2015 Nitrogen Fertilizer Technology Studies on Lettuce

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

Summary: Nitrogen fertilizer technologies are commonly used in the Corn Belt to improve nitrogen use efficiency of applied fertilizer and to reduce nitrogen losses via volatilization of urea and ammonical fertilizers, as well as nitrate leaching. Two general classes of materials exist, nitrification inhibitors and controlled release fertilizers. Nitrification inhibitors disrupt the activity of the bacteria (*Nitrosomonas sp.* and *Nitrobacter sp*.) that convert ammonium to nitrate, thereby maintaining a higher percentage of the nitrogen as positively charge ammonium which is less susceptible to leaching. Controlled release forms of nitrogen slowly release nitrate from plastic coated prills of urea or are forms of urea that slowly break down in the soil. We have evaluated these materials for several years to see if they might have a fit in cool season vegetable production. Materials tested included: NovaTec (ammonium sulfate treated with dimethlpyrazolphosphate (DMPP)); ammonium sulfate treated with nitrapyrin at two rates; and Duration ST, Everest and Galaxy (polyurethane coated prills of urea). Four trials were conducted on lettuce in 2015 to evaluate the efficacy of nitrogen technology. In general, all trial showed positive trends where the fertilizer technologies applied with moderate levels of nitrogen provided an increase in yield over the unamended moderate levels of nitrogen. There were no statistically significant results, but each material showed a trend in the right direction. In some treatments, particularly NovaTec, had increased levels of soil ammonium over a larger portion of the growing cycle than the unamended treatment.

Methods: ***Trials No. 1&2:*** These trials were conducted in cooperation with a grower and Wilbur Ellis, Inc. west of Soledad. The soil type at the site was Metz fine sandy loam. Half the field was preplanted with 400 lbs of 3.5-12-14 (14 lbs N/A). Replications 1 & 2 were on the preplanted area and replications 3 & 4 did not receive preplant. The quantity of nitrogen in the preplant was quite low and we did not feel that it would confound the evaluation. All treatments received an application of anti-crustant of 30 gallons/A of 5-20-0 (15 lbs N/A). Half of the experimental area was planted with romaine and the other half head lettuce on April 21, 2015. The crop was thinned on May 16. Each plot was one 80-inch wide bed by 540 feet long. Two sidedress applications of 20-0-0-5 were made with commercial equipment; the quantity of 20-0-0-5 was adjusted to make the standard, the moderate nitrogen and the moderate nitrogen plus nitrapyrin treatments. Nitrapyrin was applied at 0.5 and 1.0 lbs a.i./A to two treatments. Two 50-foot long strips of Duration and Novatec were included in the trial as observational treatments. These are both dry materials and were applied by hand. See table 1 for rates of materials and timing. The crops were grown with standard production practices. Soil samples were collected every 10 days during the growing. Harvest evaluations were conducted by sampling 60 heads from each plot and weighing and subsampling them for total N content. The harvest for romaine took place on June 26 and head lettuce on July 1. Data was converted to tons/A from stand count data conducted earlier in the season.

Trial No. 3: This trial was 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 trial was seeded with the variety ‘Sun Belt’ on June 17.

Anticrustant at the rate of 25 gallons/A of 6-16-0 (15.5 lbs N/A) was applied on June 18 and the first water was applied on June 19. The field was thinned on July 8. The fertilizer treatments were applied in two ways: a post thinning application was made on July 12 by shanking the fertilizer between the seedlines using a Fairbanks small-plot dry fertilizer applicator; the remainder of all fertilizer treatments were applied through the drip system. The crop was sprinkler irrigated until after thinning when the drip tape was applied on July 12. The first drip irrigation and fertigation to the drip treatments was applied on July 13 and the second on July 29. See table 5 for treatments and rates. Each plot was 2 40-inch beds wide by 150 feet long and replicated 4 times in a RCBD. The field was sprinkler irrigated until thinning and then was irrigated with drip for the rest of the growth cycle. The drip system applications of liquid fertilizer were injected into the drip irrigation system by use of a multi-port manifold with backflow prevention valves which fed two inch layflat that provided water and fertilizer for each treatment. 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. Irrigation levels were managed at 140% of ET. Treatments were evaluated for soil nitrate three times during the growth cycle, and total nitrogen content at harvest. Nitrate leaching was conducted in each plot by sampling down to three feet at the beginning of the cropping season to establish the baseline levels and at the end of the cropping season to evaluate nitrate movement to deeper soil depths.

