2012 Spinach Nitrogen Fertilizer Evaluations

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Summary: A trial was conducted on a first crop site with a sandy loam texture. Given the dry winter, it was difficult to locate the trial on a site with low levels of residual soil nitrate. The site had 20 ppm nitrate-N at the onset of the trial; however, in spite of this high level, there was a strong response to applied nitrogen in the trial. It is assumed that between the germination water and subsequent sprinkler irrigations that the nitrate was moved below the rooting zone of the spinach. Rooting depth evaluations indicated that the roots of this spinach crop extended down to 11.5 inches deep in the soil 3 weeks after the first germination water.

The trial evaluated various rates and timings of Duration 45 (D45) which is a controlled release fertilizer with a relatively 'rapid' release pattern. It was tested either alone or followed by topdress application of ammonium sulfate; this material was compared with a grower standard and untreated control. The preplant applications of D45 either alone or followed by a topdress application gave the highest yield in the trial. A second trial included some other fertilizer treatments, but had to be abandoned because the trial site was accidentally treated with topdress fertilizer 18 days after the first germination water. However, one interesting observation was that the nitrification inhibitor, DMPP applied on granular ammonium nitrate maintained high levels of ammonium-N in the soil for 14 days following the first germination water. The results from these trials indicate that controlled release fertilizers and nitrification inhibitors may have a role for use in spinach production. If this turns out to be the case, they may be able to provide a tool to help increase the nitrogen use efficiency of applied nitrogen to spinach.

Methods: ***Trial No. 1:*** The trial was conducted on a commercial spinach production field with a cooperating grower north of Salinas. The soil at the site was Placentia sandy loam. This was the first crop of the season on this block, but residual soil nitrate levels were still high following the dry winter; however, we took the chance that they would be low enough to allow for the spinach to respond to applied nitrogen. A fertilizer trial was established and each plot was one 80-inch bed wide by 15 feet long with four replications and laid out in a randomized complete block design. There were three fertilizer application timings: 1) preplant, 2) at-planting, and 3) topdressed – see tables for application rates and fertilizer type. The slow release fertilizer, D45, was applied on April 27 (four days prior to planting) by applying the fertilizer prills to the surface of the soil and then running the bed shaper over the beds to mulch the fertilizer prills to a depth of 3 inches. The spinach variety 'Missouri' was seeded on May 1. The at-planting fertilizer treatments were made on the same day by hand spreading the dry fertilizer materials on the top of the bed; the first sprinkler applied germination water was applied on May 2 which incorporated the at-planting fertilizer applications into the soil. Topdress materials were made on May 21 by hand applying ammonium sulfate to the top of the bed which was watered in on May 22. The spinach was harvested on June 4 (33 days after the first germination water) by hand harvesting an area 0.5 m^2 in each plot. The harvested spinach was weighed and a subsampled was dried, ground and sent to the UC Davis analytical laboratory for total nitrogen analysis.

Trial No. 2: The trial was conducted on a commercial spinach production field with a cooperating grower south of Castroville. The soil at the site was Arnold sandy loam soil. This

was the first crop of the season on this block and residual soil nitrate levels were low. The plot size and treatments were laid out as described above; the preplant applications were made on May 30 and the field was planted on June 13. The trial was accidentally topdressed during the application to the rest of the field and the trial was terminated half way through the growth cycle; however, one set of soil and biomass evaluations were conducted before terminating the trial.

Results: ***Trial No. 1:*** Due to the relatively dry winter, the residual soil nitrate-N levels were 20.3 ppm at the beginning of the trial (Table 1). This was higher than ideal for a nitrogen fertilizer trial, but high residual soil nitrate levels were difficult to avoid in the spring of 2012. Duration 45 (D45) is a polyurethane coated urea prill that was tested at various rates and timings (see Table 1). The nitrate-N levels in the untreated control declined to 15.0 ppm on May 10 and continued to steadily decline over the course of the growing season and were 2.6 ppm at harvest. Soil nitrate-N levels in the at-planting and preplant applications of 80 lbs N/A as D45 were not significantly different than the untreated control on May 10, whereas the preplant application of 120 lbs N/A of D45 and 80 lbs N/A (with 40 lbs N/A as ammonium sulfate at-planting (treatment 2)) had 26.6 and 26.5 ppm nitrate-N respectively, on May 10. All treatments declined to under 10 ppm nitrate-N by harvest except for treatment 6 – 120 lbs N/A preplant as D45 plus 80 lbs N/A topdress.

