Water and Nutrient Management in Non-Bearing Walnuts

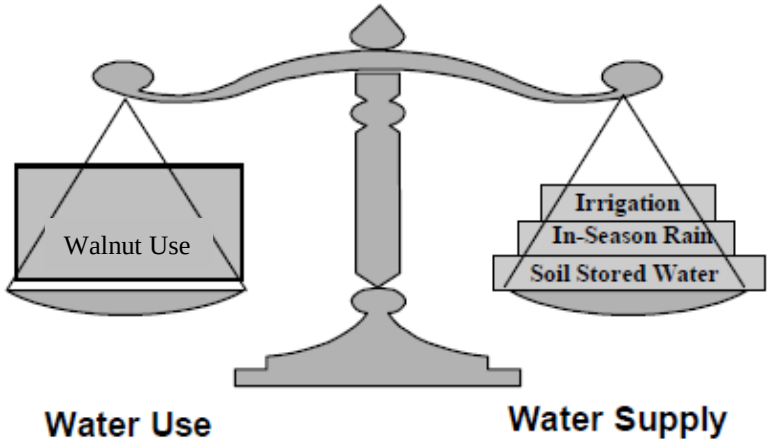
Moneim Mohamed

UCCE Irrigation and Soils Advisor

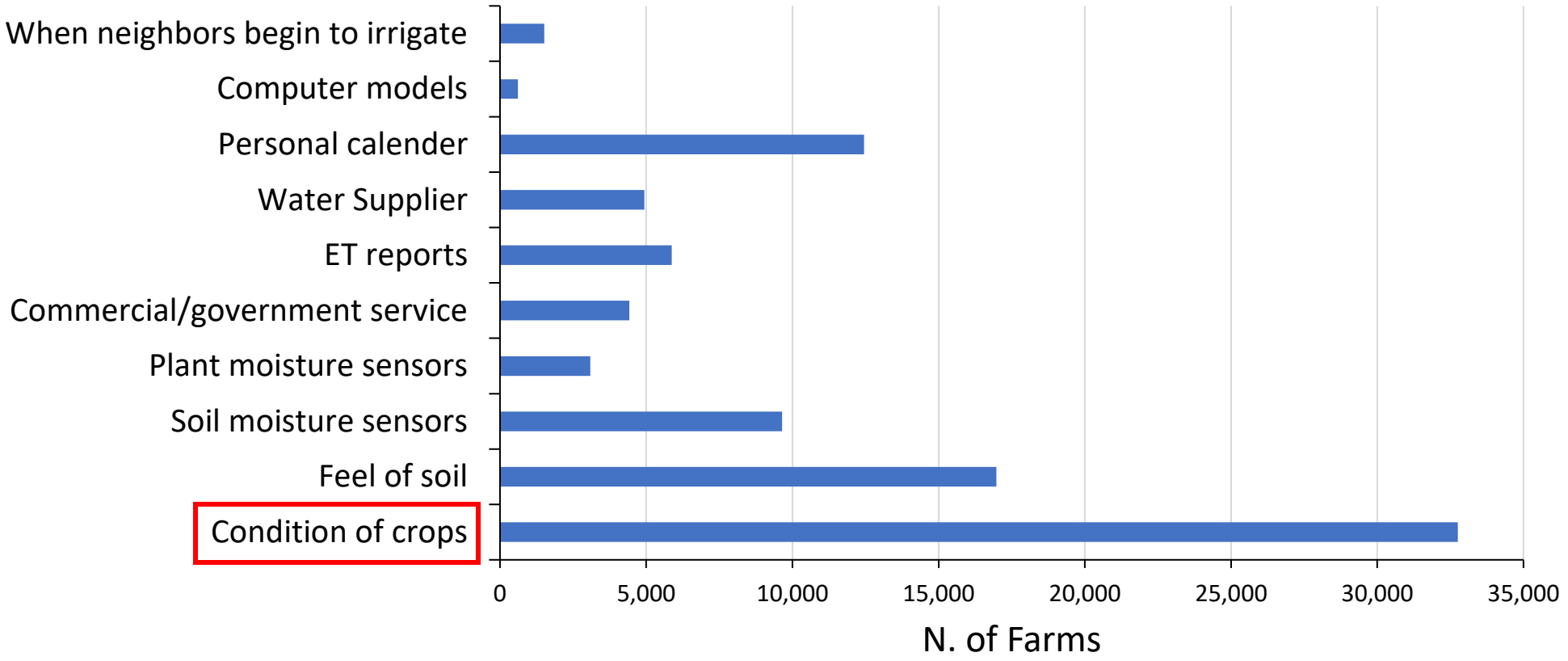
Stanislaus, San Joaquin & Merced

Presentation outline

1. Irrigation system consideration
2. Irrigation scheduling methods
3. Nutrient Best Management Practices



Methods Used in Deciding When to Irrigate in California



When Can I safely turn it off? For how long?

Don’t guess! Get data!

