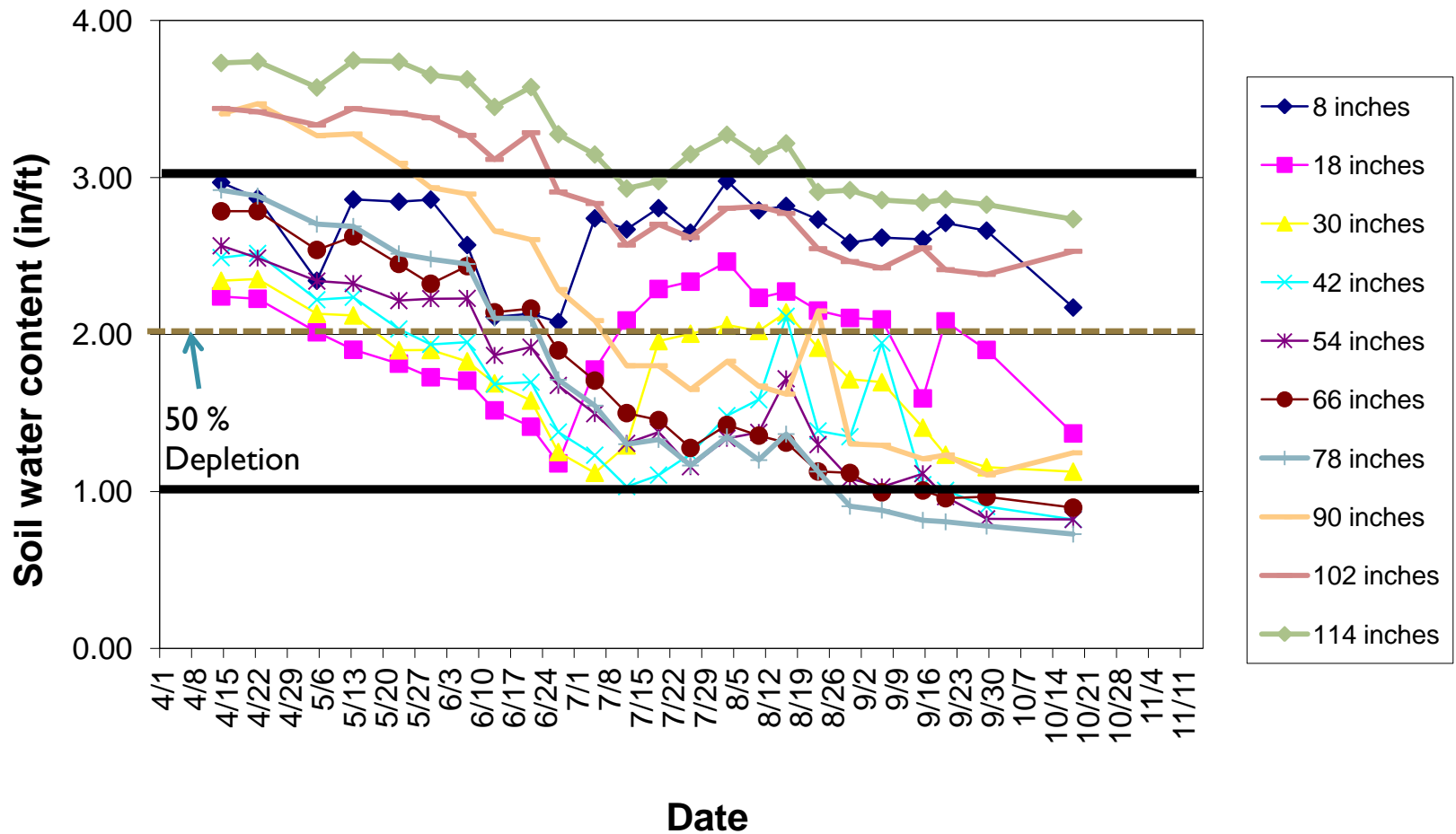
Summary of orchard water status (pressure chamber)



2009-11

Pressure Chamber Reading (- bars)	WALNUT
0 to -2.0	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.
-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.

2011 Soil Moisture Depletion



Corning Area Case Study

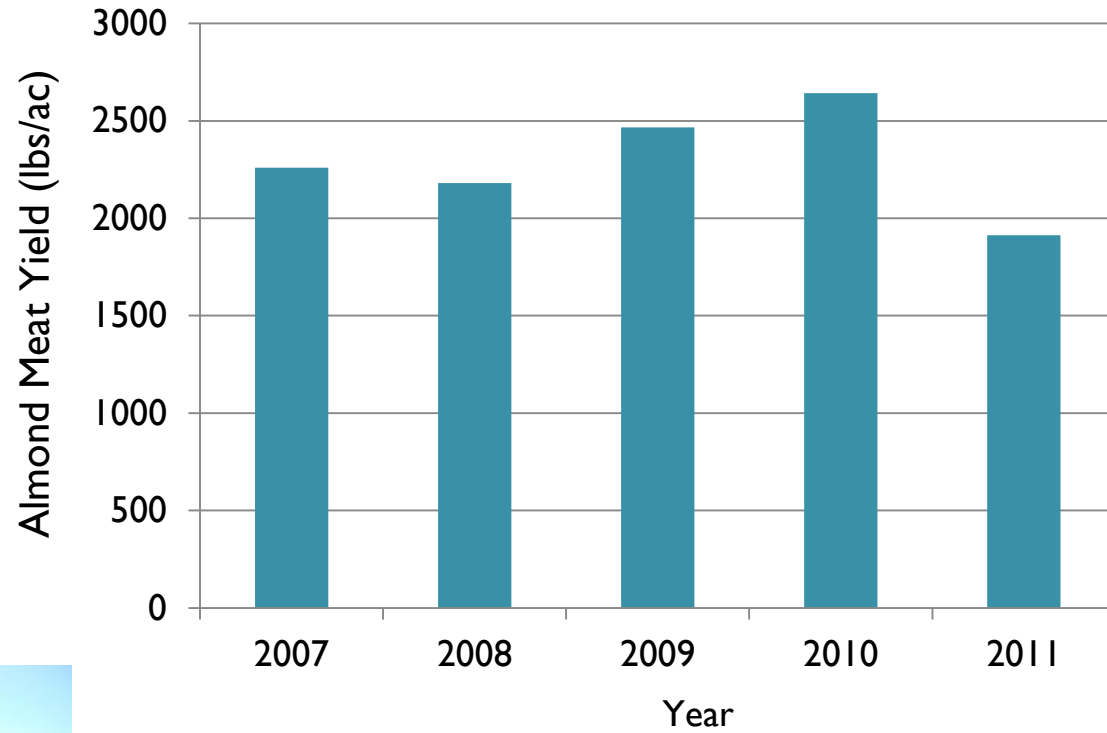


Background

- Butte, Padre, Mission almonds
- 45 acres
- Planted in 1996 (N), 1997 (S)
- 70 % Tehama silt loam
- 30 % Arbuckle gravelly loam
- Rainbird, 14 gph microsprinkler

