

2011 Nitrification Inhibitor Trials

University of California Cooperative Extension, Monterey County

Richard Smith and Aaron Heinrich, Vegetable Crop and Weed Science Farm Advisor and Staff Research Assistant

Summary: The key comparison in these trials is between the moderate level of applied N with and without the fertilizer additives tested in these trials. The moderate level of N was chosen in order to not maximize yield, but to be able to observe improvements in yield that fertilizer additives may provide. We were examining whether nitrification inhibitors can improve nitrogen use efficiency. Nitrification inhibitors slow the mineralization of ammonium to nitrate. Ammonium has a positive charge and can be bound to the negative charges on soil clay and organic matter and thereby be less susceptible to leaching. If successful, this technology can help increase the efficiency of applied nitrogen, increase yields and reduce nitrate leaching. Two trials were conducted and increase in fresh yield of the moderate rate of applied N was observed in the Agrotain Plus treatment over the same treatment without the additive. There were no differences in any of the other yield components evaluated. In a second trial on a much lighter and more gravelly soil, no differences were observed in any of the moderate N rate treatments and those with additives. These results were not as positive as we had hoped, but the one positive result indicates that there is promise for this technology; there may be factors that affect the function of these material that we do not yet fully understand.

Methods: Trial No. 1: Conducted at the Hartnell East Campus Research Facility. No preplant nitrogen was applied to the field prior to planting with the romaine variety 'Green Towers' on April 18. Each plot was 2 40-inch beds wide by 120 feet and replicated 3 times in a RCBD. The soil type was Chualar loam. The field was germinated with drip irrigation on April 19 and was irrigated with drip for the entire growth cycle; irrigation water that was applied at 176% of crop ET. A small amount of nitrogen was applied 2 weeks following planting on April 27. The lettuce was thinned on May 12. Two fertigation applications of N were applied (see Table 1). Biomass evaluations were conducted on June 6 and 13, and harvest was conducted on June 20. See tables for dates of soil sampling and biomass evaluations. **Trial No. 2:** Conducted at the USDA Spence Research Station. 300 lbs/A of potassium chloride (180 pounds K/A) was applied at listing approximately one month prior to planting. The romaine variety 'Green Towers' was seeded on June 15. The anti-crustant 7-7-0-7 was applied at the rate of 35 gallons/A after seeding (provided 25 lbs N/A to all treatments). Each plot was 2 40-inch beds wide by 162 feet long and replicated 4 times in a RCBD. The soil type was Chualar loam. The field was sprinkler irrigated through thinning and then was switched to drip irrigation for the remainder of the crop cycle beginning July 12; irrigation water was applied at 193% of crop ET. Two fertigation applications were made (see Table 6). Biomass evaluations were conducted on July 28 and August 3, and harvest was conducted on August 10. See tables for dates and evaluations. **Details common to both trials:** First and second sidedress of the liquid fertilizer treatments 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 (and additives added at the appropriate rates). 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. Soil mineral nitrogen was monitored in both trials five times by collecting 8-12 soil cores (3/4" in

diameter by 1 foot deep) per plot; samples were homogenized and KCl extracts of the soil was taken and the extract analyzed for nitrate and ammonium. Nitrate leaching was evaluated in each plot using suction lysimeters.

Results: *Trial No. 1:* This trial had an untreated control and standard fertilizer treatment in comparison with a moderate N fertilizer treatment with and without nitrification inhibitor additives (Table 1). There were few differences in the quantities of ammonium measured in the soil (Table 2). On June 9, there was greater ammonium in the 4% DCD treatment than the 100 lbs N/A treatment. On May 25 there was less nitrate in the soil in the Agrotain Plus treatment and the 4% DCD treatment than the 100 lbs N/A treatment; on May 31, these two treatments and the 8% DCD treatments were lower than the 100 lbs N/A treatment. On June 9 only the 8% DCD treatment was lower than the 100 lbs N/A treatment. On June 6 and 13 there were no differences in biomass, N content or N uptake between the fertilizer treatments; however, all fertilizer treatments had greater biomass, N concentration and N uptake than the untreated control (Table 3). At harvest on June 20, there was a significant response to nitrogen with the untreated having the lowest yield and the standard treatment the highest yield (Table 4). Agrotain Plus had greater fresh yield than the 100 lbs N/A treatment. There were no significant differences between these two treatments on the other yield and N uptake parameters. N uptake by roots was a small percentage of total crop uptake (Table 5). Interestingly, there was greater root biomass, but lower N concentration in tissue and total N uptake in the untreated control.

