Experiences with Irrigation Scheduling in Almonds and Walnuts

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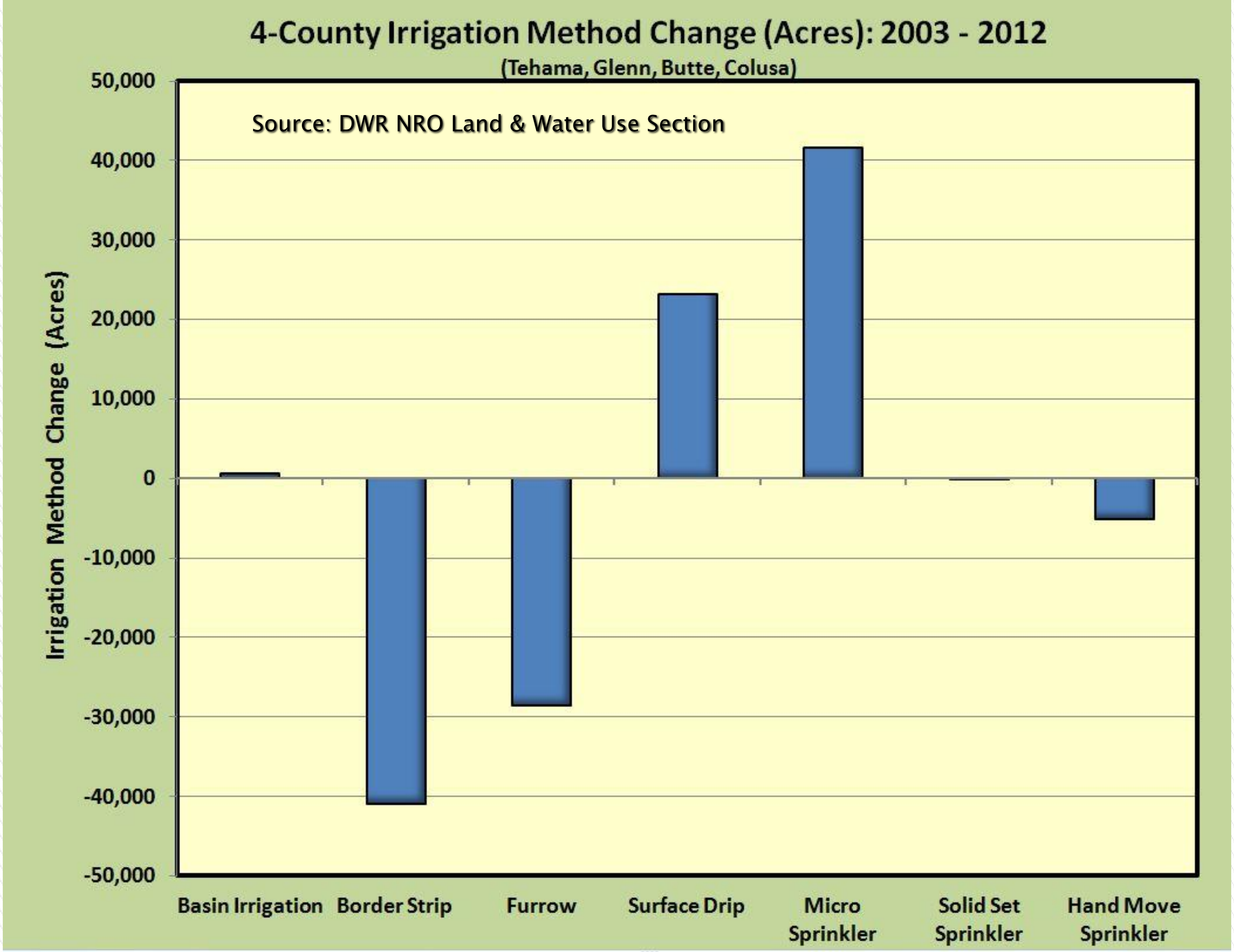
Tehama, Glenn, Colusa, and Shasta Counties

Today's discussion

- Trends in California's almond and walnut industries
- Research impacts and challenges
  - Irrigation scheduling tools
  - Production
  - Water use efficiency

Trends in California's almond and walnut industries

- 780,000 acres of bearing almonds in 2012
  - An increase of 250,000 acres in last decade
  - Statewide average production up 30 %, 1750 to 2285 lbs/ac
- 245,000 acres of bearing walnuts in 2012
  - An increase of 50,000 acres in last decade
  - Statewide average production up 75 %, 1.2 to 2.1 tons/ac
- ~ an additional 100,000 acres of non-bearing and new plantings of almond and walnut in 2012
- On average, demand and prices of both commodities increasing even though production increases, expect more expansion
  - Heart healthy foods and other
  - Growing "middle class" worldwide



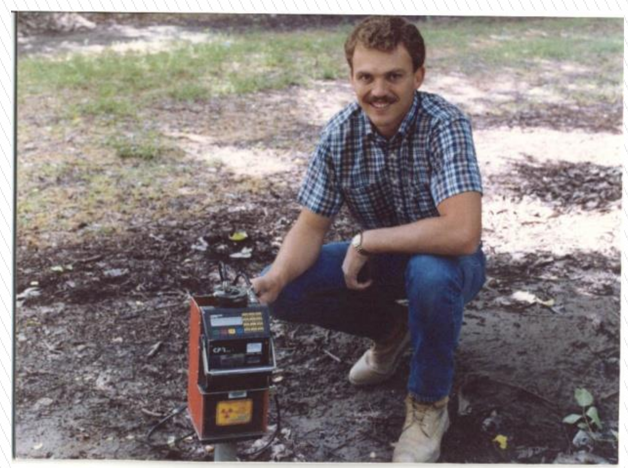
4-County Irrigation Method Change (Acres): 2003 - 2012
(Tehama, Glenn, Butte, Colusa)
Source: DWR NRO Land & Water Use Section
Irrigation Method Change (Acres)
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
-50,000
Basin Irrigation
Border Strip
Furrow
Surface Drip
Micro Sprinkler
Solid Set Sprinkler
Hand Move Sprinkler

A few years back…

- Seven year study in bearing walnuts

"This study documents the effects of managing on-farm irrigation practices, with and without using CIMIS information, in a Kings County walnut orchard. In this example, increased water use, increased production, and increased profits were experienced as a result of implementing CIMIS information."

