Irrigation 1.0 Standards

December 9, 2015

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Irrigation 1.0 Standards

Bob Curtis, Almond Board

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Water Management and Efficiency

Bob Curtis, Almond Board

Almond Irrigation Improvement Continuum

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Water Management and Efficiency

Almond Irrigation Improvement Continuum

- Water Management and Efficiency
  - One of four key components of the Accelerated Innovation Management (AIM) program adopted by Almond Board of California's (ABC) Board of Directors.
  - California experts have noted there are a range of tools growers could be implementing without wholly new technologies.
  - Focuses on accelerating almond grower transition and adoption of research based, commercially available, and increasingly water efficient irrigation management and scheduling tools.
  - An Almond Irrigation Improvement Continuum has been developed to describe the steps of this transition.

Almond Irrigation Improvement Continuum

- Three proficiency levels
  - ***Level 1.0*** (minimum) outlines research-based irrigation management practices that are within reach for all California Almond growers. (Room 310 – 311)
  - ***Level 2.0*** (intermediate) and ***level 3.0*** (advanced) advance practices to more sophisticated levels that attain even more "crop per drop." (Room 307)
- Comprehensive program of irrigation management and scheduling practices in five key areas
  - Assessing irrigation system performance and efficiency regularly
  - Estimating orchard water requirements based on evapotranspiration
  - Determining the water applied
  - Evaluating soil moisture
  - Evaluating plant water status
- Guidance on how to effectively integrate the practices at each level

Almond Irrigation Improvement Continuum

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Measurement	1.0 Minimum	2.0 Intermediate	3.0 Advanced
Irrigation System Performance	Evaluate irrigation system for pressure variation and average application rate at least once every 3 years. Correct any diagnosed system performance problems.	Assess distribution uniformity and average application rate by measuring water volume at least every 3 years. Correct any diagnosed system performance problems.	Assess distribution uniformity and average application rate by measuring water volume at least every 2 years. Correct any diagnosed system performance problems.
Applied water	Use application rate and duration of irrigation to determine water applied.	Use water meters to determine flow rate and water applied.	Use water meters to determine applied water and compare to crop water use (ETc, evapotranspiration) to determine irrigation efficiency.
Orchard Water Requirements	Estimate orchard water requirements using “normal year” regional ETc to estimate irrigation demand on a monthly time step.	Estimate orchard water requirements using “normal year” regional ETc – adjusting for current weather and cover crop use on a bi-weekly time step.	Estimate orchard water requirements using “normal year” regional ETc to plan irrigations then use real time ETc data to correct the schedule on a weekly time step.
Soil Moisture	Evaluate soil moisture based upon feel and appearance by augering to at least 3-5 feet. Monitor on a monthly time step.	Use manually operated soil moisture sensors to at least 3-5 feet and monitor on a bi-weekly time step. Use information to ensure calculated water is not over/under irrigating trees.	Use automated moisture sensors that store data over time. Review weekly to ensure calculated water is not over/under irrigating trees.
Plant Water Status	Evaluate orchard water status using visual plant cues just prior to irrigation or on a bi-weekly time step.	Use pressure chamber to measure midday stem water potential just prior to irrigation on a monthly time step. Ensure calculated water applications are not over/under irrigating trees.	Use pressure chamber to measure midday stem water potential prior to irrigation on a weekly time step. Ensure calculated water applications are not over/under irrigating trees. Use it to assess when to start irrigating.
Management			
Integrating Approaches	Combine irrigation system performance data with “normal year” regional ETc estimates to schedule irrigations. Check soil moisture status with auger occasionally.	Use irrigation system performance data with regional estimates of “normal year” ETc to schedule irrigations and adjust based on feedback from monitoring soil moisture or crop water status.	Develop an irrigation schedule based on predicted “normal year” demand, monitor status using soil and plant based methods. Adjust irrigation schedule with real-time ETc as the season progresses.

*The web version of this continuum, available on Almonds.com/Growers after Mar. 1, 2016, will feature a “More Information and Guidance” link in each square explaining how that step can be achieved.

Almond Irrigation Improvement Continuum Outreach

- The Almond Board's objective is to assist all almond growers in meeting level 1.0 proficiency
- Beyond this, to work with growers to progress along the continuum to levels 2.0 and 3.0 proficiency
- This will be done in partnership with the many trusted and respected technical experts and resources available to California Almonds
  - University of California Cooperative Extension
  - USDA NRCS
  - CSU Fresno, Cal Poly SLO
  - CDFA SWEEP Program
  - Private companies and services, irrigation districts, and others
- Adoption will be assessed via the Almond Sustainability Program
- Web version of Continuum will be available on Almonds.com/Growers after March 1, 2016 and will feature a "More information and Guidance" link in each square explaining how that step can be achieved, answering:
  - What do I need to know?
  - What are the key resources I need?
  - How do I execute?

Larry Schwankl,
UCCE Irrigation Specialist Emeritus

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Irrigation 1.0 Standards

(Moving forward on ABC's Irrigation Continuum)

Larry Schwankl
UCCE Irrigation Specialist Emeritus

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Big Picture: Good Irrigation Water Management

1. Estimate how much water needs to be applied
   - Tree water use plus some for irrigation inefficiency
2. Know your irrigation system
   - Application rate – in/hr, “how long to apply an inch of water”, gph/tree
3. Check if you are on target
   - Soil moisture monitoring
   - Plant water status
4. Correct irrigations as needed
5. Repeat through the irrigation season

How to do this will be on the ABC web site

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Almond Irrigation Improvement Continuum

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Almond Irrigation Management Continuum

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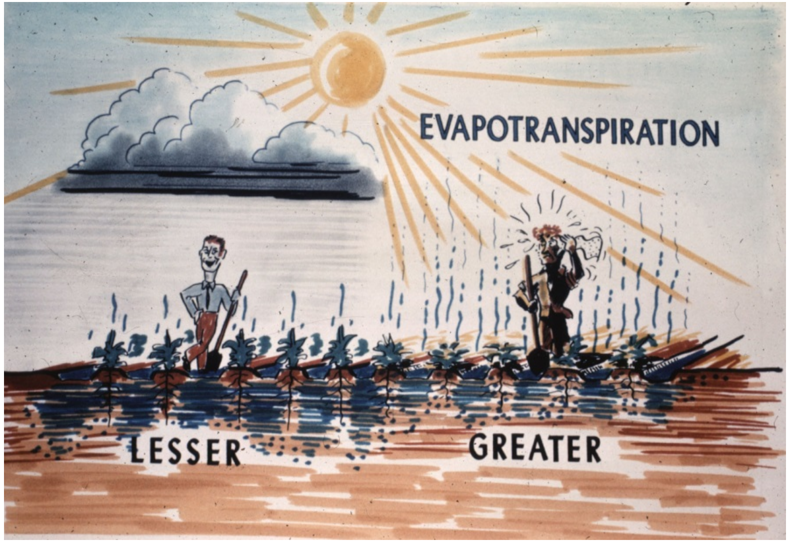
Orchard Water Requirements

- A good way to estimate the orchard water use is to estimate the Evapotranspiration (ET).
  - Evapotranspiration = Evaporation + Transpiration
  - Done by measuring the weather and then estimating the Evapotranspiration.



Orchard Water Requirements

- Evapotranspiration (ET) = Estimate of almond orchard water use
- Two types of ET information are available:
  - “Normal Year”, Historic ET_{almond} – Information will be on the web site
    - Uses ET averages over past years – e.g. last 30 years.
    - Good place to start with ET scheduling
    - Very good for planning ahead for irrigations
  - “Real-time” ET
    - More advanced ET scheduling
    - Accounts for “this year” weather which may be different from long-term average
    - Often used by planning irrigations using “normal year” ET, then check with “real-time” ET to correct if needed.

ET Information

- How do you use it?
  - Estimate how much ET (water use) since the last irrigation.
  - That amount (plus a little extra for irrigation inefficiency) is the amount of irrigation water you need to apply.

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ET Information

Historical ET (inches per month)

Month	K_c	Chico, Fresno, Madera, Modesto, Visalia	Red Bluff, Woodland	Bakersfield, Los Banos	Coalinga Hanford
Jan	0.40	0.5	0.62	0.50	0.62
Feb	0.41	0.81	0.92	0.92	1.04
Mar	0.62	2.11	2.30	2.30	2.49
Apr	0.80	4.09	4.09	4.57	4.57
May	0.94	6.44	6.44	7.02	7.31
June	1.05	8.2	8.20	8.51	9.14
July	1.11	8.93	9.61	9.61	10.30
Aug	1.11	7.90	8.59	8.59	9.28
Sept	1.06	5.73	6.05	6.50	6.68
Oct	0.92	3.41	3.69	3.69	3.97
Nov	0.69	1.23	1.44	1.44	1.64
Dec	0.43	0.40	0.66	0.53	0.66
Total		49.73	52.61	53.73	57.72

From:
“Drought Management for CA Almonds” by Doll & Shackel
UC ANR Pub. 8515

Will be on ABC web site

ET Information

Historical ET (in/day during period)

Month	Chico, Fresno, Madera, Modesto, Visalia	Red Bluff, Woodland	Bakersfield, Los Banos	Coalinga Hanford
Mar 16-31	0.09	0.07	0.09	0.10
Apr 1-15	0.12	0.09	0.13	0.14
Apr 16-30	0.15	0.12	0.17	0.17
May 1-15	0.20	0.15	0.21	0.22
May 16-31	0.23	0.20	0.25	0.26
June 1-15	0.26	0.23	0.27	0.29
June 16-30	0.28	0.26	0.29	0.31
July 1-15	0.29	0.28	0.31	0.33
July 16-31	0.29	0.31	0.31	0.34
Aug 1-15	0.27	0.31	0.29	0.32
Aug 16-31	0.25	0.29	0.27	0.29
Sept 1-15	0.21	0.27	0.22	0.24
Sept 16-30	0.17	0.22	0.18	0.20
Oct 1-15	0.13	0.18	0.14	0.15
Oct 16-31	0.10	0.14	0.11	0.11
Seasonal Total	49.73	52.61	53.73	57.72

Based on:
“Drought Management for CA Almonds” by Doll & Shackel
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Will be on ABC web site

ET Information

- How do you use it?
  - ET information is in “inches of water use”.
  - Sprinklers – we measure applied water in in/hr
  - Microirrigation: dripper or microsprinkler discharge is measured in gal/hr

- Can convert ET (in) into gal/tree for microirrigation

$$\underset{\text{(gal/day)}}{\text{Tree Water Use}} = \underset{(\text{ft}^2)}{\text{Tree Spacing}} \times \underset{\text{(in/day)}}{\text{Tree Water Use}} \times 0.623$$

  - There is a better way of handling this – we’ll show how later

Measurement	1.0 Minimum	2.0 Intermediate	3.0 Advanced
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Monitor Irrigation System Performance

- Why is this important?
  - We can determine Application Rate and how evenly (Uniformity) water is applied.
  - If you know how much you want to apply, you need to know the application rate in order to apply the correct amount of water.

