2014 Nitrogen Fertilizer Technology Studies on Lettuce

University of California Cooperative Extension, Monterey County
Richard Smith, Tricia Love and Elizabeth Mosqueda, Vegetable Crop and Weed Science Farm Advisor, Staff Research Assistant and Student Assistant

Methods: Conducted at the USDA Spence Research Station south of Salinas on Chualar loam soil. The field was listed with 300 pounds/A of potassium sulfate (130 lbs K) one month prior to planting. The fertilizer was applied in two ways 1) applied with a tractor in two applications preplant on June 9 (5 inches below the seedlines) and as a sidedress (3 inches towards the center of the bed and 3 inches deep) on June 27 (both applications were made with a Fairbanks small-plot dry fertilizer applicator); and 2) injected through the drip system in two applications and July 14 and 22. The romaine variety 'Sunbelt' was planted on June 10 and 25 gallons/A of 7-7-0-7 was applied on June 11 to the seedline as an anticrustant to facilitate seedling emergence. Sprinkler irrigated was initiated to germinate the crop on June 12 and continued until prior to thinning on July 7-8; drip tape was installed and the first drip irrigation and fertigation to the drip treatments was applied on July 14. Irrigation levels were managed at 200% of crop evapotranspiration (ETc) (Figure 1) to challenge the effectiveness of the fertilizer to maintain mineral nitrogen in the root zone of the lettuce; a total 12.9 inches of water were applied and 6.5 inches of water were used by ETc. Soil samples were collected 5 times to evaluate mineral N: samples were collected at one foot intervals down to three feet deep on July 2 (baseline sample), August 5 and August 19 (post harvest) and samples from the top foot of soil were collected on July 17 and July 28. Each plot was two 40-inch beds wide by 100 feet long and replicated 4 times in a RCBD. Fertigations were applied by use of a multi-port manifold with backflow prevention valves that fed two-inch layflat that provided water and fertilizer for each treatment (Table 1 and photo 1). Injector ports in each layflat were used to inject the appropriate rate of UAN 32 liquid fertilizer. Battery powered pumps were used to inject fertilizer/nitrification inhibitors mixtures into the layflat and injections were made during the middle third of irrigation events. Percent nitrogen of leaf tissue was evaluated on August 5. Yield evaluation was conducted on August 14 by harvesting 65 heads from each plot; eight plants from each plot were subsampled for tissue moisture and total N content.

Results: The trial site at the USDA Spence Research Station had high levels of residual soil nitrate at the onset of the 2014 season. Part of the reason for this issue was due to low rainfall over the previous winter that did not move residual soil nitrates out of the root zone. Soil nitrate levels on July 2 (baseline evaluation for the three foot soil depths) were 39.6 ppm NO_3-N; the soil samples on this date were taken from between the seedlines and did not reflect the levels of N added by the anticrustant. This level of residual soil nitrate made it difficult to detect differences among fertilizer treatments; however, between June 12 and July 3 we irrigated with 4.83 inches of water while during this same time ETc was 2.3 inches (210% excess of ETc). This level of irrigation, helped to reduce the residual soil nitrate levels in the trial, but also challenged the preplant tractor-applied fertilizer applications.

The trial compared applications of fertilizer + N technology materials through the drip and dry materials injected in a band with a tractor pulled applicator; however, the results were a bit confusing. For instance on the July 17 evaluation date, the overall average soil nitrate levels for the tractor application in the top foot of soil were 37.8 ppm NO_3-N and 24.3 ppm NO_3-N for the

drip applied materials (Table 2). This was in spite of the fact that the tractor-applied materials were applied on June 27 and the drip applied materials on July 14. The soil ammonium levels for the tractor-applied materials were also higher than the drip applied materials on July 17 (Table 3). It may be that comparing the tractor-applied treatments with the drip may be unrealistic because the N source for the standard and nitrapyrin treatments in the tractor and drip applied treatments were ammonium sulfate and UAN32, respectively. As such, in this write up we compared treatments within the 0method of application. On July 28, the highest soil nitrate levels were associated with 155 lbs N/A treatments; however, for tractor-applied soil ammonium levels the 105 lbs N/A nitrapyrin and Novatec treatments had ammonium levels equivalent to the 155 lb N/A treatments. On August 5 there were no significant differences among the 1 and 2 foot nitrate N levels. At the three foot level in the drip applied treatments the standard and moderate treatments had the greatest amount of nitrate down at the three foot level in the soil. In the tractor applied treatments, the moderate and moderate + nitrapyrin had the greatest level of nitrate at the third foot. Soil ammonium levels were only elevated in the tractor applied standard and standard + nitrapyrin treatments. After harvest on August 19 there were no statistical differences in soil nitrate levels at the first and third foot in the soil and higher soil nitrate levels were associated with the 155 lb N/A application rate. Soil ammonium levels were elevated in the tractor applied 155 lb N/A, 155 lb N/A + nitrapyrin and 155 lb N/A as Duration ST treatment.

