SELECTING THE *RIGHT SOURCE* OF FERTILIZER N IN MANITOBA

"Stabilized, Controlled- and Slow-Release EEFs are designed to better synchronize crop N uptake with delayed availability from the fertilizers"

BACKGROUND

- Conventional N options are mainly anhydrous ammonia (82% N), granular urea (46% N) and UAN (28 to 32% N)
- Enhanced efficiency fertilizers (EEFs) are of several types used for certain purposes:
  - ***Stabilized*** - contain inhibitors for urease (conversion of urea to ammonia; ex. Agrotain and Limus), or nitrification (conversion of ammonia to nitrate; ex. eNtrench and N-Serve), or with both (ex. SuperU and Agrotain Plus) (Figure 1)
  - ***Controlled-Release*** - coated urea granules to release N based on soil moisture and temperature (ex. Environmentally Smart Nitrogen (ESN) polymer-coated urea) (Figure 2)
  - ***Slow-Release*** - urea formulated to breakdown to ammonia upon microbial degradation (ex. methylene urea, isobutylidene diurea, urea formaldehyde)
  - ***Nutrient Blended*** - are marketed as premium fertilizers and not enhanced efficiency fertilizers and are designed to provide multiple nutrients simultaneously to a crop (ex. MicroEssentials)
- The timing of peak N demand varies with crop species. Short season crops such as barley, oats and spring wheat need N from planting to the end of the stem elongation phase (less than 60 days). Longer season crops such as corn, potato and sunflower need N from planting until the end of the silking phase, bulking phase and R6 flowering phase respectively (longer than 60 days). Canola is intermediate with the branching and bud formation phases having the highest N requirements (approximately 60 days after planting)
- Stabilized, Controlled- and Slow-Release EEFs are designed to better synchronize crop N uptake with delayed availability from the fertilizers
- Research in Manitoba has primarily involved Stabilized and Controlled-Release EEF sources for reduced losses of N and synchronization of crop N demand

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> "Conventional and EEFs are recommended to be surface banded, and even better, subsurface banded"

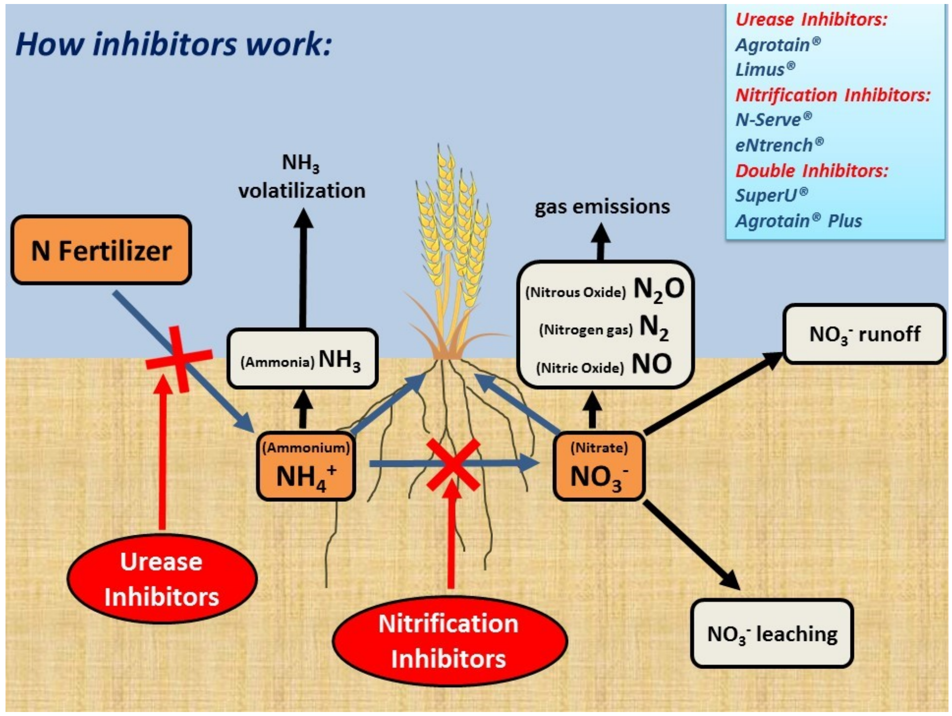

Figure 1: Stabilized EEFs: how urease and nitrification inhibitors work in soil.

