Title: *Nitrogen stabilizers to enhance nitrogen use efficiency and reduce greenhouse gas emissions in Alberta cereal crops*

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Research Objectives and findings in the Context of 4R Nutrient Stewardship

Right Source, Rate and Time: The objective of this research was to compare the performance of conventional urea to enhanced efficiency fertilizers (ESN, eNtrench-treated urea and SuperU), banded in the fall or sping, with respect to wheat yields (at 0, 0.5, 1.0 and 1.5 times the recommended N rate) and growing season soil N_2O emissions (at 0 and 1.0 times the recommended N rate).

Research activities were carried out on Black Chernozemic soils at the University of Alberta Ellerslie research farm in Edmonton, AB and on Dark Brown Chernozemic soils at the Alberta Agriculture and Forestry Farm in Lethbridge, AB.

Recommended N rates were based on soil samples taken in the fall prior to both growing seasons. For the Ellerslie site, the recommended N rate was 80 kg N ha^{-1} for both years, resulting in N rate treatments of 0, 40, 80 and 120 kg N ha^{-1}, corresponding to the 0, 0.5, 1.0 and 1.5 levels. For the Lethbridge site, the recommended N rate was 60 kg N ha^{-1}, for both years, resulting in N rate treatments of 0, 30, 60 and 90 kg N ha^{-1}, corresponding to the 0, 0.5, 1.0 and 1.5 levels.

At Ellerslie, annual and growing season precipitation was slightly below normal for both growing seasons (365 and 348 mm of growing season precipitation). At Lethbridge, growing season precipitation was adequate in 2016 (260 mm), but there was a significant drought late in the 2017 growing season and there was only 154 mm of growing season precipitation.

Despite soil tests indicating N deficiency, wheat yield response to added N fertilizer was inconsistent and low regardless of fertilizer type at both sites, but greater response was observed at Ellerslie. The highest observed yields were not consistently associated with a given fertilizer type at either site in either year. At Ellerslie, wheat grain yields varied from 2200 to 3700 kg ha^{-1} (30 – 50 bu/ac) in 2016 and from 3100 to 4100 kg ha^{-1} (46 to 61 bu/ac) in 2017. At Lethbridge, wheat grain yields varied from 4200 to 4800 kg ha^{-1} (61 – 73 bu/ac) in 2016 and from 3300 to 4800 kg ha^{-1} (49 to 73 bu/ac) in 2017. Because soil samples for fertilizer recommendations were taken in the fall when soil conditions are dry, it is possible that soil test nitrate was not representative of the potential N supplying power of the soil.

With respect to cumulative N_2O emissions (see Fig. 1), the controlled release, polymer-coated product (ESN) consistently showed higher average N_2O emissions compared to conventional urea in all cases except when spring-banded at Lethbridge in 2016, but these differences were not consistently, statistically significant. There were also significant late-season fluxes (July, August) in the ESN treatments at the Ellerslie site in both growing seasons (Fig. 3, 4). The significant late season fluxes are likely because there was still significant amounts of urea being released from the fertilizer prills into the soil late in the growing season, resulting excess available N when crop uptake was low.

The products with nitrification inhibitors (eNtrench) and urease inhibitors (SuperU) did not consistently show lower average N_2O emissions compared to conventional urea. It appears that inhibitor efficacy was reduced under the growing conditions that occurred during these growing seasons. Peak daily N_2O fluxes were associated with soil thawing for fall-banded treatments, and following significant precipitation events after seeding for both fall- and spring-banded treatments. These peak flux events account for a large proportion of the annual cumulative emissions. However, with the exception of fall-banded SuperU at Ellerslie in 2016, and spring-banded eNtrench at Ellerslie in 2017, inhibitor-treated urea did not show significantly lower peak fluxes compared to conventional urea.

If the efficacy of the inhibitors in the SuperU and eNtrech products were reduced the reasons are not clear at this point. There is some evidence in the literature than soil organic matter levels may influence the efficacy of nitrification inhibitors (McGeough et al., 2016). Another possibility is that soil freeze-thaw cycles may affect the efficacy of inhibitors, but this is only a hypothesis. These products have performed well in other locations in western Canada.

For producers, regardless of fertilizer type, the best way to reduced emissions and increase crop yields is to place fertilizer bands as close to the seed row as possible and deeper than the seed row to ensure that the crop will be able to access applied N as early in the growing season as possible.

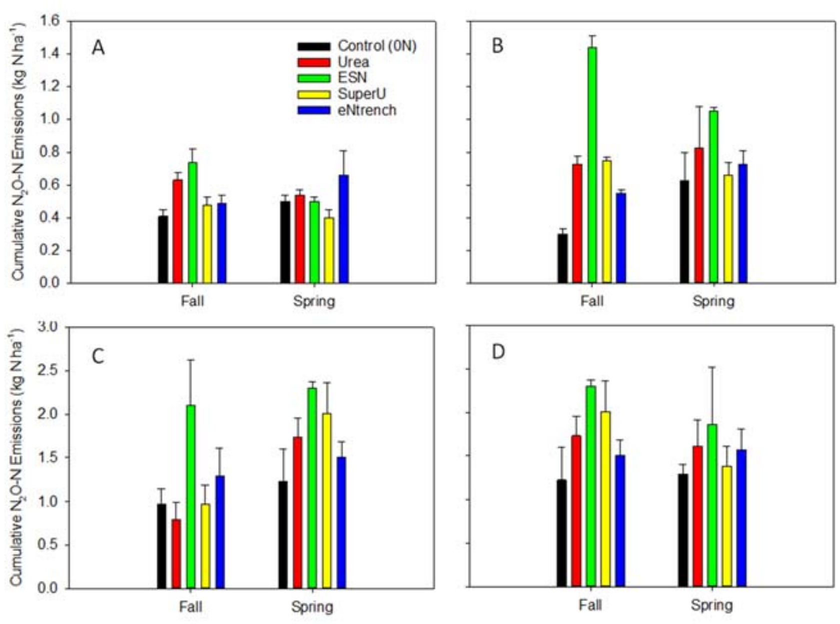

Figure 1: Summary of average (N=4), cumulative soil N_2O-N emissions (kg N ha^{-1} day^{-1}): A) Lethbridge, 2016; B) Lethbridge, 2017; C) Ellerslie, 2016, and D) Ellerslie, 2017.