Walnut Irrigation Management

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Benefits of good irrigation management

- Productivity
  - Earlier
  - Higher and more consistent
  - Better crop quality and more value

Experiments - walnut responses to irrigation

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

- Chandler variety
- Tehama County
  - Young (8^{th} – 13^{th} 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 water stress on walnuts
- Supported by walnut research board from 2002 - 2004

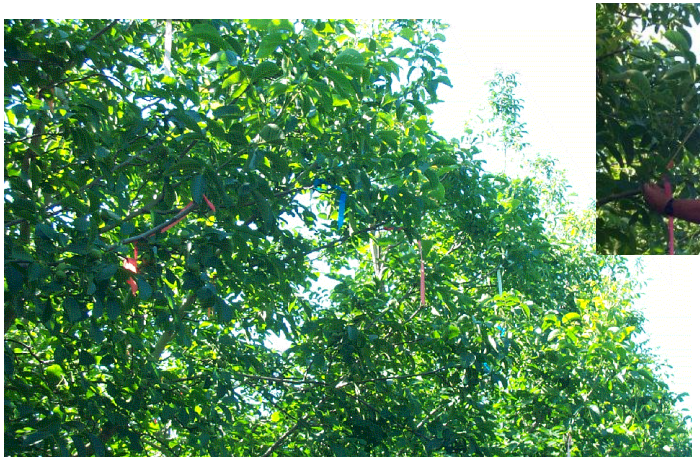
Defining the irrigation treatments

- Strategy: crop stress increased as season progressed
- Monitored by SWP measurements with pressure chamber and measurement of applied water with flow meters

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	3.5 a
-6.2	3.4 a
-7.5	2.4 b
	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	1.98 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

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 Equal Shoot Growth

Benefits of irrigation management

- Productivity
  - Earlier
  - Higher and more consistent
  - Better crop quality and more value
- Improved orchard life span

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)	Tree death or trees in severe decline (%)
Paradox	-4.0	42	0.0
	-6.2	28	1.3
	-7.2	23	1.3
Northern California Black	-4.0	42	24.2 a
	-6.2	28	3.0 b
	-7.2	23	0.0 b

