Irrigation Scheduling in Walnuts and Almonds

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What is Irrigation scheduling?

- Making decisions about when to irrigate and how much water to apply
- Different scheduling methods

Benefits of irrigation scheduling

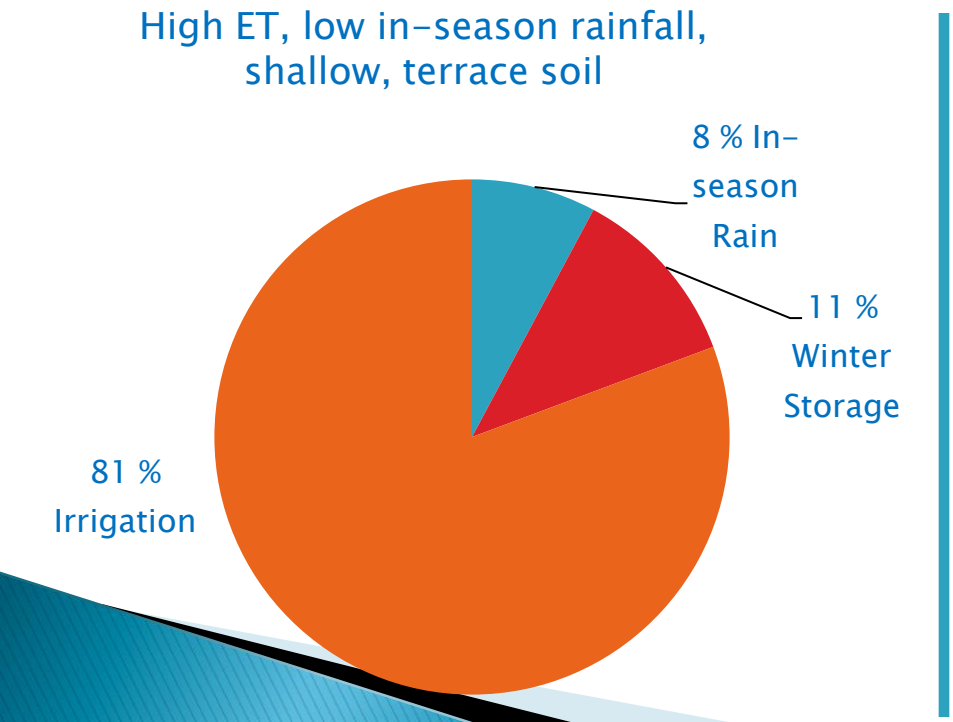
- Productivity
  - Earlier
  - Higher and more consistent
  - Better crop quality and more value
- Improved orchard life span
- Complements other cultural practices
- Resource stewardship
- Water and energy conservation?

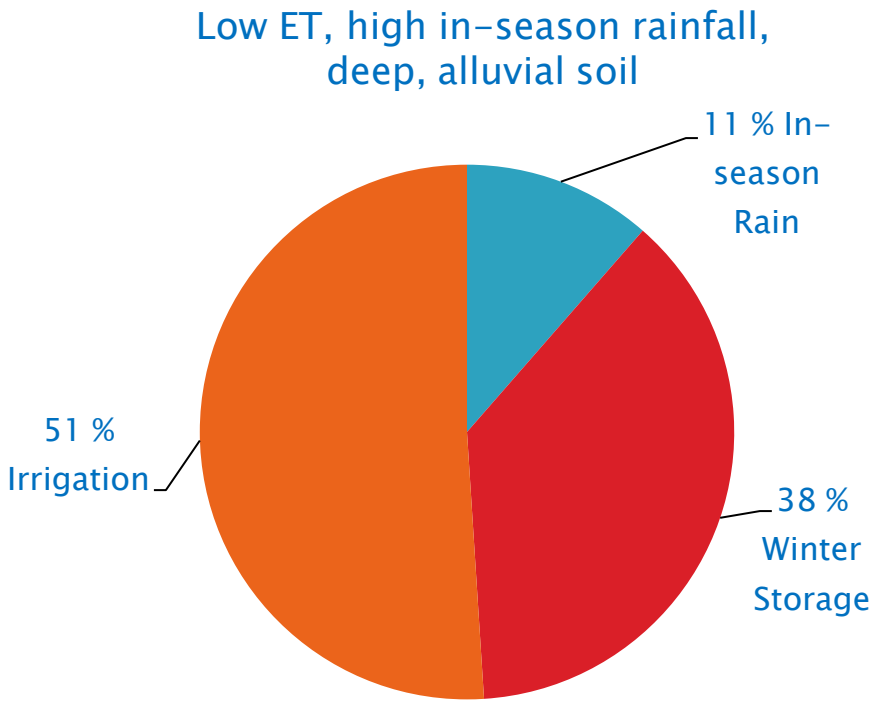
Evapotranspiration (ETc)?

