

Assessment of Orange Irrigation and Fertilization by Combining Grower Operational Records, Actual Evapotranspiration, Soil, and Plant Tissue Data

Background and Objectives

High-frequency, low-rate (HFLR) irrigation systems (i.e., drip and microspray) are increasingly common in California. They are often cited as a management practice to increase both water and nitrogen use efficiencies (WUE, NUE). However, system operation strongly influences WUE and NUE, so the potential benefits of widespread HFLR infrastructure can only be realized if the systems are operated in modes that allow the achievement of these goals.

Objective: Identify opportunities to improve production and environmental outcomes based on detailed operational, soils, and ET information for a 29-acre block of Atwoods.

Methods

- **Location:** medium-sized farm on the Kings River fan near Fresno, California, with 29 acres of Atwood oranges with significant north-south heterogeneity (Figure 1).
- Leaching assessed with site-specific ETa and soil sampling.
- Soil survey and operational information, were used to better understand site-specific performance and identify specific management shifts.
- 3 fields served by a single pump without isolation valving. Modified to facilitate isolated operation & to add flow meter.
- ETa (Paul et al, 2016) for the fields for a 7-year period, along with soil nitrate and salinity (ECe) profiles and leaf tissue N (both from 2017), provided multiple, independent indicators of management and outcomes.
- Grower evaluated production & environmental outcomes and increased irrigation & fertigation frequency while sharply reducing overall amounts.

Results

- Preliminary indicators only:
 - Maintained soil moisture in adequate range without triggering evident drought stress.
 - Field is producing more vigorous growth in better and poorer areas, tissue N sufficient.

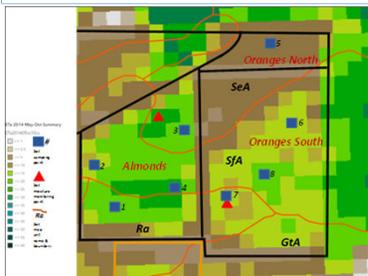


Figure 1. Paul et al. (2016) used a Surface Energy Balance Algorithm (SEBS) to estimate ETa from California's irrigated lands, and this map shows ETa from the 2014 season, with permanent soil sampling locations selected within the dominant soil mapping units.

Table 1. Soil analysis indicating downward nitrate and salinity mobilization in 2017.

Date	Nitrate (lb/a)		EC (dS/m)	
	Top ft	2-6 ft	Top ft	2-6 ft
Mar-17	66	301	1.2	0.8
Jun-18	23	58	0.6	0.5
Aug-18	27	63	0.7	0.5
Mar-18	50	154	0.5	0.5
Jul-18	41	68	0.5	0.5
Aug-18	38	73	0.7	0.7



Table 4. Effect of irrigation frequency on application depth. Note that 2.1 inches fills 75% of the profile's AWC in half the field.

Parameter	Units	2017	2018
Runs/week (April - Sept)	#	1.0	1.8
Max run time	h	48	15
Average run time	h	31	10
Upper estimate @ max run time	in	2.1	0.6
Lower estimate @ max run time	in	1.0	0.3
Upper estimate (April - Sept)	in	35	21
Lower estimate (April - Sept)	in	17	10

Figure 2. Grower with trees in strong southern, and poor, gravelly northern section of field. Note stunted tree in middle frame. All trees exhibit more new growth than previously during 2018.

Results (cont.)

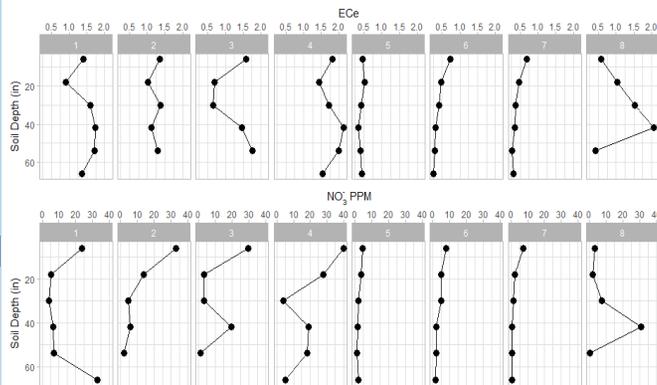


Figure 3. June soil EC_e and nitrate profiles from representative, permanent soil sampling locations.