❖ Soil-based

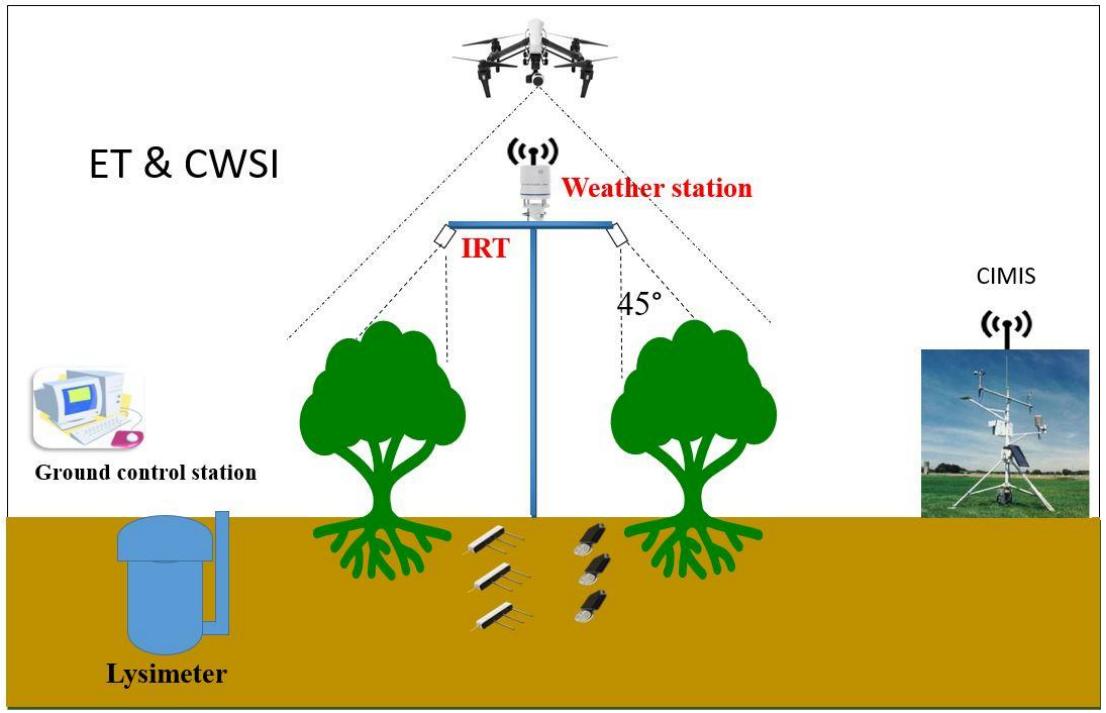
- Soil moisture sensors

❖Plant-Based

- Stem/leaf water potential and sap flow
- Canopy temperature

❖Weather-based

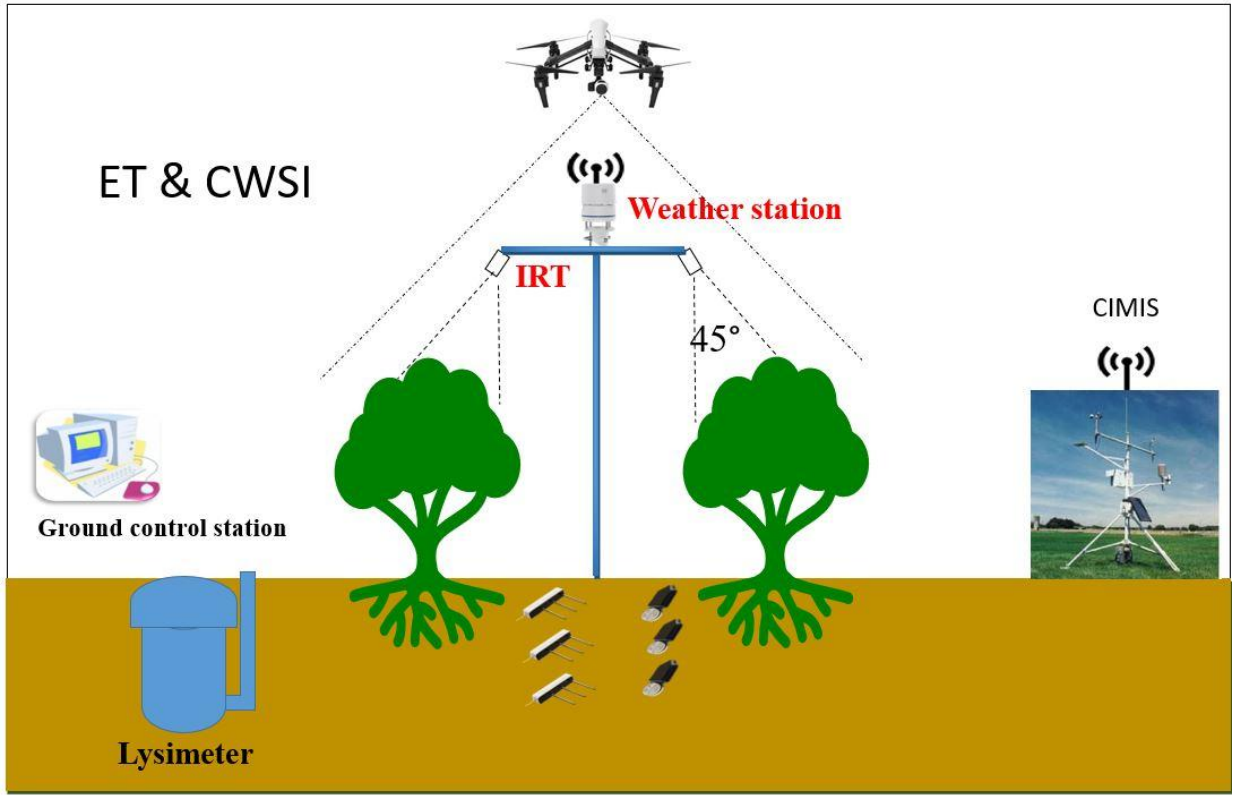
- ET and crop coefficients



When Can I safely turn it off? For how long?

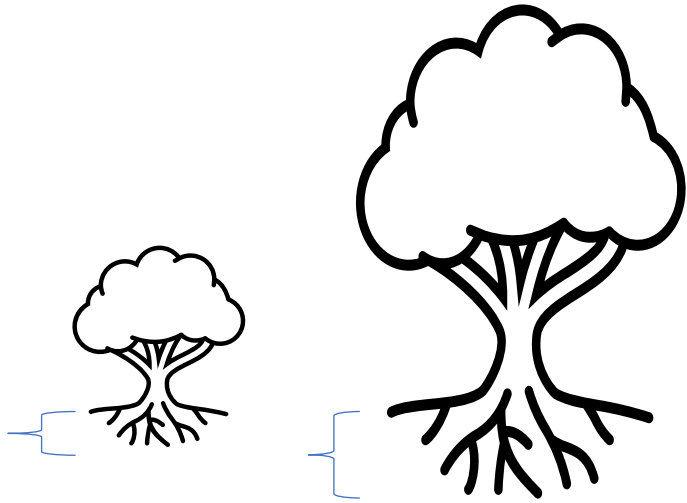
Don’t guess! Get data!

- Soil-based
  - Soil moisture sensors
- Weather-based
  - ET and crop coefficients
- Plant-Based
  - Stem/leaf water potential and sap flow gauges
  - Canopy temperature



Apply irrigation in the root zone not outside!!

1st	0.5 -3 ft
2nd	2-4 ft
3rd	3-5 ft



Katherine Pope& Allan Fulton

In young orchard, avoid watering areas with no roots …> increased evaporation losses, promotion of weed growth, and wasting water

Microsprinkler system in young walnut

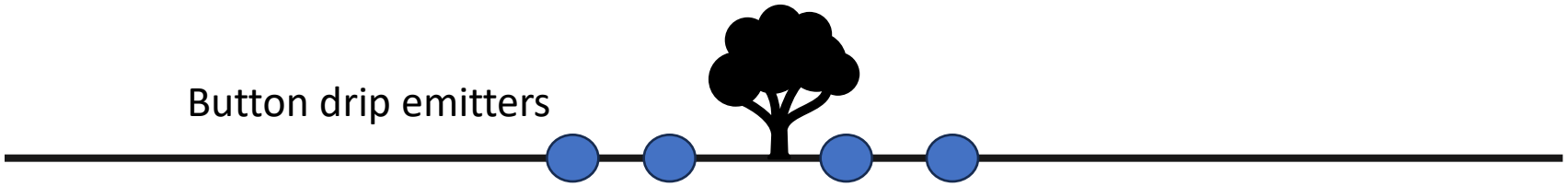
- Increase soil water evaporation compared to drip
- Encourage bigger root volume
- Better for frost protection compared to drip

Drip irrigated young walnut

- Reduces soil water evaporation
- Need to add another drip line when tree fully developed in order to meet ET demand

