Using Polymer-Coated Controlled Release Urea for Seed-Placing Nitrogen with Wheat and Canola

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Introduction

As Western Canadian farming practice shifts from conventional farming systems to direct seeding and reduced tillage systems, farmers must cope with the challenges of changing their crop rotation strategies, residue management, weed control, seeding and fertilizer management. Fertilizer management in reduced tillage systems requires that most or all fertilizer must be applied in a single pass at the time of seeding. Placing N fertilizers, such as urea, with the seed can damage emerging seedlings or prevent them from germinating

As fertilizer urea is broken down in the soil it releases ammonia, which is toxic to seedlings (Bremner and Kromeier 1989). Because of this toxicity, urea must be physically separated from seeds either by increasing the spread of seed and fertilizer through the opener (increasing seed-bed utilization), or by separating the seed and fertilizer by means of precision placement such as double-shoot systems. A third possibility is to modify the properties of urea to reduce its toxic effects. Urease inhibitors have been used with some success to reduce seedling damage from seed-placed urea under Western Canadian field conditions (Pauly *et al.* 1996). A controlled release urea (CRU) which uses a polymer coating to surround the granule should be able to slow urea release to the soil and reduce ammonia volatilization (Blaise and Prasad 1995; Trenkel 1997.) In 1998 we set out to test the effectiveness of CRU at reducing seed-placed damage in a series of field experiments, by comparing the CRU treatments to seed-placed urea (SPU) and banded urea.

Methodology

In 1998, nine field trials were established at sites in Alberta and Saskatchewan to measure yield response of wheat and canola to seed-placed nitrogen fertilizers. The experiments were established as two-factor randomized blocks with 4 replicates. Nitrogen sources were: no added N, banded urea (below seeding depth), seed-placed urea (SPU), CRU1- seed placed, CRU2 - seed placed. Treatments were applied across 4 rates of N: 25, 50, 75 and 100 kg ha^{-1}. CRU products were selected on the basis of their ability to release all available N within 40 to 60 days when immersed in water at 23° C. CRU1 had a release near 40 days while CRU2 had a release closer to 60 days under these conditions.

We selected 9 sites from a variety of soil and climatic regions in Alberta and Saskatchewan which had low to moderate soil test N levels (< 15 ppm in the upper 30 cm). Plots were seeded into standing stubble using a research air seeder equipped with Flexi-Coil Stealth seed openers on a 20 cm spacing. This system was estimated to have a seed-bed utilization of between 10 and 15%. Phosphate fertilizer (mono-ammonium phosphate [12-51-0]) was also seed-placed at rates of 25 kg P_2O_5 ha^{-1}, while wheat experiments received 25 kg K_2O ha^{-1} as KCl (0-0-60) and canola received 15 kg S ha^{-1} as ammonium sulfate (20.5-0-0-24). CDC Teal wheat was seeded to achieve a target stand of 100 plants m^{-2} and 45A71 canola was seeded at 9 kg ha^{-1}. Weed control consisted of pre-emergent application of Roundup (glyphosate) and registered post-emergent herbicides. Plant stand counts were taken approximately 30 days after seeding at each site. Grain yields were determined by threshing the entire plot with a plot combine and determining the grain weight and moisture.

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Results: A. Plant Stand

The 1998 field season provided an excellent opportunity to detect and quantify seedling damage from seed-placed fertilizers in Central Alberta and Saskatchewan with warm early season conditions combined with a 10 to 30 day delay in rainfall at all sites.

Table 1. Mean plant stand (plants m^{-2}) at each site averaged across 4 rates of applied N.