Benefits of irrigation management

- Productivity
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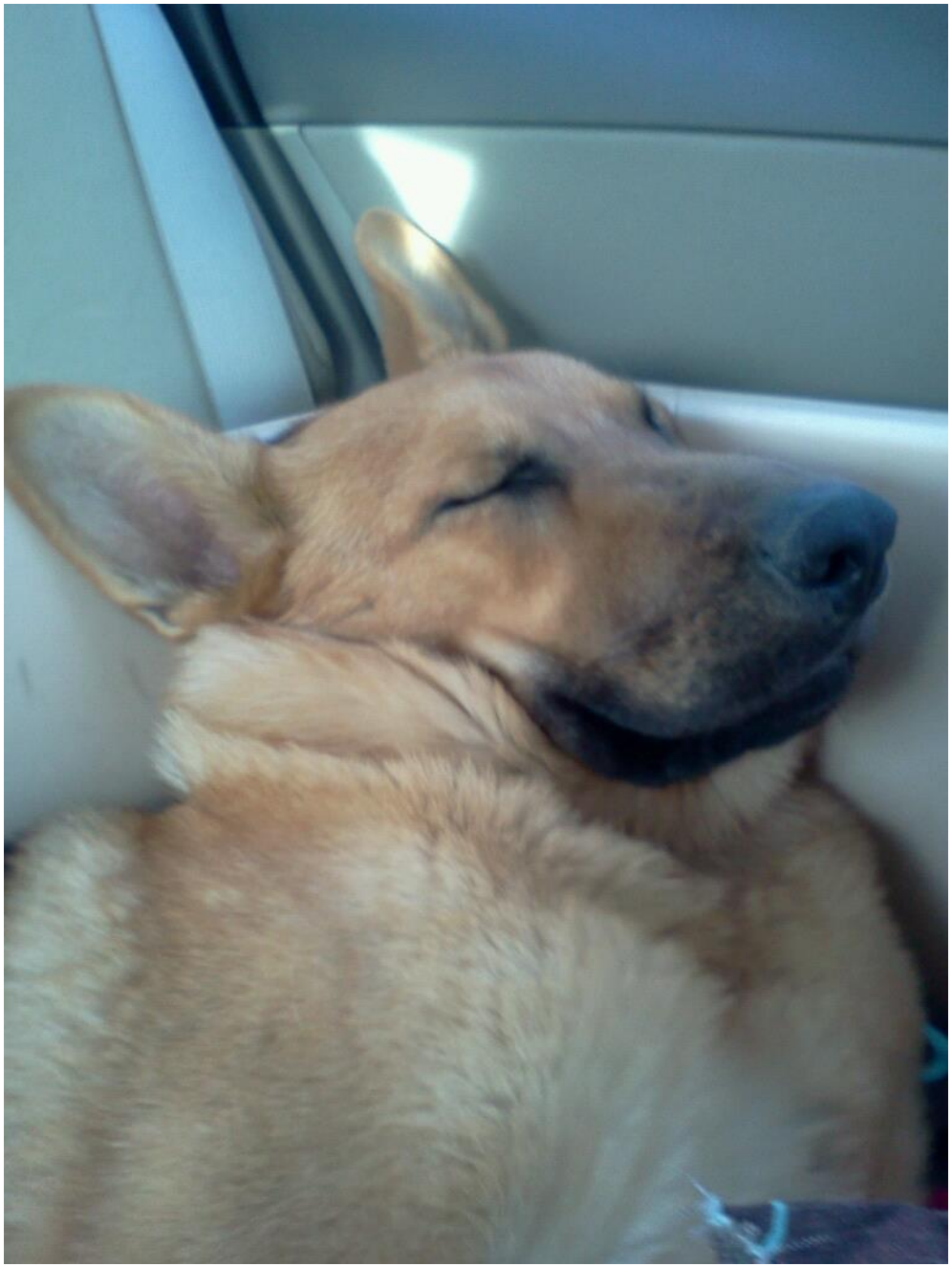
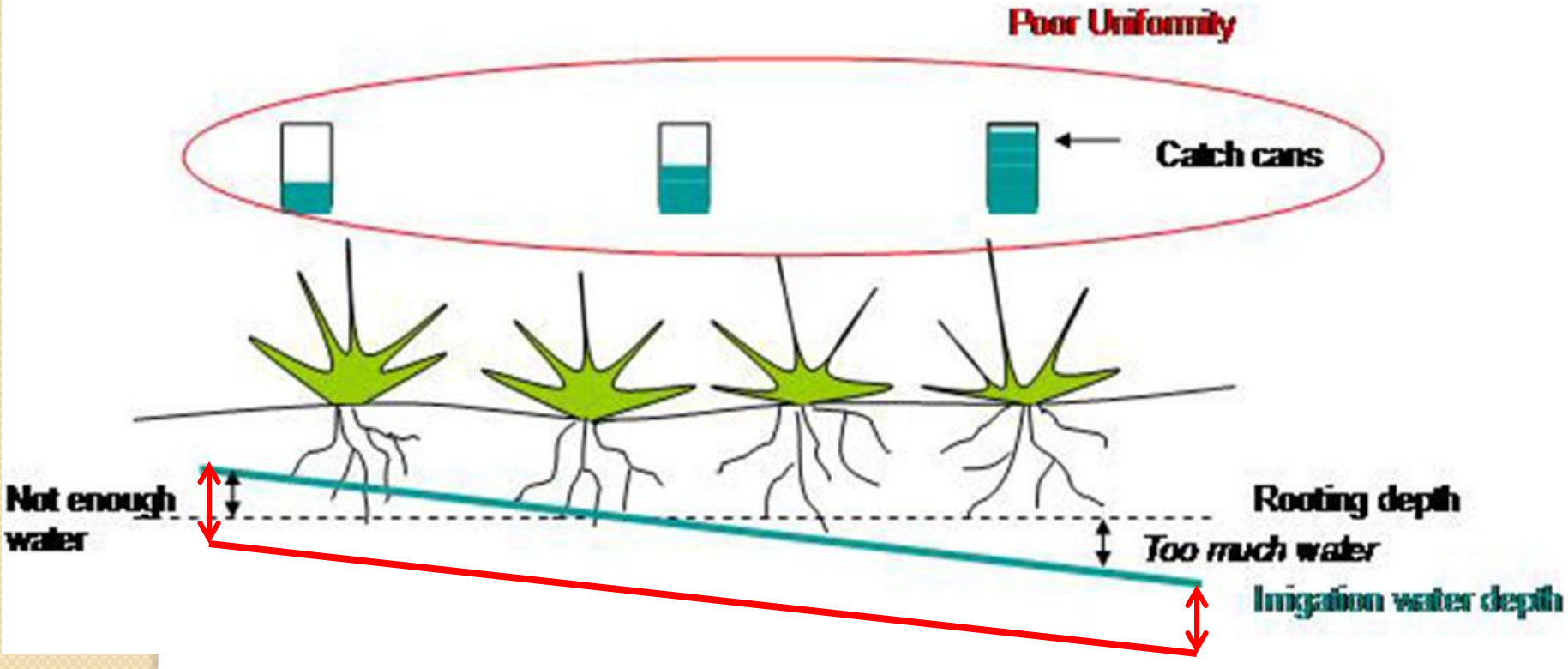
  - Better crop quality and more value
- Improved orchard life span
- Complements other cultural practices
- Resource stewardship
- Water and energy conservation?



What is irrigation management?

- Making decisions about when to irrigate and how much water to apply
  - Understanding how well an irrigation system is performing and fixing it as needed
  - Attention to water placement, infiltration, and drainage
  - Choosing among different scheduling tools and applying at least one of them