Application Rate – Impact Sprinklers

- First step can be to measure the pressure.
- Sprinklers: application rate is measured in in/hr

$$\text{Sprinkler Application Rate (in/hr)} = \frac{96.3 \times (\text{Sprinkler discharge-gpm})}{\text{Sprinkler spacing In tree row (ft)} \times \text{Sprinkler spacing across tree row (ft)}}$$

  – Measure the pressure and get the sprinkler discharge

Table 2. Sprinkler discharge rates (gpm) for various nozzle sizes (in) and pressures (psi)

Pressure (psi)	Nozzle size (in) 3/32	7/64	1/8	9/64	5/32	11/64	3/16	13/64	7/32	15/64	1/4
20	1.17	1.60	2.09	2.65	3.26	3.92	4.69	5.51	6.37	7.32	8.34
25	1.31	1.78	2.34	2.96	3.64	4.38	5.25	6.16	7.13	8.19	9.32
30	1.44	1.95	2.56	3.26	4.01	4.83	5.75	6.80	7.86	8.97	10.21
35	1.55	2.11	2.77	3.50	4.31	5.18	6.21	7.30	8.43	9.69	11.03
40	1.66	2.26	2.96	3.74	4.61	5.54	6.64	7.80	9.02	10.35	11.79
45	1.76	2.39	3.13	3.99	4.91	5.91	7.03	8.30	9.60	10.99	12.50
50	1.85	2.52	3.30	4.18	5.15	6.19	7.41	8.71	10.10	11.58	13.18
55	1.94	2.64	3.46	4.37	5.39	6.48	7.77	9.12	10.50	12.15	13.82
60	2.03	2.76	3.62	4.50	5.65	6.80	8.12	9.56	11.05	12.68	14.44
65	2.11	2.88	3.77	4.76	5.87	7.06	8.45	9.92	11.45	13.21	15.03
70	2.19	2.99	3.91	4.96	6.10	7.34	8.78	10.32	11.95	13.70	15.59
75	2.27	3.09	4.05	5.12	6.30	7.58	9.08	10.66	12.32	14.19	16.14

Note: Metric conversions: 1 gal = 3.785 l; 1 in = 2.54 cm; 1 psi = 6.89 kPa

Application Rate - Rotators

- First step can be to measure the pressure
- Sprinklers: application rate is measured in in/hr

$$\text{Sprinkler Application Rate (in/hr)} = \frac{96.3 \times (\text{Sprinkler discharge-gpm})}{\text{Sprinkler spacing In tree row (ft)} \times \text{Sprinkler spacing across tree row (ft)}}$$

  - Measure the pressure and get the sprinkler discharge
  - **Nelson Rotator sprinklers**

Remove the head and replace with pressure gauge

R10 Plate/Nozzle Options and Flow Performance in GPM and LPH

Plate Series	Plate Options	Recommended Nozzles	PSI 25	PSI 30	PSI 35	PSI 40	PSI 45	PSI 50	BAR 1.75	BAR 2	BAR 2.25	BAR 2.5	BAR 2.75	BAR 3	BAR 3.25
P2	P2 9° Red Radius 18-20′ (5.5-6.1 m) Stream Ht.14-23″ (36-58 cm)	Lt. Blue #40	—	—	.28	.30	.32	.34	—	—	61.4	64.7	68.0	71.3	74.6
		Lt. Purple #45	.29	.32	.35	.37	.39	.42	66.4	71.3	76.3	80.6	83.9	87.2	91.5
		Dk. Green #50	.36	.39	.43	.46	.48	.51	82.3	87.2	93.4	99.4	104	108	112
		.35 10FC	Within the recommended pressure range of 25-50 PSI (1.75-3.25 BAR), the .35 10 FC flow control nozzle is flow regulating within a flow range of no more than 0% greater and 10% less than the nominal flow of .35 GPM (79.5 LPH).												
P4	P4 9° White Radius 18-22′ (5.5-6.7 m) Stream Ht. 14-24″ (36-61 cm)	Dk. Green #50	—	—	.43	.46	.48	.51	—	—	93.4	99.4	104	108	112
		Lt. Yellow #55	.44	.48	.52	.55	.59	.62	101	107	114	120	125	131	137
		Lt. Red #60	.51	.56	.61	.65	.69	.73	117	125	133	141	147	154	161
	P4 15° Orange Radius: 23-25′ (7.0-7.6 m) Stream Ht. 40-50″ (102-127 cm)	.50 10FC	Within the recommended pressure range of pressure range of 25-50 PSI (1.75-3.25 BAR), the .5 10 FC flow control nozzle is flow regulating within a flow range of no more than 0% greater and 10% less than the nominal flow of .5 GPM (114 LPH).												

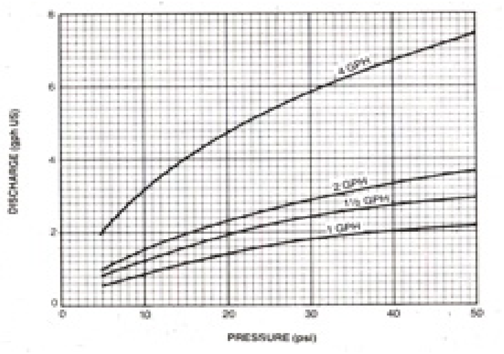
Application Rate – Drip Emitters

- First step can be to measure the pressure
- Microirrigation: application rate can be measured in in/hr

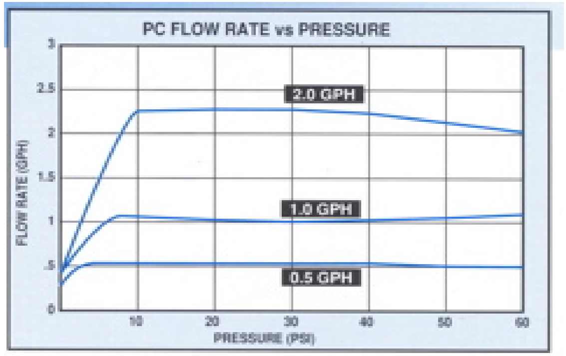
$$\text{Microirrigation Application Rate (in/hr)} = \frac{\text{Average Tree Application Rate (gph)}}{\text{Tree Spacing (ft}^2\text{)}} \times 1.6$$

  - This is easier than converting all ET (in) info. into gal/tree
  - Measure pressure with:
    - Pressure gauge with drip fitting
    - Pitot tube on pressure gauge – punch hole in tubing, fix with goof plug

Non-pressure-compensating (NPC) drip emitters



Pressure-compensating (PC) drip emitters



End of laterals

Head of laterals

Punch hole & measure

Application Rate - Microsprinklers

- First step can be to measure the pressure
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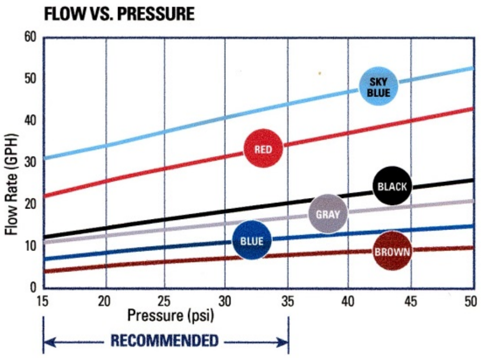
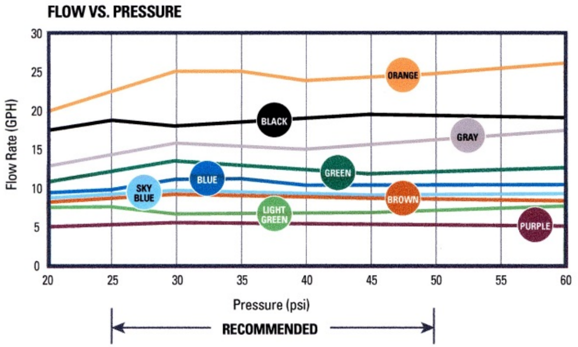
Non-pressure-compensating (NPC) microsprinklers



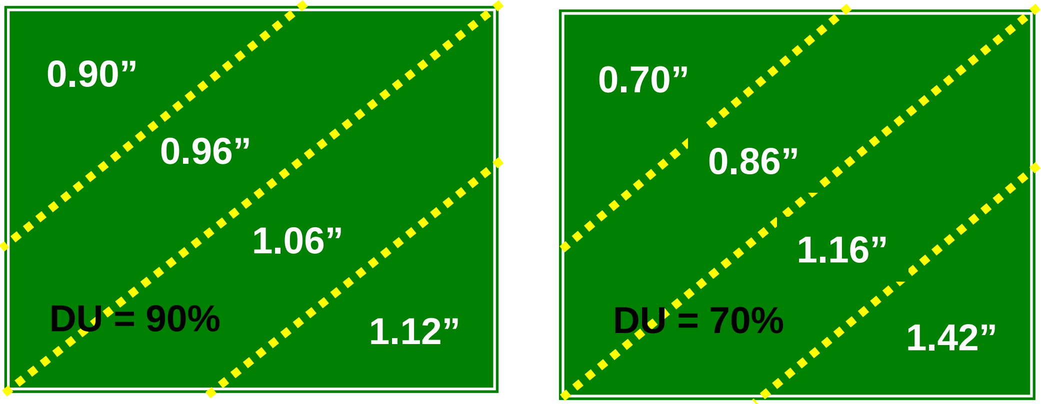
Pressure-compensating (PC) microsprinklers

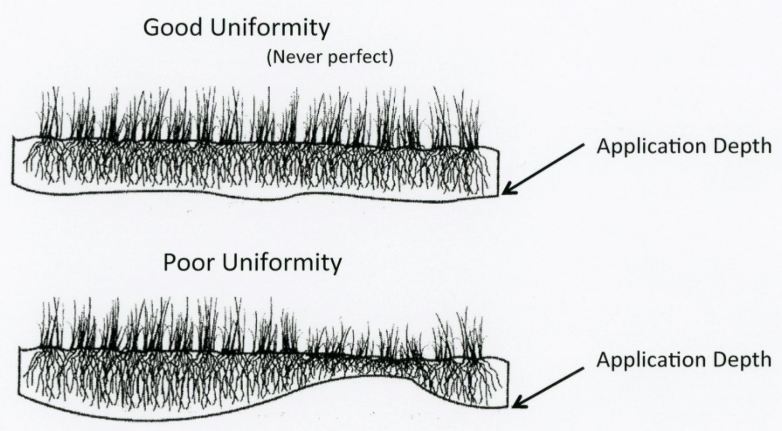


Irrigation Uniformity

- Why is it important?
  - Poor uniformity means that some areas of the orchard receive less water than others.
  - To adequately irrigate most areas of the orchard, non-uniformity means you end up over-irrigating much of the orchard.
  - Over-irrigating much of the orchard leads to irrigation inefficiency and leaching of water and chemicals (e.g. nitrates) present in the root zone.

Target Application = 1 inch "on the average"





Irrigation Uniformity

- Usually measured as Distribution Uniformity (DU) – will be measured as more advanced.
- Pressure measurements can give some guidance.
  - If you have large (greater than 10-20%) pressure differences, you may have uniformity problems.
    - Pressure differences are caused by elevation differences and too great a friction loss in pipe / tubing.

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Monitor the Water Applied

- Know the Application Rate (in/hr)
- Keep good records of irrigation set times (hrs)

$$\text{Seasonal Water Application (in)} = \text{Application Rate (in/hr)} \times \text{Irrigation Time (hrs)}$$

- Next step is to use a good flow meter – easier and more accurate.

