Measuring Crop Water Use
How Much To Irrigate & When

Dixon/Solano RCD Water Quality Coalition
November 29, 2018

Irrigation Scheduling

Irrigation Efficiency = $\frac{\text{amount of water application required by the crop}}{\text{amount of water applied to the field}}$

Grower's objectives

-Meet the crop water requirement
-Avoid crop stress
-High yields/high quality
-Avoid unnecessary runoff
-Avoid unnecessary deep percolation

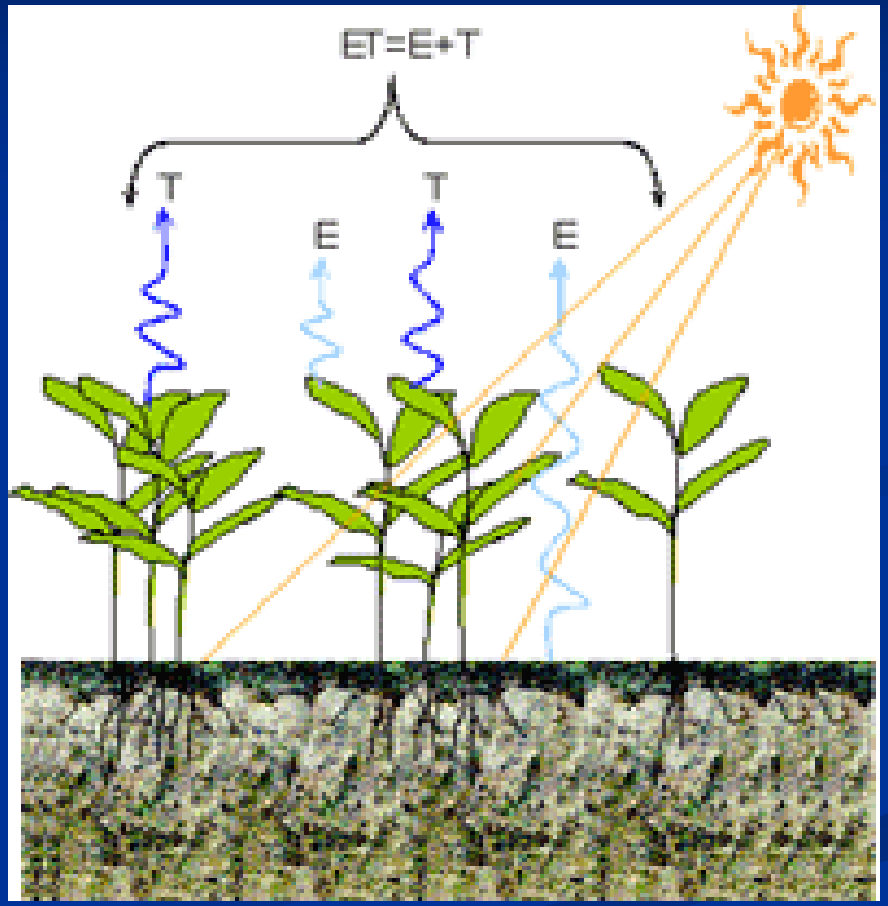
Best approach

-Proper irrigation scheduling
- Understand Evapotranspiration concepts
- Know your soil texture & structure
- Monitor soil moisture & leaf stem water potential (pressure bomb)
- Know your crop characteristics
- Visual inspection

Measure Crop Water Uptake: Evapotranspiration

- Evapotranspiration (ET) is the sum of water losses from plant uptake (transpiration), and evaporation from soil & plant surfaces.

- Quantifying moisture losses from ET in inches/day or in./week can help growers determine how much and when to irrigate, to restore ET losses



"Irrigate to Restore ET Losses"