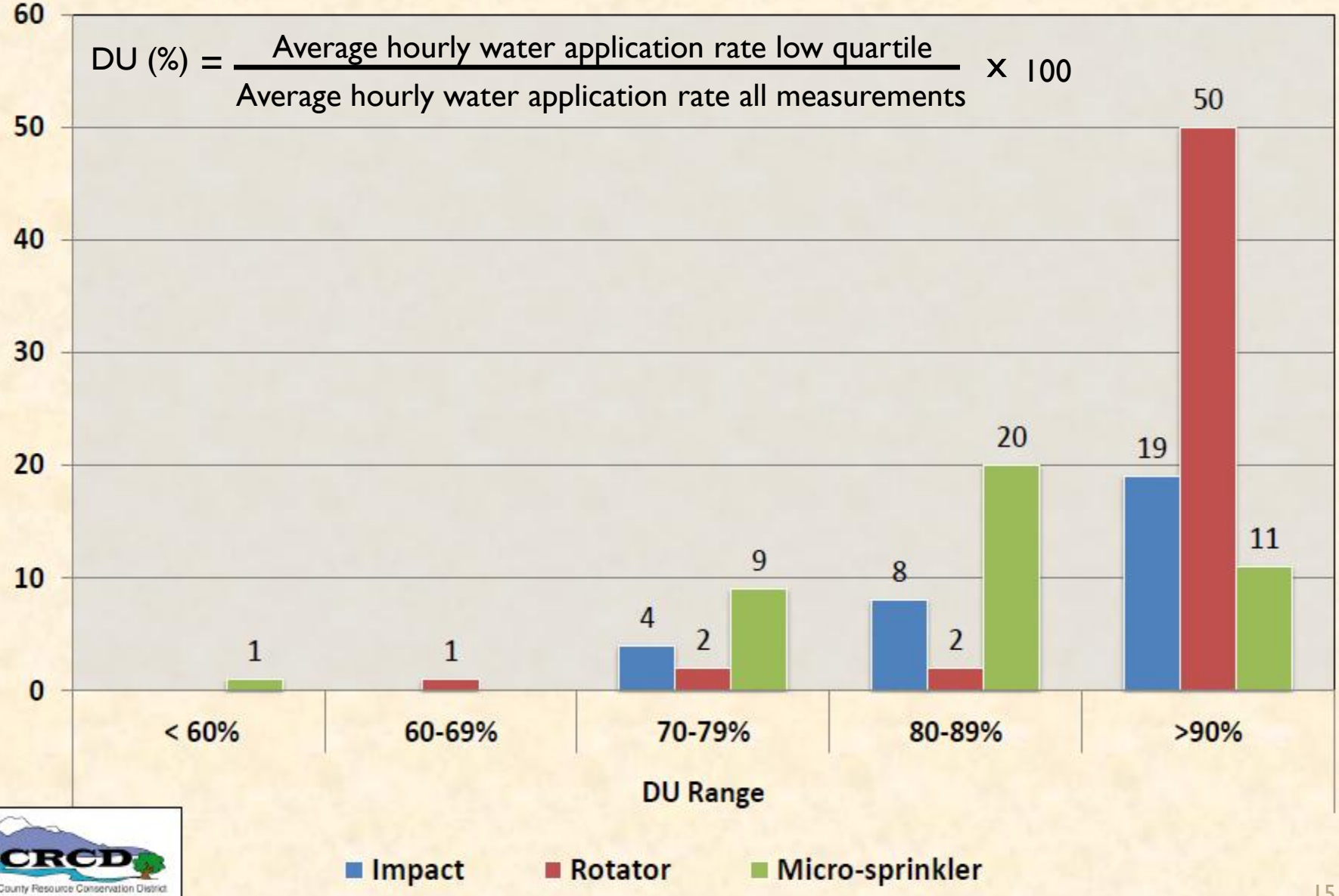
Poor Distribution Uniformity (DU) = Over & Under Irrigation



Slide prepared by Kevin Greer, Tehama County Mobile Irrigation Lab

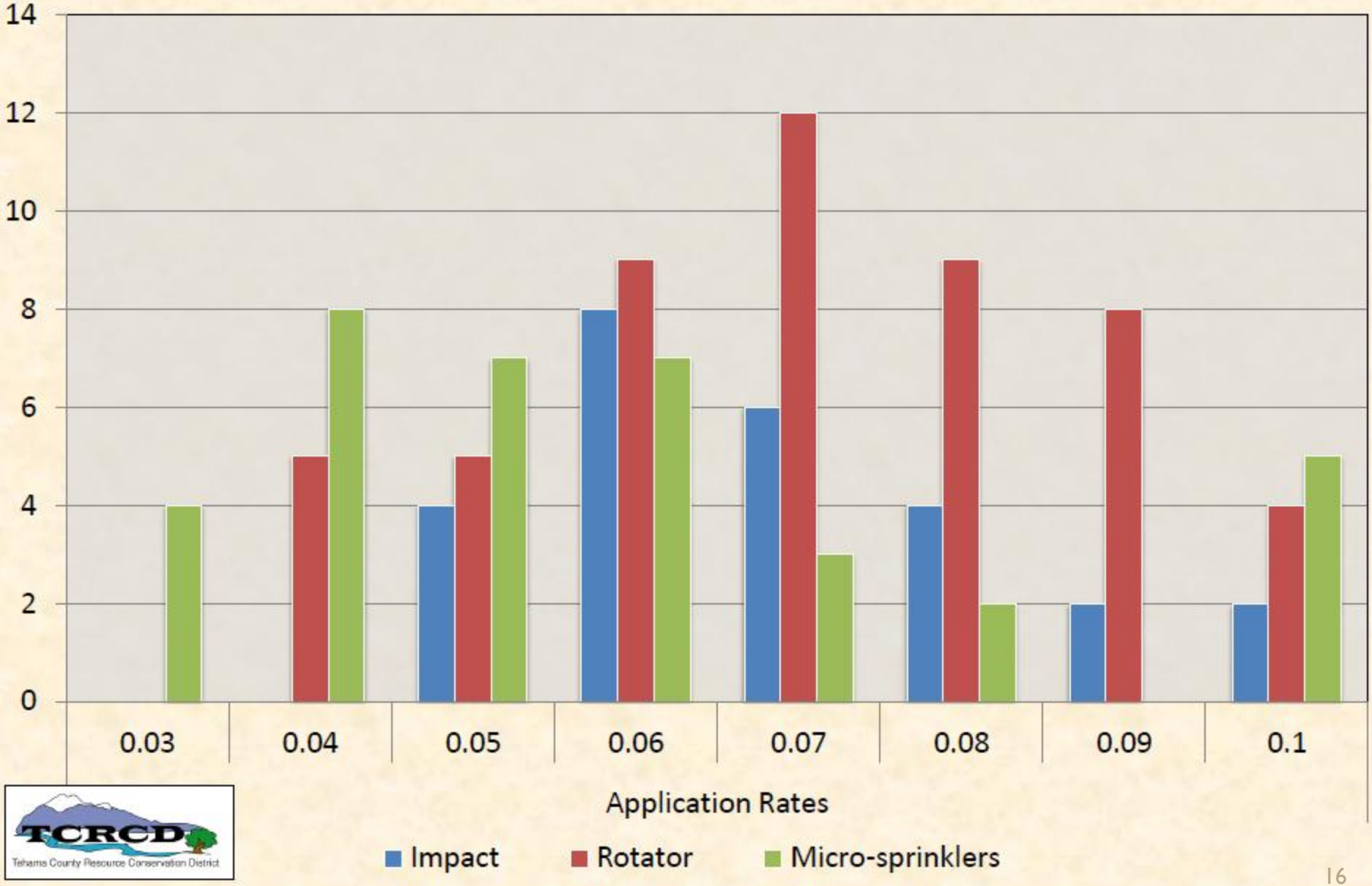
Evaluated Irrigation Systems (127) for Walnuts

