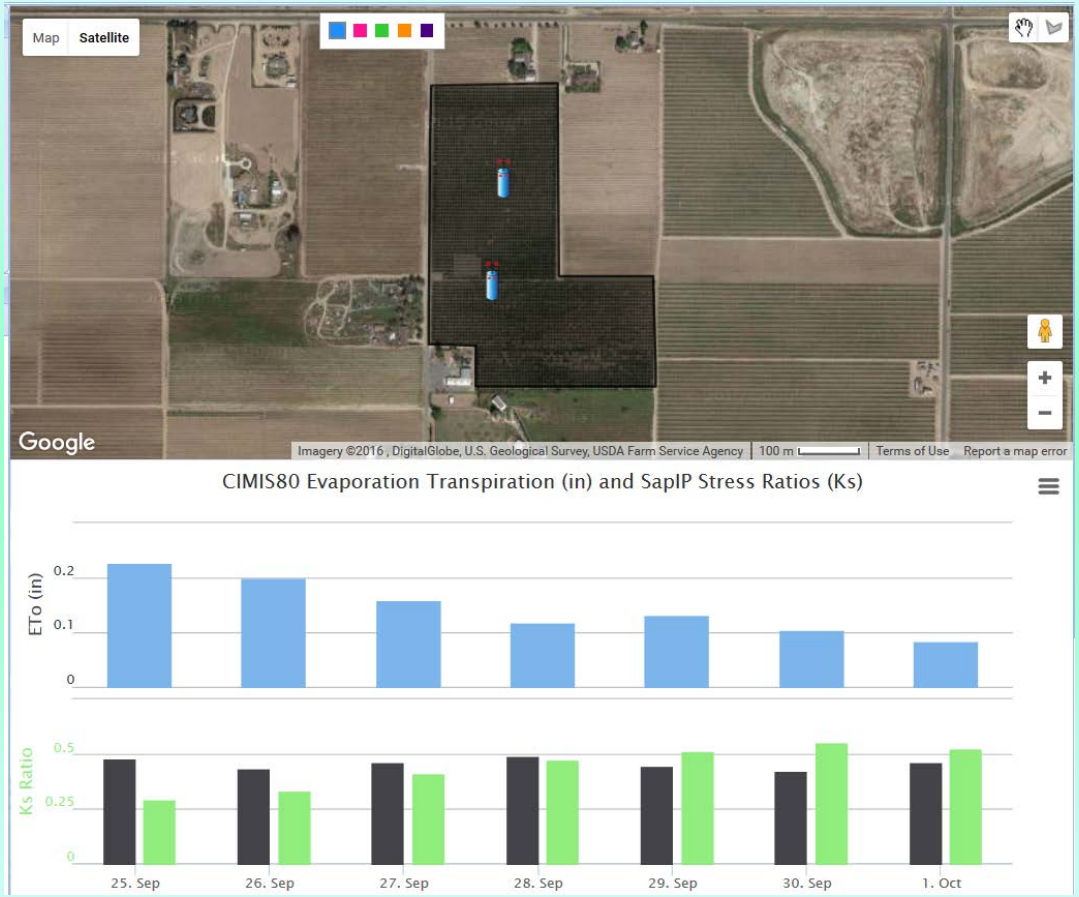


Advancing Water Requirements for Mandarin Orange with New Sensor Methods

5/9/2016

Water Management Deployment Objectives

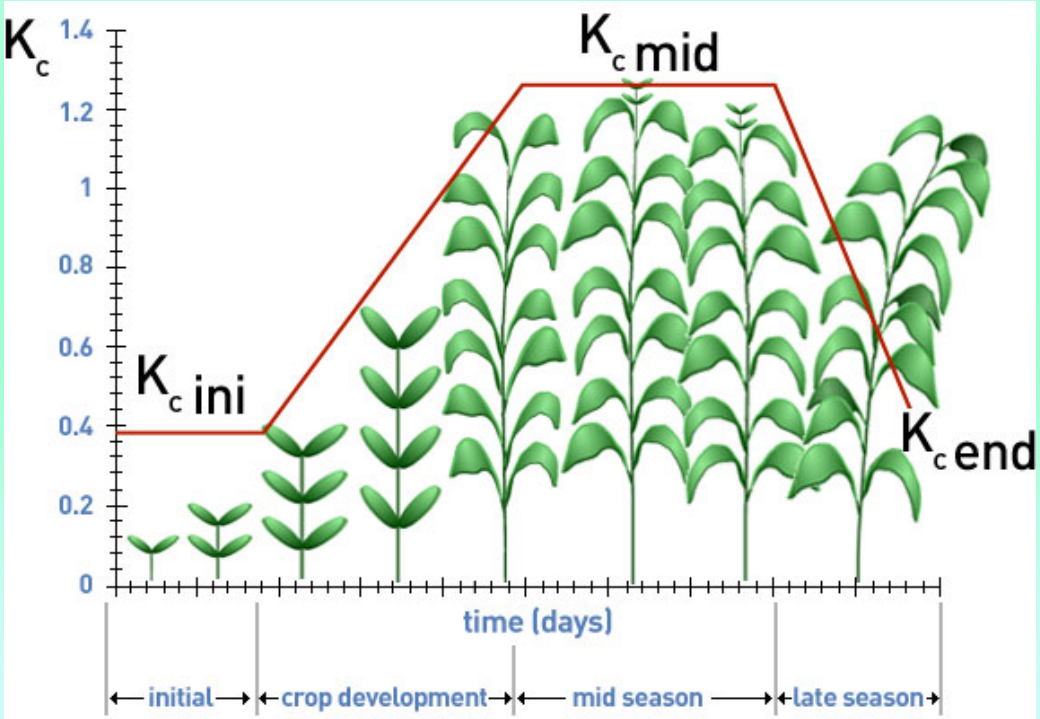
- Research Plan
  - Increased water requirement reliability – complete data sets
  - Monitor two varieties in the same ranch
    - South Side – Satsuma Mandarin
    - North Side – W Murcott
  - Data sets in real time – no water stress
  - Future Irrigation on sap flow required by trees
  - Find Kc for Well Watered and Ks for Stressed.

