Water Management Strategies for Efficient Use of Nitrogen in Organic Systems

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Some challenges with supplying N in organic systems

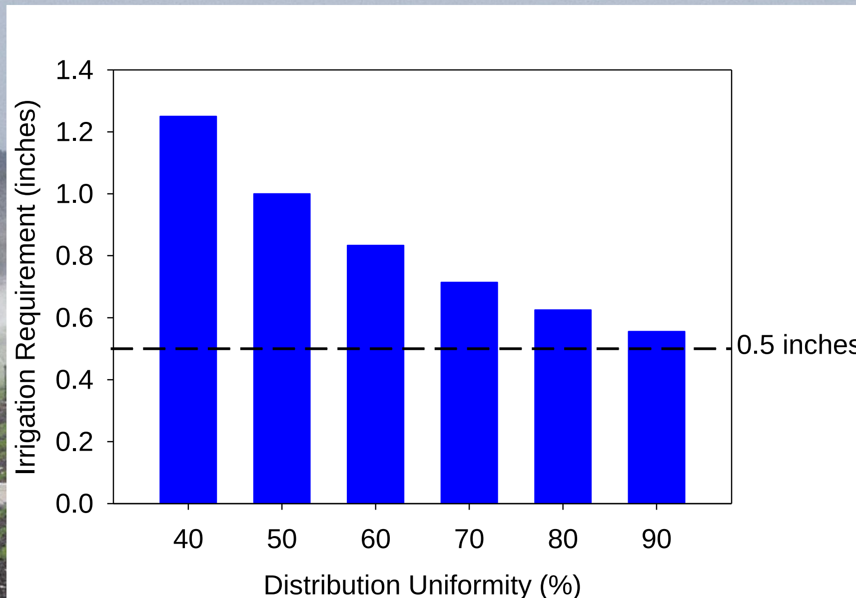
- Organic fertilizers are expensive
- Reliance on dry fertilizers (vegetables)
- Mineralization required for organic sources of nitrogen


Water Quality Challenges in Organic Systems

Water management strategies to optimize N use efficiency in organic systems

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

How uniformly is water applied?