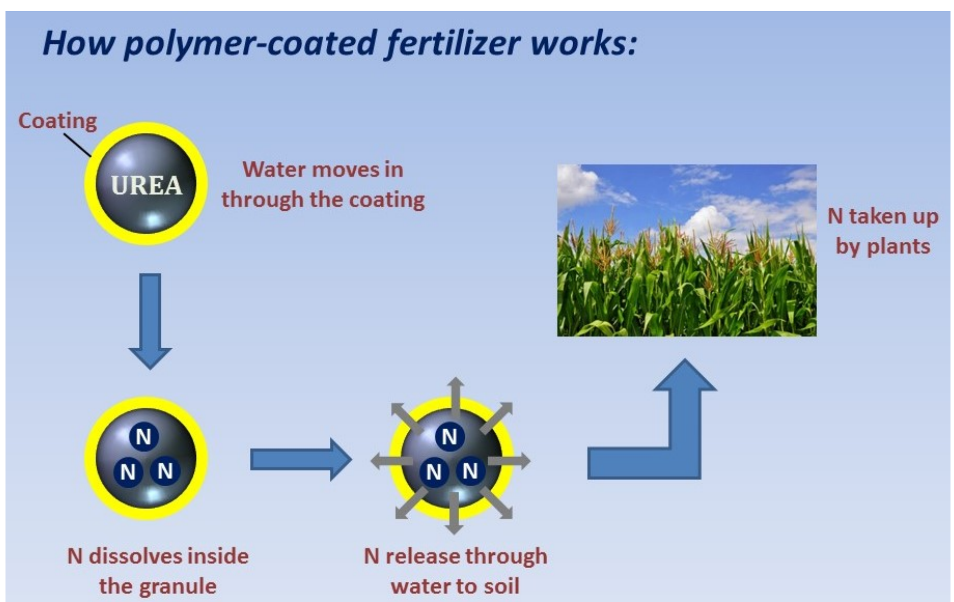

Figure 2: Controlled-Release EEFs: how polymer coated urea works in soil.

WHAT SHOULD WE DO?

- Consider your field's specific soil texture, pH, time of crop N requirements and potential N loss pathways when selecting N fertilizer type
- Tailor the rate, placement and timing of application to the selected N fertilizer type
- Consider using urease inhibitor with Conventional N fertilizer when surface applying without incorporation to reduce ammonia volatilization losses
- Where N is vulnerable to leaching in early season, consider reducing the risk of N losses by:
    - subsurface banding nitrification inhibitor Stabilized EEFs for best effectiveness
    - subsurface applying Controlled-Release EEFs
- Conventional and EEFs are recommended to be surface banded, and even better, subsurface banded (ex. side or mid-row banded)
- Controlled-Release EEFs should not be left on the soil surface because the coated granules need complete contact with soil and will release the urea at specific thresholds of soil temperature and moisture
- Use of double inhibitor Stabilized EEFs is beneficial when applying N fertilizer in early- or mid-fall in moist soil because the inhibitors will minimize N conversions in the soil by soil microbes until the soil freezes thereby reducing N losses in fall and preserving N until spring
- Consider if conditions (soil texture and moisture, weather forecast) justify the use of EEFs to prevent N losses; wet years benefit from EEFs whereas dry years may not
- The potential benefits of EEFs are reduced when N fertilizers are split-applied to match crop needs; consider UAN for in-season application
- Avoid using Stabilized or Controlled-Release EEFs late in the growing season as the slowed release of N may limit N uptake of crops
- We are still researching nitrification inhibitor use with anhydrous ammonia with fall application and currently are unable to provide a recommendation

"The potential benefits of EEFs are reduced under conditions that do not favour N losses, typical of a dry year with little snow or rain, dry soil surface, or when N fertilizers are split-applied to match crop needs"

HOW SHOULD WE DO IT?

- With all N fertilizer sources, apply the rate necessary to obtain the economic yield, but no more – based on soil testing, field experience and expert opinion
- When using Conventional fertilizers alone, perform split application for long season crops such as corn and potato
- When no other option than surface application of urea-based fertilizers, use a source having a urease inhibitor
- When applying N fertilizer in early- or mid-fall, consider using double inhibitor Stabilized EEF or Controlled-Release EEF

"Avoid using Stabilized or Controlled-Release EEFs late in the growing season as the slowed release of N may limit N uptake of crops"

POTENTIAL ADVANTAGES:

- EEFs used in tandem with Conventional N fertilizers have the potential to increase fertilizer N use efficiency resulting in lower N rates or increased yield, thereby benefitting both growers and environment
- Controlled-Release EEFs allow flexibility for application timing
- EEFs reduce the risk of N losses through leaching and gases under warm wet conditions
- Where split applications are typically done for long season crops, single application of a Controlled Release urea product at planting may be sufficient and thus result in a labour saving

POTENTIAL DISADVANTAGES AND UNCERTAINTY:

- EFFs have a 10-25% higher cost premium than Conventional fertilizers
- Conventional N fertilizer use has a higher potential for N losses, particularly with broadcast incorporation with a single application at seeding
- EEF have less benefit on non-irrigated coarse textured soils, particularly during dry years
- Do not use nitrification inhibitors alone with surface-applied N because it can increase ammonia volatilization
- Yield increases are not consistent each year using EEFs. Variation is due to risk of N loss based on soil type and weather conditions

HOW DO WE KNOW THIS?