Site	Crop	SPU	Banded	CRU1	CRU2	LSD (0.05)	Effect*
Delmas	Canola	36	70	75	76	25	**
Didsbury	Canola	38	116	106	117	26	**
Marwayne	Canola	22	53	51	59	18	**
Ellerslie	Canola	95	136	121	99	32	**
Wainwright	Wheat	71	94	94	98	22	**
Hussar	Wheat	50	92	85	95	15	**
Sedgewick	Wheat	62	76	75	78	22	ns
Battleford	Wheat	48	68	69	49	19	**
Delisle	Wheat	19	43	34	46	21	**

* - Effect indicates the presence of stand reduction at a given site as indicated by a significant difference between the stands of seed-placed and banded treatments.
** - indicates significance at the 0.05 level of probability

All of the sites displayed some level of stand reduction from SPU when compared to banded urea (Table 1.) This stand reduction was significant (at α=0.05) at 8 of 9 sites. CRU treatments had greater plant stands when compared to SPU in 7 of the 8 effective sites. At the Delisle site with wheat, CRU1 treatments had plant stands in between those of banded urea and SPU. The CRU2 treatment was as effective as banding in maintaining plant stand at 6 of the 8 effective sites. With wheat at Battleford and with canola at Ellerslie the CRU2 product did not provide any protection against seed-placed urea injury. At the Ellerslie canola site, it is unlikely that the stand reduction would result in yield loss, because of the ability of canola to compensate for reduced plant stand by increasing production per plant, however maturity date and standability of the crop could be adversely affected by reduced stands.

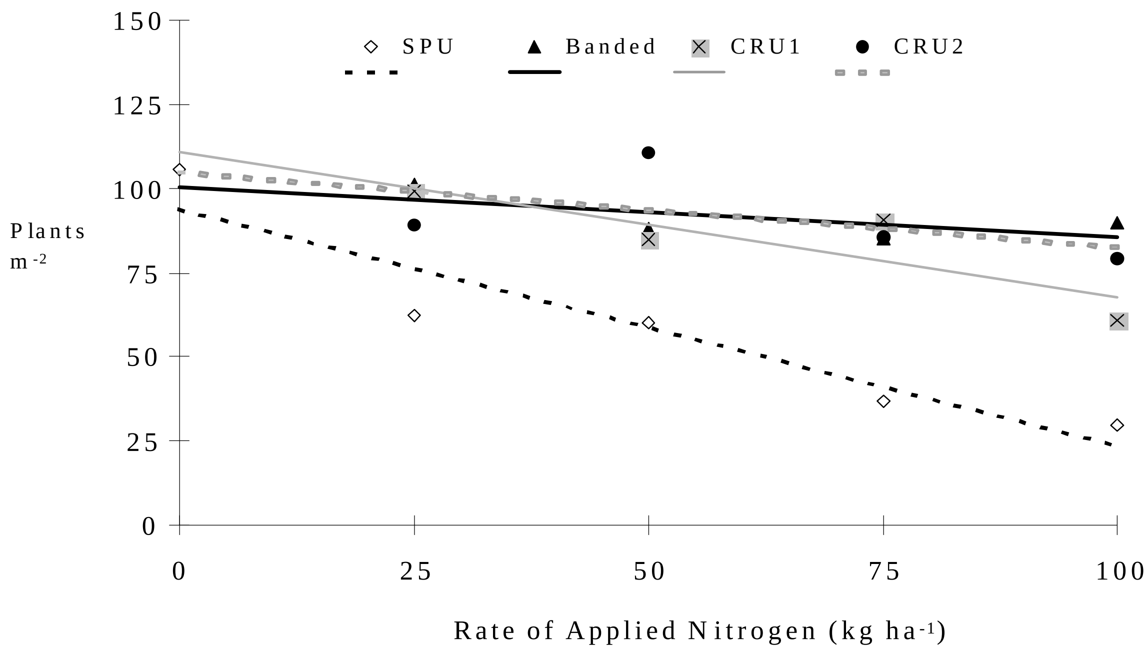

Figure 1. Plant Stand of Canola (data from 4 sites combined)

