Nitrogen Fertilization of Winter Wheat—Alternative Sources and Methods

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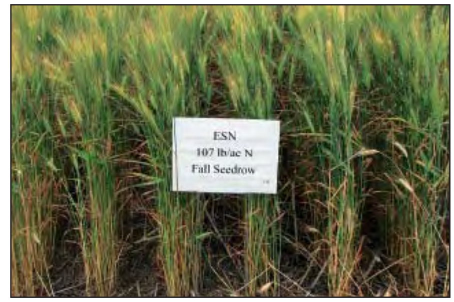
Research results evaluating N sources and placement methods at planting in the early fall for winter wheat production show that controlled release urea (CRU) can be either seed-row or side-band placed while regular urea performs better when side-banded. These N fertilizer methods are considered as feasible replacements to the previously recommended practice of applying the majority of N as ammonium nitrate (AN) in early spring.

A formerly recommended N fertilization practice for winter wheat production was to apply no N or a low rate of N fertilizer at planting, then broadcast the remainder of N required as AN in early spring (Fowler, 2002). Due to the recent removal of AN as a generally available commercial product in the Northern Great Plains Region, alternative strategies are required for N fertilization of winter wheat.

One strategy is to replace AN with urea as the N source and apply it in the early spring, but this can sometimes result in unwanted losses due to ammonia volatilization when urea is hydrolyzed on the surface from the action of urease enzyme present in soil and crop residues. Another method is to apply the N at the time of planting in the early fall. It can be placed in the seed-row, but this can result in excessive ammonia toxicity damage to germinating seed when normally required N rates are used. An alternative way to allow use of urea at planting is to side-band the N away from the seed-row. Yet another way is to replace regular urea with CRU in the seed-row at planting. The objective of this study was to evaluate the effectiveness of seed-row and side-banded urea and CRU at the time of winter wheat planting.

Field experiments were conducted at three locations in 2002-03, 2003-04, and 2004-05 (**Table 1**). In the Canadian and U.S. taxonomic systems, soils at the Bow Island site were Brown Chernozemic and Aridic Borolls. At the Lethbridge, Magrath, and Spring Coulee sites, they were Dark Brown Chernozemic and Typic Borolls. Locations had been no-till seeded for a period of at least 3 years prior to study initiation. The Bow Island location was in a fallow-spring wheat rotation, while other locations were continuously cropped. The experiment evaluated different options of applying N fertilizer at seeding in mid-September. The experiment consisted of three treatment factors: 1) N placement—seed-placed vs. side-banded, 2) fertilizer type—20-day CRU (ESN), 40-day CRU, and conventional urea, and 3) N rate—0, 27, 54, 80, and 107 lb N/A. The CRU products had polymer coatings that provide a gradual release of all urea within 20 days or 40 days when immersed in water at 73 ºF (Agrium Inc., Calgary, Alberta). Plots were arranged in a split-plot design with three blocks, with N placement as main plot treatment and fertilizer type and N rate as sub-plot treatments.



Controlled release urea (20-day).

Soil samples were obtained just before seeding. Five soil cores (2 in. diameter per site) were combined for sample depths of 0 to 6 in., 6 to 12 in., 12 to 24 in., and 24 to 36 in. Samples were air-dried and ground to pass a 0.08 in. sieve. All samples were analyzed for extractable NO_3-N, P, K, and SO_4-S. Soil pH and electrical conductivity were determined in 2:1 water extracts.

Winter wheat cultivar AC Bellatrix was no-till planted with a small-plot seeder equipped with Stealth openers (Flexi-Coil, Saskatoon, Saskatchewan). Seedbed utilization was approximately 10%. Plots were seeded at a target plant density of 23 plants/ft^2, based on germination counts (approximately 95%) and an assumed seedling mortality of 15%. Each plot contained eight rows of winter wheat at a row spacing of 7 in. The outer rows of each plot were separated by a distance of 21 in. All plots received 19 lb P_2O_5/A as triple superphosphate applied with the seed. Weed control was achieved with recommended herbicides.

Table 1. Site characteristics.

Year	Site	Location	Soil Series	Texture[1]	Previous crop	Soil NO_3-N lb N/A	Soil pH
2002-03	BI03	Bow Island	Chin	SiL	Fallow	40	6.1
	LB03	Lethbridge	Lethbridge	CL	Wheat	13	7.3
	MG03	Magrath	Cradduck	CL	Wheat	6	7.5
2003-04	BI04	Bow Island	Chin	SiL	Fallow	36	6.6
	LB04	Lethbridge	Lethbridge	CL	Wheat	39	7.4
	SC04	Spring Coulee	Cradduck	CL	Wheat	18	7.2
2004-05	BI05	Bow Island	Chin	SiL	Fallow	25	6.2
	LB05	Lethbridge	Lethbridge	CL	Wheat	16	7.7
	SC05	Spring Coulee	Cradduck	CL	Wheat	25	5.9

[1]SiL = Silt loam; CL = Clay loam.

Plant density was determined in the last week of October and at the 2- to 3-leaf stage in the spring. Plant counts were determined in an area of 3.9 ft^2 in each plot.

Plots were trimmed to a length of 23 ft. prior to harvest and whole plots (107 ft^2) were harvested with a small-plot grain combine. Grain protein concentration was determined using near infrared spectroscopy. Grain N yield was estimated assuming a protein to N ratio of 5.7. All yields and concentrations are reported on a 14% moisture basis.