1982



1986

Implementing CIMIS at the farm level: A grower's experience in walnuts. Fulton, Beede, and Phene. Sept-Oct. 1991. California Agriculture

Fast forward to 2013 ...

- Changes in almond and walnut culture
  - New varieties and rootstocks
  - Different orchard designs
  - Changes in pruning and canopy management, less pruning
  - More micro irrigation and fertigation

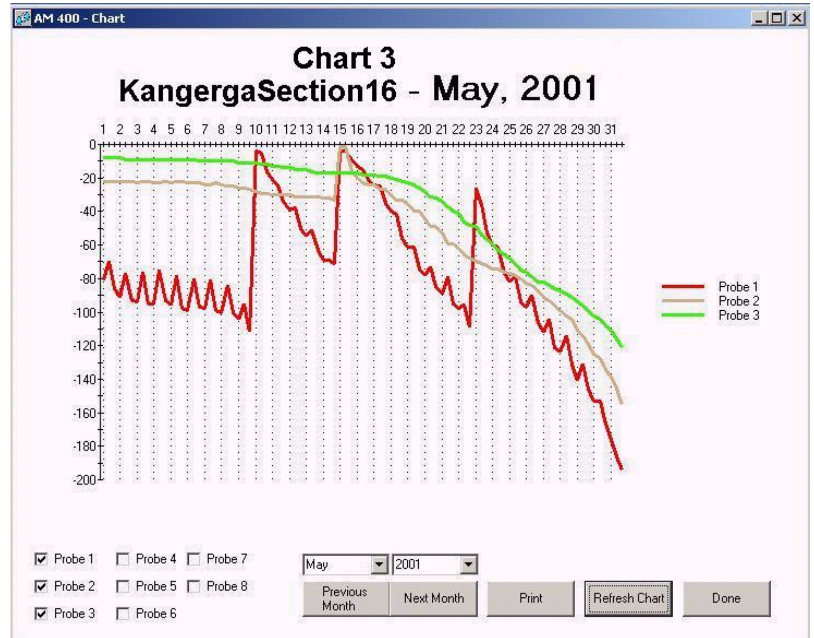
- Changes in grower support
  - Internet and mobile communication
  - More involvement from private sector
  - Advanced research tools among public sector
  - More holistic perspectives

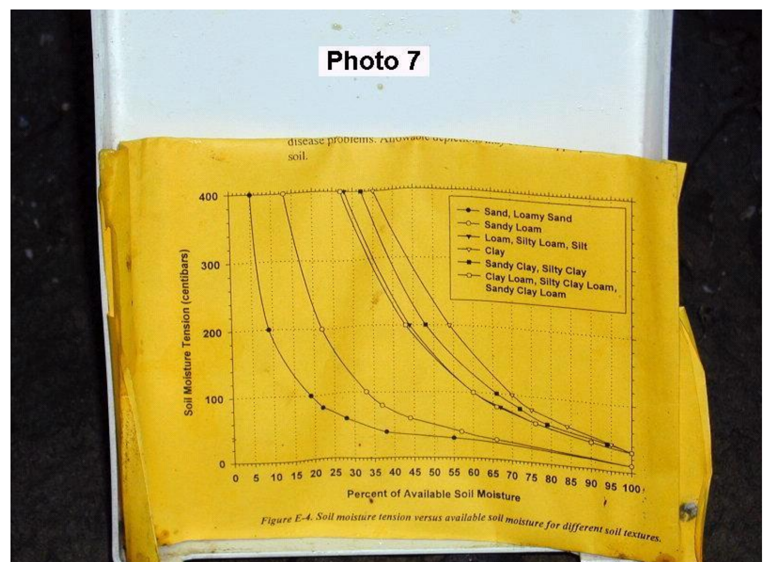
- So, what have been the impacts and what challenges lie ahead?

A 2012 survey of almond growers

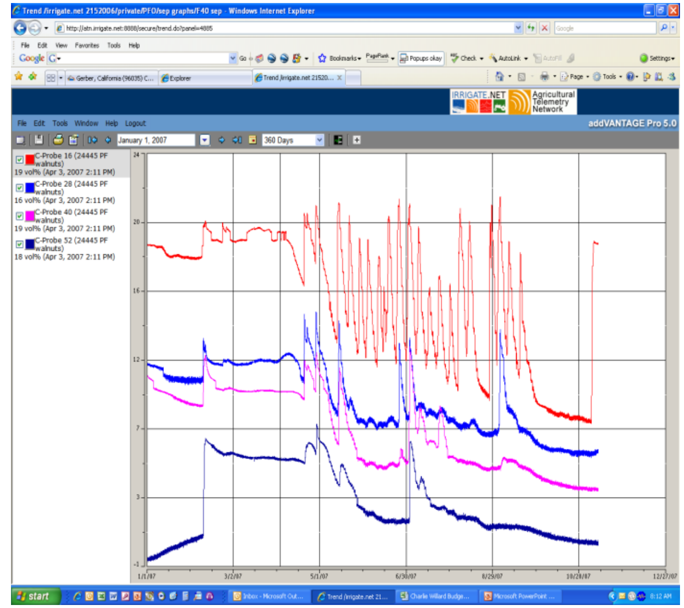
- More adoption of scientific methods to decide when to irrigate and how much water to apply.
  - 47 % – Use automated soil moisture monitoring to aid decision making
    - 64 % shovel or auger

