Nitrogen for Improved Yield, Quality, and Profitability of Potato
Alberta Location – Interim Report
March 31, 2015

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 is 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. However, 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 sites years marketable yield decreased. The decrease was because of ammonium accumulation in soil deforming tubers resulting increased culls.

A problem with elucidating if controlled released or stabilized products increase yield in the aforementioned studies has been the lack of comparison of the performance of the same N form (ex. urea) with or without being controlled release (ESN) or stabilized (ex. SuperU). Thus, it is difficult to determine the impact of the enhanced efficiency fertilizers when treatment comparisons vary in the form of the N.

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 is 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 2013. Soil N 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 23 at both locations, Top-dressed N was applied by hand prior to power hilling June 27 and fertigation was simulated by applying ammonium nitrate and irrigating on three dates, July 22, August 8 and August 21, 2014 (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, but was inadvertently applied at 100% as soil test N was not accounted for at the time of application.

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

		Pre-plant		Hilling	Simulated Fertigation			
	Treatments	Urea	ESN	Top-Dressed	22 Jul	8 Aug	21 Aug	Applied
1	Untreated Check							0
2	Urea Pre-Plant Broadcast; 100%	190						190
3	Urea Split (60:40)	115		75				190
4	Urea/ESN Split (60:40)	115		75				190
5	ESN + Fertigation D (60:40)		115		25	25	25	190
6	ESN Broadcast; 100%		190					190
7	50% ESN / 50% Urea Broadcast	95	95					190
8	High Broadcast + Fertigation A	115			25	25	25	190
9	Urea/ESN 60:40 Split + Fertigation B	70		45	25	25	25	190
10	ESN:Urea 50:50 Split + Fertigation C	58	58		25	25	25	190

Treatments included:

1. No additional nitrogen (approximately 73 kg/ha soil test plus MAP) – check
2. Urea applied pre-plant (190 kg/ha) – 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 (190 kg/ha) – ESN 100% pp

7. Urea:ESN (50:50) applied pre-plant (95 kg/ha urea and 95 kg/ac ESN) – Pre-plant 50:50
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

2014
Russet Burbank seed (E3) was cut (approximately 70 to 85 g seed pieces), suberized, and treated with MaximMZ™ 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 27, 2014. 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.

Roundup (1 L/ac) was sprayed prior to planting (May 21) to reduce weed pressure. Seed of standard cultivars was provided by Edmonton Potato Growers and seed of test cultivars was provided by each participant. Potatoes were planted June 5, 2014 approximately 5 to 5½"deep using a two-row tuber unit planter. Seed was planted at 30cm spacing in 6m rows spaced 90cm apart.

The potatoes were hilled June 27 with a power hiller. Sencor 75DF (100 g/ac) and Centurion (76 mL/ac) were applied prior to emergence (June 3) to control weeds. The plots were irrigated to maintain soil moisture close to 70%. 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 2014 to prevent early and late blight development.

Date of Application	***Fungicide***	***Rate***
16 July	Bravo	1 L/ac
26 July	Dithane	900 g/ac
5 Aug	Bravo	1 L/ac
12 Aug	Dithane	900 g/ac

19 Aug	Dithane	900 g/ac
27 Aug	Bravo	1 L/ac
2 Sept	Bravo	1 L/ac
8 Sept	Bravo	1 L/ac

Additional ESN and urea were applied (top-dressed) to treatments 3, 4, and 9 prior to hilling June 27th.

Petiole samples were taken at three times (July 23, August 8 and August 21 during the season to follow the N-status of the crop throughout the season. Simulated fertigation treatments (ammonium nitrate broadcast) were applied immediately after petiole sampling (July 23, August 8, and August 21) and irrigated in.

Soil samples were taken at depths of 0 to 30cm prior to the first (July 21) and second (Aug. 8) petiole sampling and 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 stores at 4C until they were analyzed.

Approximately 1 week prior to desiccation, 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.

Reglone (1.0 L/ac) was applied Sept 15 and again September 19 to desiccate potato vines. All treatments were harvested mechanically September 29 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 25 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

In Brooks, petiole nitrate levels for all treatments declined between the first and second sampling date. For pre-plant applied treatments, nitrogen declined between the second and third sampling as well. Treatments including fertigation showed much less of a decline, and in one treatment 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 9,000 ppm for the check to over 20,000 ppm for treatments with the majority of the N applied pre-plant (Fig 1). As expected, treatments with less nitrogen applied pre-plant started out with lower petiole nitrate levels.