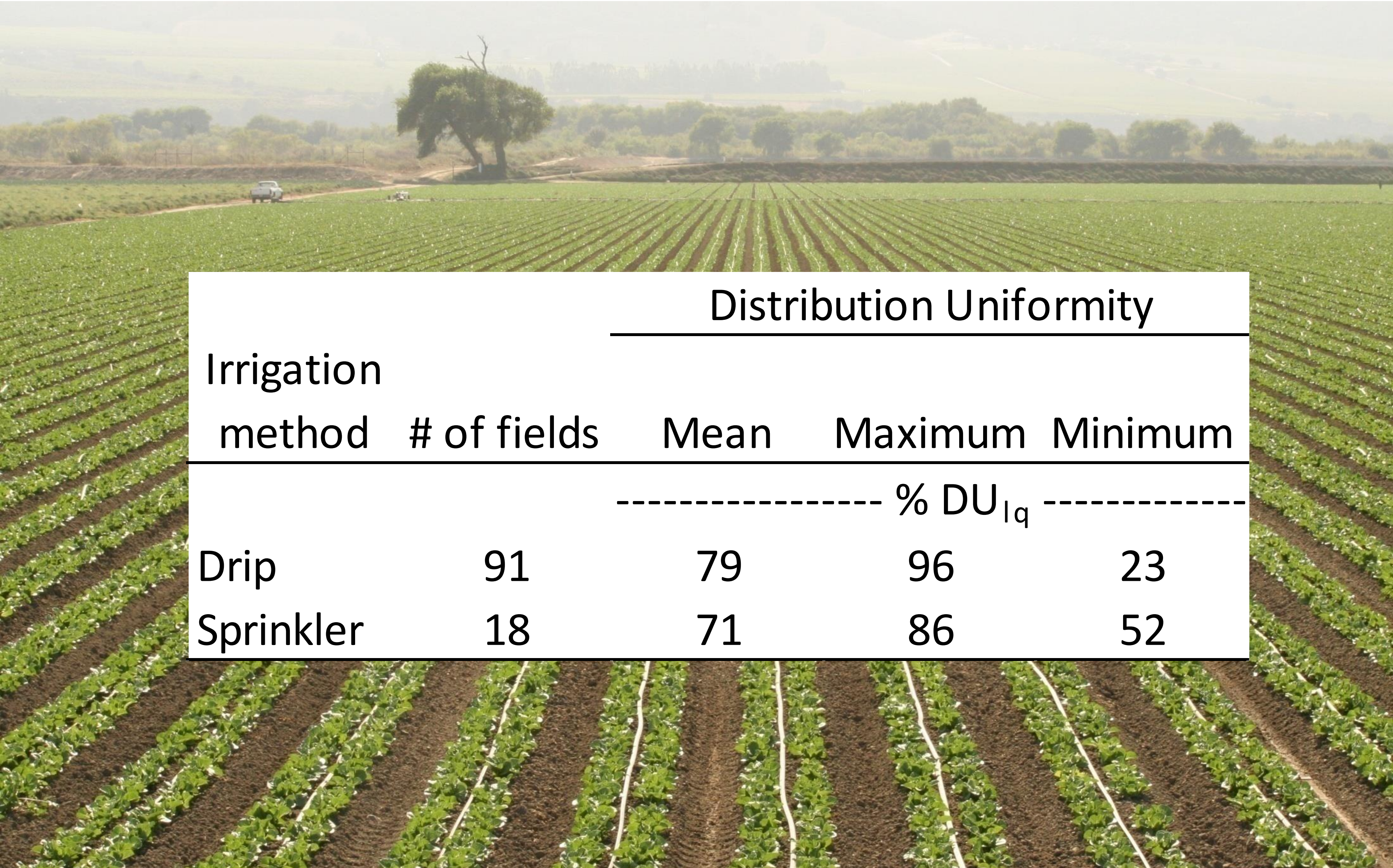


Potential Distribution Uniformity

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

Uniform pressure is the key to drip

Pressure reducing valves can help maintain optimal pressure in drip

Achieving uniform distribution on slopes is challenging

Drip requires constant maintenance

Optimizing Sprinkler Uniformity

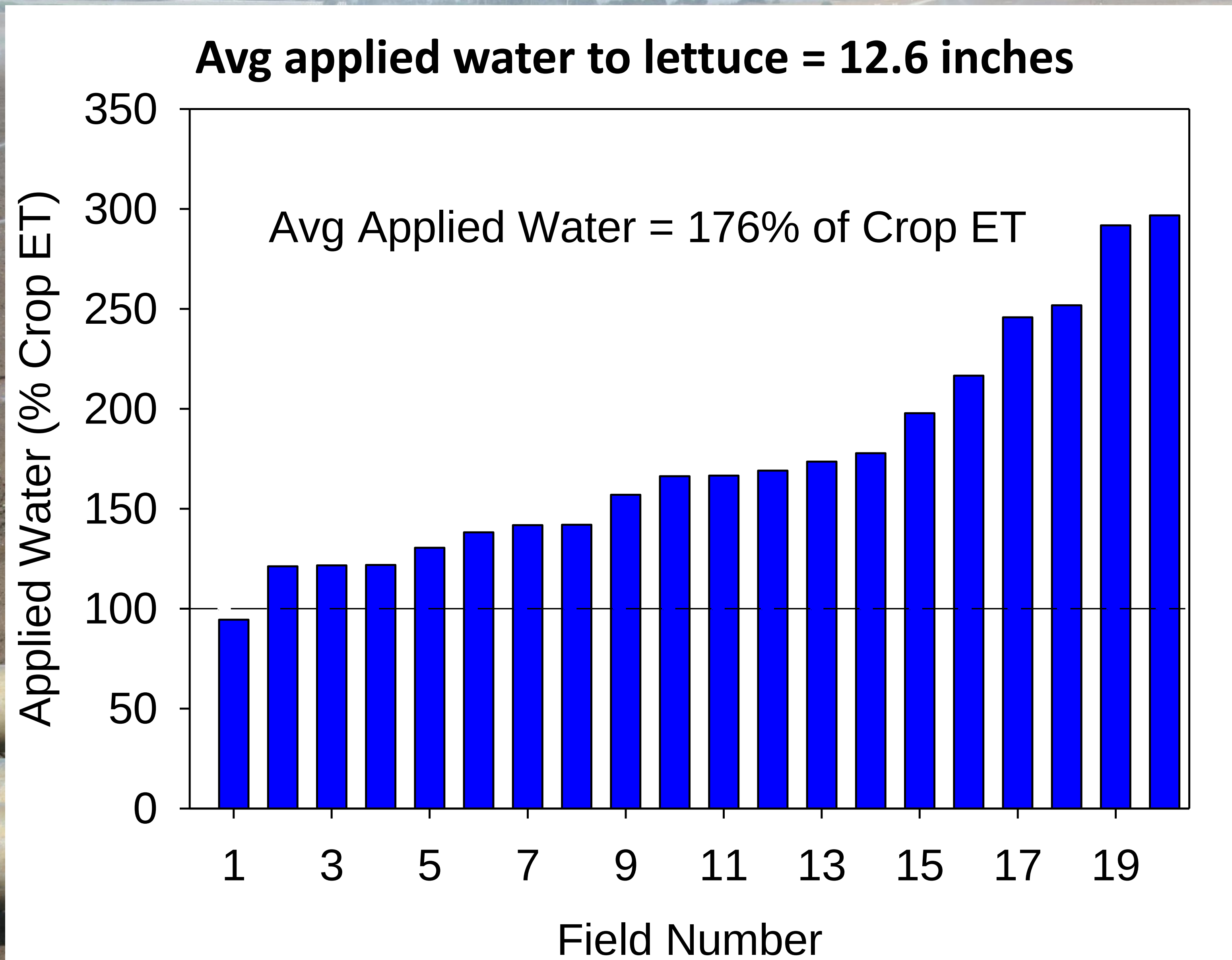
Optimizing Sprinkler Uniformity

- Nozzle sizes (mixed, worn)
- Wind (> 5 mph)
- Pressure management
- Lateral spacing

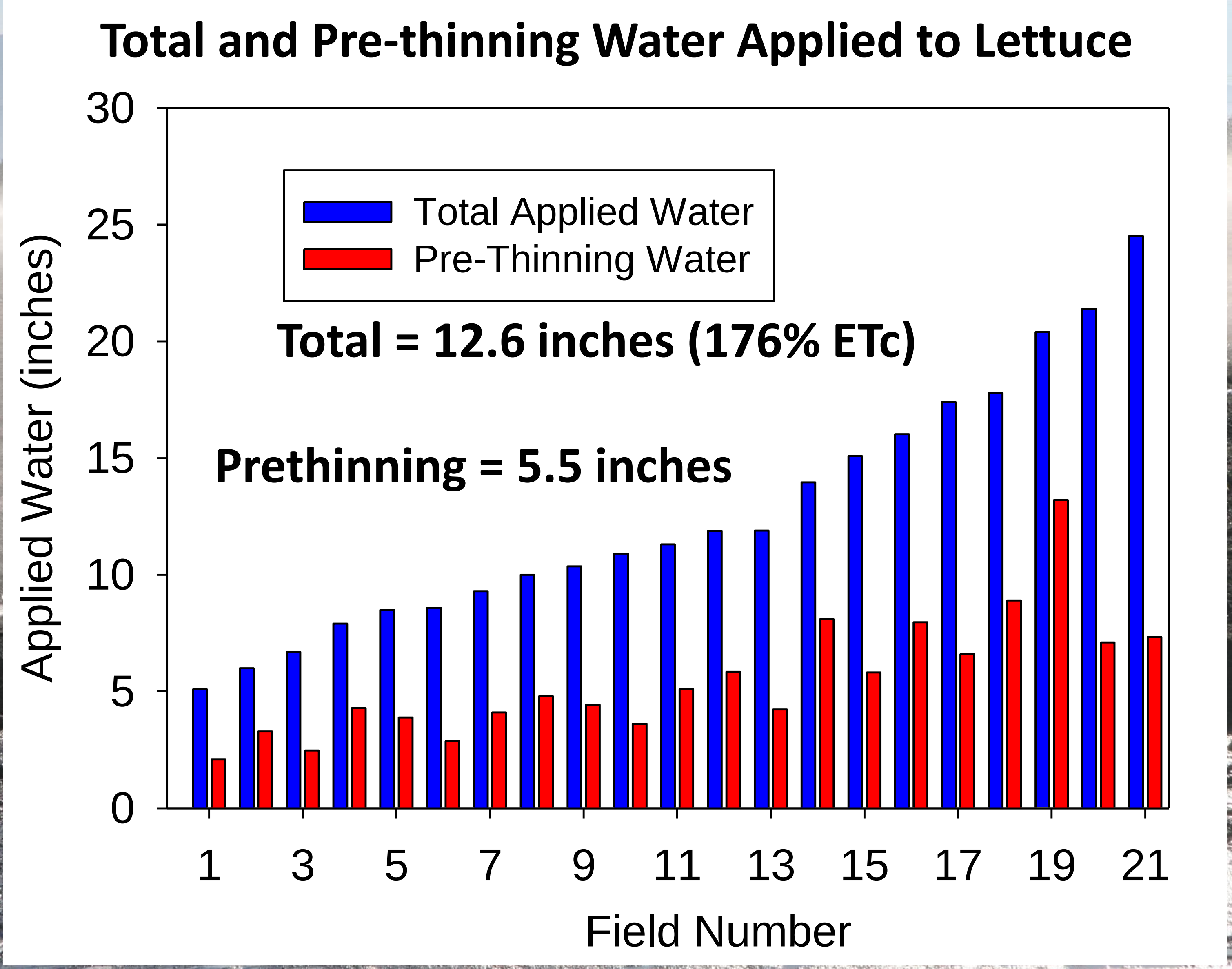
Permanent sprinkler lines for leafy greens

Trained staff is critical for good irrigation management

How much water did you apply?