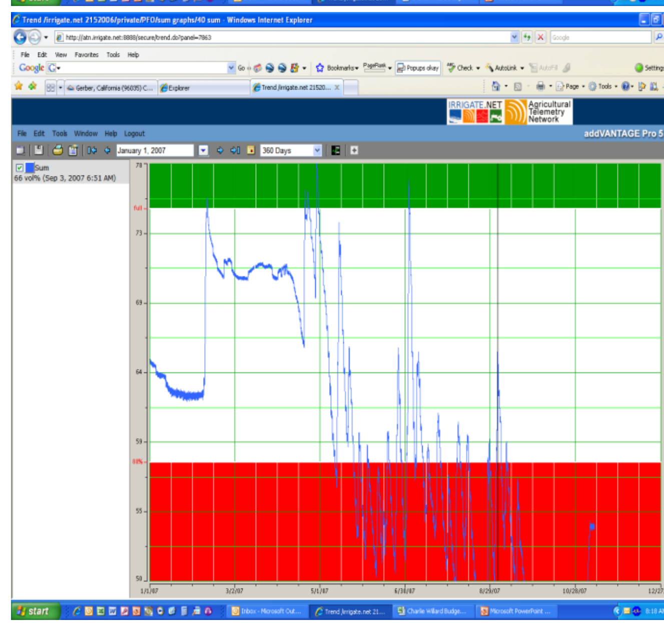
Resistance sensors and dataloggers for monitoring of soil moisture depletion