- Several research projects have been undertaken by the University of Manitoba and Agriculture and Agri-Food Canada on heavy clay soils of the Red River Valley as well as sandy loam and clay loam soils in southwestern Manitoba to study the effectiveness of different N sources on crop yields, N uptake and losses (see Research Highlights section for more detail).
- These local studies aim to compare N_2O emissions and N use efficiency of a variety of Conventional N fertilizers typically used by producers in Manitoba as well as Controlled-Release and Stabilized EEFs under the same management (Figure 3).
- To measure N loss to the atmosphere as N_2O, enclosed chambers are strategically placed on the soil surface over the zone of N fertilizer application. Gas samples are extracted from the chamber at regular intervals over a given period of time. Increasing concentrations of N_2O in the chamber over time indicates N loss from the soil to the atmosphere, and the reverse is true with decreasing concentrations (Figure 4).
- Nitrogen use efficiency for crops is determined using a yield-based emission intensity indicator which represents how many kg of N (soil + fertilizer applied N) was lost as N_2O emissions over the growing season per tonne of grain produced.

Figure 3. N source test plots growing spring wheat at Warren, MB with chambers for measuring N_2O-N losses (photo: K. Baron)

Figure 4. Measuring N_2O-N losses from N source test plots at Glenlea, MB in fall following application of anhydrous ammonia (photo: K. Baron)

RESEARCH HIGHLIGHTS

Asgedom H., Tenuta M., Flaten, D.N., Gao X. and Kebreab E. 2014. *Nitrous oxide emissions from a clay soil receiving granular urea formulations and dairy manure*. Agron. J. 106: 732-744.

- This 2-year study on a heavy clay soil in the Red River Valley, MB aimed to determine the effect of broadcast incorporated Conventional N fertilizers, EEFs and solid dairy manure on N_2O emissions from a field cropped to rapeseed and hard red spring wheat. Results indicated that Controlled-Release EEF ESN was most effective at reducing N losses. Stabilized EEF SuperU was found to be ineffective at reducing the risk of N losses on heavy clay soil compared to conventional granular urea.

Baron K. and Tenuta M. 2014. *Developing best management practices to mitigate greenhouse gas emissions from irrigated potato production in Manitoba*. Final Report AAFC#:3000528623.

- This report synthesized results of recently completed greenhouse gas emission studies implementing 4R strategies in potato production systems in Manitoba and other temperate regions. One particular study near Carberry, MB focussed on the effects of N source, rate and placement on N_2O emissions. Results indicated that peaks in N_2O were frequently delayed with EEF and banded Conventional N fertilizer compared to broadcast incorporation. It was also found that N losses from Conventional N fertilizers were reduced when using split application.

"Tailor the rate, placement and timing of application to the selected N fertilizer type "

Burton D.L., Li X. and Grant C. 2008. *Influence of fertilizer nitrogen source and management practice on N_2O emissions from two Black Chernozemic soils*. Can. J. Soil Sci. 88: 219-227.

- This 3-year study examined the influence of nitrogen source (Conventional vs EEFs), time and method of application on N_2O emissions from two Black Chernozemic soils located near Winnipeg and Brandon MB growing hard red spring wheat. Overall precipitation, soil water content and soil texture as they influence soil aeration were the dominant controlling factors for N losses as N_2O emissions.

Gao X., Asgedom H., Tenuta M. and Flaten, D. 2015. *Enhanced efficiency urea sources and placement effects on nitrous oxide emissions*. Agron. J. 107: 265-277.

- This paper reported a 2-year field study investigating the effects of band placement of EEFs on N_2O emissions at two locations growing spring wheat within the Red River Valley. It was found that grain yield and crop N uptake were unaffected by sources and placement, however for early season warm wet conditions EEFs can reduce N losses compared to granular urea.

Tiessen K.H.D., Flaten D.N., Bullock P.R., Burton D.L., Grant C.A. and Karamanos R.E. 2006. *Transformation of fall-banded urea: application date, landscape position, and fertilizer additive effects*. Agron. J. 98: 1460-1470.

- This 2-year study examined the effects of early, mid or late fall application of banded urea fertilizer, as well inclusion of urease (NBPT) and nitrification (DCD) inhibitors on soil NH_4^+ and NO_3^- concentrations at sites in the Red River Valley (Kane and Rosser) and Brandon, MB. Late fall (late Oct. to early Nov.) application of banded urea recovered the highest concentrations of NH_4^+ and lowest concentrations of NO_3^- compared to early fall (mid-Sep. to early Oct.). Use of double inhibitors with early fall banded urea delayed nitrification by 50% compared to without inhibitors, thereby maintaining high concentrations of NH_4^+ and low concentrations of NO_3^- in late fall at the time of freeze-up.

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