2018 Nitrogen Fertilizer Technology Studies on Lettuce

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Summary: Nitrogen (N) fertilizer technologies are commonly used in the Corn Belt to improve nitrogen use efficiency (NUE) of applied fertilizer and to reduce nitrogen losses via volatilization of urea and ammonical fertilizers, as well as nitrate leaching. Nitrification inhibitors disrupt the activity of bacteria (*Nitrosomonas sp.* and *Nitrobacter sp*.) that convert ammonium to nitrate, thereby potentially maintaining a higher percentage of mineral N as positively charge ammonium which is less susceptible to leaching. Nitrification inhibitors are frequently used in the fall in the Corn Belt when cool soil temperatures reduce their degradation. However, it is unclear how long they remain active during the summer production season in the Salinas Valley. In this evaluation, we examined three rates of nitrapyrin (35, 70 and 140 fl oz/A) applied during the first fertigation following thinning and three rates (17.5, 35 and 70 fl oz/A) applied during the first and second fertigation following thinning. The nitrapyrin was applied at a moderate rate of N fertilizer, 80 lbs N/A, which would not result in maximum lettuce yield; this would allow us to observe if any of the treatments provided an increase in yield, thereby indicating an increase in the NUE. These treatments were compared with a standard application (150 lbs N/A) and an untreated control. Other treatments in the trial included Calcinite (15.5-0-0-19), CAN 17 (17-0-0-8.8) and BioLink N14, all applied at the moderate N fertilizer rate. There was low residual soil nitrate (6.9 ppm NO3-N) at the time of the first fertigation and a strong response to applied N in the yield evaluation was observed. The standard treatment had higher fresh biomass, mean head weight and N uptake/A uptake than all other treatments. However, there were no statistical differences between the unamended moderate treatment and the amended moderate treatments in fresh biomass, mean head weight, dry biomass and N uptake. The plots were irrigated excessively (130% crop ET) to leach nitrate and test improvements of NUE by any of the treatments. No statistical improvements in NUE were observed from any of the treatments in this trial.

Methods: This trial was conducted at the USDA Spence Research Station. The soil at the site was Chualar sandy loam: pH 7.22; OM (LOI) 1.45%; Sand, Silt Clay 67, 18, 15%, respectively. The variety 'Sun Valley' was seeded in two seedlines on 40-inch wide beds on June 15 and the first germination water was applied with sprinklers on June 16. No preplant N was applied, and potassium sulfate was applied at 300 lbs/A at listing. The crop was sprinkler irrigated until the plants were thinned to 10 inches apart on July 6. The crop was thinned and one drip tape was installed in the middle of the bed on July 7. All fertilizer was applied through the drip system in two applications on July 13 and July 27 (see Table 1 for rates and types of materials tested). BioLink N14 is a hydrolyzed soybean protein. Given its solubility, we could only apply 10 lbs N/A per application, which required applications in 8 separate irrigations over the crop cycle; this reduced its equivalence to the other moderate N treatments but did provided a first opportunity to work with this material and observe its solubility. The standard fertilizer used was urea ammonium nitrate (UAN 32) except for the treatments that provided all their own N. A drip application system that had 12 separate manifolds was used to apply treatments (one treatment per manifold see photo 1). Battery powered pumps were used to inject fertilizer and fertilizer additive mixtures into each manifold. All injections were made during the middle third of irrigation events. Each plot was two 40-inch beds wide by 100 feet long and treatments were arranged in a randomized complete block design with four replications. The moderate rate of fertilizer was 80 lbs N/A; this rate of N was not sufficient to achieve maximum yield but allowed us to detect improvements in yield by the additives. All amended moderate N treatments were also applied at 80 lbs N/A and any increase in yield over the unamended moderate treatment may indicate a beneficial effect of that treatment. These treatments were compared with the standard

fertilizer treatment (150 lbs N/A) and an untreated control (0 lbs N/A). The field was irrigated with 130% ET which supplied excess irrigation water to test which materials provide an improvement in yield under an excessive irrigation regime. Soil samples were collected from the top foot of soil five times during the crop cycle and analyzed for ammonium (NH_4-N) and nitrate (NO_3-N). Tissue samples of the most recently matured leaf were collected on August 2 and analyzed for total N and calcium (Ca). Lettuce was harvested on August 10 by cutting fifty-four untrimmed heads from the two inside seedlines of each plot and weighing them to provide a measure of total crop biomass. Six heads from each plot were subsampled, dried and analyzed for total N content to provide a measure of biomass N.

Results:
In the leaf tissue samples, the untreated control had lower N in the leaves than all other treatments; all other treatments did not different from each other (Table 1). There were no differences in the percent Ca in the leaf tissue in any of the treatments. There was a strong response to applied N in the yield evaluation. The untreated control had lower yield and N uptake than all other treatments. The standard treatment had higher fresh biomass, mean head weight and N uptake/A uptake than all other treatments. The unamended moderate N treatment yield was intermediate to the untreated control and standard treatments which provided an opportunity to determine if the experimental treatments improved yield and nitrogen use efficiency. However, there were no statistical differences between the unamended moderate treatment and the amended treatments in fresh biomass, mean head weight, dry biomass and N uptake.

There were low amounts of residual soil nitrate (6.9 ppm NO_3-N) in the soil prior to the first fertigation (Table 2). Following the July 13 fertigation, Calcinit, CAN 17 and standard treatment had the highest levels of nitrate and ammonium in the soil; other than this observation, none of the amended moderate N treatments had higher ammonium or nitrate than the unamended moderate N treatment.


