On-Farm Trials Evaluating the Fertilizer Value of Nitrogen in Irrigation Water

Michael Cahn, Laura Murphy, Richard Smith, Tim Hartz
UCCE Monterey and UCD Plant Science

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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

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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.

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Nitrogen is available in irrigation water

Well water
(2 to 70 ppm Nitrate-N)

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

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**

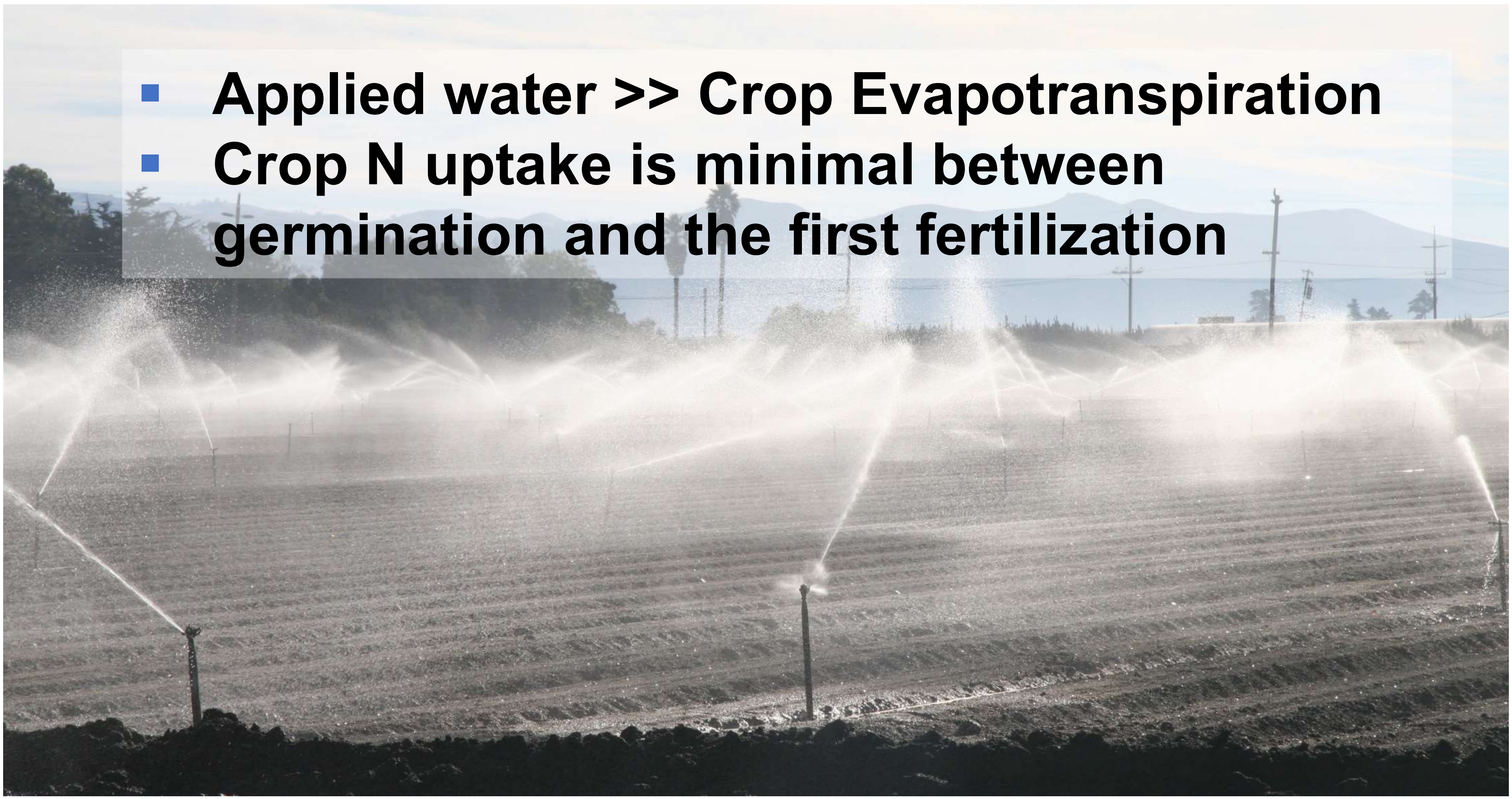
2 inches x 30 ppm NO_3-N x 0.23

= <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
- ✓ Need to adjust for nitrate in the soil
- ✓ Many plantings to manage simultaneously in most mid to large scale vegetable operations

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

Crediting for N in water and soil

Soil Nitrate

Current N status of Soil

+

N in water

Future N contribution

Commercial Field Trials in 2016 and 2017

- Conducted at sites with high nitrate well water
- Sites had different levels of residual N in soil
- Sites had different levels of salinity in water