Trial No. 4: This trial was conducted with a commercial grower south of Gonzales. The soil at the site was Metz fine sandy loam. The fertilizer materials were shanked into the beds with a commercial applicator on April 18. The field was planted to the Romaine lettuce variety 'Sun Belt' on April 20 and the first irrigation was applied on April 21. Each treatment was several 80-inch beds wide by the length of the field. Soil samples were taken roughly every 10 days during the crop cycle. And harvest evaluations were made on June 22 by harvesting 32 heads in three locations in each strip.

Results: ***Trials No. 1&2:*** The standard treatment had the highest levels of mineral nitrogen on the June 18 and July 2 evaluation dates (Table 1). On June 18 both nitrapyrin treatments had higher soil nitrate-N than the moderate or untreated treatments. There were no statistical differences in the fresh weight of romaine at harvest (Table 2). However, there is a trend that indicates that higher dry weight in the nitrapyrin treatments than the moderate nitrogen treatments and greater nitrogen uptake in the nitrapyrin treatments than the moderate treatment. There were few differences in soil mineral nitrogen among the moderate nitrogen treatments (Table 3). There were no statistical differences in the yield of head lettuce among the moderate nitrogen treatments, but there were trends indicating higher yield with the nitrapyrin treatments (Table 4). The same trends were evident in the combined data of both the romaine and head lettuce trials.
Trial No. 3: The main statistical differences were between the untreated and other treatments (Table 5). As was seen in trials 1 & 2, there are trends that indicate higher yield in the fertilizer technology treatments over the moderate nitrogen treatment. The exception was the nitrapyrin at 1.0 lb a.i./A which may have had some phytotoxicity. The nitrogen technology treatments did not have higher percent nitrogen in the tissue, but higher nitrogen uptake than the moderate nitrogen treatment was attributable to greater biomass. The same trends were evident in the tractor and drip applied nitrogen treatments. Yield increases in the nitrogen technology treatments over the moderate nitrogen treatments were typically around 2.0 tons/A. There was greater nitrate at the

2nd foot in the soil at harvest in the standard treatment (Table 6); all other treatments had less nitrate at the 2nd foot. ***Trial No. 4:*** NovaTec maintained higher soil ammonium levels than any other treatment in all sampling dates (Table 7). All treatments maintained elevated levels of nitrate in the soil until the May 21 sampling date. ESN had the highest soil nitrate-N levels until harvest. None of the treatments gave statistically improved yield over the grower's standard treatment (Table 8). However, there is a trend showing Everest and NovaTec had improved yield over the grower's standard.

Table 1. Trial No. 1. Romaine lettuce, nitrate and ammonium levels on five evaluations

Treatment	Sidedress No. 1 May 16 lbs N/A	Sidedress No. 2 May 29 lbs N/A	Total N/A[1]	May 28		June 3		June 11		June 18		July 2	
				NO_3-N ppm	NH_4-N ppm	NO_3-N ppm	NH_4-N ppm	NO_3-N ppm	NH_4-N ppm	NO_3-N ppm	NH_4-N ppm	NO_3-N ppm	NH_4-N ppm
Standard	60	80	140	13.2	12.8	10.6	18.1	18.1	8.0	8.7^{A}	3.8	9.6^{A}	4.8^{A}
Moderate + Nitrapyrin 0.5 lbs a.i./A	60	40	100	6.6	1.7	5.2	4.2	4.6	1.0	2.7^{AB}	0.9	0.7^{B}	0.7^{BC}
Moderate + Nitrapyrin 1.0 lbs a.i./A	60	40	100	4.0	1.0	6.7	5.3	2.9	1.0	2.7^{AB}	2.6	0.9^{B}	0.6^{BC}
Moderate	60	40	100	2.6	0.5	6.5	6.7	3.3	0.7	1.8^{B}	0.4	2.6^{B}	0.8^{AB}
Untreated	0	0	0	2.4	0.6	2.6	0.5	1.8	0.5	1.0^{B}	0.5	0.4^{B}	0.6^{C}
Pr>F treat				0.2433	0.3093	0.1309	0.1481	0.0546	0.3848	0.037	0.2212	0.0159	0.0091
$LSD_{0.05}$				NS	NS	NS	NS	NS	NS	-	NS	-	-
Observational													
Duration	60	40	100	3.8	1.2	3.7	2.5	2.9	4.1	1.5	0.5	0.6	0.7
Novatec	60	40	100	3.2	0.7	4.5	1.1	2.8	2.7	1.3	0.4	0.9	0.9

1 – In addition, all treatments received 15 lbs N/A with the anti-crustant, replications 1&2 14 lbs N/A preplant, reps 3&4 no preplant.