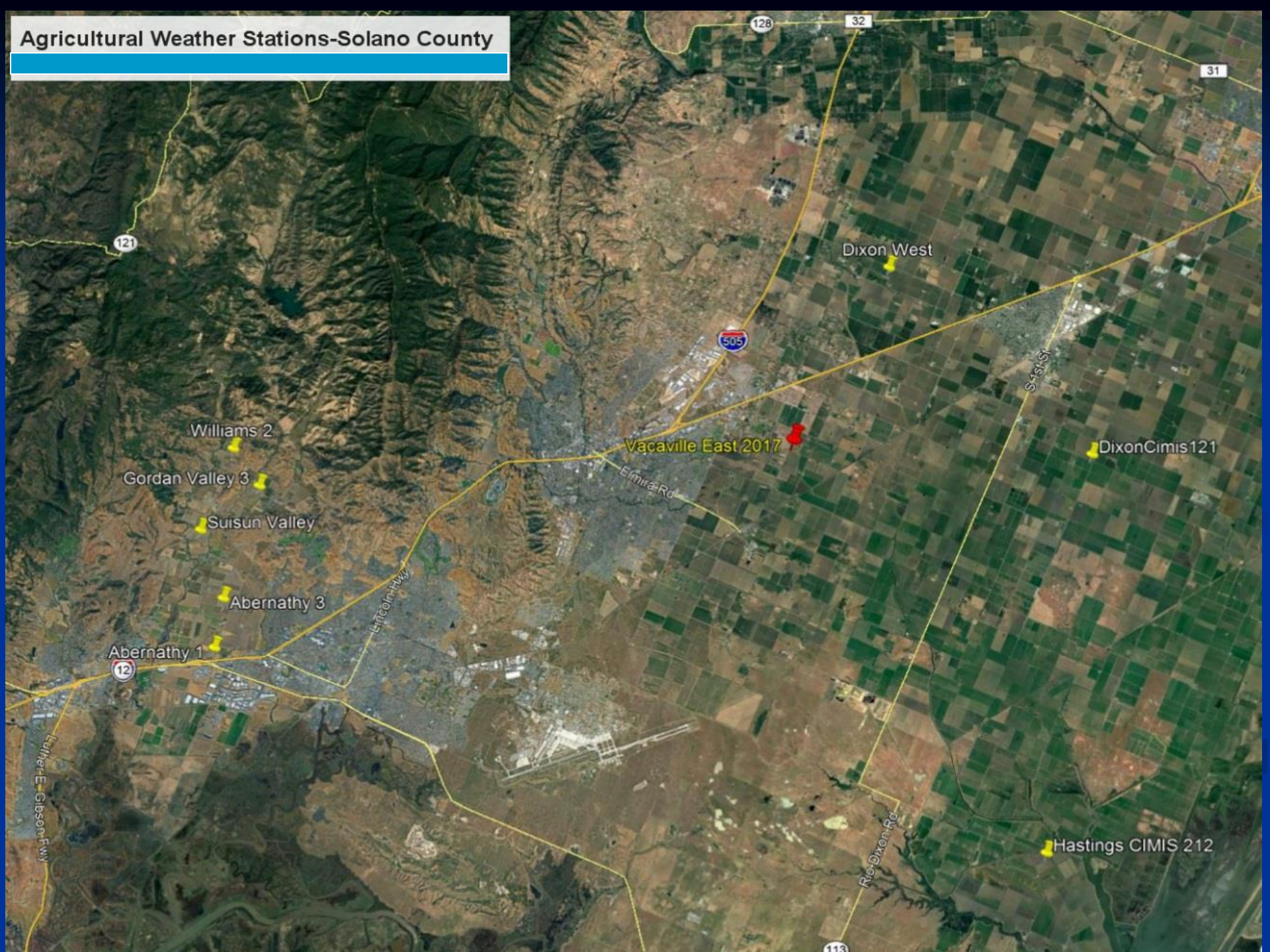
ETo = "Reference ET" = the amount of water use by a well irrigated, mowed alfalfa, pasture, or grass. ETo is affected by daily changes in:

- temperature
- relative humidity
- solar radiation
- wind

Alfalfa example of Reference ET

ETo rates for Solano County are available on the following websites:

- www.sid.westernweathergroup.com
- www.CIMIS.ca.gov
- www.westernweathergroup.com (forecast subscription)


Agricultural Weather Stations-Solano County
Dixon West
Williams 2
Vacaville East 2017
DixonCimis121
Gordan Valley 3
Suisun Valley
Abernathy 3
Abernathy 1
Hastings CIMIS 212
Elmira Rd
Lincoln Hwy
S 1st St
Rio Dixon Rd
Leather-E Gibson Fwy
128
32
31
121
505
12
113

ETo at www.sid.westernweathergroup.com

Last 7 Days

Daily Data | America/Los_Angeles

Abernathy 1 (A

as of 11/16/18 8:16 AM

Date	Daily Max Temp (°F)	Max RH (%)	RH (%)	Daily ETo (in)	7 Day ETo (in)
11/15/18	64.8	75	56	0.05	0.41
11/14/18	66.2	72	50	0.06	0.49
11/13/18	64.3	62	45	0.04	0.53
11/12/18	70.6	62	38	0.06	0.58
11/11/18	74.1	73	30	0.11	0.62
11/10/18	64.3	69	50	0.05	0.63
11/9/18	64.0	61	40	0.05	0.67