Manifold for Irrigation Treatments

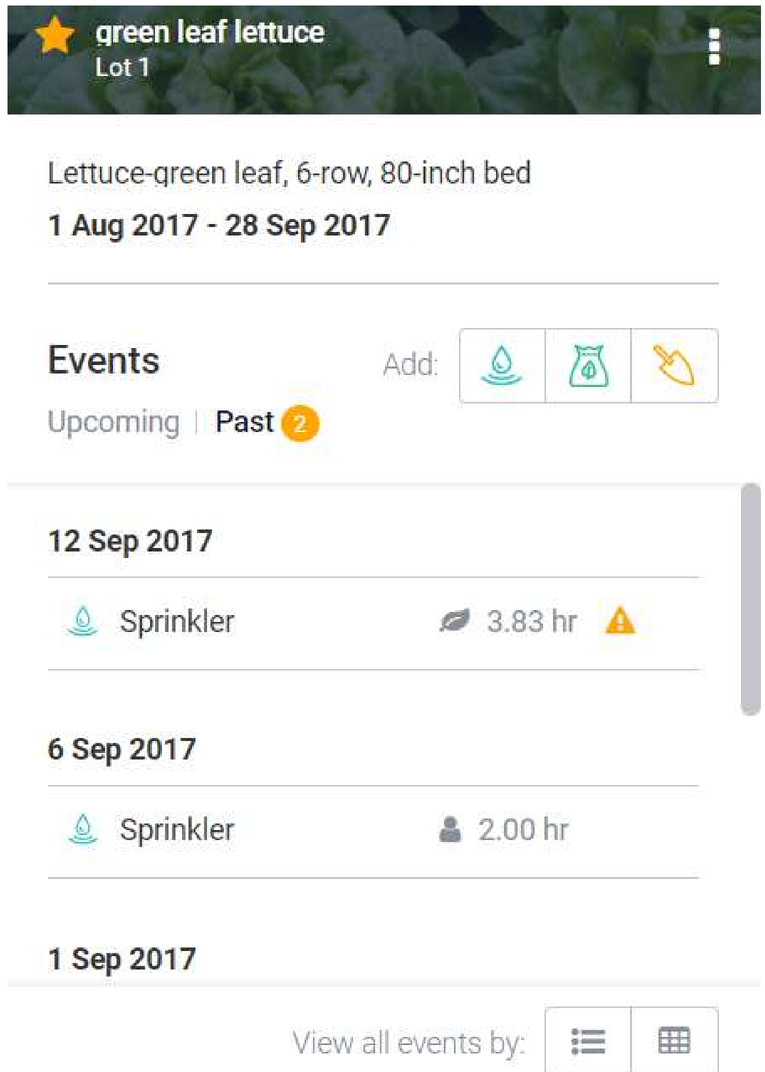
Strip Trial Treatments (2016 & 2017)

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

Replicated Trial Treatments (2017)

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

CropManage was used to guide BMP treatments



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Evaluated N concentration of irrigation water after every irrigation:

Determine average nitrate concentration in irrigation water

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

N fertilizer treatments (strip plots)

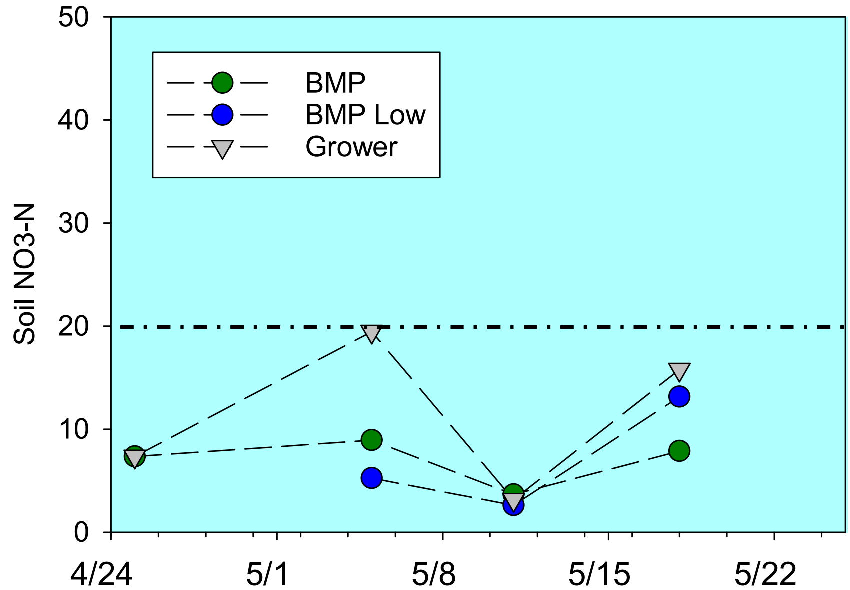
		Applied Fertilizer N		
Trial #	Crop	Grower	BMP	Intermediate
		------------	lbs/acre	------------
		----------------------------	2016	----------------------
Trial 1	Iceberg	154	140	--
Trial 2	Iceberg	62	32	--
		----------------------------	2017	----------------------
Trial 3	Romaine	120	128	160
Trial 4	Iceberg	63	7	32
Trial 5	Iceberg	155	118	122
Average		111	85	