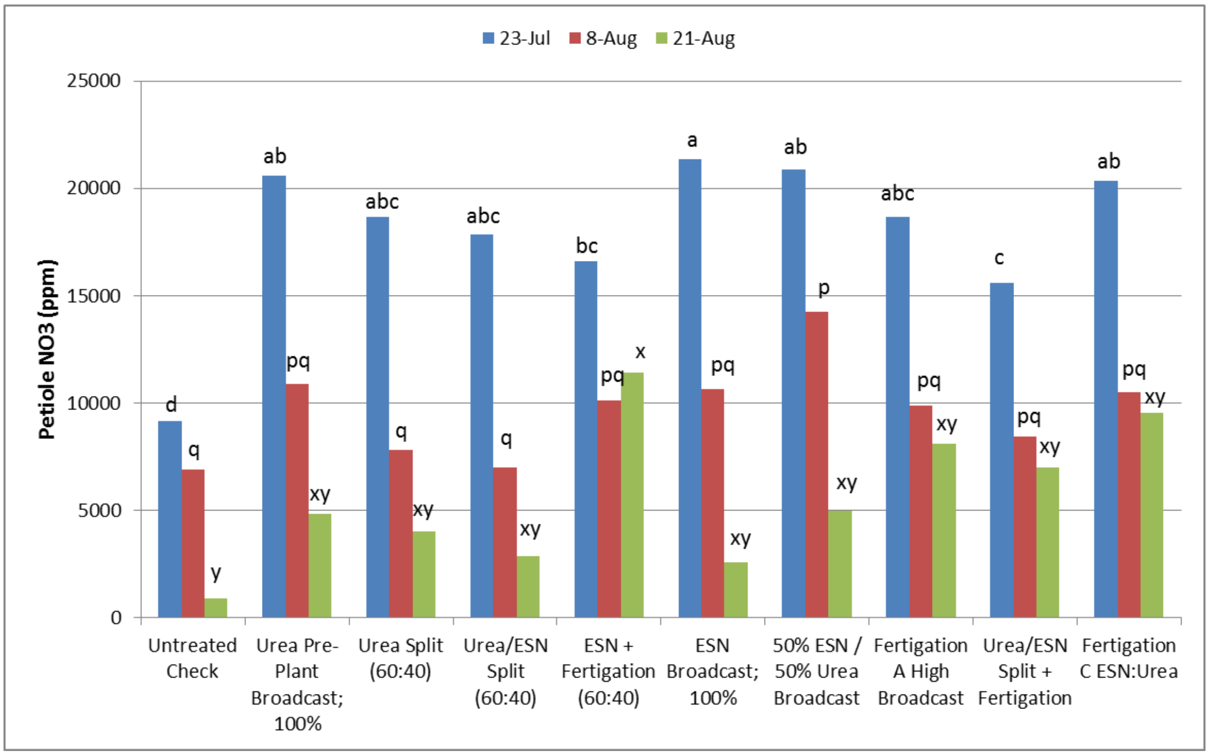

Figure 1: Petiole nitrate levels for each treatment at the Lethbridge, AB location. Samples were taken from the fourth petiole from up to eighty stems at three times during the 2015 growing season.

Potato Yield and Grade

Total yield, mean tuber size and specific gravity are presented in Table 3 for each treatment harvested in Lethbridge in 2015. Only Treatment 6 (ESN 100% pre-plant) resulted in total yield that was significantly greater than the check. Mean tuber size for Treatment #2 (Urea 100% pre-plant), #7 (50% urea and 50% ESN pre-plant) and #9 (urea plus ESN pre-plant followed by fertigation) was significantly greater than the check. This implies that supplying too little N (check) or providing N later in the growing season can reduce the mean tuber size. Only Treatment #2 (100% Urea pre-plant) reduced specific gravity significantly relative to the check. Highest specific gravity was measured for the check (Treatments #1), the 100% ESN pre-plant (Treatments #6), and the urea/ESN split application (Treatment #4).

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 2014

Trt #		Treatment	Total Yld (ton/ac)	Mean tuber size (oz.)	SG
1	Untreated Check	Untreated Check	12.6 b	5.7 c	1.088 a
2	Urea Pre-Plant Broadcast; 100%	Urea Pre-Plant Broadcast; 100%	14.7 ab	7.5 a	1.078 b
3	Urea Split (60:40)	Urea Split (60:40)	15.5 ab	6.7 abc	1.084 ab
4	Urea/ESN Split (60:40)	Urea/ESN Split (60:40)	15.9 ab	6.0 bc	1.086 a
5	ESN + Fertigation D (60:40)	ESN + Fertigation (60:40)	16.8 ab	6.3 abc	1.084 ab
6	ESN Broadcast; 100%	ESN Broadcast; 100%	18.6 a	6.2 abc	1.089 a
7	50% ESN / 50% Urea Broadcast	50% ESN / 50% Urea Broadcast	14.3 b	7.6 a	1.083 ab
8	High Broadcast + Fertigation A	Fertigation A High Broadcast	14.0 b	6.2 abc	1.081 ab
9	Urea/ESN 60:40 Split + Fertigation B	Urea/ESN Split + Fertigation	13.4 b	7.3 ab	1.084 ab
10	ESN:Urea 50:50 Split + Fertigation C	Fertigation C ESN:Urea	12.7 b	6.5 abc	1.081 ab

