Nitrogen for Improved Yield, Quality, and Profitability of Potato
Alberta Location – Interim Report
January 10, 2018

Project Description:

Introduction

The competitiveness of Canada's potato industry is dependent upon the production of high quality tubers in the most cost-efficient manner possible. Management of nitrogen fertilizer additions is one of the most practical means by which growers have to improve the economics of their production system and limit environmental impacts of potato production (Zebarth and Rosen 2007). Reviews of nitrogen management in potato stress the importance of matching crop demand for N by controlling the timing, placement, source and rate of additions and considering the N supply capacity of soil (Davenport et al. 2005, Monoz et al. 2005, Zebarth and Rosen 2007, Vos 2009).

Matching crop N demand with N availability in soil is the best means of optimizing nitrogen use efficiency and marketable yield of potato (Zebarth and Rosen 2007). Splitting the application of N to applying some at planting and then later as top-dressing at hilling or in irrigation water as fertigation can improve nitrogen use efficiency in soils prone to leaching of nitrate (Errebhi et al. 1998) and similar to conditions in eastern Canada and irrigated potato in the west. How to assess in crop N status to set fertigation amounts however is uncertain. Tools such as nitrate concentration of petioles (Goffart et al. 2008), reflectance of the crop (van Evert et al. 2012), and chlorophyll content (Olivier et al. 2006) relate well to N status of the crop. How to use these in crop measures to best adjust N additions at hilling or with fertigation however remains to be resolved. A different approach to matching N demand and N availability relies upon slowing the release of N from fertilizer added at planting such banding products near the seed so it is less prone to leaching prior to the period of greatest N demand, tuber bulking (Westermann and Sojka (1996). Recently available enhanced efficiency fertilizers that either stabilize N for longer in soil as ammonium with soil enzyme inhibitors or retard release of urea by coating granules with polymer (Trenkel 2010), are new options to growers. If the price premium of these products over regular urea granules is warranted remains to be resolved for our growing conditions.

Matching the availability of added fertilizer to potato N demand should result in maximizing nitrogen use efficiency. It is recommended that potato growers apply fertilizer N partly at planting and later once plants have emerged (Province of Manitoba Soil Fertility Guide). This is usually achieved by split application of fertilizer with some at planting and remainder at hilling or fertigated with irrigation water. Split application of fertilizer N is beneficial in soils prone to leaching of nitrate such as in sand soil and humid conditions (Errebhi et al. 1998). Split application of fertilizer increases production costs such as labour and fuel. Thus, it is important to growers to insure maximal return in investment for these added costs. One example of increased production costs is the increasing use of fertigation in the Prairie Provinces though hard evidence to the benefit to nitrogen use efficiency and returns is lacking. Further, fertigation during hot summer periods likely will promote volatilization of urea in the urea ammonium nitrate solution applied. Fertigation is actively promoted in the Pacific NorthWest of the U.S.A. (Lang et al. 1999) and the processers familiar with that production system are promoting the practice in the Prairies where they also manage processing facilities.

Recently, enhanced efficiency fertilizers such as SuperU (slow release urea with urease and nitrification inhibitors) and ESN (controlled release with polymer coated urea) have become available to growers. It remains uncertain if the price premium for the products is justified by increased returns. In Minnesota, Hyatt et al. (2010) reported polymer coated urea did not increase yield but did decrease emissions of the greenhouse gas, nitrous oxide. In the same state, Wilson et al. (2009) reported lower N rates with polymer coated urea (ESN) were required to achieve maximum yield. Kelling et al. (2011) reported that for 3 of 6 site years in Wisconsin, the nitrification inhibitor, DCD with ammonium sulfate, increased gross yield but for 4 of 6 site year's marketable yield decreased. The decrease was because of ammonium accumulation in soil deforming tubers resulting increased culls.

The purpose of the current research is to provide data to determine whether ESN, split applications, fertigation or a combination of these strategies can be used in potato production to improve nitrogen use efficiency while maintaining yield and quality.