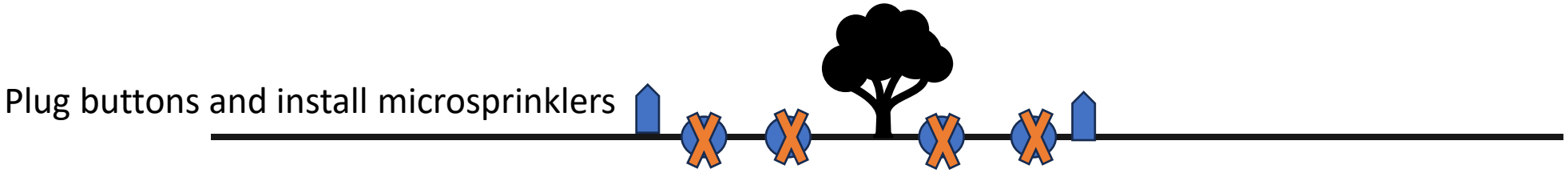
Irrigation System Consideration

1st and 2nd Leaf irrigation system



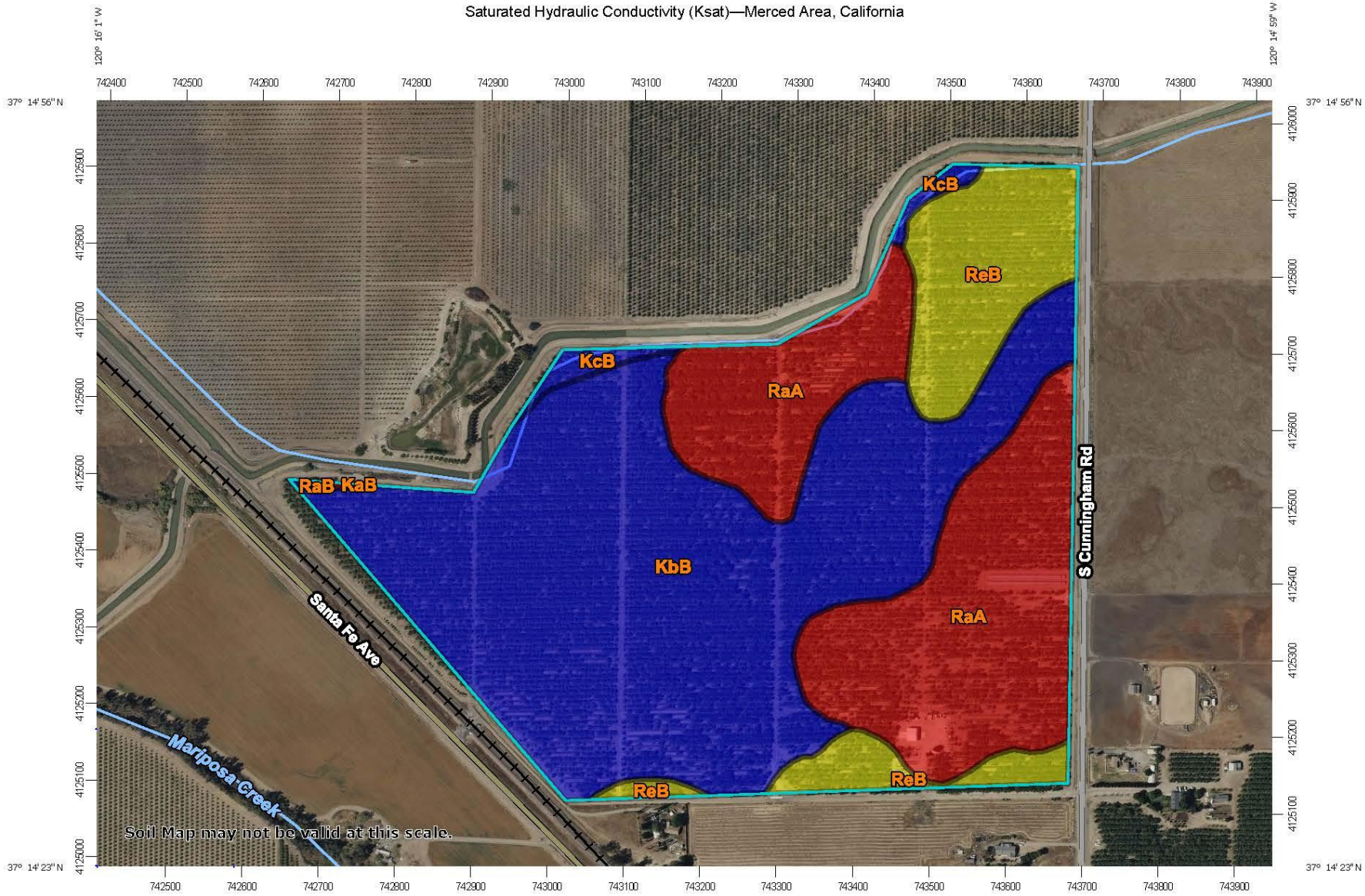
Two 1-gph external emitters placed about 10 to 15 inches to each side of the tree provide enough capacity to adequately irrigate the newly-planted trees in the first year.

3rd Leaf irrigation system



Another way: You could adapt a mini-sprinkler system to a young orchard by installing sprinklers within a couple feet of the tree with caps that limit the spray radius during the first two years. You can remove the caps and move the sprinkler stakes away once the trees are growing well and the root system has grown

Saturated Hydraulic Conductivity (Ksat)—Merced Area, California



Map Scale: 1:7,030 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 100, 200, 400, 600

Feet: 0, 300, 600, 1200, 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Example:

Daily ETc = 0.25 inches/day
Root Zone Depth = 2 feet
MAD = 50% (0.50)

- WHC for sand ~ 1.0 inch of water/foo
- So,

$TAW = 1.$

$MAD = TAW$

$Irrigation\ int$

$0.25\ in/day$

$Net\ depth = 4\ days \times 0.25\ in/$

$= \mathbf{1.0}\ inch$

- W clay ~ 2.0 inch of water/foot

$= 4.0\ in$

$50 = 2.0\ in$

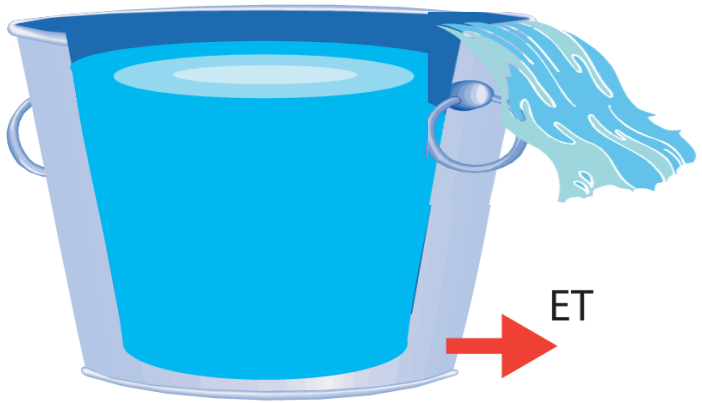
$= \mathbf{8\ days}$

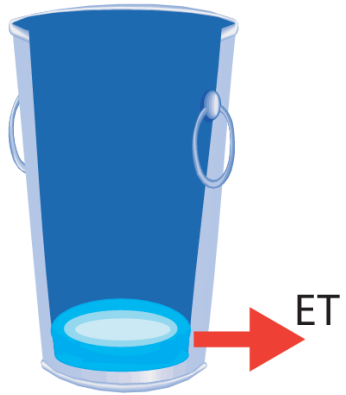
$0.25\ in/day$

$depth = 8\ days \times 0.25\ in/day$

$= \mathbf{2.0}\ inch$

Irrigate the clay area on the same schedule as the sandy soil (every 4 days with 1 inch of water):





Surface ponding in Micro-irrigation due to long runtimes

Variable Frequency Drives (VFDs)

- A VFD allows the pump to speed up or slow down to meet the needs of an irrigation system.
- If the system requires less flow or pressure (for example, when watering fewer blocks), the VFD slows the pump down.
- Reducing electricity/energy the pump is using results in savings in pumping costs.
- SWEEP, Utility companies or NRCS might offer rebates for VFDs.

Irrigation Scheduling Methods

- Soil-based
  - Soil moisture sensors
- Plant-Based
  - Stem/leaf water potential and sap flow
  - Canopy temperature
- Weather-based
  - ET and crop coefficients

Tree water status Or/and soil moisture condition is more useful than ET reports in the first two months of planting

Pressure Chamber

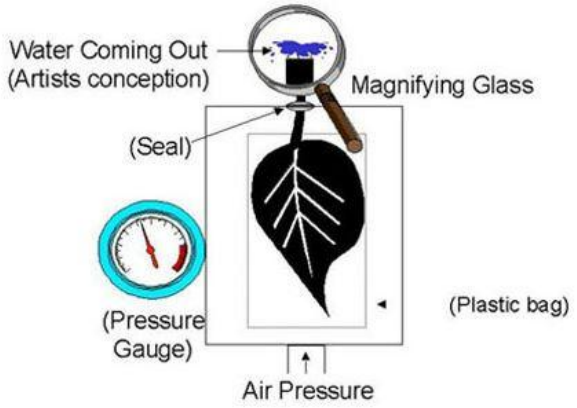
- Orchard water status representative: Under uniform growth and health trees, sample one leaf/tree and 10 trees/irrigation management

- 10 leaves samples size with 10-minutes covering reduce measurements error to 0.5 bar

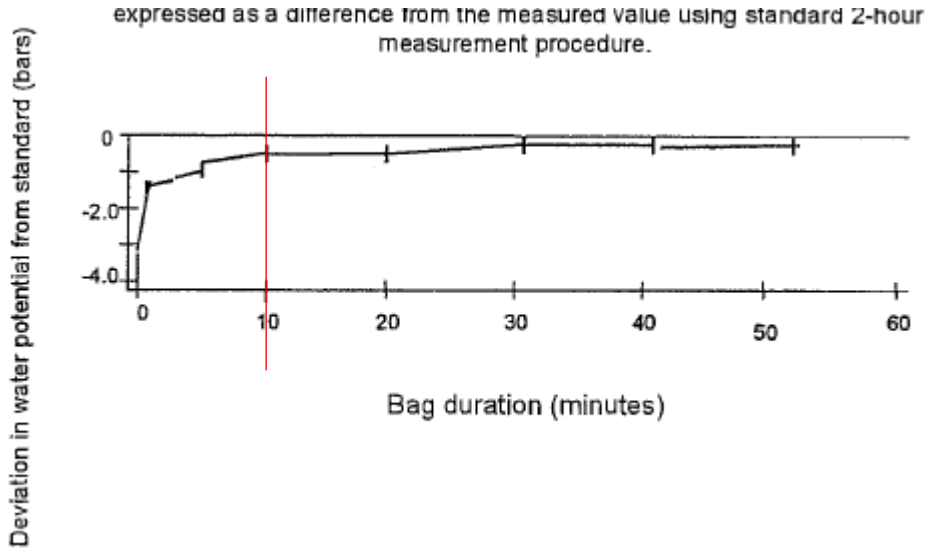
- Select 3 or 4 side by side rows of uniformly growing trees in a representative area, choose 3-4 trees for SWP measurements then using rational schedule (measure SWP in a different row each time)