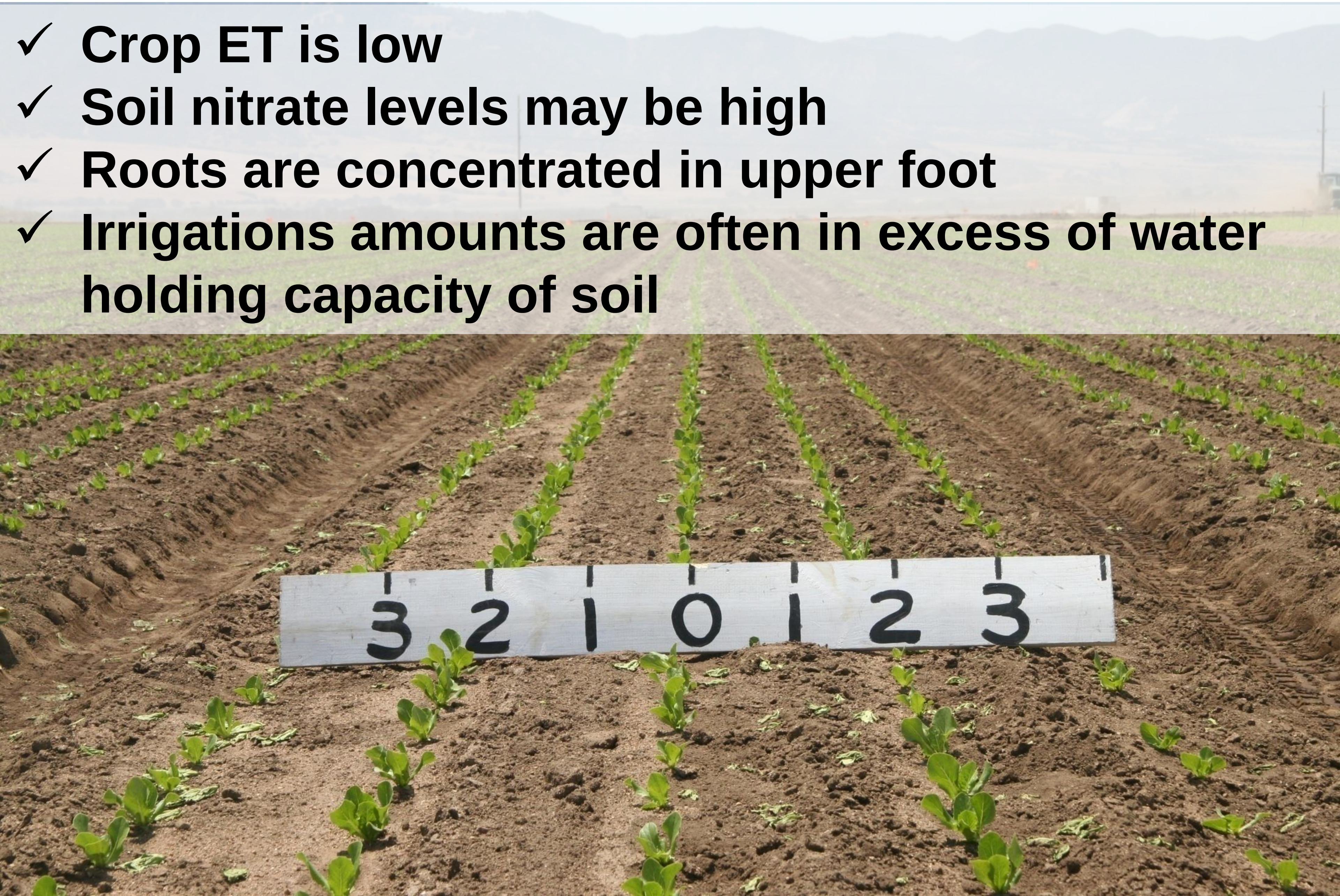
Reducing water for stand establishment



Potential to leach significant amounts of N

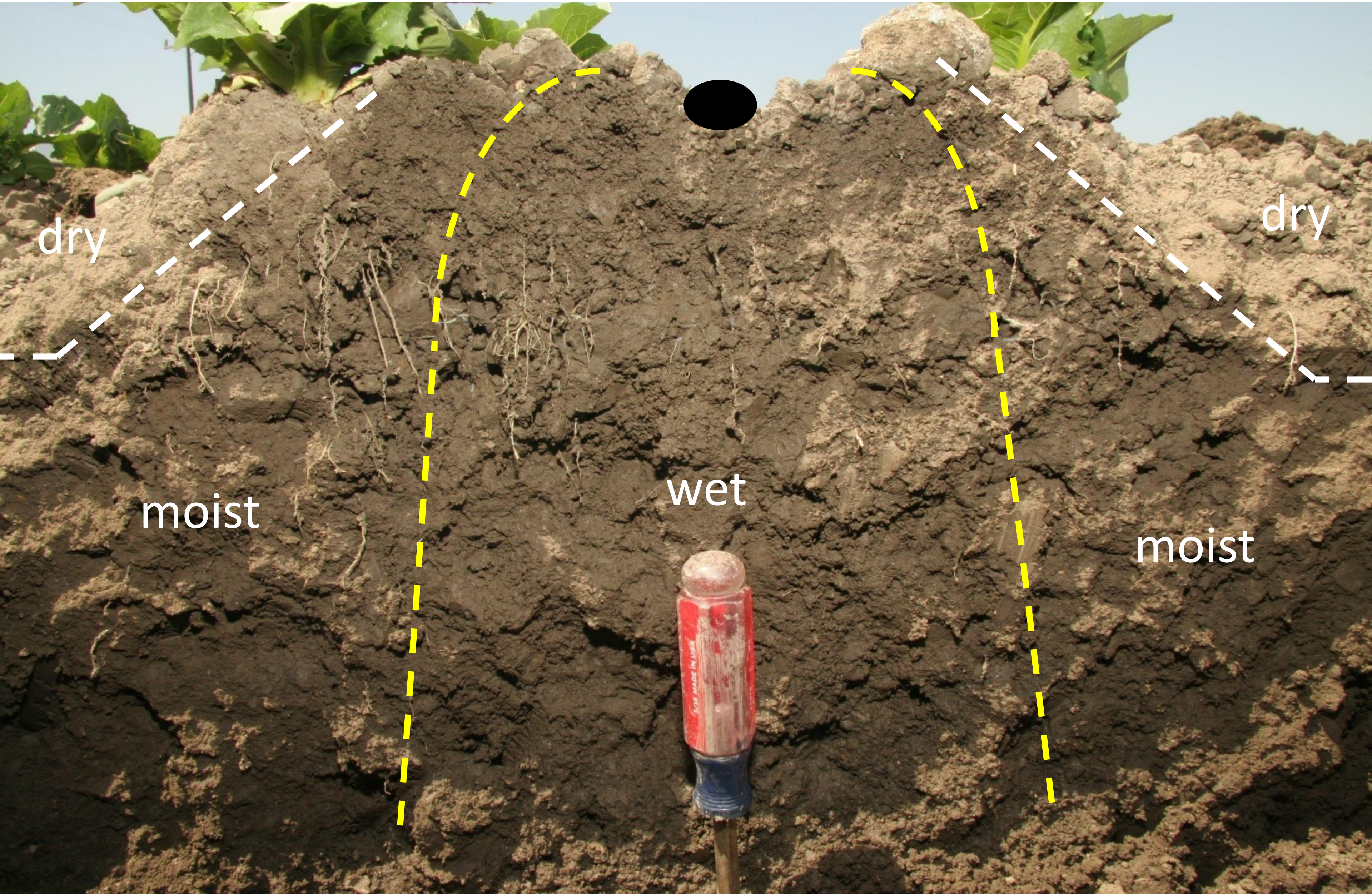
Avoid exceeding water holding capacity of soil