The objectives include:

1. Determine optimal timing and source of N fertilizers for irrigated potato.
2. Evaluate the effectiveness of monitoring plant N status to adjust fertigation additions.
3. To determine the effect of combinations of urea and polymer coated urea on yield, specific gravity and quality of Russet Burbank potatoes; and
4. To determine whether polymer coated urea can replace the need for in-season N applications (top-dressing, side-dressing or fertigation).

Approach Taken

The trial was conducted on Russet Burbank potatoes at the Alberta Irrigation Technology Centre in Lethbridge, AB to ensure that background N was low, N applications could be controlled, and the crop was irrigated using a pivot system. The trial was planned for 2 - 4 years to determine the impact of the treatments under a variety of environmental conditions. This trial is part of a larger initiative being led by Dr. Mario Tenuta of the University of Manitoba.

Six soil samples were taken at depths of 0 to 15cm and 15 to 120cm to make a composite soil sample in the fall of 2016. Soil N (77 kg/ha) was taken into account when calculating N applications for each treatment.

Various quantities of urea and ESN (polymer-coated urea) were used pre-plant. Some of the treatments also involved N applications at the time of hilling and others included simulated fertigation treatments to reach the same total N applied. The nitrogen treatments were applied using a Conserv-a-Pak machine May 3, 2017. Top-dressed N was applied by hand prior to power hilling May 31 and fertigation was simulated by applying ammonium nitrate and irrigating on three dates, July 5, July 26 and August 16, 2017 (Table 1). All treatments included an application of mono-ammonium phosphate (MAP) to provide starter P. Approximately 10 kg/ha N was supplied with the MAP and is included in the total N column (soil plus applied). The target N was intended to be approximately 80% of an agronomist recommended rate for Russet Burbank Production in southern Alberta (200 kg/ha).

Table 1: Nitrogen treatments (kg/ha) used in 2017 to determine the effects of fertilization strategies on irrigated Russet Burbank in Alberta.

		Pre-plant		At Hilling		Simulated Fertigation		
	Treatments	Urea	ESN	Urea	ESN	5 Jul	26 Jul	16 Aug
1	Check	0	0					
2	Urea Pre-Plant Broadcast; 100%	105						
3	Urea Split (60:40)	63		42				
4	Urea/ESN Split (60:40)	63			42			
5	ESN + Fertigation D		63			15	14	13
6	ESN Pre-plant Broadcast; 100%		105					
8	High Broadcast +Fertigation A	63				15	14	13
9	Urea/ESN Split + Fertigation B	38			25	15	14	13
10	ESN/Urea pre-plant+ Fertigation C	32	32			15	14	13
11	Urea: ESN (60:40) at Hilling	0	0	63	42			

Treatments included:

1. No additional nitrogen (approximately 88 kg/ha soil test plus MAP) – check
2. Urea applied pre-plant (105 kg/ha N) – urea 100% pp
3. 60% N applied as urea pre-plant; 40% N applied as urea at hilling – urea split
4. 60 % N applied as urea pre-plant; 40% N applied as ESN at hilling – urea/ESN split
5. 60% N applied pre-plant as ESN; 40% N applied via three fertigation events – ESN + fertigation
6. ESN applied pre-plant (105 kg/ha) – ESN 100% pp
7. Omitted in 2017
8. 60% N applied pre-plant as urea; 40% N applied via three fertigation events – Urea + fertigation A
9. Urea applied pre-plant; ESN applied at hilling; three fertigation events – Split + fertigation B
10. Urea and ESN applied pre-plant; three fertigation events – 50:50 + fertigation C
11. No pre-plant N; Urea:ESN blend (60:40) at hilling
12. Omitted in 2017

2017

Russet Burbank seed (E2 was cut (approximately 70 to 85 g seed pieces), suberized, and treated with MaximD™ seed piece treatment (500g/100kg seed) prior to planting. Tubers were planted approximately 13 to 14 cm deep and 30 cm apart in rows spaced 0.90 metres apart using a four-row cup planter in Lethbridge on May 10, 2017. Treatments were set up as a split plot, with pre-plant N as a main treatment. Each treatment was 4 rows wide. The centre two rows were used for petiole sampling. Only one of the centre rows was harvested for yield estimates and tuber evaluations. Each treatment was replicated 4 times to reduce some of the variability inherent in small plot research (Appendix A).