Water Requirements Differ

Varied and undefined by application (FAO).

ET a = Kc * ETo

- http://www.fao.org/nr/water/cropinfo_citrus.html
- Requirements for water depend on:
  - Stage of development
  - Species – Undefined
  - Soil type, undefined
  - Irrigation efficiency?



	Stages of Development					Plant date	Region
Crop characteristic	Initial	Crop Development	Mid-season	Late	Total		
Stage length, days	60	90	120	95	365	Jan	Mediterranean
Depletion Coefficient, p:	-	-	-	-	0.5		
Root Depth, m	-	-	-	-	1.2		
Crop Coefficient,Kc: Citrus no ground cover 70 % canopy 50 % canopy 20 % canopy	0.7 0.65 0.5	>> >> >>	0.65 0.60 0.45	0.70 0.65 0.55	- - -		
Crop Coefficient,Kc: Citrus no ground cover 70 % canopy 50 % canopy 20 % canopy	0.75 0.80 0.85	>> >> >>	0.70 0.80 0.85	0.70 0.80 0.85	- - -		

Stage of development will vary Water requirements from Kc = .45 to .85

Water needs in Crop Development

- Water deficit to be avoided during growth
- Too Vigorous growth to be avoided during Fruit set and flowering.

Ground Cover adds Water requirements (FAO)

	J	F	M	A	M	J	J	A	S	O	N	D
Large mature trees providing @ 70 % tree ground cover, clean cultivated	.75	.75	.7	.7	.7	.65	.65	.65	.65	.7	.7	.7
No weed control	.9	.9	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85

UC Drought Tips 92.34 (Snyder, 1992)

- Indicated the ETc = Kc * ETo * 80 % will not reduce yield,
- and 60 % of ETc will reduce yield.
- In Central CA: Kc is recommended **0.65**
- In Desert Area CA: Kc is recommended **0.70**,
- However all the data from 1992, before drip was applied.

University of Arizona:

- Mandarins are 10 % less than Oranges. Advice for Orange up to 1.0!

2. $E = ET_o \times K_c$

Where:

- ET_o = the pan evaporation in inches per day. This can be found on the web site for AZMET, the Arizona Meteorological Network. The web page address is: http://ag.arizona.edu/azmet/.
- From the first page, choose Yesterday's Weather Summary, and then select the ET value for the AZMET station closest to you.
- K_c = the crop coefficient for citrus. This varies by month as shown in the following table:

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
0.50	0.50	0.80	0.80	0.80	0.85	1.00	1.00	1.00	0.85	0.50	0.50

Confusing and various references.