- The sum of the water evaporated from the orchard floor and transpired through the orchard canopy
- Can be estimated hourly, daily, weekly, monthly, or seasonally
- Walnut ETc – 38 to 42 inches/acre annually
- Almond ETc – 44 – 60 inches/acre annually
  - Lively ongoing debate with regard to almonds

Seasonal evapotranspiration (ETc) does not equal irrigation requirement

- In-season, effective rainfall
- Winter rainfall storage contribution
- Irrigation



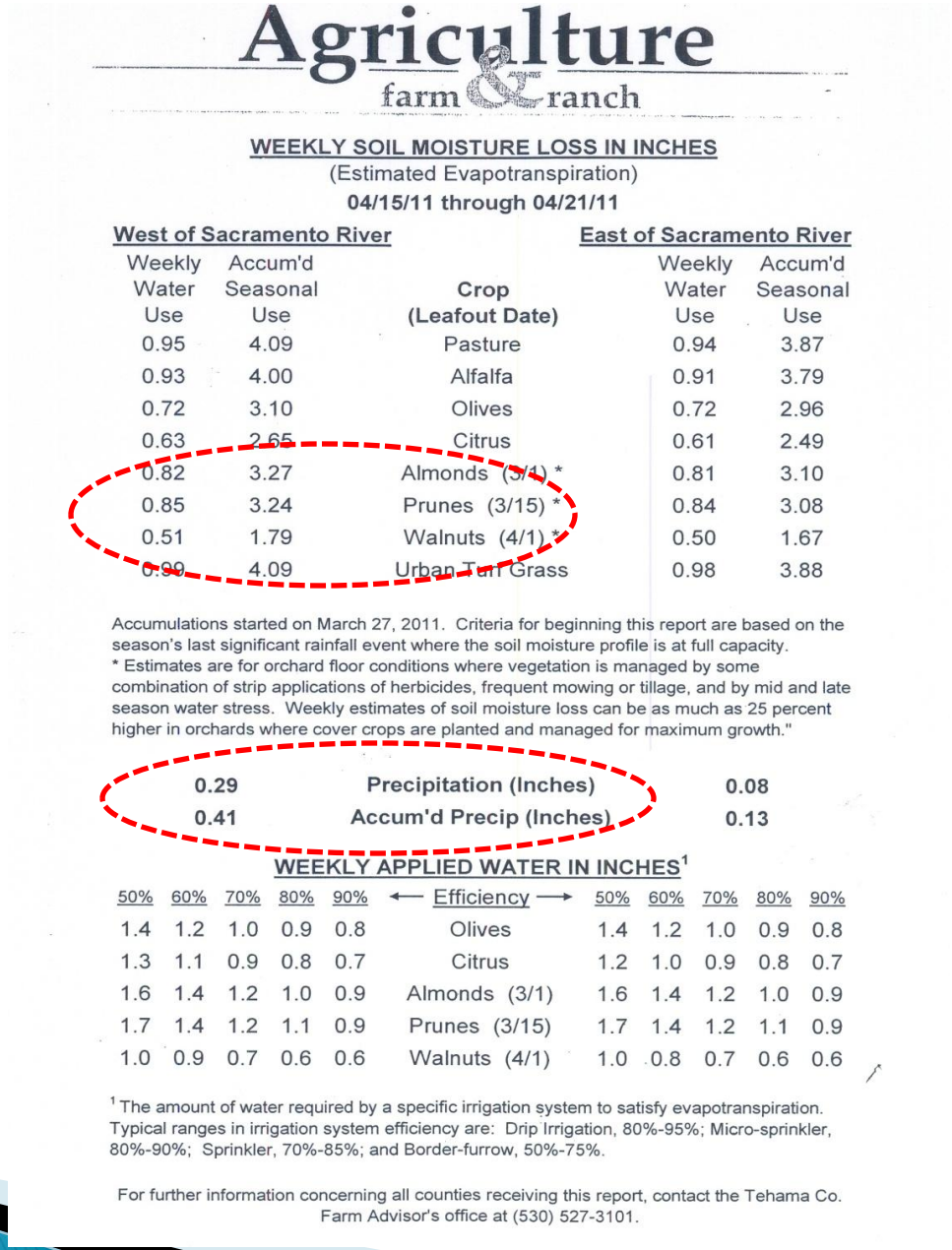


Different irrigation scheduling methods

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

Note: Research and development of each of these irrigation scheduling methods dates back to about1960 or earlier. All three methods are linked together by the "soil-plant-atmospheric continuum"

