2019 Nitrogen Fertilizer Technology Studies on Romaine 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. In the east, nitrification inhibitors are frequently used in the fall 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 two rates of nitrapyrin (35 and 70 fl oz/A) applied one time in the first fertigation following thinning and three rates (17, 35 and 70 fl oz/A) applied two times during the first and second fertigations. The nitrapyrin was applied with a sub-optimal amount of N fertilizer, 80 lbs N/A, which would allow us to observe if any of the treatments provided an increase in yield. These treatments were compared with a standard application (150 lbs N/A) and an untreated control. Other treatments evaluated in this trial included Agrotain Plus SC (a DCD nitrification inhibitor additive) and the following liquid organic fertilizers: True 7-0-0 (liquid soy protein hydrolysate); True 4-2-2 (beet extract & corn steep liquor); True 3-1-5 (fish and molasses); and True 6.5-0.5-0 (fish protein hydrolysate) all applied at the moderate N fertilizer rate (80 lbs N/A). The irrigation water had 4.5 ppm NO_3-N and there was low residual soil nitrate (2.4 ppm NO_3-N).

A strong response to applied N was observed. The standard treatment had higher total biomass N uptake and percent N than all other treatments. There was no statistical difference in fresh biomass and mean head weight between the standard treatment and the unamended sub-optimal rate of N, as well as most of the sub-optimal plus additives or the organic fertilizers; however, there are numerical trends in which nitrapyrin at 17 and 70 fl oz/A applied two times and True 6.5-0.5-0, were similar to the standard treatment. There were no statistically significant differences in dry biomass between the standard and sub-optimal treatments, but following treatments have numerically similar dry biomass weights to the standard treatment: nitrapyrin applied two times at 17 fl oz/A, Agrotain Plus SC applied two times, True 7-0-0 and True 6.5-0.5-0. The nitrapyrin treatments tended to have lower soil nitrate values than the unamended sub-optimal treatment; these results may give some evidence the nitrapyrin is reducing the amount of nitrate, although commensurately higher ammonium levels were not observed.

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 romaine lettuce variety ‘Sun Valley’ was seeded in two seedlines on 40-inch wide beds on July 1 and the first germination water was applied with sprinklers on July 3. 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 22. Drip irrigation tape was placed on the in the middle of each bed on July 24. All fertilizer was applied through the drip system in two applications on July 29 and August 13 (see Table 1 for rates and types of materials tested). The fertilizer used for the standard, moderate, nitrapyrin and Agrotain Plus SC treatments was urea ammonium nitrate (UAN 32). A drip application system that had 13 separate manifolds was used to apply treatments (one treatment per manifold see photo 1). Battery powered pumps were used to inject fertilizers and additive mixtures into each manifold. Injections of the UN 32 treatments were made during the middle third of irrigation events, but the organic materials were applied over a longer portion of the irrigation event due to their lower concentration of N. Water was run long enough to clean out the fertilizer at the end of all the fertigations. 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. All amended moderate N treatments were also applied at 80 lbs N/A and any increase in yield over the unamended sub-optimal 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 to provide an improvement in yield under an excessive irrigation regime. Soil samples were collected from the top foot of soil four times during the crop cycle and analyzed for ammonium (NH_4-N) and nitrate (NO_3-N). Lettuce was harvested on August 29 by cutting 48 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: There was a strong response to applied N in the trial. The standard treatment had greater percent N in the tissue and total biomass N than all other treatments other treatments. There was no statistical difference in fresh biomass and mean head weight between the standard treatment and the unamended sub-optimal rate of N, as well as most of the sub-optimal plus additives or the organic fertilizers; however, there are numerical trends in which nitrapyrin at 17 and 70 fl oz/A applied 2 times and True 6.5-0.5-0, yielded similarly to the standard treatment. There were no statistically significant differences in dry biomass between the standard and sub-optimal treatments, but following treatments had dry biomass weights similar to the unamended sub-optimal treatment: nitrapyrin applied two times at 17 fl oz/A, Agrotain Plus SC applied two times, True 7-0-0 and True 6.5-0.5-0.

There were low amounts of residual soil nitrate (2.4 ppm NO_3-N) in the soil prior to the first fertigation (Table 2). The standard treatment had higher soil nitrate levels than all other treatments on the three evaluation dates following the fertigation events on July 29 and August 13. The nitrapyrin treatments had numerically lower levels of nitrate than the moderate treatment on all three soil sampling dates.