ET for specific crops = ETc (Crop Evapotranspiration)

ETc = ETo x the "Crop Coefficient" or Kc

ETo x Kc = ETc

Kc is available:

www.Wateright.net Go to "references" then find Crop Coefficients

ETc is available:

www.itrc.org/reports/pdf/californiacrop.pdf

go to ITRC Report #R03-001

ETc for almonds, prunes & walnuts

Sent on behalf of Katherine Jarvis-Shean, Orchard Systems Advisor for Sacramento, Solano, and Yolo counties

WEEKLY SOIL MOISTURE LOSS IN INCHES
(Estimated Crop Evapotranspiration)
8/31/18 through 9/6/18

Crops	Woodland			Crops	Davis		
	Past Week of Water Use	Accum'd* Seasonal Water Use	Next Week's Estimated** Etc		Past Week of Water Use	Accum'd* Seasonal Water Use	Next Week's Estimated** ETc
Almonds (2/12)	1.59	41.97	1.49	Almonds (2/12)	1.53	40.33	1.49
Prunes (3/27)	1.33	35.52	1.23	Prunes (3/27)	1.28	34.15	1.23
Walnuts (4/17)	1.65	28.95	1.57	Walnuts (4/17)	1.60	27.77	1.57
Past 7 days Precipitation (in)		0.00		**Past 7 days Precipitation (in)**		0.00	
Accum'd In-Season Precip* (in)		4.82		**Accum'd In-Season Precip* (in)**		4.98	

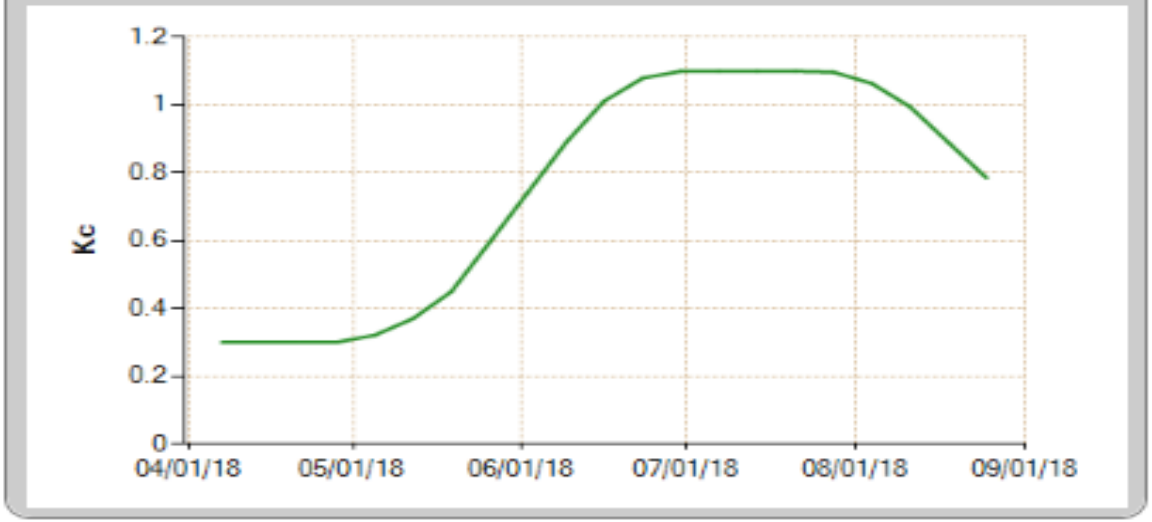
Crops	Dixon			Crops	Verona (near Knight's Landing)		
	Past Week of Water Use	Accum'd* Seasonal Water Use	Next Week's Estimated** ETc		Past Week of Water Use	Accum'd* Seasonal Water Use	Next Week's Estimated** ETc
Almonds (2/12)	1.60	41.32	1.49	Almonds (2/12)	1.47	39.28	1.49
Prunes (3/27)	1.34	35.03	1.23	Prunes (3/27)	1.23	33.31	1.23
Walnuts (4/17)	1.66	28.70	1.57	Walnuts (4/17)	1.53	27.09	1.57
Past 7 days Precipitation (in)		0.00		**Past 7 days Precipitation (in)**		0.00	
Accum'd In-Season Precip* (in)		7.00		**Accum'd In-Season Precip* (in)**		7.46	

