NITROGEN FERTILIZER RATE X TIME OF APPLICATION STUDIES

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Introduction

Post emergence applications of nitrogen fertilizer were discouraged in Manitoba prior to the 1990's. With the advent of quality payment for sugar beets and the achievement of consistently higher plant populations over the past decade, the option of applying some nitrogen after planting was reevaluated. The main objective of these studies was to determine if post emergence nitrogen applications could result in better management of nitrogen levels once a population of sugar beets was established.

Methods

Five experiments were conducted between 1990 and 1992 to assess the effect of splitting the nitrogen fertilizer applied so that a portion was added after sugar beets had emerged. Another six experiments were conducted between 1993 and 1995 to further evaluate splitting the nitrogen application using a wider range of nitrogen fertilizer rates. Individual tests between 1990 and 1992 used a latin square design with 6 treatments, while the 1993-95 tests used a factorial design with 12 treatments and 6 replications. The 1993-95 tests were also arranged in 6 columns, however, column differences were not accounted for in any tests when statistical analysis was performed over locations.

Soil testing to a 4 ft depth was conducted the fall before planting sugar beets for all experiments, 1990-95 inclusive. Urea was the nitrogen carrier used in all the tests conducted. All preplant incorporated (ppi) nitrogen applications were banded at 6 inch spacing, to a 3 inch depth. Post emergence (post-e) nitrogen applications were broadcast when sugar beets were in the 4-6 to the 8-10 leaf stage, depending on the location. Post-e nitrogen was incorporated immediately after application with a S-tine row crop cultivator. Five different sugar beet varieties were used in the 11 individual tests conducted. Varieties included Betaseed Beta 1996, Beta 2259, KW 1479 and Hilleshog HM 1254 and HM 7022. All tests used 4 row plots planted in 22 inch rows with final dimensions of 7.5 x 30 feet. Planting dates ranged from May 2nd to May 21st.

For the 1990-92 tests, the recommended rate of nitrogen based on the soil test, was applied ppi or split applied 2/3 ppi + 1/3 post-e to sugar beets thinned to either a low (77 beets/100ft) or high (177 beets/100ft) population. These populations equate to 18295 and 42055 plants/acre, respectively. Sugar beets were hand thinned at leaf stages ranging from 4 to 8-10 leaf. Two additional treatments were applied using 2/3 the recommended nitrogen rate ppi on a low and a high population of sugar beets. The high population had an additional application of 2/3 the recommended nitrogen rate applied post-e. PPI treatments were applied the fall prior to growing sugar beets for the 1990 and 1991 tests. PPI treatments were applied in the spring, prior to seeding sugar beets in 1992.

For the 1993-95 tests nitrogen rates of 0, 45, 90 and 135 lbs N/acre were applied ppi in the fall, as a fall ppi/post-e split application and entirely post-e. In addition to yield and quality results, leaf color ratings were reported for these tests. Leaf color was rated in mid to late August to compare the degree to which leaves in different treatments were green or yellow, higher numbers indicating leaves which were more yellow. These tests were planted to a final stand at 5.25 inch spacing.

For all tests, 1990-95 inclusive, the center 2 rows of each plot were harvested in their entirety for yield, sugar and impurity analysis. Harvest dates ranged from September 18th to October 16th.

Results (1990 - 1992)

Soil testing results for 5 split nitrogen application tests (1990-92) are reported in Table 1. Soil nitrate nitrogen levels from 0 to 2 feet were considered moderate in 1990 and 1992 and low in 1991. Nitrate nitrogen levels from 2 to 4 feet were considered normal for Manitoba. Nitrogen recommendations are not adjusted when nitrate nitrogen levels are below 40 lbs/acre from 2 to 4 feet. The average 0 to 2 foot soil nitrate nitrogen level for the 5 experiments was 42 lbs/acre. This soil nitrate level resulted in an average nitrogen recommendation of 81 lbs N/acre for the 5 tests.

Table 1. Soil testing results for 5 split nitrogen application tests (1990-92).