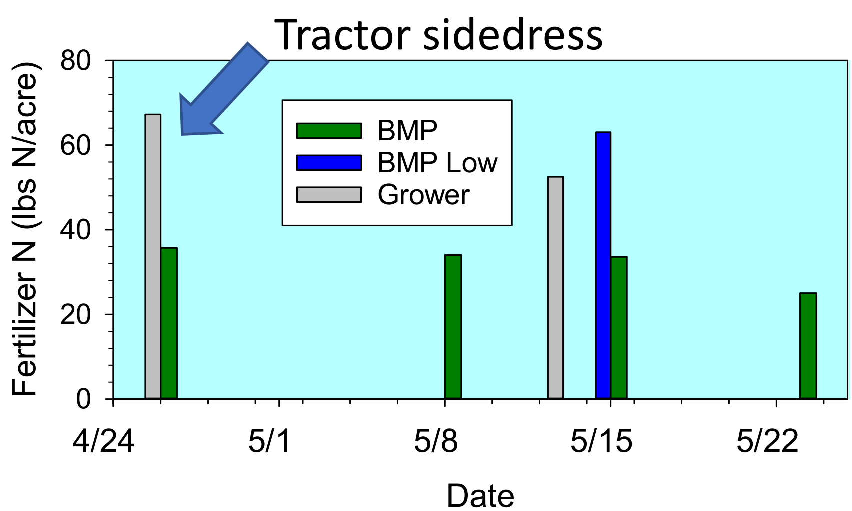
Commercial Yield Evaluation

Marketable Yield (Strip Plots)

	Grower	BMP	Intermediate
		Marketable Yield relative to Standard	
	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

Soil Nitrate and Fertilizer N (Trial 3)





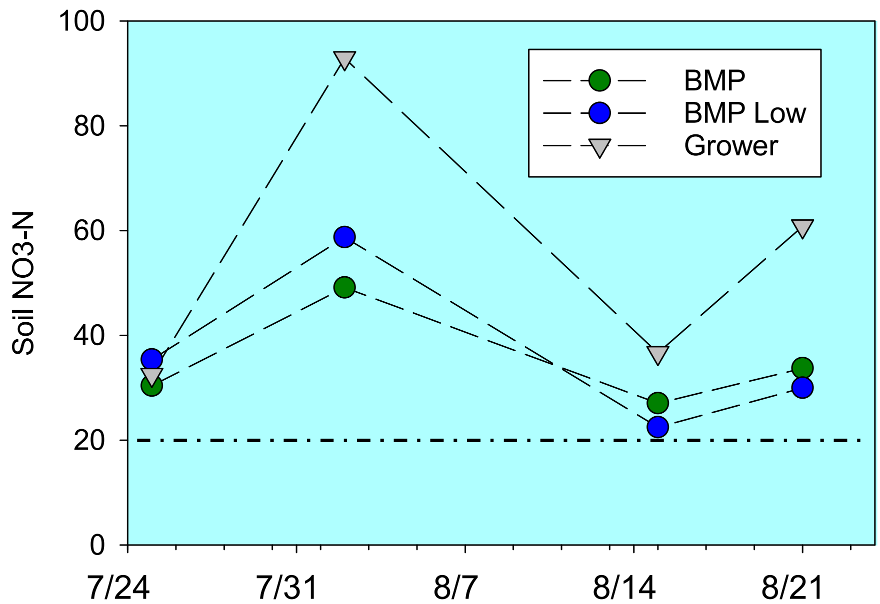
- Romaine
- 1st Crop
- Irrigation water = 26 ppm N
- Cropley silty clay

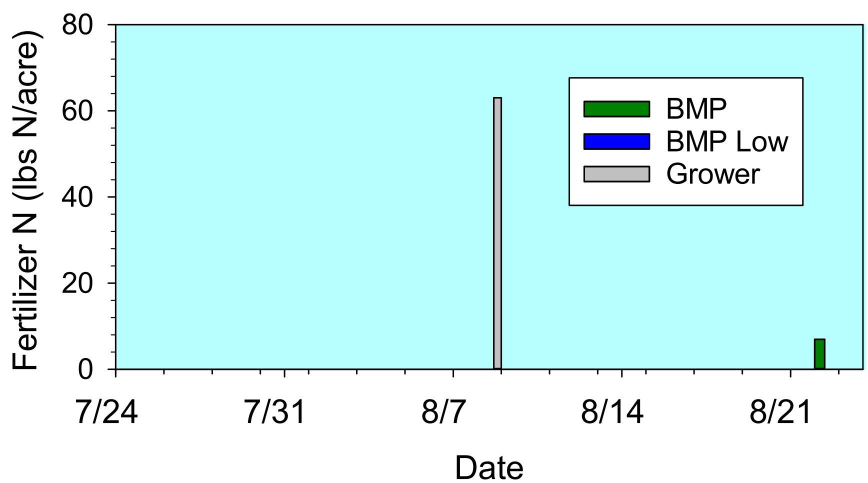
Treatment	Total applied N
	lbs N/acre
BMP	128
BMP-Low	63
Grower	120

Marketable Yield (Replicated Trial 3)

Treatment	number of reps	Applied N	Total yield: carton yield	Total yield: marketable yield	% 24's	untrimmed head wt.
		lbs N/acre	ct/acre	lbs/acre	%	lbs/plant
Grower	2	120	1030	36114	99	2.3
BMP	3	128	1046	37411	100	2.6
BMP-Low	3	63	997	33827	97	1.9

