

## **CALIFORNIA LEAFY GREENS RESEARCH PROGRAM**

April 1, 2018 – March 31, 2019

**Title:** On-Farm Evaluations of Fertilizer Value of Nitrate in Irrigation Water

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### **ABSTRACT**

A total of six trials were conducted from 2016 to 2018 evaluating the use of residual soil nitrate and nitrate in irrigation water for managing nitrogen applications to lettuce. All trials were conducted with cooperating growers in large-scale field trials. Nitrate-N levels in the water of the trials ranged from 26 to 80 ppm. Trials were conducted in fields sprinkler irrigated to establish the crop and then drip irrigated following thinning. Trials were initiated after thinning by installing a set of manifolds in the field that allowed for replication of the treatments; these small plots were harvested and graded by members from the harvest crew. In addition, each treatment was also applied in an area the width of a harvester by the length of the field. These areas were harvested by a commercial harvest crew. Treatments were: 1) grower standard, 2) best management practice (BMP) guided by recommendations from CropManage and 3) a low-N treatment, or 4) an intermediate treatment in the non-replicated portion of the trial. Nitrogen fertilizer treatments were guided by weekly soil nitrate-N sampling and irrigation amounts were scheduled by ET evaluations recommended by CropManage. Results demonstrated that the combination of accounting for N in irrigation water and residual soil N can substantially reduce the fertilizer requirements of lettuce without causing yield loss. Nitrogen fertilizer rates in the BMP treatment ranged from 7 to 128 lbs N/acre in 2017 & 2018 which is substantially less than the average amount reported for lettuce to the regional water quality control board of 175 lbs N/acre. The replicated trials showed that the reduction in fertilizer N did not cause yield loss compared to higher rates applied in the grower standard or intermediate treatments.

### **OBJECTIVE**

The immediate objective of this project was to conduct a large-scale evaluation of the fertilizer value of nitrate-N in irrigation water at a site in south county. The long-term objective is to develop practical methods to help growers factor the N concentration of irrigation water into crop nutrient budgets

### **PROCEDURES**

One trial was conducted in commercial lettuce fields north of King City during the 2018 season. The trial included large unreplicated plots that could be harvested using commercial equipment and labor, and small replicated plots that could be evaluated by hand harvest to determine if treatments were statistically different. Irrigation water at the field site was 66 ppm Nitrate-N (Table 1). Treatments in the large plot trial included 1) Grower fertilization practice, 2) Best Management Practice (BMP) following CropManage recommendations for fertilizer N which accounts for residual soil nitrate-N and nitrate in irrigation water; and 3) intermediate fertilizer N treatment that was lower than the grower treatment. Treatments in the replicated plot trial were the same as in the large plot trial with the exception of treatment 3, which was a low N treatment included to determine if reducing the N rate more than the BMP treatment would result in yield

loss. The fertilizer treatments were applied after thinning. A manifold divided the irrigation water into three layflat submains, utilized to supply different rates of fertilizer to the treatments. Soil nitrate-N was measured over the course of the crop cycle and was used to make fertilizer application decisions in the BMP, low and intermediate treatments. Yields in the large unreplicated plots were measured in coordination with a commercial harvest company; The number of cartons and average weight of the cartons were determined for each large plot. Plants were hand-harvested from 50 feet of the 2 middle beds in each small plot by a commercial crew for determination of carton yield. Trimmed and untrimmed plant weight and biomass yield was determined from 40 plants in each plot. A subsample of plants from each plot were analyzed for N content to determine crop N uptake.

## RESULTS

The nitrate-N concentration of the irrigation water from the 2018 was 66 (Table 1). The quantity of N applied in the replicated trial was 155 lbs N/acre in the standard fertilizer treatment, 92 lbs N/A in the BMP treatment 74 lbs N/acre in the low N treatment (Table 2). In the large, unreplicated plot trials, the N application rate of the intermediate was 137 lbs N/acre (Table 3).

Marketable yields of the grower standard and the BMP treatments were statistically the same in replicated trial (Tables 4, 6 & 7); In the unreplicated trials, marketable yield of the BMP and intermediate N treatments were lower than the grower standard treatment (Table 5). Details of yield of the 2018 trial are shown in Tables 6 & 7. Soil nitrate values and N fertilizer applications of the treatments are summarized in Figures 1. Soil nitrate levels declined over the course of the season in the BMP and low treatments while the grower standard stayed > 40 ppm NO<sub>3</sub>-N over the crop cycle (Figure 1). The water contributed 115 lbs N/acre over the cropping cycle and the BMP and low replicated treatments were fertilized with 63 and 81 lbs N/acre less fertilizer N, respectively, than the grower treatment with no impact on yield. In the unreplicated strips there were some complications that make the data a bit difficult to interpret. There was a different variety in the grower treatment (Revolt) vs in the BMP and intermediate treatments (Declaration). This issue highlights one of the hazards of doing a large-scale evaluation; it is more difficult to keep all the factors the same in a commercial production field. In the replicated trial, all of the factors were more uniform and we have greater confidence in the results.