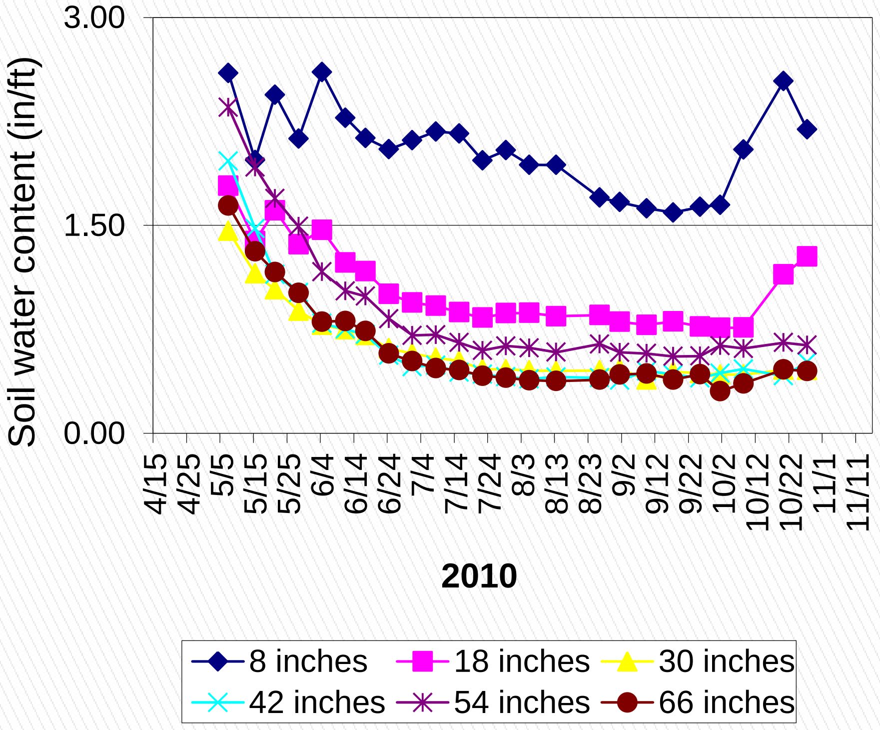


Dielectric sensors and radio telemetry for monitoring soil moisture depletion

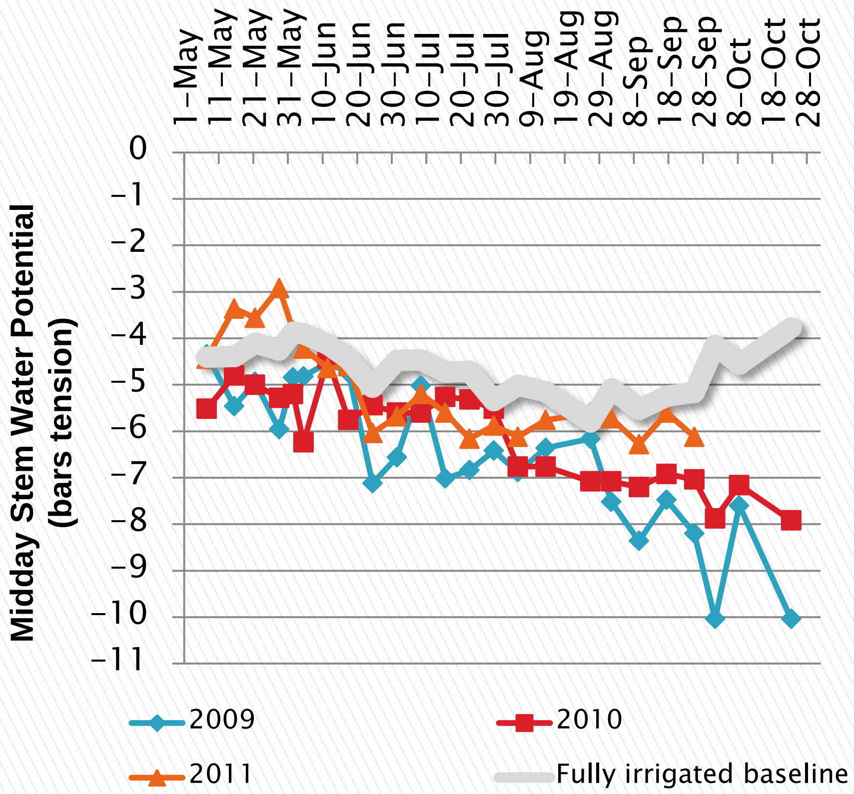




Uncertainty in monitoring soil moisture depletion?



Weekly measurement of soil moisture depletion in Tehama County walnut Orchard



Weekly measurement of orchard water status in same walnut Orchard

A 2012 survey of almond growers

- More adoption of scientific methods to decide when to irrigate and how much water to apply.

  - 47 % – Use automated soil moisture monitoring to aid decision making
    - 64 % shovel or auger
  - 44 % – Consider real-time ETc when making decisions
    - Prefer real-time ETc to historic or normal year averages
    - 60 % know water application rates of irrigation systems

ETc = (ETo x Kc)

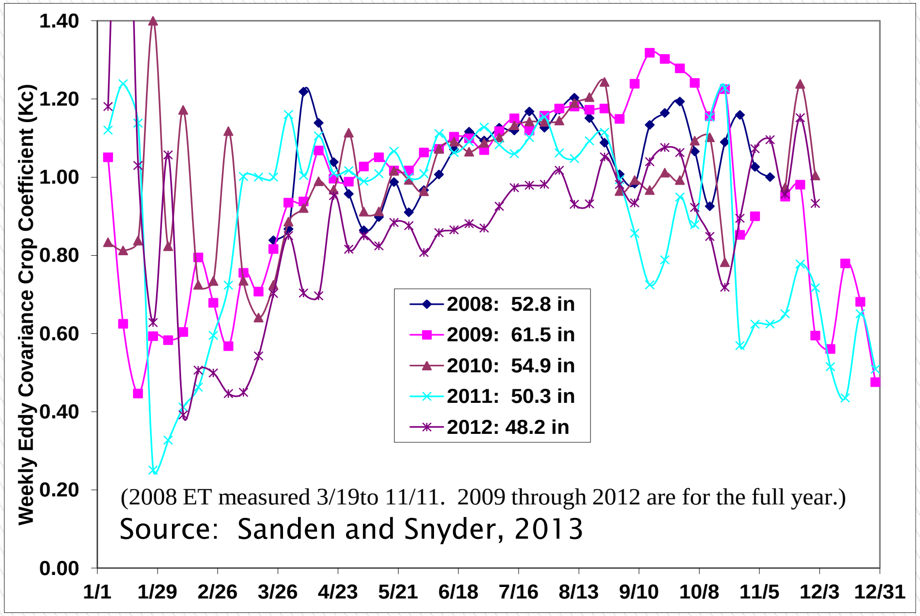
Applied Water = ETc

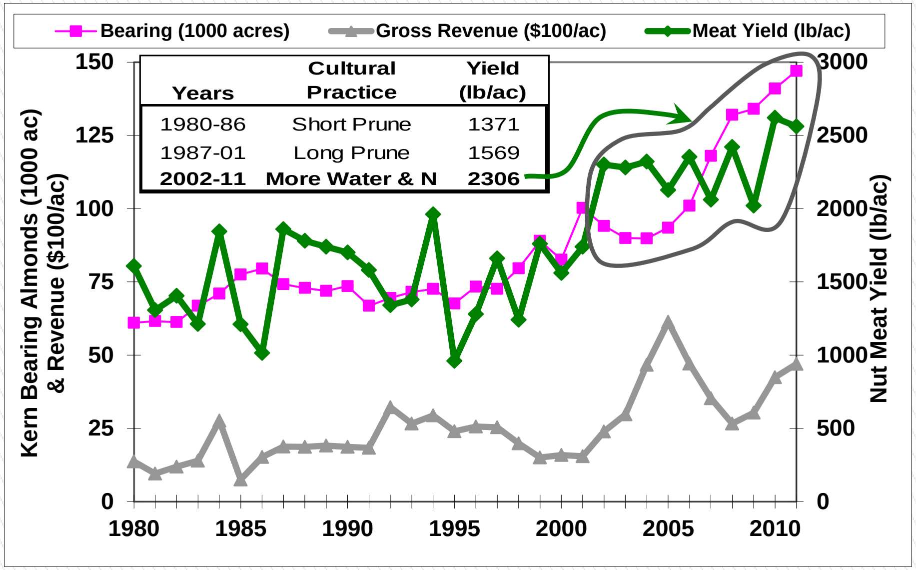
- Account for contribution from dormant season soil storage
- Account for effective in-season rainfall

The need to re-evaluate ETc and Crop Coefficients (Kc = ETc/ETo)?