Challenges

Questions:

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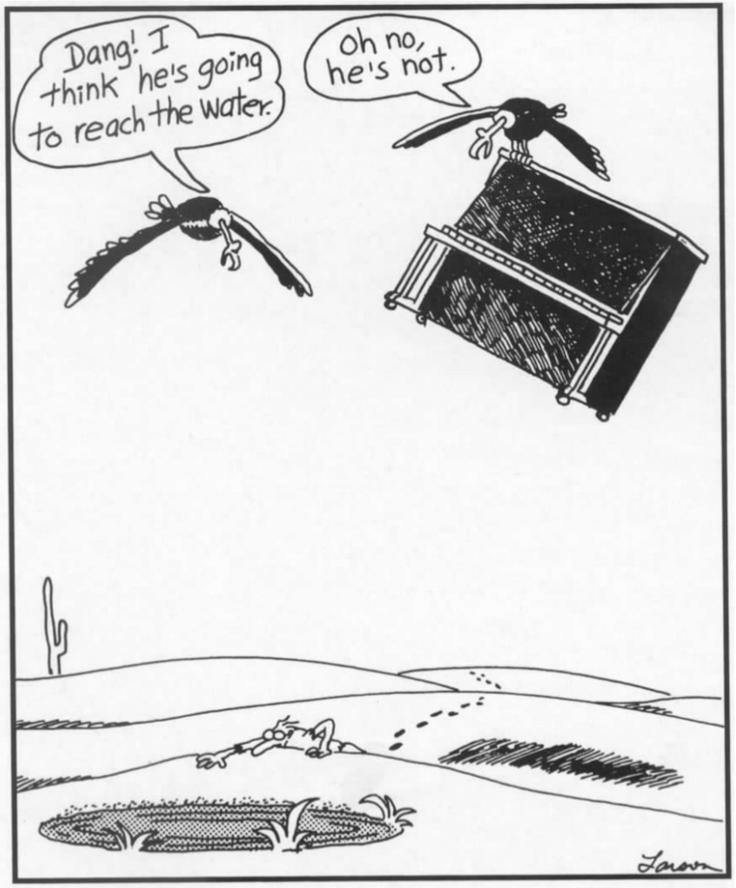

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Irrigation 1.0 Standards (cont.)

- Understanding/checking soil moisture
- Monitoring plant water status
- Managing fertilizer nitrogen
- Tying it all together

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Measurement	1.0 Minimum	2.0 Intermediate	3.0 Advanced
Soil Moisture	Evaluate soil moisture based upon feel and appearance by augering to at least 3-5 feet. Monitor on a monthly time step.	Use manually operated soil moisture sensors to at least 3-5 feet and monitor on a bi-weekly time step. Use information to ensure calculated water is not over/under irrigating trees.	Use automated moisture sensors that store data over time. Review weekly to ensure calculated water is not over/under irrigating trees.
Plant Water Status	Evaluate orchard water status using visual plant cues just prior to irrigation or on a bi-weekly time step.	Use pressure chamber to measure midday stem water potential just prior to irrigation on a monthly time step. Ensure calculated water applications are not over/under irrigating trees.	Use pressure chamber to measure midday stem water potential prior to irrigation on a weekly time step. Ensure calculated water applications are not over/under irrigating trees. Use it to assess when to start irrigating.

4 Points:

- Getting it in
- Getting it uniform
- Getting the right timing
- Getting the right amount

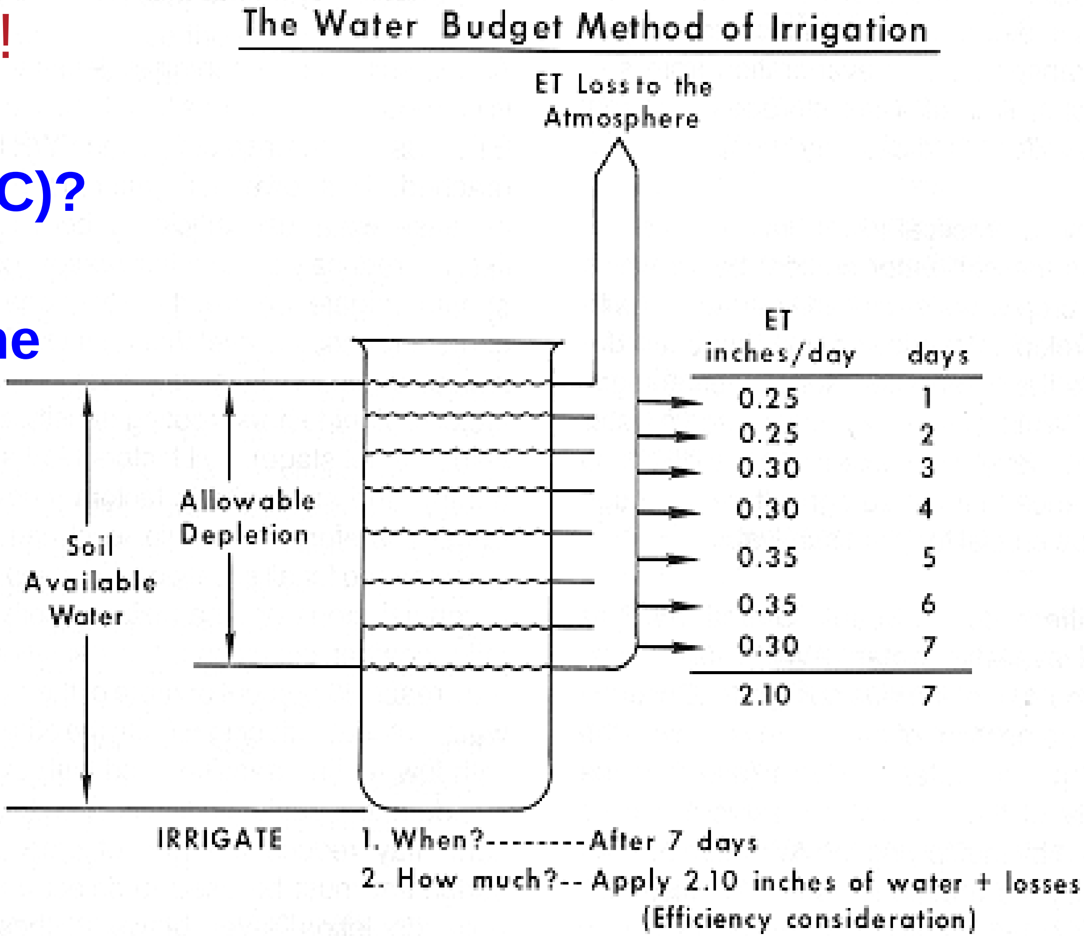
SOIL MOISTURE

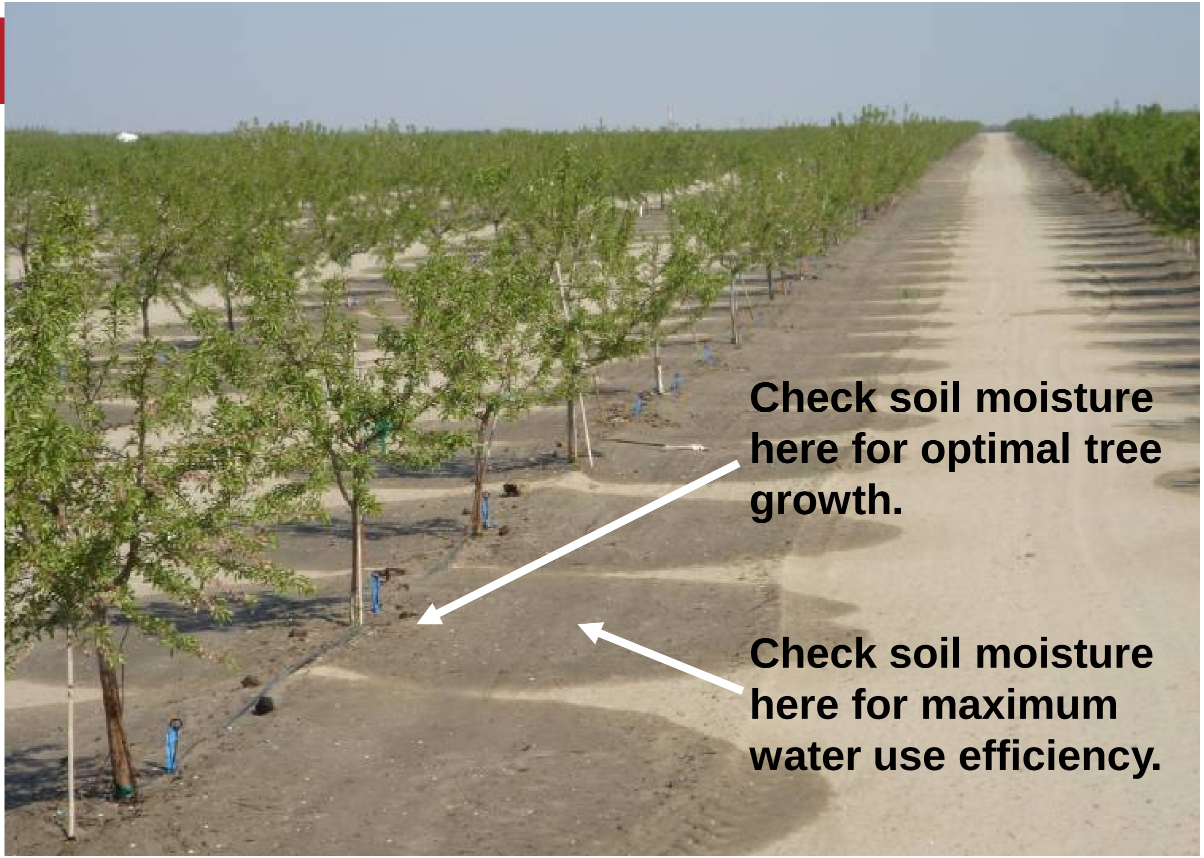
Micro-irrigation system capable of injecting fertilizer and applying 0.6 to 1.5 inches/day

california almonds
Almond Board of California

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)?**





Is all this water available to my 1st leaf trees with a small developing rootzone? What about evaporative losses and deep percolation?

For optimal growth these young trees may only use 50% of the applied water with this type of system the first 2 years.

californía almonds
Almond Board of California

So what's the big deal about monitoring soil moisture and/or plant stress?

One answer:

Each field, crop, climate and grower has unique characteristics. 15-25% of CA almonds are still flood irrigated. Infiltration is often uncertain – maybe 1.5 inches up to 12 inches per irrigation depending on the mix of soil and water chemistry.

The “dirt” is the thing. Know your soil!

Soil Texture	Field Capacity (in/ft)	Wilting Point (in/ft)	Available Soil Moisture (in/ft)	Avg Drip Subbing Diameter from 1 to 4' Depth (ft)	*Moisture Reserve (gals)
Sand	1.2	0.5	0.7	2	4
Loamy Sand	1.9	0.8	1.1	3	16
Sandy Loam	2.5	1.1	1.4	4	35
Loam	3.2	1.4	1.8	5	70
Silt Loam	3.6	1.8	1.8	6	102
Sandy Clay Loam	3.5	2.2	1.3	7	100
Sandy Clay	3.4	1.8	1.6	7	123
Clay Loam	3.8	2.2	1.7	8	170
Silty Clay Loam	4.3	2.4	1.9	9	241
Silty Clay	4.8	2.4	2.4	9	305
Clay	4.8	2.6	2.2	10	345

*This is the maximum gallons of water stored to a 4' depth beneath a single drip emitter. In fine textured soils, the wetted volume of one emitter merges with another on the same hose and final gallons of moisture reserve per emitter will be less than the number shown in the table. Plant stress will usually be seen when about 50% of this reserve has been used.

