Enhanced efficiency nitrogen fertilizers: the What, When & Where

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Enhanced efficiency fertilizers:
Combining right source, time, and place

Controlled release:
- Coated or encapsulated
  - Sulfur coated urea
    - Polymer coated urea

Stabilized N:
- Inhibitor treated
  - Urease
  - Nitrification
  - Both

Mechanisms

Urea

\[ \text{Urea} \rightarrow \text{NH}_3 \leftrightarrow \text{NH}_4^+ \]

Plant uptake

Urea hydrolysis

Nitrification

\[ \text{NH}_4^+ \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^- \rightarrow \text{N}_2 \]

Denitrification

\[ \text{N}_2 \rightarrow \text{NO} \rightarrow \text{N}_2\text{O} \]
Mechanisms: Controlled release

Polymer coated

Urea → Urea

NH$_3$ ↔ NH$_4^+$ → NO$_2^-$ → NO$_3^-$ → N$_2$O → N$_2$ → NO

Urea hydrolysis

Nitrification

Denitrification
Mechanisms: Urease inhibition

Urea hydrolysis

\[ \text{Urea} \rightarrow \text{NH}_3 \leftrightarrow \text{NH}_4^+ \]

Nitrification

\[ \text{NH}_3 \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^- \rightarrow \text{NO} \rightarrow \text{N}_2 \]

Denitrification

\[ \text{NO}_2^- \rightarrow \text{NO}_3^- \rightarrow \text{N}_2 \text{O} \rightarrow \text{N}_2 \]
Mechanisms: Nitrification inhibition

Urea → NH₃ ⇌ NH₄⁺ → NO₂⁻ → NO₃⁻ → N₂O → N₂ → Leaching

Nitrification

Denitrification
Polymer coated urea
Impacts of polymer coated urea

$\text{NH}_3$ ▼▼▼▼

$\text{N}_2\text{O}$ ▼▼▼▲

$\text{Yield}$ ▲▲▼▼

$\text{NO}_3^-$ ▲▼▼


▲ Increase
▼ Decrease
Effects on $\text{N}_2\text{O}$ emissions

- Inhibitors
- Urea
- Polymer coat
- Manure
- Control

Literature survey*: Yield effects of polymer coated urea

Max = 171%
Median = 0%
Min = -48%
Average = 3%

*381 observations. 21 published studies conducted in Alberta, Saskatchewan, Manitoba, Montana, or North Dakota
Literature survey*: grain N effects of polymer coated urea

Max = 158%
Median = 0%
Min = -55%
Average = 1%

*169 observations. 21 published studies conducted in Alberta, Saskatchewan, Manitoba, Montana, or North Dakota
Effects of placement: In the seedrow

Alternative to side-banded urea in fall and spring


Mean effect of polymer coated urea relative to uncoated urea on yields

Blending of polymer coated urea and non-coated urea may increase grain yield under high moisture conditions of Boreal Transition and Aspen Parkland


Polymer coated urea outperformed non-coated urea

Differences across the topography

Yields*(kg ha\(^{-1}\)) at different slope positions

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall banded urea</td>
<td>2805</td>
<td>2505</td>
</tr>
<tr>
<td><strong>Fall banded coated</strong></td>
<td><strong>2900</strong></td>
<td><strong>2660</strong></td>
</tr>
<tr>
<td>Spring banded urea</td>
<td>3005</td>
<td>2795</td>
</tr>
<tr>
<td>Spring banded coated</td>
<td>2910</td>
<td>2685</td>
</tr>
</tbody>
</table>

*Mean effect for 2 of 6 site years

Inhibitors
Urease inhibitor

\( \text{NH}_3 \) ◀◀◀

\( \text{N}_2\text{O} \) ◀◀▲

\( \text{NO}_3^- \) ▲ (one study, +nitrification inhibitor)

Yield ▲▼

Urease inhibitor effects on NH$_3$ volatilization

Fig. 2. Effect of N-(n-butyl)thiophosphoric triamide (NBPT) and simulated rainfall (2.0 cm on day 4 and day 7) on volatilization losses from surface applied urea fertilizer (29).
Nitrification inhibitor

\[ \text{NH}_3 \quad \text{Increase} \]

\[ \text{N}_2\text{O} \quad \text{Decrease} \]

\[ \text{NO}_3^- \quad \text{Decrease} \]

Literature survey*: yield effects of urease inhibitors

Max = 161%
Median = 0%
Min = -28%
Average = 7%

*171 observation, 16 published studies conducted in Alberta, Saskatchewan, Manitoba, Montana, or Dakotas
Literature survey*: grain N effects of urease inhibitors

Max = 160%
Median = 1%
Min = -47%
Average = 3%

*121 observation, 16 published studies conducted in Alberta, Saskatchewan, Manitoba, Montana, or Dakotas
Effects of placement: In the seedrow

Effects of timing: Fall vs Spring

Other studies comparing effects of urease inhibitor:

Fall broadcasted treated urea: Yields increased by 3 to 8%

Spring broadcasted treated urea*: Yields decreased by 0 to -1%


Effect across topography

Well drained:
- Yields were 3% less with urea + urease inhibitor
- Differences not significant

Poorly drained:
- Yields were 1% more with urea + urease inhibitor
- Differences only significant 1 of 4 site years

## Effect of combining with a nitrification inhibitor

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield relative to non-treated urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urease inhibitor</td>
<td>-1 to -7%</td>
</tr>
<tr>
<td>Urease + nitrification inhibitor</td>
<td>5 to 29%</td>
</tr>
</tbody>
</table>

Winter wheat, Beiseker, Alberta: Jensen. 2007. Personal communication.
Summary

- Enhanced efficiency fertilizers can reduce nitrogen losses in high risk environments, but consider modes of action [1]
- Variable effects on yields
  - Polymer coated urea and urease inhibitors
    - Placement in the seed row
    - Fall application with high loss risk
    - Blending of non- and polymer coated urea in spring
  - Combing urease and nitrification inhibitors may provide additional benefits for enhanced efficiency of urea

Thank you

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