The grower standard N rate had 155 lbs N/acre which is less than the average N fertilizer rate of 175 lbs N/acre reported for lettuce to the region 3 regional water quality control board. Based on the results of the 6 trials conducted from 2016 to 2018, we estimated the potential N fertilizer savings that can be expected from various levels of N in the irrigation water assuming a standard N fertilizer rate of 175 lbs N/acre. Potential N fertilizer savings are modest for irrigation waters <30 ppm nitrate-N, but can be substantial for waters >70 ppm nitrate-N (Figure 2). The residual soil nitrate level and irrigation management would also affect the potential N fertilizer savings, where greater savings could be attained when soil nitrate concentrations are high (> 20 ppm NO<sub>3</sub>-N) and irrigation water is applied with a high uniformity and matching crop evapotranspiration demand.

## Conclusions

Six trials conducted in commercial fields from 2016 to 2018 demonstrated that nitrate present in the irrigation water has fertilizer value for lettuce. Fertilizer savings were moderate when nitrate concentration was less than 30 ppm N and substantial when nitrate concentration was greater than 70 ppm N. Soil nitrate and water management need to be factored into management to optimize N in water. These trials also demonstrated that decision support tools such as CropManage can assist growers in determining appropriate N fertilizer rates based on residual soil N and nitrate in irrigation water and provide guidance on water management.

Table 1. Initial soil nitrate levels and nitrate concentration and salinity of irrigation water.

Trial No.	Soil NO <sub>3</sub> -N*	Water NO <sub>3</sub> -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
-----2018-----					
Trial 6		66	7.7	115	

\* 1 ft depth at thinning

Table 2. Fertilizer rates of treatments in replicated trials.

		Applied Fertilizer N		
		Standard	BMP	Low N
		-----lbs N/acre-----		
-----2017-----				
Site 3	Romaine	120	128	63
Site 4	Iceberg	63	7	0
Site 5	Iceberg	155	118	90
-----2018-----				
Site 6	Iceberg	155	92	74
Average		123	86	57

Table 3. Fertilizer rates of treatments in unreplicated trials.

Trial No.	Crop	Applied Fertilizer N		
		Grower	BMP	Intermediate
-----lbs N/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
-----2018-----				
Trial 6	Iceberg	155	92	137
Average		118	86	---

Table 4. Marketable yield of treatments in 2017 & 2018 replicated trials.

Trial No.	Grower Lbs/A	BMP	Low N
		-----%-----	
2017			
Trial 3	36,114	4	-6
Trial 4	53,088	4	4
Trial 5	33,306	-1	7
2018			
Trial 6	43,086	1	1
Average	41,398	2	1

Table 5. Marketable yield of treatments in 2016 to 2018 unreplicated trials.

Trial No.	Grower Lbs/A	BMP	Intermediate
		-----%-----	
2016			
Trial 1	53,573	2	---
Trial 2	42,387	-1	---
2017			
Trial 3	36,832	10	4
Trial 4	41,526	8	17
Trial 5	22,511	21	16
2018			
Trial 6	42,289	-3	-8
Average	39,853	6	

Table 6. Details on Site 6.

Replicated plots

Treatment	Applied N* (lbs N/A)	Applied Drip Water** (Inches)	N in Water* (lbs N/acre)	Total cartons/acre	Marketable Yield lbs/acre	Percentage of boxes 24 count
Standard	155.0	7.7	115	1179	43086	86.0
CropManage	92.0	9.7	145	1183	46848	98.9
Low N	73.8	9.7	145	1175	44566	92.3

\* 66.0 ppm nitrate-N (15 lbs N/acre inch of applied water).

\*\* 13.8 inches of water applied by sprinklers prior to drip to all treatments.

Table 7. Details on Site 6.

Commercial harvest strips

Treatment	Applied N* (lbs N/A)	Applied Drip Water** (inches)	N in water* Lbs N/A	Total cartons/A	#24s/A	#30s/A	#38s/A
Standard	155.0	7.7	115	1092	1022	37	33
Intermediate	136.8	9.7	145	1167	1136	31	0
CropManage	92.0	9.7	145	1053	1049	4	0

\* 66.0 ppm nitrate-N (15 lbs N/acre inch of applied water).

\*\* 13.8 inches of water applied by sprinklers prior to drip to all treatments.