Table 2. Trial No. 1. Romaine lettuce, leaf N on June 11 and yield evaluations and nitrogen uptake on June 26

Treatment	Sidedress No. 1 May 16 lbs N/A	Sidedress No. 2 May 29 lbs N/A	Total N/A[1]	Leaf %N June 11	Mean head wt lbs	Fresh lbs/A	Fresh tons/A	Dry lbs/A	%N	lbs N/A
Standard	60	80	140	3.69	1.76	73,405.9	36.70	4669.4	3.16^{A}	147.3
Moderate + Nitrapyrin 0.5 lbs a.i./A	60	40	100	3.57	1.68	70,252.2	35.13	4409.6	2.85^{BC}	126.3
Moderate + Nitrapyrin 1.0 lbs a.i./A	60	40	100	3.57	1.65	67,468.5	33.73	4363.1	2.86^{BC}	124.5
Moderate	60	40	100	3.62	1.50	66,030.9	33.02	4015.4	2.93^{AB}	116.9
Untreated	0	0	0	2.39	1.32	57,331.2	28.67	3453.3	2.32^{C}	81.9
Pr>F treat				<0.0001	0.1187	0.2141	0.2138	0.0618	0.0211	0.0158
$LSD_{0.05}$				0.0032	NS	NS	NS	NS	-	33.674
Observational										
Duration	60	40	100	3.12	1.62	71,727.4	35.86	4592.3	2.77	127.2
Novatec	60	40	100	2.71	1.52	66,348.9	33.17	4208.3	2.62	110.2

1 – In addition, all treatments received 15 lbs N/A with the anti-crustant, replications 1&2 14 lbs N/A preplant, reps 3&4 no preplant.

Table 3. Trial No. 2. Head lettuce, nitrate and ammonium levels on five evaluations

Treatment	Sidedress No. 1 May 16 lbs N/A	Sidedress No. 2 May 29 lbs N/A	Total N/A[1]	May 28		June 3		June 11		June 18		July 2	
				NO_3-N ppm	NH_4-N ppm	NO_3-N Ppm	NH_4-N ppm	NO_3-N ppm	NH_4-N ppm	NO_3-N ppm	NH_4-N ppm	NO_3-N ppm	NH_4-N ppm
Standard	60	80	140	5.7	0.7	7.8	5.2	14.6[A]	0.5	10.2	3.9	9.0	0.7
Moderate + Nitrapyrin 0.5 lbs a.i./A	60	40	100	4.2	0.6	4.9	1.0	4.3[B]	0.7	3.1	0.5	3.7	1.4
Moderate + Nitrapyrin 1.0 lbs a.i./A	60	40	100	4.6	0.7	9.6	0.7	5.1[B]	3.4	3.1	3.4	3.2	0.9
Moderate	60	40	100	5.0	0.8	8.7	1.7	3.3[BC]	0.5	3.1	0.5	5.8	0.8
Untreated	0	0	0	4.3	0.8	3.9	0.4	1.5[C]	0.5	0.9	0.6	1.2	0.6
Pr>F treat				0.7360	0.6937	0.0625	0.7544	0.0018	0.8572	0.0023	0.3036	0.0483	0.4513
LSD $_{0.05}$				NS	NS	NS	NS	-	NS	3.9011	NS	5.0449	NS

1 – In addition, all treatments received 15 lbs N/A with the anti-crustant, replications 1&2 14 lbs N/A preplant, reps 3&4 no preplant.