The percent N in leaf tissue was higher in all treatments over the untreated control, but there were no statistical differences between fertilizer treatments (Table 4). The fresh weight yield of the tractor-applied treatments did not differ from each other; as a group, the tractor-applied treatments had a lower yield than drip-applied treatments. The yield of the drip-applied treatments was highest in the standard treatment. There is a strong trend indicating that all of the drip-applied fertilizer technologies at 105 lbs N/A improved the yield over the moderate treatment, but only Novatec had statistically greater yield.

Summary: Soil mineral nitrogen evaluations were inconclusive and difficult to interpret in this trial. They did not show clear trends indicating higher levels of mineral N in the root zone or clear evidence of reduced nitrate leaching in the nitrogen technology treatments. The tractor-applied treatments had lower yield in this trial than the drip applied treatments; this is possibly due that half of most materials and all of the Duration ST was applied prior to planting. These treatments underwent greater time and irrigation than the drip-applied treatments. In future trials, it will be important to evaluate applying the dry nitrogen fertilizer technology treatments applied as sidedress treatments at thinning. The most significant observation of this trial is that all of the drip-applied nitrogen technology treatments with moderate amounts of N (105 lbs N/A) showed a trend of increased yield over the 105 lbs N/A treatment alone; of these treatments Novatec had significantly greater yield than the unamended 105 lbs N/A treatment.

Figure 1. Inches of water applied in irrigation and inches of crop ET

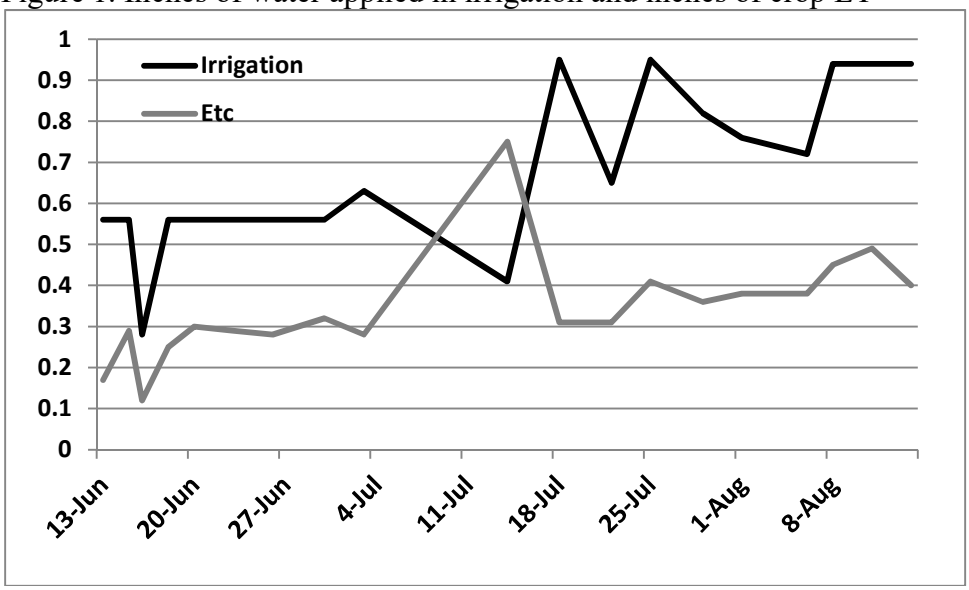

Photo 1. Overview of drip injection ports and injection pumps

Table 1. Application timing, dates and rates (lbs N/A)

No.	Material	Preplant Lbs N/A Tractor June 9	Anticrustant 7-7-0-7 June 11	1st Application Tractor June 27 Drip July 14	2nd Application Drip July 22	Total N/A	Mode of action by the fertilizer additive
1	Untreated	0	25	0	0	25	---
Drip applied							
2	155 (Standard)[1]	0	25	65	65	155	---
3	105 (Moderate)[1]	0	25	40	40	105	---
4	Nitrapyrin 0.50 lb ai[2]	0	25	65	65	155	nitrification inhibitor (Nitrapyrin®)
5	Nitrapyrin 0.50 lb ai[2]	0	25	40	40	105	nitrification inhibitor (Nitrapyrin®)
6	N-Sure (50:50)[3]	0	25	40	40	105	urea triazone
7	Novatec (DMPP)[4]	0	25	40	40	105	nitrification inhibitor (DMPP®)
Tractor applied							
8	155 (Standard)[5]	65	25	65	0	155	---
9	105 (Moderate)[5]	40	25	40	0	105	---
10	Nitrapyrin 0.50 lb ai[6]	65	25	65	0	155	nitrification inhibitor (Nitrapyrin®)
11	Nitrapyrin 0.50 lb ai[6]	40	25	40	0	105	nitrification inhibitor (Nitrapyrin®)
12	Novatec (DMPP) [4]	40	25	40	0	105	nitrification inhibitor (DMPP®)
13	Duration ST[7]	130	25	0	0	155	polymer coated urea
14	Duration ST[7]	80	25	0	0	105	polymer coated urea