$$DU\ (\%) = \frac{\text{Average hourly water application rate low quartile}}{\text{Average hourly water application rate all measurements}} \times 100$$



Tehama County Resource Conservation District

Ranges in Hourly Application Rates for Walnuts by MIL 2009-2012



TCRCD
Tehama County Resource Conservation District

Placement of water

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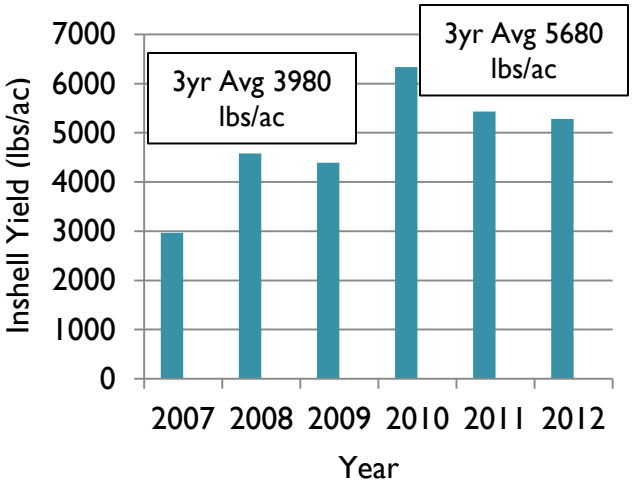
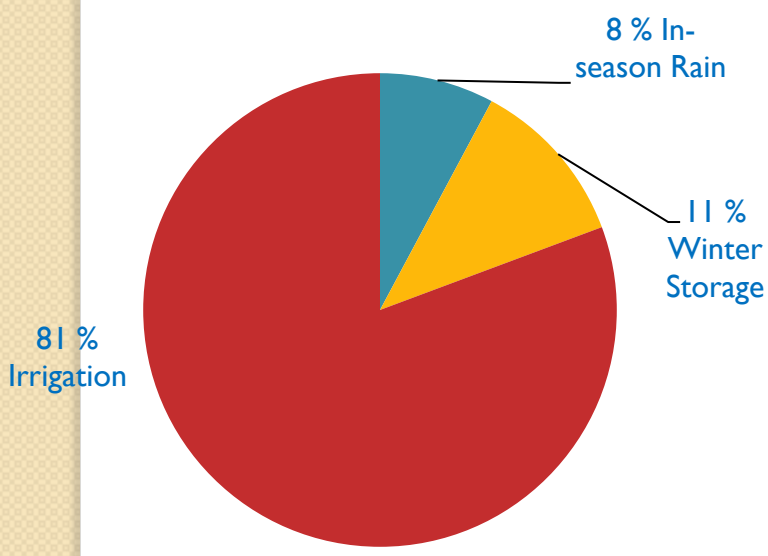
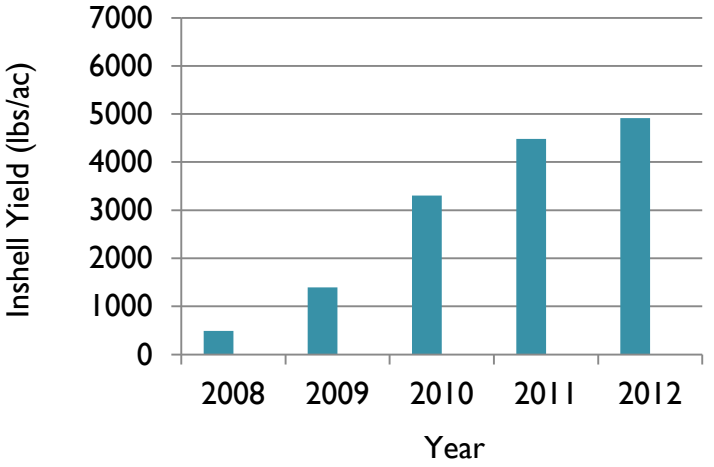
Why use an irrigation scheduling tool(s)?