- ✓ Crop ET is low
- ✓ Soil nitrate levels may be high
- ✓ Roots are concentrated in upper foot
- ✓ Irrigations amounts are often in excess of water holding capacity of soil



Lateral movement of moisture is a frequent concern

Moisture often spreads laterally below the soil surface

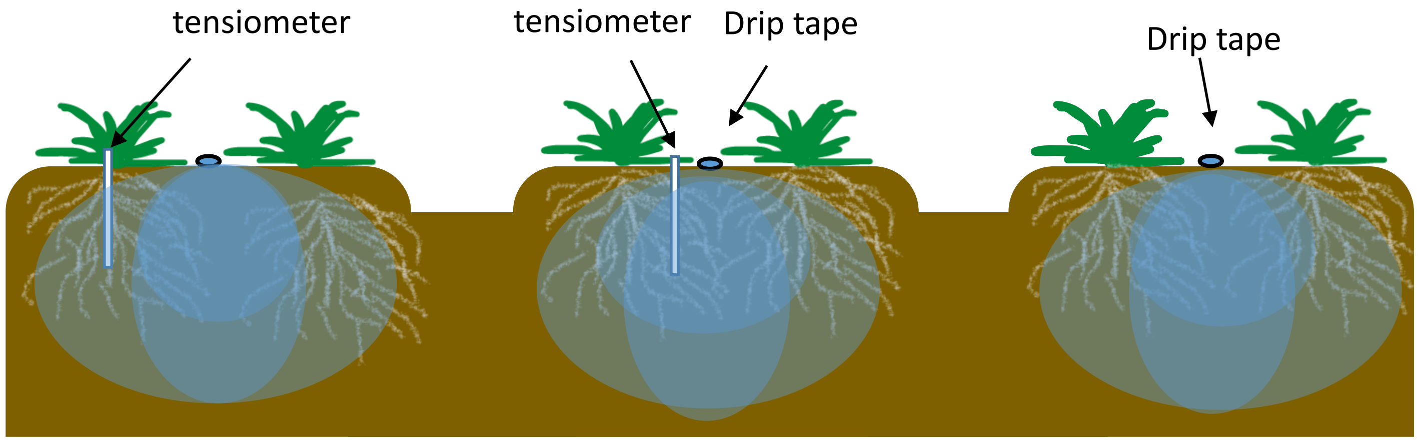


Soil Moisture Monitoring

Tension

Volumetric

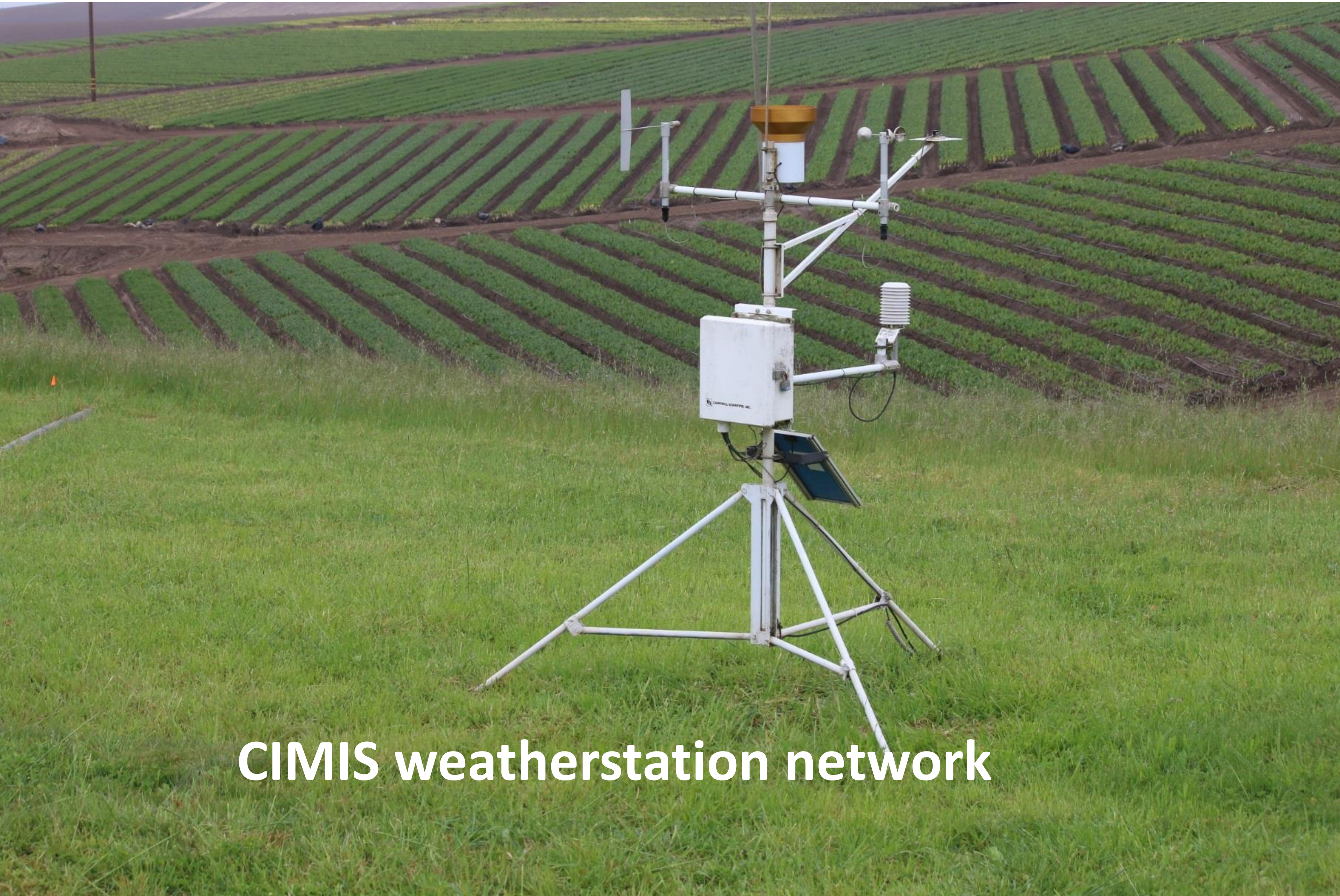
Soil moisture monitoring can be challenging with drip