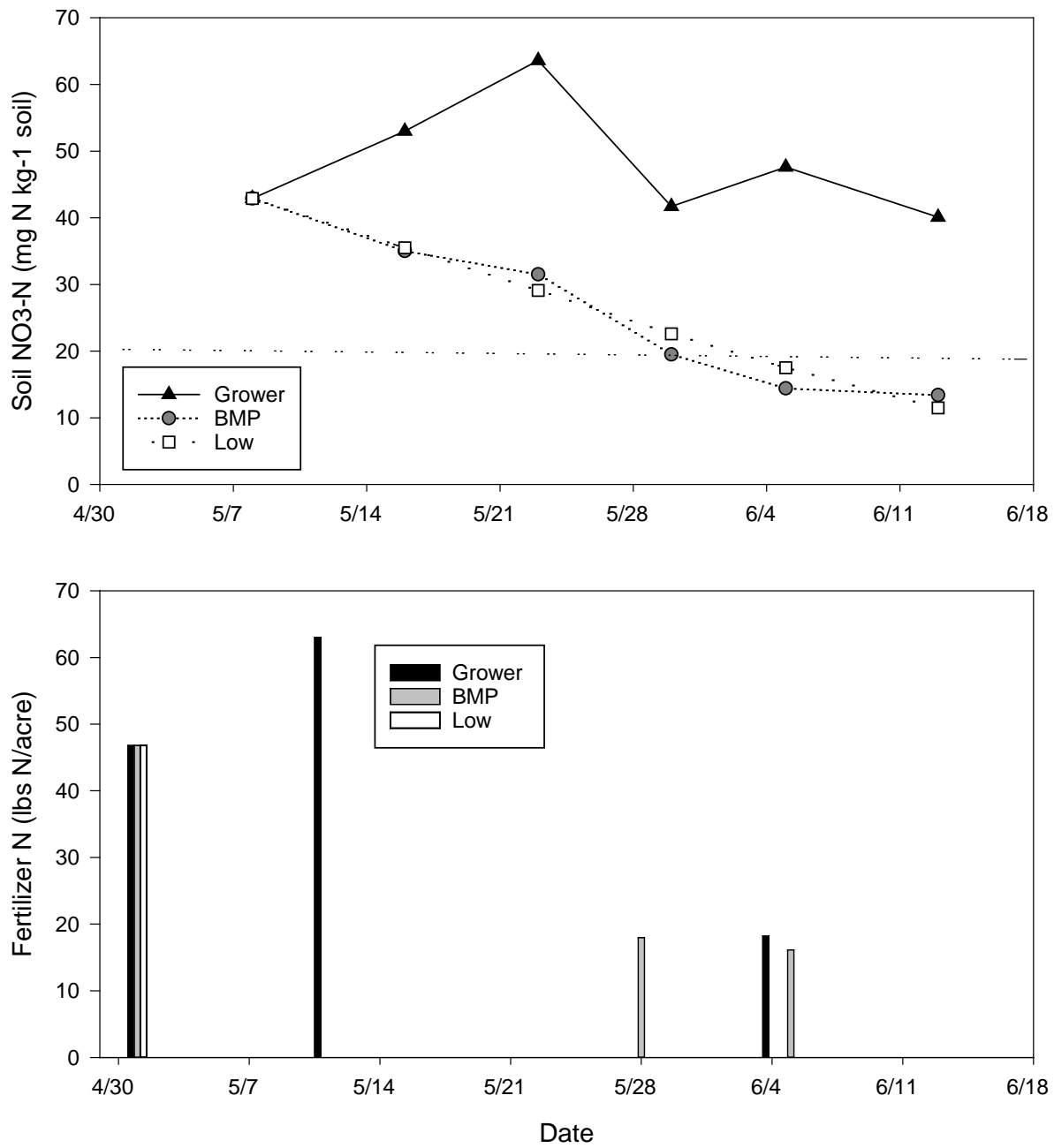


Figure 1. Soil nitrate and applied nitrogen in the replicated plots.

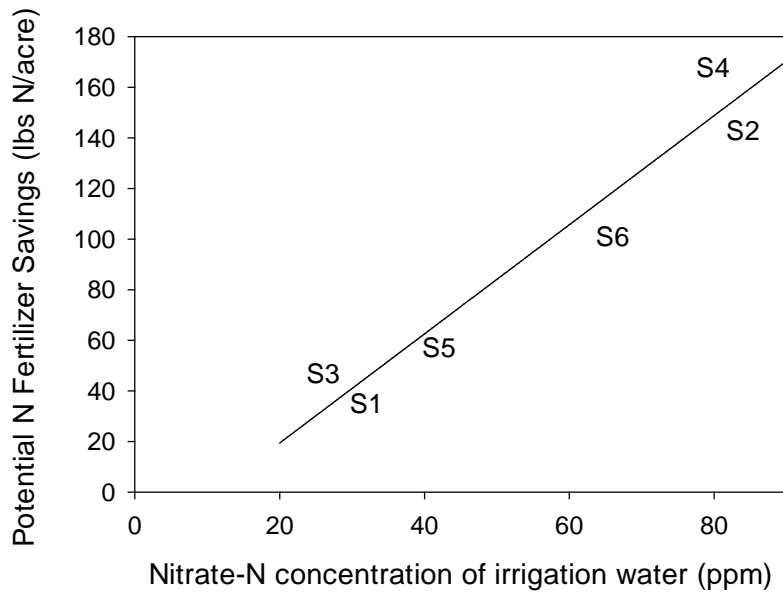


Figure 2. Potential fertilizer savings from crediting nitrogen in irrigation water. Plotted data are from sites 1-6 (S1, S2, S3, etc). Estimates are based on fertilizer reduction achieved in replicated trials and an average standard fertilizer rate of 175 lbs N/acre for lettuce.