Soil Nitrate and Fertilizer N (Trial 4)





- Crisphead lettuce
- Previous crop: lettuce
- Irrigation water = 80 ppm N
- Gorgonio sandy loam

Treatment	Total applied N
	lbs N/acre
BMP	7
BMP-Low	0
Grower	63

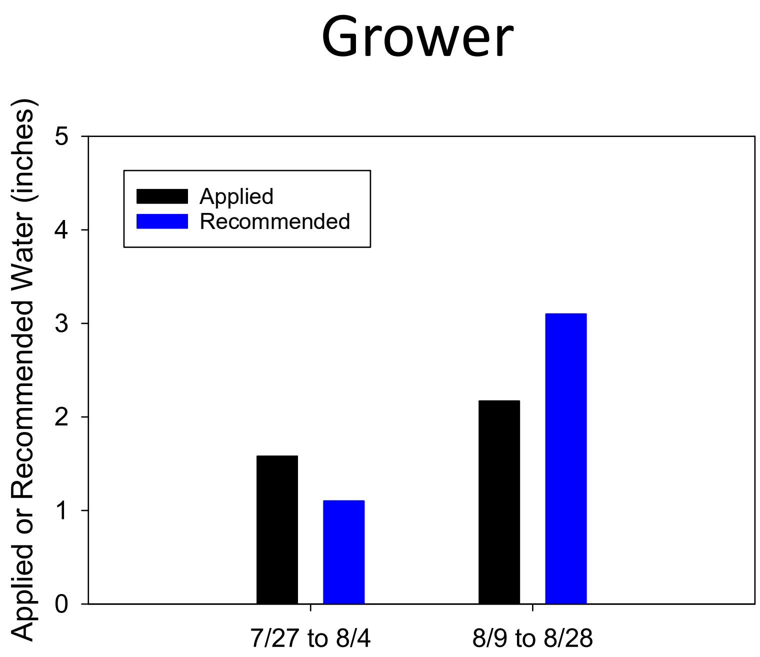
Marketable Yield (Replicated Trial 4)

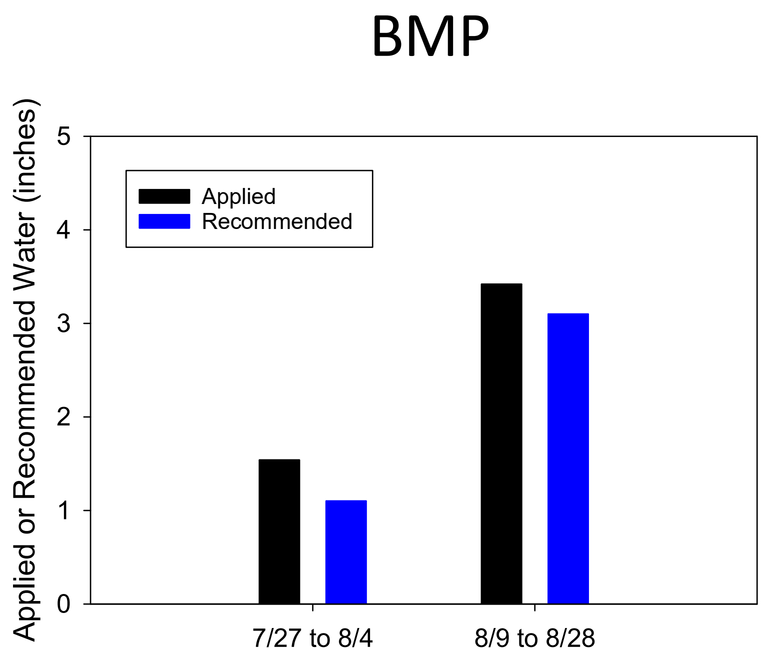
Treatment	Applied N	total yield: carton yield	total yield: marketable yield	Untrimmed head wt.	24 count cartons
	lbs N/acre	cartons/acre	lbs/acre	lbs/head	%
Grower	63	1206	53088	2.55	87
BMP	7	1203	55459	2.89	94
BMP-Low	0	1209	55268	2.96	90
$LSD_{0.05}$		NS	NS	0.34	

Marketable Yield (Strip Plots Trial 4)

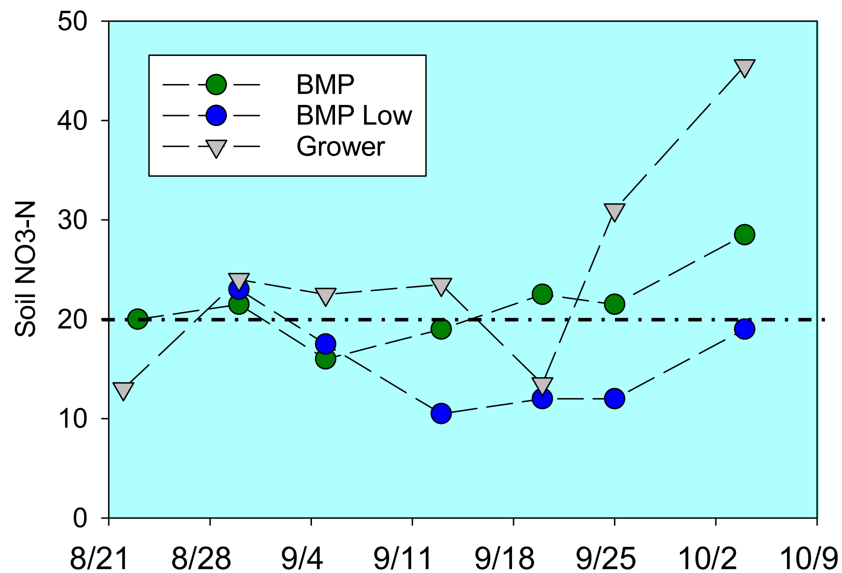
			carton yield		
Treatment	Applied N	carton wt.	marketable wt.	total cartons	%24s
	lbs N/acre	lb/box	lbs/acre	ct/acre	%
Grower	63	43.3	41526	1033	89
BMP	7	45.3	44758	1058	95
Intermediate	32	47.7	48661	1084	97