Yield of potatoes in different size categories and marketable yield are summarized in Table 4. Marketable yield (over 4 oz.) was significantly greater for most of the treatments relative to the check. Three of the treatments that included fertigation (Treatments 8, 9 and 10) resulted in marketable yields that were not significantly better than the check. This is likely related to the shorter growing season and the relative lateness of the applied fertigation treatments. The greatest marketable yield was observed with Treatment #6 (100% ESN pre-plant), but this yield was nor statistically different treatments other than the check. Treatments #2 (100% urea pre-plant), #7 (50% urea/50% ESN pre-plant), and Treatment #9 (Urea/ESN split plus fertigation) resulted in the largest tuber profiles. None of the treatments affected the yield of deformed tubers.

The data suggests that urea applied earlier in the season encourages larger tubers, while treatments with less N available after planting may produce more small tubers.

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 2014. 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	5.5 a	4.2 ab	2.1 b	0.2 c	0.5 a	6.6 c
Urea Pre-Plant Broadcast; 100%	2.9 cd	3.2 b	5.2 a	2.3 ab	1.1 a	10.7 ab
Urea Split (60:40)	3.6 bcd	4.0 ab	5.5 a	1.9 abc	0.6 a	11.3 ab
Urea/ESN Split (60:40)	4.3 abc	5.0 ab	5.4 a	0.8 bc	0.5 a	11.1 ab
ESN + Fertigation (60:40)	5.2 a	4.6 ab	5.0 a	1.3 bc	0.7 a	11.0 ab
ESN Broadcast; 100%	4.9 ab	6.6 a	5.3 a	1.2 bc	0.7 a	13.0 a
50% ESN / 50% Urea Broadcast	2.6 d	2.9 b	4.5 a	3.3 a	1.0 a	10.7 ab
Fertigation A High Broadcast	3.3 cd	4.3 ab	4.6 a	1.3 bc	0.4 a	10.3 abc
Urea/ESN Split + Fertigation	2.8 cd	2.8 b	4.7 a	2.5 ab	0.5 a	10.1 abc
Fertigation C ESN:Urea	3.6 bcd	3.8 ab	3.5 ab	1.2 bc	0.6 a	8.5 bc

This data is from the first year of a four-year trial. A minimum of 2 and a maximum of 4 site years of data will be generated and should provide sufficient 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 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 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. Additional data from the second and third year of 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 using the fertilizer strategies under soil type and environmental conditions specific to Alberta.

References

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Appendix A: Plot plan of AITC Nitrogen Trial 2015.

BMP 2014

N →

Planted May 27

Row	0m		12	24	36		Treatment
1	Guard		Guard	Guard	Guard		
2	4001		3001	2001	1001	T3	Urea 115 Pre-plant
3	4002		3002	2002	1002	T3	
4	Guard		Guard	Guard	Guard		
5	Guard		Guard	Guard	Guard		
6	4003		3003	2003	1003	T4	Urea 115 Pre-plant
7	4004		3004	2004	1004	T4	
8	Guard	3m	Guard	Guard	Guard		
9	Guard		Guard	Guard	Guard		
10	4005		3005	2005	1005	T8	
11	4006		3006	2006	1006	T8	Urea 115 Pre-plant
12	Guard	3m	Guard	Guard	Guard		
	9m						
13	Guard		Guard	Guard	Guard		
14	4007		3007	2007	1007	T2	Urea Prepla
15	4008		3008	2008	1008	T2	
16	Guard		Guard	Guard	Guard		
17	Guard		Guard	Guard	Guard		
18	4009		3009	2009	1009	T9	Urea Pre-p
19	4010		3010	2010	1010	T9	
20	Guard	3m	Guard	Guard	Guard		
21	Guard		Guard	Guard	Guard		
22	40011		3011	2011	1011	T7	Urea & ES Pre-plan
23	4012		3012	2012	1012	T7	
24	Guard	3m	Guard	Guard	Guard		
25	Guard		Guard	Guard	Guard		
26	4014		3013	2013	1013	T10	Urea & ESN Pre-plant
27	4015		3014	2014	1014	T10	
28							
29							
30	4016		3015	2015	1015	T5	ESN Pre-plant
31	4017		3016	2016	1016	T5	
32							
33							
34	4017		3017	2017	1017	T6	ESN Pre-plant
35	4018		3018	2018	1018	T6	
36							
	4019		3019	2019	1019	T1	P only Pre-plant
	4020		3020	2020	1020	T1	
16	Guard	3m	Guard	Guard	Guard		

23-May

Hilling