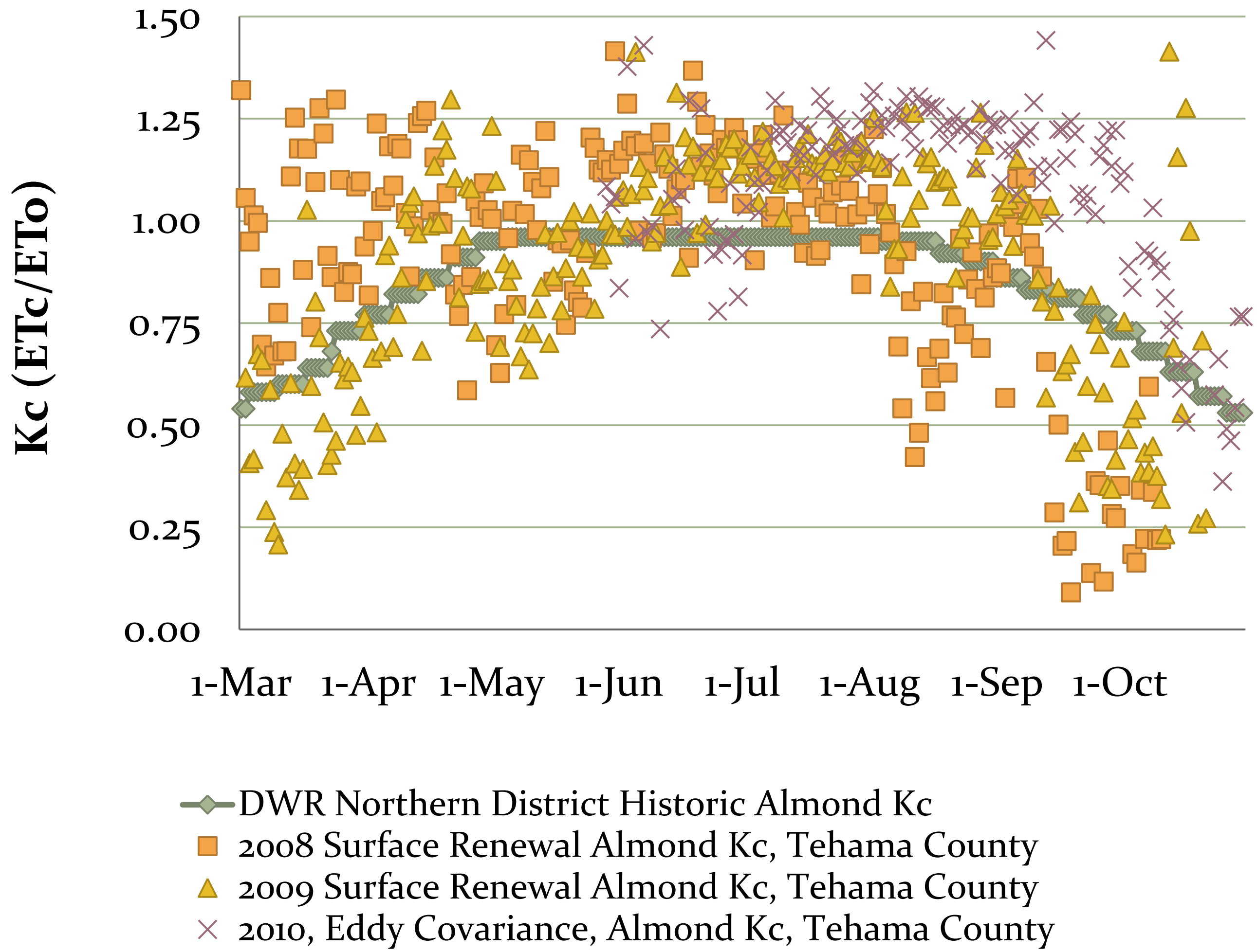
Re-evaluation of almond Kc's in the southern SJV

DATE	Almond Kc – 1996	Almond Kc– 2013
Mar 1-15	NA	0.54
Mar 15-31	0.54	0.77
Apr 1-15	0.60	0.94
Apr 16-30	0.66	0.99
May 1-15	0.73	1.02
May 16-31	0.79	1.04
June 1-15	0.84	1.08
June 16-30	0.86	1.11
July 1-15	0.93	1.11
July 16-31	0.94	1.11
Aug 1-15	0.94	1.11
Aug 16-31	0.94	1.06
Sept 1-15	0.94	0.93
Sept 16-30	0.91	0.77
Oct 1-15	0.85	0.65
Oct 16-31	0.79	0.52
Nov 1-15	0.70	0.28
Total ETc	**38-42"**	**48-56"**





Re- evaluation of Kc's for almonds in the northern Sacramento Valley. (Connell, Fulton, and Snyder, 2010)