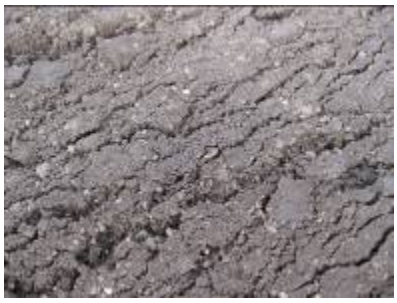
The untreated control had low ammonium levels throughout the trial (Table 2). The 120 lbs N/A as D45 applied preplant (treatment 1) had moderate ammonium levels throughout the season. The high soil ammonium levels on May 23 probably reflected a rapid release of ammonium following the topdress application made to those treatments on May 21.

The preplant applications of D45 either alone or followed by a topdress application gave the highest yield in the trial (Table 3). Following these treatments, all the rest of the fertilizer treatments yielded at a similar level. The untreated control gave substantially lower yield indicating that, although there was 20 ppm nitrate-N at the beginning of the trial, the nitrate levels declined steadily and were not sufficient to attain maximum yield. We do not know how much irrigation water was applied to the soil, but the soil was sandy and it can be assumed that nitrate from the germination water and subsequent irrigations was sufficient to move nitrate below the root zone. Spinach rooting depth was measured on two dates: on May 16: deepest roots were found at 9.5”, and the greatest density of roots was found at 4-6” deep; May 24 deepest roots were found at 11.5” and greatest root density was still at 4-6” deep. There was some soil compaction at 6-8” which may have affected rooting depth.

Trial No. 2: This trial was an iteration of trial 1 and it was unfortunate that it had to be discontinued. In spite of this problem, the trial provided us with a glimpse into how the materials functioned during the first 22 days of the trial. There was a low amount of both ammonium and nitrate on July 2(14 days after first germ water) in the untreated control (treatment 7) (Table 4). There were sizeable amounts of ammonium-N in the other treatments, but a very large amount was measured in the DMPP treatment. DMPP is a nitrification inhibitor that is used in Europe and appears to have effectively reduced the mineralization of ammonium to nitrate for 14 days at this site. Nitrate-N levels were at moderate levels in all treatments except the untreated control on July 2. On July 10 we discovered that fertilizer had been accidentally applied over the trial area and we conducted a quick biomass evaluation to salvage some data from the trial. All treatments that were evaluated had greater fresh and dry yield, percent N in the tissue and N uptake over the untreated control.

D45 applied to unmulched soil

Mulching in D45



Mulched bed with D45

Fert. plot showing grower fert. application omitted from trial site (note lack of white fert. in trial area)

Spinach growth near harvest

Table 1. Trial No. 1. Nitrate-N in top foot of soil on five dates

Treatment No.	Pre-plant fert. & lbs N/A	At-planting fert. & lbs N/A	Top dress fert. & lbs N/A	Total lbs N/A	April 30[1]	May 10	May 16	May 23	June 6
1	120 D45[2]	0	0	120	20.3	26.6	28.6	29.6	5.3
2	80 D45	40	0	120	20.3	26.5	27.4	32.4	5.8
3	80 D45	0	80 AS	160	20.3	19.2	21.0	23.9	6.1
4	0	80 D45	80 AS	160	20.3	16.9	18.2	16.7	5.5
5	0	80 AS[4]	80 AS	160	20.3	20.3	26.5	19.0	3.1
6	120 D45	0	80 AS	200	20.3	26.8	36.0	34.3	15.2
7	0	0	0	0	20.3	15.0	11.9	8.2	2.6
8	87 U&AS[3]	0	95 AS	182	20.3	21.8	22.9	18.8	4.6
				Pr>F treat	NA	0.0001	0.0012	0.0024	<0.0001
				$LSD_{0.05}$	NA	4.7	8.9	11.2	3.2

1 – Baseline soil sample at the beginning of the trial; 2 – Duration 45: Polyurethane coated urea (44% N);
3 – mixture of urea and ammonium sulfate – 29% N; 4 – Ammonium sulfate