Water budget – requires an estimate of ETc



Agriculture
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WEEKLY SOIL MOISTURE LOSS IN INCHES
(Estimated Evapotranspiration)
04/15/11 through 04/21/11

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
0.95	4.09	Pasture	0.94	3.87
0.93	4.00	Alfalfa	0.91	3.79
0.72	3.10	Olives	0.72	2.96
0.63	2.65	Citrus	0.61	2.49
0.82	3.27	Almonds (3/1) *	0.81	3.10
0.85	3.24	Prunes (3/15) *	0.84	3.08
0.51	1.79	Walnuts (4/1) *	0.50	1.67
0.99	4.09	Urban Turf Grass	0.98	3.88

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."

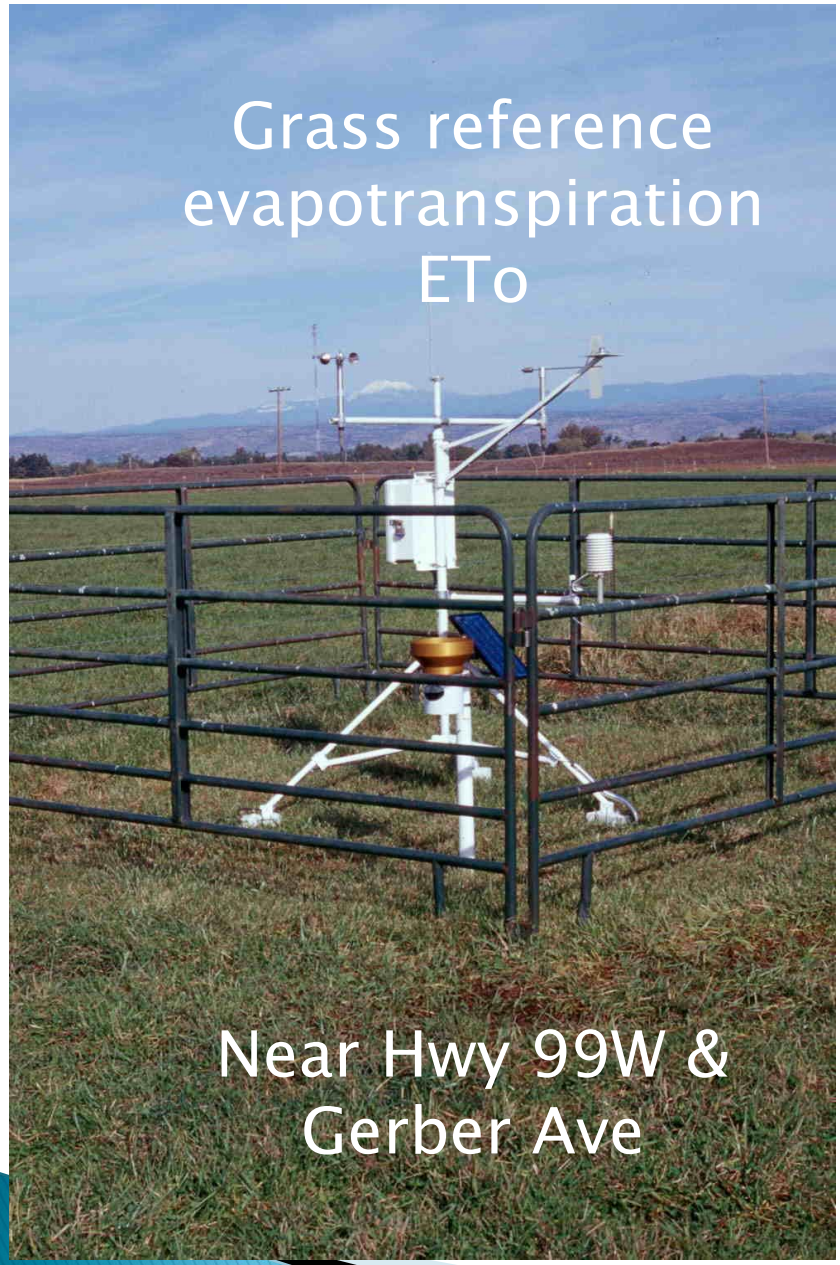
0.29	**Precipitation (Inches)**	**0.08**
0.41	**Accum'd Precip (Inches)**	**0.13**