Table 2. Field soil AWC.

Mapping Unit (NRCS)	AWC36 ^a		Area	
	(in)	(acres)	(% of field)	
Ra	4.9	3.2	11%	
Rc	5.2	3.2	11%	
SeA	3.0	0.1	0%	
SfA	5.3	9.1	31%	
GtA	2.8	13.5	46%	
Total		29.1		

^aAWC in the orange root zone, which is estimated to extend to about 36 inches depth.

Table 3. Running Atwoods and two other blocks together may drop pressures & application rates.

Parameter	Units	All 3 on	Almond	Atwood
Area	acres	68	18	28
Volume	a-f	2.83	0.64	0.92
Run time	h	21.5	8	7.5
Application rate (flow meter)	a-f/h	0.13	0.08	0.12
	in/h	0.02	0.05	0.05
Design rate	in/h	0.043	0.043	0.043
Ground measured rate	in/h		0.021	0.021

Yet to Come

- Analyze 2018 soil and plant tissue results relative to management shifts and production information.
- Evaluate production outcomes and identify needed adjustments.
- Investigate opportunities to independently operate the 3 fields depending on a single pump.
- Once long-term practices are identified, modify infrastructure to render them sustainable and replicable.

Table 5. Yield and N balance over time.

Season	Field yield (cartons/a)	CV Ave (cartons/a) ¹	N removed (lb/a) ²	N balance (lb/a) ³
15-16	1,089	762	64	
16-17	815	646	48	
17-18	657	618	39	70
18-19 ⁴	862	681	51	57

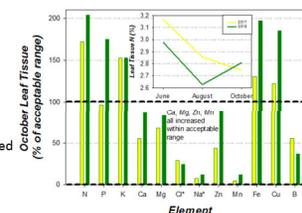
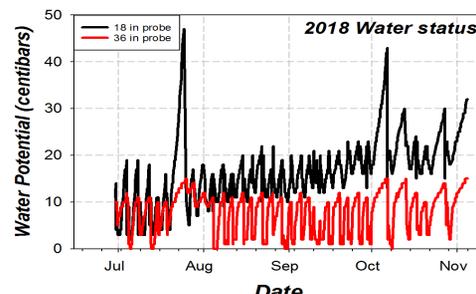
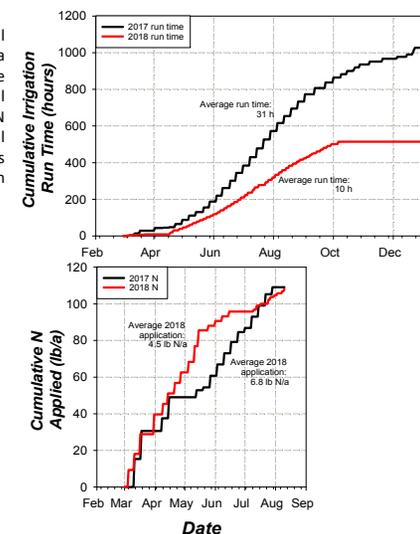
¹CDFA. 2018-19 California Navel Orange Objective Measurement Report.

²With coefficient from Geissler (2016)

³Difference between N applied and N removed in harvested fruit

⁴Field yield based on field history and projected CV average. Projected CV average based on CDFA estimated crop.

Figure 4. Operational records indicate a sharp shift to more frequent and overall reduced rates of N and water, yet soil moisture appears adequate and growth good.



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References

- Geissler, Daniel. 2016. Nitrogen Concentrations in Harvested Plant Parts – A Literature Overview. December 2.
 Paul, G., Schmid, B., Hawkins, T., Chong, C.S., Roberson, M., Williams, D., Smith, A. 2016. California Statewide Regional and field Scale Evapotranspiration Mapping Using MODIS & Landsat, and Surface Energy Balance System (SEBS). ASA-CSSA-SSA International Annual Meeting, November 6–9, 2016, Phoenix, AZ.

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- Kings River Watershed Coalition Authority
- Tule Basin Water Quality Coalition
- Westside Water Quality Coalition

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