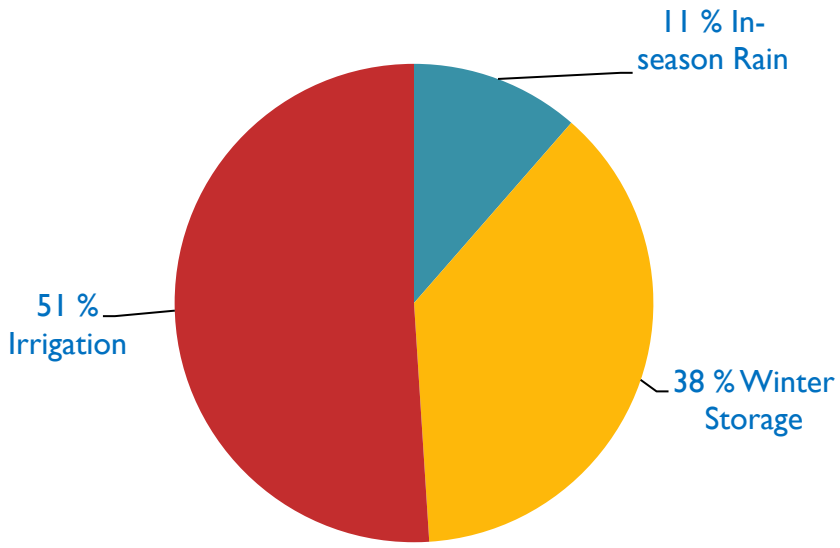
In-shell yield. Corning case study.
Chandler Variety, 11th to16th Leaf.





In-shell yield. Los Molinos case study.
Chandler Variety, 4th to 8th Leaf.





Different irrigation scheduling methods

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

A Water budget compares

- **Water losses**
  - Evapotranspiration (ETc)
  - Inefficiencies
- **Water supplies**
  - Dormant season soil storage
  - In-season rainfall
  - Irrigation

Evapotranspiration (ETc)?

- The sum of the water evaporated from the orchard floor and transpired through the orchard canopy
- Walnut ETc – 38 to 42 inches/acre during growing season

Seasonal evapotranspiration (ETc) does not equal irrigation requirement.

Example water budget

WEEKLY SOIL MOISTURE LOSS IN INCHES

(Estimated Evapotranspiration

03/30/12 through 04/05/12

West of Sacramento River

Past Week of Water Use	Accum'd Seasonal Water Use	NOAA Forecasted Week of Water Use	Crop (Leafout Date)
0.84	3.52	0.83	Pasture
0.84	3.52	0.83	Alfalfa
0.64	2.68	0.64	Olives
0.54	2.26	0.53	Citrus
0.65	2.30	0.67	Almonds (3/1) *
0.63	1.24	0.68	Prunes (3/15) *
0.35	0.35	0.44	Walnuts (4/1) *
0.84	2.88	0.87	Urban Turf Grass

Accumulations started on March 1, 2012 or on the approximate leafout date for a s
parentheses. Criteria for beginning this report are based on the season's last signif
profile is estimated to be near its highest level for the new season.
* Estimates are for orchard floor conditions where vegetation is managed by some
frequent mowing or tillage, and by mid and late season shading and water stress.
as much as 25 percent higher in orchards where cover crops are planted and mana

0.44 **Past Seven days Precipitation (Inches**

3.32 **Accum'd Precip (Inches)**

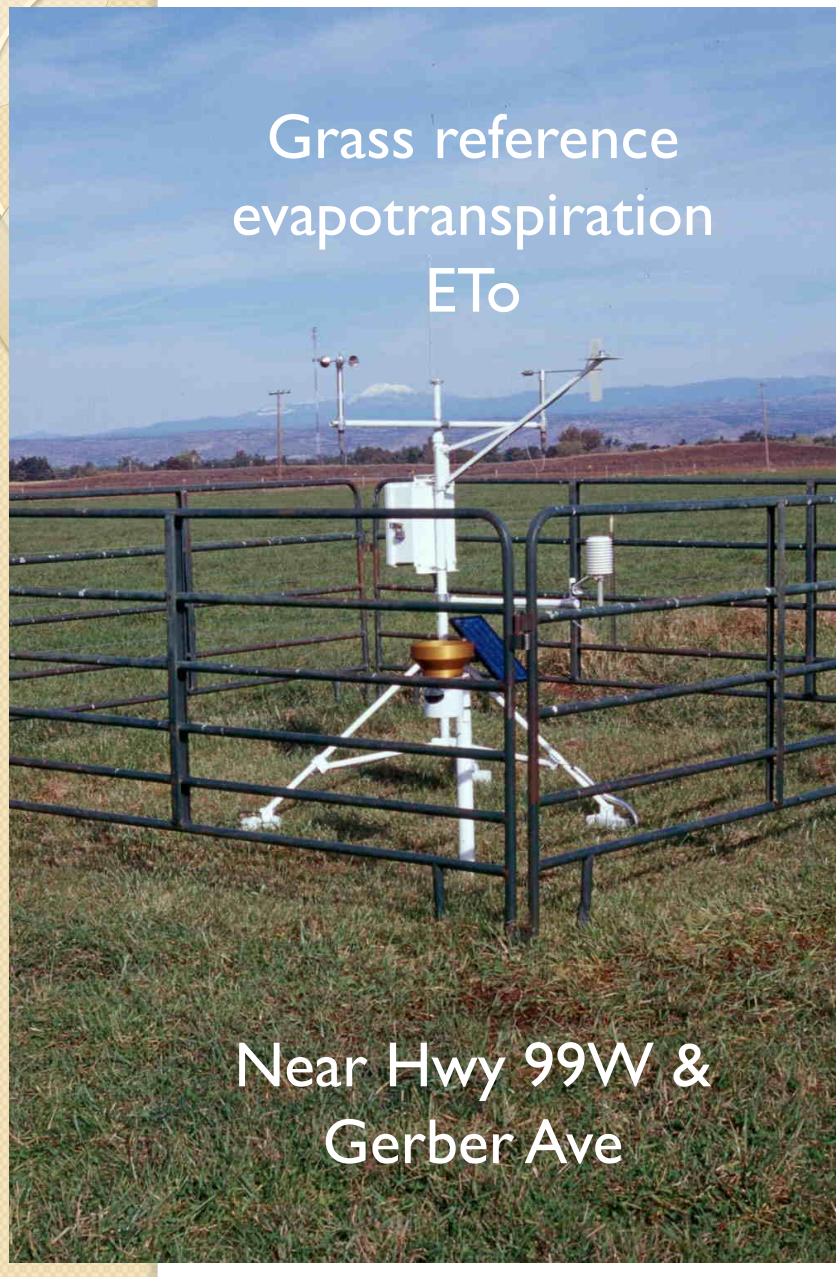
PAST WEEKLY APPLIED WATER IN INCHES, ADJU