Production Background

Corning Area Almond Case Study - Meat Yield (lbs/ac)



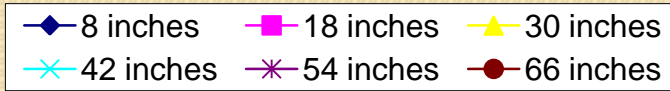
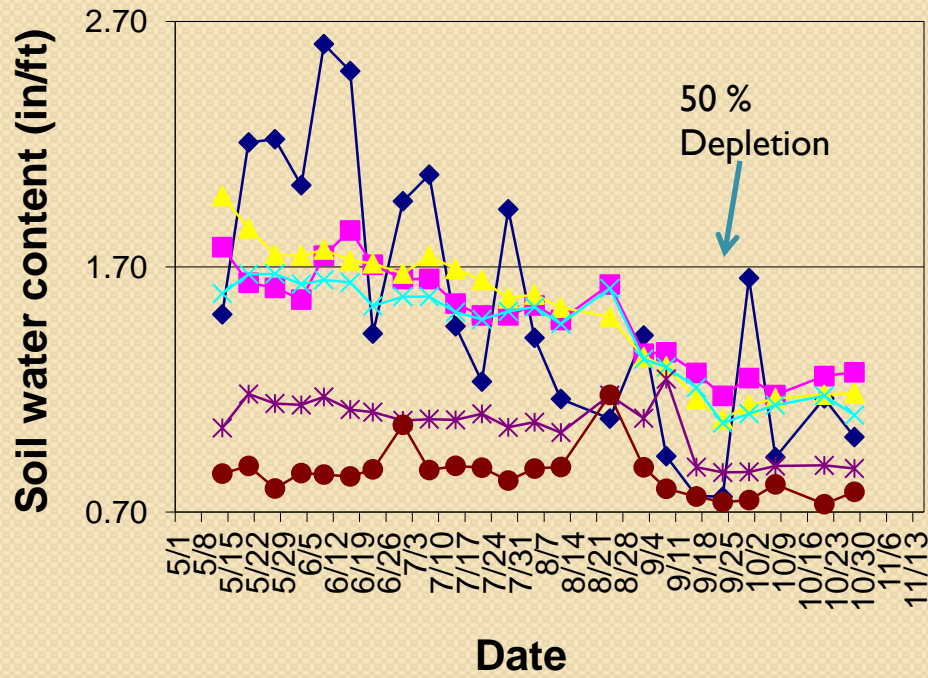
Water Budget Summary for Corning Site

Year	Cumulative Walnut ETc	Measured Cumulative Applied Water	Effective In-season rainfall ¹	Needed soil storage contribution	Cumulative ETc Supplied
----- INCHES -----					
2008	42.2	43.9	1.6	0.0	108
2009	43.5	45.3	3.4	0.0	112
2010	40.7	40.7	5.0 ²	0.0	112
2011	38.9	31.5	7.2 ²	0.2	99

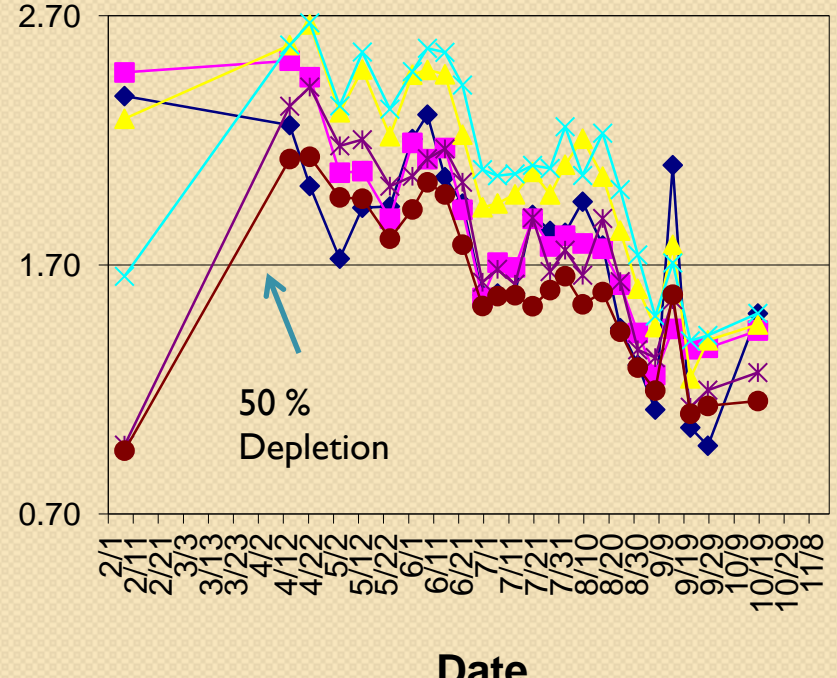
¹ Assumed 60 percent of total in-season rainfall to effectively contribute to ETc.

² Most likely in-season rainfall was less effective than assumption of 60 percent.