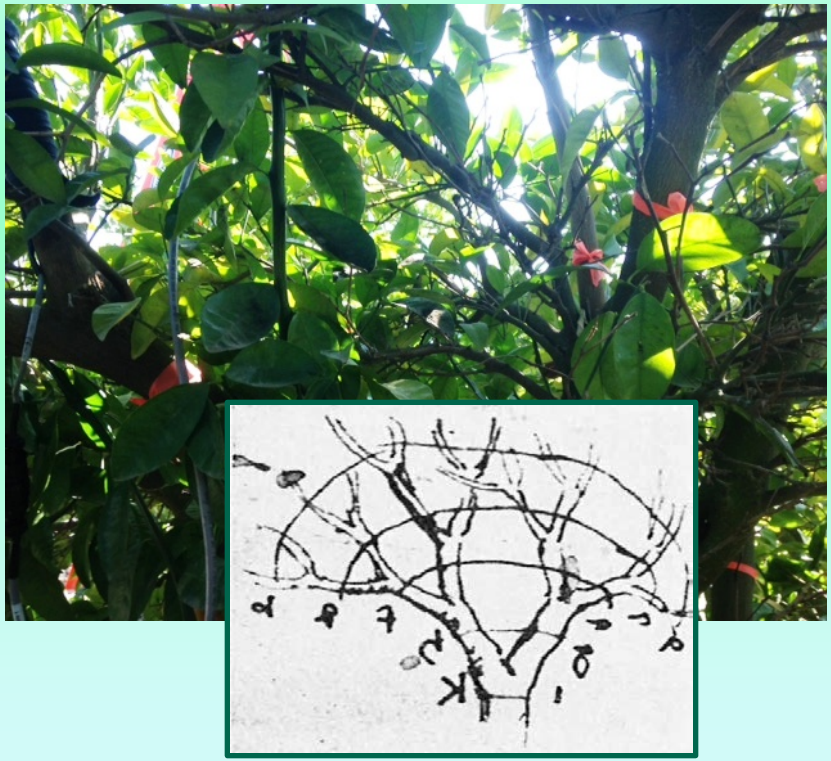
- **Advances in Irrigation Agronomy: Fruit Crops, M.K.V. Carr.**
- Cambridge University Press, Mar 27, 2014 - 350 pages
- In this publication 20 reasons water consumption studies cited on various responses to citrus stomata, stomata cycling, wax, adaptation of stem water potential to the water stress.
- There are no evidence that water deficit increases productivity. No consensus on water savings will benefit farmers
- There are no studies that determine how much water to apply. The results are not clear even when replacement irrigation is applied.
- Water deficit studies were reported mostly on orange trees – Uruguay and Spain.

Solution: Monitor Trees with Sap Flow Sensors

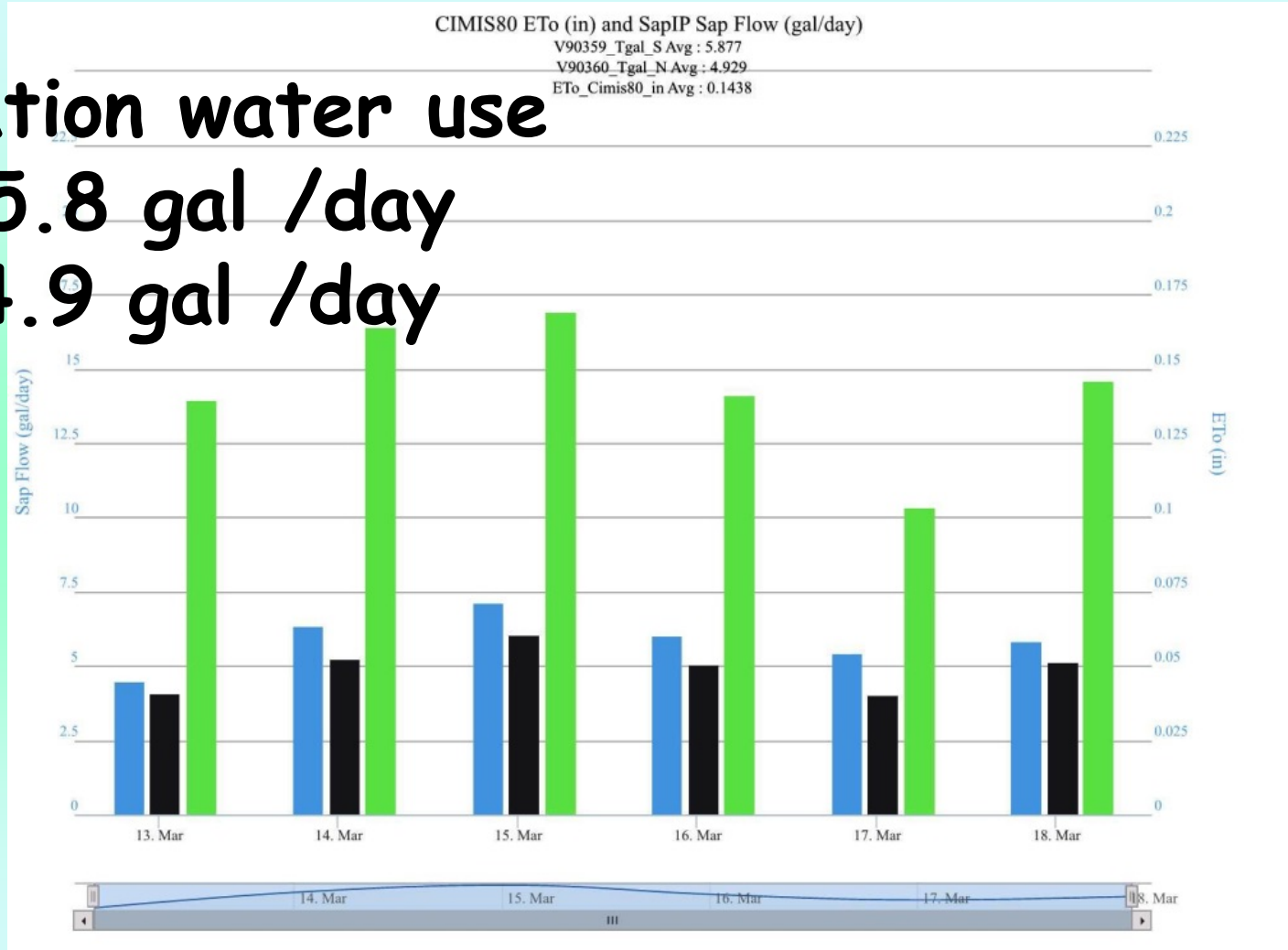
- Track real-time and report results on water use in two varieties
- Compare Sap flow with ETo
- Produce Kc for future reference
- Apply low stress during growth
- Monitor for stress before harvest