Trial No. 2: This trial had an untreated control and standard fertilizer treatment in comparison with a moderate N fertilizer treatment with and without nitrification inhibitor additives (Table 6). All treatments, including the untreated control, had 25 lbs N/A applied at planting as an anticrustant to facilitate establishment of the stand of lettuce. There was no increase in the levels of soil ammonium in any of the moderate N fertilizer treatments with nitrification additives over the moderate N fertilizer treatment without additives (Table 7). The differences in soil ammonium levels were mostly between the untreated control and other treatments. There were no differences detected in levels of soil nitrate-N between the treatments until the final evaluation date on August 2 when the moderate N fertilizer treatment had significantly greater soil nitrate-N than all other moderate N fertilizer treatments with nitrification inhibitor additives except 771G77 @ 2 gal/A. There were differences in biomass N concentration and N uptake between the untreated control and all other treatments on July 28 (Table 8); no differences were observed between the moderate N fertilizer rates with and without additives. On the second biomass evaluation on August 3, the only significant differences in biomass, mean head weight and N concentration and uptake were measured between the untreated control and all other treatments; no differences were observed between the moderate N fertilizer rates with and without additives. At harvest on August 10, all significant differences observed between treatments were between the untreated control and other treatments.

Table 1. Trial No. 1. Nitrogen application details

Total seasonal lbs N/A applied and nitrification treatments	Lbs N/A Early season N April 27	Lbs N/A First Sidedress May 19	Lbs N/A Second Sidedress May 31	Total N/A applied
Untreated	10	0	0	10
150 (Standard N)	10	70	70	150
100 (moderate level)	10	45	45	100
100 + AgrotainPlus ¹	10	45	45	100
100 + DCD @ 4% ²	10	45	45	100
100 + DCD @ 8% ²	10	45	45	100

1 – rate = 15 lbs per ton of UN 32 (640 lbs N/ton) contains approximately 1.8% dicyandiamide (DCD)/lb N. 2 – rate = 4 or 8% DCD/lb N of fertilizer N/A.

Table 2. Trial No. 1. Soil ammonium and nitrate levels in the soil on five evaluation dates

Treatments (lbs N over season and additives)	Ammonium-N					Nitrate-N				
	May 17	May 25	May 31	June 9	June 16	May 17	May 25	May 31	June 9	June 16
Untreated	0.6	0.5	0.7	0.5	1.0	5.5	5.0	4.0	3.2	3.2
150 (Standard N)	0.6	1.6	1.7	1.1	1.0	6.0	9.7	13.4	22.1	17.2
100 (moderate level)	0.8	1.6	1.5	1.0	1.1	5.5	9.8	18.0	16.5	9.8
100 + AgrotainPlus	0.7	2.2	1.7	0.9	1.4	4.8	7.8	10.5	14.8	22.8
100 + DCD @ 4%	0.7	1.4	1.2	1.9	1.4	5.7	6.1	12.4	19.7	7.8
100 + DCD @ 8%	0.5	2.5	2.4	1.3	0.9	5.7	11.2	8.2	11.0	15.3
Pr>F treat	0.226	0.606	0.197	<0.001	0.613	0.824	0.044	0.009	0.002	0.278
Pr>F block	0.481	0.798	0.896	0.094	0.225	0.508	0.752	0.141	0.282	0.859
LSD 0.05	NS	NS	NS	0.4	NS	NS	1.7	1.9	2.0	NS

Table 3. Trial No. 1. Biomass evaluations on two dates: Fresh and dry biomass, N concentration in leaf and N uptake by crop

Treatments (lbs N over season and additives)	June 6				June 13			
	Biomass Fresh wt.	Biomass Dry biomass	Biomass N concentration	N uptake by plant	Biomass Fresh wt.	Biomass Dry biomass	Biomass N concentration	N uptake by plant
	tons/A	lbs/A	percent	lbs N/A	tons/A	lbs/A	percent	lbs N/A
Untreated	3.8	521.5	3.0	15.6	10.6	1441.2	2.6	37.5
150 (Standard N)	5.2	668.6	4.3	29.0	15.7	1958.0	3.8	74.3
100 (moderate level)	5.0	656.0	4.2	27.3	14.5	1806.2	3.5	63.4
100 + AgrotainPlus	5.5	704.3	4.3	30.0	15.6	1993.8	3.5	69.8
100 + DCD @ 4%	4.9	661.2	4.2	27.8	13.6	1775.0	3.5	62.1
100 + DCD @ 8%	5.2	675.4	4.2	28.6	14.6	1846.5	3.6	65.6
Pr>F treat	0.004	0.012	<0.001	<0.001	0.016	0.110	0.010	0.017
Pr>F block	0.162	0.024	0.192	0.026	0.613	0.491	0.287	0.895
LSD 0.05	0.7	87.0	0.3	2.9	2.7	399.1	0.5	18.5