Summary of Soil Moisture Depletion

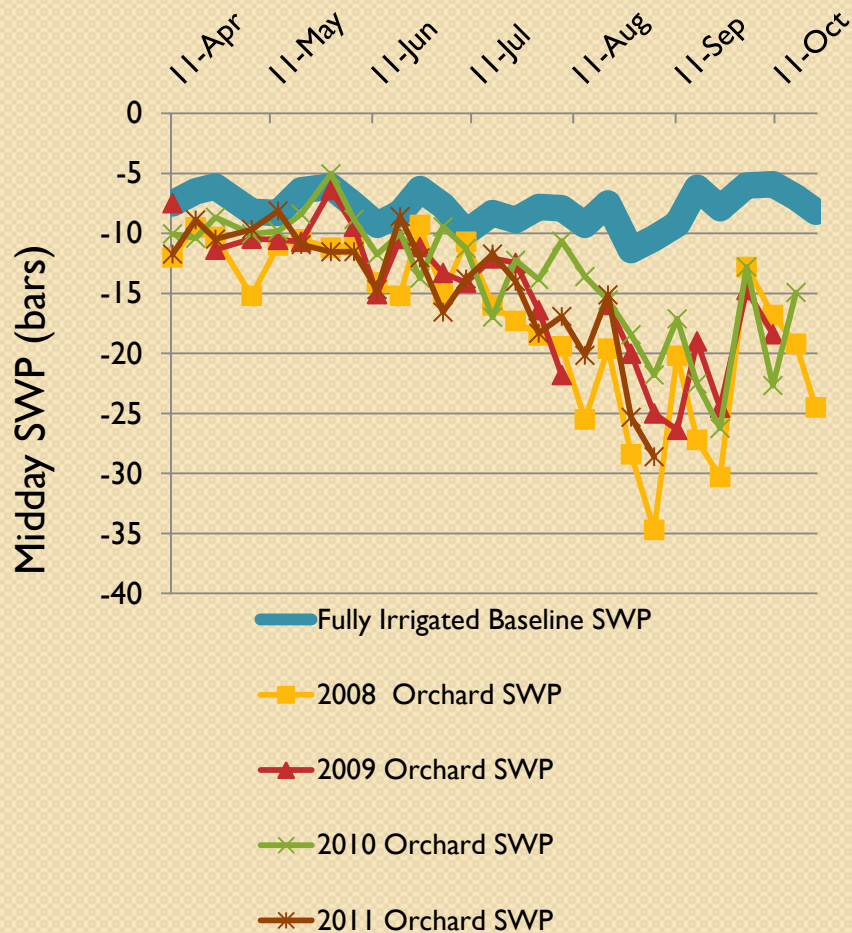


2009



2011

Summary of orchard water status (pressure chamber)

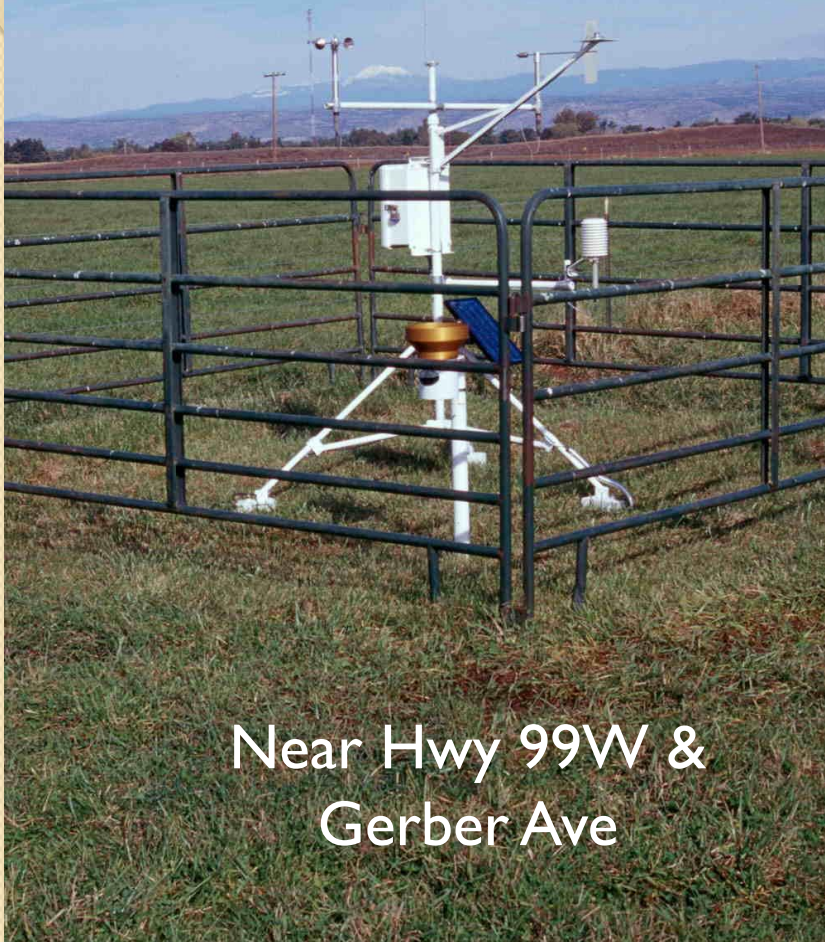


2008-11

Pressure Chamber Reading (- bars)	ALMOND
0 to -6.0	Not commonly observed
-6.0 to -10.0	Low stress, indicator of fully irrigated conditions, ideal conditions for shoot growth. Suggest maintaining these levels from leaf-out through mid June.
-10.0 to -14.0	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).
-14.0 to -18.0	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
-18.0 to -20.0	Transitioning from moderate to higher crop stress levels
-20 to -30	High stress, wilting observed, some defoliation
Less than -30	Extensive defoliation has been observed

* 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.