Photo 1. Injection manifold

Table 1. Yield and biomass N evaluations on August 10, 2019

Material	Additive Rate	Total Fertilizer N/A	Yield and N uptake evaluations					
			Fresh Biomass tons/A	Mean head lbs	% solids	Dry Biomass lbs/A	Total biomass N/A	Total biomass %N
Untreated	---	0	16.02^{C}	1.02^{C}	5.90^{A}	1883^{C}	39.7^{D}	2.10^{E}
Standard N	---	150	27.51^{AB}	1.75^{AB}	5.15^{BC}	2836^{AB}	92.1^{A}	3.26^{A}
Moderate N	---	80	25.89^{AB}	1.65^{AB}	5.17^{BC}	2685^{AB}	77.6^{B}	2.90^{BC}
Nitrapyrin	35 fl oz/A 1x	80	26.58^{AB}	1.70^{AB}	5.09^{BC}	2700^{AB}	76.8^{B}	2.86^{BC}
Nitrapyrin	70 fl oz/A 1x	80	25.91^{AB}	1.65^{AB}	5.23^{BC}	2709^{AB}	75.8^{B}	2.80^{BCD}
Nitrapyrin	17 fl oz/A 2x	80	27.42^{AB}	1.75^{AB}	5.21^{BC}	2864^{A}	82.5^{AB}	2.89^{BC}
Nitrapyrin	35 fl oz/A 2x	80	26.18^{AB}	1.67^{AB}	4.84^{C}	2525^{BC}	76.0^{B}	3.01^{AB}
Nitrapyrin	70 fl oz/A 2x	80	27.20^{AB}	1.73^{AB}	4.91^{C}	2670^{AB}	78.5^{B}	2.94^{BC}
Agrotain Plus SC	2.6 gal/180 gal UN32 2x	80	26.32^{AB}	1.68^{AB}	5.50^{AB}	2895^{A}	80.0^{B}	2.76^{BCD}
True 7-0-0	---	80	26.33^{AB}	1.68^{AB}	5.50^{AB}	2899^{A}	79.1^{B}	2.73^{CD}
True 4-2-2	---	80	26.51^{AB}	1.69^{AB}	5.17^{BC}	2741^{AB}	73.8^{BC}	2.71^{CD}
True 3-1-5	---	80	25.46^{B}	1.62^{B}	5.07^{BC}	2575^{ABC}	65.5^{C}	2.55^{D}
True 6.5-0.5-0	---	80	28.17^{A}	1.80^{A}	5.03^{BC}	2834^{A}	77.0^{B}	2.72^{CD}
Pr>F treat			<.0001	<.0001	0.0064	0.0407	<.0001	<.0001

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

Material	Additive Rate	July 29		Aug 8		Aug 19		Aug 30	
		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	---	0.2	2.4	0.6^{D}	2.0^{E}	0.4^{F}	1.8^{F}	0.5^{D}	2.3^{D}
Standard N	---	0.2	2.4	1.4^{A}	14.3^{A}	1.9^{ABCD}	18.6^{A}	3.1^{A}	13.1^{A}
Moderate N	---	0.2	2.4	0.9^{BCD}	7.9^{B}	2.9^{A}	10.3^{AB}	1.4^{BC}	5.9^{BCD}
Nitrapyrin	35 fl oz/A 1x	0.2	2.4	0.5^{D}	5.4^{BCD}	2.2^{ABC}	7.3^{ABC}	1.5^{BC}	3.4^{CD}
Nitrapyrin	70 fl oz/A 1x	0.2	2.4	0.6^{D}	5.9^{BCD}	1.8^{ABCDE}	5.1^{CDE}	2.3^{AB}	2.9^{CD}
Nitrapyrin	17 fl oz/A 2x	0.2	2.4	0.7^{CD}	5.2^{CD}	1.5^{BCDEF}	7.9^{BCD}	1.8^{AB}	5.3^{BCD}
Nitrapyrin	35 fl oz/A 2x	0.2	2.4	0.9^{BCD}	5.3^{BCD}	2.8^{A}	6.1^{BCDE}	2.1^{AB}	2.3^{D}
Nitrapyrin	70 fl oz/A 2x	0.2	2.4	0.9^{ABCD}	3.5^{DE}	2.5^{AB}	4.9^{CDEF}	2.4^{AB}	3.1^{CD}
Agrotain Plus SC	2.6 gal/180 gal UN32 2x	0.2	2.4	1.3^{AB}	5.4^{BCD}	2.1^{ABC}	5.7^{BCDE}	1.9^{AB}	4.6^{BCD}
True 7-0-0	---	0.2	2.4	0.7^{CD}	4.9^{CD}	1.4^{BCDEF}	6.4^{CDE}	1.3^{BCD}	6.4^{BC}
True 4-2-2	---	0.2	2.4	0.7^{CD}	6.0^{BCD}	1.3^{CDEF}	6.7^{BCD}	1.3^{BCD}	6.3^{BC}
True 3-1-5	---	0.2	2.4	0.5^{D}	4.0^{CDE}	0.6^{EF}	3.6^{EF}	0.7^{CD}	5.1^{BCD}
True 6.5-0.5-0	---	0.2	2.4	1.0^{ABC}	6.4^{BC}	0.8^{DEF}	4.4^{DEF}	1.5^{BC}	7.7^{B}
Pr>F treat		NA*	NA*	0.0029	<.0001	0.0017	0.0003	0.0028	0.0002