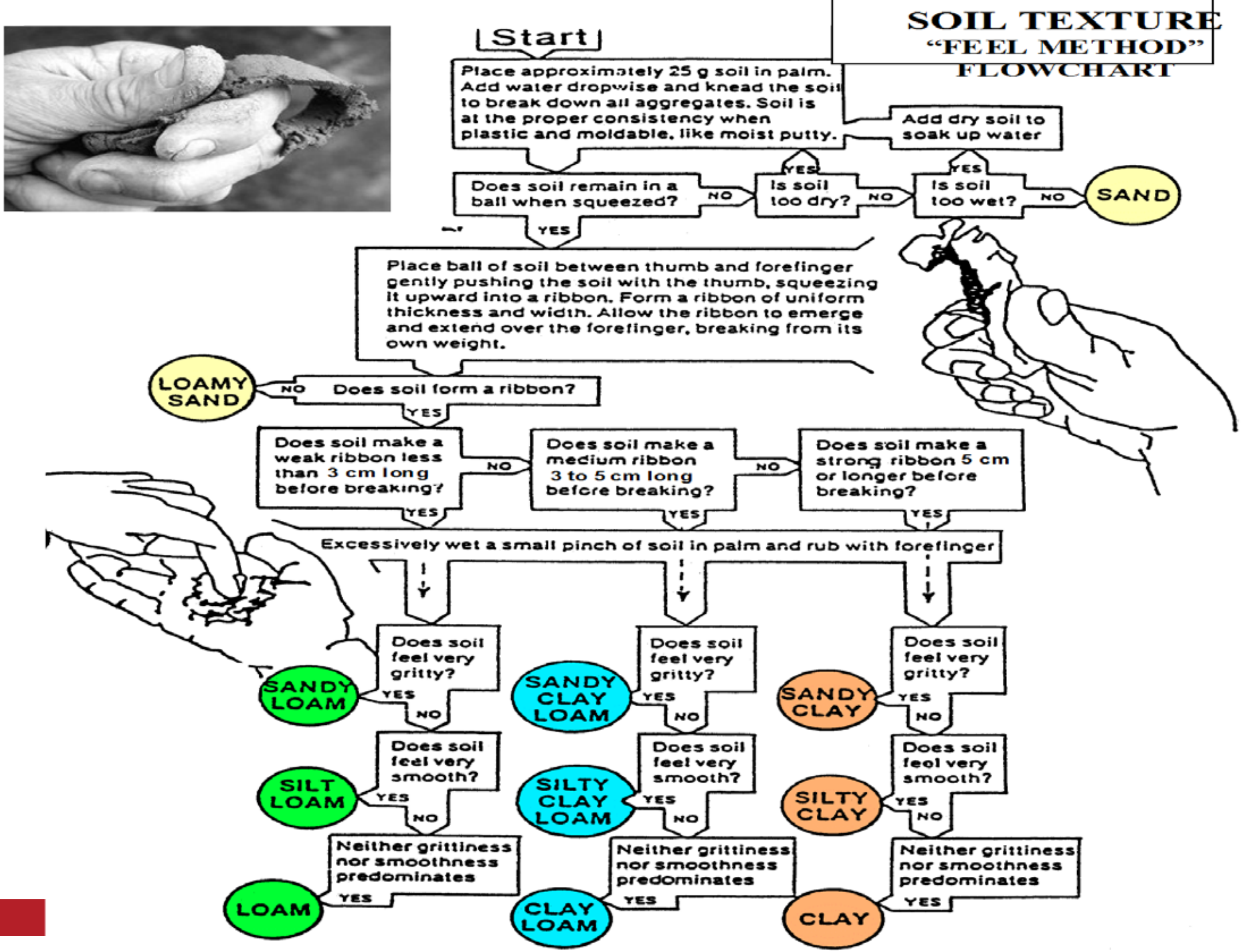
Ref: Ratliff LF, Ritchie JT, Cassel DK. 1983. Field-measured limits of soil water availability as related to laboratory-measured properties. Soil Sci Soc Am. 47:770-5.

How to do it

SOIL TEXTURE by the “ribbon test”

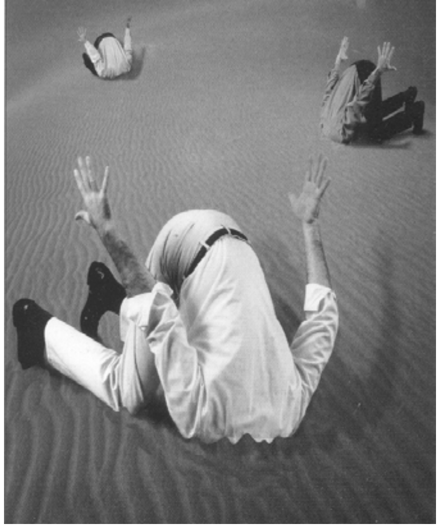
Making a soil “ribbon” from a moistened ball. Sandy Clay Loam – Westside Kern County

Almond Board of California


SOIL TEXTURE
"FEEL METHOD"
FLOWCHART
Start
Place approximately 25 g soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.
Add dry soil to soak up water
Does soil remain in a ball when squeezed?
NO
Is soil too dry?
YES
NO
Is soil too wet?
YES
NO
SAND
YES
Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.
LOAMY SAND
NO
Does soil form a ribbon?
YES
Does soil make a weak ribbon less than 3 cm long before breaking?
NO
Does soil make a medium ribbon 3 to 5 cm long before breaking?
NO
Does soil make a strong ribbon 5 cm or longer before breaking?
YES
YES
YES
Excessively wet a small pinch of soil in palm and rub with forefinger
Does soil feel very gritty?
YES
NO
SANDY LOAM
Does soil feel very gritty?
YES
NO
SANDY CLAY LOAM
Does soil feel very gritty?
YES
NO
SANDY CLAY
Does soil feel very smooth?
YES
NO
SILT LOAM
Does soil feel very smooth?
YES
NO
SILTY CLAY LOAM
Does soil feel very smooth?
YES
NO
SILTY CLAY
Neither grittiness nor smoothness predominates
YES
LOAM
Neither grittiness nor smoothness predominates
YES
CLAY LOAM
Neither grittiness nor smoothness predominates
YES
CLAY

Backhoe Pits – the Worm's Eye View!

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



Deep, well drained, non-alkali sandy to sandy clay loam

california almonds Almond Board of California

Hand-powered twist augers ($150 - $300)

california almonds
Almond Board of California

3 foot push or slide hammer probe ($150-$250)

SOIL TEXTURE DETERMINES AVAILABLE WATER HOLDING CAPACITY

SOIL TEXTURE
“FEEL METHOD”

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

Simplified soil texture categories, associated USDA soil textures, approximate available water holding capacity (AWHC) and length of soil "ribbon".

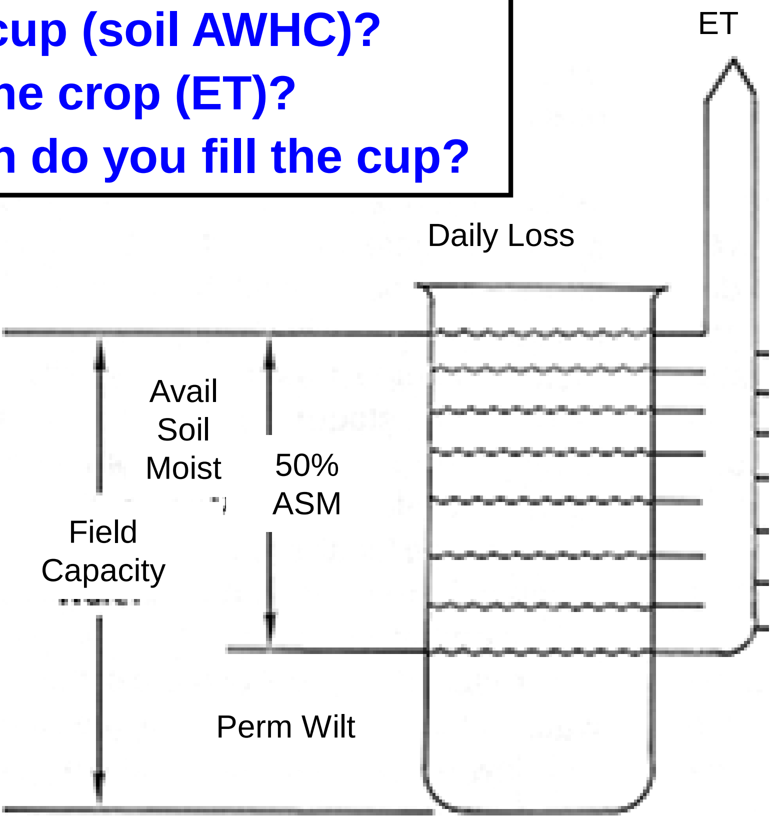
Category	Textures	AWHC (in/12 inch soil)	"Ribbon" Length (inches)
Coarse	S / LS	0.6 – 1.2	None. Ball only.
Sandy	LS / SL / L	1.2 – 1.8	0.4 - 1
Medium	L / SCL	1.4 – 2.2	1 - 2
Fine	SiL / SiCL / CL / SiC	1.7 – 2.4	> 2

AWHC(in/ft soil) = length of ribbon

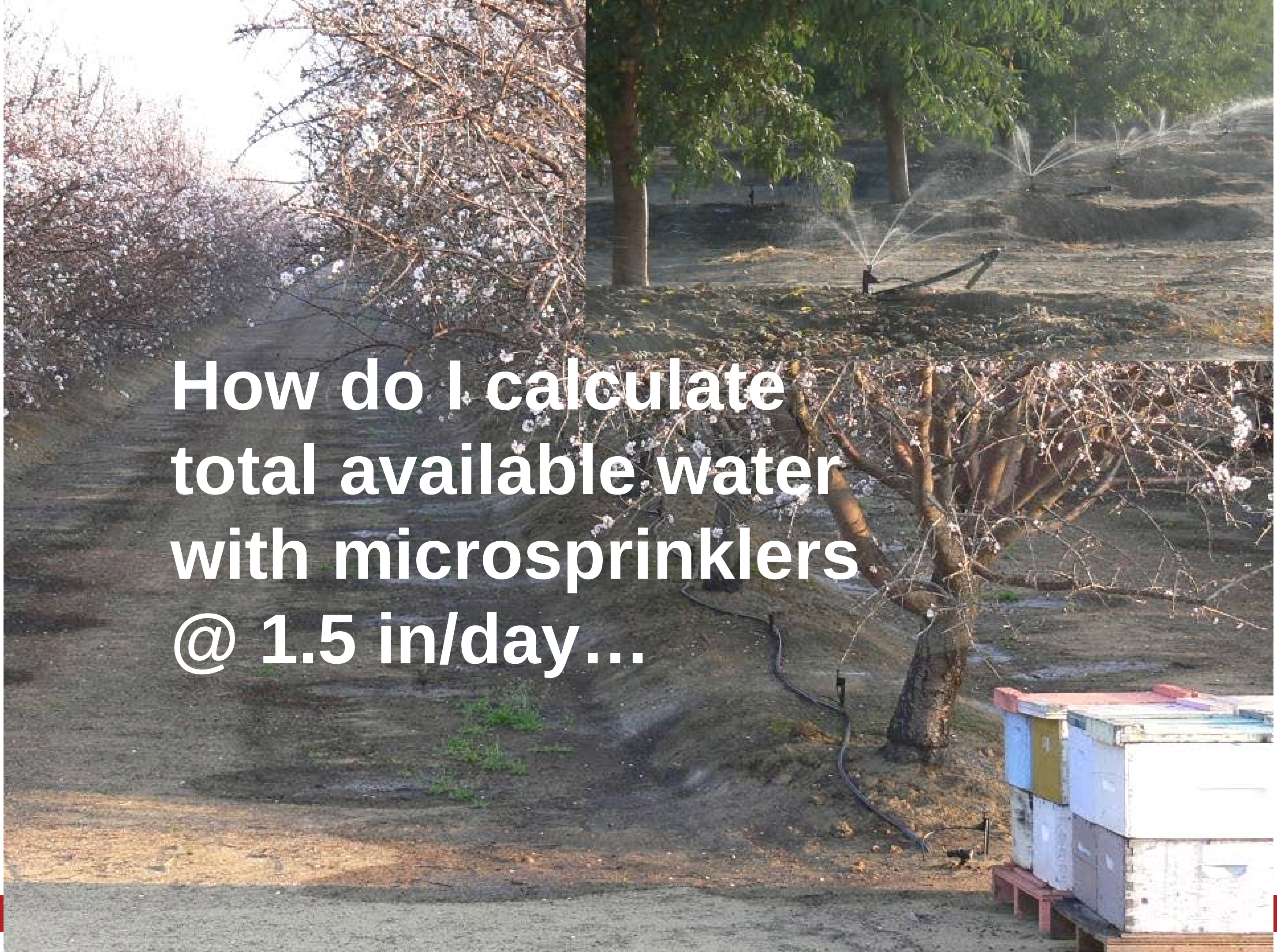
Supply: Available Soil Water Holding Capacity