Grass reference
evapotranspiration
 ET_0



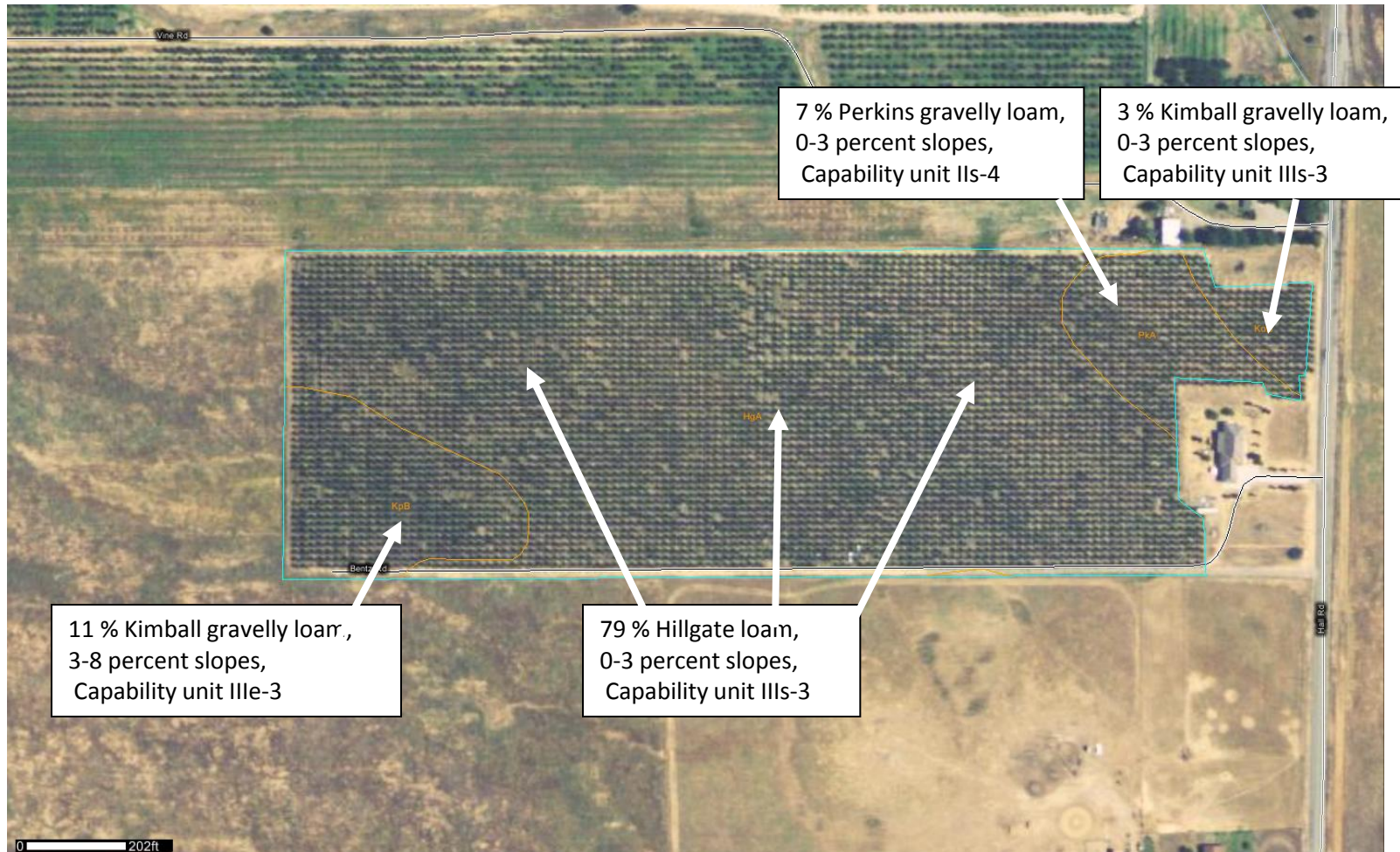
Near Hwy 99W &
Gerber Ave

DATE	ALMOND K_c^1	ALMOND K_c^2
Mar 1-15	0.57	0.54
Mar 15-31	0.69	0.77
Apr 1-15	0.81	0.94
Apr 16-30	0.91	0.99
May 1-15	0.95	1.02
May 16-31	0.96	1.04
June 1-15	0.96	1.08
June 16-30	0.96	1.11
July 1-15	0.96	1.11
July 16-31	0.96	1.11
Aug 1-15	0.95	1.11
Aug 16-31	0.93	1.06
Sept 1-15	0.84	0.93
Sept 16-30	0.86	0.77
Oct 1-15	0.68	0.65
Oct 16-31	0.58	0.52
Nov 1-15	0.53	0.28

¹ Pruitt and Snyder, 1989

² Sanden, et. al., 2011 (tentative)

Prune orchard site – 28.5 acres managed by first generation grower



Other orchard features -

- Located west of Sacramento River and northeast of Corning
- ½ planted in 1996, other ½ in 1997
- Myrobalan seedling rootstock
- 183 trees per acre (17 ft between rows, 14 ft in row)
- Single line drip irrigation
 - 30 inch in-line emitter spacing, 5.6 emitters per tree at 0.6 gph
 - Average hourly water application rate 0.023 in/hr, 90 % DU
- Fertilizer practices
 - 500 lbs potassium sulfate banded per acre annually
 - 200 lbs N/ac annually as UAN-32 through drip system
 - Use mid summer tissue testing to adjust

First approximation of weekly irrigation needs

Saturday, July 30, 2011 - Daily News 5A

Agriculture farm & ranch

WEEKLY SOIL MOISTURE LOSS IN INCHES

(Estimated Evapotranspiration)

07/22/11 through 07/28/11

West of Sacramento River			East of Sacramento River		
Weekly Water Use	Accum'd Seasonal Use	Crop (Leafout Date)	Weekly Water Use	Accum'd Seasonal Use	
1.84	26.60	Pasture	1.61	23.93	
1.77	25.71	Alfalfa	1.54	23.05	
1.38	20.10	Olives	1.20	18.08	
1.21	17.33	Citrus	1.05	15.54	
1.77	24.86	Almonds (3/1) *	1.54	22.26	
1.77	24.83	Prunes (3/15) *	1.54	22.24	
2.12	21.76	Walnuts (4/1) *	1.82	19.24	
1.72	25.06	Urban Turf Grass	1.54	22.68	

Accumulations started on March 27, 2011. Criteria for beginning this report are based on the season's last significant rainfall event where the soil moisture profile is at full capacity.
* Estimates are for orchard floor conditions where vegetation is managed by some combination of strip applications of herbicides, frequent mowing or tillage, and by mid and late season water stress. Weekly estimates of soil moisture loss can be as much as 25 percent higher in orchards where cover crops are planted and managed for maximum growth.*

0.00	Precipitation (Inches)	0.00
4.77	Accum'd Precip (Inches)	5.40

WEEKLY APPLIED WATER IN INCHES¹

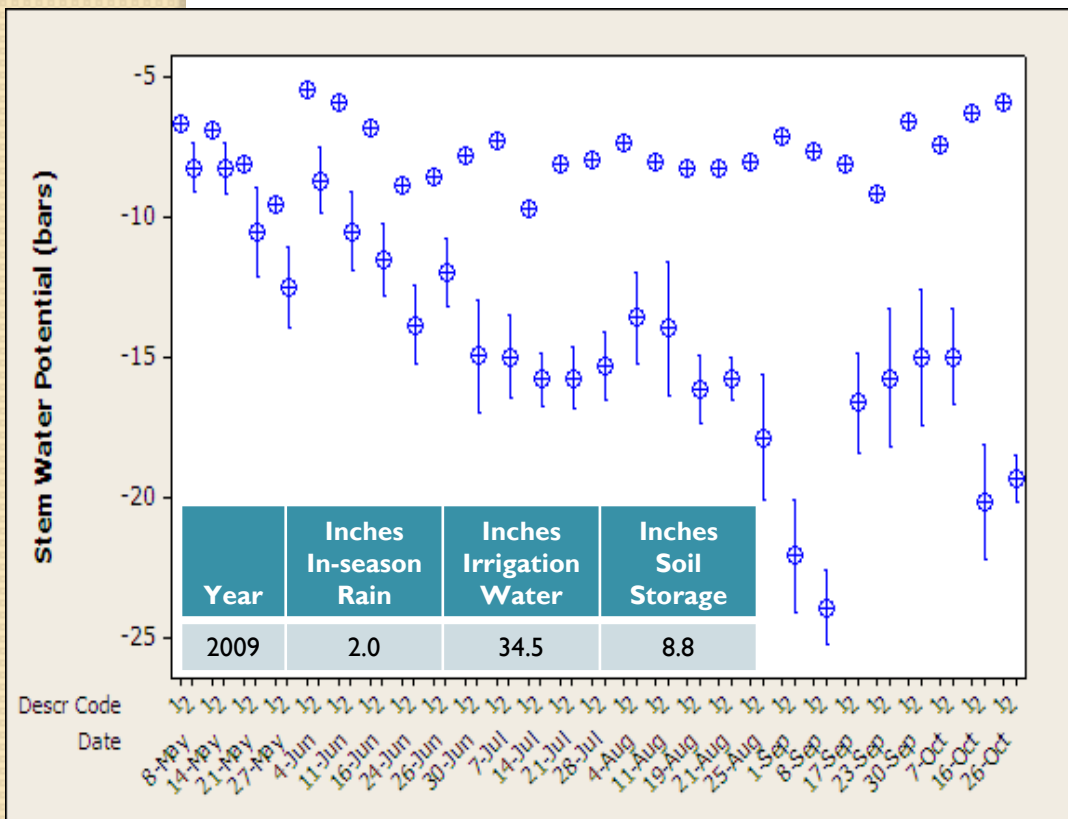
50%	60%	70%	80%	90%	← Efficiency →	50%	60%	70%	80%	90%
2.8	2.3	2.0	1.7	1.5	Olives	2.4	2.0	1.7	1.5	1.3
2.4	2.0	1.7	1.5	1.3	Citrus	2.1	1.8	1.5	1.3	1.2
3.5	3.0	2.5	2.2	2.0	Almonds (3/1)	3.1	2.6	2.2	1.9	1.7
3.5	3.0	2.5	2.2	2.0	Prunes (3/15)	3.1	2.6	2.2	1.9	1.7
4.2	3.5	3.0	2.7	2.4	Walnuts (4/1)	3.6	3.0	2.6	2.3	2.0