Photo 1. Injection manifold

Table 1. Application protocol of fertilizer treatments, tissue Ca and N, and yield of lettuce

Material	Additive Rate	Total Fertilizer N/A	Tissue - Aug 2[3]		Yield - August 10					
			%N	%Ca	Fresh Biomass tons/A	Mean head lbs	% solids	Dry Biomass lbs/A	Total biomass %N	Total biomass N/A
Untreated	---	0	2.24	0.61	17.017	1.09	7.04	2365.7	2.10	49.5
Standard N	---	150	3.42	0.60	28.963	1.85	5.51	3199.8	3.38	107.5
Moderate N	---	80	3.24	0.64	25.801	1.65	5.88	3024.1	2.87	86.8
Nitrapyrin 35 fl oz[1]	35 fl oz/A 1x	80	3.29	0.63	26.980	1.72	5.88	3162.9	2.91	91.4
Nitrapyrin 70 fl oz[1]	70 fl oz/A 1x	80	3.32	0.57	26.354	1.68	5.67	2991.0	2.87	85.6
Nitrapyrin 140 fl oz[1]	140 fl oz/A 1x	80	3.30	0.59	25.899	1.65	5.87	3043.3	2.80	85.2
Nitrapyrin 17.5 fl oz[2]	17.5 fl oz/A 2x	80	3.28	0.62	26.214	1.67	6.14	3215.2	2.73	87.7
Nitrapyrin 35 fl oz[2]	35 fl oz/A 2x	80	3.28	0.63	25.721	1.64	5.84	3002.4	2.77	83.2
Nitrapyrin 70 fl oz[2]	70 fl oz/A 2x	80	3.29	0.59	26.921	1.72	5.74	3089.5	2.87	88.4
Calcinit (15.5-0-0-19)	258 lb/A	80	3.43	0.58	25.859	1.65	5.93	3067.1	2.91	89.1
CAN 17 (17-0-0-8.8)	18.6 gallons/A	80	3.27	0.65	26.681	1.70	5.69	3035.2	3.01	91.2
BioLink N14	5 lbs/5 gallons	80	3.18	0.59	24.378	1.55	5.84	2848.8	2.95	83.8
Pr>F treat			<0.0001	0.6311	<0.0001	<0.0001	0.0245	0.0047	<0.0001	<0.0001
LSD $_{0.05}$			0.34	NS	2.287	0.14	0.71	360.7	0.25	10.1

1 – one application made on July 13; 2 – two applications made on July 13 and July 27; 3 – youngest mature leaf

Table 2. Mineral nitrogen levels in the top foot of soil on five evaluation dates during the crop cycle

Material	Additive Rate	July 13[3]		July 17		July 25		August 2		August 14	
		NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N
Untreated	---	0.9	6.9	0.9^{C}	3.6^{E}	0.8	4.3	0.8^{F}	1.8^{F}	0.9	1.7^{C}
Standard N	---	0.9	6.9	6.4^{A}	18.9^{AB}	1.3	9.0	1.8^{AB}	17.1^{A}	1.2	7.4^{A}
Moderate N	---	0.9	6.9	2.7^{B}	11.2^{D}	1.0	9.2	1.1^{CD}	8.1^{BC}	0.9	4.6^{ABC}
Nitrapyrin 35 fl oz[1]	35 fl oz/A 1x	0.9	6.9	3.2^{AB}	13.0^{CD}	1.2	5.3	1.1^{CD}	6.9^{BCD}	1.0	2.9^{BC}
Nitrapyrin 70 fl oz[1]	70 fl oz/A 1x	0.9	6.9	2.7^{B}	11.8^{D}	1.1	5.0	1.4^{BC}	4.1^{DEF}	1.2	3.3^{BC}
Nitrapyrin 140 fl oz[1]	140 fl oz/A 1x	0.9	6.9	3.2^{B}	12.1^{D}	1.2	4.9	2.2^{A}	5.1^{CDEF}	1.4	2.6^{BC}
Nitrapyrin 17.5 fl oz[2]	17.5 fl oz/A 2x	0.9	6.9	2.7^{B}	13.4^{BCD}	1.1	4.4	1.1^{CD}	5.2^{CDE}	1.1	3.3^{BC}
Nitrapyrin 35 fl oz[2]	35 fl oz/A 2x	0.9	6.9	2.6^{B}	13.7^{BCD}	2.0	9.0	1.2^{BC}	6.1^{BCDE}	1.1	3.5^{BC}
Nitrapyrin 70 fl oz[2]	70 fl oz/A 2x	0.9	6.9	3.7^{AB}	12.1^{D}	1.6	4.2	1.6^{A}	3.6^{DEF}	1.1	1.9^{C}
Calcinit (15.5-0-0-19)	258 lb/A	0.9	6.9	0.9^{C}	23.0^{A}	0.9	7.3	0.9^{EF}	8.8^{B}	0.9	5.5^{AB}
CAN 17 (17-0-0-8.8)	18.6 gallons/A	0.9	6.9	0.8^{C}	17.8^{ABC}	0.9	9.4	0.9^{EF}	7.9^{BC}	0.9	4.4^{ABC}
BioLink N14	5 lbs/5 gallons	0.9	6.9	0.8^{C}	4.4^{E}	0.9	3.8	1.1^{DE}	3.1^{EF}	1.0	4.7^{ABC}
Pr>F treat		NA	NA	<.0001	<.0001	0.2056	0.0930	<.0001	<.0001	0.0900	0.0323

1 – one application made on July 13; 2 – two applications made on July 13 and July 27; 3 – baseline soil sample