# Enhanced Efficiency N Fertilizers, Application Timing and Method Affect Winter Wheat Grain Yield and Protein

*Yesuf Assen Mohammed[1], Chengci Chen[2], Tom Jensen[3], and Johnna Heser[4]*
*[124]Central Agricultural Research Center, Moccasin, MT, [3] International Plant Nutrition Institute, Saskatoon, SK*

## Introduction

Urea fertilizer can quickly convert to ammonia or to nitrate when it is applied to soil. Ammonia at the soil surface can be lost to volatilization, and nitrate can be lost to leaching or to nitrous oxide ($N_2O$) gas. These losses may reduce yield and protein benefits of using N fertilizer. Additions of inhibitors or coatings to urea fertilizer slow down the available N release to soil. This enables longer N availability for plant uptake. However, the effectiveness of these inhibitors and coatings in reducing N loss is affected by several soil and environmental factors, and application method. We evaluated the effect of enhanced efficiency fertilizers, application timing, and method of N fertilizer application on grain yield, protein content, N uptake, and residual soil mineral N content.

## Methods

The experiment was conducted on a no-till field at the Central Agricultural Research Center, Moccasin, MT, during the 2010-2011 and 2011-2012 crop years using winter wheat (cv Yellowstone). Three N products (urea, Super-U® which contains urease and nitrification inhibitors, and ESN® which is a polymer coated urea) were applied at 80 lb N/ac in the fall or spring using three methods (broadcast, sub-surface banded 2” deep between rows, and seed placed). Additional broadcast treatments included adding Agrotain® (urease inhibitor) or Agrotain® with N-Serve® (nitrification inhibitor) to regular urea. Treatments are shown in Table 1. The experiment was a randomized complete block design with four replications.

Table 1. Treatment description.

| Treatment | Urea type | Method | Time | Inhibitors |
|---|---|---|---|---|
| RUBF | Regular | Broadcast | Fall | None |
| RUBS | Regular | Broadcast | Spring | None |
| RUABF | Regular | Broadcast | Fall | Agrotain (urease) |
| RUANSBF | Regular | Broadcast | Fall | Agrotain+N-Serve (urease and nitrification) |
| SUBF | Super U | Broadcast | Fall | Urease and nitrification |
| RUDF | Regular | Banded between rows | Fall | None |
| RUSF | Regular | Applied with seed | Fall | None |
| ESNF | ESN | Applied with seed | Fall | None, polymer coating |
| RUABS | Regular | Broadcast | Spring | Agrotain (urease) |
| RUANSBS | Regular | Broadcast | Spring | Agrotain+N-Serve (urease and nitrification) |
| SUBS | Super U | Broadcast | Spring | Urease and nitrification |
| Check | none | -- | -- | -- |

## Results

Treatment results are shown in Table 2. In 2011, there was a greater grain yield (36.5 bu/ac) and protein (12.9%) from spring broadcasting of urea (RUBS) than fall regular urea application (RUBF; 27.7 bu/ac and 8.9%). These results indicate possible N loss through leaching from fall application of urea in 2010/2011. Annual crop-year rainfall from Oct 2010 through Sept 2011 was 21.6 inches, significantly higher than the 2011-2012 crop year (11.0 inches; http://ag.montana.edu/carc/Weather). However, yield response to timing of urea application was reversed in 2012. The RUBF treatment produced higher yield (31.9 bu/ac) than RUBS (26.9 bu/ac). Spring broadcast application increased grain protein content by

44% compared to fall application in 2011, but the protein contents did not differ between the two treatments in 2012.

In both years grain yield was very low when urea was applied with seed (RUSF; 16.2 and 19.8 bu/ac in 2011 and 2012, respectively) compared to RUBF and sub-surface mid-row banded (RUDF) N, which were equal. This might be due to toxicity as the number of seedlings was very low (Table 2).

In 2011, fall broadcast application of urea with Agrotain® + N-Serve® (RUANSBF) resulted in 20% more grain yield than RUBF. Yield in 2011 was not significantly different between fall application of ESN® (ESNF) and RUANSBF, but both treatments had greater yields than RUBF and Super-U® (SUBF). When rainfall was low in 2012, RUBF resulted in similar grain yield as urea with Agrotain® (RUABF), urea with Agrotain® + N-Serve® (RUANSBF), and Super-U®, but the fall broadcasting urea out-yielded ESN® applied with seed by 6.4 bu/ac. Therefore, the impact of inhibitors on yield is affected by rainfall amounts. .