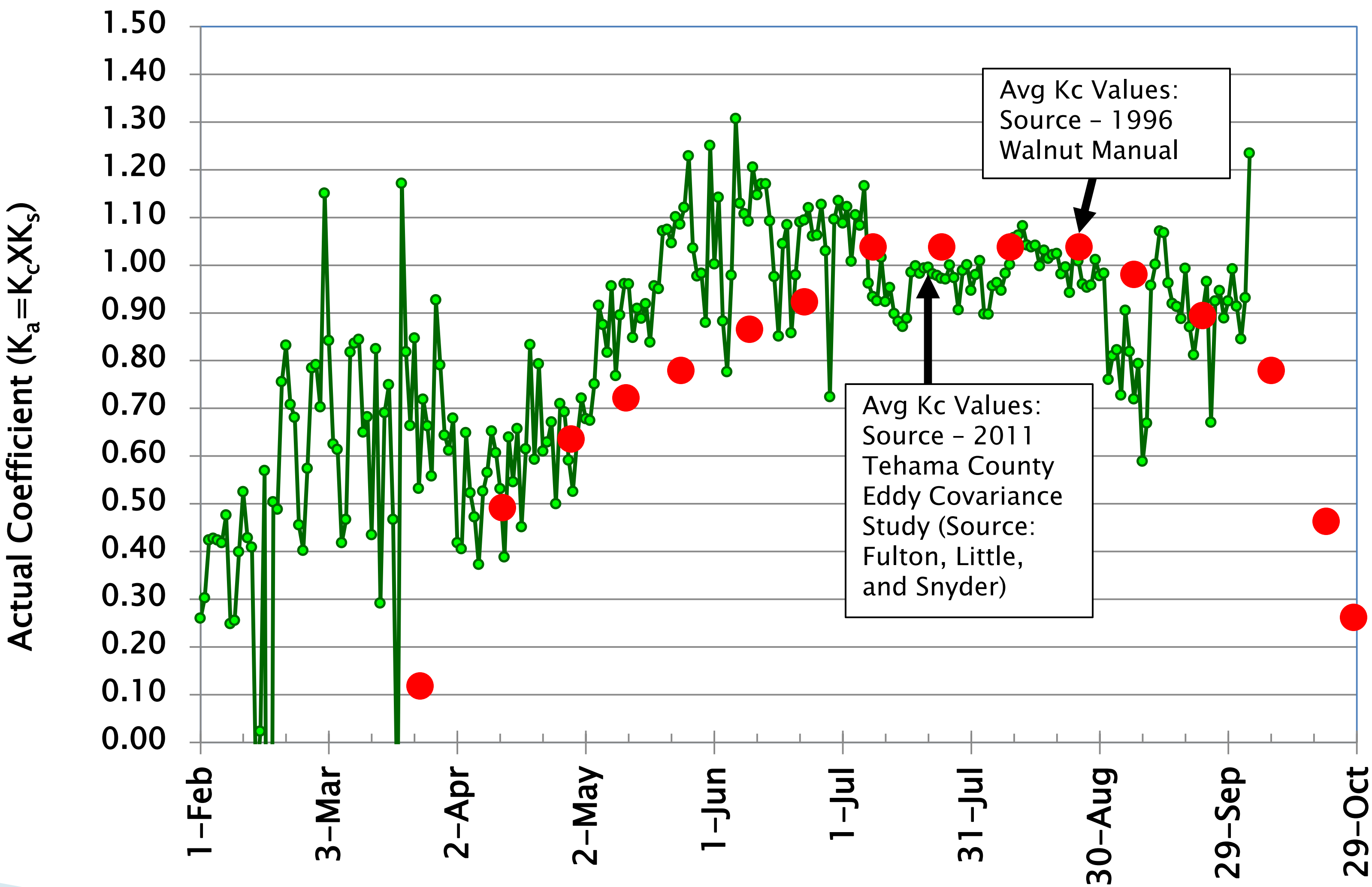
1998 walnut production manual, ANR Publication 3373.

Table 20.2 Long-term, historical average ET_c for mature Chico walnut under clean cultivation in the San Joaquin Valley.

Date	ET_o (in/day)	K_c	ET_c (in/day)	Cumulative ET_c (in)	ET_c (gal/tree/day)*
Mar.16–31	0.103	0.12	0.01	0.2	3.6
Apr. 1–15	0.157	0.53	0.08	1.4	28.7
Apr. 16–30	0.157	0.68	0.11	3.0	39.4
May 1–15	0.197	0.79	0.16	5.4	57.3
May 16–31	0.197	0.86	0.17	8.1	60.9
June 1–15	0.256	0.93	0.24	11.7	86.0
June 16 –30	0.256	1.00	0.26	15.6	93.2
July 1–15	0.275	1.14	0.31	20.3	111.1
July 16 –31	0.275	1.14	0.31	25.2	111.1
Aug. 1–15	0.236	1.14	0.27	29.3	96.7
Aug. 16–31	0.236	1.14	0.27	33.6	96.7
Sept. 1–15	0.177	1.08	0.19	36.5	68.1
Sept. 16–30	0.177	0.97	0.17	39.0	60.9
Oct. 1–15	0.110	0.88	0.10	40.5	35.8
Oct. 16–31	0.110	0.51	0.06	41.5	21.5
Nov. 1–15	0.047	0.28	0.01	41.6	3.6

*Based on 24-by-24-foot spacing. The following equation can be used to calculate individual tree water use for other spacings:
gal/tree/day = ET (in/day) × (ft^2) × 0.622 (gal/in-ft^2).