	1990	1991A	1991B	1992A	1992B
Depth	Soil nitrate nitrogen (lbs/acre)				
0-2 feet	51	29	24	53	51
2-4 feet	16	25	16	34	25
Nitrogen recommendation (lbs N/ac)	65	103	110	61	65
Soil textural class	Sandy clay loam	Clay loam	Very fine sandy loam	Clay loam	Very fine sandy loam

A summary of sugar beet stand, yield and quality results for the 1990-92 split nitrogen tests is reported in Table 2. The treatments applied had no significant effect on sugar beet yield but significantly affected the extractable sugar/tonne (EST) of sugar beets. Treatments with a high sugar beet population(177 beets/100 ft.) averaged about 4 kg/tonne more extractable sugar than treatments with a low sugar beet population (77 beets/100 ft.), when they received the same nitrogen fertilizer application.

EST was the same when comparing splitting the recommended nitrogen fertilizer rate or applying it all prior to planting on a low sugar beet population. Applying two thirds of the recommended nitrogen rate tended to increase EST when the sugar beet population was low, although this increase was not significant. This may indicate that the recommended nitrogen rate could be further reduced when the population of sugar beets is low.

A high population of sugar beets had significantly higher EST when the nitrogen was split applied than when it was all applied prior to planting. Split applying more than the recommended rate of nitrogen significantly reduced the EST of a high sugar beet population compared to split applying the recommended rate.

Significant treatment effects were observed in extractable sugar/acre (ESA) and these were primarily the result of the significant differences observed in EST. Treatments with a high population had more ESA than treatments with a low population of sugar beets. Splitting the nitrogen recommendation or applying it all ppi did not have a significant impact on ESA.

The established stand was the stand after hand thinning the sugar beets. Harvested stand represented sugar beets which were harvested by the mechanical lifter. High population treatments had 26% fewer sugar beets after harvest than at establishment, while the number of beets was essentially the same when this comparison was made for low populations. Splitting the nitrogen recommendation or applying higher or lower than recommended nitrogen rates had no effect on sugar beet stand.

Table 2. Summary of results for 5 split nitrogen application tests (1990-92).

Treatment	Extractable Sugar (kg/ acre)	(kg/ tonne)	Beet Yield (tonnes/ acre)	Established Stand (pl/100')	Harvested Stand (pl/100')
77 beets/100', Recommended N rate (ppi)	2741	151.70	18.07	77	79
177 beets/100', Recommended N rate (ppi)	2851	154.11	18.54	177	130
77 beets/100', 2/3 rec. N (ppi) + 1/3 rec. N (post-e)	2743	151.62	18.19	77	77
177 beets/100', 2/3 rec. N (ppi) + 1/3 rec. N (post-e)	2839	157.41	18.10	177	130
77 beets/100', 2/3 rec. N (ppi)	2772	153.45	18.06	77	79
177 beets/100', 2/3 rec. N (ppi) + 2/3 rec. N (post-e)	2892	153.73	18.85	177	132
Mean	2806	153.67	18.30	127	104
LSD (.05)	106	2.30	NS		4.5
LSD (.01)	NS	3.02	NS		5.9
C.V. (%)	7	2.95	7.23		14.1

Results (1993 - 1995)

Soil testing results for 6 nitrogen timing/rate tests (1993-95) are reported in Table 3. Soil nitrate nitrogen levels from 0 to 2 feet were considered moderate to low. Nitrate nitrogen levels from 2 to 4 feet were considered normal for Manitoba. The average 0 to 2 foot soil nitrate nitrogen level for the 6 experiments was 34 lbs/acre. This soil nitrate level resulted in an average nitrogen recommendation of 91 lbs N/acre for the 6 tests.

Table 3. Soil testing results for 6 nitrogen timing/rate tests (1993-95).