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

Soil Text	Field Capacity	Perm't Wilt Pt (15 b)	Total Avail Soil Moist	50% Avail (std allowable dpltn)
	in/ft	in/ft	in/ft	in/ft
Sand	1.2	0.5	0.7	0.35
Sandy loam	2.5	1.1	1.4	0.7
Clay loam	4.0	2.2	1.8	0.9



Monitoring Soil Moisture (ANR 21635)

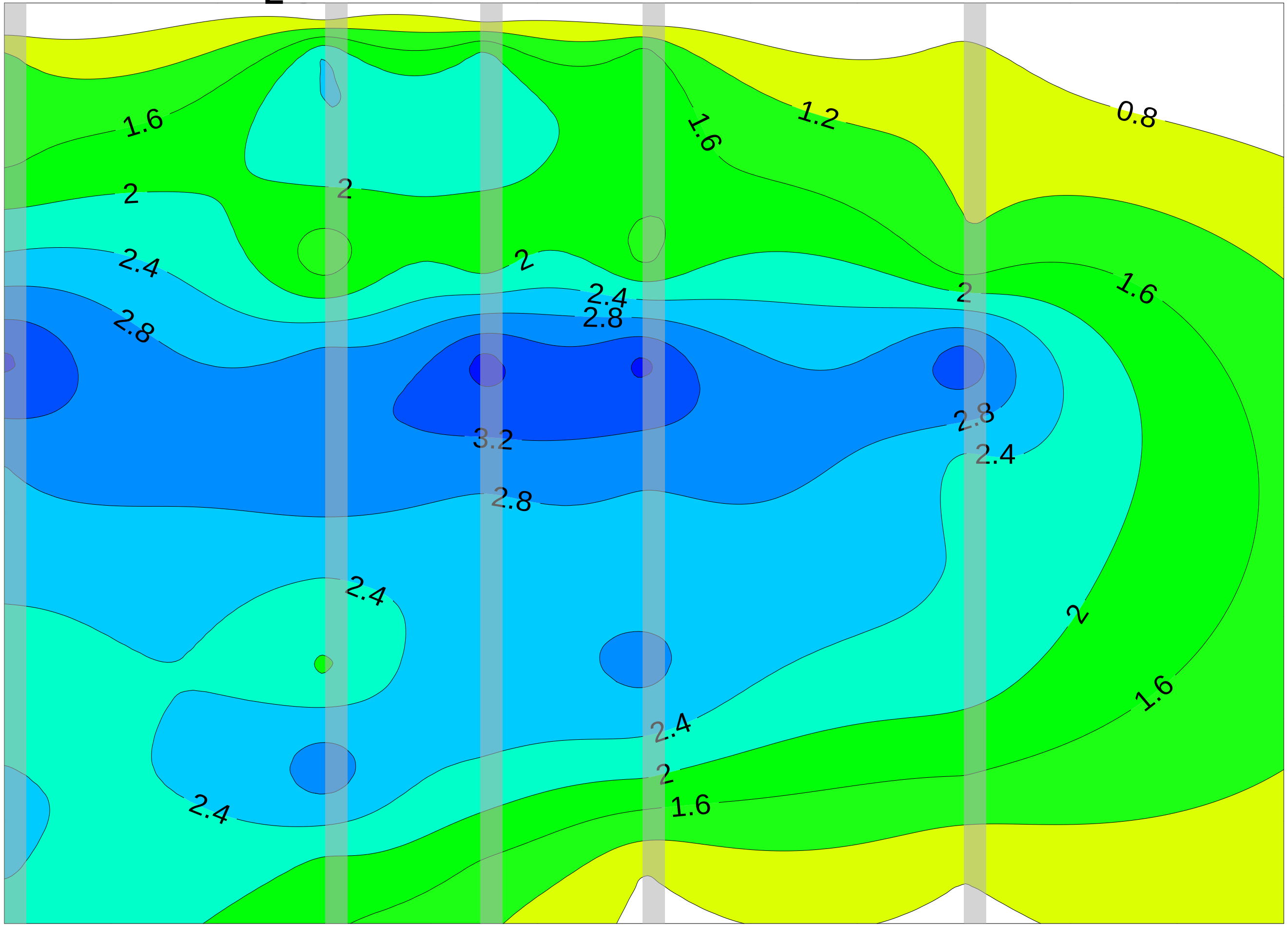


How do I calculate total available water with microsprinklers @ 1.5 in/day…

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

TREE

DRIP HOS E



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.

Guide for Estimating Actual Available Field Soil Moisture by the "Feel" Method.

SOIL TEXTURE CLASSIFICATION								
Coarse (loamy sand)		**Sandy (sandy loam)**		**Medium (loam)**		**Fine (clay loam, silty clay loam)**		
Available Water (AW) in the Soil by Appearance (inches/foot soil)								
0.6-1.2 in/ft *AW@FC		**1.2-1.8 in/ft AW@FC**		**1.4-2.2 in/ft AW@FC**		**1.7-2.4 in/ft AW@FC**		
	AW		**AW**		**AW**		**AW**	Moisture Deficiency
Leaves wet outline On hand when	1.0	Appears very dark leaves wet outline	1.6	Appears very dark leaves wet outline	1.9	Appears very dark, leaves slight moisture	2.2	0
squeezed. Appears moist,	0.7	on hand, makes a short ribbon (0.5-0.75 inch)		on hand, will ribbon about 1 – 2 inches.	1.7	on hand when squeezed, will ribbon > 2 inches.		0.2
Makes a weak ball. Appears slightly		Quite dark color makes a hard ball.	1.2	Dark color, forms a plastic pall, slicks when rubbed.	1.4	Dark color will feel slick And ribbons easily	1.8	0.5
moist, sticks together slightly.	0.4	Fairly dark color, makes a good ball	1.0	Quite dark, forms a hard ball	1.2	Quite dark, will make		0.7
Dry, loose, flows thru fingers. (wilting point)	0	Slightly dark color makes a weak ball	0.7	Fairly dark, forms a	1.0	thick ribbon may slick when rubbed.	1.4	1.0
		Lightly colored by moisture, will not	0.4	a good ball		Fairly dark, makes a good ball.	1.1	1.2
		ball. Very slight color	0	Slightly dark, forms weak ball	0.6	Will ball, small clods will flatten out but not crumble.	0.7	1.4
		due to moisture. (wilting point)		Lightly Colored, small clods crumble	0.2	Slightly dark, clods	0.4	1.7
				Fairly easily. Slight color due to		Crumble with pressure. Some darkness due to		1.9
				moisture, small colds hard (wilting point).	0	unavailable moisture, clods are hard, cracked (wilting point)	0	2.2

* **AW@FC:** Available Water @ Field Capacity = the available water a soil can store against gravity after irrigation and drainage.

Adapted from: Merriam, J.L. 1960. Field method of approximating soil moisture for irrigation. Am. Soc. Agri. Engr. Vol. 3. No.1.

CHECKING PLANT WATER STATUS

Measurement	1.0 Minimum	2.0 Intermediate
Plant Water Status	Evaluate orchard water status using visual plant cues just prior to irrigation or on a bi-weekly time step.	Use pressure chamber to measure midday stem water potential just prior to irrigation on a monthly time step. Ensure calculated water applications are not over/under irrigating trees.

Flagging, cupped leaves, no fresh shoot growth on terminals, ashen color to leaves are obvious signs of stress.

DRIP IRRIGATED ORCHARD

An open invitation to mite infestation

At best poor scheduling/water penetration creates stress conditions that help mites to come in…

HEAD end of same rows – more on time/infiltra-tion, more water for ET, more leaching

Sparse canopy, small leaves and minimal shoot growth indicate stress from deficit irrigation and/or salt accumulation and maybe high pH alkali zones. But full canopy trees in the same row with lower limb dieback indicate trees are usually well irrigated.

2nd leaf almonds end of season, irrigated like young pistachios, alkali ground, Zn deficient, deficit irrigation, hardened terminals, SW Kern

2nd leaf almonds end of season, optimally irrigated, supple rubbery terminals, SE Kings

Dry almonds Westside Kern County July 22, 2015:
1 foot of water total.

california almonds
Almond Board of California

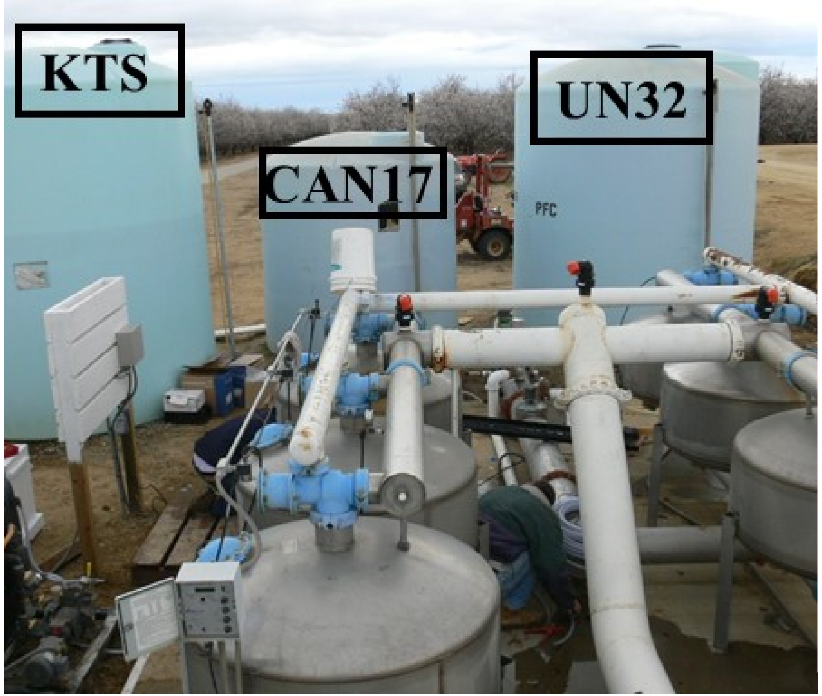
NITROGEN MANAGEMENT

(Sorry, even the Irrigation 1.0 basic guys don't get a pass on this one!)

growing ADVANTAGE
The Almond Conference

All growers > 60 acres required to have NITROGEN MANAGEMENT PLANS on file for all fields as of March 1, 2016