The plots were scouted and managed following recommendations of a contract agronomist, ProMax Agronomy Services. The plots were irrigated with a centre pivot and low-pressure nozzles as required to maintain soil moisture close to 70% capacity, typically once or twice per week.

The potatoes were hilled May 31 with a power hiller. Roundup (0.48L/ac) was applied prior to planting (May 26) to control weeds. Sencor 75DF (125 g/ac) and Prism (24 g/ac + Agral 90 0.2% v/v) were applied June 22 to control weeds. The plots were irrigated to maintain soil moisture close to 70% (25 irrigation events between June 20 and September 23; total of 386mm).

Foliar fungicides were applied several times during the growing season to prevent early and late blight from developing (Table 2).

Table 2: Foliar fungicides applied to the potato crop in 2017 to prevent early and late blight development.

Date of Application	***Fungicide***	***Rate***
6 July	Luna Tranquility	240 mL/ac
6 July	Penncozeb	0.91 kg/ac
20 July	Penncozeb	0.88 kg/ac
8 Aug	Bravo	0.88 L/ac
10 Aug	Penncozeb	0.88 kg/ac
17 Aug	Bravo	0.88 L/ac
25 Aug	Penncozeb	0.91 kg/ac
1 Sept	Bravo	0.88 L/ac
8 Sept	Bravo	0.88 L/ac

Additional ESN and urea were applied (top-dressed) to treatments 3, 4, and 9 prior to hilling May 31st.

Petiole samples were taken at three times (July 5, July 26 and August 15, 2017) during the season to follow the N-status of the crop throughout the season. Soil samples were taken at depths of 0 to 30cm around the same time as the petiole samples were collected (July 4, July 27 and August 16) and before the fertigation events. Twelve cores were taken from each plot to make a composite sample. Four core samples were taken from the top of the hills, and eight were taken from the shoulder of the hills within each plot. Samples were dried at 50C for approximately 1 week and ground, then stored at 4C until they were analyzed. Simulated fertigation treatments (ammonium nitrate broadcast) were applied immediately after soil sampling (July 5, July 27, and August 16) and irrigated in.

Prior to desiccation (Sept. 20), two whole potato plants were removed from the field. Fresh biomass was measured and the plants were dried in a forage dryer at 50C. Dry biomass was measured and the plant material was ground using a plant tissue grinder and held at 4C until analyzed for N.

No desiccation was required in 2017 as a light frost helped condition potato vines. All treatments were harvested mechanically September 27 using a one-row Grimme harvester. Immediately following the potato harvest, soil samples were taken from the soil disturbed by the harvester. These samples were dried and ground and stored at 4C until analyzed.

Tubers were stored at 8˚C until graded. Tubers were graded into size categories (less than 113g, 113 - 170g, 171 – 284g over 284g and deformed). A sample of twenty-five tubers (113 – 284g) from each replicate was used to determine specific gravity using the weight in air over weight in water method. The tubers in the specific gravity sample were cut longitudinally to assess internal defects. Another sub-sample of 8 tubers was washed, diced, freeze dried and ground. Tuber tissue was analyzed for N content as well.

The data presented here have been statistically analyzed using ANOVA and Tukey's Multiple Range Test; ($p \leq 0.05$).