	1993A	1993B	1994A	1994B	1995A	1995B
Depth	Soil nitrate nitrogen (lbs/acre)					
0-2 feet	10	38	37	47	45	24
2-4 feet	52	46	23	41	20	33
Nitrogen rec. (lbs N/ac)	123	81	87	69	74	109
Soil textural class	Sandy loam	Clay	Clay	Loam	Clay loam	Clay
Organic Matter (%)	3.8	4.1	6.1	4.8	5.8	4.8

A summary of sugar beet stand, leaf color, yield and quality results for the 1993-95 nitrogen timing/rate tests is reported in Tables 4 and 5. No significant differences were observed in beet yield, extractable sugar/acre (ESA) or extractable sugar/tonne (EST) with different timings of nitrogen application. EST was slightly higher when nitrogen applications were split, however differences were not significant like they were in the 1990-92 tests. Amino nitrogen was the only quality factor significantly affected by the timing of nitrogen application, post-e applications having a higher average value than ppi or split applications. This would agree with late August leaf color ratings which showed entirely post-e nitrogen applications to have greener leaves than the other two application timings. One of six tests also showed a significant reduction in early season vigor when nitrogen was applied entirely post-e.

It should be noted at this point that the 1994 and 1995 tests were conducted in years when rainfall and soil mineralization of nitrogen were higher than normal in the latter part of the growing season. Check treatments with no nitrogen applied and relatively low soil test nitrogen levels yielded an average of 24.1 tonnes/acre in these two years. Sugar beet yield response to increasing nitrogen fertilizer rates was less than expected in light of the fall soil tests in 1994 and 1995. The only significant yield increase when averaging all 6 tests occurred with the first 45 lb N/acre application of fertilizer.

The nitrogen fertilizer rates applied had a more expected effect on EST than on beet yield. Increasing fertilizer rates reduced EST in a stepwise manner. This reduction in EST was the sum of a significant reduction in percent sugar and a significant increase in loss to molasses. The loss to molasses increase was due to amino nitrogen and sodium increases in the beet. Potassium was unaffected by nitrogen fertilizer addition. Leaf canopy color in late August was significantly greener with higher nitrogen applications.

The maximum ESA for the 6 tests occurred with a nitrogen rate of 45 lbs N/acre. This is half the rate recommended by soil tests but is consistent with higher amounts of mineralization having occurred in 4 of the 6 tests. The timing of nitrogen application or the rate applied did not have a significant effect on either emergence or harvested stands in these tests. Populations in these tests were consistently high and were in line with what growers are currently trying to achieve commercially. No timing of application x nitrogen rate interactions were observed for any of the factors measured in these tests. Some significant location x nitrogen rate interactions occurred for some factors as might be expected with the differing environmental conditions over the 3 years of testing.

Summary (1990 - 1995)

These tests indicated that applying some of the nitrogen after planting would be a reasonable option if a grower wanted to adjust the nitrogen rate once a population of sugar beets was established. When plant populations were adequate, applying some of the recommended nitrogen after planting produced similar extractable sugar/acre and tended to increase extractable sugar/tonne when compared with applying all the recommended nitrogen fertilizer ppi. A 1/3 lower than recommended nitrogen rate was sufficient for maximum extractable sugar/acre when a low population of sugar beets was established. There was no indication that sugar beets required more nitrogen than was recommended by soil tests to achieve maximum extractable sugar/acre or extractable sugar/tonne. There was no indication that soil test recommendations should change based on the timing of nitrogen application.

Table 4. Timing x nitrogen rate tests (1993-1995) - 6 test average.

