Nitrogen for Improved Yield, Quality, and Profitability of Potato
Alberta Location – Interim Report
March 22, 2017

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 site year's 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 2015. Soil N (35 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 April 27, Top-dressed N was applied by hand prior to power hilling May 18 and fertigation was simulated by applying ammonium nitrate and irrigating on three dates, June 30, July 21 and August 15, 2016 (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 (193 kg/ha).

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

Treatments 2016		Planned applications							Total N
		Pre-plant		Top-Dress					Kg/ha
		Urea	ESN		Simulated Fertigation (AN)				
1	Untreated Check	0	0					0	46
2	Urea Pre-Plant Broadcast; 100%	157						157	203
3	Urea Split (60:40)	95		62				157	203
4	Urea/ESN Split (60:40)	95		62				157	203
5	ESN + Fertigation (60:40)		95		23	21	18	157	198
6	ESN Broadcast; 100%		157					157	196
8	Fertigation A High Broadcast	95			23	21	18	157	203
9	Urea/ESN Split + Fertigation	57		38	23	21	18	157	196
10	Fertigation C ESN:Urea	48	48		23	21	18	158	200
11	NJB1	0	0	95:62				157	203

Treatments included:

1. No additional nitrogen (approximately 36 kg/ha soil test plus MAP) – check
2. Urea applied pre-plant (193 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 (193 kg/ha) – ESN 100% pp
7. Omitted in 2106
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. NJB1 – Urea:ESN blend (60:40) at hilling
12. Omitted in 2016

2016

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 April 28, 2016. 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 18 with a power hiller. Lorox (1L/ac) was applied prior to emergence (May 25) to control weeds. Sencor 75DF (125 g/ac) and Select (76 mL/ac + Amigo 0.5% v/v) were applied June 8 to control weeds. The plots were irrigated to maintain soil moisture close to 70%. Plots were sprayed with Prism (24 g/ac) with Amigo (0.5%) post-emergence (June 23) to control weeds.

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 2016 to prevent early and late blight development.

Date of Application	***Fungicide***	***Rate***
30 June	Luna Tranquility	240 mL/ac
30 June	Bravo	0.88 L/ac
8 July	Dithane	900 g/ac
15 July	Dithane	900 g/ac
22 July	Bravo	0.88 L/ac
28 July	Dithane	880 g/ac
5 Aug	Bravo	1 L/ac
12 Aug	Dithane	880 g/ac
19 Aug	Dithane	880 g/ac
26 Aug	Dithane	880 g/ac
25 Aug	Bravo	0.8 L/ac

Additional ESN and urea were applied (top-dressed) to treatments 3, 4, and 9 prior to hilling May 18^{th}.

Petiole samples were taken at three times (June 28, July 19 and August 9, 2016) during the season to follow the N-status of the crop throughout the season. Soil samples were taken at depths of 0 to 30cm shortly after the petiole samples were collected (June 30, July 21 and August 15) 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 stores at 4C until they were analyzed. Simulated fertigation treatments (ammonium nitrate broadcast) were applied immediately after soil sampling (June 30, July 21, and August 15) and irrigated in.

Prior to desiccation (Sept. 6), 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 (1.4 L/ac) was applied Sept 7 to desiccate potato vines. All treatments were harvested mechanically September 14 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.