Soil moisture varies:

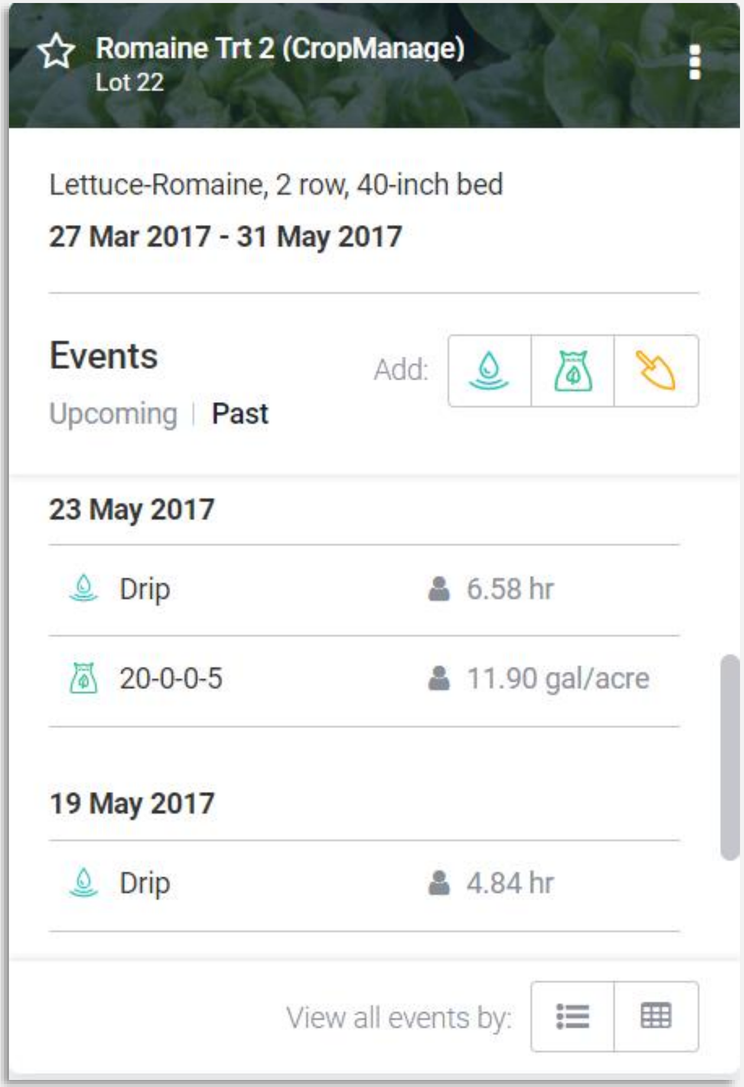
- Within the field
- Within the bed
- With time

Improving irrigation scheduling using weather information



Online irrigation scheduling calculators can facilitate ET calculations

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



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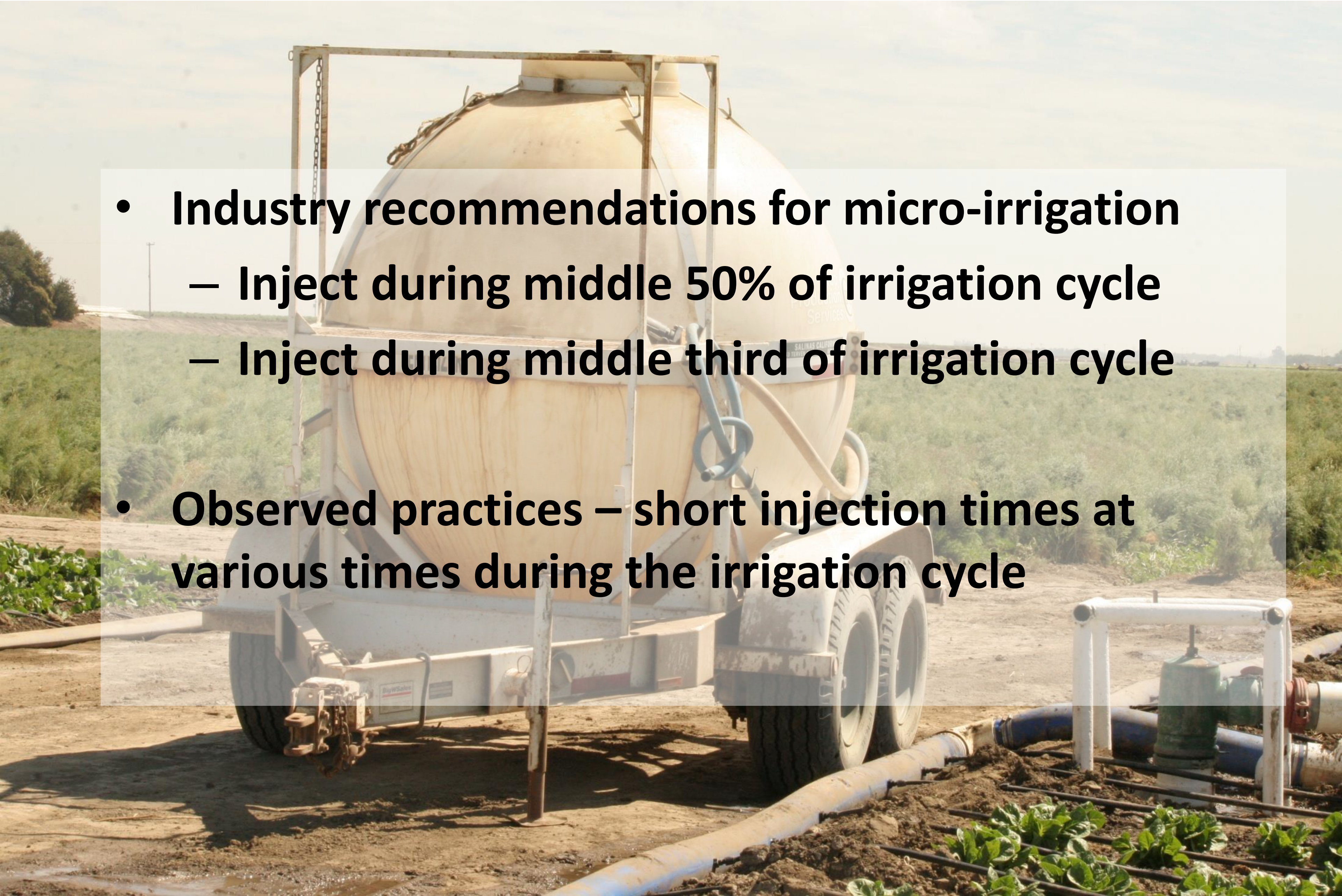
Fertigation Practices for Micro-Irrigation