TREATMENT	Extractable Sugar kg/acre	kg/ tonne	Sugar %	Loss to Molasses %	Beet Yield tonnes /acre
TIMING OF N APPLICATION					
ppi (fall)	2750	136.87	16.46	2.44	19.94
ppi(fall)/post-e	2773	137.62	16.52	2.42	20.03
post-e	2727	135.99	16.41	2.48	19.97
LSD (.05)	NS	NS	NS	NS	NS
LSD (.01)	NS	NS	NS	NS	NS
NITROGEN RATE (lb N/ac)					
0	2690	138.96	16.61	2.38	19.14
45	2793	137.97	16.55	2.42	20.14
90	2779	135.99	16.41	2.48	20.33
135	2737	134.39	16.28	2.51	20.32
LSD (.05)	56	1.88	0.14	0.06	0.34
LSD (.01)	74	2.47	0.18	0.08	0.45
RATE x TIMING (lb N/ac, N timing)					
0, (check)	2703	137.86	16.50	2.38	19.40
45, fall banded	2766	138.29	16.58	2.42	19.87
90, fall banded	2769	136.86	16.47	2.45	20.03
135, fall banded	2760	134.45	16.30	2.52	20.46
0, (check)	2682	139.06	16.63	2.39	19.08
45, 2/3 fall banded - 1/3 post-e broadcast	2808	138.67	16.60	2.40	20.17
90, 2/3 fall banded - 1/3 post-e broadcast	2834	136.91	16.46	2.43	20.58
135, 2/3 fall banded - 1/3 post-e broadcast	2768	135.85	16.38	2.46	20.31
0, (check)	2685	139.94	16.69	2.36	18.94
45, post-e broadcast	2804	136.93	16.48	2.45	20.39
90, post-e broadcast	2735	134.20	16.30	2.55	20.38
135, post-e broadcast	2684	132.87	16.16	2.54	20.19
INTERACTIONS					
Timing of application x N rate	NS	NS	NS	NS	NS
Location x timing of application	NS	NS	NS	NS	NS
Location x N rate	**	**	**	*	**
Location x timing x N rate	NS	NS	NS	NS	NS
MEAN	2750	136.83	16.46	2.45	19.98
C.V. (%)	8	5.16	3.18	9.44	6.44

** and * are statistically significant at the 1% and 5% levels, respectively.

Table 5. Timing x nitrogen rate tests (1993-1995) - 6 test average.

TREATMENT	Emerg. Stand (pl/100')	Harvested Stand (pl/100')	Color Rating (0-9)	Amino Nitrogen (meq/100g fresh weight)	Sodium	Potassium
TIMING OF N APPLICATION						
ppi (fall)	156	127	3.95	2.19	2.48	4.88
ppi (fall)/post-e	158	130	3.81	2.17	2.40	4.91
post-e	159	130	3.55	2.30	2.52	4.92
LSD (.05)	NS	NS	0.21	0.07	NS	NS
LSD (.01)	NS	NS	0.28	0.09	NS	NS
NITROGEN RATE (lb N/ac)						
0	158	126	4.66	1.96	2.28	4.96
45	158	130	3.97	2.14	2.42	4.90
90	157	130	3.46	2.32	2.54	4.89
135	158	130	2.99	2.47	2.62	4.85
LSD (.05)	NS	NS	0.24	0.08	0.15	NS
LSD (.01)	NS	NS	0.32	0.11	0.20	NS
RATE x TIMING (lb N/ac, N timing)						
0, (check)	158	127	4.56	1.98	2.29	4.95
45, fall banded	157	127	4.19	2.11	2.41	4.89
90, fall banded	155	129	3.72	2.25	2.52	4.85
135, fall banded	154	127	3.33	2.41	2.69	4.84
0, (check)	158	126	4.69	1.93	2.28	5.00
45, 2/3 fall band - 1/3 post-e bcast	157	129	3.97	2.10	2.36	4.90
90, 2/3 fall band - 1/3 post-e bcast	158	132	3.56	2.25	2.46	4.87
135, 2/3 fall band - 1/3 post-e bcast	161	134	3.03	2.41	2.50	4.86
0, (check)	159	126	4.72	1.96	2.27	4.92
45, post-e broadcast	160	133	3.74	2.20	2.48	4.91
90, post-e broadcast	158	130	3.11	2.47	2.63	4.97
135, post-e broadcast	160	129	2.61	2.60	2.69	4.86
INTERACTIONS						
Timing of application x N rate	NS	NS	NS	NS	NS	NS
Location x timing of application	NS	NS	NS	NS	NS	NS
Location x N rate	NS	**	**	NS	NS	**
Location x timing x N rate	NS	NS	NS	NS	NS	NS
MEAN	158	129	3.77	2.22	2.47	4.90
C.V. (%)	7	9	24.27	13.92	23.16	5.91

** and * are statistically significant at the 1% and 5% levels, respectively.