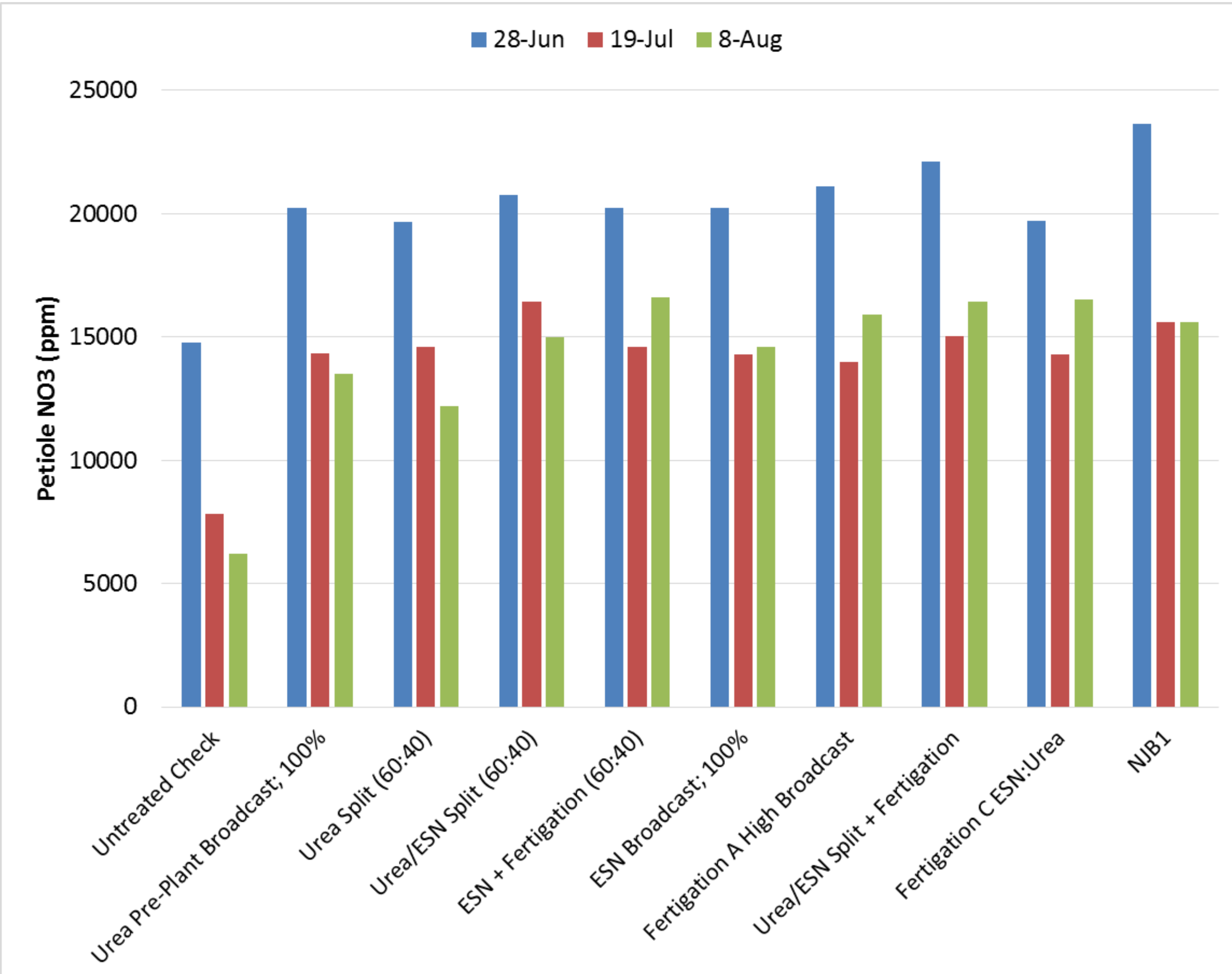


Figure 1: Petiole nitrate levels for each treatment at the Lethbridge, AB location. Samples were taken from the fourth petiole from up to eighty stems at three times during the 2016 growing season.

Potato Yield and Grade

Total yield, mean tuber size and specific gravity are presented in Table 3 for each treatment harvested in Lethbridge in 2016. In 2016, there were no significant differences in total yield or mean tuber size between treatments. There were not statistically significant differences in specific gravity between treatments in 2016 either. The trial was harvested earlier in 2016 than in other years, possibly before tubers had finished bulking.

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 2016

Trt #		Total Yld (ton/ac)	Mean tuber size (oz.)	SG
1	Untreated Check	18.8 a	6.2 a	1.090 a
2	Urea Pre-Plant Broadcast; 100%	20.0 a	6.7 a	1.089 a
3	Urea Split (60:40)	20.1 a	6.6 a	1.088 a
4	Urea/ESN Split (60:40)	19.7 a	6.5 a	1.090 a
5	ESN + Fertigation D (60:40)	18.1 a	6.5 a	1.087 a
6	ESN Broadcast; 100%	17.1 a	6.2 a	1.088 a
8	High Broadcast + Fertigation A	19.7 a	6.8 a	1.084 a
9	Urea/ESN 60:40 Split + Fertigation B	21.2 a	6.5 a	1.088 a
10	ESN:Urea 50:50 Split + Fertigation C	19.3 a	6.0 a	1.088 a
11	NJB1 – urea:ESN (60:40) at hilling	19.9 a	6.5 a	1.089 a

Yield of potatoes in different size categories and marketable yield are summarized in Table 4. None of the size categories yielded statistically significant differences from one another or the check. There was more variability in the data collected in 2016 and the crop was harvested before many of the potatoes had bulked up. The size profile in the check treatments was shifted toward smaller tubers, but was not statistically different from the other treatments. The greatest marketable yield was harvested from Treatments 2 (pre-plant urea), 3 (urea split application), 4 (urea/ESN split application), 8 (urea plus fertigation) and 11 (urea and ESN at hilling). There was no significant difference in yield of tubers in each size category, although shifts were evident with the different nitrogen strategies. As with previous years, treatments with the highest marketable yield, tended to have greater yields of tubers in the larger size categories as well.