- You don't have to have a system this complicated



- **But you have to fill this out…**

CROP NITROGEN MANAGEMENT PLANNING	
6. Crop	ALMOND
7. Production Unit	
8. Projected Yield (Units/Acre)	3000
9. N Recommended (lbs/ac)	204
10. Acres	
Post Production Actuals	
11. Actual Yield (Units/Acre)	
12. Total N Applied (lbs/ac)	
13. ** N Removed (lbs N/ac)	
14. Notes:	

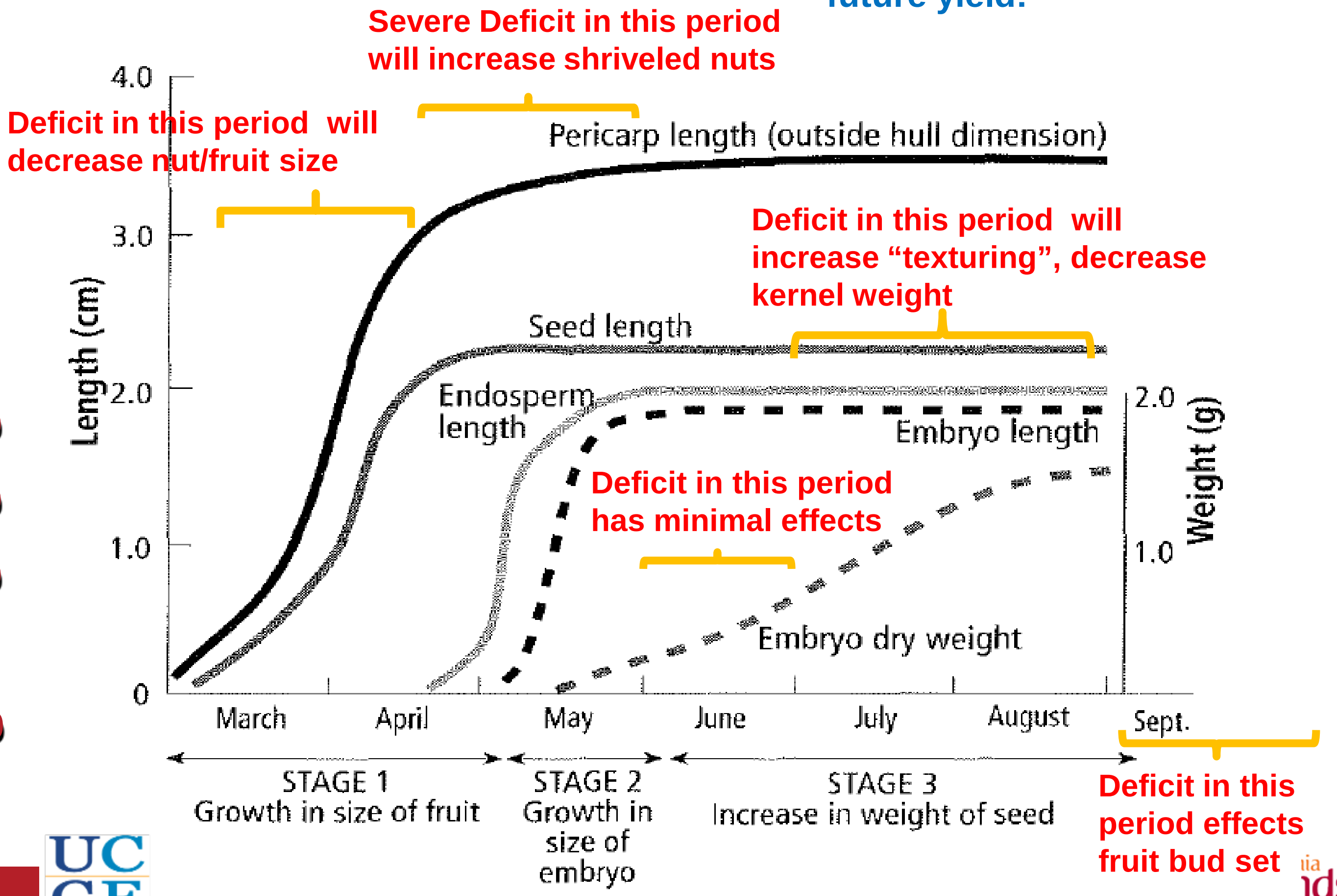
N APPLICATIONS/CREDITS	15. Recommended/ Planned N	16. Actual N
17. Nitrogen Fertilizers		
18. Dry/Liquid N (lbs/ac)	153	
19. Foliar N (lbs/ac)		
20. Organic Material N		
21. Available N in Manure/Compost (lbs/ac estimate)	40	
22. Total Available N Applied (lbs per acre)	193	
23. Nitrogen Credits (est)		
24. Available N carryover in soil; (annualized lbs/acre)	(15 PPM 126 lb/ac to 3')	
25. N in Irrigation water (annualized, lbs/ac)	17.5	
26. Total N Credits (lbs per acre)	17.5	
27. Total N Applied & Available	210	

Nutrient and Water Uptake for Almonds

Stress at any period reduces vegetative growth, affects future yield!

Fertility strategy:
Direct injection 4 times/year

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



TYING IT ALL TOGETHER & Moving up in the Almond Irrigation Continuum

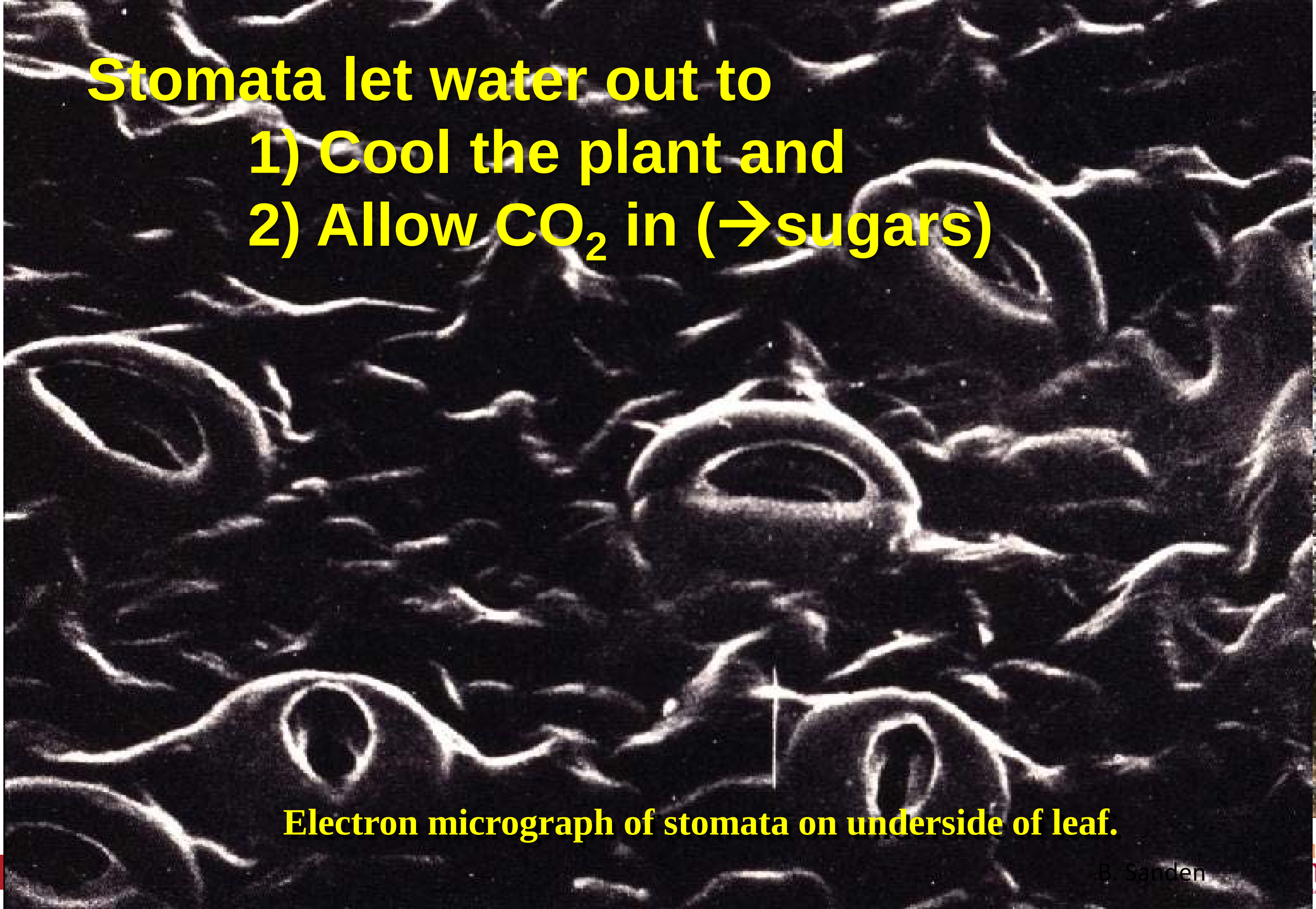
Measurement Management	1.0 Minimum	2.0 Intermediate	3.0 Advanced
Integrating Approaches	Combine irrigation system performance data with “normal year” regional ETc estimates to schedule irrigations. Check soil moisture status with auger occasionally.	Use irrigation system performance data with regional estimates of “normal year” ETc to schedule irrigations and adjust based on feedback from monitoring soil moisture or crop water status.	Develop an irrigation schedule based on predicted “normal year” demand, monitor status using soil and plant based methods. Adjust irrigation schedule with real-time ETc as the season progresses.

***The web version of this continuum, available on Almonds.com/Growers after Mar. 1, 2016, will feature a “More Information and Guidance” link in each square explaining how that step can be achieved.**

Stomata let water out to

1) Cool the plant and

2) Allow CO_2 in (→sugars)



Electron micrograph of stomata on underside of leaf.

B. Sanden

Checking stem (SWP) or leaf water potential

Pressure applied to the leaf forces liquid out of the xylem.

4^{th} leaf Nonpareil: same orchard

Match the water/ nitrogen schedule, & amount with what the tree needs and the soil can hold.

