CONTROLLED-RELEASE UREA, IS IT A VIABLE NITROGEN SOURCE FOR IRRIGATED POTATO?

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Optimum potato yields require good cultural practices that includes proper fertilizer management. Large amounts of nitrogen is needed for high yields and better tuber quality (Dean, 1994). Nitrogen deficiency causes stunted growth, yellowing of leaves, reduced tuber size and yield, as well as lower tuber specific gravity (Schaupmeyer, 1992). Excess nitrogen can delay maturity, thereby, reducing tuber specific gravity at harvest (Schaupmeyer, 1992). This is particularly important under short growing season environments, e.g. on the Canadian prairies.

Supplemental nitrogen is essential for potatoes since soil nitrogen alone cannot satisfy the nitrogen requirement of the crop (Westermann et al. 1993). Studies in Alberta have shown that approximately 200 kg/ha N is required for optimum potato yields (Schaupmeyer, 1992). Sufficient nitrogen is needed throughout the growing season to produce high yields and better tuber quality. However, nitrogen demand can vary depending on the crop growth stage (Harris, 1992 and Westermann, 1994). Split application of nitrogen is more efficient than a single application as it favours better nitrogen utilization by the crop while reducing leaching and denitrification losses. Nitrogen application after planting is normally done during hilling operations using granular fertilizers or through sprinklers (fertigation). Fertigation is done several times during the crop season to maintain adequate nitrogen status in relation to the various crop growth stages.

The commonly used nitrogenous fertilizers (ammonium sulphate, ammonium nitrate, and urea) are highly soluble, consequently there can be considerable losses due to leaching in addition to depletion through denitrification and immobilization by soil microbes. These losses can be even higher if heavy rain follows fertilizer application (Carefoot, 1993). The efficiency of nitrogen uptake can be improved using controlled-release urea that can be applied at planting with the anticipation that it will meet the crop nutrient needs for the entire growing season. Carefoot (1993) and Shaviv and Mikkelson (1993) have ascribed several agronomic, economic, and environmental advantages for the use of controlled-release fertilizers compared to conventional ammonium nitrate and urea formulations.

AGRONOMIC:

Increased nutrient availability.
2. Nutrients released faster under high temperature and high soil moisture levels, conditions favourable for active plant growth, i.e. improved fertilizer efficiency.
3. Reduces toxicity caused by excess nutrient concentration.

ECONOMIC

1. Lower nutrient losses due to leaching, volatilization, and surface run-off.
2. Reduces fertilizer costs as only a single application, at planting, would supply the nutrient requirement for the entire crop.
3. Controlled-release fertilizers can be applied in the fall which eases the spring rush.

ENVIRONMENTAL

1. Decrease ground water contamination.
2. Reduces health hazards due to high nitrate concentrations in the environment.
3. Controls the harmful impact of ammonia volatilization on the ecosystem.

This study examines the effectiveness of controlled-release urea with conventional split application (at planting and at hilling) of granular formulation of ammonium nitrate on productivity of potato grown under irrigation.

MATERIALS AND METHODS

The study was conducted at the Saskatchewan Irrigation Development Centre, Outlook during 1993 and 1994 summer seasons. The soil at this site was classified as a calcareous Bradwell SiL (Stushnoff and Acton, 1987). Potato cultivars Norland (early-maturing table market) and Russet Burbank (late-maturing processing type) were used in this study. The various nitrogen treatments were formulated to provide 200 kg N/ha during both 1993 and 1994 although the types of controlled-release urea tested and the rate combinations were different in the two years (Table 1). Three types of controlled-release urea were tested in this study: T-60, T-90, and T-120 formulations designed to be effective for periods of 60, 90, and 120 days respectively after soil incorporation. Phosphorus and potassium were applied at the rates of 120 kg P_2O_5 and 200 kg K_2O per ha as blanket application. The top dressing of nitrogen was done at hilling when the plants were approximately 15 cm tall. Seed pieces weighing approximately 50 g were planted at a spacing of 90 cm (between row) x 30 cm (within row). The soil moisture was maintained at 65% field capacity using supplemental sprinkler irrigation. The crop was harvested 120 after planting and the tubers were graded into three size categories according to diameter: 25-45 mm (small), 45-90 mm (marketable), and >90 mm (over-size). As the marketable tubers constituted major proportion of the total yield, discussions in this paper will be limited marketable tubers only.

RESULTS

Soil Analysis

The spring soil analysis for samples collected prior to planting are presented in Table 2. The soil at the 1994 test site had a more favourable pH range and contained higher levels of nitrogen and potassium than the 1993 site.