WEEKLY APPLIED WATER IN INCHES[1]

← Efficiency →						← Efficiency →				
50%	60%	70%	80%	90%		50%	60%	70%	80%	90%
1.4	1.2	1.0	0.9	0.8	Olives	1.4	1.2	1.0	0.9	0.8
1.3	1.1	0.9	0.8	0.7	Citrus	1.2	1.0	0.9	0.8	0.7
1.6	1.4	1.2	1.0	0.9	Almonds (3/1)	1.6	1.4	1.2	1.0	0.9
1.7	1.4	1.2	1.1	0.9	Prunes (3/15)	1.7	1.4	1.2	1.1	0.9
1.0	0.9	0.7	0.6	0.6	Walnuts (4/1)	1.0	0.8	0.7	0.6	0.6

[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.

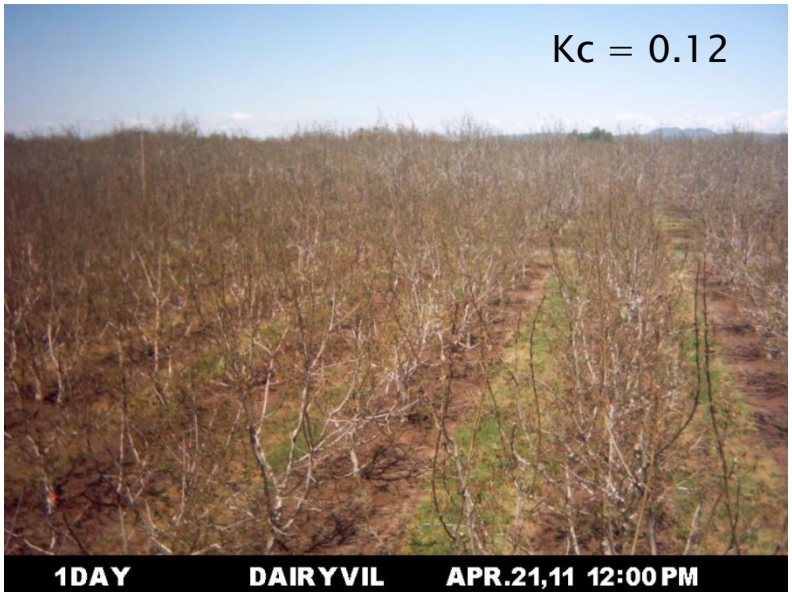


DATE	WALNUT Kc[1]	ALMOND Kc[2]
Mar 1–15	NA	0.54
Mar 15–31	NA	0.77
Apr 1–15	0.12	0.94
Apr 16–30	0.53	0.99
May 1–15	0.68	1.02
May 16–31	0.79	1.04
June 1–15	0.86	1.08
June 16–30	0.93	1.11
July 1–15	1.00	1.11
July 16–31	1.14	1.11
Aug 1–15	1.14	1.11
Aug 16–31	1.14	1.06
Sept 1–15	1.08	0.93
Sept 16–30	0.97	0.77
Oct 1–15	0.88	0.65
Oct 16–31	0.51	0.52
Nov 1–15	0.28	0.28

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

[2] Sanden, et. al., 2011

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



Water budget requires knowledge of how irrigation system is performing

Measure applied water

Mobile Irrigation Lab

Water budget – need to account for Soil Storage Contribution and In-season Rainfall

Soil Texture	Available Water Holding Capacity
	(Inches/ft)
Fine sand	1.0
Sandy loam	1.4
Fine sandy loam	1.8
Loam	2.0
Silt loam	2.1
Clay loam	2.0
Clay	1.4

Example Water Budget Summary in Walnut

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.