Table 3. Trial No. 1. Ammonium-N in top foot of soil on five dates

Treatment No.	Pre-plant fert. & lbs N/A	At-planting fert. & lbs N/A	Top dress fert. & lbs N/A	Total lbs N/A	April 30[1]	May 10	May 16	May 23	June 6
1	120 D45[2]	0	0	120	1.5	9.2	5.6	9.2	4.7
2	80 D45	40	0	120	1.5	11.2	11.6	11.6	2.8
3	80 D45	0	80 AS	160	1.5	4.8	7.3	36.5	9.2
4	0	80 D45	80 AS	160	1.5	6.7	15.2	52.7	12.4
5	0	80 AS[4]	80 AS	160	1.5	13.6	22.0	86.8	23.2
6	120 D45	0	80 AS	200	1.5	5.1	16.4	58.8	8.5
7	0	0	0	0	1.5	1.7	3.0	2.1	2.3
8	87 U&AS[3]	0	95 AS	182	1.5	7.1	7.4	24.5	8.6
				Pr>F treat	NA	0.1450	0.0040	0.0009	0.1047
				$LSD_{0.05}$	NA	NS	9.0801	35.118	NS

1 – Baseline soil sample at the beginning of the trial; 2 – D45 = Duration 45: Polyurethane coated urea (44% N);
3 – mixture of urea and ammonium sulfate – 29% N; 4 – Ammonium sulfate

Table 3. Trial No. 1. Yield and nitrogen uptake evaluation on June 4 (33 days after germination water)

Treatment No.	Pre-plant fert. & lbs N/A	At-planting fert. & lbs N/A	Top dress fert. & lbs N/A	Total lbs N/A	Yield fresh lbs/A	Yield fresh tons/A	Yield dry lbs/A	Tissue N percent	Tissue N lbs/A
1	120 D45[1]	0	0	120	28,521	14.3 ab	2,474	5.5	136.5
2	80 D45	40	0	120	26,181	13.1 bc	2,222	5.3	117.8
3	80 D45	0	80 AS	160	31,812	15.9 a	2,439	5.6	136.7
4	0	80 D45	80 AS	160	24,527	12.3 bc	2,017	5.1	102.0
5	0	80 AS[3]	80 AS	160	26,248	13.1 b	2,176	5.0	108.9
6	120 D45	0	80 AS	200	30,225	15.1 a	2,316	5.9	135.9
7	0	0	0	0	13,656	6.8 d	1,382	3.1	43.1
8	87 U&AS[2]	0	95 AS	182	25,346	12.7 bc	2,182	4.9	106.3
				Pr>F treat	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
				$LSD_{0.05}$	4,450	2.2	225	0.3	13.4

1 – Duration 45: Polyurethane coated urea (44% N); 2 – mixture of urea and ammonium sulfate – 29% N; 3 – Ammonium sulfate

Table 4. Trial No. 2. Ammonium and nitrate-N (July 2) and biomass and nitrogen uptake evaluations (July 10)

Treatment No.	Pre-plant fert. & lbs N/A	At-planting fert. & lbs N/A	Total lbs N/A[1]	NH_4-N July 2	NO_3-N July 2	Fresh biomass T/A	Dry biomass lbs/A	N in tissue %	N uptake lbs N/A
1	120 D45[2]	0	120	6.1	16.9	1.814	298.1	5.32	15.82
2	80 D45	40	120	13.6	22.7	---	---	---	---
3	80 D45	0	80	6.7	16.0	1.319	233.1	5.05	11.87
4	120 D45	40	160	16.7	22.7	---	---	---	---
5	0	80 SU[3]	80	9.2	19.2	1.404	250.6	5.07	13.37
6	0	80 DMPP[4]	80	55.4	10.4	---	---	---	---
7	0	0	0	2.1	4.5	0.296	79.5	3.47	2.79
8	87 U&AS[5]	0	87	13.0	13.9	1.372	242.6	5.39	13.10
			Pr>F treat	0.0001	0.0001	0.0203	0.0198	0.0006	0.0216

1 – the trial was cut short and these totals do not reflect the amount of nitrogen that would have been topdressed if the trial had run to its conclusion; 2 – Duration 45: Polyurethane coated urea (44% N); 3 – Super U (urea with urease inhibitor and nitrification inhibitor); 4 – DMPP applied on granular ammonium sulfate (nitrification inhibitor not registered for use in the US); 5 – mixture of urea and ammonium sulfate – 29% N; 3 – Ammonium sulfate