¹ The amount of water required by a specific irrigation system to satisfy evapotranspiration. Typical ranges in irrigation system efficiency are: Drip irrigation, 80%-95%; Micro-sprinkler, 80%-90%; Sprinkler, 70%-85%; and Border-furrow, 50%-75%.

For further information concerning all counties receiving this report, contact the Tehama Co. Farm Advisor's office at (530) 527-3101.

Date	Current Kc's for French prune
3/16	0.55
5/5	0.96
8/17	0.95
10/31	0.53

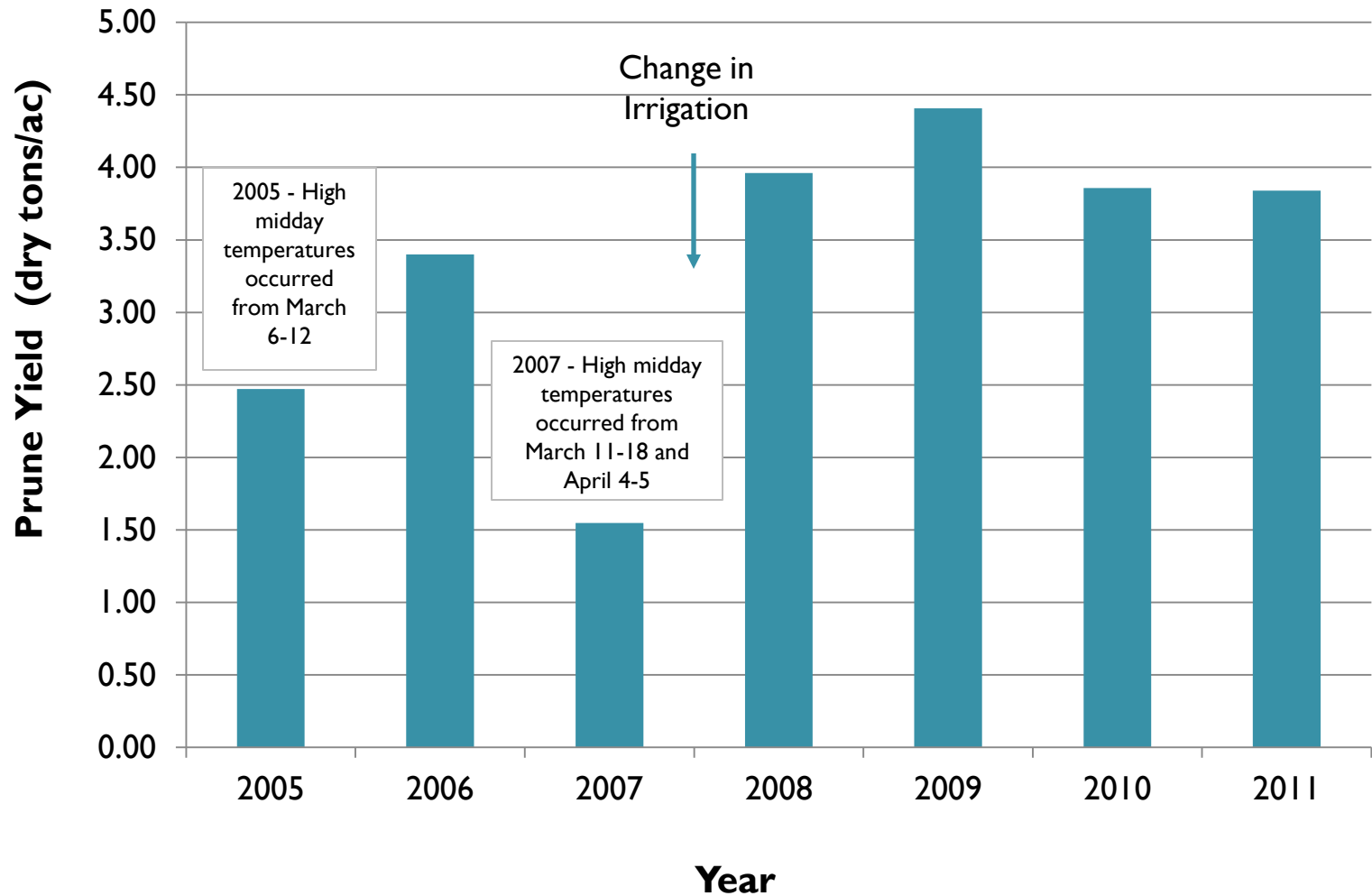
2009 Baseline and Orchard Stem Water Potential (SWP) with 95 % Confidence Interval for the Orchard SWP Mean