Sample size (N)	95% confidence Intervale (bars)
3	± 0.7
5	± 0.6
10	± 0.4
20	± 0.3

Fulton et al. (2001)



PMS instruments



Values of midday stem water potential (SWP in Bars tension) to expect for fully irrigated walnut trees under different conditions of air temperature and relative humidity.

(Table courtesy of Ken Shackel, Department of Pomology, University of California Davis)

Air Temp (°F)

RH (%)	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120
10	-4.1	-4.2	-4.3	-4.4	-4.5	-4.7	-4.8	-4.9	-5.1	-5.2	-5.4	-5.6	-5.7	-5.9	-6.1	-6.3	-6.5	-6.8	-7.0	-7.3	-7.6	-7.8	-8.1	-8.5	-8.8	-9.1	-9.5
15	-4.1	-4.1	-4.2	-4.3	-4.4	-4.6	-4.7	-4.8	-4.9	-5.1	-5.2	-5.4	-5.6	-5.7	-5.9	-6.1	-6.3	-6.6	-6.8	-7.0	-7.3	-7.6	-7.8	-8.1	-8.5	-8.8	-9.1
20	-4.0	-4.1	-4.2	-4.2	-4.3	-4.5	-4.6	-4.7	-4.8	-5.0	-5.1	-5.2	-5.4	-5.6	-5.7	-5.9	-6.1	-6.3	-6.6	-6.8	-7.0	-7.3	-7.5	-7.8	-8.1	-8.4	-8.8
25	-3.9	-4.0	-4.1	-4.2	-4.3	-4.4	-4.5	-4.6	-4.7	-4.8	-4.9	-5.1	-5.2	-5.4	-5.6	-5.7	-5.9	-6.1	-6.3	-6.5	-6.8	-7.0	-7.2	-7.5	-7.8	-8.1	-8.4
30	-3.8	-3.9	-4.0	-4.1	-4.2	-4.2	-4.3	-4.5	-4.6	-4.7	-4.8	-4.9	-5.1	-5.2	-5.4	-5.5	-5.7	-5.9	-6.1	-6.3	-6.5	-6.7	-7.0	-7.2	-7.5	-7.7	-8.0
35	-3.8	-3.8	-3.9	-4.0	-4.1	-4.1	-4.2	-4.3	-4.4	-4.5	-4.7	-4.8	-4.9	-5.0	-5.2	-5.3	-5.5	-5.7	-5.8	-6.0	-6.2	-6.4	-6.7	-6.9	-7.1	-7.4	-7.6
40	-3.7	-3.7	-3.8	-3.9	-4.0	-4.0	-4.1	-4.2	-4.3	-4.4	-4.5	-4.6	-4.7	-4.9	-5.0	-5.1	-5.3	-5.4	-5.6	-5.8	-6.0	-6.2	-6.4	-6.6	-6.8	-7.0	-7.3
45	-3.6	-3.7	-3.7	-3.8	-3.9	-3.9	-4.0	-4.1	-4.2	-4.3	-4.4	-4.5	-4.6	-4.7	-4.8	-4.9	-5.1	-5.2	-5.4	-5.5	-5.7	-5.9	-6.1	-6.3	-6.5	-6.7	-6.9
50	-3.5	-3.6	-3.6	-3.7	-3.8	-3.8	-3.9	-4.0	-4.1	-4.1	-4.2	-4.3	-4.4	-4.5	-4.6	-4.8	-4.9	-5.0	-5.1	-5.3	-5.4	-5.6	-5.8	-5.9	-6.1	-6.3	-6.5
55	-3.5	-3.5	-3.6	-3.6	-3.7	-3.7	-3.8	-3.9	-3.9	-4.0	-4.1	-4.2	-4.3	-4.4	-4.4	-4.6	-4.7	-4.8	-4.9	-5.0	-5.2	-5.3	-5.5	-5.6	-5.8	-6.0	-6.1
60	-3.4	-3.4	-3.5	-3.5	-3.6	-3.6	-3.7	-3.7	-3.8	-3.9	-3.9	-4.0	-4.1	-4.2	-4.3	-4.4	-4.5	-4.6	-4.7	-4.8	-4.9	-5.0	-5.2	-5.3	-5.5	-5.6	-5.8
65	-3.3	-3.3	-3.4	-3.4	-3.5	-3.5	-3.6	-3.6	-3.7	-3.7	-3.8	-3.9	-3.9	-4.0	-4.1	-4.2	-4.2	-4.3	-4.4	-4.5	-4.6	-4.7	-4.9	-5.0	-5.1	-5.3	-5.4
70	-3.2	-3.3	-3.3	-3.3	-3.4	-3.4	-3.5	-3.5	-3.5	-3.6	-3.6	-3.7	-3.8	-3.8	-3.9	-4.0	-4.0	-4.1	-4.2	-4.3	-4.4	-4.5	-4.6	-4.7	-4.8	-4.9	-5.0
75	-3.2	-3.2	-3.2	-3.2	-3.3	-3.3	-3.3	-3.4	-3.4	-3.5	-3.5	-3.6	-3.6	-3.7	-3.7	-3.8	-3.8	-3.9	-4.0	-4.0	-4.1	-4.2	-4.3	-4.4	-4.4	-4.5	-4.6
80	-3.1	-3.1	-3.1	-3.1	-3.2	-3.2	-3.2	-3.3	-3.3	-3.3	-3.4	-3.4	-3.4	-3.5	-3.5	-3.6	-3.6	-3.7	-3.7	-3.8	-3.8	-3.9	-4.0	-4.0	-4.1	-4.2	-4.3
85	-3.0	-3.0	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.2	-3.2	-3.2	-3.2	-3.3	-3.3	-3.3	-3.4	-3.4	-3.4	-3.5	-3.5	-3.6	-3.6	-3.7	-3.7	-3.8	-3.8	-3.9

cool normal hot

https://ucanr.edu/datastoreFiles/391-758.pdf

Consideration to maintain a good growth

- Consider minimum pruning strategy.
- Maintain **-4** to **-8** bars during May through August.
- **-10** to **-11** bars starting in September to reduce late season shoot growth and promote the green shoot tissue to be more tolerant with fall and winter temperatures.

Irrigation Scheduling Methods

- Soil-based
  - Soil moisture sensors
- Plant-Based
  - Stem/leaf water potential and sap flow gauges
  - Canopy temperature
- Weather-based
  - ET and crop coefficients

How much less water young walnut trees used?