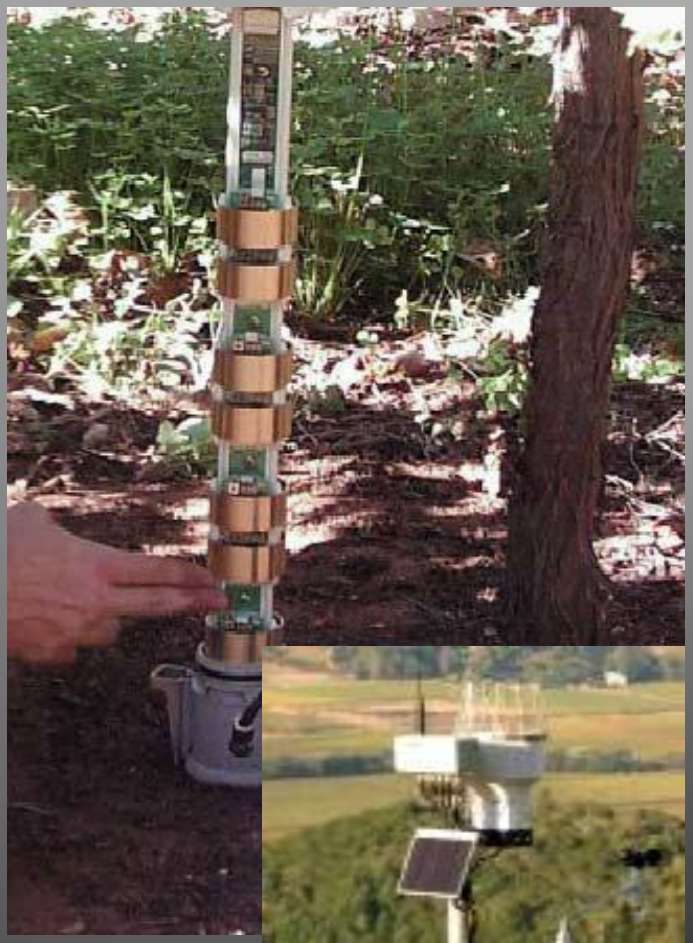
Water budget – talking points and suggestions

- Low cost, more of an entry level approach to irrigation scheduling
- Water budget is a method of coping with spatial variability in orchards.
- In case studies, the water budget method has had more error than soil moisture depletion or SWP methods
  - Representative Kc values
  - Applying reasonable assumptions about root zone
- Acquiring or delivering ETc information in a convenient and understandable form is also a challenge

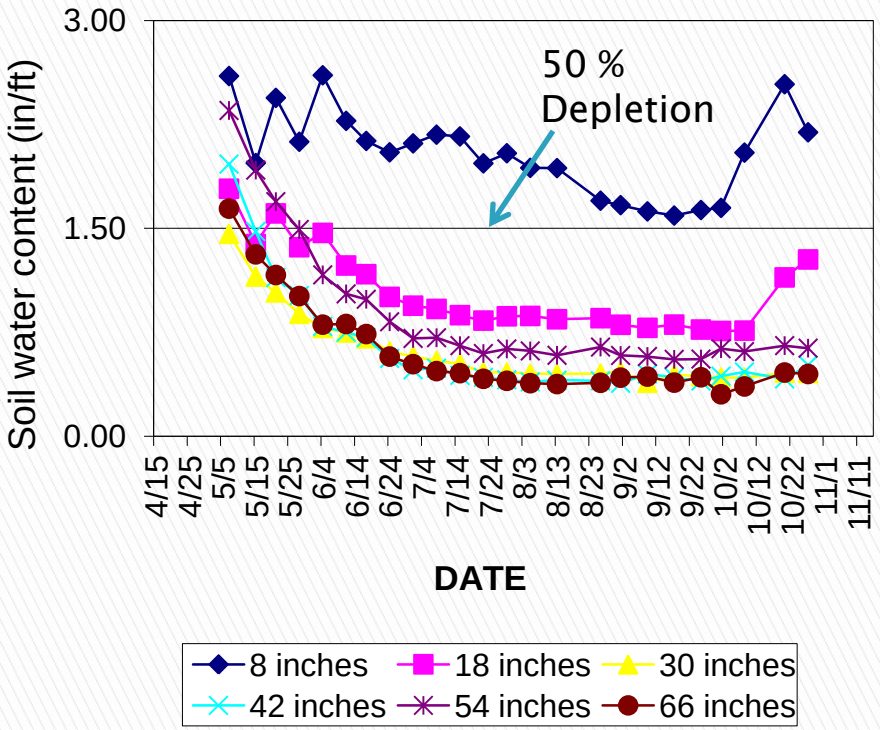
Soil moisture depletion method

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

Example sensors for routine and precise monitoring of soil moisture depletion



Example Soil Moisture Depletion Data



Manual measurement

Automated measurement

Soil Moisture Depletion – talking points and suggestions

Dielectric soil moisture sensors, resistance blocks, and radio telemetry

- Soil moisture depletion method can lead to improved irrigation scheduling
- Dielectric 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
  - Spatial soil variability
  - Depth of profile to monitor
  - Root distribution and density
  - Small volumes of soil monitored
  - Shrinking and swelling characteristics of soils