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 2016. 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	5.3 a	5.7 a	5.9a	1.2 a	0.6 a	12.9 a
Urea Pre-Plant Broadcast; 100%	3.4 a	5.0 a	8.0 a	2.8 a	0.8 a	15.8 a
Urea Split (60:40)	4.3 a	5.7 a	7.3 a	2.4 a	0.4 a	15.4 a
Urea/ESN Split (60:40)	3.2 a	5.1 a	7.6 a	2.9 a	0.9 a	15.6 a
ESN + Fertigation (60:40)	4.0 a	4.8 a	6.2 a	2.5 a	0.5 a	13.6 a
ESN Broadcast; 100%	4.9 a	5.2 a	4.9 a	1.4a	0.7 a	11.5 a
Fertigation A High Broadcast	4.0 a	5.4 a	6.9 a	2.5 a	0.9 a	14.8 a
Urea/ESN Split + Fertigation	4.6 a	6.2 a	6.7 a	2.8 a	0.8 a	15.7 a
Fertigation C ESN:Urea	5.7 a	6.2 a	5.4 a	1.2 a	0.9 a	12.8 a
NJB1 – urea:ESN (60:40) at hilling	3.9 a	5.8 a	7.0 a	2.5 a	0.6 a	15.4 a

This data is from the second 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 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. Additional data from the third and fourth years 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

Davenport, J.R., P.H. Milburn, C.J. rosen, and R.E. Thornton. 2005. Environmental impacts of potato nutrient management. Am. J. Potato Res. 82:321-328.

Errebhi, M., C.J. Rosen, S.C. Gupta, and D.E. Birong. 1998. Potato yield resonse and ntirate leaching as influenced by nitrogen management. Agron. J. 90:10-15.

Goffart, J.P., M. Olivier, and M. Frankinet. 2008. Potato crop nitrogen status assessment to improve N fertilization management and efficiency: Past-present-future. Potato Res. 51:355-383.

Kelling, K.A., R.P. Wolkowski, and M.D. Ruark. 2011. Potato response to nitrogen form and nitrification inhibitors. Am. J. Pot. Res. 88:459-469.

Lang, N.S., R.G. Stevens, R.E. Thornton, W.L. Pan, and S. Victory. 1999. Potato nutrient management for central Washington. Cooperative Extension, Washington State University, EB1871.

Monoz, F., R.S. Mylavarapu, and C.M. Hutchinson. 2005. Environmentally responsible potato production systems: A review. J. Plant Nutr. 28:1287-1309.

Trenkel, M.E. 2010. Slow- and controlled-release and stabilized fertilizers: An option for enhancing nutrient use efficiency in agriculture. International Fertilizer Industry Association (IFA). Paris, France.

van Evert, F.K., R. Booij, J.N. Jukema, H.F.M. ten Berge, D. Uenk, E.J.J. Meurs, W.C.A. van Geel, K.H. Wijnholds, and J.J. Slabbekoorn. 2012. Using crop reflectence to determine sidedress N rate in potato saves N and maintains yield. Europ. J. Agron. 43:58-67.