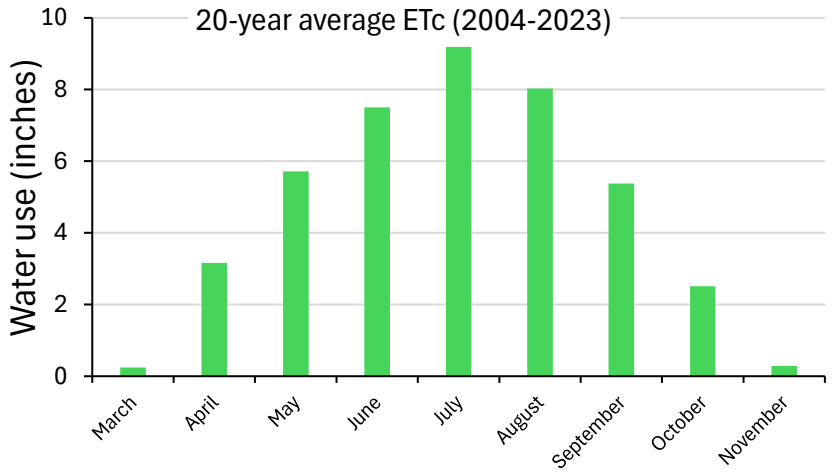
- Young trees have lower ET rates and grow rapidly

Allan Fulton

Young Walnut ET based Irrigation

1. Historical ET_c

	1st		2nd		3rd	
	in/month	in/day	in/month	in/day	in/month	in/day
April	0.4	0.01	0.9	0.03	1.6	0.05
May	1.5	0.05	2.4	0.08	4.9	0.16
June	2.3	0.08	3.5	0.12	6.6	0.22
July	3.9	0.13	5.6	0.18	9.7	0.31
August	3.4	0.11	4.6	0.15	7.6	0.25
September	2.1	0.07	2.9	0.10	5.2	0.17
October	1	0.03	1.4	0.05	2.9	0.09
Total	**14.6**		**21.3**		**38.5**	



2. % ET_c based on tree age

Tree Age	% of ET_c for Mature Trees
1st Leaf	30
2nd Leaf	50
3rd Leaf	85
4th Leaf	100

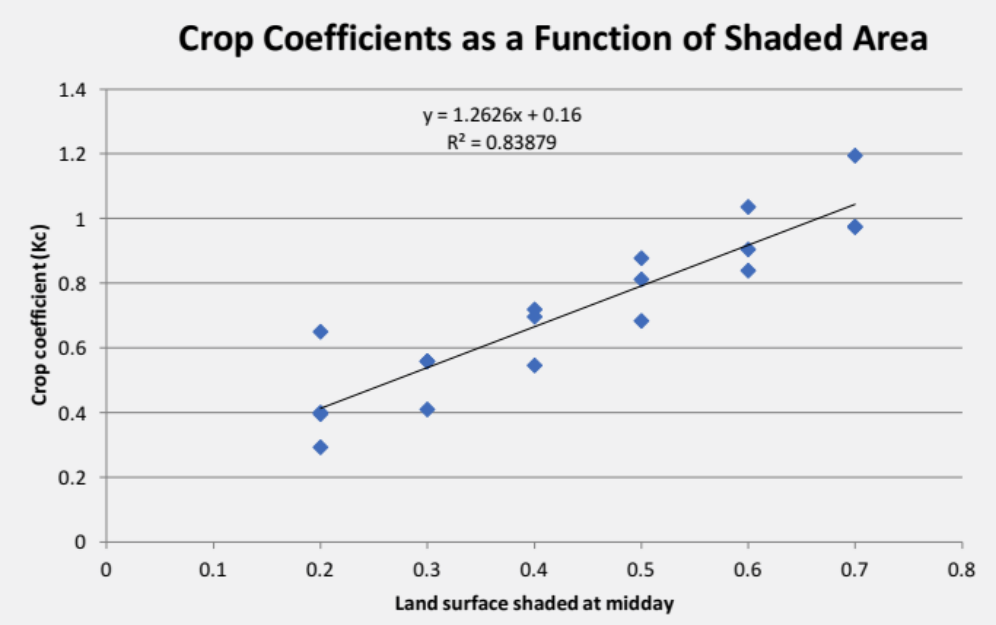
Date	1st leaf	2nd leaf	3rd leaf	4th leaf
Apr 1-15	15	35	70	100
Apr 16-30	20	40	75	100
May 1-15	25	45	85	100
May 16-31	30	45	90	100
June 1-15	30	50	95	100
June 16-30	35	50	95	100
July 1-15	40	55	100	100
July 16-31	40	60	100	100
Aug 1-15	45	60	100	100
Aug 16-31	45	60	100	100
Sept 1-15	40	55	100	100
Sept 16-30	40	55	100	100
Oct 1-15	35	50	100	100

3. % ET_c based on % midday canopy shading

Fraction of midday canopy shaded area	% of ET_c for mature orchards
20	41
30	54
40	67
50	79
60	92
70	100

3. Midday canopy shaded area

- Photosynthetically Active Radiation (PAR) = % canopy light interception of orchard



Canopy Shading = 18/44=41%

iPAR

Created by the people at the Lampinen Lab.

Adjusted weekly ET_c estimates to irrigate young walnut

- After transplanting, average PAR is 1%.
- The table suggests ET_c changes 2 (41/20) % per 1% reduction in canopy shaded area for trees smaller than 20% midday shaded area.
- An estimated average canopy of 1% suggests a K_c adjustment of 2%.
- This means to reduce the weekly crop ET report to 2%

Fraction of midday canopy shaded area	Fraction (percent) of K_c or ET_c for mature orchards
20	41
30	54
40	67
50	79
60	92
70	100

HEALTHY FOOD SYSTEMS • HEALTHY ENVIRONMENTS • HEALTHY COMMUNITIES • HEALTHY CALIFORNIANS

University of California
Agriculture and Natural Resources
Making a Difference for California

UCCE

UCCE/DWR Weekly Crop Water Use Report

Reduced ET example for Small potted trees, 1-8 weeks of planting

WEEKLY CROP WATER USE - Based on local CIMIS Weather Stations (in inches)
(Estimated Crop Evapotranspiration or ETc)
06/16/23 through 06/22/23

Crops (Leafout Date)		#70 Manteca			#194 Oakdale			#206 Denair II		
	Weekly Kc	6/16- 6/22 Water Use	Accum'd Seasonal Water Use	6/23- 6/29 Estimated ETc	6/16- 6/22 Water Use	Accum'd Seasonal Water Use	6/23- 6/29 Estimated ETc	6/16- 6/22 Water Use	Accum'd Seasonal Water Use	6/23- 6/29 Estimated ETc
Almonds (2/27) *	1.05	1.89	16.86	1.91	1.83	16.76	2.05	1.95	17.82	2.05
Peaches (3/10) *	0.86	1.55	11.08	1.64	1.53	10.97	1.78	1.61	11.70	1.78
Walnuts (4/14) *	0.93	1.64	9.13	1.68	1.60	9.07	1.82	1.70	9.71	1.82
Vineyard Established (4/7)	0.78	1.38	6.20	1.50	1.33	6.13	1.61	1.43	6.58	1.61
Alfalfa (2/1)	0.97	1.75	20.83	1.75	1.69	20.72	1.89	1.81	22.12	1.89
Pasture (2/1)	1.0	1.82	21.49	1.82	1.76	21.38	1.96	1.88	22.78	1.96
Past 7 days precipitation (inches)			0.00			0.00			0.00	
Accumulated precipitation (inches) (3/1/2022)			5.57			5.41			4.61	

Accumulations started on February 1, 2022 or on the approximate leafout date for a specific crop as indicated in parentheses. Criteria for beginning this report are based on the season's last significant rainfall event where the soil moisture profile is estimated to be near its highest level for the new season.

* Estimates are for orchard/vineyard floor conditions where vegetation is managed by some combination of strip applications of herbicides, frequent mowing or tillage, and by mid and late season shading. Weekly estimates of soil moisture loss can be as much as 25 percent higher in orchards where cover crops are planted and managed more intensively for maximum growth.

PAST WEEKLY APPLIED WATER IN INCHES, ADJUSTED FOR EFFICIENCY [1]

Crops	#70 Manteca			#194 Oakdale			#206 Denair II		
System Efficiency >>	75%	85%	95%	75%	85%	95%	75%	85%	95%
Almonds (2/27)	2.5	2.2	2.0	2.4	2.2	1.9	2.6	2.3	2.1
Peaches (3/10)	2.1	1.8	1.6	2.0	1.8	1.6	2.1	1.9	1.7
Walnuts (4/14)	2.2	1.9	1.7	2.1	1.9	1.7	2.3	2.0	1.8
Vineyard Established (4/7)	1.8	1.6	1.5	1.8	1.6	1.4	1.9	1.7	1.5
Alfalfa (2/1)	2.3	2.1	1.8	2.3	2.0	1.8	2.4	2.1	1.9

1 The amount of water required by a specific irrigation system to satisfy evapotranspiration. Typical ranges in irrigation system efficiency are: Drip, 80%-95%; Micro-sprinkler, 80%-90%; Sprinkler, 70%-85%; and Flood, 50%-75%.
For further information concerning this report, contact Roger Duncan or Moneim Mohammad the University of California Cooperative Extension office in Stanislaus County at (209) 525-6800.