- **Industry recommendations for micro-irrigation**
  - **Inject during middle 50% of irrigation cycle**
  - **Inject during middle third of irrigation cycle**
- **Observed practices – short injection times at various times during the irrigation cycle**

How uniform are fertigation applications?

Distribution Uniformity of Water and Fertilizer

Field #	Lettuce Type	Bed width	Irrigation DU[1]	Fertilizer Uniformity	Pressure Uniformity
		inches	--------------	%	--------------
1	Romaine	40	58	54	82
2	Romaine	80	75	82	87
3	Romaine	80	81	73	62
4	Iceberg	40	80	75	89
5	Romaine	40	83	74	91
6	Romaine	80	46	66	79
7	Romaine	80	86	78	77
8	Iceberg	40	88	46	89
9	Romaine	80	38	32	43
10	Iceberg	80	81	80	86
11	Romaine	40	87	74	99
Average			73	67	80

1. Distribution Uniformity of the lowest quarter

Rules of thumb for fertigation

1. Inject before a filter
2. Begin injecting fertilizer after system fully pressurizes and leaks are fixed
3. Assure that fertilizer complete mixes before branches in the irrigation system
4. Inject as slowly as possible
5. Irrigate a sufficient time for all of the fertilizer to completely flushed out

Salinity Management

How much leaching for salinity management?

- Credit winter rains, pre-irrigation and germination water
- Use an appropriate leaching fraction (Leach Fraction > 30%, ECwater = ECsoil)
- Irrigating more frequently (with drip) can offset some of the salinity effects on growth
- Do not apply N fertilizer before leaching events

More info: Leaching for salt management
http://anrcatalog.ucanr.edu/pdf/8550.pdf

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)

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>

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 estimate how much water will be applied between fertilizer events
- ✓ Many plantings to manage simultaneously in most mid to large scale vegetable operations

Crediting for N in water and soil

Soil Nitrate

\+

N in water

Current N status of Soil

Future N contribution

20 ppm = 70 to 80 lbs N/acre

2016-2018 Field Trials

Objective: Evaluate the fertilizer value of N in irrigation water in commercial lettuce fields

- **Drip irrigated iceberg and romaine lettuce**
- **Conducted at sites with high nitrate well water.**
- **Mineral N in soil and salinity and nitrate concentration of irrigation water varied among sites.**

Manifold for Irrigation Treatments

Strip Trial Treatments (2016 - 2018)

1. Grower Practice
2. Best Management Practice (BMP)
3. Intermediate (2017, 2018)

Replicated Trial Treatments (2017, 2018)

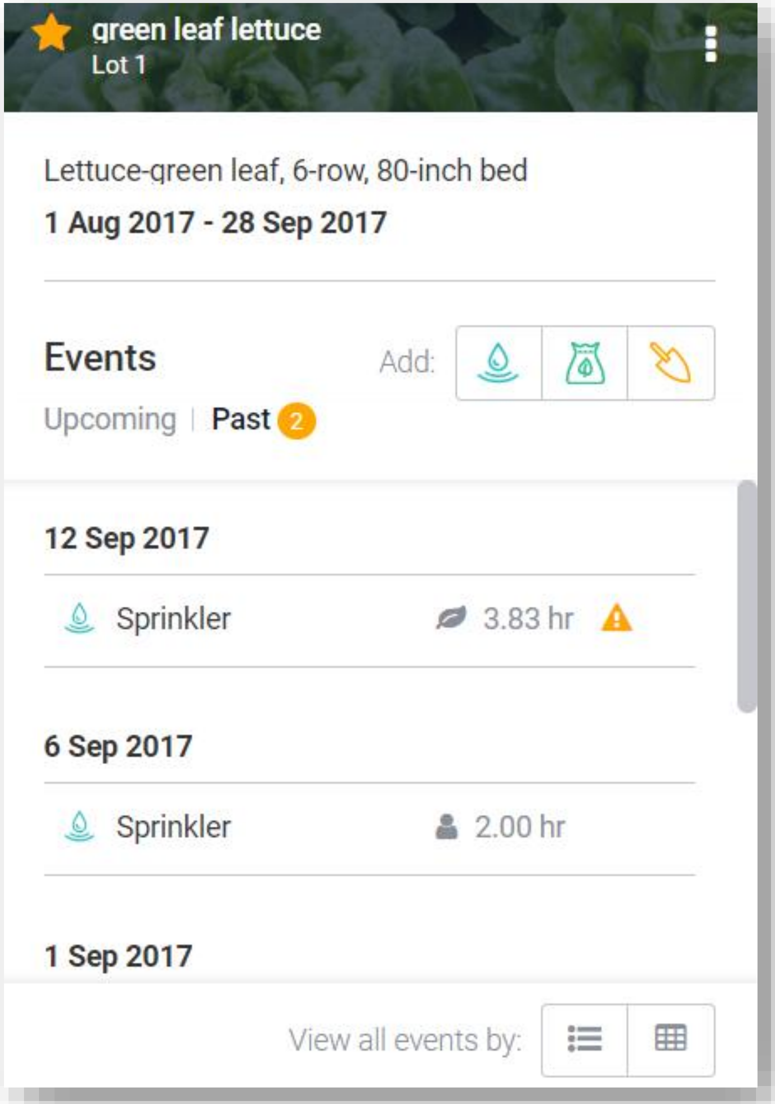
1. Grower Practice
2. Best Management Practice (BMP)
3. BMP-Low