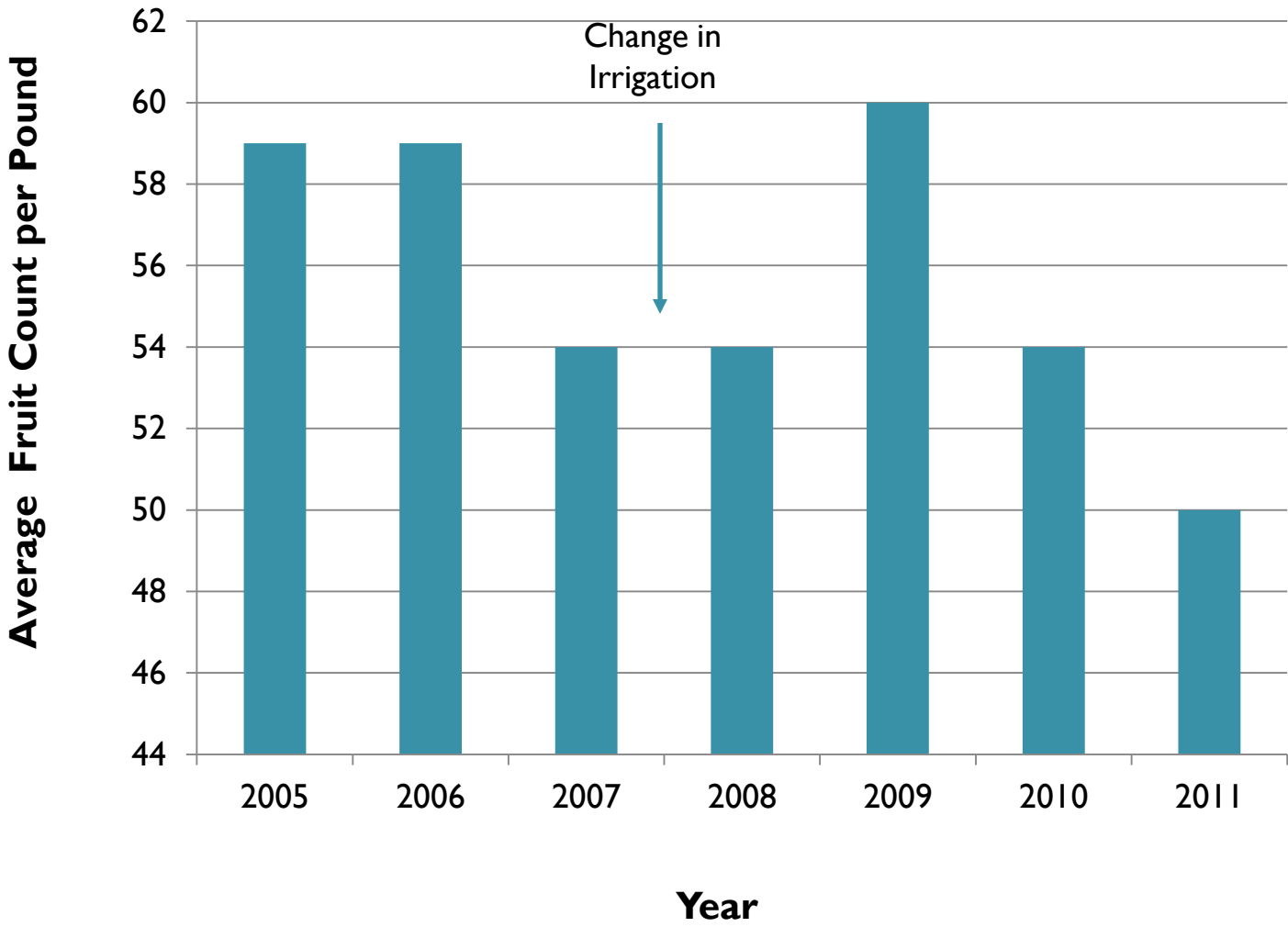
Pressure Chamber Reading (- bars)	PRUNES
0 to -6.0	Not commonly observed
-6.0 to -8.0	Low stress, common from March to mid April under fully irrigated conditions. Ideal for maximum shoot growth.
-8.0 to -10.0	Suggested levels in late April through mid June. Low stress levels enabling shoot growth and fruit sizing.
-10.0 to -12.0	Suggested mild levels of stress during late June and July. Shoot growth slowed but fruit sizing unaffected.
-12.0 to -16.0	Mild to moderate stress suggested for August to achieve desirable sugar content in fruit and to reduce "dry-away" (drying costs).
-16.0 to -20.0	Moderate stress acceptable in September.
-20 to -30	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
Less than -30	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.

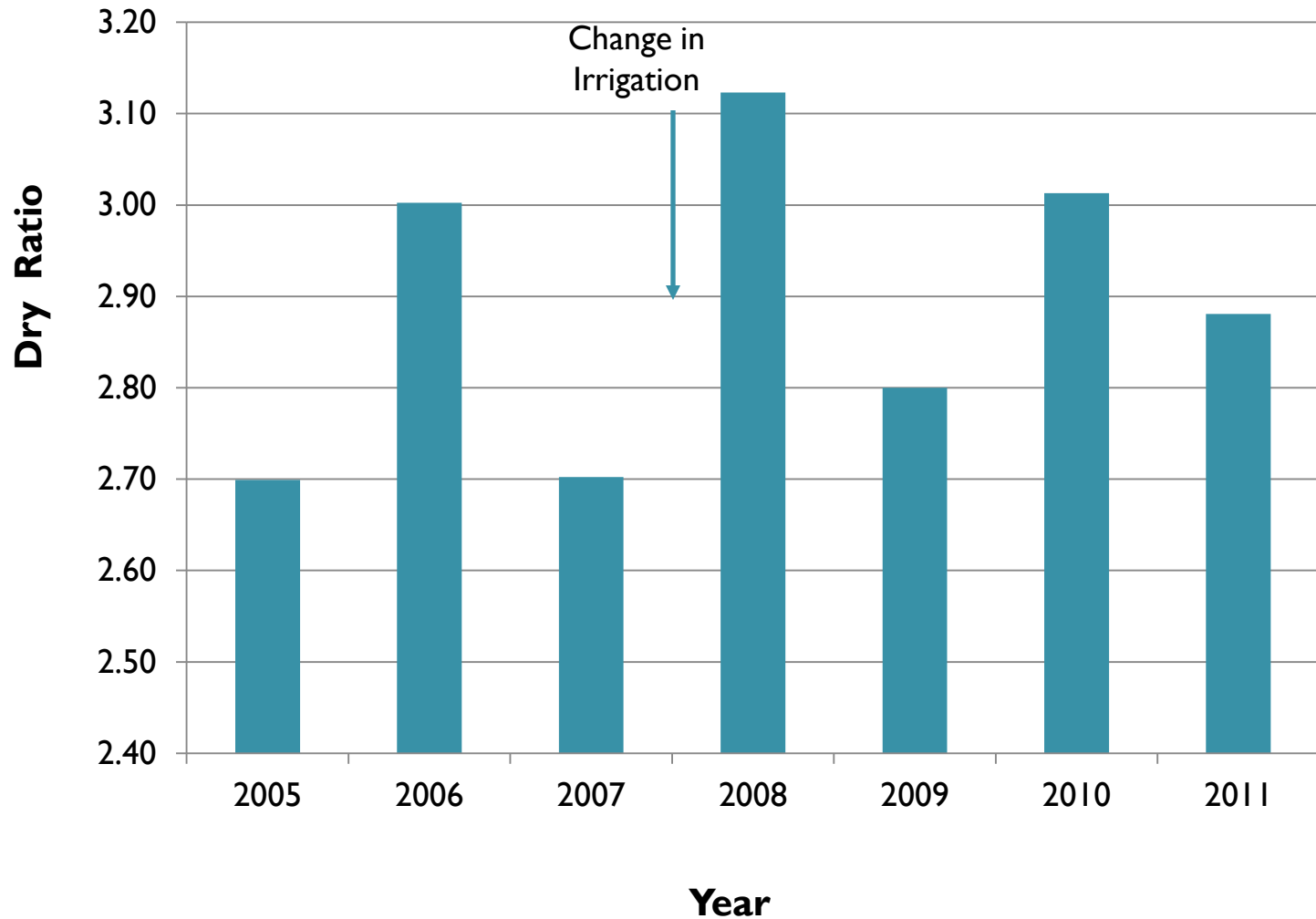
Yield trend after four years of modified irrigation management.