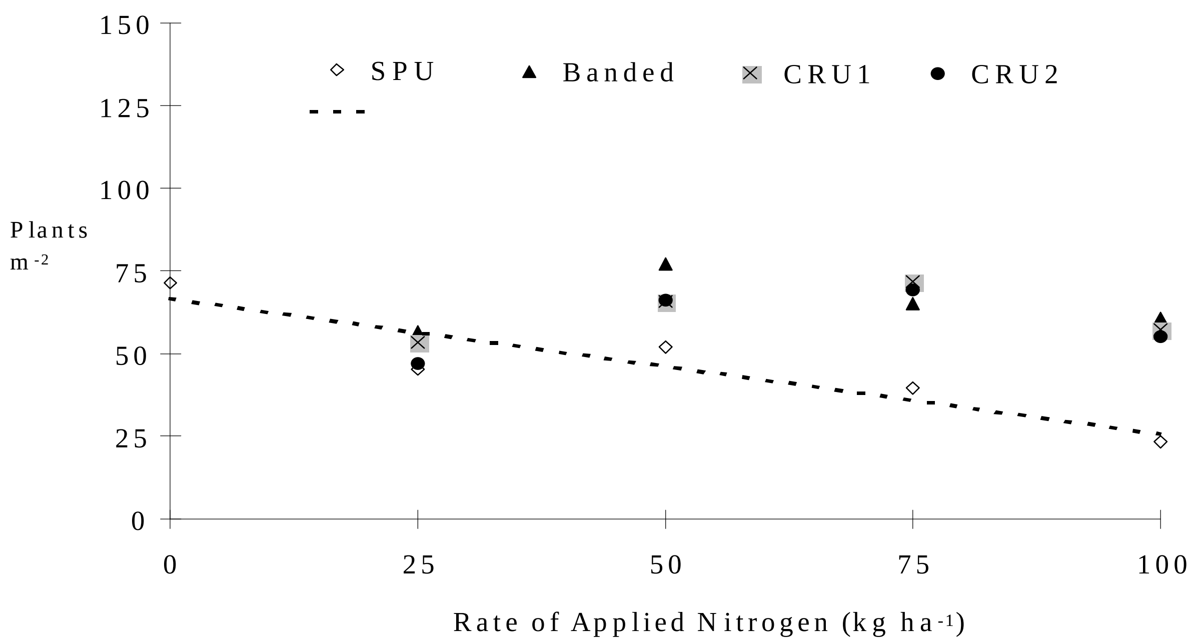

Figure 2. Plant Stand of Wheat (data from 5 sites combined)

Data from the effective sites within each crop were combined to determine the effect of N rate on the plant stand counts (Figure 1). For canola, all treatments had a negative linear relationship with increasing N rate (using contrast analysis at $p = 0.05$). Combined wheat data showed a similar negative linear effect to increasing N rate in the SPU treatments. There was no statistically significant relationship between N rate and plant stand for the banded urea or CRU treatments in the wheat experiments.

Results: B. Grain Yield.

Because of large differences in growing conditions across the prairies in 1998 there was a wide range of yields between sites. For canola the highest mean seed yield was at Ellerslie (2875 kg ha^{-1}) while the lowest was at Marwayne (1008 kg ha^{-1}.) For wheat, mean yield values ranged from 283 kg ha^{-1} at Sedgewick to 1995 kg ha^{-1} at Hussar.

Table 2. Mean grain yield (kg ha^{-1}) at each site averaged across 4 rates of applied N.

Site	Crop	SPU	Banded	CRU1	CRU2	LSD (0.05)	Effect*
Delmas	Canola	1175	1491	1445	1606	194	**
Didsbury	Canola	2069	2410	2494	2461	174	**
Marwayne	Canola	856	1104	1099	1151	264	ns
Ellerslie	Canola	2874	2894	2978	2866	152	ns
Wainwright	Wheat	713	948	895	937	167	**
Hussar	Wheat	1760	2278	2103	2120	265	**
Sedgewick	Wheat	220	268	290	375	63	ns
Battleford	Wheat	969	1155	1219	1187	117	**
Delisle	Wheat	142	452	341	460	195	**

* - Effect indicates the yield reduction at a given site as indicated by a significant difference between the yields of seed-placed and banded treatments.
** - indicates significance at the 0.05 level of probability

Significantly lower yields with the SPU treatment compared to the banded treatment were observed in 2 of 4 canola sites and at 4 of 5 wheat sites. At the effective sites, yield of the CRU treatments were also greater than those of SPU treatments, and similar to banded urea in all cases. In the canola experiment at Ellerslie, it is likely that the stand reduction early in the season was not great enough to result in yield loss at the end of the season. At Marwayne there was a trend toward lower yields of canola in the SPU treatments, but the variability at this site was too great to detect this difference statistically.

