RESIDUAL SOIL NITRATE AND POTATO YIELD WITH POLYMER COATED UREA

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ABSTRACT

Potato (*Solanum tuberosum* L.) requires steady, but not excessive nitrogen (N) supply for maximum tuber yield, size, and solids, as well as minimal internal and external defects. Although more costly and labor intensive than dry broadcast applications, growers typically apply a majority of N via fertigation. A controlled release N fertilizer, polymer coated urea (PCU), is a possible alternative to this growers' standard practice. A newly formulated PCU may meet plant demand in a timely and efficient manner through temperature-controlled release of N into the soil solution, thereby possibly increasing yield and tuber quality, reducing N loss via leaching and denitrification, and reducing application costs. The objectives of this study were to determine the effects of PCU on the yield and quality of Russet Burbank potatoes grown in Southeast Idaho during 2006-2007. Nitrogen was applied at four rates (33, 67, 100, or 133% of recommended) at three locations with four methods of application, namely: 1) urea at emergence, 2) urea split applied, 3) PCU at emergence, and 4) PCU pre-plant (only the 67% rate) and compared to an untreated control. Results showed significant increases in US No. 1, marketable, and total yield, as well as increases in crop value for PCU treatments over the other treatments. Post harvest soil analyses showed that nitrate levels in and below the rooting zone were reduced for PCU as compared to uncoated urea. The optimum rate of 67% PCU applied at emergence consistently yielded higher than the other treatments and was significantly greater (4.2 Mg ha^{-1} or 1.9 ton ac^{-1}) in marketable tubers than the grower's standard practice. The optimum PCU rate resulted in 6 mg kg^{-1} (ppm) less residual soil nitrate than the grower standard practice.

INTRODUCTION

Potatoes rank 8th in acreage and 3rd in value among crops according to the most recent US agricultural census (National Agricultural Statistics Service, 2002). This valuable crop is particularly sensitive in its requirement for a steady supply of nutrients, especially nitrogen (N) (Stark et al., 2004; Westermann, 2005). A substantial percentage (20%) of the total operating cost is fertilizer (Milburn et al., 1990; Munoz et al., 2005; Zvomuya et al., 2003). The express need for N by potatoes is compounded by the common deficiency in mineral soils of plant-available N. Potato recovery of the available N is inefficient, as only 16-36% recovery is experienced under conditions of severe leaching (Errebhi et al., 1998). Nitrogen deficiencies cause poor vine health, increase pathogen and insect susceptibility, reduce tuber yields, and diminish tuber quality (Ojala et al., 1990; Olsen et al., 2003; Stark et al., 2004; Stark and Love, 2003). Proper N management techniques reduce both N loss and potentially negative impacts to the environment (groundwater contamination and emission of nitrous oxide – a potent greenhouse gas; Hill, 1986; Honisch et al., 2002; Milburn et al., 1990; Munoz et al., 2005;

Zvomuya et al., 2003). Currently growers' standard practice includes 25-50% of N applied pre-emergence followed by multiple in-season applications of N via fertigation in an effort to maximize yields and tuber quality. However, these split applications are costly and labor intensive. A new polymer coated urea (PCU) product (Environmentally Smart Nitrogen, ESN®, Agrium Advanced Technologies, Brantford, Ontario) has been engineered to release N on a "plant-need basis", with the release rate corresponding to soil temperature and, therefore, root growth.

OBJECTIVES

The objectives of this study are to determine the effects of ESN in potato production on N use efficiency, tuber yield, tuber quality, and N losses to the atmosphere and groundwater.

