Evaluation of a Polymer Coated Urea on Irrigated Kidney Bean and Potato Production on a Coarse Textured Soil

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Abstract

Polymer coated urea (PCU) for irrigated crop production has been documented to reduce nitrate-N leaching and improve N use efficiency while maintaining yields. Until recently PCU use was not cost-effective for most row crops due to its high price without an offsetting increase in yield or reduction in N rate. A new cost effective PCU, (ESN, Agrium, Inc.) has become available. Field studies were conducted comparing rate and application timing of ESN and uncoated urea on Montcalm kidney beans (*Phaseolus vulgaris* L.) and Russet Burbank potatoes (*Solanum tuberosum* L.) with respect to yield and nitrate-N leached. Uncoated urea was applied in multiple applications and a single early application was used for ESN. Nitrate-N leaching was determined by constructing a soil water budget and estimating soil water nitrate-N concentrations with suction samplers. Response to ESN compared with uncoated urea depended on year. In 2006, potatoes fertilized with ESN at emergence produced higher total yields than those fertilized with split urea applications, although marketable yields were not significantly different. In 2007, total and marketable tuber yields were not affected by N source. In both years, kidney beans fertilized at planting resulted in higher yields than N applied at emergence. In 2006, there was no significant difference in kidney bean yield due to N source. In 2007, uncoated urea produced significantly higher kidney bean yields. Under the low rainfall conditions of this study, nitrate-N leaching was not affected by fertilizer source for either crop. Overall, ESN performed better when applied at early sidedress in a long season crop (potato), while the short season crop, kidney beans, produced better yields when ESN was applied at planting.

Introduction

In Minnesota, potato is an important cash crop that requires irrigation because it is typically grown on coarse-textured soils with low organic matter. These soils generally lack available nitrogen and therefore high rates of nitrogen are applied in order to maximize yield. Potato production has been expanding in Minnesota on glacial outwash soils and now covers more than 20,000 hectares. Minnesota is also a leading producer of dark red kidney beans, with about half of its total acreage irrigated on glacial outwash as well. Both crops have shallow root systems, which combined with the addition of highly soluble nitrogen fertilizers, irrigation, and unpredictable rainfall, have intensified nitrate-N leaching to groundwater. Better management techniques are needed to address the increased nitrate-N leaching associated with potato and kidney bean production. Polymer coated fertilizers have been documented to reduce nitrate-N leaching while maintaining crop yields, but until recently have not been cost effective due to high prices without a significant return in yield response (Zvomuya et al., 2003). A new brand of polymer coated urea (PCU), called Environmentally Smart Nitrogen (ESN, Agrium, Inc.), has been developed which is considerably lower in price, but its effects on potato and kidney bean have not been studied.

Objective

Evaluate the effects of nitrogen source, rate, and timing on Russet Burbank and Montcalm kidney bean yield and nitrate-N leaching.

Acknowledgements

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Table 1. Nitrogen treatments for Russet Burbank at Becker, MN.

	Preplanting	Planting	Emergence and Hilling	Post-Hilling	Total
	------------------- kg N ha^{-1} -------------------				
1.	0	0	0	0	0
N source - Diammonium phosphate at planting + Urea after planting					
2.	0	45	23	1x 22	90
3.	0	45	68	1x 67	180
4.	0	45	113	1x 112	270
5.	0	45	158	1x 157	360
6.	0	45	113	5x 22	270
N source - DAP @ planting + ESN					
7.	0	45	45	0	90
8.	0	45	135	0	180
9.	0	45	225	0	270
10.	0	45	315	0	360
11.	225	45	0	0	270
12.	0	45+225	0	0	270

Table 2. Nitrogen treatments for Montcalm Kidney Beans at Staples, MN.

	N Source	Planting	+2 Week Sidedress	Prebloom	Total
		------------------- kg N ha-1 -------------------			
1.	None	0	0	0	0
2.	Urea	67	0	0	67
3.	ESN	67	0	0	67
4.	Urea	0	34	0	34
5.	ESN	0	34	0	34
6.	Urea	0	34	33	67
7.	ESN	0	67	0	67
8.	Urea	0	34	67	101
9.	ESN	0	101	0	101

Methods and Materials

Two, 2 year studies were conducted over the 2006 and 2007 growing seasons:

Potatoes
- Location: Sand Plain Research Farm, Becker, MN
  - Cultivar – Russet Burbank potato
  - Soil – Hubbard loamy sand
  - 12 treatments each year in RCBD, 5 replications (Table 1)
  - Planted 4th week of April; Vines killed 3rd week of September
  - 12 treatments each year in RCBD