Installation – Two Trees with Canopy Mapping to Each Area

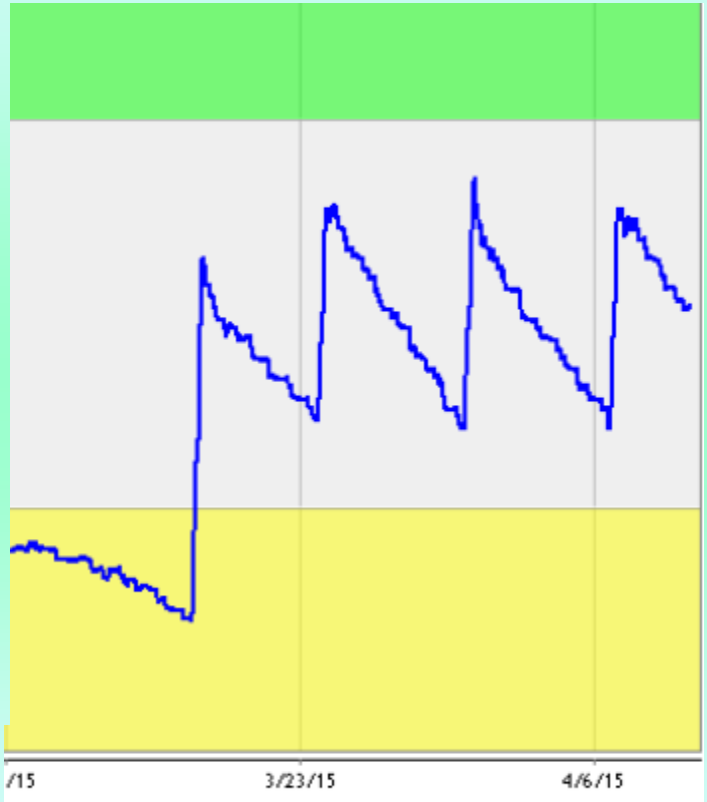
- Sap Flow Index from branch measurements using a modified Leonardo Da Vinci "Rule of Trunk Area" and the xylem pipe model.
- Alternative is the sapwood to leaf ratio and often referred to as the 'Huber value' (Huber 1928).
- http://prometheuswiki.publish.csiro.au/tiki-index.php?page=Water+balance+traits+-+leaf+to+sapwood+area+ratio