Yield as a function of N rate is plotted for each treatment for the combined effective canola sites (Figure 3) and combined effective wheat sites (Figure 4). For canola there was no significant relationship between grain yield and N rate for the banded and CRU treatments. The SPU treatment in canola displayed a significant linear decreasing trend with increased N rate (contrast analysis at α=0.05). Minimal available soil moisture early in the season and lower than average rainfall later on resulted in low yield potentials and no positive response to N additions. However, these same conditions contributed to early season seedling toxicity due to seed-placed urea, and allowed us to observe the performance of the CRU treatments.

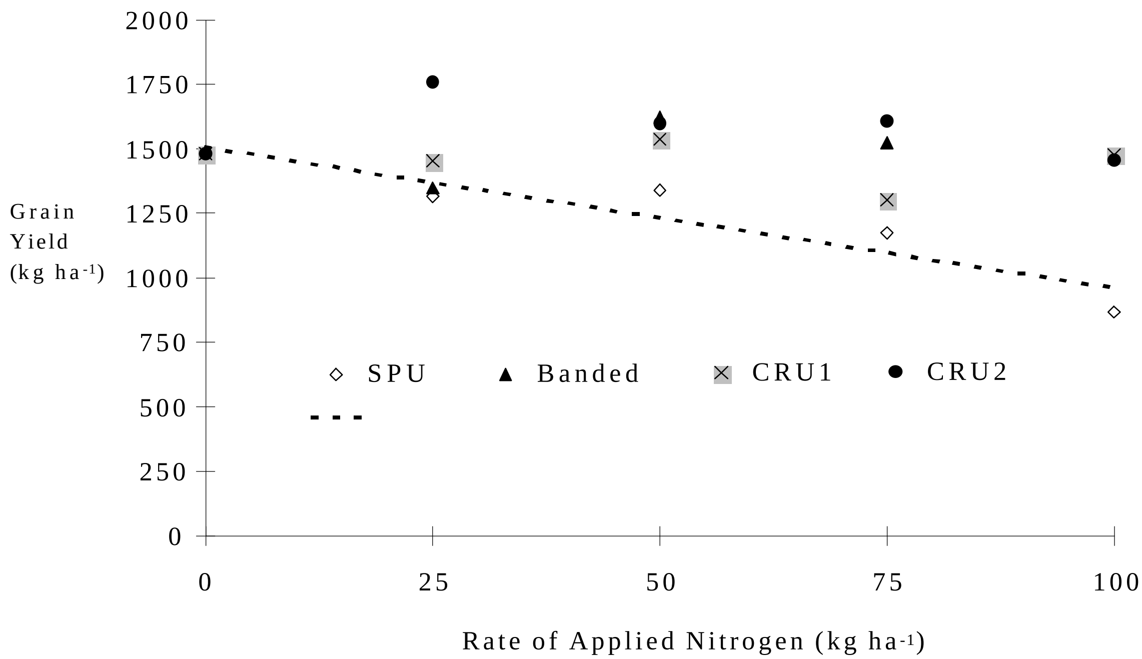

Figure 3. Canola Yield (2 Sites Combined)