2011 Tehama County Eddy Covariance Results



Relationship between almond and walnut canopy size and Kc's in question

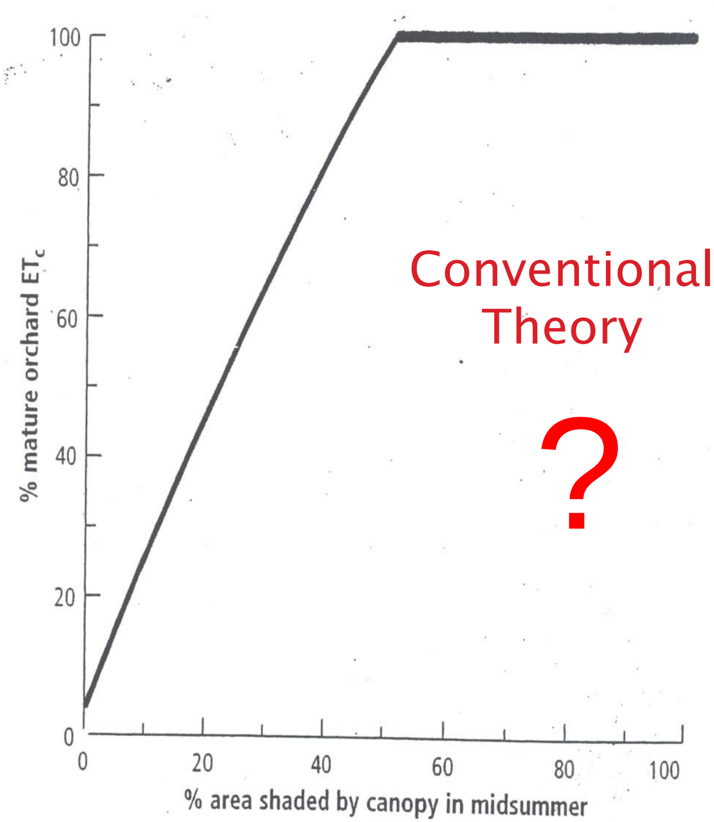
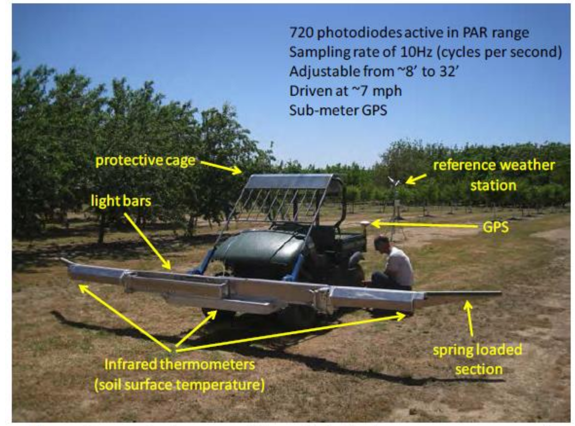
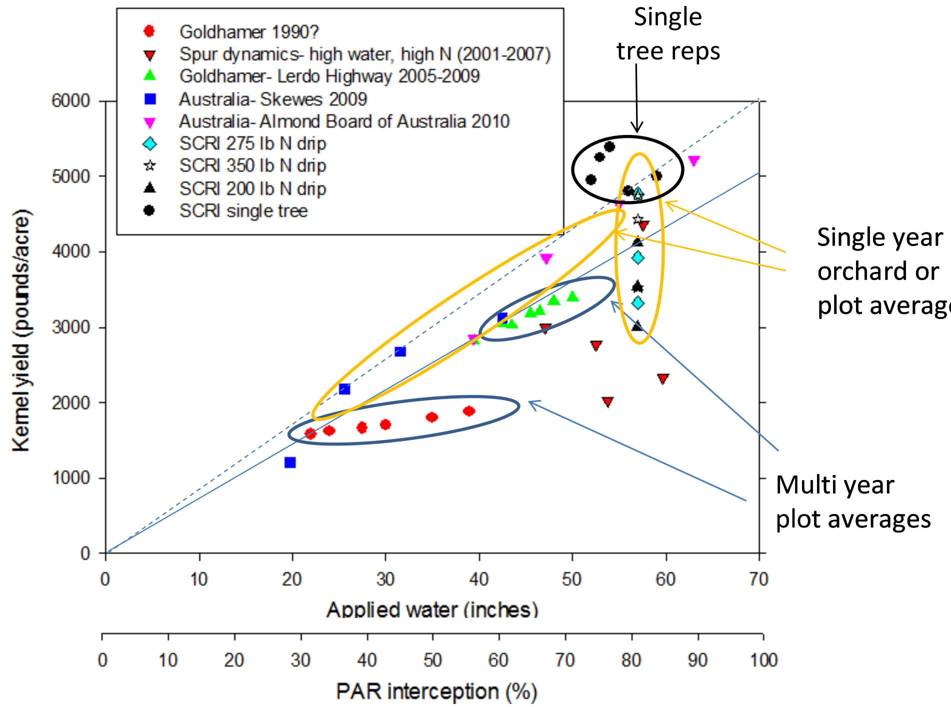


Figure 20.3 The relationship between percentage of ground cover and almond ET_c (from Fereres et al. 1982). Note that it is not 1 to 1.





Source: Bruce Lampinen, UC Davis Statewide Almond and Walnut Specialist, 2012

A 2012 survey of almond growers

- More adoption of scientific methods to decide when to irrigate and how much water to apply.
  - 47 % – Use soil moisture monitoring to aid decision making
    - 64 % shovel or auger
  - 44 % – Consider real-time ETc when making decisions
    - Prefer real-time ETc to historic or normal year averages
    - 60 % know water application rates of irrigation sytems
  - 23 % – Crop stress, pressure chamber and stem water potential
    - 58 % look for and respond to visual signs of crop stress

A guide for using the pressure chamber and midday stem water potential in almonds, walnuts, and prunes. (Fulton, Grant, Buchner, and Connell, 2013).