Pre-irrigation water use
Satsuma 5.8 gal /day
Murcott 4.9 gal /day



Soil Monitoring

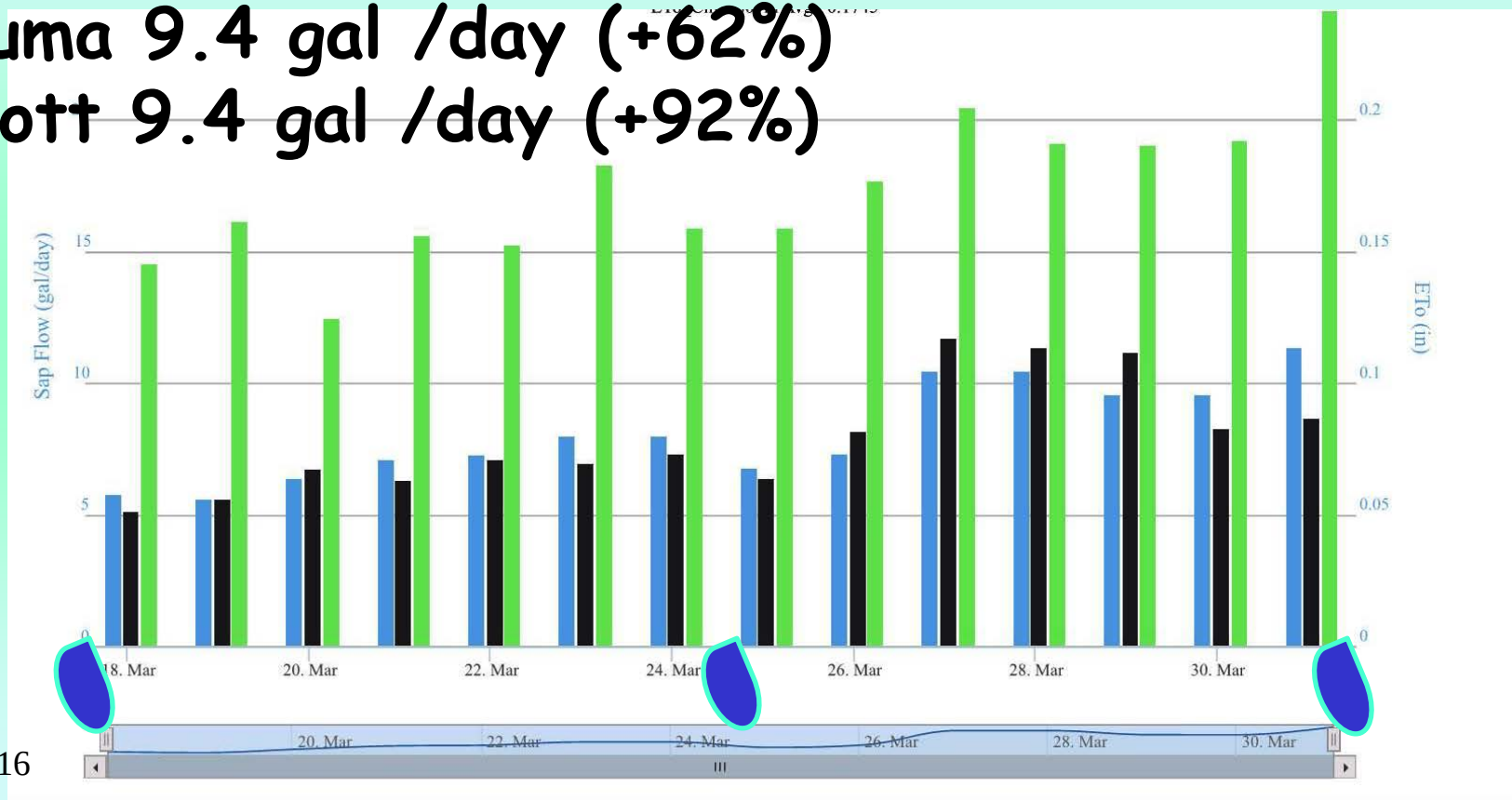


- Irrigation once a week, starting March 18, 2015

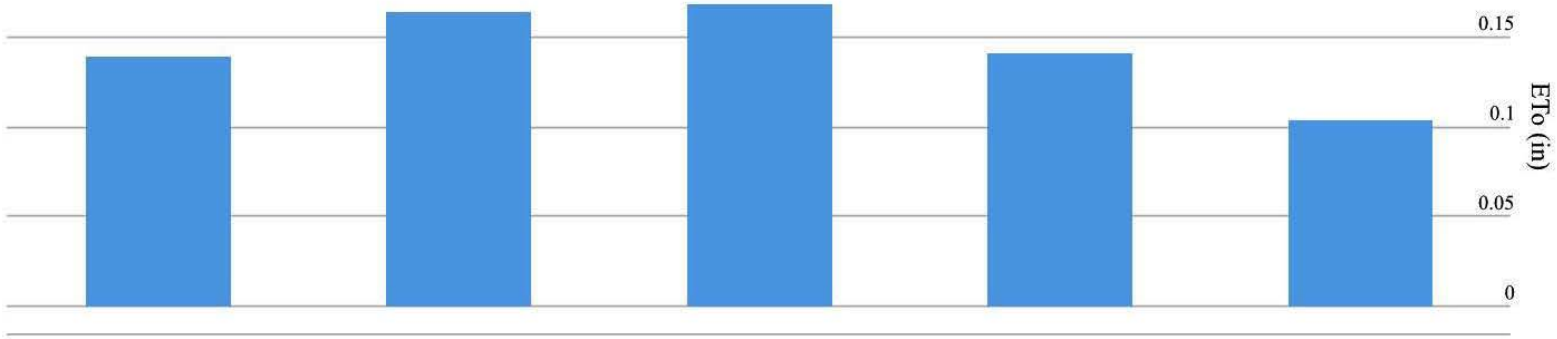
After two irrigations, water use – End Mar

Satsuma 9.4 gal /day (+62%)

Murcott 9.4 gal /day (+92%)

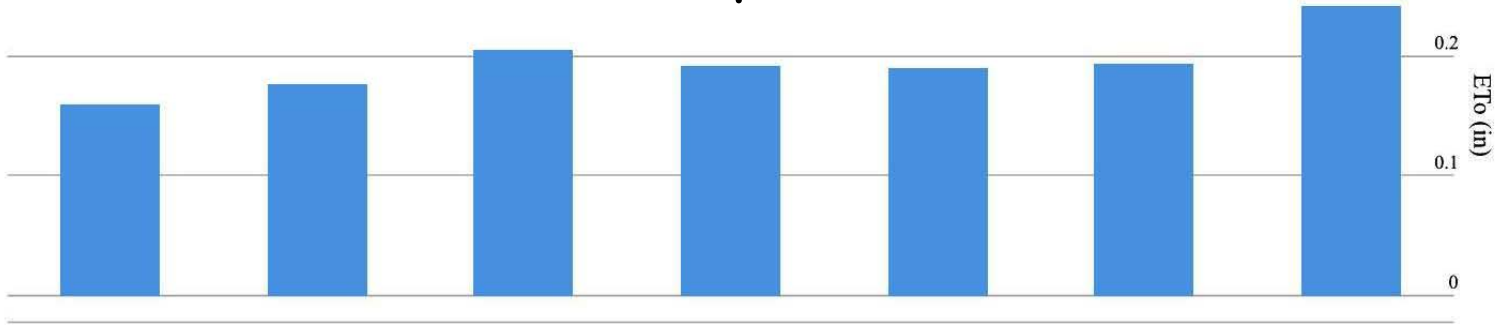


Water use before irrigation at .143 in/day avg. How is that represented with Kc or Ks (stress)?