1 – UAN 32 applied by drip injection; 2 – nitrapyrin mixed at the rates shown with UAN 32; 3 – applied as 50% UAN 32 and 50% as N-Sure; 4 – DMPP treated ammonium sulfate; 5 – ammonium sulfate; 6 – nitrapyrin treated ammonium sulfate; 7 – Polyurethane coated urea (44% N)

Table 2. Nitrate-N at three depths on three sampling dates and at the first foot on all sampling dates.

Treatment	depth (ft)	July 2	July 17	July 28	Aug. 5	Aug. 19
Untreated	0-1	39.6	15.6	2.1	5.8	5.9
	1-2	19.0	-	-	4.5	1.9^{D}
	2-3	8.1	-	-	6.9^{E}	5.3
Drip applied Standard 155	0-1	39.6	23.6	13.4	9.2	6.6
	1-2	19.0	-	-	21.1	5.7^{ABCD}
	2-3	8.1	-	-	27.8^{A}	11.3
Drip applied Moderate 105	0-1	39.6	21.6	8.9	4.5	3.2
	1-2	19.0	-	-	15.2	2.1^{CD}
	2-3	8.1	-	-	25.9^{AB}	6.0
Drip applied Nitrapyrin 155	0-1	39.6	25.9	11.0	8.3	14.9
	1-2	19.0	-	-	19.1	6.3^{ABCD}
	2-3	8.1	-	-	19.0^{ABCD}	12.4
Drip applied Nitrapyrin 105	0-1	39.6	17.9	3.8	4.7	8.6
	1-2	19.0	-	-	17.1	4.0^{ABCD}
	2-3	8.1	-	-	11.1^{BCDE}	10.6
Drip applied NSure 105	0-1	39.6	34.9	7.0	12.2	10.5
	1-2	19.0	-	-	15.5	6.6^{ABC}
	2-3	8.1	-	-	12.6^{ABCDE}	11.5
Drip applied Novatec 105	0-1	39.6	21.9	2.6	4.3	4.8
	1-2	19.0	-	-	9.9	2.5^{BCD}
	2-3	8.1	-	-	7.9^{DE}	5.6
Tractor applied Standard 155	0-1	39.6	47.4	16.9	10.3	17.6
	1-2	19.0	-	-	15.8	14.2^{A}
	2-3	8.1	-	-	12.3^{ABCDE}	14.7
Tractor applied Moderate 105	0-1	39.6	30.5	7.1	8.6	10.9
	1-2	19.0	-	-	12.3	7.9^{ABC}
	2-3	8.1	-	-	28.7^{A}	17.0
Tractor applied Nitrapyrin 155	0-1	39.6	34.7	9.0	7.7	11.3
	1-2	19.0	-	-	13.9	11.4^{A}
	2-3	8.1	-	-	10.3^{CDE}	7.4
Tractor applied Nitrapyrin 105	0-1	39.6	45.1	7.4	13.0	12.2
	1-2	19.0	-	-	20.6	7.5^{ABC}
	2-3	8.1	-	-	22.7^{ABC}	25.2
Tractor applied Novatec 105	0-1	39.6	34.5	6.7	5.7	3.8
	1-2	19.0	-	-	16.4	2.6^{CD}
	2-3	8.1	-	-	10.9^{CDE}	10.5
Tractor applied Duration ST 155	0-1	39.6	38.0	7.0	8.9	18.7
	1-2	19.0	-	-	11.2	11.4^{AB}
	2-3	8.1	-	-	11.0^{ABCDE}	8.4
Tractor applied Duration ST 105	0-1	39.6	34.2	7.0	4.6	4.7
	1-2	19.0	-	-	6.4	3.3^{ABCD}
	2-3	8.1	-	-	9.9^{CDE}	5.8
0-1 ft	Pr>F treat	NA	0.1636	0.0023	0.5971	0.4463
	LSD 0.05	NA	NS	6.3	NS	NS
1-2 ft	Pr>F treat	NA	-	-	0.0700	0.0538
	LSD 0.05	NA	-	-	NS	-
2-3 ft	Pr>F treat	NA	-	-	0.0292	0.4444
	LSD 0.05	NA	-	-	-	NS

Table 3. Ammonium-N in the first foot of soil on five evaluation dates.

