2016 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 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 breakdown at higher soil temperatures and it is unclear how long they remain active in Salinas Valley soils given soil temperatures during the summer production season. In this evaluation, we examined two rates of nitrapyrin (0.5 and 1.0 lbs a.i./A) applied: 1) total amount applied on dry ammonium sulfate in the first fertilizer application, 2) total amount applied with urea ammonium nitrate (UN 32) in the first fertigation and 3) total amount split between the first and second fertigations. Fertilizer treatments evaluated included a standard application (150 lbs N/A) compared with a moderate rate of fertilizer (80 lbs N/A) intended to not supply sufficient N to achieve optimal yield. All fertilizer technology treatments were applied at the moderate rate to observe if they provided an increase in yield, thereby indicating an increase in the nitrogen use efficiency (NUE). An increase in NUE would probably be due to a higher percentage of applied nitrogen fertilizer remaining as ammonium which is less likely to leach beyond the root zone during irrigation events. We observed a lower yield in the 0.5 and 1.0 lb a.i./A nitrapyrin treatments applied on dry ammonium sulfate in the first sidedress application; it is unclear as to the mechanism for the observed yield reduction. In the fertigation treatments, there was a trend indicating a higher yield of the moderate treatment + nitrapyrin over the unamended moderate treatment when the nitrapyrin application was split between both the first and second fertigation. These results may indicate a greater efficacy of nitrapyrin on yield and improved NUE when it is applied over a longer portion of the crop cycle vs just in one application.

Methods: This trial was conducted at the USDA Spence Research Station. The soil at the site was Chualar loamy sand: pH 6.98; CEC 17.9; OM (LOI) 1.76%; Sand, Silt Clay 60, 24, 16%, respectively. The variety 'Sun Valley' was seeded on June 21 and the first sprinkler germination water was applied on June 22. No nitrogen was applied at or prior to planting. The crop was sprinkler irrigated until thinning (10 inch spacing) on July 15. Fertilizer was applied in two ways: 1) dry fertilizers applied in the first application (July 19) followed by liquid fertilizer injected into the drip system for the second application (August 5); and 2) liquid fertilizer injected into the drip system for both the first (July 22) and second fertilizer (August 5) applications. Dry fertilizer materials were applied with a Fairbanks small-plot dry fertilizer applicator on July 19. The dry materials were applied with two shanks applied to the inside of the seedlines 2-3 inches deep. The surface drip irrigation was installed on July 20 and 21 and was used to irrigate and fertigate the crop for the remainder of the crop cycle. Treatments fertigated on the first application date were applied on July 22, and all treatments that received a second fertilizer application, were fertigated on August 5 (see Table 1). Fertilizer used for all fertigations was urea ammonium nitrate (UAN 32). A 12 mainline manifold was used to apply the fertilizers to each treatment and to keep the treatments separate. 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. Nitrapyrin at 0.5 and 1.0 lbs a.i./A was applied in three methods: 1) total quantity of nitrapyrin was applied to ammonium sulfate crystals and applied as a dry material, 2) total quantity of nitrapyrin was applied in the first fertigation, and 3) the total quantity of nitrapyrin was divided in half and split between the first and second fertigation (see Table 1). Each plot was two 40-inch beds wide by 100 feet long and all treatments were arranged in a randomized complete block design with four replications. All experimental fertilizer treatments were applied at a moderate fertilizer amount (80 lbs N/A) and were compared with an unamended treatment also applied at 80 lbs N/A and a standard treatment applied at 150 lbs N/A. Nitrapyrin rates (0.5 and 1.0 lbs a.i./A) were applied based on the area treated. The field was irrigated with 130% ET which supplied excess irrigation water to test which materials maintain a greater percentage of mineral N as ammonium which is less likely to leach. Soil samples were collected four times during the crop cycle. Lettuce was harvested on August 23 by cutting thirty six heads from each plot, weighing them and subsampling them for dry weigh and total N content.

Results: All treatments had significantly higher yield parameters than the untreated control indicating a good yield response to applied N in the trial. The following table shows the preliminary soil mineral nitrogen levels at planting on June 21 and prior to the first fertilizer application on July 22. Residual soil nitrate levels were low at the trial site at the beginning of the trial through thinning.