Avg. Satsuma Ks= .23 (Gr) W Murcott Ks =.22 (BL)

Water use +62%, while ET went up only 36% .194 in/day from .143 in. How is that represented with Kc?



Avg. Satsuma Ks= .27 (Gr) W Murcott Ks =.31 (BL)

- Water Use

  ET actual = ETa = 117% Ks x 136% Eto

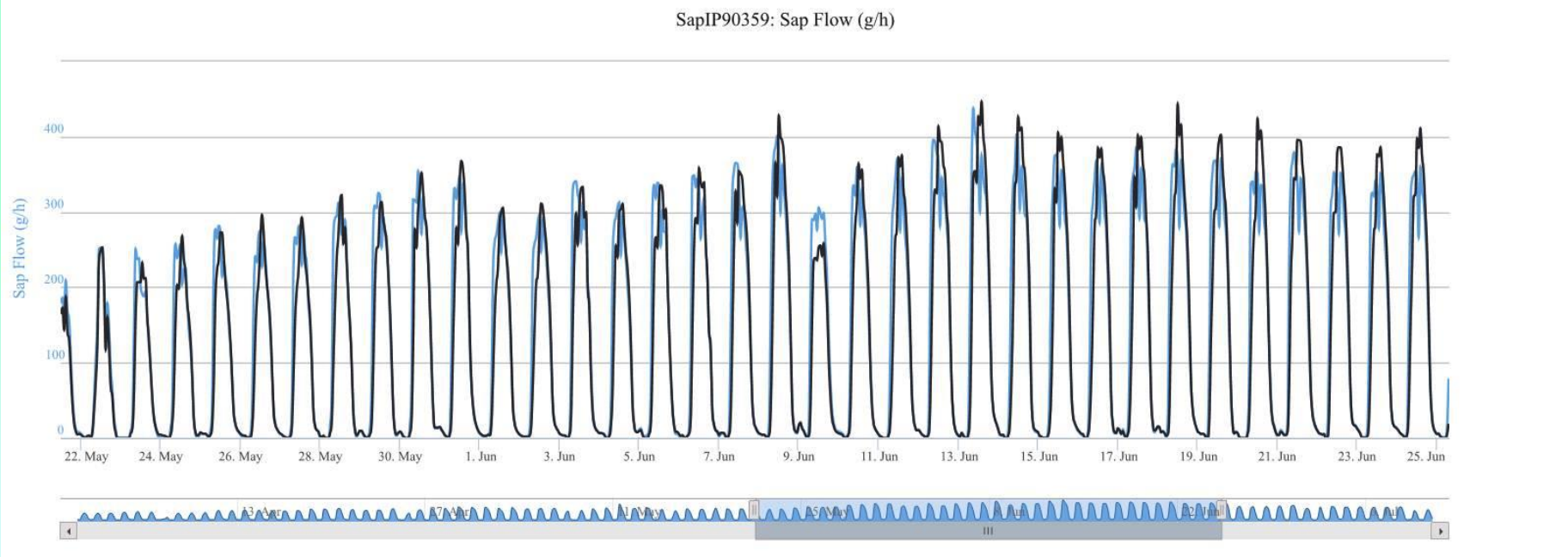
  +60% increase in Satsuma

  ET actual = ETa = 141% Ks x 136% Eto