Results:

Petiole Nitrates

Petiole nitrate levels for all treatments declined between the first and second sampling date. The decline was less dramatic for split N treatments and treatments involving fertigation. Nitrogen declined between the second and third sampling as well, but treatments involving fertigation maintained higher petiole N at the third sampling date than treatments where N was all applied pre-plant. Treatments including fertigation showed much less of a decline, and in several treatments an increase between the second and third sampling date. Nitrate levels in the petioles at the first sampling date in mid-July ranged from about 15,000 ppm for the check to over 20,000 ppm for most of the fertilized treatments (Fig 1). As expected, treatments with ESN applied pre-plant started out with slightly lower petiole nitrate levels.

Figure 1: Petiole nitrate levels for each treatment at the Lethbridge, AB location. Samples were taken from the fourth petiole from up to eighty stems at three times during the 2017 growing season.

Potato Yield and Grade

Total yield, mean tuber size and specific gravity are presented in Table 3 for each treatment harvested in Lethbridge in 2017. In 2017, there were no significant differences in total yield between treatments. Mean tuber size ranged from 6.0 oz. for the split urea treatment (Trt. 3) to 7.9 oz. for the urea pre-plant treatment (Trt. 2). Mean tuber size from other treatments were not statistically different from these or one another. There were no statistically significant differences in specific gravity between treatments in 2017.

Table 3: Total yield (estimated ton/ac), mean tuber size (oz.) and specific gravity of potatoes harvested from plots in Lethbridge, AB grown with different nitrogen strategies in 2017

Trt #		Total Yld (ton/ac)	Mean tuber size (oz.)	SG
1	Untreated Check	22.1 a	6.4 ab	1.087 a
2	Urea Pre-Plant Broadcast; 100%	18.7 a	7.9 b	1.082 a
3	Urea Split (60:40)	19.3 a	6.0 a	1.085 a
4	Urea/ESN Split (60:40)	20.5 a	7.1 ab	1.086 a
5	ESN + Fertigation D (60:40)	19.5 a	7.0 ab	1.087 a
6	ESN Broadcast; 100%	20.8 a	7.1 ab	1.084 a
8	High Broadcast + Fertigation A	20.2 a	7.2 ab	1.084 a
9	Urea/ESN 60:40 Split + Fertigation B	21.1 a	7.1 ab	1.085 a
10	ESN:Urea 50:50 Split + Fertigation C	20.9 a	6.9 ab	1.086 a
11	NJB1 – urea:ESN (60:40) at hilling	22.6 a	7.0 ab	1.085 a

Yield of potatoes in different size categories and marketable yield are summarized in Table 4. There were some significant differences in yield of specific size categories. The check treatment and the urea broadcast pre-plant were shifted toward the smaller categories. A significantly greater yield of small potatoes was observed in the check treatment compared to Trt 2 (urea broadcast pre-plant) and the high broadcast plus fertigation (Trt 8). There were no significant differences between treatments in size categories over 6 oz., and no significant differences in the marketable yield.

Table 4: Estimated yield (ton/ac) in each weight category (< 4oz., 4 to 6 oz., 6 to 10 oz. > 10 oz., and deformed) for each variety grown at Lethbridge, AB in 2017. Data shown is the mean of four replicates. Data followed by the same letter in each column of the table are not significantly different at the $p < 0.05$ level.