	Depth	NH_4-N	NO_3-N	Total
June 21	1st foot	2.23	9.64	11.87
	2nd foot	2.16	4.71	6.86
July 22	1st foot	2.90	9.27	12.17
	2nd foot	2.26	6.53	8.79

Dry fertilizer applied by tractor followed by fertigation of liquid fertilizer treatments: There was no difference in yield between the standard treatment (150 lbs N/A) and the unamended moderate treatment (80 lbs N/A). Even though yield did not differ, there was a significantly less N uptake in the moderate N treatment. The nitrapyrin treatment had more ammonium and less nitrate on July 28 and less nitrate on August 5 and 18 than the unamended moderate treatment (Table 2). There was a trend indicating lower yield in the nitrapyrin treatments than the unamended moderate treatment and it appears that some difference in the N nutrition of the nitrapyrin treatment when applied to ammonium sulfate may have negatively affected the yield of lettuce. All feather meal was all applied on the first fertilizer application and it released N more slowly than other treatments. It had low ammonium and nitrate levels on July 28 which was 7 days after activation of the material by irrigation water and indicates that there may have resulted in low N available to the lettuce crop at this stage of the crop cycle. On August 5 there were high nitrate and ammonium levels in the soil, but they returned to low levels by August 18. It had the lowest yield, N uptake and N concentration in crop tissue of all fertilizer treatments. ***Fertigation of liquid fertilizer for both fertilizations:*** There was significantly lower yield in the unamended moderate N treatment than the standard treatment in the drip application followed by drip application treatments. There was no difference in yield between the unamended moderate N rate and nitrapyrin treatments applied only in the first fertigation application. However, there was a trend of higher yield in the nitrapyrin treatments split between the first and second fertigations over the unamended moderate N treatment. All nitrapyrin treatments had lower nitrate in the soil on the August 5 and August 18 soil sampling dates. This data may give evidence that nitrapyrin applications spread over a large part of the crop cycle may have a more beneficial effect on yield than nitrapyrin applications made at one point in the crop cycle. This result may give some indication that the longevity of nitrapyrin in the soil may be limited due to warm summer soil temperatures which ranged from 70 to 75 °F during the course of the trial.

Table 1. Application protocol of fertilizer treatments and yield components of lettuce on August 23

Material	Nitrapyrin application timing	1st Application		2nd Application		Total	Fresh Biomass tons/A	Head wt lbs	% solids	Dry Biomass lbs/A	N uptake lbs/A	Tissue %N
		Method	lbs N/A	Method	lbs N/A	N/A						
Untreated	---	---	0	---	0	0	17.897	1.14	5.72	2,042.3	52.2	2.56
Standard	---	dry tractor	75	liq. drip	75	150	27.706	1.77	5.30	2,938.1	107.6	3.66
Moderate	---	dry tractor	40	liq. drip	40	80	27.359	1.74	5.08	2,776.6	94.8	3.43
Nitrapyrin 0.50 lb ai[1]	1st app.	dry tractor	40	liq. drip	40	80	24.697	1.57	5.29	2,603.3	88.6	3.41
Nitrapyrin 1.0 lb ai[1]	1st app.	dry tractor	40	liq. drip	40	80	25.961	1.66	5.18	2,681.5	89.5	3.35
Feather meal 12-0-0[2]	---	dry tractor	80	liq. drip	0	80	23.014	1.47	5.36	2,469.7	73.0	2.97
Standard	---	liq. drip	75	liq. drip	75	150	28.313	1.81	5.00	2,814.9	102.4	3.64
Moderate	---	liq. drip	40	liq. drip	40	80	23.566	1.50	5.21	2,458.1	80.6	3.29
Nitrapyrin 0.50 lb ai[3]	1st app.	liq. drip	40	liq. drip	40	80	23.832	1.52	5.40	2,573.9	82.0	3.19
Nitrapyrin 1.0 lb ai[3]	1st app.	liq. drip	40	liq. drip	40	80	24.619	1.57	5.12	2,519.7	80.6	3.21
Nitrapyrin 0.50 lb ai[4]	1st & 2nd app.	liq. drip	40	liq. drip	40	80	25.363	1.62	5.13	2,592.4	83.3	3.21
Nitrapyrin 1.0 lb ai[4]	1st & 2nd app.	liq. drip	40	liq. drip	40	80	25.727	1.64	5.36	2,758.9	86.3	3.14
Pr>F treat							<0.0001	<0.0001	0.1179	<0.0001	<0.0001	<0.0001
$LSD_{0.05}$							2.980	0.19	ns	283.5	9.2	0.31