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

CropManage was used to guide BMP treatments



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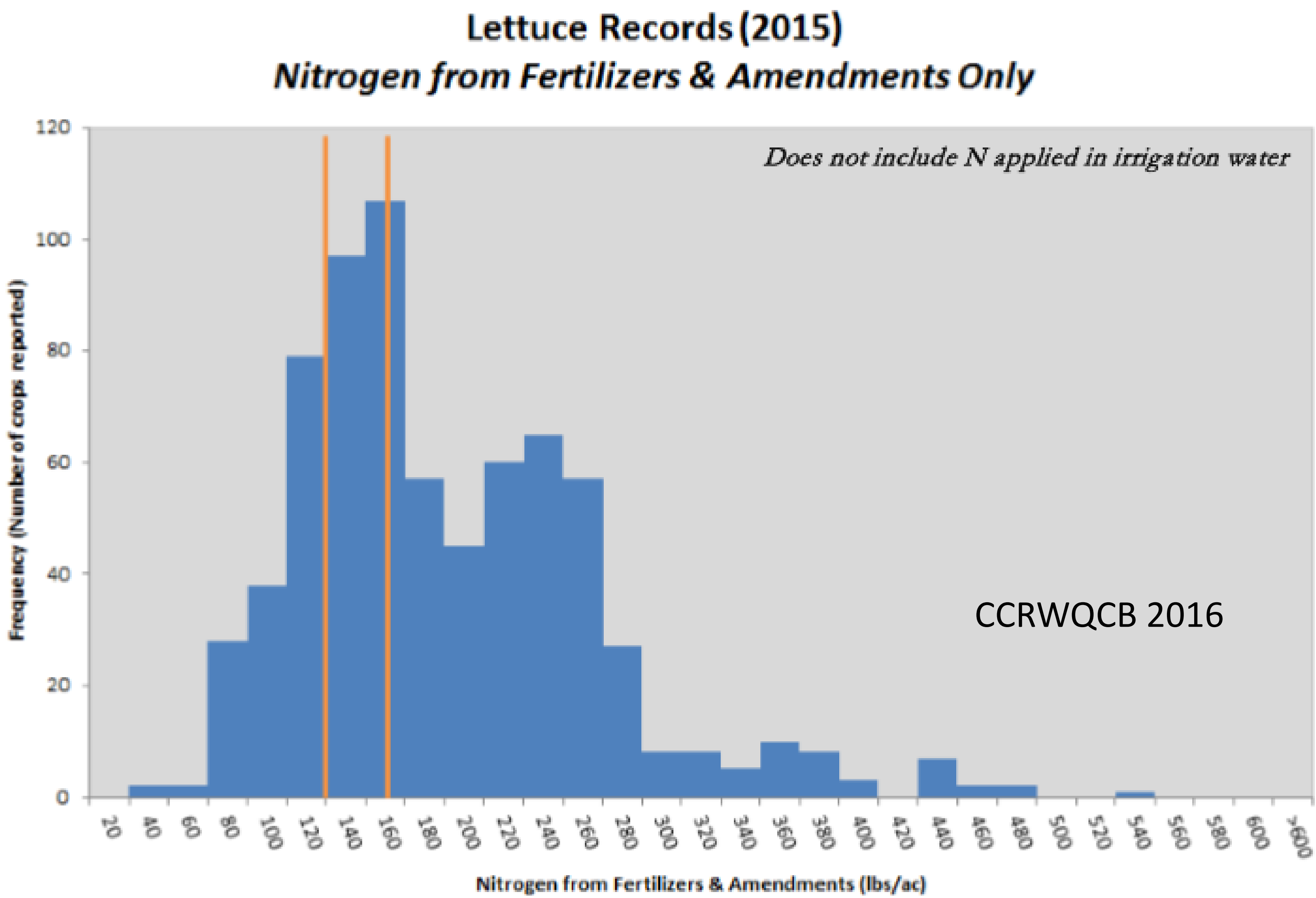
Commercial Yield Evaluation

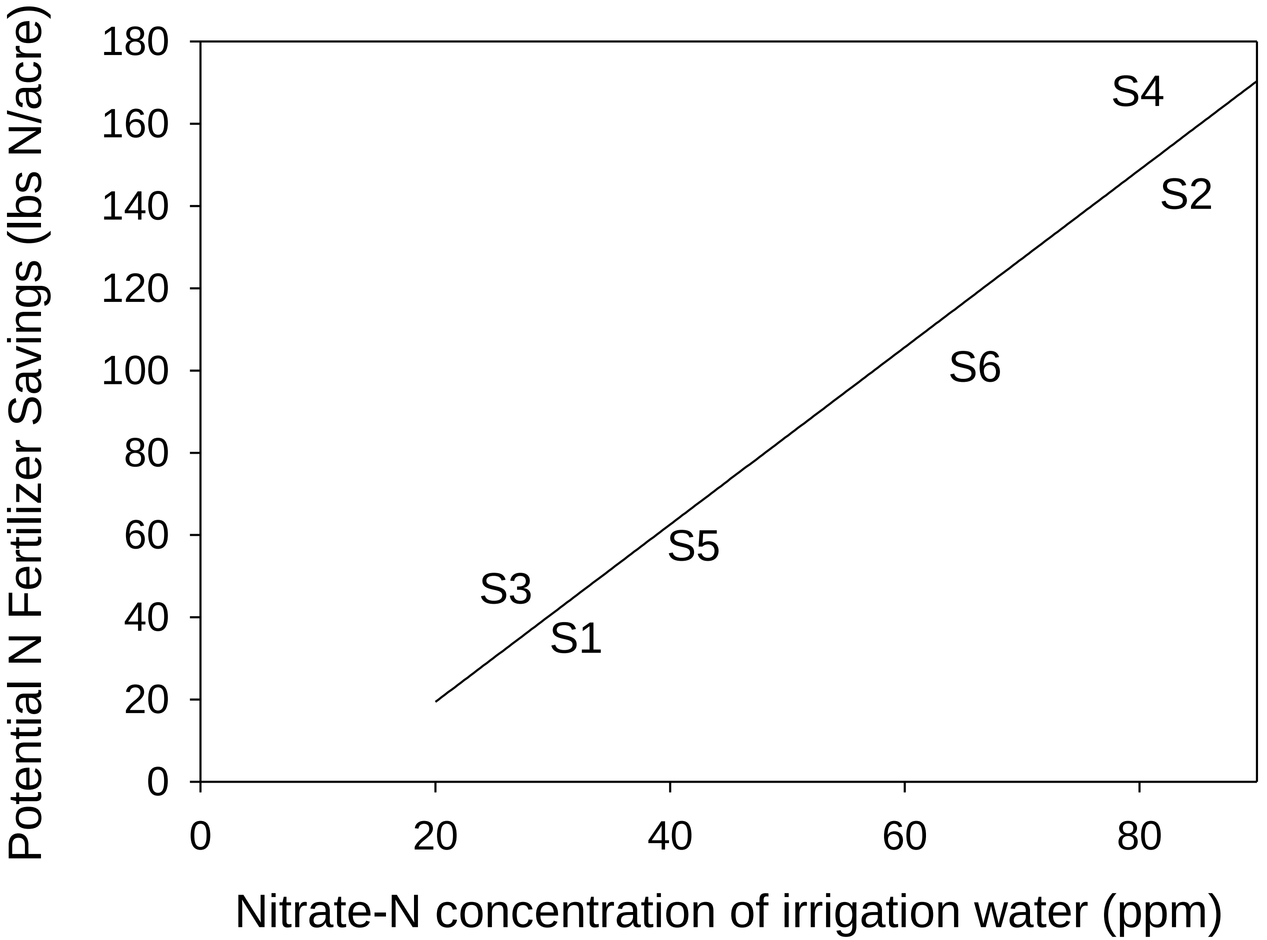
Marketable Yield (Strip Plots)