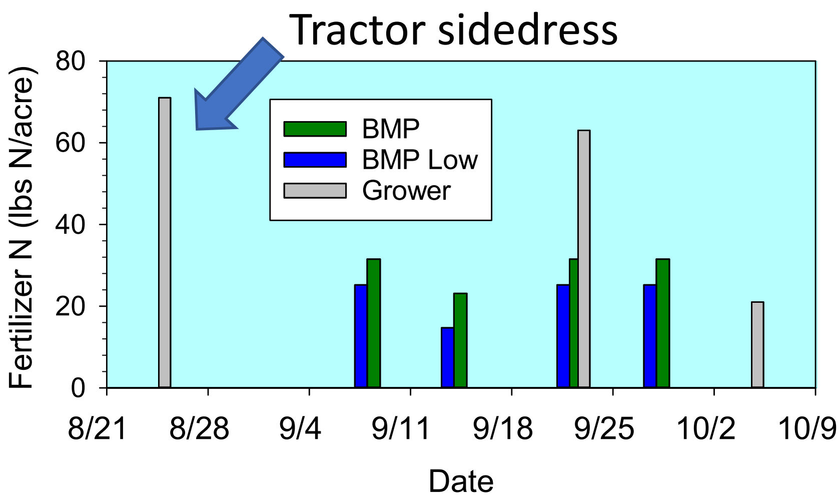
Applied vs Recommended Drip Water (Trial 4)





Soil Nitrate and Fertilizer N (Trial 5)





- Crisphead lettuce
- Previous Crop: Cauliflower
- Irrigation water = 42 ppm N
- Salinas clay loam
- Water EC = 1.8 dS/m

Treatment	Total applied N
	lbs N/acre
BMP	118
BMP-Low	90
Grower	155

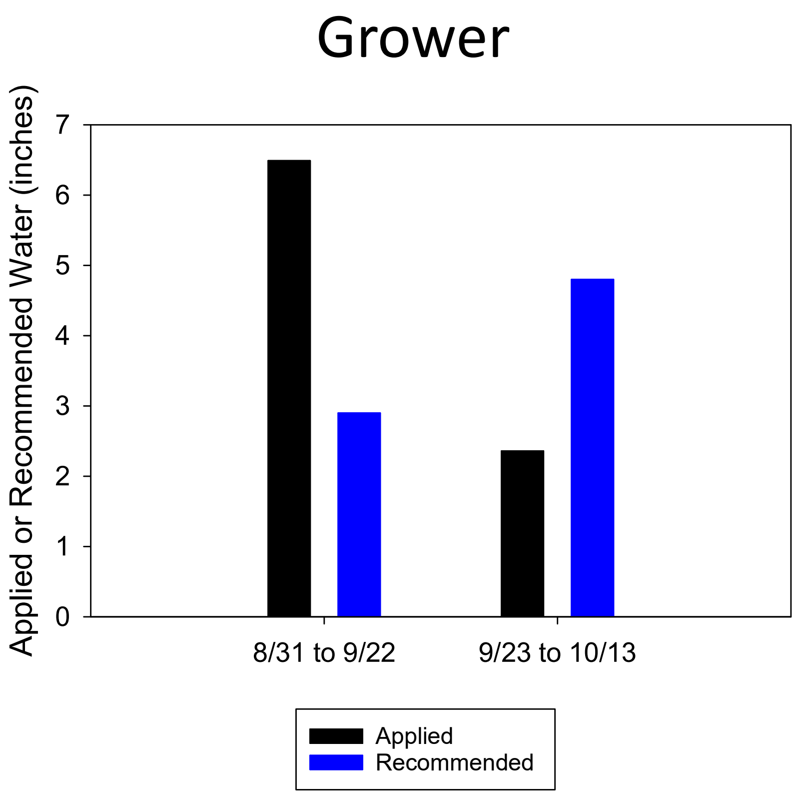
Marketable Yield (Replicated Trial 5)