	NH4-N (mg/kg soil)				
Treatment	July 2*	July 17	July 28	Aug. 5	Aug. 19
Untreated	1.2	0.7^{F}	0.6^{E}	0.7^{D}	0.5
Drip applied Standard 155	1.2	1.6^{CDEF}	1.2^{BCDE}	1.7^{ABC}	0.8
Drip applied Moderate 105	1.2	0.9^{EF}	1.1^{CDE}	1.1^{CD}	0.6
Drip applied Nitrapyrin 155	1.2	1.1^{DEF}	1.4^{BCDE}	1.1^{CD}	5.1
Drip applied Nitrapyrin 105	1.2	1.6^{CDE}	1.0^{DE}	0.7^{D}	0.7
Drip applied NSure 105	1.2	2.0^{CDE}	1.2^{BCD}	1.3^{BC}	1.2
Drip applied Novatec 105	1.2	1.0^{EF}	0.9^{DE}	0.8^{CD}	2.2
Tractor applied Standard 155	1.2	56.6^{A}	13.4^{A}	24.1^{A}	24.7
Tractor applied Moderate 105	1.2	6.1^{ABC}	4.1^{ABCD}	3.1^{AB}	2.9
Tractor applied Nitrapyrin 155	1.2	29.0^{AB}	16.2^{ABC}	36.6^{A}	23.6
Tractor applied Nitrapyrin 105	1.2	26.6^{AB}	14.9^{AB}	1.0^{BCD}	1.4
Tractor applied Novatec 105	1.2	30.9^{A}	10.6^{ABCD}	4.8^{BC}	6.9
Tractor applied Duration ST 155	1.2	10.1^{CDE}	13.7^{ABCD}	4.8^{BCD}	17.3
Tractor applied Duration ST 105	1.2	11.1^{BCD}	5.9^{BCDE}	1.1^{CD}	1.1
Pr>F treat	NA	<0.0001	0.0128	0.0010	0.0698
Pr>F block	NA	NA**	NA**	NA**	NA**
LSD 0.05	NA	-	-	-	NS

Table 4. Harvest evaluation, %N in harvested heads and N uptake in crop (August 14) and leaf %N (August 5)

Treatment	Fresh wt (lbs/A)	Fresh wt (tons/A)	Dry wt (lbs/A)	Head wt untrimmed (lbs)	Whole plant %N	Crop N uptake N/A	Leaf %N 8/5
Untreated	64463.3	32.23	3339.6	2.06	2.99	100.22^{C}	2.58
Drip applied Standard 155	74719.4	37.36	3805.7	2.38	3.01	114.21^{AB}	3.03
Drip applied Moderate 105	65984.9	32.99	3306.3	2.10	3.11	103.49^{BC}	2.88
Drip applied Nitrapyrin 155	72048.1	36.02	3560.5	2.30	3.32	118.14^{A}	3.23
Drip applied Nitrapyrin 105	69997.7	35.00	3558.1	2.23	3.19	113.41^{AB}	2.99
Drip applied NSure 105	71078.3	35.54	3468.5	2.27	3.35	115.93^{AB}	3.06
Drip applied Novatec 105	74308.8	37.15	3799.8	2.37	3.25	123.18^{A}	3.03
Tractor applied Standard 155	71506.3	35.75	3750.1	2.28	3.35	126.36^{A}	3.04
Tractor applied Moderate 105	69411.3	34.71	3526.7	2.21	3.29	116.20^{AB}	3.01
Tractor applied Nitrapyrin 155	69366.6	34.68	3601.9	2.21	3.47	125.08^{A}	3.11
Tractor applied Nitrapyrin 105	70206.6	35.10	3601.2	2.24	3.36	120.90^{A}	3.08
Tractor applied Novatec 105	70646.1	35.32	3511.4	2.25	3.27	114.78^{AB}	2.91
Tractor applied Duration ST 155	67783.1	33.89	3495.2	2.16	3.47	121.35^{A}	2.98
Tractor applied Duration ST 105	68873.8	34.44	3633.0	2.20	3.49	127.11^{A}	2.95
Pr>F treat	0.0664	0.0665	0.1223	0.0703	0.0748	0.0722	0.0565
Pr>F block	<0.0001	<0.0001	0.004	<0.0001	0.1541	0.0028	
LSD $_{0.05}$	5883.4	2.94	336.5	0.18	0.33	-	0.28
LSD $_{0.10}$	4900.8	2.45	280.3	0.15	0.28	-	0.23