2.2 x 0.02 =0.044 "
Consider lowest AE from microsprinkler water that missed root zone

Convert inches to gallons

- Gallons per week = $\frac{Inches \times 27{,}154}{Trees\ per\ acre}$

$$\frac{\mathbf{0.044} \times 27{,}154}{90} = 13 \text{ gal/week} = 1.9 \text{ gal/day}$$

- How to supply this with Microsprinkler with 10gph?

27 mins irrigation sets every other day until roots grows out of potted media (use auger to see how much fraction of water stays in the potted media)

27 mins for 3 days = 1.35 hrs = 1.35 x 10gph = 13 gal/wk

Adjusted weekly ET_c estimates to irrigate several week young walnut

- Several weeks after planting, average PAR is 5%.
- The table suggests ET_c changes 2.05 (41/20)% per 1% reduction in canopy shaded area for trees smaller than 20 percent midday shaded area.
- An estimated average canopy of 5% suggests a K_c adjustment of ~10%
- This means to reduce the weekly crop ET report to 10%

Fraction of midday canopy shaded area	Fraction (percent) of Kc or ET_c for mature orchards
20	41
30	54
40	67
50	79
60	92
70	100

HEALTHY FOOD SYSTEMS • HEALTHY ENVIRONMENTS • HEALTHY COMMUNITIES • HEALTHY CALIFORNIANS

University of California
Agriculture and Natural Resources
Making a Difference for California

UCCE

UCCE/DWR Weekly Crop Water Use Report

WEEKLY CROP WATER USE - Based on local CIMIS Weather Stations (in inches)
(Estimated Crop Evapotranspiration or ETc)
06/16/23 through 06/22/23

Crops (Leafout Date)		#70 Manteca			#194 Oakdale			#206 Denair II		
	Weekly Kc	6/16- 6/22 Water Use	Accum'd Seasonal Water Use	6/23- 6/29 Estimated ETc	6/16- 6/22 Water Use	Accum'd Seasonal Water Use	6/23- 6/29 Estimated ETc	6/16- 6/22 Water Use	Accum'd Seasonal Water Use	6/23- 6/29 Estimated ETc
Almonds (2/27) *	1.05	1.89	16.86	1.91	1.83	16.76	2.05	1.95	17.82	2.05
Peaches (3/10) *	0.86	1.55	11.08	1.64	1.53	10.97	1.78	1.61	11.70	1.78
Walnuts (4/14) *	0.93	1.64	9.13	1.68	1.60	9.07	1.82	1.70	9.71	1.82
Vineyard Established (4/7)	0.78	1.38	6.20	1.50	1.33	6.13	1.61	1.43	6.58	1.61
Alfalfa (2/1)	0.97	1.75	20.83	1.75	1.69	20.72	1.89	1.81	22.12	1.89
Pasture (2/1)	1.0	1.82	21.49	1.82	1.76	21.38	1.96	1.88	22.78	1.96
Past 7 days precipitation (inches)			0.00			0.00			0.00	
Accumulated precipitation (inches) (3/1/2022)			5.57			5.41			4.61	

Accumulations started on February 1, 2022 or on the approximate leafout date for a specific crop as indicated in parentheses. Criteria for beginning this report are based on the season's last significant rainfall event where the soil moisture profile is estimated to be near its highest level for the new season.

* Estimates are for orchard/vineyard floor conditions where vegetation is managed by some combination of strip applications of herbicides, frequent mowing or tillage, and by mid and late season shading. Weekly estimates of soil moisture loss can be as much as 25 percent higher in orchards where cover crops are planted and managed more intensively for maximum growth.

PAST WEEKLY APPLIED WATER IN INCHES, ADJUSTED FOR EFFICIENCY [1]

Crops	#70 Manteca			#194 Oakdale			#206 Denair II		
System Efficiency >>	75%	85%	95%	75%	85%	95%	75%	85%	95%
Almonds (2/27)	2.5	2.2	2.0	2.4	2.2	1.9	2.6	2.3	2.1
Peaches (3/10)	2.1	1.8	1.6	2.0	1.8	1.6	2.1	1.9	1.7
Walnuts (4/14)	2.2	1.9	1.7	2.1	1.9	1.7	2.3	2.0	1.8
Vineyard Established (4/7)	1.8	1.6	1.5	1.8	1.6	1.4	1.9	1.7	1.5
Alfalfa (2/1)	2.3	2.1	1.8	2.3	2.0	1.8	2.4	2.1	1.9

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

For further information concerning this report, contact Roger Duncan or Moneim Mohammad the University of California Cooperative Extension office in Stanislaus County at (209) 525-6800.

1.7 x 0.10 =0.17 "
Consider better AE and water targeting better the root zone

Convert inches to gallons

- Gallons per week = $\frac{Inches \times 27{,}154}{Trees\ per\ acre}$

$$\frac{\mathbf{0.17} \times 27{,}154}{90} = 51 \text{ gal/week} = 7 \text{ gal/day}$$

- How to supply this with drip irrigation system with 3gph?

  Two sets of 9hrs irrigation sets scheduled every 3&4 days apart

What if it was a Microsprinkler (10gph)?

- This suggest longer duration less frequent irrigation!
  Irrigation schedule (five hours/week)

Rootstocks and Tree & Row spacing

Spacing	Rootstock	Dry Weight per Acre (lbs) 2020[1]	
22'x22'	Paradox Seedling	1264.18	cd
	RX1	**2836.73**	**a**
	VX211	2382.75	ab
26'x26'	Paradox Seedling	1047.15	cd
	RX1	2529.88	ab
	VX211	1669.38	bc
30'x30'	Paradox Seedling	868.52	d
	RX1	1593.11	bc
	VX211	1104.20	cd