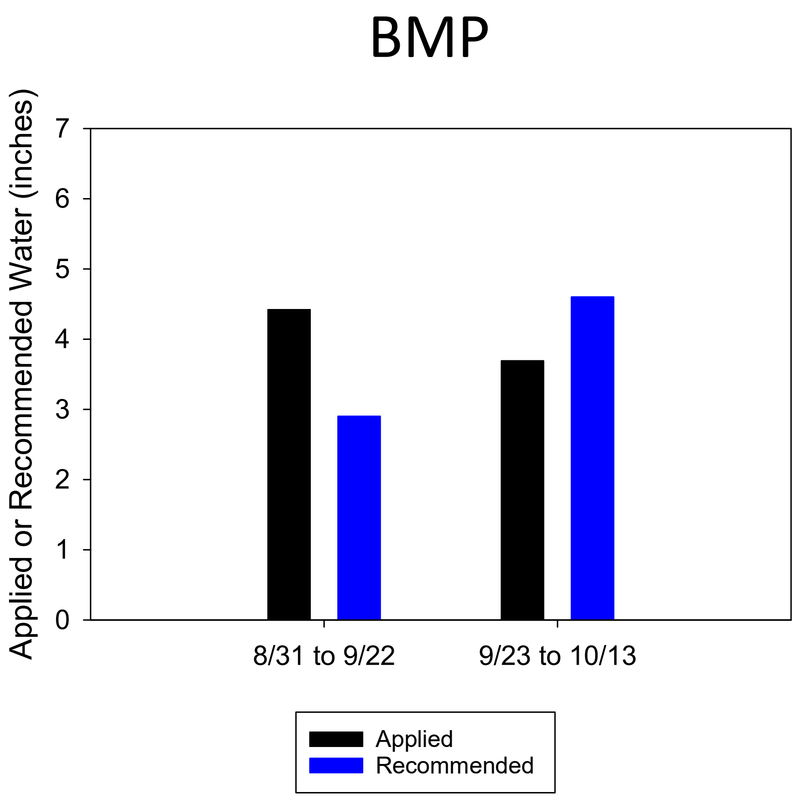
Treatment	Applied N	total yield: carton yield	total yield: marketable wt.	total biomass
	lbs N/acre	ct/acre	lbs/acre	lbs/acre
Grower	155	957	33306	62920
BMP	118	960	33086	67225
BMP-Low	90	981	35484	67780
$LSD_{0.05}$		NS	NS	2037

Marketable Yield (Strip Plots Trial 5)

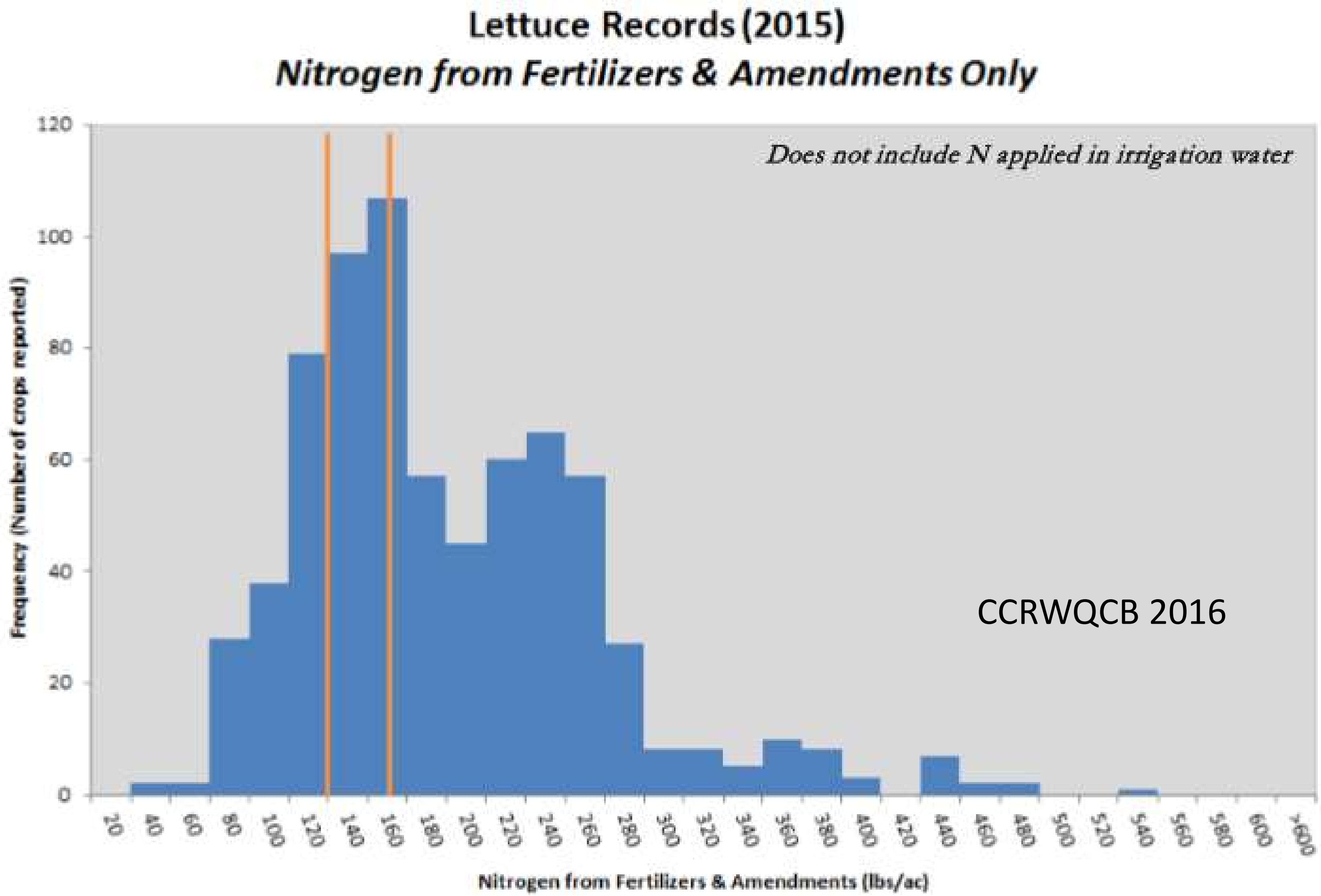
			Marketable Yield		
Treatment	Applied N	carton wt.	carton yield	marketable wt.	% 24s
	lbs N/acre	lbs/carton	ct/acre	lbs/acre	%
Grower	155	35.9	683	22511	89
BMP	118	37.2	796	27185	86
Intermediate	122	37.1	766	26047	91