MATERIALS AND METHODS

Study site locations were selected in southern Idaho near Aberdeen, Blackfoot, and Rupert in 2006 and 2007. Treatments were applied in a completely randomized block design with 4 replications. Fertilizers were applied at 5 rates: 0, 33, 67, 100, and 133% of University of Idaho recommended N guidelines (100% rate ranged between 247-314 kg ha^{-1} or 220-280 lb ac^{-1}; varied based upon yield goal, residual soil N, previous crop residue, and N in irrigation water). There were 4 timings of the fertilizers: regular urea at emergence (RE), regular urea split applied (RS), PCU at emergence (CE), PCU at pre-plant (CP) at only a 67% rate. Plots were four rows (6.1 m or 12 ft) wide by 12.2 m (40 ft) in length. The middle two rows were harvested (6.1 m or 20 ft). Harvested potatoes were graded for size, shape, solids and internal and external defects after 4-6 weeks of storage. Statistical analysis was performed by ANOVA with LSD mean separation.

RESULTS AND DISCUSSION

Total, US No. 1, and marketable yields consistently were the highest for the 67% rate of ESN applied at emergence (location interaction not significant; rate X N source highly significant at $Pr > F$ 0.0019). Total and marketable yields for 67% ESN rate applied at emergence (67% CE) were significantly higher than the grower's standard practice (100% RS) in 2006. US No. 1 and marketable yields for 67% ESN rate applied at emergence (67% CE) were significantly higher than the grower's standard practice (100% RS) in 2007. These results suggest that the optimum N rate for ESN is lower than for regular urea (45 kg N ha^{-1} or 40 lb ac^{-1} average difference in this trial; correlation data not shown), which results in approximately 6 mg kg^{-1} or ppm less residual nitrate (data not shown). Optimum timing for ESN appears to be at emergence based on this and data from studies in other states.

CONCLUSION

The ESN effectively increased potato yield and quality when compared to urea applied all at once or in split applications. The ESN appears to have improved N use efficiency, with reduced rates proving to be more effective than the grower's standard practice full rates. In addition, ESN has the potential to reduce residual soil nitrate. Therefore, ESN may result in reduction in groundwater contamination and/or reductions in greenhouse gas emissions (nitrous oxide). ESN appears to be a good alternative for N use in potatoes grown under conditions similar to those in this study.