1 - total quantity of nitrapyrin applied in the 1st application on ammonium sulfate; 2 – all feather meal applied in the first application with the tractor; 3 - total quantity of nitrapyrin applied in the first application in UN32; 4 – total quantity of nitrapyrin split between 1st and 2nd applications in UN32

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

Treatment	Application Methods	Total N applied	July 28			August 5			August 18		
			NH_4-N	NO_3-N	total	NH_4-N	NO_3-N	total	NH_4-N	NO_3-N	total
Untreated	---	0	2.43^{D}	2.90	5.33	2.34^{D}	6.41	8.75	2.26^{F}	1.94^{E}	4.21^{E}
Standard	tractor/drip	150	22.21^{A}	5.40	27.61	8.99^{A}	23.01	32.00	7.42^{AB}	11.39^{A}	18.80^{A}
Moderate	tractor/drip	80	4.31^{ABC}	7.31	11.61	6.38^{BC}	20.74	27.12	2.55^{BCD}	7.29^{AB}	9.84^{ABC}
Nitrapyrin 0.50 lb ai[1]	tractor/drip	80	7.70^{A}	2.59	10.29	4.72^{AB}	16.10	20.82	8.90^{ABC}	2.77^{CD}	11.67^{ABCD}
Nitrapyrin 1.0 lb ai[1]	tractor/drip	80	7.26^{AB}	2.21	9.47	9.19^{AB}	6.60	15.79	5.77^{A}	2.29^{DE}	8.06^{AB}
Feather meal 12-0-0[2]	tractor/drip	80	2.50^{CD}	3.12	5.62	2.06^{D}	11.73	13.79	2.66^{CDE}	4.25^{BCD}	6.91^{BCD}
Standard	drip/drip	150	5.82^{A}	12.19	18.01	2.96^{ABC}	22.60	25.56	2.35^{DEF}	8.15^{A}	10.50^{A}
Moderate	drip/drip	80	3.22^{ABCD}	7.28	10.50	2.98^{BC}	20.87	23.86	2.15^{F}	4.87^{ABC}	7.02^{BCD}
Nitrapyrin 0.50 lb ai[3]	drip/drip	80	3.48^{ABCD}	7.94	11.41	2.89^{CD}	12.53	15.42	2.57^{DE}	2.74^{DE}	5.31^{DE}
Nitrapyrin 1.0 lb ai[3]	drip/drip	80	3.46^{ABC}	5.62	9.07	3.43^{ABC}	7.59	11.01	2.40^{DEF}	2.78^{DE}	5.18^{DE}
Nitrapyrin 0.50 lb ai[4]	drip/drip	80	2.78^{BCD}	7.08	9.85	2.60^{CD}	11.34	13.94	2.39^{EF}	3.84^{BCD}	6.22^{BCD}
Nitrapyrin 1.0 lb ai[4]	drip/drip	80	3.80^{AB}	3.79	7.58	2.93^{CD}	12.36	15.29	2.45^{DEF}	3.00^{CD}	5.45^{CDE}
Pr>F treat			0.0310	0.0681	0.1634	0.0010	0.1971	0.2452	<.0001	<.0001	0.0004

1 - total quantity of nitrapyrin applied in the 1st application on ammonium sulfate; 2 – all feather meal applied in the first application with the tractor; 3 - total quantity of nitrapyrin applied in the first application in UN32; 4 – total quantity of nitrapyrin split between 1st and 2nd applications in UN32