Trend in average fruit count after four years of modified irrigation management.



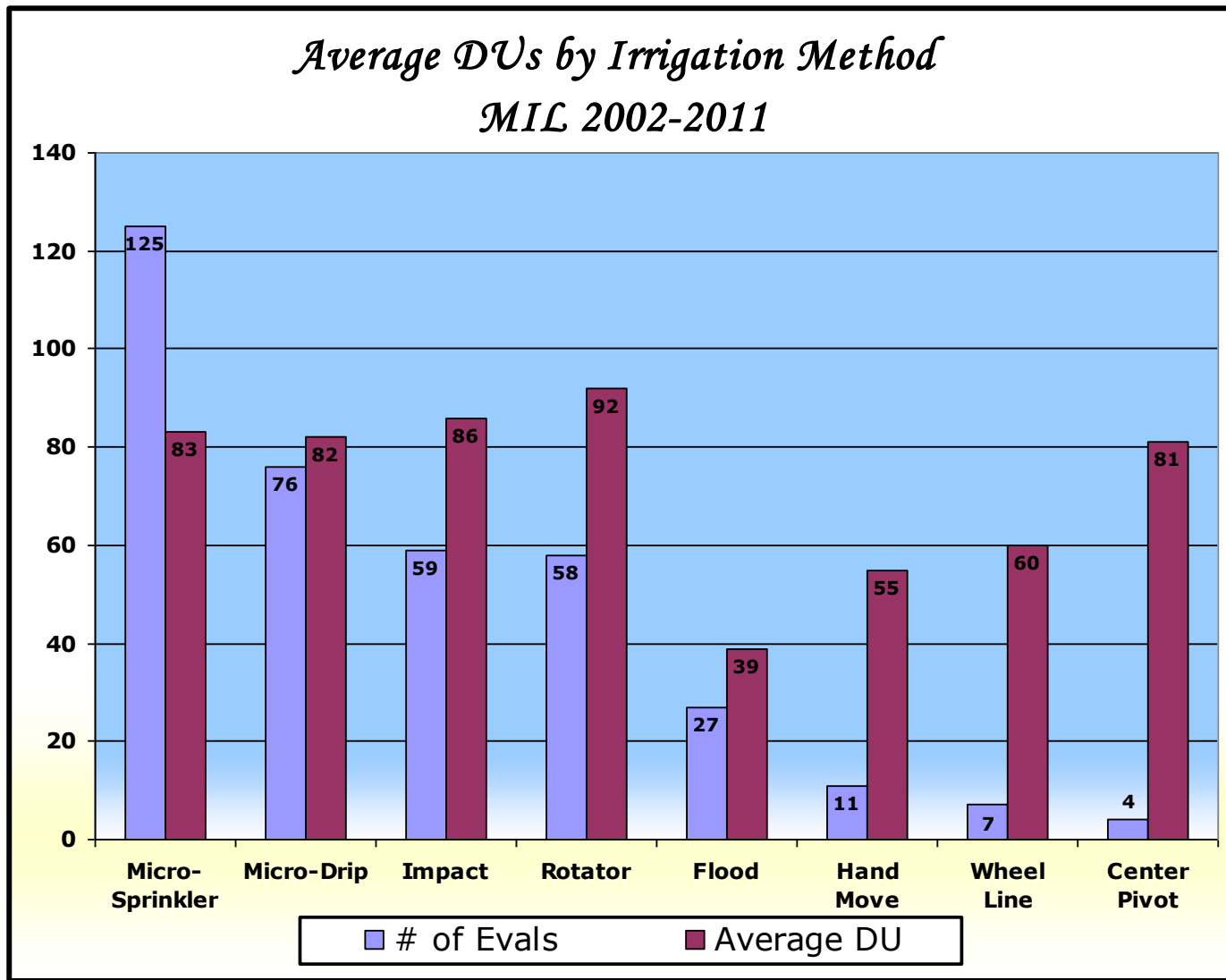
Trend in dry ratio of prunes after four years of modified irrigation management.



Are the Current Crop Coefficients (Kc's) for French prune reasonable?