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

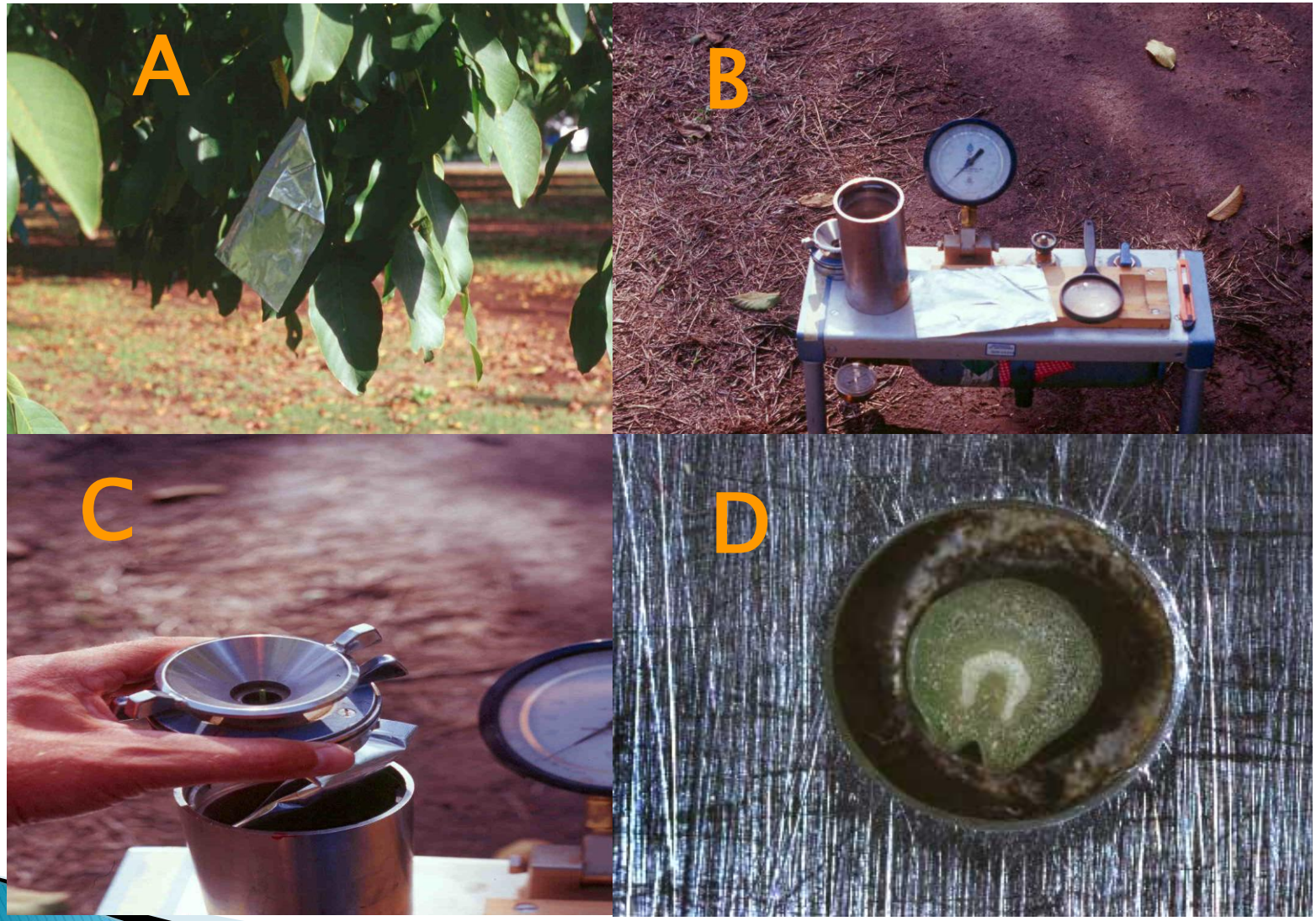
Three types of pressure chambers for monitoring orchard water status