Coarse loamy sand rootzone – insufficient water holding capacity for grower preferred 48 hour sets

Fine sandy loam rootzone – sufficient water holding capacity for grower preferred 48 hour sets

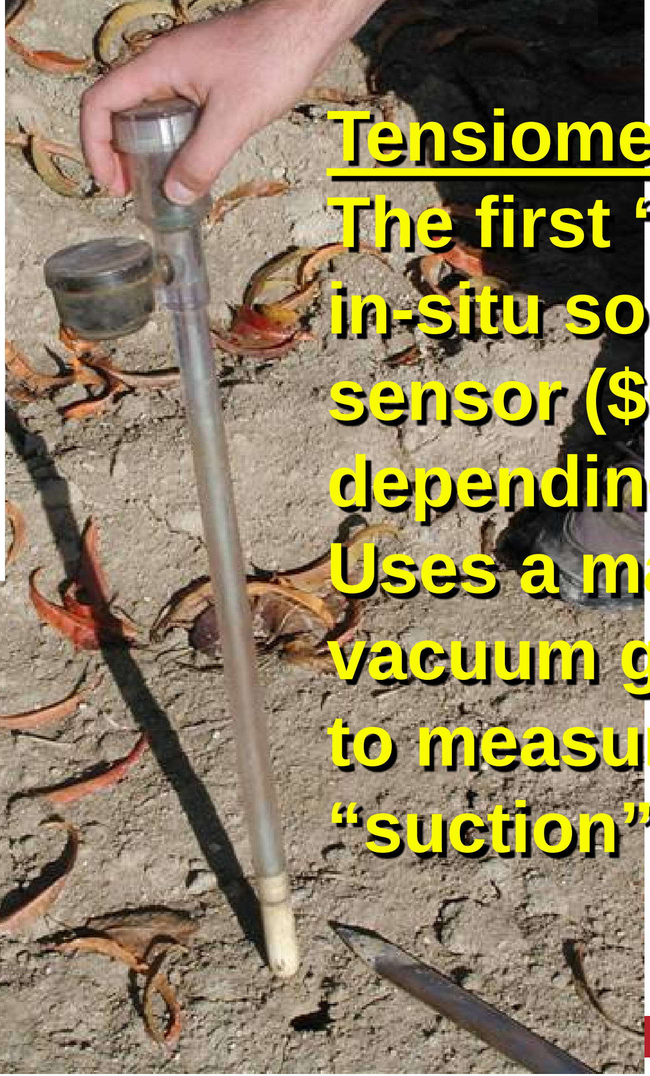
Achieving Irrigation 2.0 + 3.0 Efficiencies

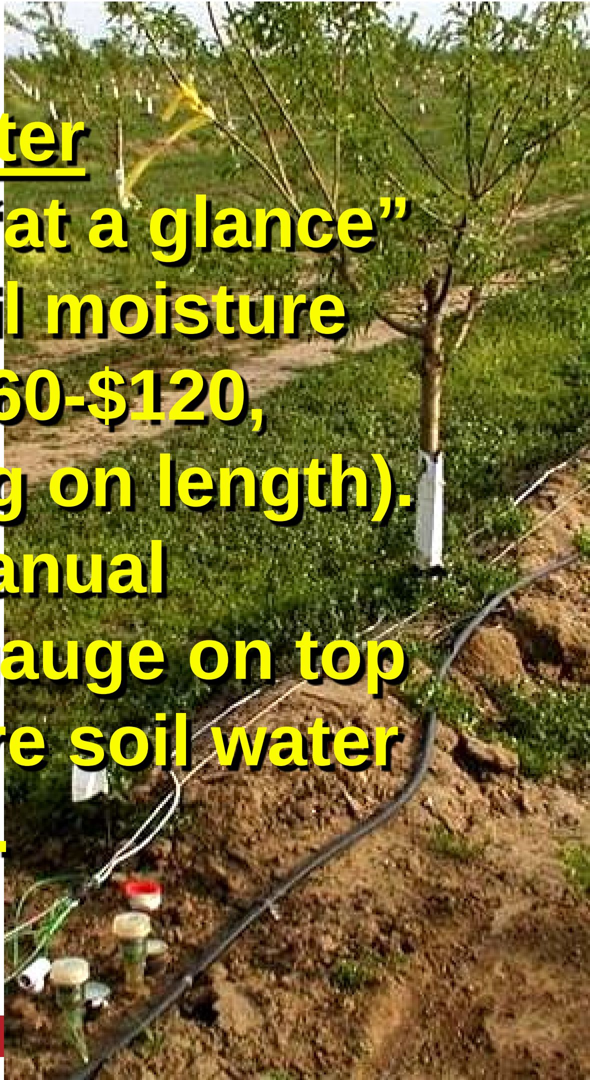
- (Moving forward on ABC's Irrigation Improvement Continuum
- CRYSTAL BALL LOOK INTO YOUR FUTURE!)

Allan Fulton -- Irrigation and Water Resources Advisor,
Tehama, Glenn, Colusa, and Shasta Counties

Terry Prichard – UCCE Irrigation Specialist Emeritus
San Joaquin County

growing ADVANTAGE The Almond Conference





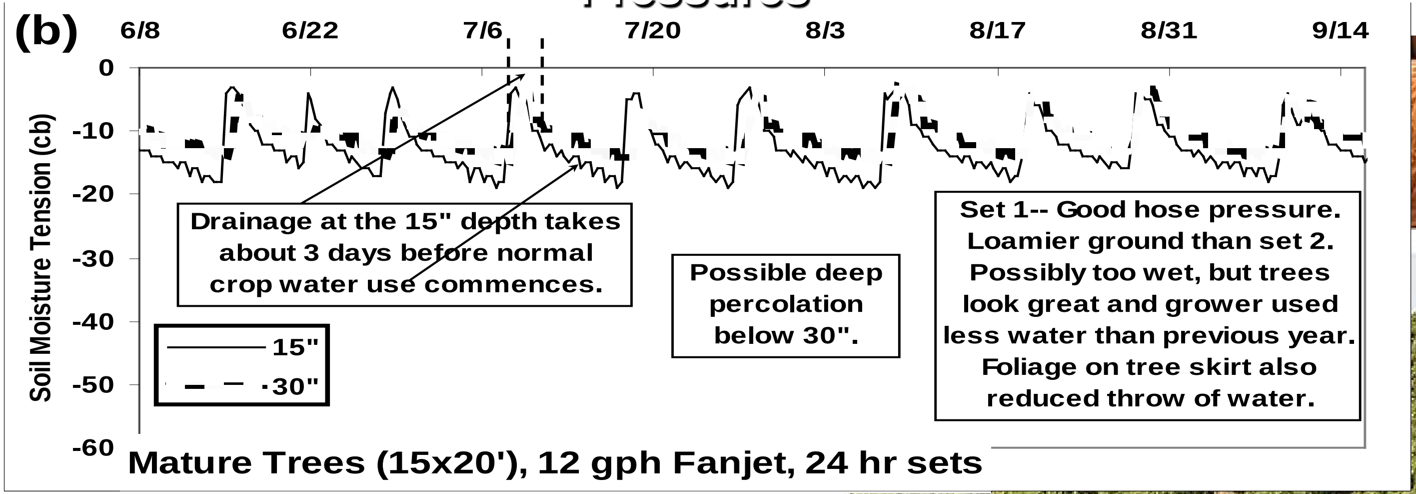
<u>Tensiometer</u>

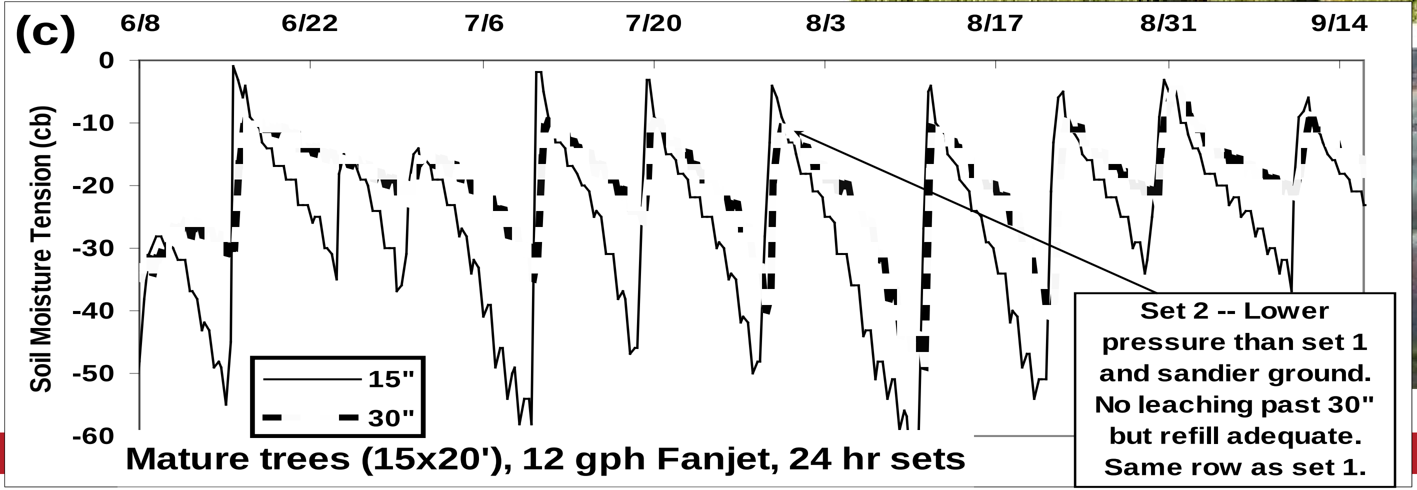
The first "at a glance" in-situ soil moisture sensor ($60-$120, depending on length). Uses a manual vacuum gauge on top to measure soil water "suction".

Installing Watermark blocks and a Hanson AM400 logger in citrus

Fine silty soil and a good shot of water down the hole improves contact with soil pores. Good capillary movement of water is what makes these sensors work.

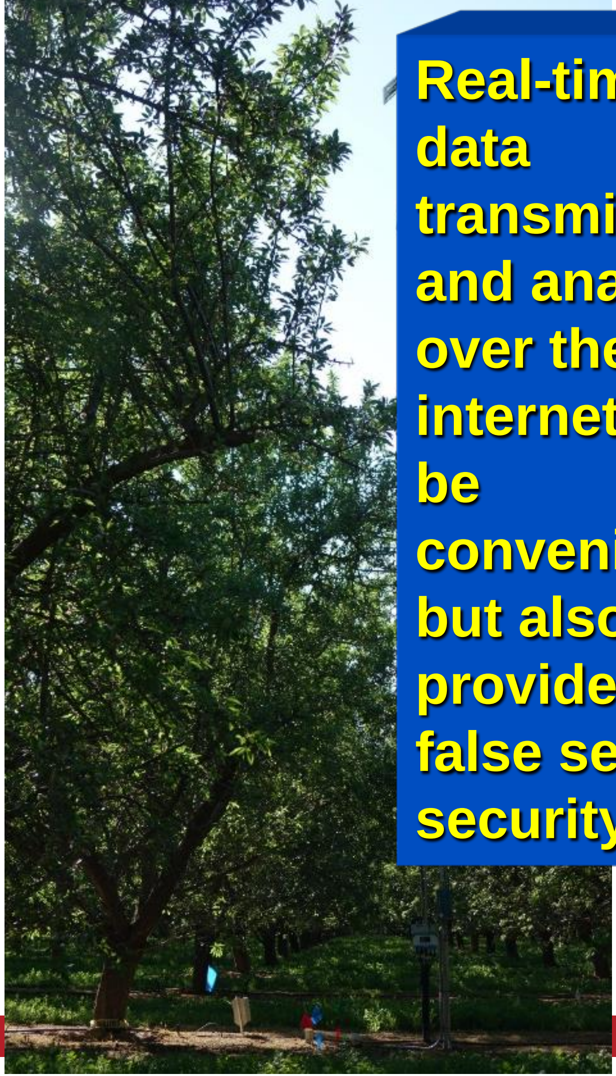
Soil Moisture Changes in Citrus Under Different Set Pressures