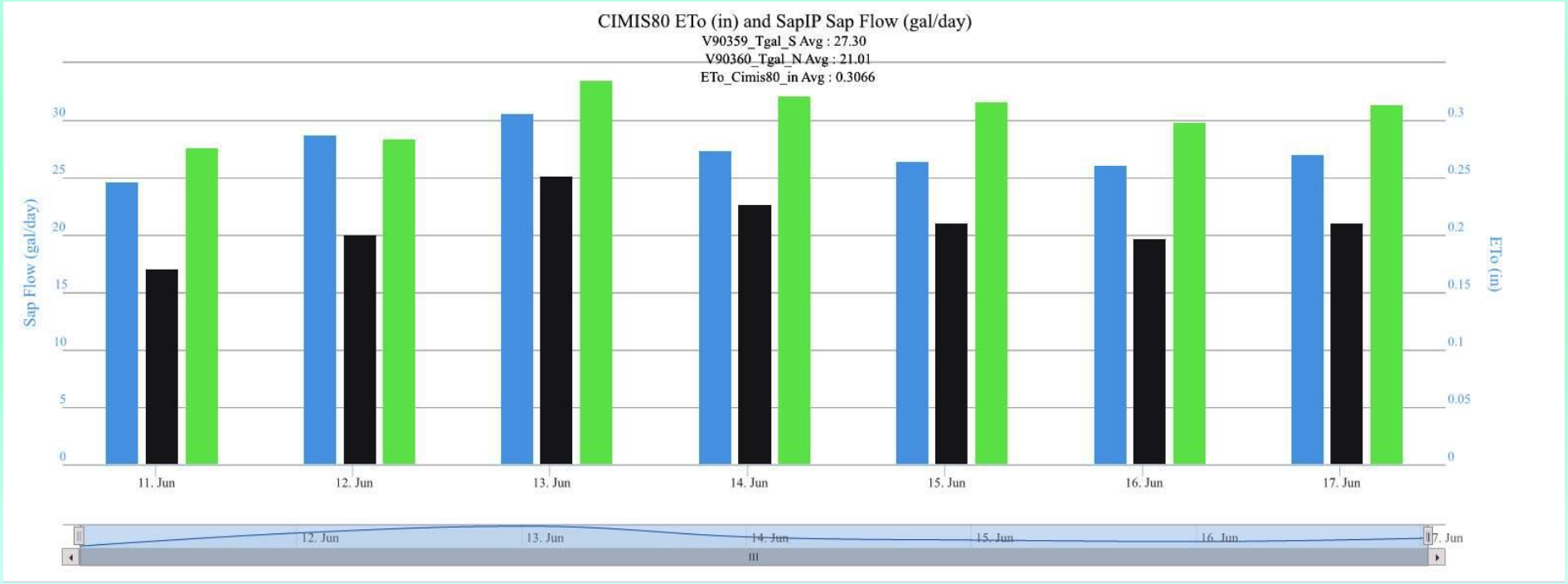
  +92% increase in W Murcott

  - "Winter" and water stressed trees are stressed trees;
  - Great difference with published data.
  - Ks = Stressed Trees , Kc = Non Stressed

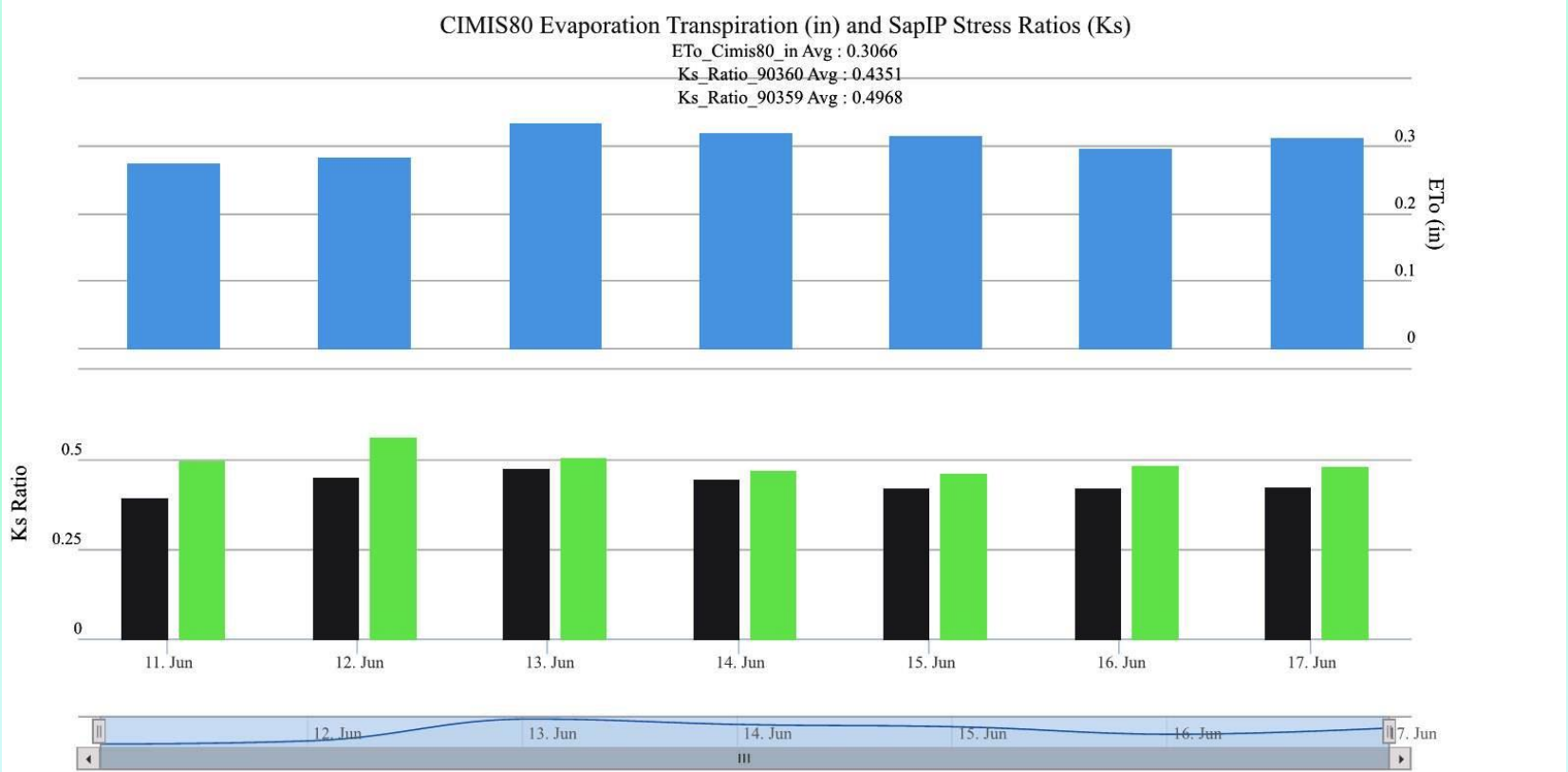
- Large Increase in Sap Flow
- Season and Growth progresses from May to June. New Leaves added.