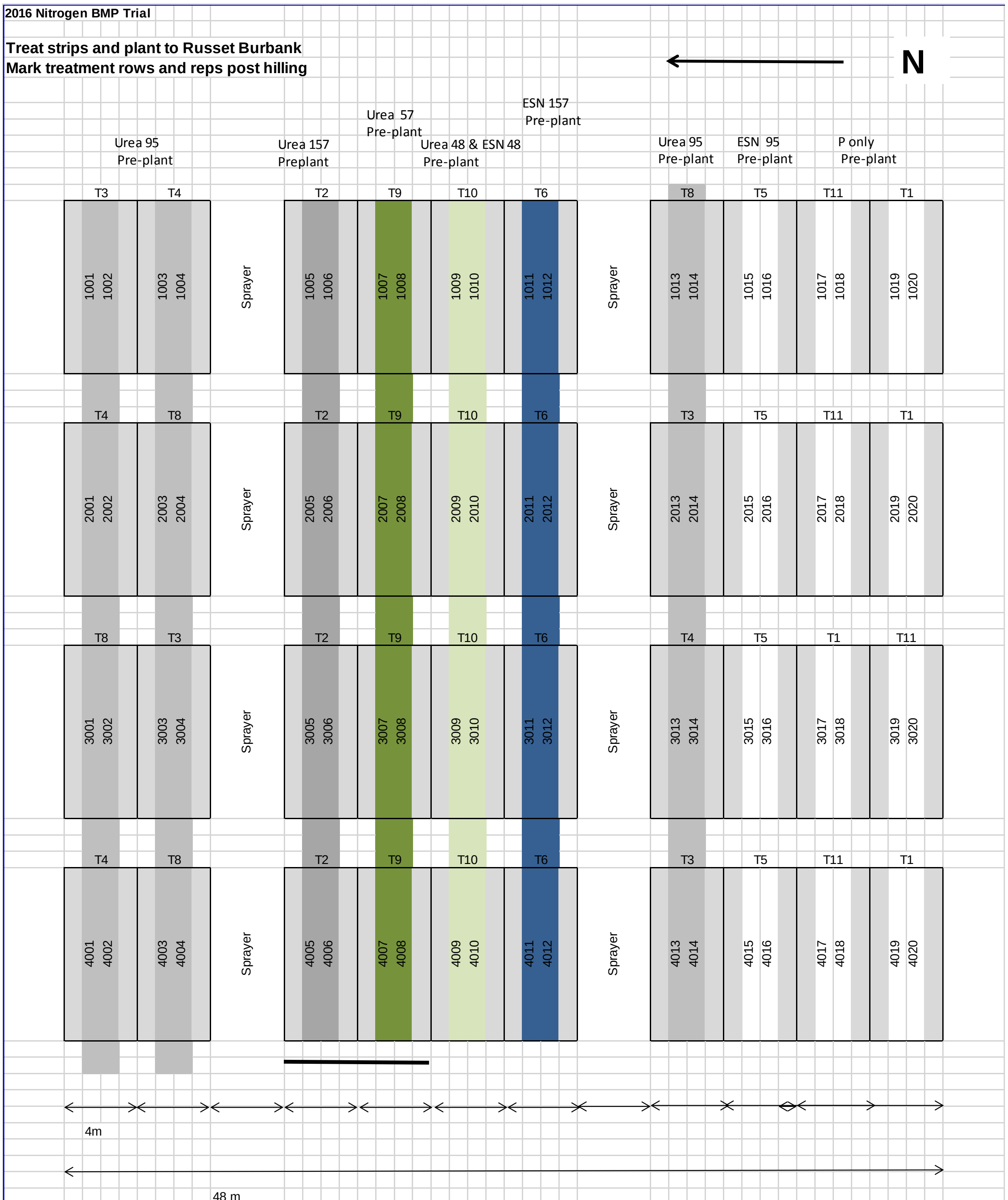
Westermann, D.T., and R.E. Sojka. 1996. Tillage and nitrogen placement effects on nutrient uptake by potato. Soil Sci. Soc. Am. J. 60:1448-1453.

Wilson, M.L., C.J. Rosen, and J.R. Moncrief. 2010. Effects of polymer-coated urea on nitrate leaching and nitrogen uptake by potato. J. Env. Qual. 39:492-499.

Zebarth, B.J., and C.J. Rosen. 2007. Research perspective on nitrogen BMP development for potato. Amer. J. Potato Res. 84:3-18.

Zebarth, B.J., C.F. Drury, N. Tremblay, and A.N. Cambouris.2009. Opportunities for improved fertilizer nitrogen management in production of arable crops in eastern Canada: a review. Can J Soil Sci. 89:113–132.

Appendix A: Plot plan of AITC Nitrogen Trial 2016.



Applications April 28 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 (341 kg/ha)
3	Treatment 3	Urea split application 46-0-0 207 kg/ha pre-plant
4	Treatment 4	Urea /ESN split application 46-0-0 207 kg/ha pre-plant
5	Treatment 5	ESN + fertigation 44-0-0 205 kg/ha pre-plant
6	Treatment 6	ESN boradcast 44-0-0 341 kg/ha (2 passes of XXX)
8	Treatment 8	High broadcast + fertigation 117 kg/ha urea pre-plant
9	Treatment 9	Urea/ESN + fertigation 104 kg/ha 46-0-0 pre-plant
10	Treatment 10	Urea/ESN + fertigation 48kg/ha of 46-0-0 and 48 kg/ha ESN pre-plant
11	NJB1	MAP at Planting + Urea:ESN at Hilling 60:40 (95:62)