	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

Average applied N for lettuce = 175 lbs/acre

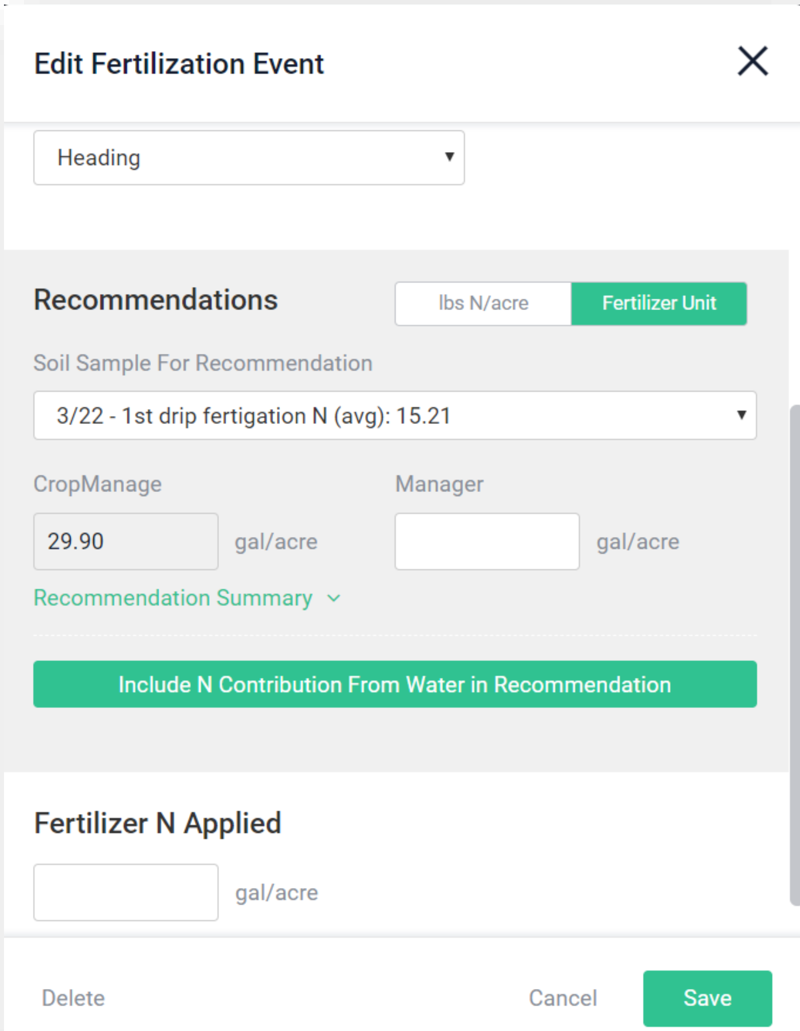


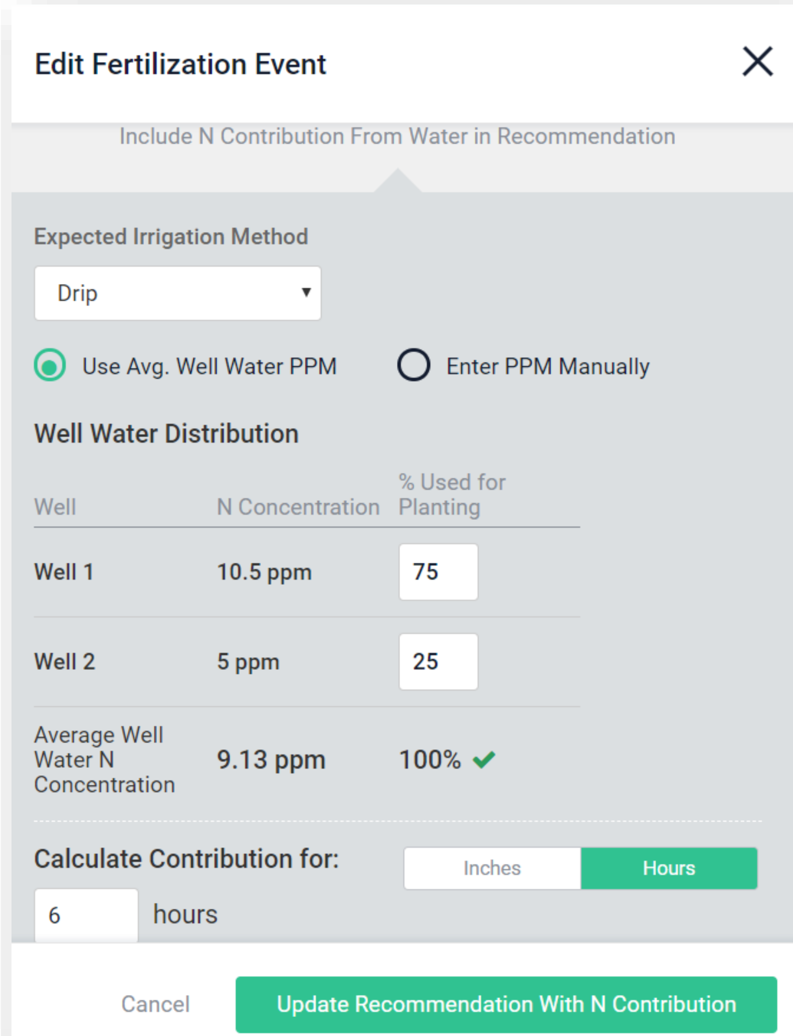
How much fertilizer* could potentially be saved by crediting N in water?



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

CropManage can calculate N contribution from irrigation water





Irrigation strategies for optimizing production and use of N fertilizer

- Assure that the irrigation system has a high DU
- Minimize irrigation water for stand establishment (less water per irrigation, transplants)
- Avoid irrigations that exceed the water holding capacity of the soil
- Avoid heavy irrigations after fertilizing
- Fertigate uniformly
- Match irrigation schedule with crop water requirement
- Use an appropriate leaching fraction