Table 4. Trial No. 2. Head lettuce, leaf N on June 11 and yield evaluations on July 2

Treatment	Sidedress No. 1 May 16 lbs N/A	Sidedress No. 2 May 29 lbs N/A	Total N/A[1]	Leaf %N June 11	Fresh lbs/A	Fresh tons/A	Dry lbs/A	%N	lbs N/A	Combined Head and Romaine		
										Fresh tons/A	Dry lbs/A	lbs N/A
Standard	60	80	140	4.56	78,395.0	39.20	3209.0	3.56	114.0	37.95	3,939.2	130.7
Moderate + Nitrapyrin 0.5 lbs a.i./A	60	40	100	4.43	73,126.9	36.56	3344.1	3.09	102.7	35.84	3,876.8	114.5
Moderate + Nitrapyrin 1.0 lbs a.i./A	60	40	100	4.45	73,669.8	36.83	3474.0	3.18	110.4	35.28	3,918.5	117.4
Moderate	60	40	100	4.28	68,997.4	34.50	3232.8	3.10	100.1	33.75	3,624.1	108.4
Untreated	0	0	0	2.70	47,183.2	23.59	2664.6	1.77	48.0	26.12	3,059.0	64.9
Pr>F treat				<0.0001	0.0006	0.0006	0.0610	<0.0001	<0.0001	<0.0001	0.0022	<0.0001
LSD $_{0.05}$				0.3335	11520	5.76	NS	0.2871	15.087	4.38	460.7	16.8

1 – In addition, all treatments received 15 lbs N/A with the anti-crustant, replications 1&2 14 lbs N/A preplant, reps 3&4 no preplant.

Table 5. Trial No. 3. Spence Trial. Application timing, dates and rates (lbs N/A)

Material[1]	App. Method[2]	1st app. N/A	2nd app. N/A	Total N/A	Mean head wt lbs	Fresh yield lbs/A	Fresh yield tons/A	Dry yield lbs/A	Biomass %N	Biomass lbs N/A
Untreated	---	0	0	15	1.76	55,063.0	27.53	2,844.9^{E}	2.67	76.2
Standard	tractor	65	65	145	2.19	68,700.9	34.35	3,244.4^{ABCD}	3.69	119.5
Moderate	tractor	40	20	75	2.02	63,248.6	31.62	2,994.1^{DE}	3.11	93.0
Nitrapyrin 0.50 lb ai	tractor	40	20	75	2.17	68,121.7	34.06	3,183.3^{ABCDE}	3.06	97.5
Nitrapyrin 1.0 lb ai	tractor	40	20	75	2.01	63,150.7	31.58	3,061.5^{BCDE}	2.94	89.7
Duration ST	tractor	40	20	75	2.15	67,509.3	33.75	3,324.5^{AB}	3.07	102.1
Novatec	drip	40	20	75	2.12	66,431.5	33.22	3,163.6^{ABCD}	3.20	101.6
NSure/UN 32 (25:75)	drip	40	20	75	2.20	68,935.8	34.47	3,281.6^{ABC}	3.11	102.1
NSure/UN 32 (25:75) NBPT	drip	40	20	75	2.15	67,383.9	33.69	3,149.0^{ABCD}	3.04	95.5
NSure/24-0-0-10S (25:75)	drip	40	20	75	2.15	67,415.6	33.71	3,104.3^{CDE}	3.27	101.2
Standard	drip	65	65	145	2.26	70,865.1	35.43	3,347.9^{A}	3.36	112.6
Moderate	drip	40	20	75	2.00	62,789.0	31.39	3,054.0^{DE}	2.92	89.4
Pr>F treat					0.0007	0.0007	0.0007	0.0215	<.0001	<.0001
LSD $_{0.05}$					0.19	5,924.7	2.96	**	0.28	11.4

1 all treatments received 15 lbs N/A as an anticrustant; 2 – all 2nd applications were applied with the drip system

Table 6. Trial No. 3. Nitrate-N at three depths in the soil on four sampling dates during the crop cycle