Kidney Beans
- Location: Central Lakes Irrigation Station, Staples, MN
  - Cultivar – Montcalm kidney beans
  - Soil – Verndale sandy loam
  - Split Plot design, six replications with 2 tillage treatments as whole plots and 9 nitrogen treatments as subplots (Table 2)
    - Yields by nitrogen treatment were averaged over tillage for the purpose of this poster
  - Planted last week of May; Harvested last week of August

Nitrate leaching estimates for both studies
- Nitrate concentrations measured with suction tubes from planting until ground freeze
- Nitrate leaching was estimated by calculating a soil water budget (Zvomuya *et al.* 2003) and measuring nitrate concentrations
  - Only reported for 2006 since data are still being collected for 2007

Results

Figure 1. Irrigation and precipitation at Becker, MN – 2006.

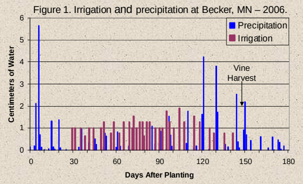


Figure 4. Irrigation and precipitation at Staples, MN – 2006.

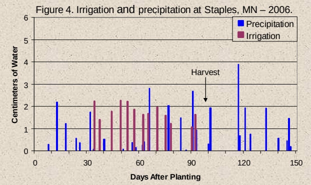


Figure 2. Nitrate-N concentrations at 4ft depth for Potato - 2006.

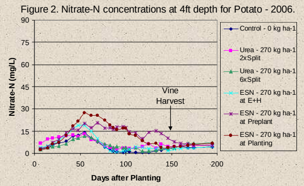


Figure 5. Nitrate-N concentrations at 4ft depth for Kidney Bean - 2006.

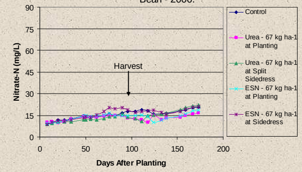


Figure 3. Total nitrate-N leached for Potato - 2006.

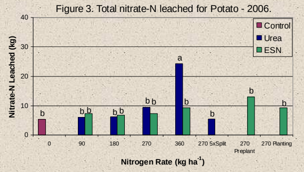


Figure 6. Total nitrate-N leached for Kidney Bean - 2006.

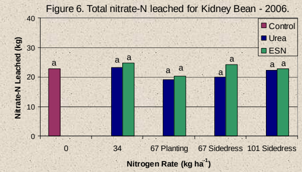


Table 3. Tuber Yields for Russet Burbank in 2006 & 2007.

Treatment				2006		2007	
	N Source	N Rate	Timing PP, P, EH, PH[1]	Total Yield	Marketable Yield	Total Yield	Marketable Yield
				------------Mg ha^{-1}------------			
1	None	0	0, 0, 0, 0	58.0 e	42.3 d	53.0 d	40.9 d
2	Urea	90	0, 45, 23, 22	68.1 d	50.9 c	78.4 bc	62.7 c
3	Urea	180	0, 45, 68, 67	75.4 ab	61.6 a	78.2 bc	67.5 bc
4	Urea	270	0, 45, 113, 112	71.9 bcd	58.6 ab	78.8 bc	71.0 ab
5	Urea	360	0, 45, 158, 157	69.5 cd	57.0 ab	79.1 bc	71.2 ab
6	Urea	270	0, 45, 113, 5x22	68.5 d	54.6 bc	82.2 ab	72.9 a
7	ESN	90	0, 45, 45, 0	74.1 abc	57.9 ab	76.9 c	62.8 c
8	ESN	180	0, 45, 135, 0	78.4 a	60.9 a	84.8 a	71.5 ab
9	ESN	270	0, 45, 225, 0	75.0 ab	59.3 ab	83.2 ab	72.3 ab
10	ESN	360	0, 45, 315, 0	75.3 ab	58.6 ab	78.1 bc	68.3 ab
11	ESN	270	225, 45, 0, 0	69.0 dc	55.3 bc	80.5 abc	71.1 ab
12	ESN	270	0, 270, 0, 0	72.8 bcd	57.2 ab	78.2 bc	71.0 ab

[1]PP, P, EH, PH= Preplanting, Planting, Emergence & Hilling, and Post-Hilling, respectively

Table 4. Kidney bean yields in 2006 & 2007.