Applied vs Recommended Drip Water (Trial 5)

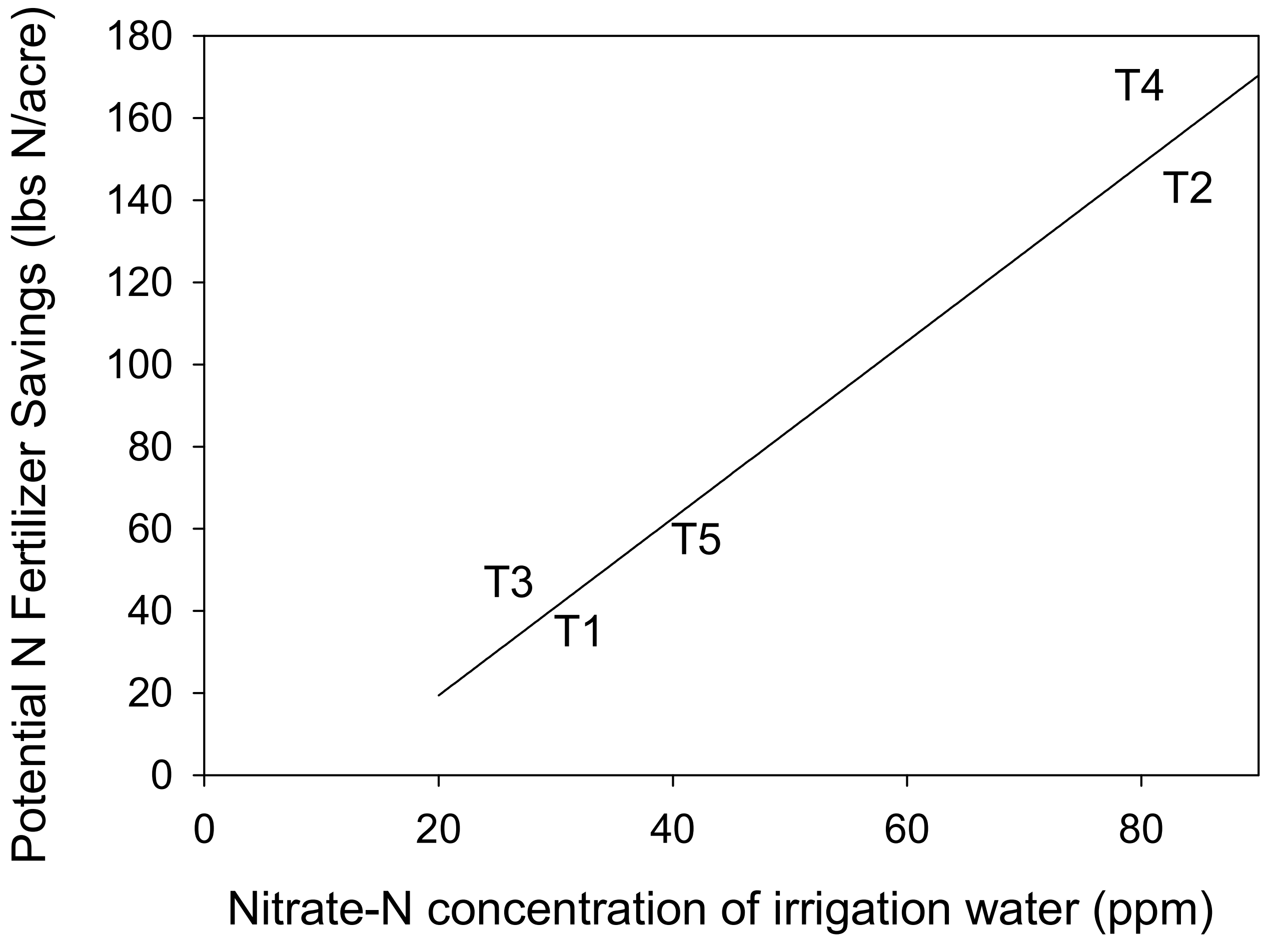




Average applied N for lettuce = 175 lbs/acre

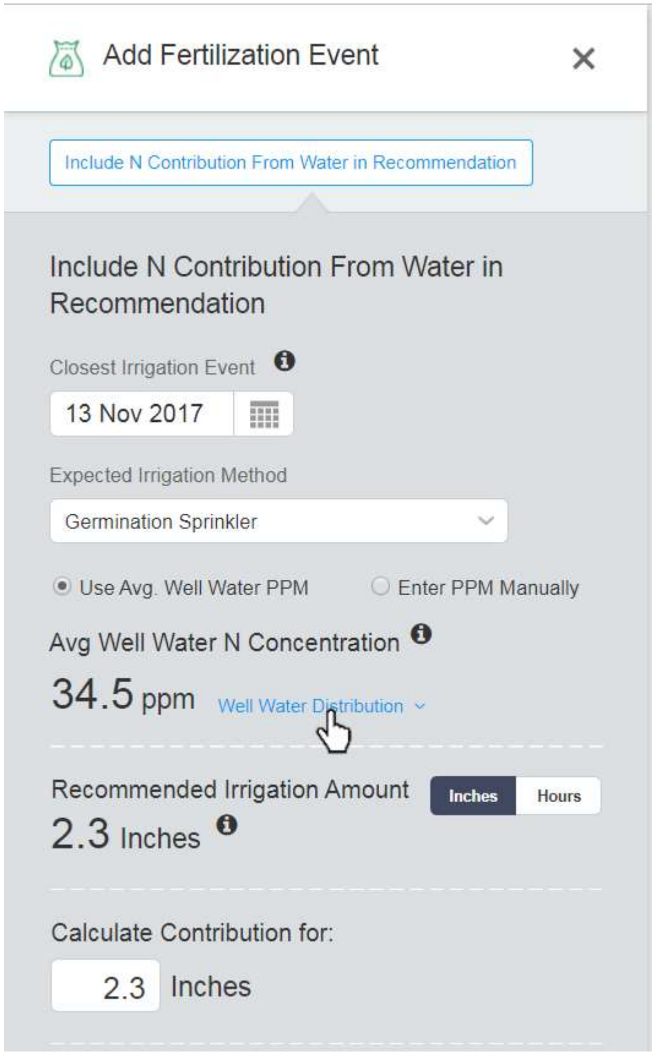


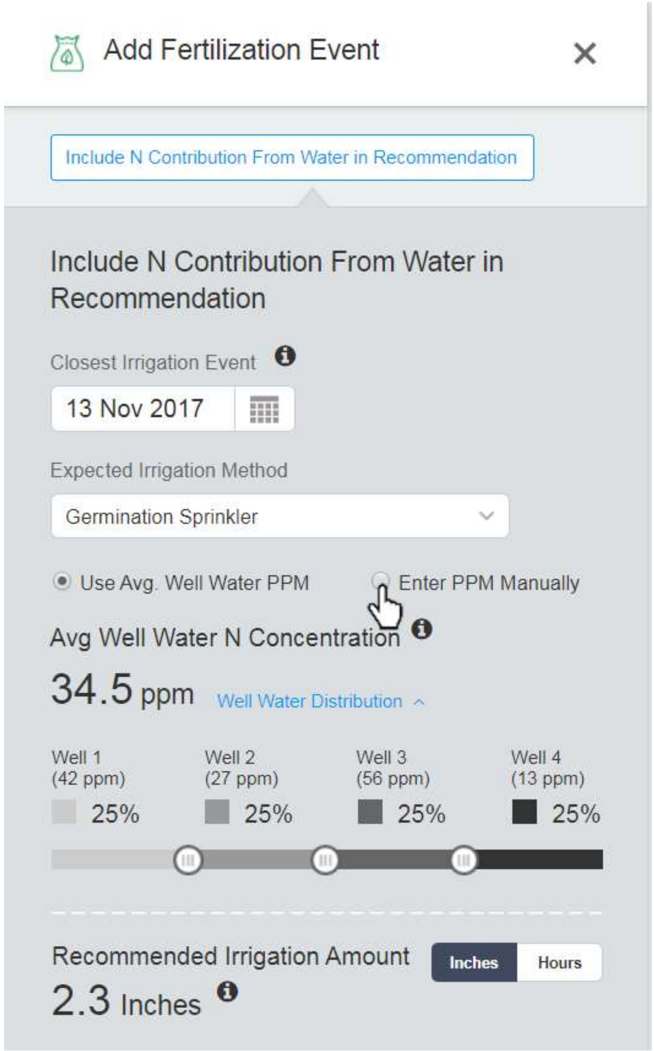
How much fertilizer* could potentially be saved by crediting N in water?



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

CropManage: N in irrigation water calculator





Summary

- ✓ Commercial field trials demonstrated that nitrate in irrigation water can potentially reduce fertilizer N requirements of lettuce.
- ✓ Also need to evaluate the residual N level of the soil.
- ✓ Begin crediting for N in water after the crop is established.
- ✓ Crops will be most efficient in utilizing N in water if irrigation volumes follow the evapotranspiration demand of the crop.


Questions?