When N fertilizer was side-banded, plant densities were unaffected by fertilizer type or rate of N application. When N fertilizer was seed-placed, plant densities were reduced

Abbreviations and notes for this article: N = nitrogen; NO_3^- = nitrate; P = phosphorus; K = potassium; S = sulfur; SO_4 = sulfate.

Controlled release urea (20-day).

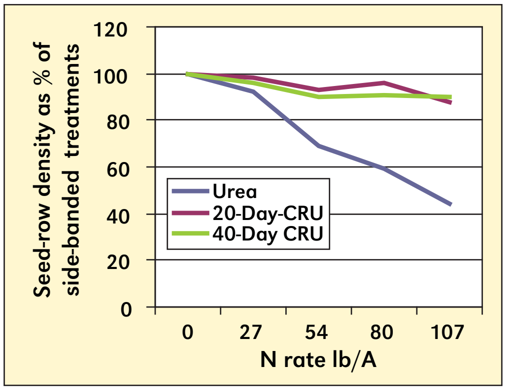


Figure 1. Effect of seed-placed fertilizer type and application rate on stand density of winter wheat at the 2- to 3-leaf stage in the spring. Nine-site average is expressed relative to the average stand density of side-banded treatments, which were unaffected by fertilizer type or application rate (standard deviation = 9).

by urea at most sites when application rates exceeded 27 or 54 lb N/A, but were unaffected by application of the two CRU types (**Figure 1**). Use of CRU was highly effective for reducing seedling damage to winter wheat caused by seed-row application of urea. Current recommendations for maximum safe rates of seed-placed urea for cereals range from 0 to 36 lb N/A, depending on soil texture, row spacing, seedbed utilization, and moisture conditions (Karamanos et al., 2004). The recommended maximum safe rate of urea for our equipment and soil types is approximately 27 lb N/A under good moisture conditions, with a substantial reduction recommended under dry soil conditions. These recommendations were valid for most locations in our study. Stand density declined significantly at most locations when the rate of seed-placed urea was increased from 27 to 54 lb N/A (**Figure 1**). In contrast, application of CRU did not reduce stand density at application rates up to 107 lb N/A, even when applied under dry conditions (**Figure 1**).

At almost all sites, N fertilizer provided a highly significant increase in grain yield, protein concentration, and N uptake (**Table 2**). The average increase was 21% for grain yield, 13% for grain protein concentration, and 36% for grain N uptake.

Table 2. Average N response due to N fertilizer application (excluding seed-placed urea treatment).

	Grain yield, bu/A		Grain protein conc., %		Grain N yield, lb N/A	
Site	No N	N response	No N	N response	No N	N response
BI03	74	17*	7.3	1.6*	57	29*
LB03	79	13*	9.9	1.0*	82	23*
MG03	47	33*	7.1	1.0*	34	34*
BI04	79	6*	9.3	1.2*	77	15*
LB04	111	13*	7.5	1.3*	86	28*
SC04	76	15*	10.8	1.1*	85	27*
BI05	69	15*	7.8	1.7*	56	28*
LB05	91	20*	9.8	0.2 NS	93	22*
SC05	80	19*	8.4	0.8*	71	25*
All	78	17*	8.7	1.1*	71	26*

Average gain due to N fertilizer application; asterisk indicates statistical significance (*p = 0.05; NS = non significant).

Application of CRU significantly increased grain yield compared to seed-placed urea, but did not significantly increase grain yield compared to side-banded urea in our study at rates N rates greater than 54 lb N/A (**Figure 2**). Earlier studies often found that CRU products reduced grain yields because N release was incomplete or too slow to meet crop growth demands (Mahli and Nyborg, 1992, Delgado and Mosier, 1996). A study with a similar product (40-day release CRU) at eleven locations in Alberta and Saskatchewan found that CRU did not increase grain yield of spring wheat compared to side-banded urea, but increased grain protein concentrations at two of eleven locations and increased N fertilizer use efficiency by an average of 4% (Haderlein et al., 2001). Increased N availability during later growth is an effective means to improve grain protein concentration of cereals (Wuest and Cassman, 1992), but the release of N from the CRU used in our study was rapid enough to increase crop yield but may be too rapid to ensure increased grain protein concentration for winter wheat.

Fall application of CRU, either seed-placed or side-banded, and urea side-banded were effective means of supplying N for winter wheat in southern Alberta. Seed-placed regular urea reduced plant stand density and yields at N rates greater than 54 lb N/A. Application of CRU did not reduce stand density when seed-placed at rates as high as 107 lb N/A, although further study is required to confirm the safety of these rates under conditions less favorable for plant survival. Grain yield, protein concentration, and N uptake were similar for seed-row, and side-banded CRU and side-banded urea. BC

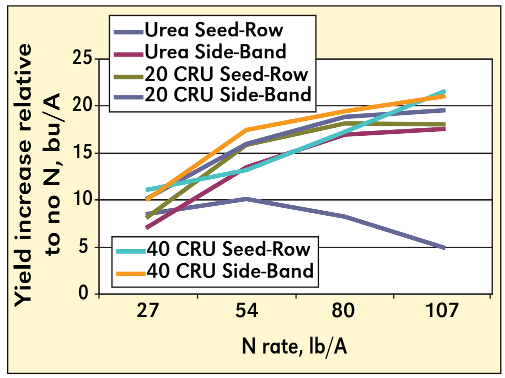


Figure 2. Effect of fertilizer placement, type, and application rate on the increase in grain yield relative to unfertilized check (all sites average, standard deviation 8 bu/A).

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