50%	60%	70%	80%	90%	Efficiency
1.3	1.1	0.9	0.8	0.7	Olives
1.1	0.9	0.8	0.7	0.6	Citrus
1.3	1.1	0.9	0.8	0.7	Almonds (3/1)
1.3	1.1	0.9	0.8	0.7	Prunes (3/15)
0.7	0.6	0.5	0.4	0.4	Walnuts (4/1)

[1] The amount of water required by a specific irrigation system to satisfy evapotransp
efficiency are: Drip Irrigation, 80%-95%; Micro-sprinkler, 80%-90%; Sprinkler, 70

For further information concerning all counties receiving this report, contact the Te
3101.

Date	Weekly ETc	Accum'd ETc	In-season Rainfall	Accum'd Rainfall	Irrigation Needed (hours per week)	
2012	(Inches per Week)				@ 0.04 in/hr	@ 0.07 in/hr
3/30-4/5	0.35	0.35	0.44	0.44	None	None
4/6-4/12	0.41	0.76	0.99	1.43	None	None
4/13-4/19	0.44	1.20	0.29	1.72	None	None
4/19-4/26	0.61	1.81	0.04	1.76	None	None
4/26-5/3	0.77	2.58	0.02	1.78	None ?	None ?
5/4-5/10	1.24	3.82	0.00	1.78	None ??	None ??
5/11-5/17	1.09	4.91	0.00	1.78	27 ?	16 ?
5/18-5/24	1.43	6.34	0.00	1.78	36	20
5/25-5/31	1.29	7.63	0.00	1.78	32	18
↕				↕		
7/20-7/26	2.12	22.26	0.00	1.88	53	30
↕				↕		
9/7-9/13	1.43	34.86	0.00	1.88	36	20
↕				↕		
10/19-10/25	0.35	39.86	0.46	2.34	None	None



DATE	MATURE WALNUT Kc[1]
Apr 1-15	0.12
Apr 16-30	0.53
May 1-15	0.68
May 16-31	0.79
June 1-15	0.86
June 16-30	0.93
July 1-15	1.00
July 16-31	1.14
Aug 1-15	1.14
Aug 16-31	1.14
Sept 1-15	1.08
Sept 16-30	0.97
Oct 1-15	0.88
Oct 16-31	0.51
Nov 1-15	0.28

[1] Goldhamer, et.al., 1996, Fulton, et.al, 2011

What is a Kc? Kc = (ETc/ETo), assumes soil moisture is <u>not</u> limiting

Experience in 2nd to 4th leaf orchards

1st Leaf ~
- 7.2 % PAR (+/- 1.8 %)
- 14 to 15 inches of water use (Not all from irrigation)
- 2 to 45 % of ETc for a mature orchard

2nd Leaf ~
- 16-23 % PAR (+/- 2.4 %)
- 21.2 inches of water use (Not all from irrigation)
- 35 to 60 % of ETc for a mature orchard

3rd Leaf ~
- 29 - 35 % PAR (+/- 5.0 %)
- 38.0 inches of water use (Not all from irrigation)
- 70-100 % of ETc for a mature orchard
- Influenced by irrigation method and orchard floor vegetation

4th Leaf ~
- 48 -50 % PAR (+/- 5.0 %)
- 42.0 inches of water use (Not all from irrigation)
- Approaching 100 % of ETc for a mature orchard
- Influenced by irrigation method and orchard floor vegetation