Table 4. Trial No. 1. Yield evaluation on June 20: Fresh and dry biomass, N concentration in leaf and N uptake by crop

Treatments (lbs N over season and additives)	Yield Fresh wt. tons/A	Yield Dry biomass lbs/A	Mean head weight lbs	Biomass N concentration percent	N uptake by plant lbs N/A	N uptake lbs N/A/day
Untreated	12.8	1775	0.85	2.3	40.0	0.4
150 (Standard N)	22.7	2775	1.51	3.1	85.9	1.9
100 (moderate level)	20.1	2540	1.34	2.7	68.2	0.8
100 + AgrotainPlus	22.3	2734	1.48	2.9	78.7	1.5
100 + DCD @ 4%	20.4	2647	1.36	2.7	71.0	1.5
100 + DCD @ 8%	20.8	2629	1.39	2.9	75.8	1.7
Pr>F treat	<0.001	<0.001	<0.001	0.001	<0.001	
Pr>F block	0.576	0.131	0.579	0.053	0.765	
LSD 0.05	2.0	267	0.14	0.3	11.5	

Table 5. Trial No. 1. Root biomass and N uptake

Treatments (lbs N over season and additives)	Mean root dry wt g/root	Root dry biomass lbs/A	N in root tissue percent	N uptake by roots lbs N/A	Percent crop N uptake in roots
Untreated	5.3	348.5	0.80	2.8	6.5
150 (Standard N)	3.7	247.1	1.74	4.2	4.7
100 (moderate level)	4.6	302.1	1.39	4.2	5.8
100 + AgrotainPlus	3.6	235.8	1.65	3.9	4.7
100 + DCD @ 4%	4.1	271.7	1.38	3.6	4.8
100 + DCD @ 8%	3.6	238.9	1.52	3.6	4.5
Pr>F treat	0.003	0.003	<0.001	<0.001	
Pr>F block	0.012	0.012	0.004	0.026	
LSD 0.05	0.7	48.6	0.26	0.3	

Table 6. Trial No. 2: Nitrogen application details

Treatments ¹ (lbs N over season and additives)	Anticrustant June 15	Lbs N/A First fertigation July 18	Lbs N/A Second fertigation July 27	Total applied N/A
Untreated	25	0	0	25
155 (Standard N)	25	65	65	155
105 (moderate level)	25	40	40	105
105 + Agrotain ¹	25	40	40	105
105 + 2x Agrotain	25	40	40	105
105 + DCD @ 4% ²	25	40	40	105
105 + DCD @ 8% ²	25	40	40	105
105 + 2 gals 771G77 ³	25	42.3	37.7	105
105 + 4 gals 771G77 ⁴	25	44.7	35.3	105
105 + 8 gals 771G77 ⁵	25	49.4	30.6	105

1 – rate = 15 lbs per ton of UN 32 (640 lbs N/ton) contains approximately 1.8% dicyandiamide (DCD)/lb N; 2 – rate = 4 or 8% DCD/lb N fertilizer N; 3 - contains 4.7 lbs N as a carrier; 4 - contains 9.4 lbs N as a carrier; 5 - contains 18.8 lbs N as a carrier

Table 7. Trial No. 2. Soil ammonium and nitrate levels in the soil on five evaluation dates