Table 1. Fertilizer treatments used in the 1993 and 1994 tests

Fertilizer application rates (kg N/ha)			
1993		1994	
Basal	Top dressing	Basal	Top dressing
T-60 @ 200	0	T-60 @ 200	0
T-60 @ 150	AN @ 50	T-90 @ 200	0
T-90 @ 200	0	T-120 @ 200	0
			50
AN[z] @ 200	AN @ 50	T-90 @ 150	50
		T-120 @ 150	50
		T-60 @ 100	100
		T-90 @ 100	100
		T-120 @ 100	100
		AN@200	0

T-60, T-90, and T-120 forms of controlled-release nitrogen are designed to release nitrogen for periods of 60, 90, and 120 days from application respectively.

[z]AN: Ammonium nitrate (34-O-O)

Table 2. Spring soil analysis of test plots: 1993 and 1994

	1993		1994	
	O-30 cm	30-60 cm	O-30 cm	30-60 cm
pH	9.0	9.5	7.8	8.6
1:1 E.C. dS/cm	0.3	0.2	0.2	0.2
NO_3-N (kg/ha)	34	lb	120	50
P (kg/ha)	60+		60	
K (kg/ha)	398		797	
SO_4-S (kg/ha)	28	96+	74	53

Tuber Yield

The effect of various forms of controlled-release fertilizer on marketable tuber yield for Norland and Russet Burbank potatoes during 1993 and 1994 growing seasons are presented in Table 3. Results of group comparisons of the different controlled-release urea sources for both cultivars are shown in Table 4.

Table 3. Marketable yield responses to controlled-release fertilizer application for Norland and Russet Burbank potatoes

Fertilizer application (kg N/ha)[z]		Marketable tuber yield (t/ha)			
		1993		1994	
Basal dressing	Top dressing	Norland	Russet Burbank	Norland	Russet Burbank
100 AN	100AN	23.5	12.1	52.9	36.1
200 T-60	0	23.8	15.8	53.2	39.3
200 T-90	0	24.2	19.2	54.3	42.0
200 T-120	0			46.1	40.7
100 T-T60	100AN	19.9	16.4	43.0	27.8
100 T-90	100 AN	25.7	17.5	50.6	39.0
100 T-120	100 AN			54.3	38.9
150 T-60	5oAN			51.2	36.0
150 T-90	5oAN			57.2	39.3
150 T-120	5oAN			49.9	43.5
ANOVA					
Significance		NS	0.05	NS	NS
LSD (5.0%)			3.9		
C.V. (%)		12.6	18.0	14.7	16.6

For Norland, there were no significant differences in tuber yield among the various controlled-release nitrogen sources and ammonium nitrate in both 1993 and 1994 (Table 3). Group comparison also showed that T-60, T-90, and T-120 produced similar tuber yields.

Table 4. Group comparison of marketable yields for Norland and Russet Burbank potatoes in response to different forms of controlled-release urea

Year	cultivar	T-60	T-90	T-120
1993	Norland	21.9a	25.0a	
	Russet Burbank	16.1a	18.4a	
1994	Norland	43.3a	47.6a	44.4a
	Russet Burbank	30.2a	34.9b	35.6b

Means followed by different letters in each row are significantly different at $P < 0.05$ level of probability.

For Russet Burbank, the controlled-release nitrogen fertilizers produced higher marketable yields than ammonium nitrate and the differences were non significant in 1994 (Table 3). According to group comparison, in 1993, the differences between T-60 and T-90 were not significant although T-90 produced 14% higher marketable tuber yield than T-60 (Table 4). In 1994, T-90 and T-120 outyielded T-60 by 16% and 18% respectively.

DISCUSSION

The overall yields for both Norland and Russet Burbank potatoes were higher in 1994 likely due to better soil nutrient status (Table 1) and favourable environmental conditions in 1994 relative to 1993 (Burton, 1966).

With Norland potato there was no added yield advantage for using controlled-release nitrogen over the conventional ammonium nitrate. This is likely because the early maturing Norland utilizes nitrogen early in the season and this can be provided by both leaching prone ammonium nitrate or the more expensive forms of controlled-release nitrogen.

Russet Burbank, is a more vigorous late maturing potato cultivar that will require nitrogen fertilizer for a relatively longer period than the early maturing Norland. Accordingly, in this test Russet Burbank produced higher yields with controlled-release fertilizer than standard ammonium nitrate. Russet Burbank responded positively to late season nitrogen availability, for example T-90 and T-120 forms outyielded T-60. It has been found that excess and/or late season nitrogen application can delay maturity and lower tuber specific gravity (Westermann *et al* 1994). Further research is necessary to quantify the influence of different types and forms of controlled-release nitrogen on yield and quality of potato considering the economic viability under irrigated production.

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