Have you used a clicker system in a presentation before today?

1. Yes
2. No

0% 0%
How often do you or your clients apply a N source (e.g. urea, manure, etc.) to a typical crop?

1. I don’t apply or recommend N
2. Once per year
3. More than once (e.g. at seeding and then topdress)
Objectives

- Illustrate crop nutrient uptake patterns
- Present fertilizer management options to better match uptake
- Explain pros and cons of enhanced efficiency fertilizers
What do you think best describes plant nutrient uptake through the season?

1. A steady rate throughout the season
2. Highest uptake during seed set/or ripening
3. Highest rates during early growth stages of tillering/branching
Cumulative N uptake by small grains

Nutrient Uptake Timing by Crops: to assist with fertilizing decisions
http://landresources.montana.edu/soilfertility
N uptake by oil seed crops

Cumulative N uptake (% maximum)

Days after emergence

Saskatchewan
Adapted from Malhi et al. 2006
Nutrient availability from ideal fertilizer

Theoretical Nutrient Release

Plant Uptake for Optimal Yield

Days After Emergence

% Nitrogen Uptake or Release

Nutrient availability from ideal fertilizer
Do you think release of conventional urea or UAN matches plant nutrient uptake?

1. Yes
2. No
Single application of conventional fertilizer

Options?

Modified from HortTechnology. 9(4): 603.
How can you better match N release to reduce potential losses and increase yield?

• Use split application (pre-plant and topdress)
• Use an “enhanced efficiency fertilizer”
Reduction of potential N loss through split applications

Other options?

Modified from HortTechnology. 9(4): 603.
Enhanced Efficiency Fertilizers (EEFs)

• Specialized fertilizers 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
What is your experience with EEFs?

1. Never heard of them
2. Heard of them but never used or recommended
3. Have used once
4. Have used more than once
5. Have recommended their use
Stabilized Urease Inhibitors

NH₄⁺ + NO₂⁻ → NO₃⁻

NH₄⁺ + NO₃⁻ → NH₃ + NO₂⁻

NH₃ + NO₂⁻ → N₂ and N₂O

Volatilization

Plant Uptake

Denitrification

Leaching

slow urea hydrolysis here, most common is NBPT

Urea

UAN
Stabilized Nitrification Inhibitors

\[
\begin{align*}
\text{Volatilization} & : \text{NH}_3 \\
\text{Plant Uptake} & : \text{NH}_4^+ \\
\text{Nitrification} & : \text{NO}_2^- \\
\text{Denitrification} & : \text{N}_2 \text{and N}_2\text{O} \\
\text{Leaching} & : \text{Urea, UAN} \\
\text{Slow conversion to nitrate here} & : \text{NO}_3^-
\end{align*}
\]
Slow and Controlled Release

NH$_4^+$

Volatilization

Plant Uptake

N$_2$ and N$_2$O

Denitrification

Leaching

Urea

UAN

Slow/control release here

Plant Uptake

N$_2$O

Nitrification

NO$_2^-$

NO$_3^-$

Volatilization

Plant Uptake

NH$_3$

NH$_4^+$

N$_2$ and N$_2$O

Denitrification

Leaching

Urea

UAN
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
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.
Effects of over-winter moisture conditions on effectiveness of PCU

Yield change with spring-banded PCU over conventional urea (%)

-4 -2 0 2 4 6 8 10 12 14 16

Barley
Canola
Wheat

Low moisture
High moisture

Grant & Downbenko 2008
spring banded PCU
Saskatchewan

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

- Irrigated
- Warm season

What about dryland cool season crops?
Timing of N uptake by spring wheat in Prairie Provinces

Adapted from Malhi et al. 2006
Saskatchewan
Timing of N uptake by spring wheat in Prairie Provinces and ESN® N release

Options for wheat?

Approx % N released by typical ESN seed placed in mid May
Adapted from Beres et al. 2009
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

Effect of N source applied with the seed on dryland spring wheat yield
How to manage PCUs

• Apply several weeks before peak crop demand
• Incorporate into the soil or seed place
• Blend with conventional fertilizer
• Adjust rates, blends and application timing for handling abrasion
Foliar application

• Some N can be absorbed through leaves
• However, most foliar applied N ends up being washed off and taken up by roots:
  Only 8-11% of foliar applied liquid urea was taken up by leaves, whereas 37-67% of soil-applied N was taken up by plant in same study (Rawluk et al., 2000).
• Risk of burn?
Timing

• Yield and quality are affected by timing

• Because urea may take days to weeks to become available, urea should be applied earlier than AN historically was for fast green-up (AN simply dissolves, UR requires a chemical reaction to become available).
Timing, continued

• Fall vs Spring
  Generally better to apply near peak uptake to avoid losses (volatilization, denitrification, leaching, immobilization). However, weather conditions (temp., precip.) in first few days after application combined with soil texture may be more important.

1. Ex: Shallow, coarse soil. Fall or Spring?
2. Ex: Cool Fall temps with large rainstorm predicted. Fall or Spring?
Questions on N?
Cumulative P and K uptake by small grains

Nutrient Uptake Timing by Crops: to assist with fertilizing decisions

http://landresources.montana.edu/soilfertility
P and K fertilization considerations

• P and K are not readily lost from the system, so they can be:
  – Placed with seed or banded early in season to ensure availability
  – Built up over time in the soil

• P and K bind strongly to soil surface so less effective topdressed than N
Phosphorus EEF

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

• Limited regional research
  Soil P levels often above critical
What is your experience with P EEF?

1. Never heard of
2. Heard of but not used or recommended
3. Have used or recommended Avail®
4. Have used or recommended other type
5. Have used or recommended Avail® and other type

0 of 5
Wheat response to P and Avail®

Karamanos et al. 2009
Alberta

Why no consistent difference?
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
Questions on P or K?
Crops’ highest rates of N, P and K uptake are during tillering and branching.

N, P and K must be available early in growing season for optimal production.

If all the needed N is applied at seeding there is higher potential for N loss.

Options are to split applications or use EEFs.

P and K have lower loss potential and should be seed placed, banded, or built up in the soil.
Conclusions

• 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 and are an NRCS CSP enhancement for this reason.

Additional info in:

Nutrient Uptake Timing by Crops (EB0191)
Enhanced Efficiency Fertilizers (EB0188)
http://landresources.montana.edu/soilfertility
Go to Fertilizer Information
Questions?

Watrous, SK, 1920's