Treatments (lbs N over season and additives)	Ammonium-N					Nitrate-N				
	14-Jun	13-Jul	20-Jul	26-Jul	2-Aug	14-Jun	13-Jul	20-Jul	26-Jul	2-Aug
Untreated	1.4	2.2	1.1	1.1	1.3	0.8	31.9	9.7	4.9	9.8
155 (Standard N)	1.4	3.2	6.0	1.5	5.4	0.8	28.2	15.6	14.2	23.5
105 (moderate level)	1.4	2.2	3.6	1.4	4.6	0.8	24.7	12.2	9.0	21.4
105 + Agrotain	1.4	1.6	2.3	1.3	3.6	0.8	21.3	13.5	7.4	13.8
105 + 2x Agrotain	1.4	1.6	2.9	1.6	5.6	0.8	18.8	12.8	6.7	10.9
105 + DCD @ 4%	1.4	1.8	4.4	2.5	3.2	0.8	24.5	12.9	7.3	9.8
105 + DCD @ 8%	1.4	2.0	3.8	1.4	6.0	0.8	23.4	12.9	8.2	9.8
105 + 2 gals 771G77	1.4	2.0	2.4	1.1	2.8	0.8	23.4	10.5	9.2	14.9
105 + 4 gals 771G77	1.4	1.4	1.9	1.5	3.1	0.8	25.0	13.8	9.8	13.0
105 + 8 gals 771G77	1.4	1.4	2.4	1.0	3.9	0.8	17.8	11.8	12.5	6.9
Pr>F treat	NA	0.265	0.061	0.024	0.002	NA	0.51	0.937	0.177	0.002
Pr>F block	NA	0.413	0.354	0.216	0.180	NA	0.134	0.445	0.33	0.139
LSD 0.05	NA	NS	2.8	0.8	2.1	NA	NS	NS	NS	7.6

Table 8. Trial No. 2: Biomass evaluations on two dates: Fresh and dry biomass, N concentration in leaf and N uptake by crop

Treatments ¹	July 28	August 3
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(lbs N over season and additives)	Biomass Fresh wt.	Biomass Dry biomass	Mean Head wt	Biomass N	N uptake by plant	Biomass Fresh wt.	Biomass Dry biomass	Mean Head wt	Biomass N	N uptake by plant
	tons/A	lbs/A	lb/head	percent	lbs N/A	tons/A	lbs/A	lb/head	percent	lbs N/A
Untreated	6.2	868.9	0.46	2.8	24.2	8.6	1,232	0.63	2.1	26.4
155 (Standard N)	7.1	974.5	0.52	4.1	39.6	15.0	1,888	1.10	3.8	72.5
105 (moderate level)	7.0	977.8	0.52	3.8	37.0	14.3	1,818	1.05	3.6	65.4
105 + Agrotain	6.9	935.7	0.51	3.8	35.7	13.6	1,774	1.00	3.4	60.0
105 + 2x Agrotain	7.3	992.8	0.54	3.8	37.4	14.1	1,841	1.04	3.4	63.0
105 + DCD @ 4%	6.3	880.1	0.46	3.8	33.8	13.5	1,787	0.99	3.6	63.5
105 + DCD @ 8%	7.4	977.5	0.54	3.8	37.6	14.5	1,844	1.07	3.5	64.6
105 + 2 gals 771G77	7.1	975.9	0.52	3.8	36.7	14.0	1,820	1.03	3.5	63.2
105 + 4 gals 771G77	6.9	952.8	0.51	3.7	35.4	13.1	1,778	0.96	2.9	51.8
105 + 8 gals 771G77	6.9	950.0	0.51	3.7	35.0	12.7	1,700	0.94	3.2	53.8
Pr>F treat	0.293	0.472	0.306	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pr>F block	0.578	0.011	0.683	0.812	0.020	0.523	0.077	0.559	0.082	0.447
LSD 0.05	NS	NS	NS	0.2	5.1	1.6	187	0.12	0.2	7.4

Table 9. Trial No. 2: Yield evaluation on August 10

Treatments ¹ (lbs N over season and additives)	Yield Fresh wt. tons/A	Yield dry biomass lbs/A	Mean Head wt lb/head	Biomass N percent	N uptake by plant lbs N/A	Biomass accumul ation tons/A/d
Untreated	13.5	1,736	0.99	1.6	28.0	0.8
155 (Standard N)	25.7	2,717	1.89	2.8	77.1	1.8
105 (moderate level)	23.3	2,494	1.71	2.5	63.0	1.5
105 + Agrotain	22.4	2,391	1.65	2.4	56.7	1.5
105 + 2x Agrotain	23.6	2,577	1.73	2.5	63.2	1.6
105 + DCD @ 4%	23.2	2,561	1.70	2.5	65.2	1.6
105 + DCD @ 8%	24.8	2,710	1.82	2.5	68.8	1.7
105 + 2 gals 771G77	24.6	2,664	1.81	2.6	69.7	1.8
105 + 4 gals 771G77	21.4	2,418	1.57	2.2	53.7	1.4
105 + 8 gals 771G77	22.5	2,472	1.65	2.4	59.5	1.6
Pr>F treat	<0.001	<0.001	<0.001	<0.001	<0.001	
Pr>F block	0.833	0.012	0.815	0.029	<0.001	
LSD 0.05	2.4	258	0.17	0.2	7.1	