Hand held manual pump up version

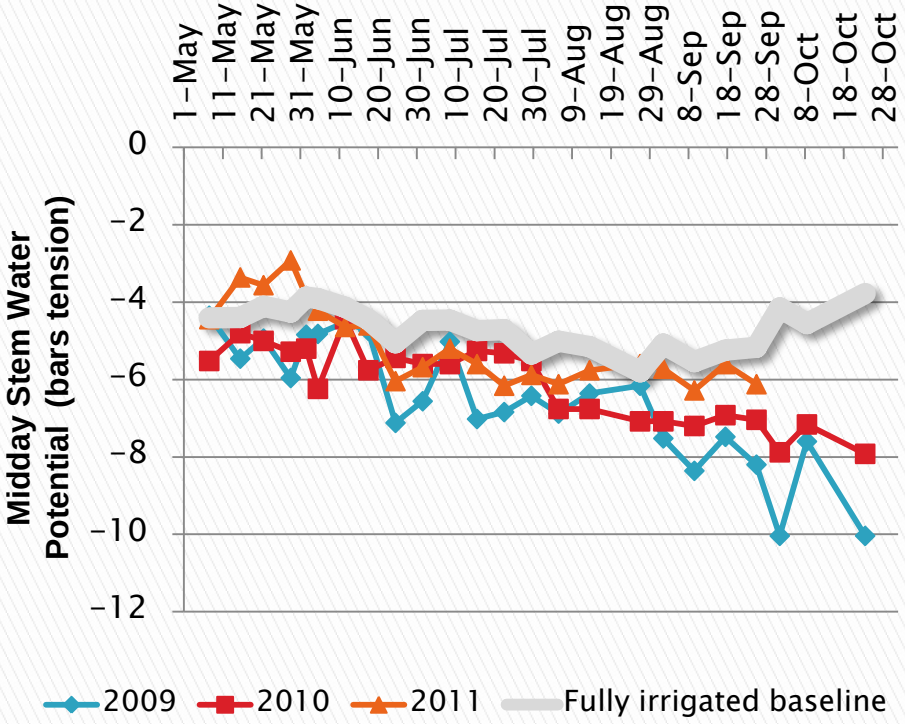
Suitcase style with external pressure tank

Bench or console style

Monitoring Midday Stem Water Potential in the Field



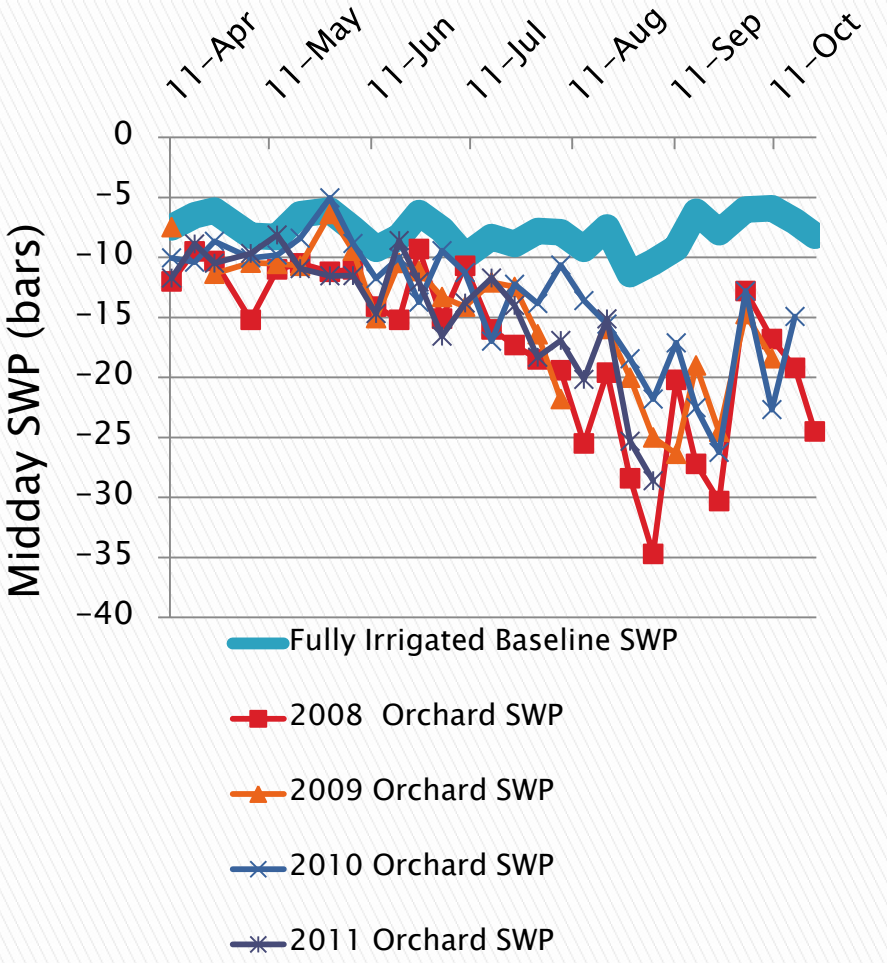
Example of orchard water status (pressure chamber) in walnuts