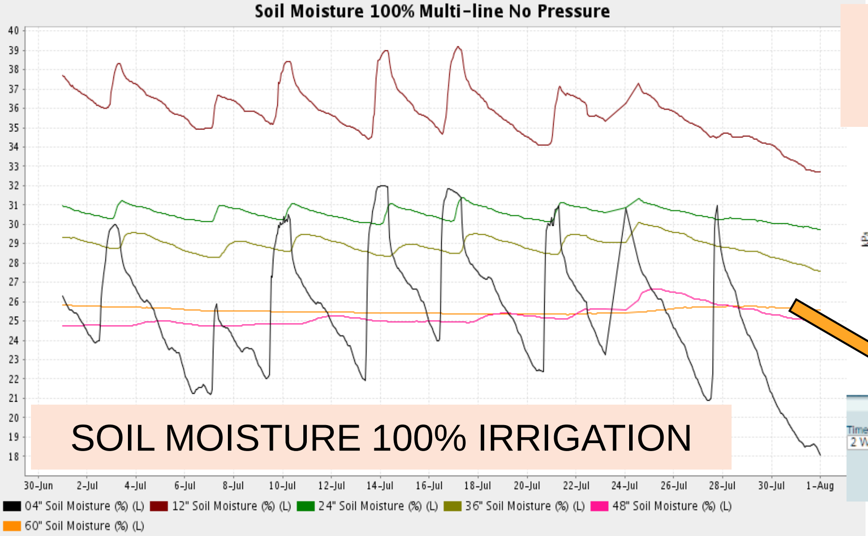




california almonds
Almond Board of California

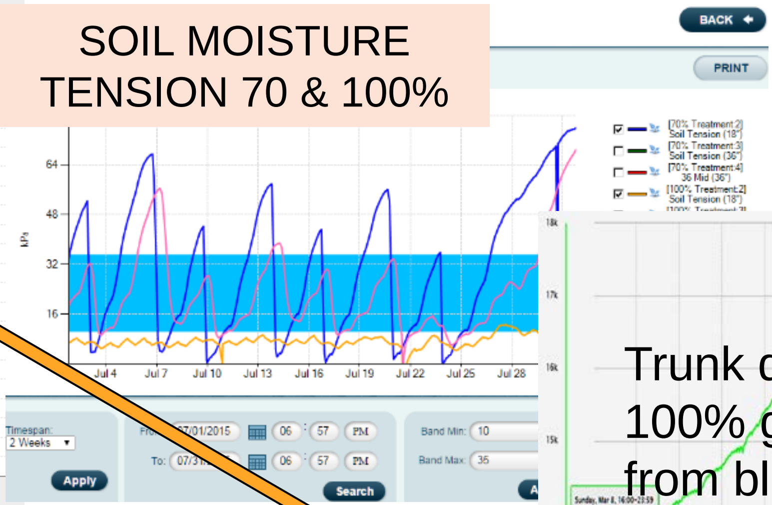
Real-time data transmission and analysis over the internet can be convenient but also provide a false sense of security.



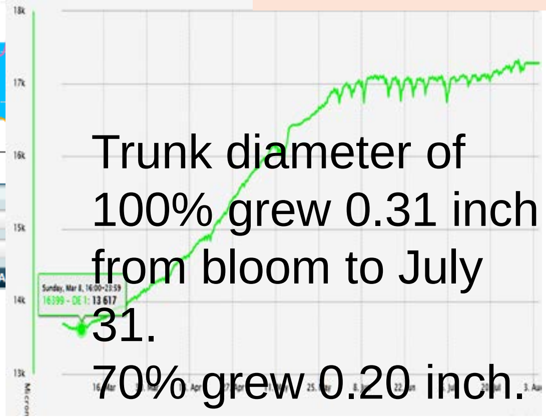


SOIL MOISTURE 100% IRRIGATION

SOIL MOISTURE TENSION 70 & 100%

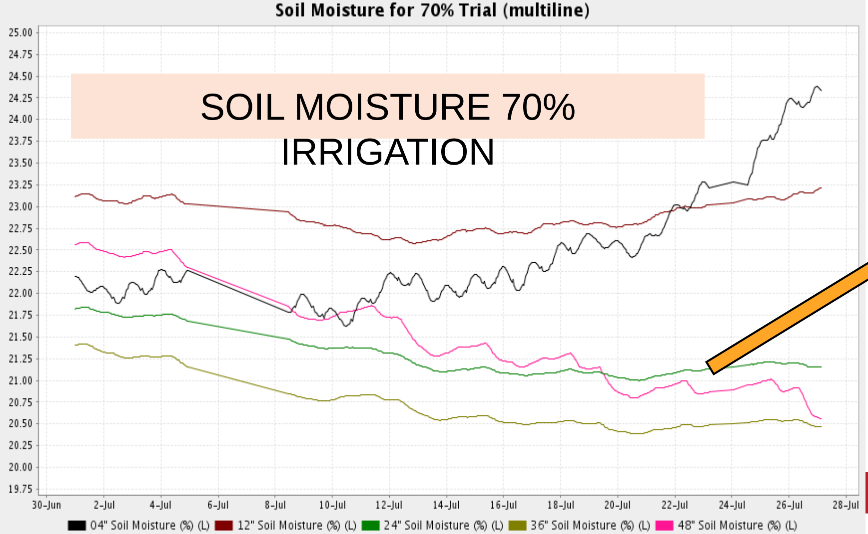


DENDROMETER – TREE GROWTH



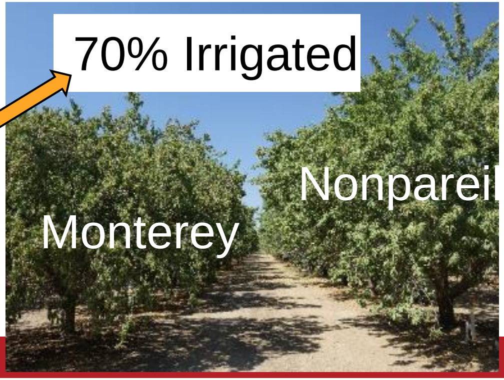
Trunk diameter of 100% grew 0.31 inch from bloom to July 31.

70% grew 0.20 inch.



SOIL MOISTURE 70% IRRIGATION

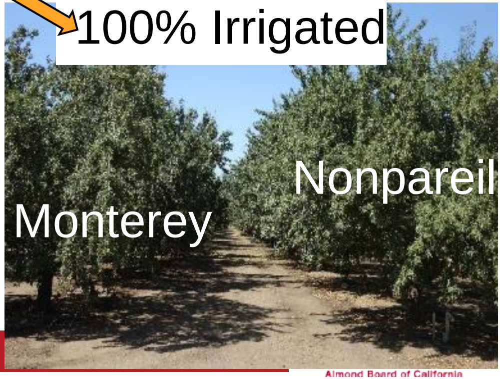
UC Almond Production Function Trial 2013-



70% Irrigated

Monterey

Nonpareil



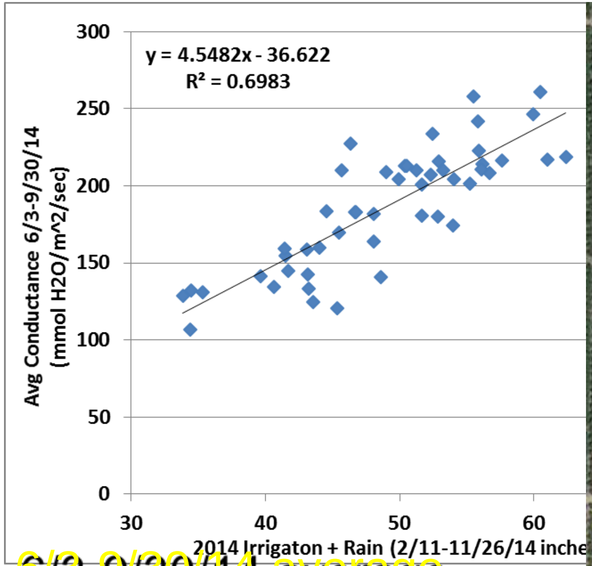
100% Irrigated

Monterey

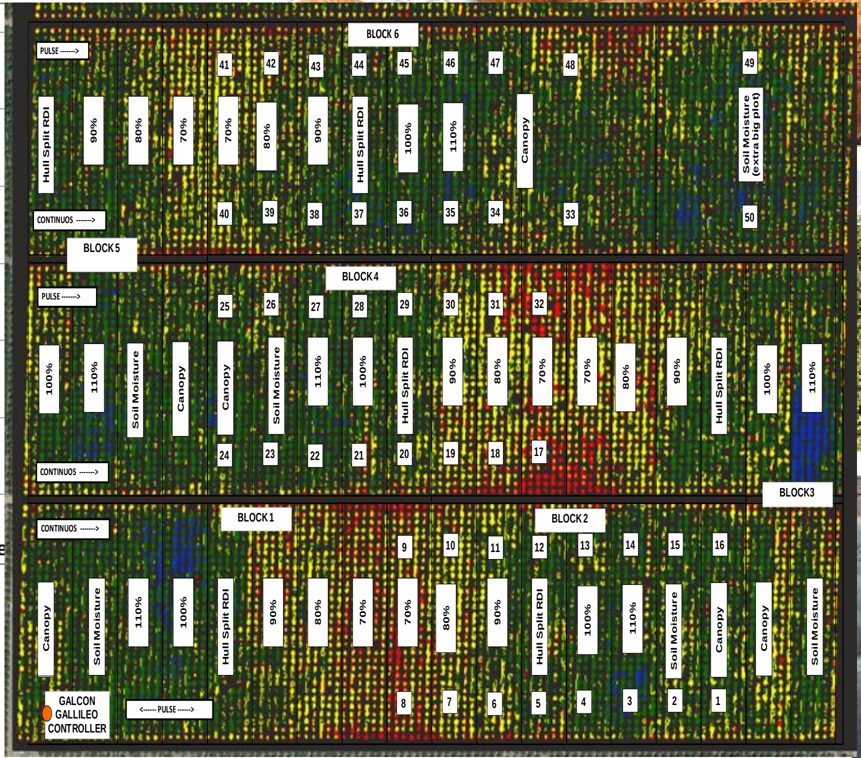
Nonpareil

Almond Board of California

AERIAL IMAGERY CAN IDENTIFY NON-UNIFORMITY

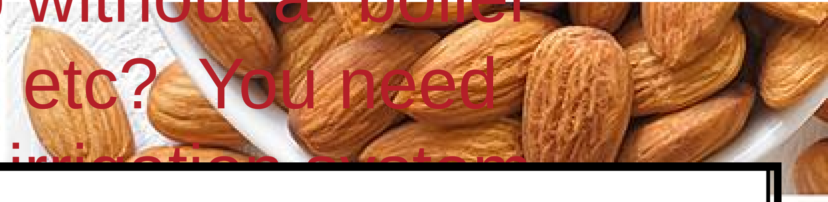


6/3-9/30/14 average almond plot water conductance by 2014 applied irrigat



Canopy Temp/Water Stress by Irrigation Treatment (CERES Spectral Imaging 6-3-14, Shackel, et al. Yield Production Function Trial)

You wouldn’t buy a pump without a “boiler plate” showing H.P., rpm, etc? You need the “boiler plate” for your irrigation system



FIELD NAME:	**12-2**	.	
SOIL TYPE:	Milham/Panoche sandy clay loam		
FIELD CAPACITY (in/ft):	2.4		
REFILL POINT (in/ft):	0.9	**Total Avail @ 100% (in):**	**9.0**
ROOTING DEPTH (ft):	6	**AREA/TREE (sq ft):**	504
ROW SPACING:	21' x 24'	**DESIGN FLOW (gph/tree):**	21.6
IRRIGATION SYSTEM:	2, 10.7 gph Fanjets		
NORMAL RUN TIME (hrs):	24	**WET AREA APPLIC (in):**	3.30
WETTED VOLUME (%):	50%	**NUMBER of SETS:**	3
		TOTAL AREA APPLIC (in):	1.65

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

SOME SIMPLE ECONOMIC CONCLUSIONS:

For soil moisture/plant monitoring and scheduling:

- Soil moisture equipment costs: $400-5,000/field
- Consulting costs: $800 (one neutron probe site) to $20/ac ($3000/ac for 150 acres)
- Cheap water, good prices, no soil sealing: not a big payback
- $60 water, on 150 acres: 6" = $4,500
- $100 water on 150 acres: 6" = $7,500
- $1000 water on 150 acres: 6" = $75,000
- 500 lb/ac kernals on 150 acs:

  @ $3 net after harvest costs = $225,000