Weekly ETc rates available by email from UC Extension
Kjarvisshean@ucanr.edu

Tomato Kc on Wateright.net

Crop Factors for Tomato (04/01/18 - 08/31/18)

For Week Ending	Average Kc for Week	For Week Ending	Average Kc for Week
4/7/2018	0.30	6/23/2018	1.08
4/14/2018	0.30	6/30/2018	1.10
4/21/2018	0.30	7/7/2018	1.10
4/28/2018	0.30	7/14/2018	1.10
5/5/2018	0.32	7/21/2018	1.10
5/12/2018	0.37	7/28/2018	1.10
5/19/2018	0.45	8/4/2018	1.06
5/26/2018	0.59	8/11/2018	1.00
6/2/2018	0.74	8/18/2018	0.89
6/9/2018	0.89	8/25/2018	0.79
6/16/2018	1.01		



Restore ET losses – When & How Much

"Checkbook Method"

ET only, no soils considerations

Restore ETc losses

Field Capacity →

Walnuts	Zone 14	Reference ET	Crop ET	Cumulative ET
	Sprinkler			ETc
Day	or Rain	ETo	ETc	Cumulative
	(inches)	(inches)	(inches)	(inches)
01-Apr		0.18	0.05	0.05
02-Apr		0.12	0.03	0.08
03-Apr		0.13	0.03	0.11
04-Apr		0.13	0.03	0.15
05-Apr		0.13	0.03	0.18
06-Apr		0.14	0.04	0.22
07-Apr		0.14	0.04	0.25
08-Apr		0.14	0.04	0.29
09-Apr		0.17	0.04	0.33
10-Apr		0.22	0.06	0.39
11-Apr		0.17	0.04	0.43
12-Apr		0.17	0.04	0.48
13-Apr		0.17	0.04	0.52
14-Apr		0.16	0.04	0.56

Grape Scheduler – UC Extension

Sonoma County Cooperative Extension

Vineyard Irrigation Scheduling Worksheet Version 1.2, January 2009

Complete Fields Shaded in Blue — Press TAB key to move between cells

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John Yeo, Senior Agricultural Program Assistant, Sonoma County Cooperative Extension

Vine Spacing (feet)		
10	x	7
Vines / Ac:		622

Emitters per Vine
2

Emitter Discharge (gph)
0.50

Estimated soil moisture contribution from root zone between irrigation start & 3 inches

Soil moisture contribution from the root zone of the soil profile is the water volume present at the first irrigation minus the water volume at harvest. The soil moisture contribution from the root zone for this time period ranges from 2.5" for deep loamy soils to 1" for shallow, rocky or sandy

Start of First Irrigation Interval	
Month	Day
4	15

Estimated Harvest	
Month	Day
9	15

Emission Uniformity: 90 %

Emission Uniformity is a function of differences in emitter discharge throughout an irrigation block. It can be calculated as the average discharge of all emitters divided by the average discharge of the 25% lowest flowing emitters. A Microsoft Excel worksheet is available from UCCE Sonoma to determine emission uniformity.

Emission Uniformity Criteria	
Excellent	Greater than 90%
Good	80% - 90%
Fair	70% - 80%

Select Nearest CIMIS Station: Windsor CIMIS Station #103 5 yr avg 2004-2008

Irrigation Interval Date Range Day and Month must be entered as numbers				Historical Average Eto	Previous Irrigation Interval Actual Eto From CIMIS or UC IPM Website	Shaded Ground At Solar Noon	Crop Coefficient (Kc)	Full Potential Water Use (Etc)	Regulated Deficit Irrigation Percentage (Krdi)	Total Rainfall During Irrigation Interval	Deficit Irrigation Requirement	Predicted Gallons / Vine	Predicted Irrigation Hours (from historical Eto)	Scheduling Adjustments: Actual Hours Applied	Actual Irrigation Requirement (From current year Eto)	Difference between Actual Irrigation Requirement and Actual Hours Applied Previous Week	Adjusted hours to apply based on historical Eto in current week and compensated hours
From		To		Inches	Inches	%		Inches	%	Inches	Inches	Gallons	Hours	Hours	Hours	Hours to Compensate	Hours
Month	Day	Month	Day														
4	15	4	21	1.119		30	0.51	0.57	80	0.00	0.32	14.0	15.6	12	17.2		
4	22	4	28	1.097	1.2	35	0.60	0.66	80	0.00	0.39	16.9	18.8	12	18.9	5.2	24.0
4	29	5	4	0.995	1.1	35	0.60	0.59	70	0.00	0.30	13.0	14.5	18	14.6	6.9	21.4
5	5	5	11	1.226	1	40	0.68	0.84	70	0.00	0.45	19.6	21.8	24	25.8	-3.4	18.4
5	12	5	18	1.316	1.4	45	0.77	1.01	65	0.00	0.52	22.7	25.2	24	22.4	1.8	27.0
5	19	5	25	1.266	1.2	50	0.85	1.08	65		0.56	24.6	27.4	24		-1.6	25.8
Totals:				7.02	5.90			4.75		0.00	2.54	110.9					