Spring application of urea with Agrotain® + N-serve® (RUANSBS) increased grain yields compared with RUBS in 2012, but there was no difference in 2011. Adding only Agrotain® to urea broadcast in spring did not improve yields compared to regular urea.

In general, protein was lower when grain yield was higher suggesting a 'dilution' effect. Grain N results were not very different from grain yield results. Soil N at harvest in 2012 was not different among treatments suggesting inhibitors did not leave more nitrate in the soil than regular urea.

**Implications and Recommendations**

This study demonstrated that precipitation is a major factor determining optimal fertilizer placement, timing, and benefit of inhibitors for winter wheat production in central Montana. Final recommendations will be made after the 2013 crop year data are available.

**Fertilizer Facts**

- Spring broadcast application of urea produced higher yield and protein than fall broadcast application in a near-record high precipitation year, yet the reverse was true in a dry year.
- Broadcast or between-row subsurface banded urea or ESN® seed-placed in the fall produced higher grain yield than regular urea applied with the seed.
- The benefit of applying urea with Agrotain® and N-serve® is dependent on rainfall amount and timing. In a wet fall/winter, Agrotain® and N-serve® may reduce leaching and denitrification losses from fall broadcast urea. In dry years, these inhibitors are more effective in the spring than in fall.
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Table 2. The effect of method, time and inhibitor application on winter wheat grain yield, protein, N, and seedling count, and soil N in 2011 and 2012 at Moccasin, Montana. Values are means of four replications.

| Main factor | Treatment | Grain yield (bu/ac) | | Grain protein (%) | | Grain nitrogen (lb/ac) | | Seedling plants/ft$^2$ | | Soil N (lb/ac) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2012 |
| Time | RUBF | 27.7b | 31.9a | 8.90b | 14.03a | 26b | 47a | 8a | 12a | 9.5a |
| | RUBS | 36.5a | 26.9b | 12.88a | 14.85a | 49a | 42a | 7a | 14a | 11.0a |
| Method | RUBF | 27.7a | 31.9a | 8.90b | 14.03b | 26a | 47a | 8a | 12a | 9.5a |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RUDF | 28.8a | 30.3a | 8.90b | 14.78ab | 27a | 47a | 7a | 14a | 10.2a |
| | RUSF | 16.2b | 19.8b | 10.02a | 15.38a | 17b | 32b | 4b | 7b | 10.8a |
| Inhibitors applied in Fall | ESNF | 32.5a | 25.5b | 9.58ab | 15.08a | 33a | 40a | 7a | 13a | 8.9a |
| | RUABF | 28.6ab | 29.0ab | 8.75b | 14.65ab | 30ab | 45a | 8a | 13a | 10.0a |
| | RUANSBF | 33.5a | 28.4ab | 9.38b | 14.40ab | 33a | 43a | 8a | 11a | 12.1a |
| | RUBF | 27.7b | 31.9a | 8.90b | 14.03b | 26b | 47a | 8a | 12a | 9.5a |
| | SUBF | 28.1b | 29.8ab | 10.50a | 14.15b | 26b | 45a | 7a | 13a | 11.3a |
| Inhibitors applied in Spring | RUABS | 33.6b | 28.8ab | 12.95a | 14.80a | 46b | 45a | 6b | 14a | 19a |
| | RUANSBS | 39.1a | 30.5a | 13.05a | 14.45a | 54a | 46a | 8a | 14a | 13a |
| | RUBS | 36.5ab | 26.9b | 12.88a | 14.85a | 49ab | 42a | 7ab | 14a | 10a |
| | SUBS | 37.8ab | 26.5b | 12.70a | 14.45a | 51ab | 40a | 8a | 14a | 31a |
| Check | | 22.4 | 24.9 | 9.27 | 10.43 | 22 | 27 | 8 | 12 | 7.5 |

Means with a common letter in a column within a main factor are equal with 90% probability.