Treatment	< 4oz.	4 to 6 oz.	6 to 10 oz.	> 10 oz.	Deformed	Marketable Yield
Untreated Check	5.1 a	6.7 a	7.3 a	2.1 a	0.8 a	16.1 a
Urea Pre-Plant Broadcast; 100%	2.3 c	3.2 b	7.8 a	4.6 a	0.7 a	15.6 a
Urea Split (60:40)	4.3 abc	4.4 ab	7.4 a	2.4 a	0.7 a	14.3 a
Urea/ESN Split (60:40)	3.9 bca	4.9 ab	7.3 a	3.6 a	0.8 a	15.8 a
ESN + Fertigation (60:40)	3.5 abc	5.2 ab	7.8 a	2.6 a	0.5 a	15.5 a
ESN Broadcast; 100%	3.1 abc	5.1 ab	8.0 a	3.9 a	0.6 a	17.0 a
Fertigation A High Broadcast	2.9 bc	4.9 ab	7.9 a	3.8 a	0.7 a	16.6 a
Urea/ESN Split + Fertigation	4.0 abc	5.2 ab	7.8 a	3.6 a	0.6 a	16.5 a
Fertigation C ESN:Urea	3.9 abc	5.5 ab	8.3 a	2.7 a	0.4 a	16.6 a
NJB1 – urea:ESN (60:40) at hilling	4.6 ab	5.2 ab	8.4 a	3.5 a	0.9 a	17.1 a

This data is from the fourth year of a four-year trial. Four site years of data were generated and provide information to develop recommendations for various fertilizer approaches as part of a nitrogen management strategy for Russet Burbank. An economic analysis of the results is planned. Nitrogen partitioning and nitrogen use efficiency will also be calculated once plant and tuber N data has been analyzed.

Project Reach:

A target audience for this research is the processing potato growers in southern Alberta. Producers need tools to improve nitrogen use efficiency and reduce cost of production for potatoes. The Potato Growers of Alberta (PGA) comprises more than 120 potato producers, 70 of whom grow processing potatoes. The PGA provided research funding toward this project. Information will be provided annually to the growers via producer meetings.

Potato processors may also benefit by keeping contract prices in a range that maintains their competitiveness in a global market. Improvements in crop quality may also be realized with timely nitrogen applications. Processors will be kept apprised of the results of the project via PGA meetings.

Indirectly, members of the public may benefit from the efficient use of resources and the prudent use of nitrogen fertilizers. The impact of the study on this group is difficult to estimate. The results of the trial may be disseminated via popular press articles at the end of the research project depending on the outcome of the trials.

Project Impact:

With new tools becoming available to producers, timing is as important as quantity for producing good yield and good processing quality. There has been some contradictory information about the use of ESN and fertigation for potato N management and impartial information for Alberta producers is essential. There is a need to determine the best approach to optimize potato yield and quality while refining costs of production. Data from the trial will:

- be useful in the development of Beneficial N Management Practices for potato production in Alberta;
- determine whether polymer coated urea can reduce total nitrogen applied or reduce the number of in-season nitrogen applications required for optimal potato yield and quality;
- provide economic evaluations of the use of polymer coated urea;
- determine whether fertigation is necessary or beneficial for optimal potato yield and quality; and
- address fertilizer strategies under soil type and environmental conditions specific to Alberta.