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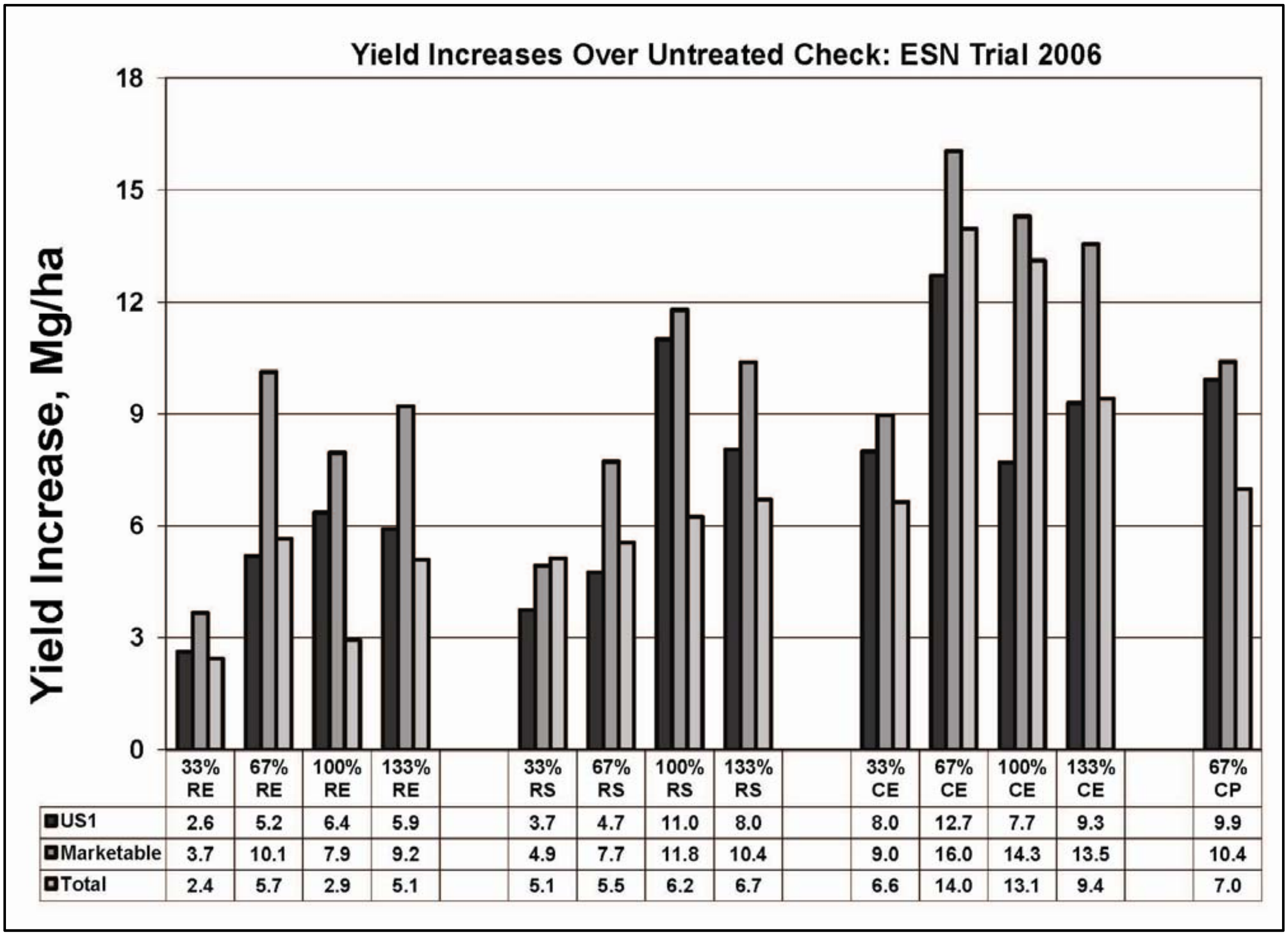
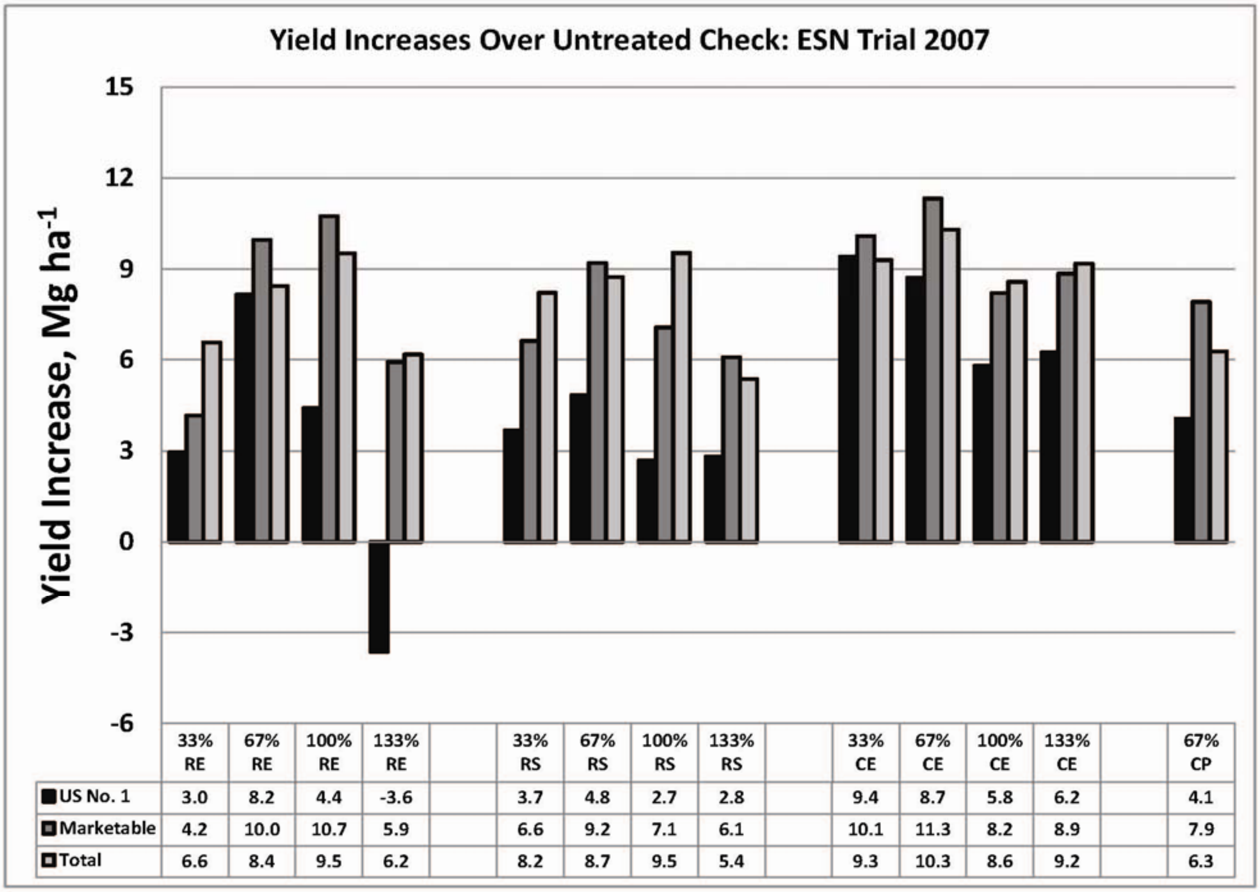