Treatment	depth (ft)	6/10/15*	7/9/15*	7/31/15	8/17/15
Untreated	0-1	22.6	10.4	2.0 ^{BC}	2.1
	1-2	14.9	10.1	-	1.3^{C}
	2-3	12.3	6.9	-	-
155 (Standard) tractor	0-1	22.6	10.4	11.6 ^{AB}	4.7
	1-2	14.9	10.1	-	7.1^{A}
	2-3	12.3	6.9	-	-
105 (Moderate) tractor	0-1	22.6	10.4	5.6 ^{BC}	2.2
	1-2	14.9	10.1	-	2.7^{BC}
	2-3	12.3	6.9	-	-
105 Nitrapyrin 0.50 lb ai tractor	0-1	22.6	10.4	2.9 ^{C}	2.2
	1-2	14.9	10.1	-	2.0^{BC}
	2-3	12.3	6.9	-	-
105 Nitrapyrin 1.0 lb ai tractor	0-1	22.6	10.4	3.8 ^{C}	1.6
	1-2	14.9	10.1	-	1.6^{C}
	2-3	12.3	6.9	-	-
105 Duration ST tractor	0-1	22.6	10.4	4.8 ^{C}	3.4
	1-2	14.9	10.1	-	1.8^{C}
	2-3	12.3	6.9	-	-
105 Novatec drip	0-1	22.6	10.4	2.2 ^{C}	1.8
	1-2	14.9	10.1	-	1.6^{C}
	2-3	12.3	6.9	-	-
105 NSure/UN 32 (25:75) 31.1 drip	0-1	22.6	10.4	5.7 ^{BC}	3.6
	1-2	14.9	10.1	-	1.9^{BC}
	2-3	12.3	6.9	-	-
105 NSure/UN 32 (25:75) 31.5 NBPT drip	0-1	22.6	10.4	3.4 ^{C}	3.4
	1-2	14.9	10.1	-	2.8^{BC}
	2-3	12.3	6.9	-	-
105 NSure/24-0-0-10S 25.2 (25:75) drip	0-1	22.6	10.4	5.2 ^{C}	2.0
	1-2	14.9	10.1	-	2.4^{BC}
	2-3	12.3	6.9	-	-
155 (Standard) drip	0-1	22.6	10.4	16.5 ^{A}	2.1
	1-2	14.9	10.1	-	3.4^{B}
	2-3	12.3	6.9	-	-
105 (Moderate) drip	0-1	22.6	10.4	6.4 ^{BC}	2.4
	1-2	14.9	10.1	-	2.2^{BC}
	2-3	12.3	6.9	-	-

* samples collected on a per rep basis.

Table 7. Trial No. 4. Soil nitrate and ammonium levels on seven evaluation dates during the crop cycle

	Soil ammonium-N ppm							Soil nitrate-N ppm						
Treatment	5/1/15	5/7/15	5/12/15	5/21/15	6/4/15	6/8/15	6/18/15	5/1/15	5/7/15	5/12/15	5/21/15	6/4/15	6/8/15	6/18/15
Everest	2.7	1.5	4.4	2.3	1.6	1.0	0.9	30.1	34.5	38.1	29.7	11.3	4.9	1.9
NovaTec	42.7	22.3	41.0	9.9	9.0	3.4	3.0	20.4	18.7	17.5	18.6	6.1	3.0	1.7
ESN	3.2	0.6	3.2	2.1	0.5	1.1	1.0	36.8	42.6	39.0	33.8	15.1	12.8	7.4
Galaxy	4.0	1.1	4.3	2.3	0.9	1.3	0.8	51.8	49.0	67.0	55.2	13.1	9.4	0.6
Grower's Std	na	na	na	0.5	0.3	0.6	0.4	na	na	na	14.5	3.6	1.8	0.4
Pr>F treat	0.0014	<0.0001	<0.0001	<0.0001	<0.0001	0.0083	0.0014	<0.0001	0.0036	<0.0001	<0.0001	0.0308	0.0039	0.0009
LSD $_{0.05}$	17.0	1.9	10.2	1.2	2.3	1.3	1.0	7.6	13.0	11.8	7.2	7.4	5.2	2.6

Table 8. Trial No. 4. Harvest and nitrogen uptake evaluations on June 22.

Treatment	head wt (lbs)	Fresh (lbs/A)	Fresh (tons/A)	Dry (lbs/A)	%N	lbs N/A
Everest	1.82	86,479.3	43.24	4,996.6	3.05	152.4
NovaTec	1.84	87,187.1	43.59	4,780.7	3.19	152.5
ESN	1.71	77,113.6	38.56	4,436.1	2.91	129.1
Galaxy	1.66	75,506.9	37.75	4,285.2	2.79	119.6
Grower's Std	1.74	81,038.2	40.52	4,549.0	2.88	131.0
Pr>F treat	0.2089	0.0162	0.0162	0.0276	NA	<.0001
LSD $_{0.05}$	NS	7991.4	3.9962	454.41	NA	13.425