Enhanced Efficiency Fertilizers

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Enhanced Efficiency Fertilizers (EEFs)

• Any fertilizer designed to:
  – Increase fertilizer availability
  – Decrease fertilizer losses

• 3 major methods of action
  – Stabilized - alter soil microbial or enzymatic reactions
  – Slow release - have additives which require chemical or biological decomposition to release nutrients
  – Controlled release - a semipermeable coating, usually a polymer, regulates release
Questions

• Who sells EEFs?
• Who has used or recommended EEFs?
Objectives

• Explain types of EEFs
• Describe how they work
• Show their benefits and limitations
Stabilized Urease Inhibitors

- Volatilization (NH₃)
- Plant Uptake
- Denitrification (N₂ and N₂O)
- Leaching

Slow urea hydrolysis here, most common is NBPT
Stabilized Nitrification Inhibitors

\[ \begin{align*}
\text{NH}_4^+ & \text{ + NO}_2^- \rightarrow \text{NO}_3^- \\
\text{NH}_4^+ & \rightarrow \text{NH}_3 \text{ (Volatilization)} \\
\text{Urea} & \rightarrow \text{NH}_4^+ \\
\text{UAN} & \rightarrow \text{NH}_4^+ \\
\text{Plant Uptake} & \rightarrow \text{NO}_3^- \\
\text{Nitrification} & \rightarrow \text{NO}_2^- \\
\text{Denitrification} & \rightarrow \text{N}_2 \text{ and N}_2\text{O} \\
\text{Leaching} & \rightarrow \text{Leaching} \\
\end{align*} \]
Slow and Controlled Release

- NH$_4^+$ + NO$_2^-$
- NH$_3$ NO$_3^-$
- N$_2$ and N$_2$O
- Volatilization

- Plant Uptake
- Denitrification
- Leaching

- Urea
- UAN

Slow/control release here
Partial list of available stabilized EEFs

• Stabilized
  Nutrisphere-N® (NSN)
  Agrotain®
  Avail®
  NSource®
  NServe®
  Instinct®
  SuperU®
  Nitamin Nfusion®
Partial list of available controlled and slow release EEFs

- **Controlled Release**
  - ESN®
  - Polyon®
  - PolyS®
  - Duration®

- **Slow Release**
  - NSure®
  - Nitroform®
  - Nutralene®
Nutrient availability from ideal slow release fertilizer

![Graph showing nutrient uptake and release over days after emergence. The graph compares theoretical nutrient release with plant uptake for optimal yield. The x-axis represents days after emergence, ranging from 0 to 100. The y-axis represents % nitrogen uptake or release, ranging from 0 to 100. Two lines are shown: one for theoretical nutrient release and another for plant uptake. The theoretical nutrient release line starts almost at 0 and gradually increases, reaching about 100% at around 80 days after emergence. The plant uptake line begins slightly below the theoretical release line and also increases to reach about 100% at around 80 days after emergence.](image-url)
N release by polymer-coated fertilizers

Water moves in through coating

Urea dissolves in prill

N moves out through coating into soil solution

Collapsed prill biodegrades

Schematic adaptation and photo courtesy of Agrium, U.S. All rights reserved.
Questions?
Under what growing conditions would you expect EEFs to work better?

- High potential volatilization loss
  - coarse soils
  - moist surface
  - warm temps
  - long time between application and incorporation

- High potential leaching
  - coarse soils
  - high moisture content/irrigation/rainfall
Effect of irrigation and NBPT on volatilization

0.8 inch irrigation on days 2 and 8
Rawluk 2000
Manitoba
NBPT uses

- Can minimize urea volatilization for up to 14 days
- ‘Buys’ time for rainfall, irrigation or mechanical incorporation to protect urea
- Warm weather top-dressing
- Cool weather broadcast
Effects of over-winter moisture conditions on effectiveness of PCU

Grant & Downbenko 2008
spring banded PCU
Saskatchewan
Average difference
ESN vs. urea: 7 bu/ac
ESN vs. UAN: 10 bu/ac
ESN vs. am.nitrate: -1 bu/ac

Blaylock and Tindall 2006
U.S. cornbelt

WHY?
What type of crops would you expect slow release to work better?