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.

Example of orchard water status (pressure chamber) in almonds



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.

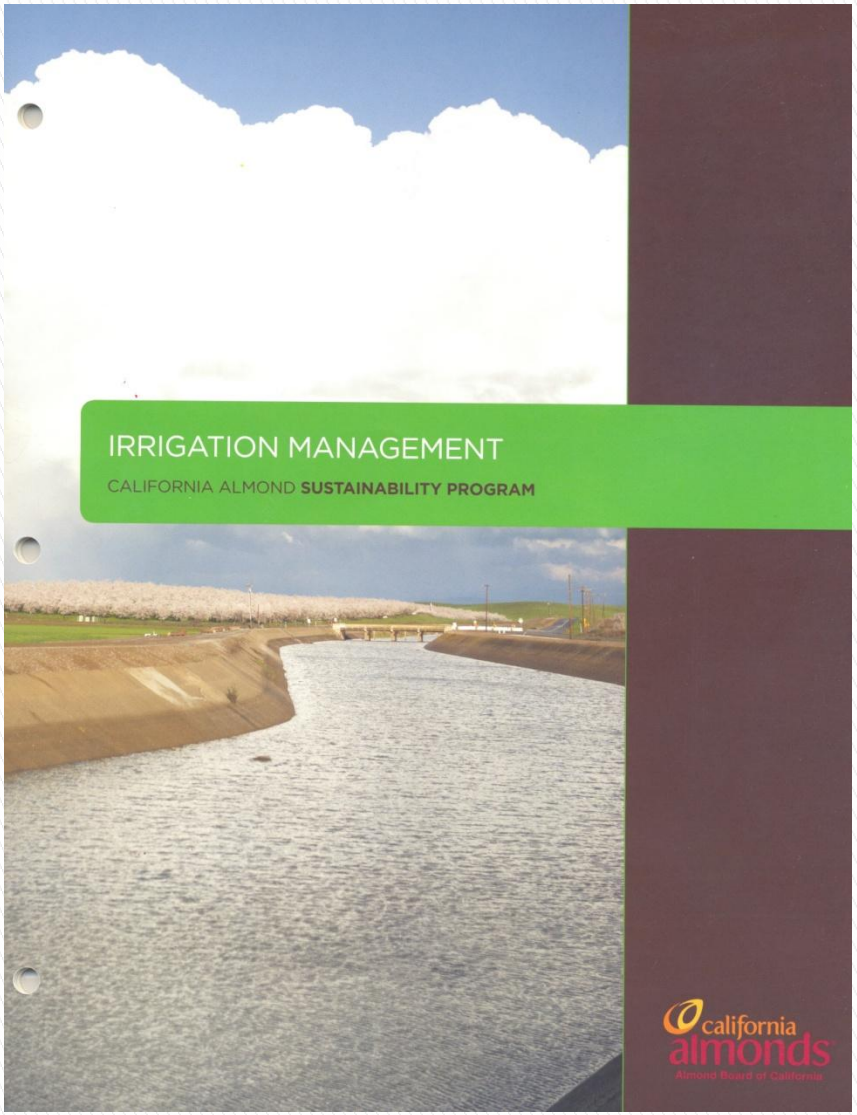
Midday SWP – talking points and suggestions

Pressure Chamber

- 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

Survey of Almond Growers Turning to more science-based information

- 43 % – Water budget (ETc)
- 55 % – Soil moisture monitoring
- 38 % – Pressure Chamber, Midday SWP



California Almond Sustainability Program

THANK YOU!

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