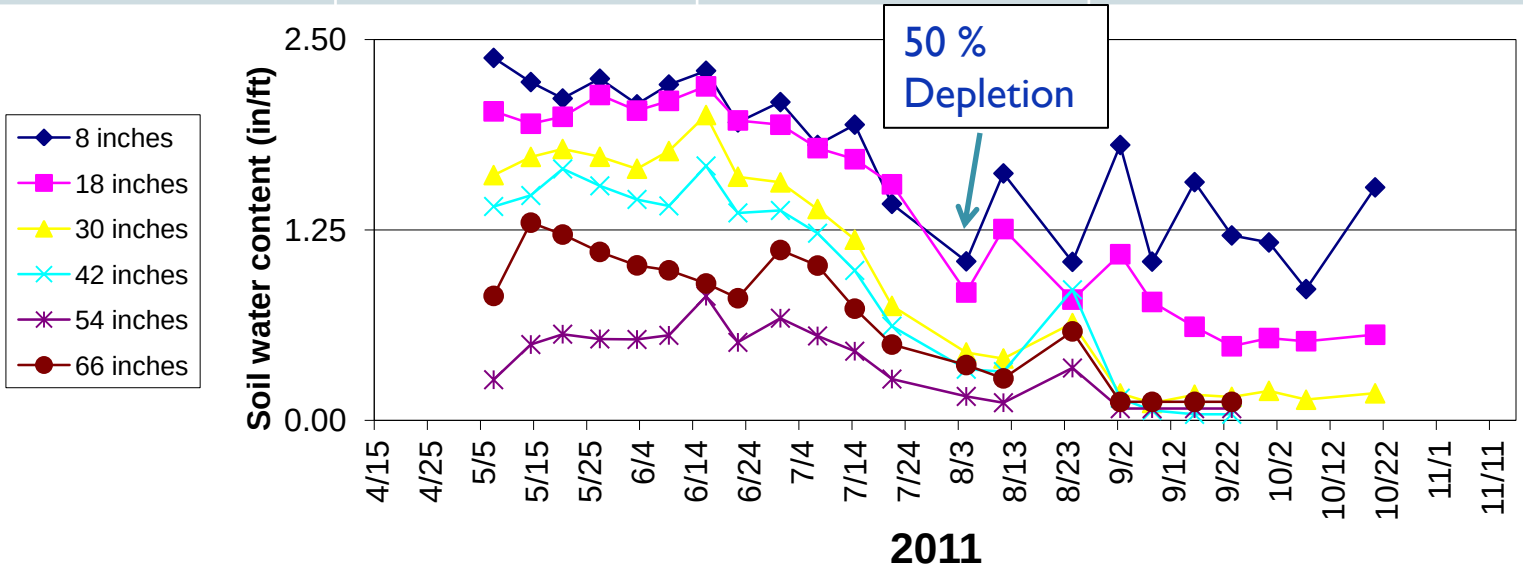
Water budget

- Low cost, first approximation of irrigation needs
- Copes with variability in orchards.
- In side-by-side comparisons, the water budget method has had more error
  - Are the Kc values representative?
  - Are assumptions about effective rainfall and root zone reasonable?
- Acquiring or delivering ETc information in a convenient and understandable form is a challenge

Example sensors to monitor soil moisture depletion

Soil moisture depletion method using volumetric moisture sensors

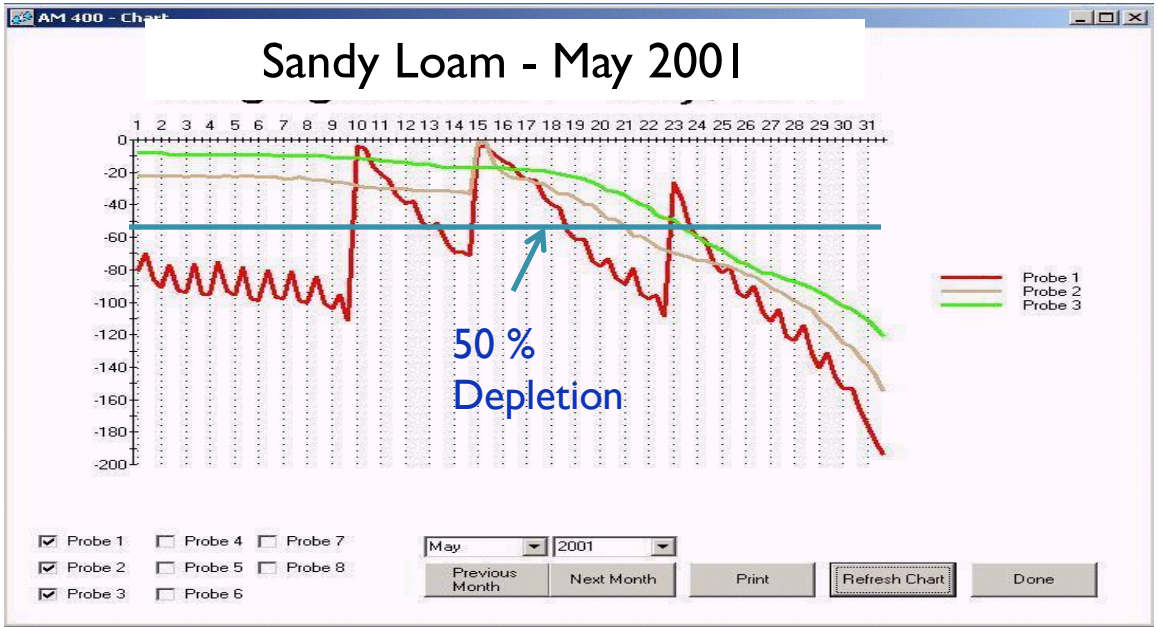
Soil Texture	Field capacity	Wilting Point	Available Water Capacity
	(Inches/ft of soil)		
Sandy loam	2.0	0.6	1.4
Fine sandy loam	2.6	0.8	1.8
Loam	3.2	1.2	2.0
Silt loam	3.5	1.4	2.1
Clay loam	3.8	1.8	2.0
Clay	4.0	2.6	1.4



Soil moisture depletion method using moisture tension sensors

Soil Tension	Sand/Loamy Sand	Sandy Loam	Loam/Silt Loam	Clay Loam/Clay
(centibars)	Depletion of the Plant Available Water (%)			
10	0	0	Not fully drained	Not fully drained
30	40	25	0	0
50	65	55	10	10
70	75	60	25	20
90	80	65	35	25
110	85	68	40	32
130	87	70	47	38
150	90	73	52	43
170	95	76	55	46
190	98	79	58	49

Table adapted from Scheduling Irrigations: When and How Much Water to Apply. Division of Agriculture and Natural Resources Publication 3396. University of California Irrigation Program. University of California, Davis. pp. 106.