- Irrigated
- Warm season
Timing of nutrient uptake by crops

Corn
Sugar Beet
Wheat
Timing of ESN® nutrient release

N Uptake as percent of crop's maximum

Date
Apr  May  Jun  Jul  Aug  Sep  Oct  Nov

0  20  40  60  80  100

Corn  Sugar Beet  Wheat

Approx % N released by typical ESN seedplaced in mid May

Options for wheat?
How does PCU work for small grains?

- Fall/winter pre-plant works well. PCU is in soil long enough to dissolve in time for plant need.
- Late winter/spring broadcast PCU does not - may dry out, release is too slow.
- Incorporation is important, especially late winter/spring.
- Blending is recommended with late winter/spring surface applied PCU.
Seed placing EEFs

• Can apply ~ 2 – 4x as much slow release product as urea directly with small grain seeds
• Saves on field passes – fuel, labor, soil disturbance
Effect of N source applied with the seed on dryland spring wheat yield

Saskatchewan, Malhi et al. 2003

Grain yield (bu/acre)

Application rate (lb N/acre)
Effect of side-banded and seed-placed N source on dryland wheat yield

Brandt et al. 2005
Saskatchewan
Handling abrasion of PCUs increases in-soil N release

In-soil N release by 7 days (%)

ESN® Seedplaced abrasion

average farm handling

scaled equip, air boom/fan applied

exit retail

Beres et al. 2009 unpubl data
Lethbridge, AB
Plant emergence decreases with increased N released within 7 days by seedplaced PCU

Beres et al. 2009 in prep.
Lethbridge
Some abrasion increases early release from PCU.

Nitrogen release/uptake (% total)

- 60% abraded: scaled equip, air boom/fan applied
- 40% abraded: average farm handling
- 20% abraded: exit retail

ESN® seedplaced

Cumulative days

Planting date = May 9 @ 54F

Beres et al. 2009 unpubl data
Lethbridge, AB
Some abrasion helps PCU meet wheat N demand

- 60% abraded: scaled equip, air boom/fan applied
- 40% abraded: average farm handling
- 20% abraded: exit retail

ESN® seedplaced

Wheat N uptake

Cumulative days

Planting date = May 9 @ 54F

Beres et al. 2009 unpubl data
Lethbridge, AB

Malhi et al. 2006
Saskatchewan
Nitrogen EEF and forage production

- Can increase mid to late season cuttings and protein, and encourage uniform growth through season
- Can be blended with urea to meet goal
  - Large early crop?  PCU too slow, but urease inhibitor can help reduce urea loss
  - Season-long forage or a late cutting?
    Delayed release of PCU desirable
- Allow application flexibility - e.g. fall broadcast on coarse soil
- Environmentally responsible but more $
How to manage PCUs

- Apply several weeks before peak crop demand
- Incorporate into the soil or seed placement
- Blend with conventional fertilizer
- Adjust rates, blends and application timing for handling abrasion
Phosphorus EEF

• Types
  Polymer coated
  Avail® which reduces the rate of P mineral formation

• Limited regional research
  Soil P levels often above critical
Wheat response to P and Avail®

Karamanos et al. 2009
Alberta

WHY no consistent difference?

Breton Olsen P 5 ppm
Ellerslie Olsen P 11 ppm
Potential limitations of Avail®

• Mechanism may have difficulty in highly calcareous soils
• Existing soil properties may outweigh product ability

Ex: 100 lb MAP with Avail® contains < 0.25 lb of organic acids – the active ingredient

Organic acids occur naturally in soil, and are elevated in the root zone
Additional incentive to use EEFs

- Alberta is close to adopting a Nitrous Oxide Emissions Reduction Protocol (NERP) which rewards use of EEFs.

- Other provinces may be soon adopt similar programs.
Conclusions

• Enhanced efficiency fertilizers (EEFs) will not increase yields and nutrient recovery under all circumstances.
• Improved EEFs and blending with conventional fertilizer may provide a good match between crop uptake and fertilizer availability.
• More EEF can be placed with the seed than conventional fertilizer, possibly saving a fertilizer pass and fuel costs.
• EEFs can reduce losses to the environment, especially in wet soils.
Conclusions

• EEFs show promise of increased yields, especially for warm season/irrigated crops.
• With product improvements and proper application practices, EEFs also show potential benefits for cool season crops.

Additional info in:
Enhanced Efficiency Fertilizers (EB0188)
http://landresources.montana.edu/soilfertility
Go to Fertilizer Information
(will also be in MAC Proceedings)
Questions?

Watrous, SK, 1920's