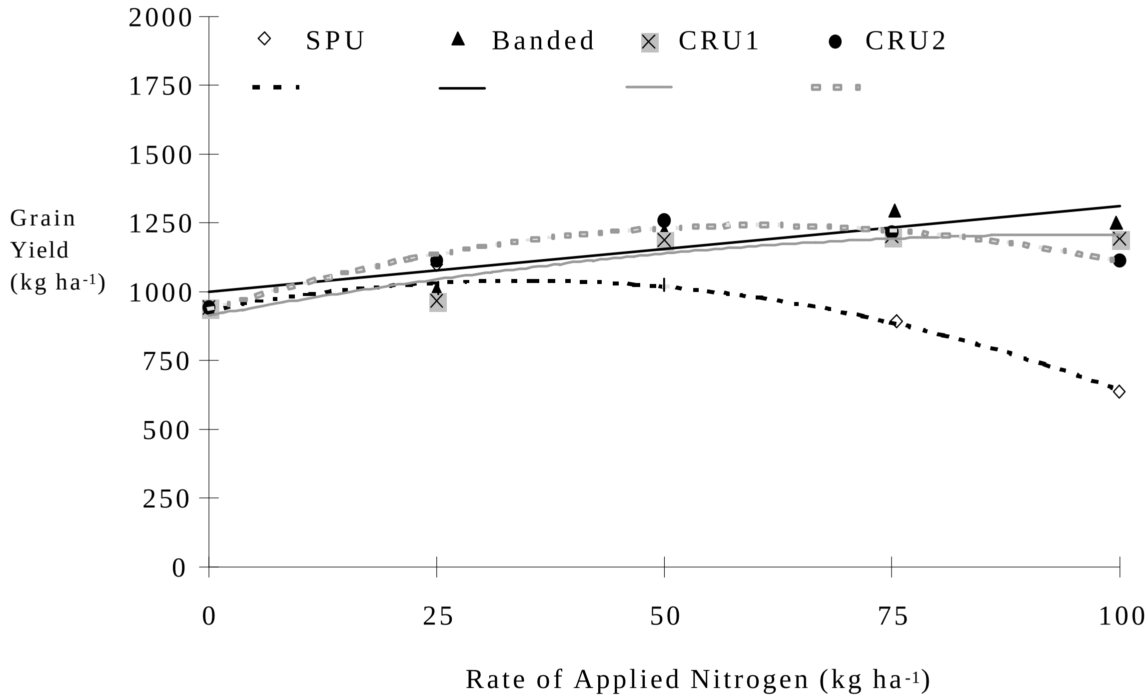

Figure 4. Wheat Yield (data from 4 sites combined)

With wheat, all treatments except banded displayed a curvilinear (quadratic) response to added N with the combined data. The yield of wheat with the banded urea treatment displayed an increasing linear trend with N rate. This data indicates that with wheat the safe seed-placement rate of untreated urea was about 25 kg ha^{-1}. For the CRU treatments the maximum safe placement rate was between 50 and 75 kg ha^{-1}.

Conclusions

CRU products were able to reduce seedling damage from seed-placed urea fertilizer as measured by plant stand reduction and yield reduction when compared to banded urea. The CRU1 product appeared to have more consistency in maintaining plant stands of canola and wheat (having been used successfully at 7 of 8 responsive sites) than the CRU2 product, which showed significantly reduced plant stands (similar to SPU) at two of the sites.

Yield response of wheat and canola to seed-placed CRU products was similar to banding at all sites. At those sites which had significant yield differences between SPU and banded urea (2 in canola and 4 in wheat), both CRU1 and CRU2 treatments had higher yields than SPU treatments. When yield was plotted as a function of N rate for each treatment, contrast analysis revealed that there was no significant relationship betweem yield response to N in the canola experiments other than a decreasing relationship with greater amounts of applied SPU. In the wheat experiments, yields from SPU dropped off above the 25 kg ha^{-1} of applied N, while safe seed-placement rate of the CRU products was between 50 and 75 kg ha^{-1} of N

References

Bremner, John M. and Michael J. Krogmeier. 1989. Evidence that the adverse effect of urea fertilizer on seed germination in soil is due to ammonia formed through hydrolysis of urea by soil urease. Proc. Natl. Acad. Sci. USA. 86:8185-8188.

Pauly, D. G., M. Nutting and R. Dowbenko. 1996. Using a urease inhibitor, N-butyl thiophosphoric triamide (NBPT) for seed-placing nitrogen with wheat, barley and canola. p. 424-430 *In* Soils and Crops '96. University of Saskatchewan, Saskatoon SK. Feb 22 and 23 1996.

Blaise, D. and R. Prasad. 1985. Effect of blending urea with pyrite or coating urea with polymer on ammonia volatilization loss form surface-applied prilled urea. Biol. Fert. Soils 20:83-85.

Trenkel, Martin E. 1997. Improving Fertilizer Use Efficiency: Controlled-Release and Stabilized Fertililzers in Agriculture. Paris: International Fertilizer Industry Association.