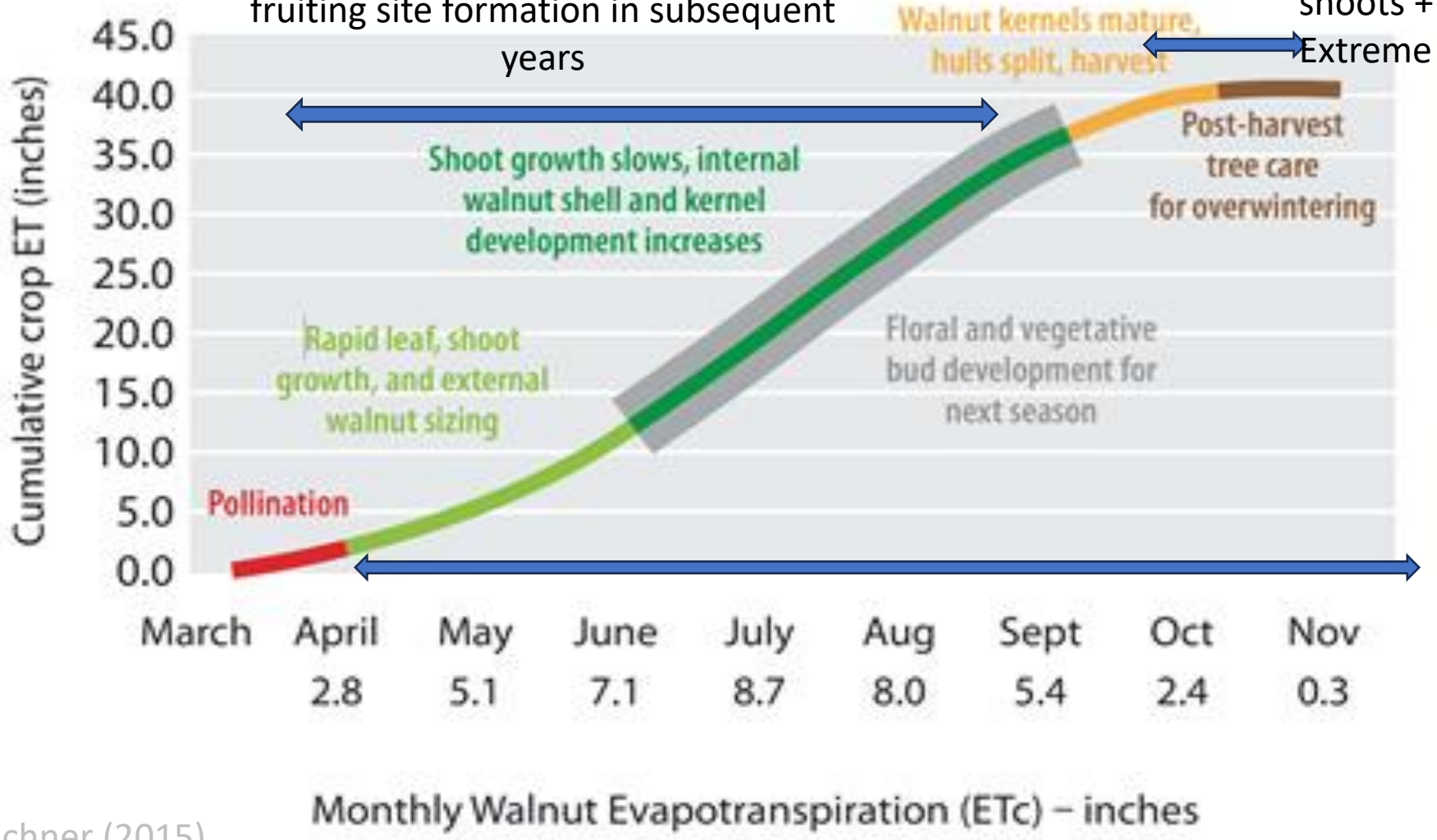
Arnold et al. (2020)

No Deficit Irrigation for young trees

Water Deficit =
decrease nut size, reduce shoot growth and new leaf development impact fruiting site formation in subsequent years

Problems with hull tights, dark kernel color

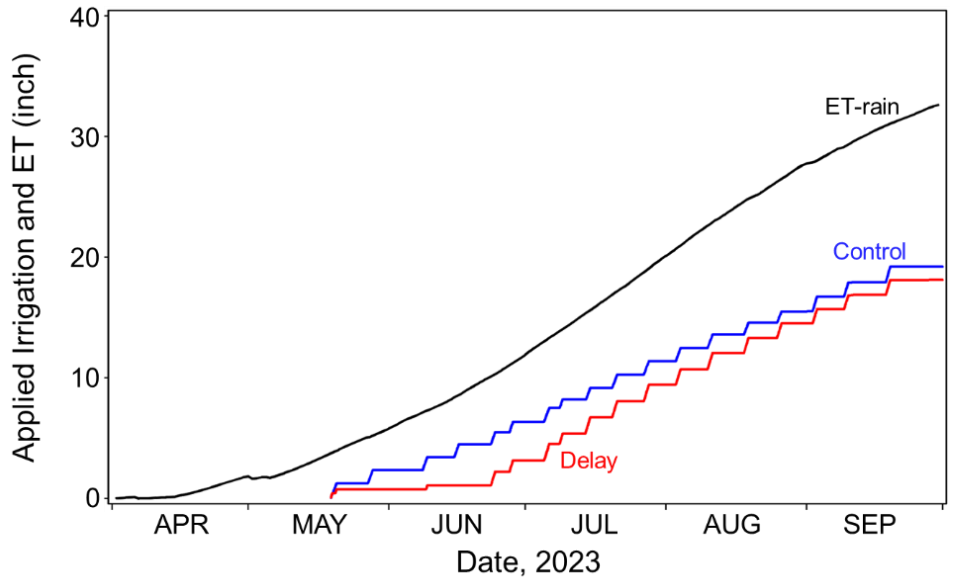
Mild deficit = harden-off new shoots + reduce frosts injured
Extreme = Winter die back

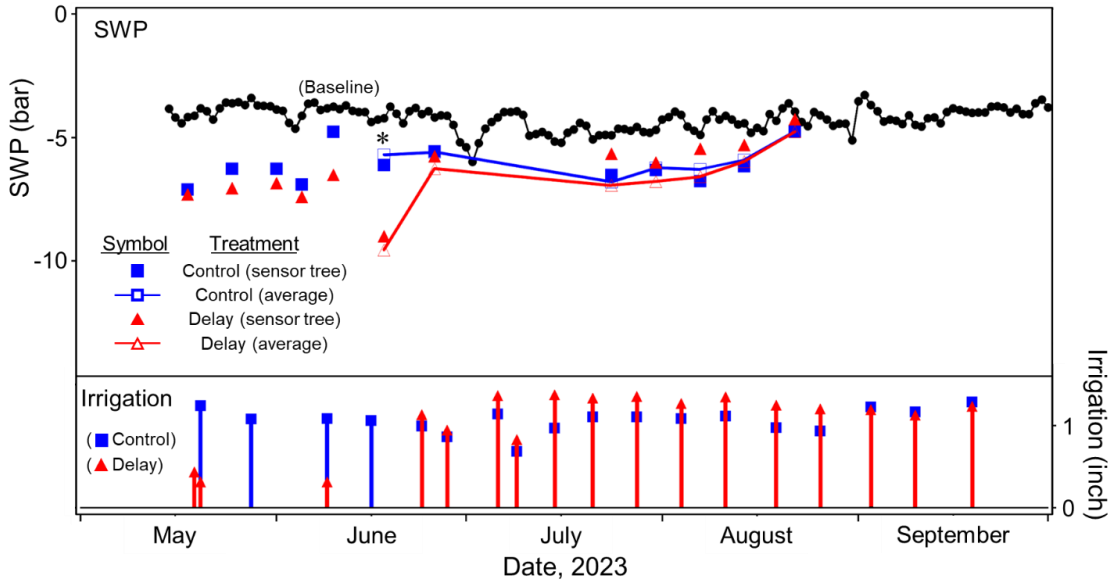


Moderate deficit (save 12 inches, moderate impact on yield and quality and less impact on shoot development

Fulton & Buchner (2015)

Delayed Irrigation in Mature Walnuts

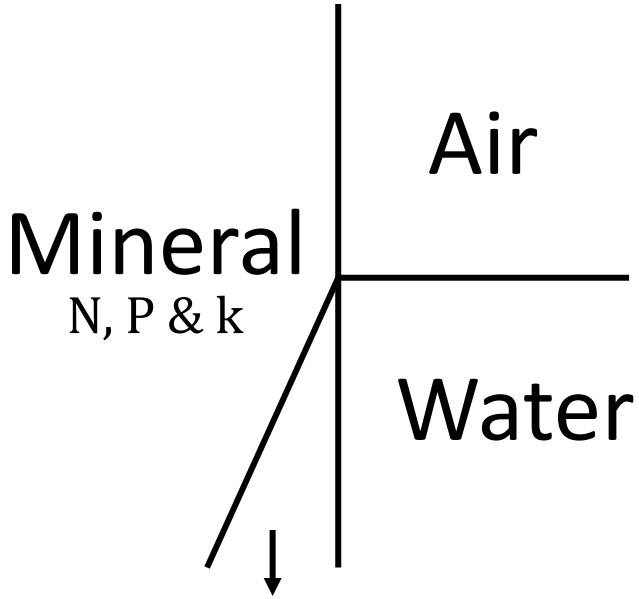




Year	PAR (%)		Yield (#/ac)		(delay % difference from control)
	Control	Delay	Control	Delay	
(2018)	-	-	4,330	4,240	-2
2019	71	58	4,140	3,740	-10
2020	78	75	3,220	2,840	-12
2021	85	83	3,750	3,900	+4
2022	84	81	4,300	3,530*	-18
2023	-	-	5,730	6,350	+11

Shackel et al., (2023)

Component of Soil



The 4 R's of fertilizer management for mature trees

Right

RATE

- Match supply with tree demand
- All inputs (Fertilizer + organic + soil + water)

TIME

- Match with tree demand and root uptake
- N Even split May-August, P in fall or winter

PLACE

- To the active root zone
- Reduce movement below root zone (Roots are

SOURCE

- Most N turn to Nitrate
- P Triple superphosphate

Fertilizer	Nitrogen (%)	Urea	Ammonium	Nitrate	Leaching	Soil Acidifier
Ammonium Nitrate	34		x	x	M	M
Ammonium sulfate	21		x		L	H
Calcuim ammonium nitrate (CAN-17)	17		x	x	M	M
Calcium nitrate	16			x	H	No
Urea	45	X		x	L	L
Urea Ammonium Nitrate (UN-32)	32	X	x	x	M	M

Kathy Kelley-Anderson et al: ANR Pub # 21623

Nitrogen (N)

In the first year, nitrogen is the only nutrient that trees may needed. N fertilization can be reduced or omitted in the first two seasons on fertile soils.