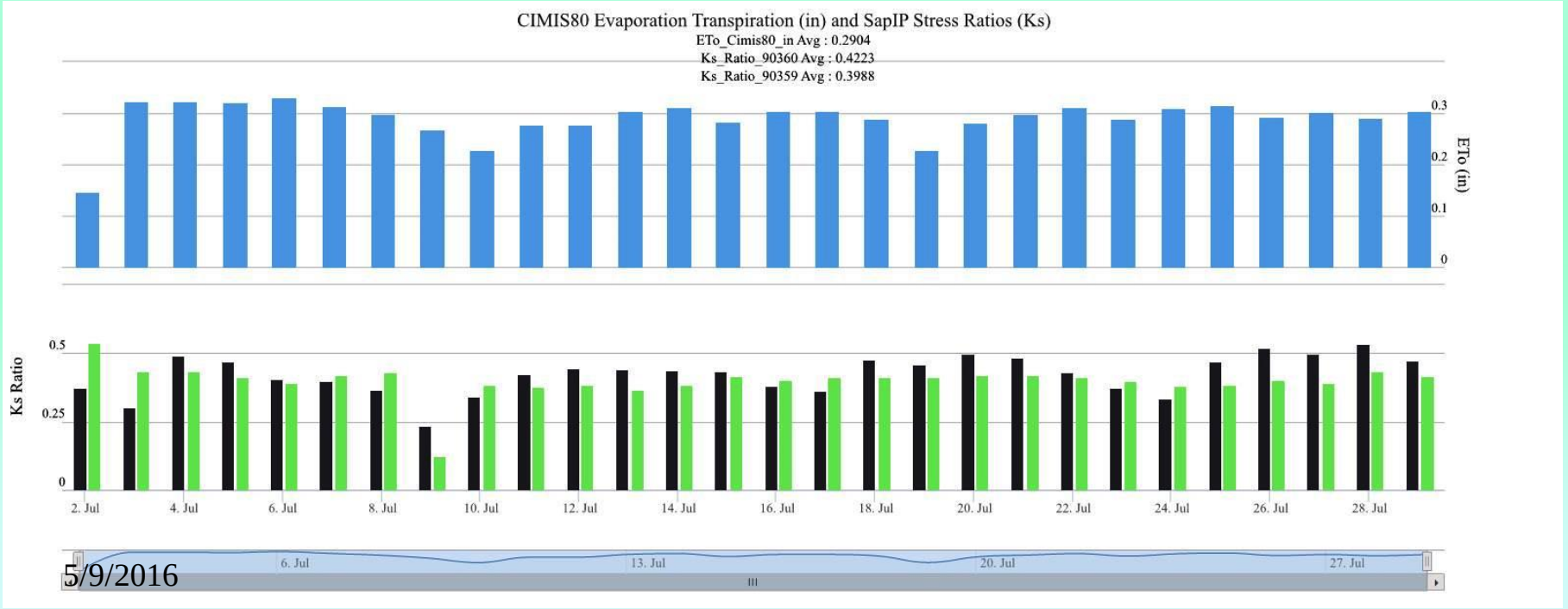
- 27 gal/d Satsuma, 21 gal/d W Murcott,
- ETo avg =.30 in



- Significant Difference – Kc (Well watered)
- Satsuma Kc=.50 Murcott Kc=.44



- By Management Practice the producer limited water application, each tree consumes 140 gal / week.
- Satsuma Ks=.40 Murcott Ks=.42



Water Management Deployment Objective
Is the commercial application upgraded?

- Preparing the monthly budget for the size, age, soil density.
- Practical textbook budget are not realistic, yet sap flow solves the issues.
- Potential water saving is 40-50%, then compare to the actual budget and make adjustments.
- Stress trees in controlled fashion when desired.
- Water budget for mandarins are like wine grapes – low water consumption! Not the normal feedback.

Thank You !

Data set and Consultation Provided by Bee Sweet Citrus Inc, Fowler CA