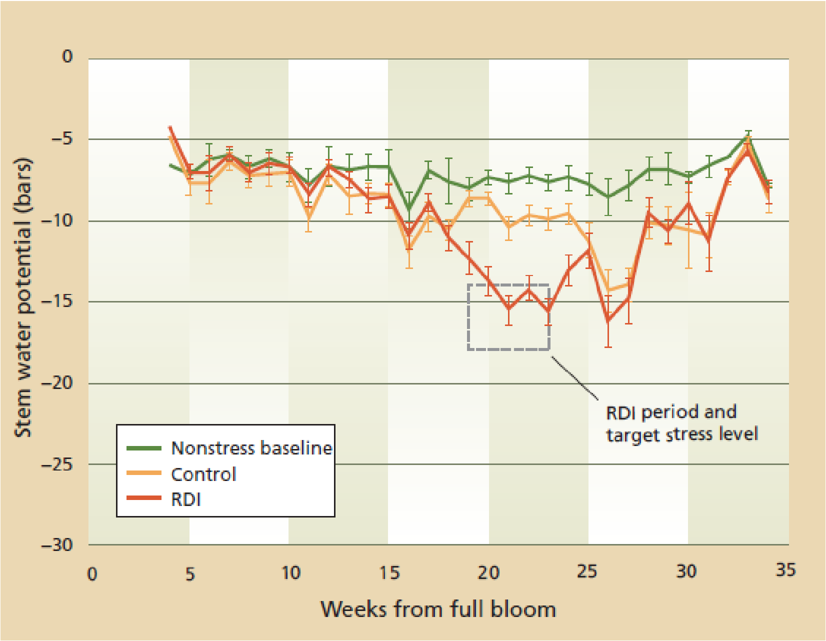
Pressure Chamber Reading (- bars)		ALMOND
0 to -6.0		Not commonly observed
-6.0 to -10.0		Low stress, indicator of fully irrigated conditions, ideal conditions for shoot growth. Suggest maintaining these levels from leaf-out through mid June.
-10.0 to -14.0		Mild to moderate stress, these levels of stress 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

Almond guidelines

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.

Walnut Guidelines

Using the pressure chamber to implement regulated deficit irrigation (RDI) in almond. Stewart, Fulton, Krueger, Lampinen, and Shackel. Apr–June, 2011. California Agriculture.



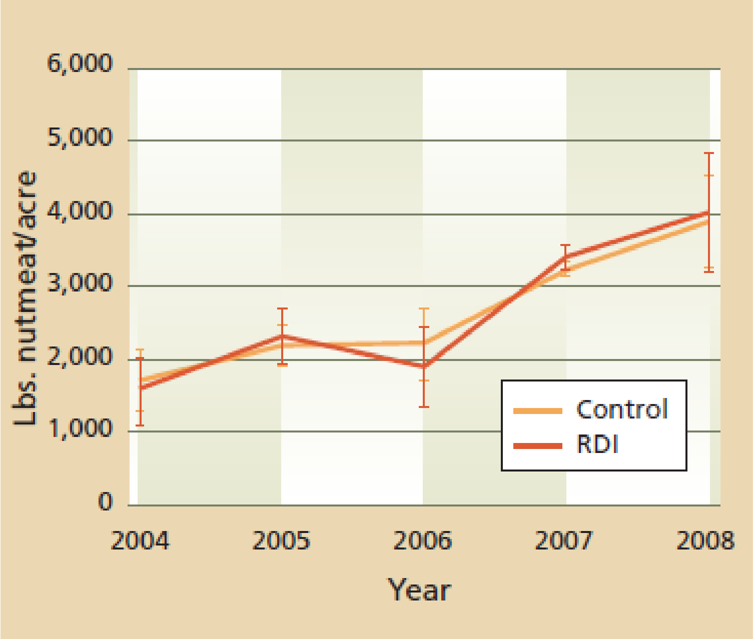


TABLE 2. Consumptive water use and overall percentage savings, 2005–2008

Year	Treatment	Consumptive use	Savings
		inches (cm)	*%*
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.

Treatment	Yield	Irrigation used
	lbs. nutmeat per acre	*gallons per lb. nutmeat*
Control	2,640 ± 920	458 ± 193
RDI	2,640 ± 1090	428 ± 213
P value	0.99 NS	0.22 NS

* Based on three-way ANOVA (year, block and treatment).

Key summary point from study

"According to a previous study, <u>mild to moderate stress may not be unusual</u> in commercial almond production (Shackel 2001). Therefore, it is difficult to determine how much water might be saved statewide if our recommendations for regulated deficit irrigation were widely adopted."

Experience with RDI in walnuts

Average Seasonal SWP (bars)	Seasonal Range in SWP (bars)	Average Applied Irrigation Water (inches / acre)
-3.6 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

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	1.98 a	2.82 a	2.24 a	0
	-6.2	1.84 a	2.33 b	1.65 b	26
	-7.5	1.74 a	2.07 b	1.31 b	42
San Joaquin County CA	-5.5	3.55 a	4.43 a	3.77 a	0
	-7.0	3.26 a	3.94 a	2.98 b	21
	-8.6	3.29 a	3.80 a	3.08 b	18

To wrap-up

- Achieving water (energy) conservation with wider adoption of irrigation scheduling tools is questionable
  - Depends on existing irrigation management
  - More water, production, farm revenue, quite possible

- Representative, automated soil moisture monitoring provides insight to irrigation needs, fate of water and rainfall, and provides detail and ease of acquiring information.

- Some important, outstanding questions still surround real-time ETc estimates for almonds and walnuts
  - In particular, the effect of canopy size on ETc?
  - What is the potential for site specific measurement of ETc?

- A reliable indicator of tree water status offers unique and important insights to making irrigation decisions
  - Many orchardists know this intuitively and indicate so
  - Labor intensity of the pressure chamber and SWP can be a barrier
  - Perhaps the tool with a greater chance of realizing water savings

Past and Future UC Collaboration with Irrigation Scheduling Tools in almonds and walnuts

Faculty, CE Specialists, Staff

- Michael Delwich
- David Goldhamer
- Blaine Hanson
- Bruce Lampinen
- Sam Metcalf
- Terry Prichard
- Larry Schwankl
- Ken Shackel
- Richard Snyder
- Dave Smart
- Shrini Upadhyaya
- Mike Whiting
- Others

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- Allan Fulton
- Joe Grant
- Janine Hasey
- Bill Krueger
- Dan Munk
- Franz Neiderholzer
- Blake Sanden
- Others

THANK YOU!