Irrigation system performance

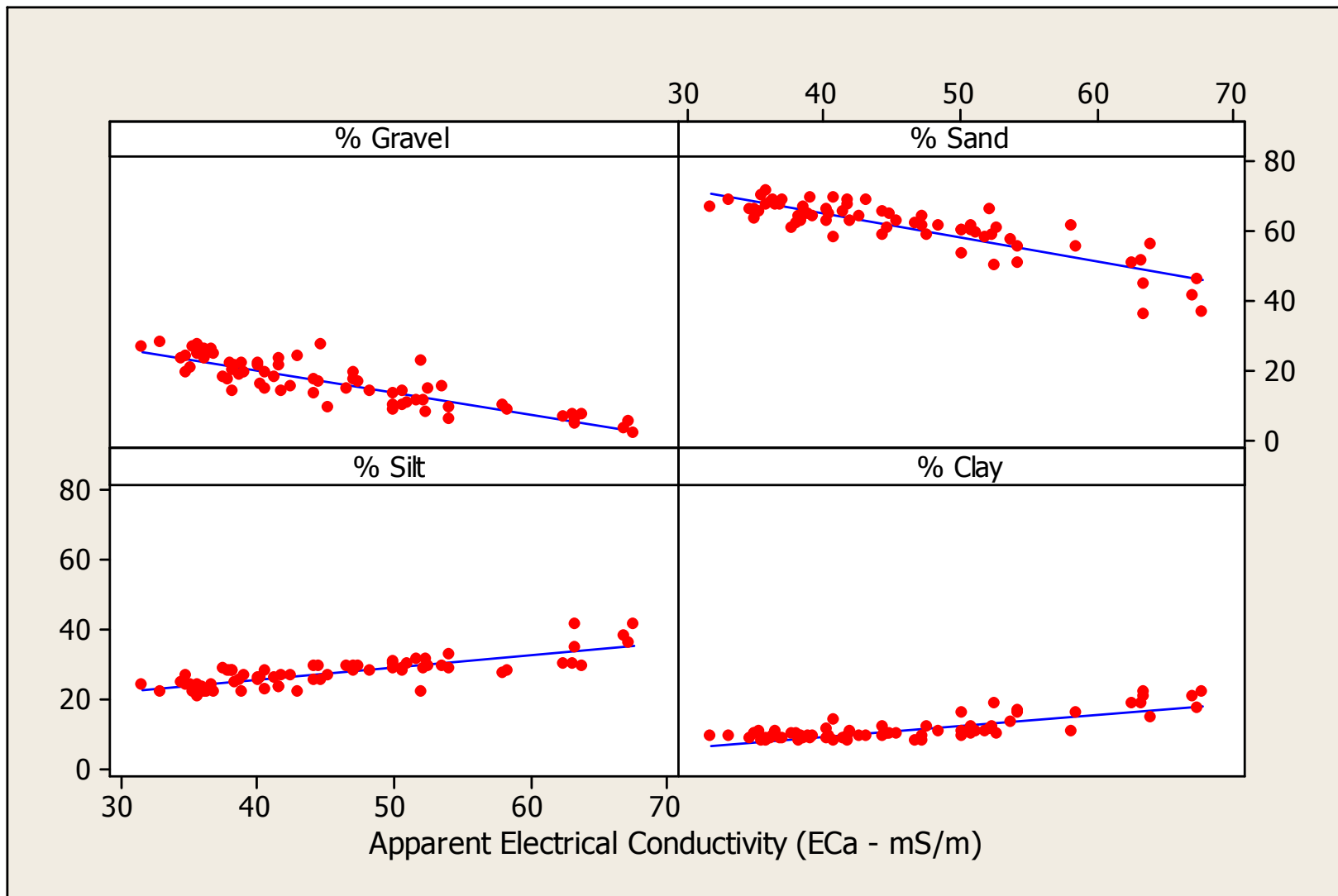


Veris Operation



- A pair of coulter electrodes penetrate a few inches of the soil surface and inject an electrical current
- Another pair of coulters receives the electrical signal
- The measure of voltage drop due to the resistivity of the soil is measured
- Distance between pairs of coulters determines depth of measurement. Usually measure to a depth of about 3 feet (1.0 meter)
- GPS used to track position in field

Percent gravel, sand, silt, and clay in relation to ECa (mS/m) measured with EM38 at Arbuckle.

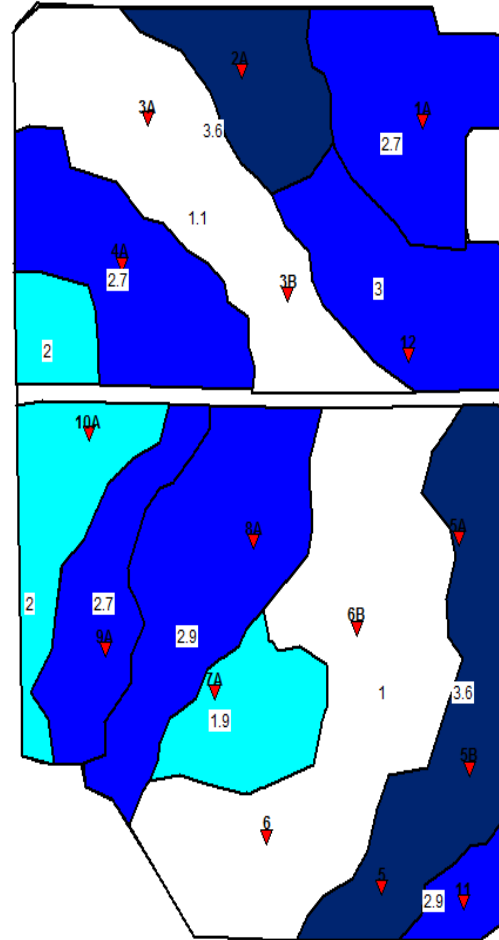
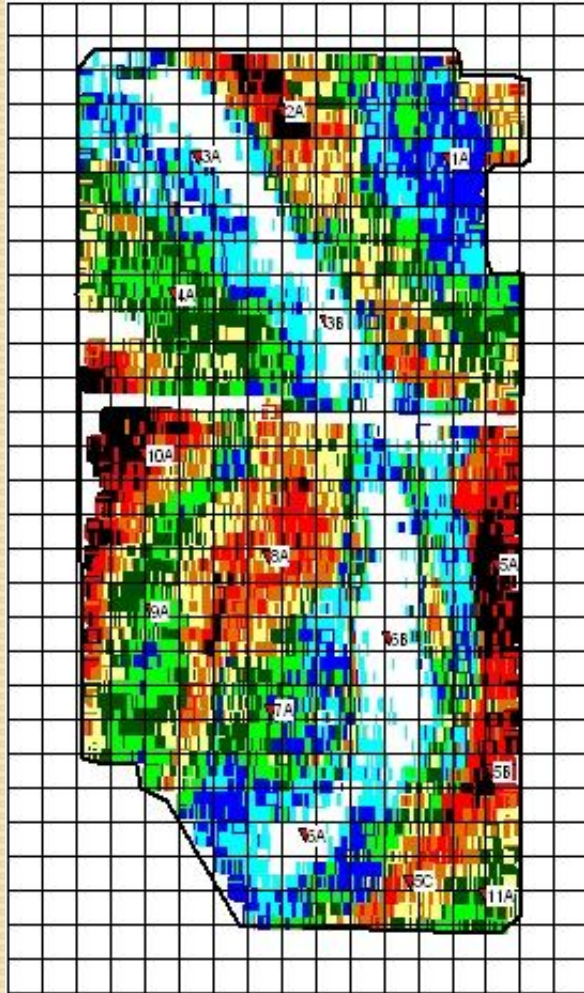


EM 38 Operation



- Two instruments one placed in horizontal mode (shallow) and the other in vertical mode (deep)
- Two electronic coils inside plastic casing, primary and secondary coil
- When energized, the primary coil radiates an electromagnetic (EM) field into the soil and creates a secondary field
- The strength of the secondary EM field is measured by the secondary coil
- Instruments are inside housing and towed across surface of land
- Detects apparent electrical conductivity (ECa) of soil to a depth of about 3 feet (1.0 meter)
- GPS used to track locations of ECa measurements

Next: A variable rate irrigation system?





THANK YOU!

**More irrigation management
information is available at
<http://cetehama.ucanr.edu>**