Treatments				2006	2007
	N Source	N Rate	Timing P, SD, PB[1]	Total Yield	Total Yield
				---------- Mg ha^{-1} ----------	
1	None	0	0,0,0	1.52 e	1.59 f
2	Urea	67	67,0,0	1.72 ab	1.80 a
3	ESN	67	67,0,0	1.68 ab	1.73 ab
4	Urea	34	0,34,0	2.02 d	2.31 de
5	ESN	34	0,34,0	1.99 de	2.16 ef
6	Urea	67	0,34,33	1.80 cd	2.02 bc
7	ESN	67	0,67,0	1.71 d	1.94 cd
8	Urea	101	0,34,67	1.93 abc	2.15 b
9	ESN	101	0,101,0	1.85 bcd	1.93 cd

[1]P, SD, PB= Planting, Sidedress, and Pre-bloom, respectively

Reference

Zvomuya F, Rosen C, Russelle M, Gupta S. 2003. Nitrate leaching and nitrate recovery following application of polyolefin-coated urea to potato. J of Env. Qual. 32:480-489.

Figure 7. Irrigation and precipitation at Becker, MN – 2007.

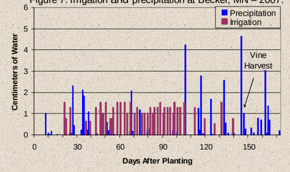


Figure 9. Irrigation and precipitation at Staples, MN – 2007.

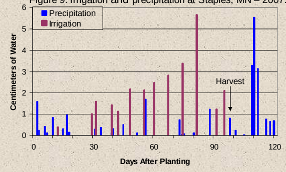


Figure 8. Nitrate-N concentrations at 4ft depth for Potato - 2007.

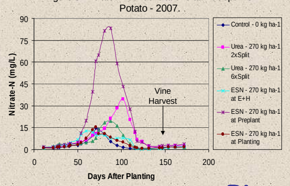
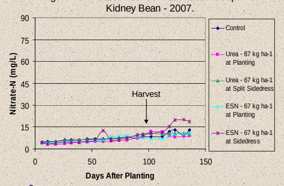


Figure 10. Nitrate-N concentrations at 4ft depth for Kidney Bean - 2007.



Discussion

Potatoes
- In 2006, coated urea (ESN) resulted in a significantly higher total tuber yield, but marketable yields were not affected by treatment. In 2007, nitrogen source at equivalent nitrogen rates did not significantly affect total or marketable tuber yield (Table 3).
- The highest total tuber yield produced by ESN for both years was at a rate of 180 kg ha^{-1} applied at emergence. For uncoated urea, the highest total tuber yields were obtained at 180 kg ha^{-1} applied in 2 split applications in 2006 and at 270 kg ha^{-1} applied in 6 split applications in 2007 (Table 3).
- Highest marketable tuber yield for ESN was at a rate of 180 kg ha^{-1} at emergence in 2006 and at 270 kg ha^{-1} at emergence in 2007. For uncoated urea, the highest marketable yields were applied at 180 kg ha^{-1} in two split applications in 2006 and at 270 kg ha^{-1} applied in 6 split applications in 2007 (Table 3).

Kidney Beans
- In 2006, nitrogen treatments did not significantly affect kidney bean yields, but in 2007, ESN at equivalent rates resulted in significantly lower yields compared to uncoated urea (Table 4).

Nitrate Leaching
- Soil water nitrate-N concentrations under potatoes tended to be higher for ESN when applied in the spring before planting. This suggests that N had been released from the coated urea and leached past the root zone before the potatoes had reached peak N uptake (Figs. 2 & 8).
- Urea applied at 360 kg ha^{-1} to potatoes resulted in significantly higher leaching than the other treatments in 2006 (Fig. 3).
- Fertilizer source did not significantly affect nitrate leaching under kidney bean (Fig. 6).

Conclusions

- In 2006 and 2007 there was unusually low precipitation during the growing season. Under these conditions when applied at equivalent N rates, ESN resulted in similar marketable yields compared with uncoated urea for tubers, and in lower yields for kidney beans in one of the two years. This suggests that the coated urea released N at a rate congruent with nitrogen uptake for 140 day potatoes while it did not for kidney beans, which have a much shorter growing season.
- Except at the very high rate of N applied, differences in nitrate-N leaching at equivalent N rates were not detected for either sources of N, although applying ESN too early may allow nitrate-N to leach past the root zone before uptake.
- Use of coated urea may eliminate or reduce the need for using fertigation for potato production.