Figure 1. Combined potato yield increases over an untreated check averaged across three Idaho ESN field trials in 2006. Nitrogen was applied at five rates with 0, 33, 67, 100, or 133% of recommended. Four methods of application were used: 1) urea at emergence (E), 2) urea with 50% applied at emergence and the remaining in three in-season applications (split), 3) ESN at emergence, and 4) ESN at pre-plant (P). The ESN P treatment was only applied at the 67% rate. Differences for total (LSD 5.4 Mg ha^{-1} or 2.4 ton ac^{-1}), US No. 1 (LSD 4.0 Mg ha-1 or 1.8 ton ac^{-1}) and marketable (LSD 4.1 Mg ha-1 or 1.8 ton ac^{-1}) were highly significant.



	33% RE	67% RE	100% RE	133% RE		33% RS	67% RS	100% RS	133% RS		33% CE	67% CE	100% CE	133% CE		67% CP
US No. 1	3.0	8.2	4.4	-3.6		3.7	4.8	2.7	2.8		9.4	8.7	5.8	6.2		4.1
Marketable	4.2	10.0	10.7	5.9		6.6	9.2	7.1	6.1		10.1	11.3	8.2	8.9		7.9
Total	6.6	8.4	9.5	6.2		8.2	8.7	9.5	5.4		9.3	10.3	8.6	9.2		6.3

Figure 2. Combined potato yield increases over an untreated check averaged across three Idaho ESN field trials in 2007. Nitrogen was applied at five rates with 0, 33, 67, 100, or 133% of recommended. Four methods of application were used: 1) urea at emergence (E), 2) urea with 50% applied at emergence and the remaining in three in-season applications (split), 3) ESN at emergence, and 4) ESN at pre-plant (P). The ESN P treatment was only applied at the 67% rate. Differences for total (LSD 4.9 Mg ha^{-1} or 2.2 ton ac^{-1}), US No. 1 (LSD 4.2 Mg ha^{-1} or 1.9 ton ac^{-1}) and marketable (LSD 4.0 Mg ha^{-1} or 1.8 ton ac^{-1}) were highly significant.

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