- **When:** Mid-spring and early summer
- **Method:** Dry form or through fertigation
- **Type:** *1st leaf*: It's recommended to use granular fertilizer as the liquid fertilizer may burn roots as a result of high fertilizer concentration in the root zone.
  2nd leaf: Liquid fertilizers (UN-32 or CAN-17)
- **How much**: table (right)

Tree Age (season)	N application rate		
	(lbs/acre)	(lbs/tree)	(ox/tree)
First	10-20	0.2-0.3	2-5
Second	25-50	0.4-0.8	6-12
Third	50-100	0.8-1.5	12-25
Fourth	63-125	1-1.9	16-31
Fifth	75-150	1.2-2.3	18-37

Nut yield	N removed	Fertilizer N required (lbs N/acre)	
(tons/acre)	(lbs/acre)	Split broadcast	Fertigation
1	48	86	2-5
1.5	72	129	6-12
2	96	0.8-1.5	12-25
2.5	120	1-1.9	16-31

Nitrogen Budgeting Worksheet for Walnuts

Name | **Date**

Block ID

1	**Nitrogen removed in the crop**	1a._____ x 40 (lb N/ton yield of walnuts) = Yield in tons of walnuts/acre	1._____lb N/acre lost in crop per year
2	**Nitrogen contributions from irrigation water**	If units are in NO_3-N ppm use line 2a; if units are NO_3 ppm use line 2b- not both. Put the result of line 2a or 2b on line 2c. 2a._____ x _____ x 2.7 = NO_3N-N ppm or mg/l Water applied (ft) OR 2c._____lb N/acre x 0.7 = Estimated N recovery 2b._____ x _____ x 0.614 = NO_3 ppm or mg/l Water applied (ft)	2._____lb N/acre from irrigation water
3	**Nitrogen contributions from manure or compost**	If none applied, skip to line 4. 3a._____ x 3b._____ x 3c._____ x 0.5 x 0.2** = Tons/acre dry % N % N released* Estimated N recovery *For one-time applications use first-year release value from Section 1, Table 1. For annual applications, use 100% **Converts tons to pounds.	3._____lb N/acre from manure or compost
4	**Nitrogen contributions from cover crops**	If none, skip to line 5. 4a._____ x 4b._____ = lb N/orchard acre in cover crop Nitrogen recovery factor For mowing, use 0.5; For disking, use 0.7	4._____lb N/acre from cover crop
5	**Total nitrogen available from nonfertilizer sources**	Add lines 2, 3, and 4. Enter the result on line 5.	5._____lb N/acre
6	**Additional nitrogen needed**	To figure how much additional nitrogen is needed by your trees, subtract line 5 from line 1. Enter the result on line 6. If the answer is negative, no fertilizer is needed.	6._____lb N/acre needed by trees
7	**Nitrogen fertilizer application rate**	Divide the amount on line 6 by an estimated nitrogen recovery factor of 0.4 (or use a lower value, see instructions). Use 0.8 for fertigation. _____ ÷ _____ = lb fertilizer N/acre needed by trees (line 6) Estimated nitrogen recovery factor	7._____lb N/acre fertilizer rate

Note: Converting metric values for use in the table: 1 kg = 2.2 lb; 1 metric ton = 1.1 ton; 1 kg/T = 1.9 lb/ton; 1 kg/ha = 0.9 lb/ac; 1,000 m^3 = 1,556 acre-feet.

N is the only element required by new trees in most California soils

	Phosphorus (P_2O_5)	Potassium(K_2O)
		Potassium may be required for soils with very low K (Very sandy or K fixing soils).
Type	triple superphosphate	Potassium chloride (KCl) or potassium sulfate (K_2SO_4) If you need repeated high doses, use K_2SO_4 instead of KCL to avoid chloride buildup.
How much	25 lbs. (11 pounds of P_2O_5)	
Where	6-inch deep trenches is more effective than broadcast applications (Trenches should be 2 feet or more away from the trunk, depending on tree size, and within the irrigation wet zone)	banded on either side of the tree or supplied with the irrigation water
When	dormant period in fall or winter	In the fall
How much (Mature)	~ 4.3 lbs (10 lbs P_2O_5)… removed within 1 ton of harvested nuts	12 lbs (15 lbs K_2O) …… removed…..within 1 ton of harvested nuts. Annual band applications of 240 lbs K_2O/acre have been recommended to K deficient trees grown on sandy soil. On heavier soils, up to 900 lbs K_2O/acre may be required

Fertigation: Injection Time

- To ensure proper mixing, injection of fertilizers should not be done in short high conc. applications.
- It takes 15 to 20 minutes for water to travel 500 ft to the end of a drip tube lateral with emitters of 1 gph spaced 4 feet.
- It takes 30 to 40 minutes for water to travel 800 ft to the end of a drip tape lateral with 0.22 gpm/100 ft discharge rate.
- For good fertilizer distribution constant long injection times recommended.

How Can I estimate fertigation injection rate?

- Injection Amount (gal) $= \frac{(Desired\ lbs\ of\ (N/acre)) \times acres \times 100}{(Fertilizer\ density\ (lbs/gal)) \times (\%\ of\ N\ in\ fertilizer)}$

- Injection Rate (gal/hr) $= \frac{(Desired\ lbs\ of\ (N/acre)) \times acres \times 100}{(Fertilizer\ density\ (lbs/gal)) \times (\%\ of\ N\ in\ fertilizer\ \times injection\ time\ (hrs)}$

How Can I estimate fertigation injection rate?

Example: Fertigation injection rate

A Walnut grower wants to apply 50 lbs per acre of nitrogen by injecting UN 32 in to microsprinkler irrigation system. The microsprinkler irrigation system serves 120 trees planted on a spacing of 28 * 28 ft. At what rate should the grower inject the fertilizer? Assume UN32 has a density of 11.1 lbs/gal.

Estimated area served by micro sprinkler irrigation system: 120 * (28 *28) = 94,080 ft^2 = 2.16 acres

Assuming injection time of 2 hours

$$Injection\ Rate\ (gal/hr) = \frac{50 \times 2.16 \times 100}{11.1 \times 32 \times 2} = \mathbf{15.2}\ \text{gph}$$

Resources:

Irrigation and Nutrient Management of Young Orchards Handbook

- Fulton, A. (2013). Evaluating Water Requirements of Developing Walnut Orchards in the Sacramento Valley. Walnut Research Reports, California Walnut Board.
- Using Adjusted Weekly ET_c Estimates to irrigate Young Orchards https://www.youtube.com/watch?v=7I4j1fc7e9U
- California Crop Fertilization Guidelines http://apps.cdfa.ca.gov/frep/docs/guidelines.html
- Nitrogen Budget for Walnuts Worksheet Instructions https://ucanr.edu/datastoreFiles/391-755.pdf
- Young Orchard Handbook

cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Thanks!
Gracias!

Questions!

Moneim Mohamed
amohamed@ucanr.edu
209-525-6812
UCCE Stanislaus
3800 Cornucopia Way,
Suite A, Modesto, CA

Contact: