Water Management Strategies for Efficient Use of Nitrogen in Organic Systems

University *of* California
Agriculture and Natural Resources

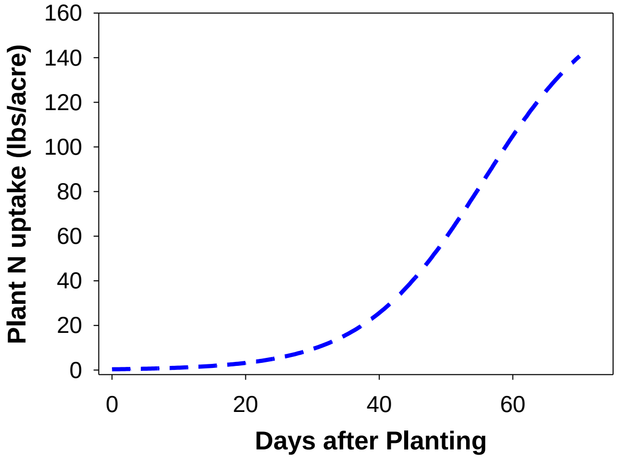
Michael Cahn Irrigation and Water Resources Advisor
UCCE Monterey, San Benito, and Santa Cruz Counties

Why is water management important for nitrogen management in organic systems?

- N mineralization rates depend on adequate soil moisture
- Water management affects crop growth and root development
- Irrigation water may contribute nitrogen to a crop
- Nitrate form of N is easily leached

Nitrogen budgeting

Crop Demand



N supply from all sources

Soil organic matter
Crop residues
Organic fertilizers and amendments
Irrigation water

But if you are not paying attention to water management you can throw N budgeting out the window:

Nitrate (NO_3^-) is easily leached

Water management strategies to optimize N use efficiency in organic systems

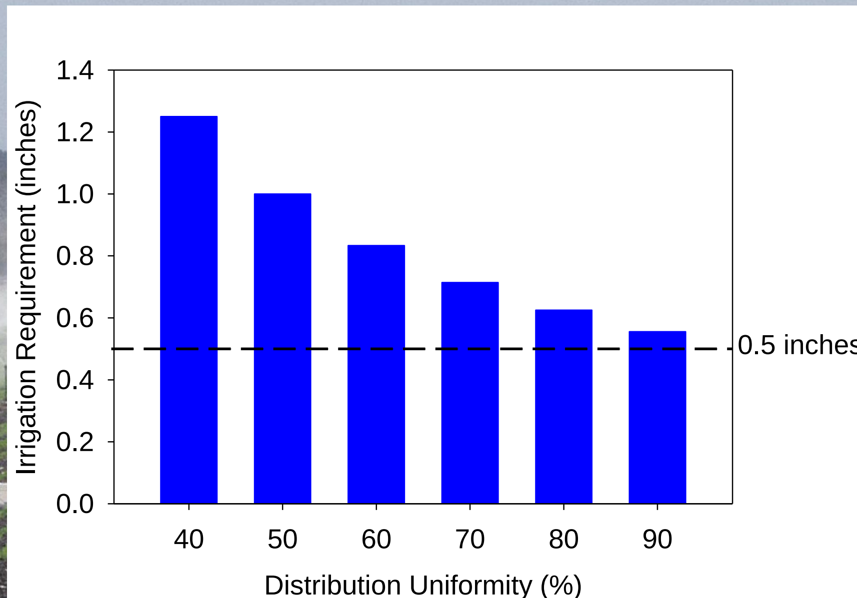
- Apply water uniformly
- Schedule irrigations to match crop water use
- Monitor soil nitrate levels
- Take credit for nitrate in irrigation water

Monitor soil nitrate levels of your fields

Salinas Valley Agriculture Blog: Details on the nitrate quick test

https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=4406

Distribution uniformity affects how much water is applied



Potential Distribution Uniformity

Drip: 85% to 90%

Sprinklers: 75% to 80%

Irrigation System Uniformity on the Central Coast (2009 -2016)

Irrigation method	# of fields	Distribution Uniformity: Mean	Distribution Uniformity: Maximum	Distribution Uniformity: Minimum
		----------------- % DU_{lq}		-------------
Drip	91	79	96	23
Sprinkler	18	71	86	52

Pressure is the key to drip irrigation

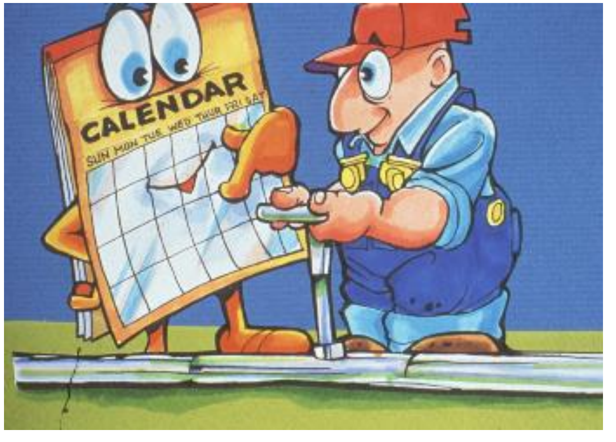
- ✓ **Right pressure**
- ✓ **Consistent pressure**

Pressure reducing valves/regulators can maintain a consistent pressure in drip systems

- ✓ Need to be selected for flow rate and pressure range of the drip system
- ✓ Need to be maintained
- ✓ Irrigators need training on using pressure regulators
- ✓ Prerequisite for accurate irrigation scheduling

Irrigation scheduling is…

1. **WHEN** to irrigate?
2. **HOW MUCH** to irrigate?



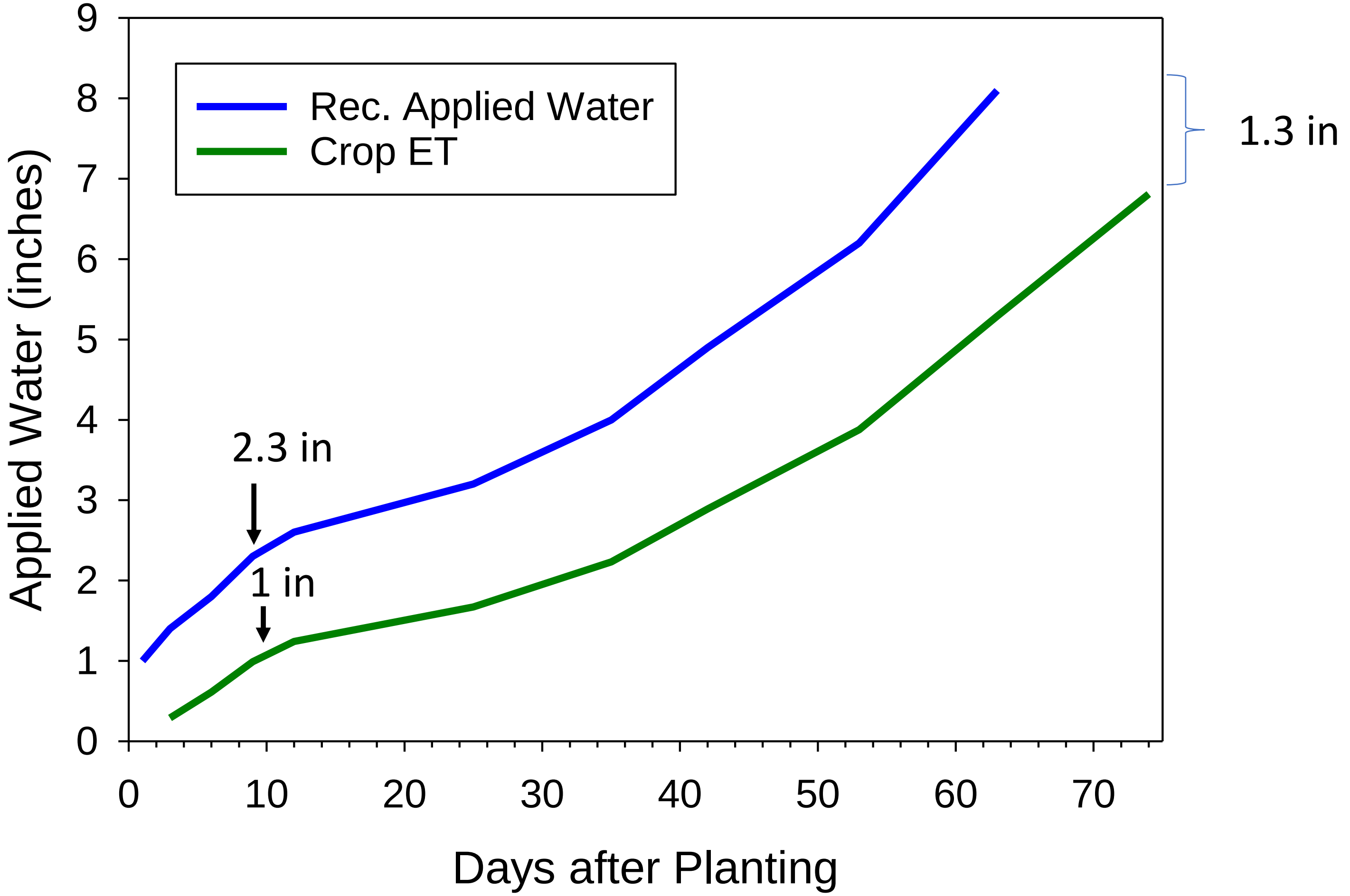
Approaches to Irrigation Scheduling

Weather-based

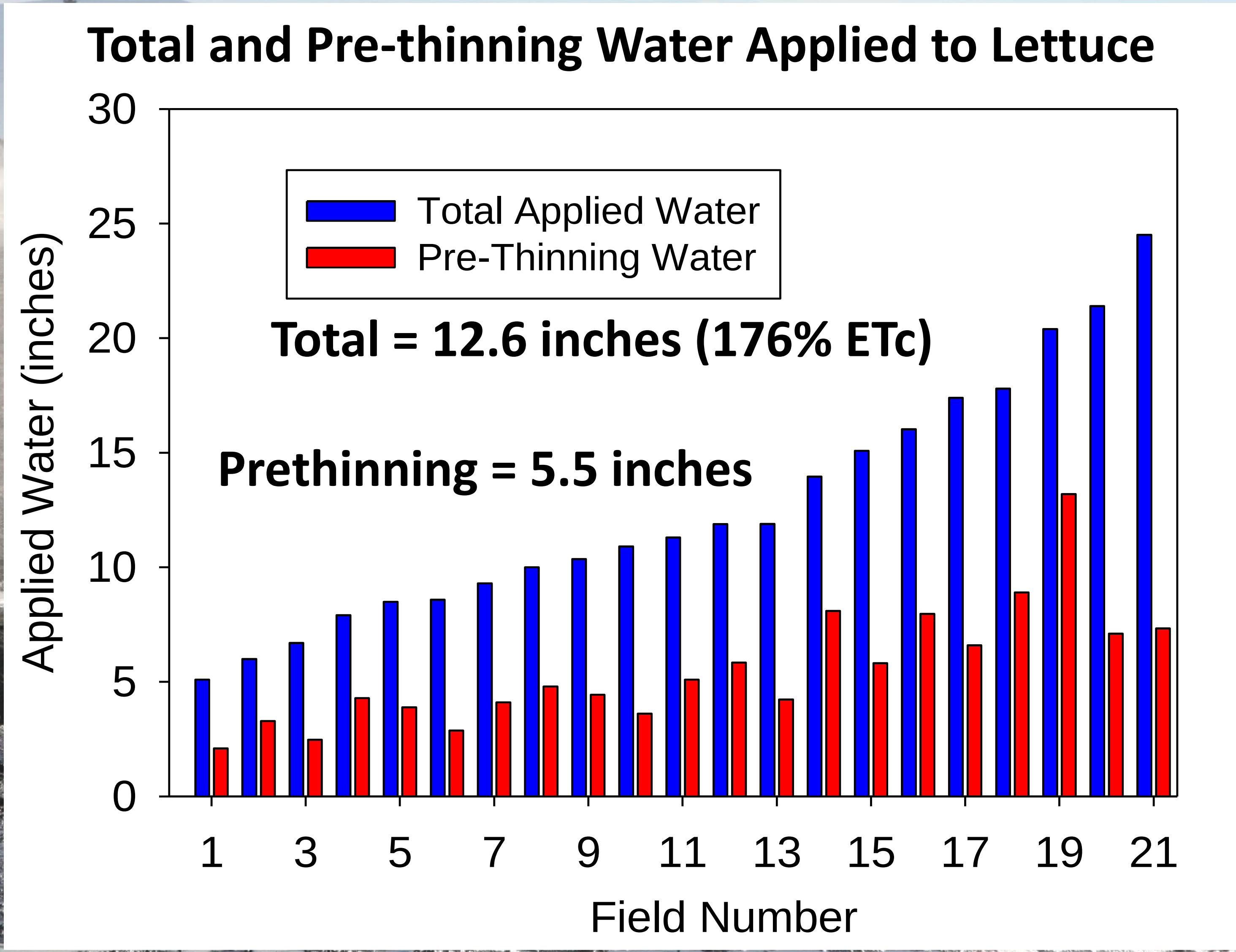
Plant-based

Soil-based

Accurate irrigation scheduling should match the crop water use pattern



Minimize water for stand establishment



The volume of water applied during a single irrigation can contribute to nitrate losses

Change in volumetric soil moisture after irrigating

	Soil water tension	
Soil texture	30 kPa	80 kPa
	inches/foot of soil depth	
Silty clay	0.4	0.6
Loam	0.5	0.7

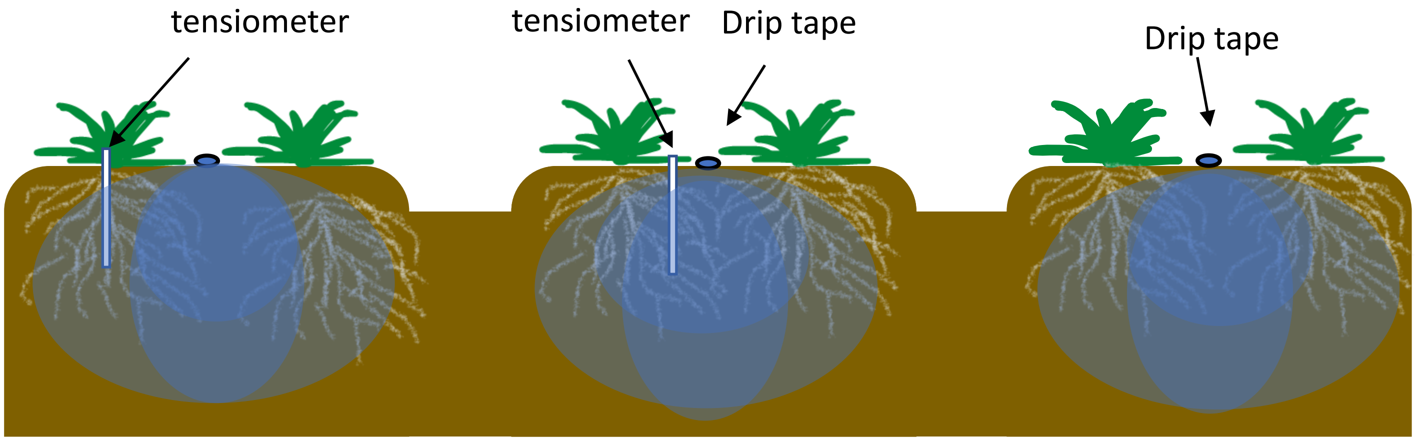
Soil Moisture Monitoring

Tension

Volumetric

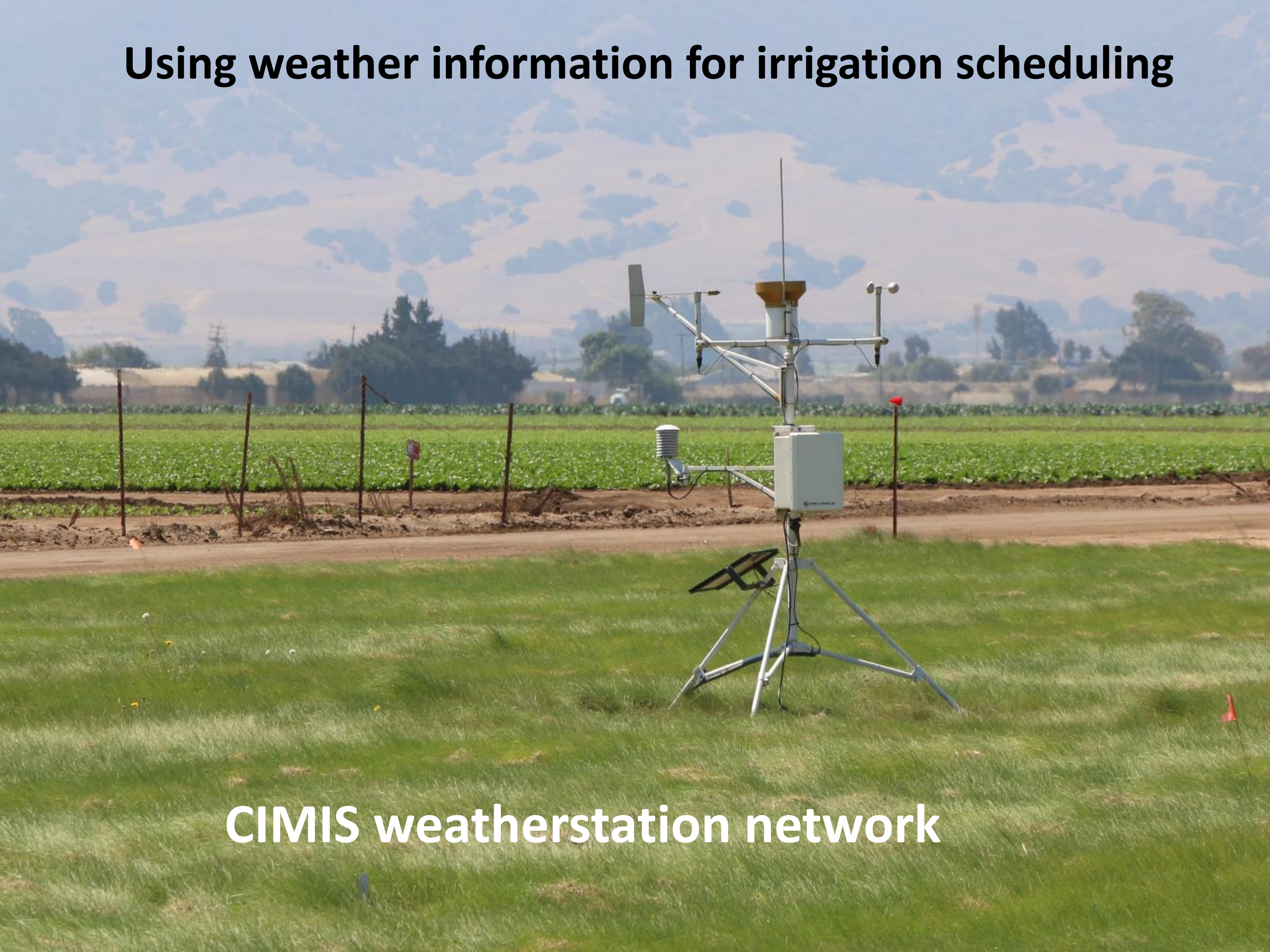
Soil moisture monitoring can be challenging with drip

Early in the crop cycle soil moisture is relatively uniform



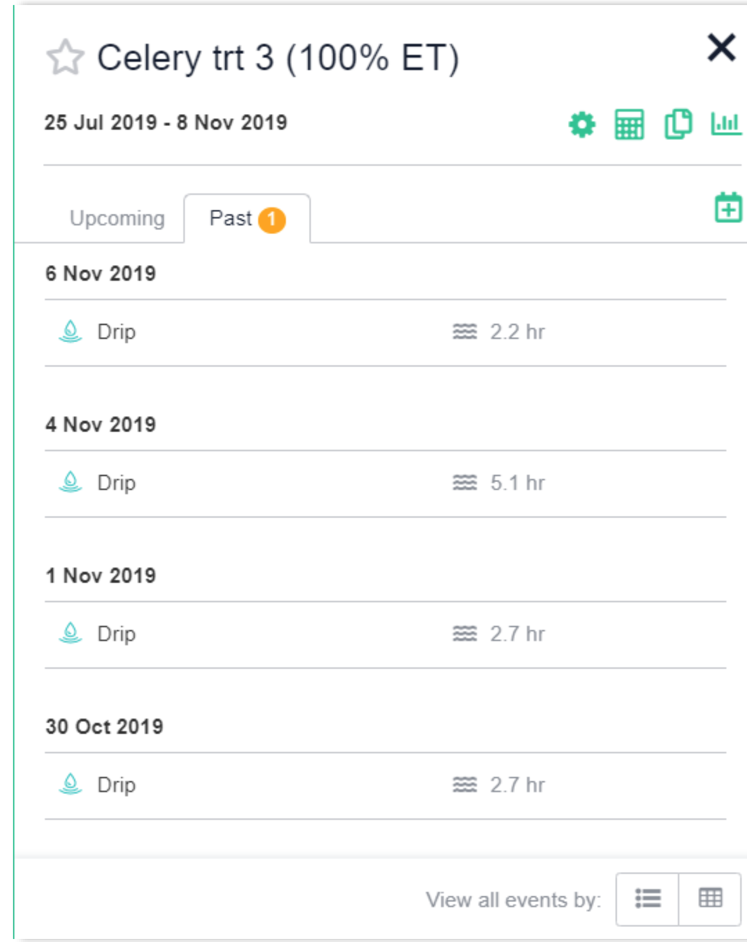
Later in the crop cycle soil moisture varies:

- Within the field
- Within the bed
- With time


Using weather information for irrigation scheduling
CIMIS weatherstation network

Online irrigation scheduling calculators can facilitate ET calculations

- Fresno State: Wateright
- UC Coop. Ext: CropManage
- WSU: Irrigation Scheduler Mobile
- OSU: Irrigation Management Online



cropmanage.ucanr.edu

Nitrogen is available in irrigation water

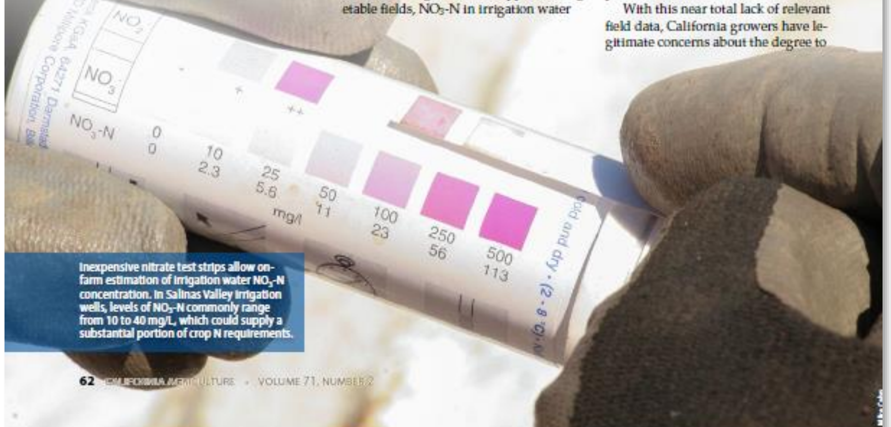
Well water
(2 to 70 ppm Nitrate-N)

Recycled water
(15 to 30 ppm N as Ammonium + Nitrate)

Replicated drip irrigation trials in lettuce (2013-2015)

Nitrogen in water affected both plant size and N content of tissue

California Agriculture



Research Article

Field trials show the fertilizer value of nitrogen in irrigation water

by Michael Cahn, Richard Smith, Laura Murphy *and* Tim Hartz

Increased regulatory activity designed to protect groundwater from degradation by nitrate-nitrogen (NO_3-N) is focusing attention on the efficiency of agricultural use of nitrogen (N). One area drawing scrutiny is the way in which growers consider the NO_3-N concentration of irrigation water when determining N fertilizer rates. Four drip-irrigated field studies were conducted in the Salinas Valley evaluating the impact of irrigation water NO_3-N concentration and irrigation efficiency on the N uptake efficiency of lettuce and broccoli crops. Irrigation with water NO_3-N concentrations from 2 to 45 milligrams per liter were compared with periodic fertigation of N fertilizer. The effect of irrigation efficiency was determined by comparing an efficient (110% to 120% of crop evapotranspiration, ET_c) and an inefficient (160% to 200% of ET_c) irrigation treatment. Across these trials, NO_3-N from irrigation water was at least as efficiently used as fertilizer N; the uptake efficiency of irrigation water NO_3-N averaged approximately 80%, and it was not affected by NO_3-N concentration or irrigation efficiency.

California agriculture faces increasing regulatory pressure to improve nitrogen (N) management to protect groundwater quality. Groundwater in agricultural regions, such as the Salinas Valley and the Tulare Lake Basin, has been adversely impacted by agricultural practices, with nitrate-N (NO_3-N) in many wells exceeding the federal drinking water standard of 10 mg/L (Harter et al. 2012). The threat to groundwater is particularly acute in the Salinas Valley, where the intensive production of vegetable crops has resulted in an estimated net loading (fertilizer N application – N removal with crop harvest) of > 100 lb/ac (> 112 kg/ha) of N annually (Rosenstock et al. 2014).

Levels of NO_3-N in irrigation wells in the Salinas Valley commonly range from 10 to 40 mg/L. Given the typical volume of irrigation water applied to vegetable fields, NO_3-N in irrigation water could represent a substantial fraction of crop N requirements, provided that crops can efficiently use this N source. Indeed, the concept of "pump and fertilize" (substituting irrigation water NO_3-N for fertilizer N) has been suggested as a remediation technique to improve groundwater quality in agricultural regions (Harter et al. 2012).

Cooperative Extension publications from around the country (Bauder et al. 2011; DeLaune and Trostle 2012; Hopkins et al. 2007) agree that the fertilizer value of irrigation water NO_3-N can be significant, but they differ as to what fraction of water NO_3-N should be credited against the fertilizer N recommendation. There is a paucity of field data documenting the efficiency of crop utilization of irrigation water N. Francis and Schepers (1994) documented that corn could use irrigation water NO_3-N, but in their study N uptake efficiency from irrigation water was low, which they attributed to the timing of irrigation relative to crop N demand and the availability of N from other sources. Martin et al. (1982) suggested that uptake efficiency of irrigation water NO_3-N could actually be higher than from fertilizer N, but their conclusion was based on a computer simulation, not on field trials.

With this near total lack of relevant field data, California growers have legitimate concerns about the degree to

Online: https://doi.org/10.3733/ca.2017a0010

Inexpensive nitrate test strips allow on-farm estimation of irrigation water NO_3-N concentration. In Salinas Valley irrigation wells, levels of NO_3-N commonly range from 10 to 40 mg/L, which could supply a substantial portion of crop N requirements.

http://calag.ucanr.edu • APRIL–JUNE 2017

Calculating N applied from irrigation water:

Applied water (inches) x NO_3-N conc. (ppm) x 0.23

= lbs N/acre

Example:

- ✓ **Applied water = 2 inches**
- ✓ **Nitrate-N concentration = 30 ppm**

2 inches x 30 ppm NO_3-N x 0.23

= <u>13.8 lbs N/acre</u>

Potential N contribution from irrigation water

Nitrate-N concentration of irrigation water	N applied in irrigation water
ppm	lbs N/acre-ft of water
5	14
10	28
15	41
20	55
25	69
30	83
35	97
40	110
45	124
50	138
55	152
60	166

Practical challenges to crediting for N in water

- ✓ Multiple wells often used to irrigate a crop
- ✓ Nitrate concentration in some wells changes during the season
- ✓ Need to know how much water is being applied

Should growers credit N in water applied during pre-irrigation and germination?

- **Applied water >> Crop Evapotranspiration**
- **Crop N uptake is minimal between germination and the first fertilization**

Practical considerations to crediting for N in water

- ✓ At a minimum use the estimated crop ET volume to credit N in the irrigation water
- ✓ May not see an effect of high nitrate water on soil nitrate levels
- ✓ Crop water and N demand are in sync

Evaluating the nitrate content of blended water

1. **Collect water from irrigation system using a drip emitter and bucket**
2. **Use quick nitrate test strips to evaluate concentration of nitrate in irrigation water sample**

Crediting for N in water and soil

Soil Nitrate

Current N status of Soil

+

N in water

Future N contribution

2016-2018 Field Trials

Strip Trial Treatments

1. Grower Practice
2. Best Management Practice (BMP)
3. Intermediate Practice

Residual Soil N and Water N

Trial #	Soil NO_3-N*	Water NO_3-N	Drip applied water	Applied N in Water	Water Salinity
	ppm		inches	lbs N /acre	dS/m
		--------------- 2016 -------------------------			
Trial 1	8	32	5.0	36	0.8
Trial 2	29	84	5.3	101	1.2
		--------------- 2017 -------------------------			
Trial 3	7	26	4.4	26	1.1
Trial 4	35	80	5.0	89	1.4
Trial 5	20	42	6.8	65	1.8

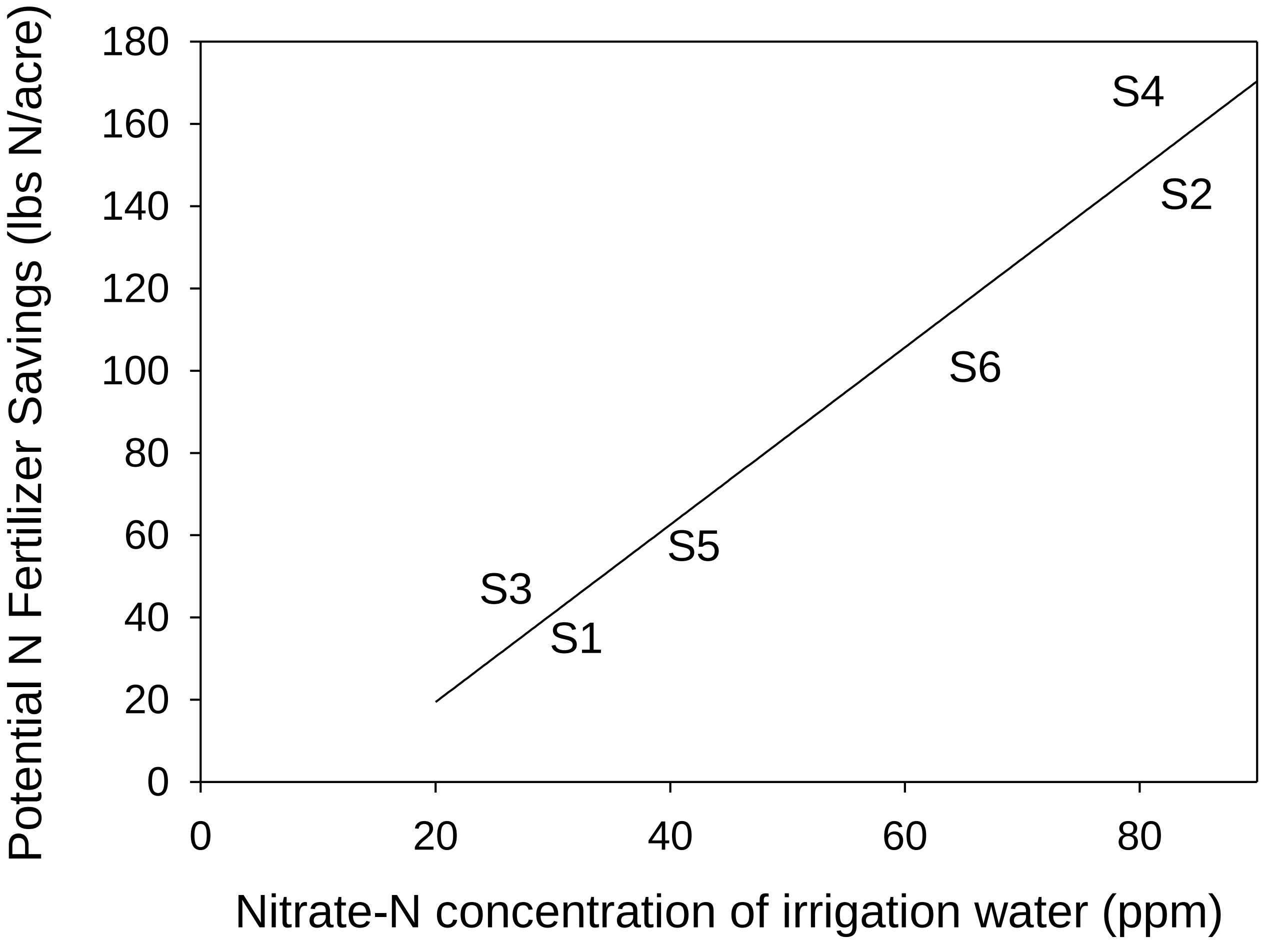
* 1 ft depth at thinning

Commercial Yield Evaluation

Marketable Yield (Strip Plots)

	Marketable Yield relative to Standard		
	Grower	BMP	Intermediate
	lbs/acre	------------ %	-----------
	--------------	2016	----------------
Trial 1	53573	2	--
Trial 2	42387	-1	--
	-------------	2017	----------------
Trial 3	36832	10	4
Trial 4	41526	8	17
Trial 5	22511	21	16
Average	33623	8	12

How much fertilizer* could potentially be saved by crediting N in water?



*based on average fertilizer rate of 175 lb N/acre for lettuce

Water Management Strategies for Efficient Use of Nitrogen in Organic Systems

- **Assure that the irrigation system has a high application (distribution) uniformity**
- **Match irrigation schedule with crop water requirement**
- **Minimize irrigation water for stand establishment (less water per irrigation)**
- **Avoid exceeding the water holding capacity of the soil when irrigating**
- **Credit nitrogen in irrigation water**