	Actual	Predicted	Corrected
Cumulative Gallons per vine =	114.0	123.2	116.5
Cumulative Hours of irrigation =	114.0	123.2	116.5
Cumulative Inches of water =	2.61	2.82	2.67

How Much Water Was Applied?

Furrow & Flood:

How many inches were applied?

$$\frac{4 \text{ cfs} \times 12 \text{ hrs}}{12 \text{ acres}} = \text{You applied } 4\text{”}$$

4 cfs at a rate of 1 ac./1 hr. = approx. 4”
4 cfs at a rate of 2 ac./1 hr. = approx. 8”
3 cfs at a rate of 1 ac./1 hr = approx. 3”

“Rule-of-Thumb”

Furrow & Flood Calculations

Calculate # hours to apply:

Hours = $\frac{\text{Area (sq. ft.) x desired inches}}{\text{96.3 x gpm x DU}}$ **Example: $\frac{\text{522,720 sq. ft. x 4.0 inches}}{\text{138,672}}$ = 15 hrs**

Calculate # inches applied to the crop:

Inches = $\frac{\text{96.3 x gpm x set time (hrs.)}}{\text{Area irrigated (sq. ft.)}}$ **Example: $\frac{\text{96.3 x 1800 gpm x 12 hrs.}}{\text{12 ac = 522,720}}$ = 4.0”**

Calculate When to apply:

Assume: soil was at field capacity since previous irrigation
Soil moisture levels have been monitored

Interval between irrigations:

Interval = $\frac{\text{AWC x MAD}}{\text{ETc per day}}$ **Example: $\frac{\text{2.0”/ft. x 2’root zone x 50\%}}{\text{.25”}}$ = 8 days**

1 cubic ft./second = 450 gallons per minute
1 acre= 43,560 sq. ft

Distribution Uniformity (DU):

- The uniformity of water infiltrated throughout the irrigated set.
- A DU of 80% = 80% of the set received the same am't of water the remaining 20 % received less water.
- Can indicate over or under-watering
- Get an Irrigation Evaluation to determine your DU

Average DU's	
Furrow/Flood Irrigation	60% - 80%
Sprinkler Irrigation	75% - 85%
Drip/Micro Irrigation	80% – 90%

DU: Must Adjust Schedule

- An 80% DU: Must apply 20% more water
- If the crop requirement is 1.0" :
  - An application of 1.2" needed to eliminate non-uniformity
- Improve DU to reduce under or over-watering

Total Available Water Holding Capacity

- The amount of water held by the soil
- AWC varies between soil types but not crop types