References

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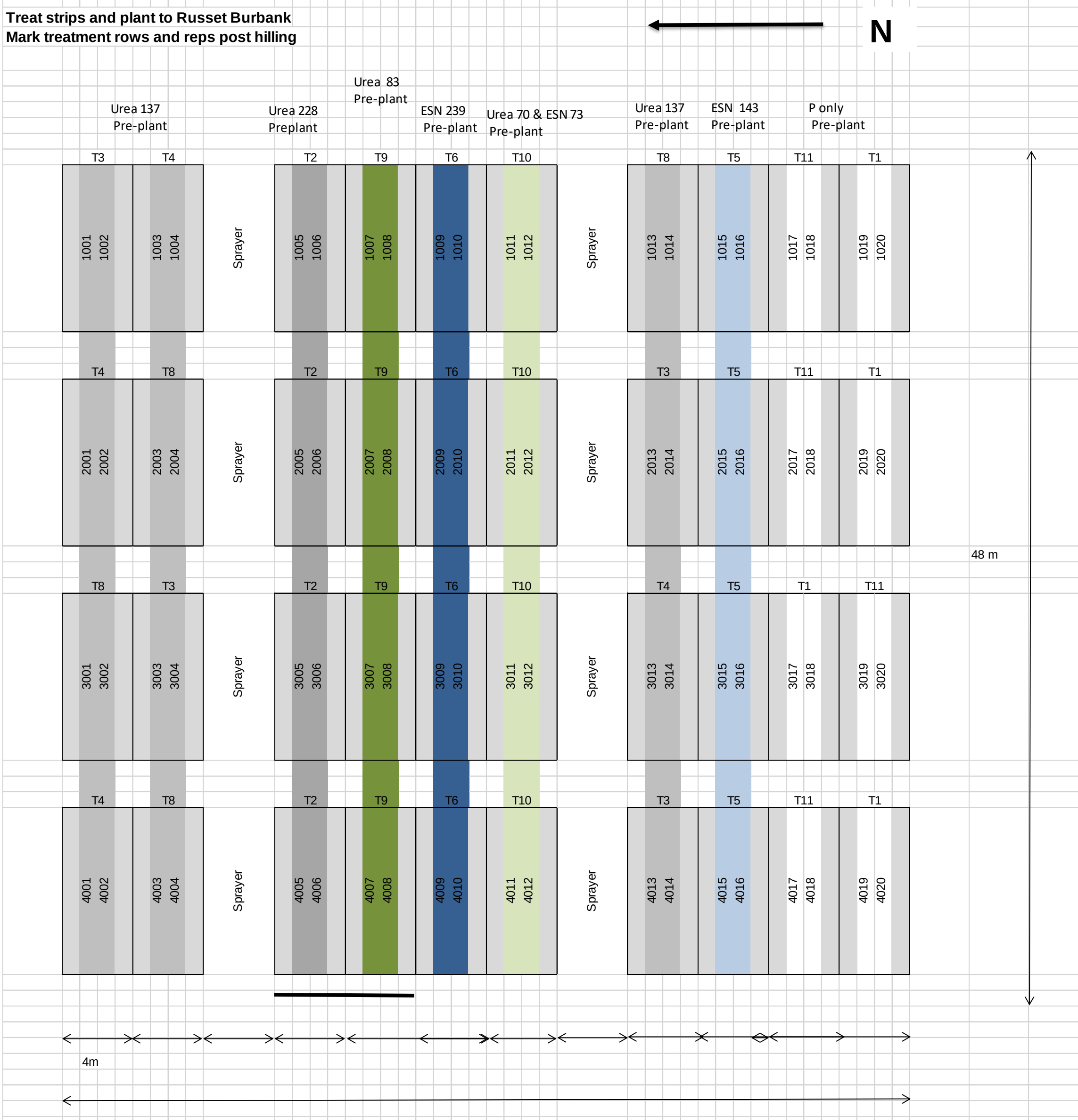
Appendix A: Plot plan of AITC Nitrogen Trial 2017.

2017 Nitrogen BMP Trial



Applications May 3 Planted

1	Treatment 1	Untreated check. 11-52-0 at 96 lbs/ac (50 lbs/ac P)
2	Treatment 2	Urea Broadcast pre-plant 46-0-0 (228 kg/ha)
3	Treatment 3	Urea split application 46-0-0 (137 kg/ha) pre-plant
4	Treatment 4	Urea /ESN split application 46-0-0 (137 kg/ha) pre-plant
5	Treatment 5	ESN + fertigation 44-0-0 (143 kg/ha) pre-plant
6	Treatment 6	ESN boradcast 44-0-0 (239 kg/ha) (2 passes of XXX)
8	Treatment 8	High broadcast + fertigation (137 kg/ha) urea pre-plant
9	Treatment 9	Urea/ESN + fertigation (83 kg/ha) 46-0-0 pre-plant
10	Treatment 10	Urea/ESN + fertigation (70 kg/ha) of 46-0-0 and (73 kg/ha) ESN pre-plant
11	NJB1	MAP at Planting + Urea:ESN at Hilling 60:40 (63:42)