Soil Moisture Depletion

- Soil moisture depletion method can lead to improved irrigation scheduling
- Soil moisture sensors and resistance blocks coupled with radio telemetry are “state of the art”
  - Excel at convenient, timely delivery of information
  - Deliver more detailed information than manual measurements
  - Useful during dormant season
- Sometimes acquiring representative data can be a challenge
  - Soil and orchard variability
  - Depth of profile to monitor
  - Root distribution and density
  - Small volumes of soil monitored
  - Gravelly soils and soils with shrinking and swelling characteristics

Weekly measurement of orchard stress (pressure chamber, midday SWP)

Three types of pressure chambers for monitoring orchard water status

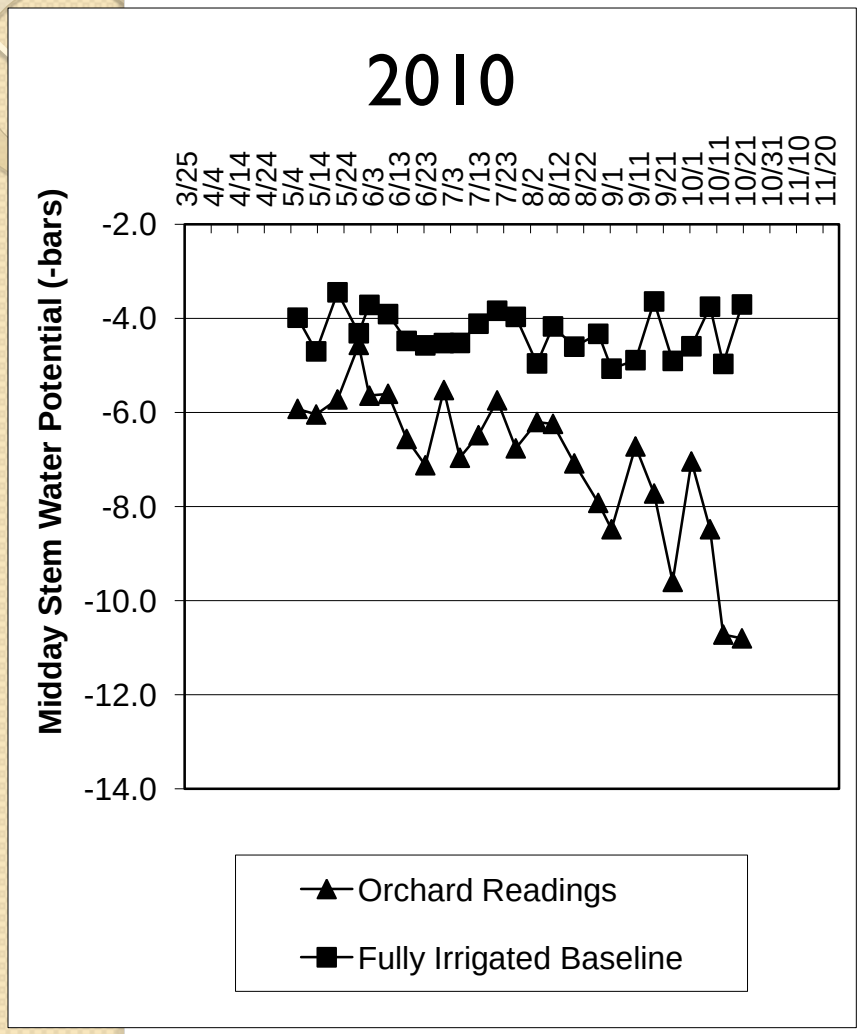
Hand held manual pump up version

Suitcase style with external pressure tank

Bench or console style

Monitoring Midday Stem Water Potential in the Field

Example data of orchard water status (pressure chamber) in walnuts



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.
-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.

Midday SWP

- Midday SWP uniquely integrates and quantifies how an orchard is responding to soil, water, and climatic conditions.
- SWP can help adjust assumptions that are made to use soil moisture depletion method or when using a water budget.
- Must go into the orchard routinely
  - Labor intensive – a negative for some
  - Encourages routine observation of an orchard, a positive for others
- Concern expressed “by the time SWP responds deep soil moisture is gone”
  - Resolve this through trial and error
  - Use SWP in combination with water budget or soil moisture monitoring

Benefits of irrigation management

Productivity

- Earlier
- Higher and more consistent
- Better crop quality and more value
- Improved orchard life span

Complements other cultural practices

Resource stewardship

Water and energy conservation?

2012 Survey of Almond Growers

- Turning to more science-based information

- 53 % Use flow meters
- 43 % Irrigation uniformity
- 44 % - Water budget (ETc)
- 49 % - Soil moisture monitoring
- 28 % - Pressure Chamber, Midday SWP

THANK YOU!

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