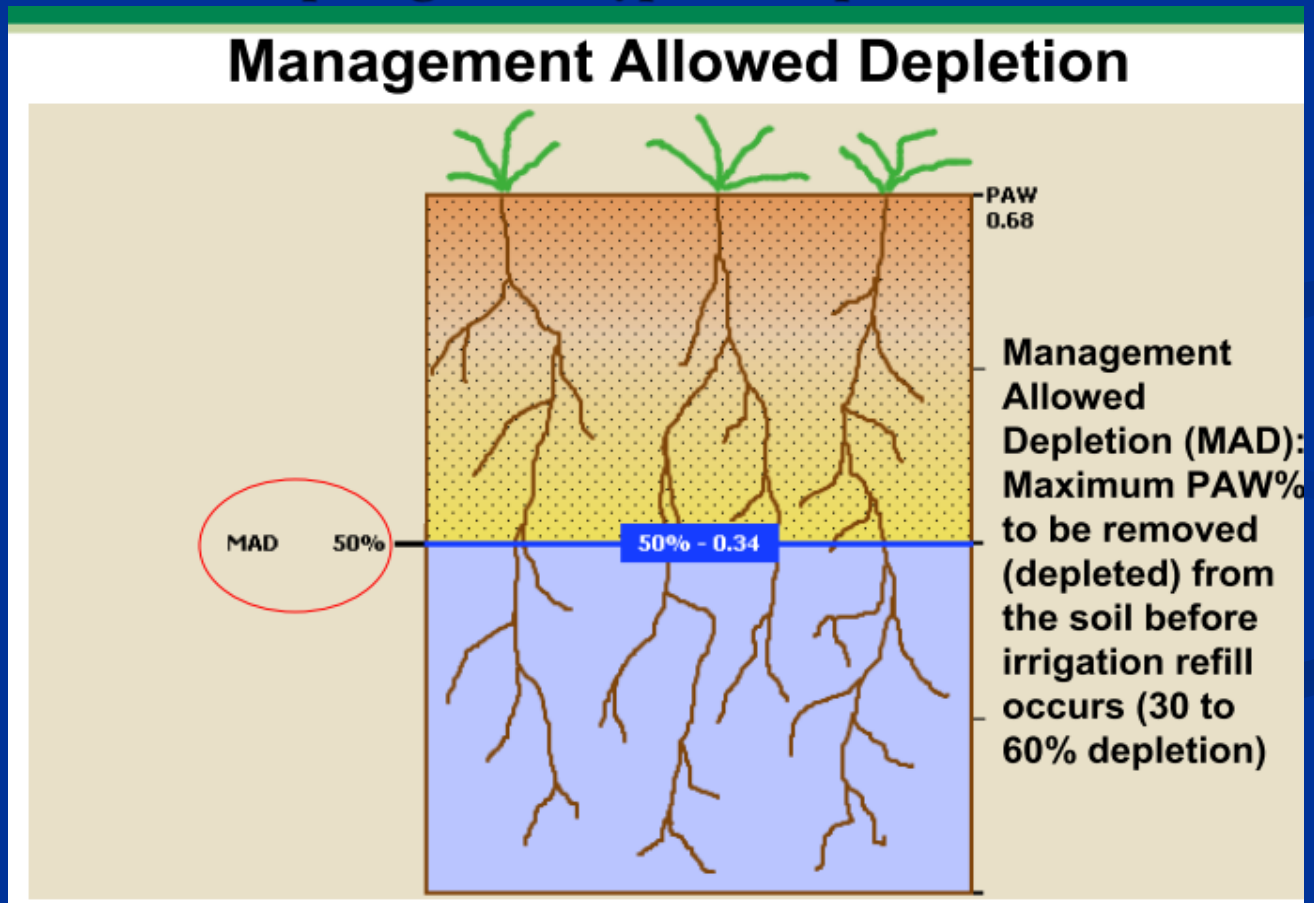
sandy loam	approx.	1.5”/foot of soil
loam	”	2.0” /foot of soil
clay loams	”	2.1” /foot of soil
clays	”	2.2” /foot of soil

-Multiply by the managed root zone depth:(grapes = 2’ - 3’)

Example: grapes on loam w/3’ root zone= 6” Total AWC

Management Allowable Depletion - "MAD"

- The soil moisture level at which the grower decides to irrigate
- % of available water that can be safely depleted
- Often is 50% of Available Water Capacity (AWC)
- Dependent on crop stages and type of crop



Drip/Micro Sprinkler Calculations

Calculate time required to deliver a desired depth of water in inches:

$$\text{Hours} = \frac{\text{ETc loss in inches since last irrigation}}{\text{Application rate in inches per hr. x DU}}$$

Example: $\frac{0.55}{0.09 \times 0.88} = 7.0$ hours

Calculate # hours to apply each day:

$$\text{Hours} = \frac{\text{Daily forecasted ETc}}{\text{Application rate in inches per hr. x DU}}$$

Example: $\frac{0.23}{0.09 \times .88} = 2.9$ hours

Convert ETc rates to #gallons/day/plant: Water use (gals/day)=crop spacing (sq. ft.) x ET (in/day x 0.623

Calculate #gallons/day needed to apply per plant: Am't required/day = ET (gal/day) / DU

Calculate the required irrigation time in hrs/day: Hours required/day =

$$\frac{\text{Am't needed to apply in gallons}}{\text{application rate (gals/hr.)}}$$

Flow Measurement – Micro-Sprinklers

Flow Measurement – Drip Irrigation

Free Irrigation Services

- Flow & pressure measurements
- Irrigation scheduling assistance
- Irrigation Evaluations/Distribution Uniformity
- Soil moisture monitoring
- Pump efficiency testing

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