Enhanced efficiency nitrogen fertilizers: Combining the right source, time, and placement

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Enhanced efficiency fertilizers:

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

- Stabilized N
Enhanced efficiency fertilizers:

Controlled release
  ▼
  Coated or encapsulated
    ▼
    Sulfur coated urea
      ▼
      Polymer coated urea

Stabilized N
  ▼
  Inhibitor treated
    ▼
    Urease
      ▼
      Nitrification
        ▼
        Both

Enhanced efficiency fertilizers:

- Controlled release
  - Coated or encapsulated
    - Sulfur coated urea
    - Polymer coated urea
- Stabilized N
  - Inhibitor treated
    - Urease
    - Nitrification
    - Both

Mechanisms

Urea → Urea

Polymer coated
Mechanisms

Urea hydrolysis

Urea

Urease inhibitor

Urea
Mechanisms

Urea \(\xrightarrow{}\) \(\text{NH}_3\) \(\rightleftharpoons\) \(\text{NH}_4^+\)

Nitrification inhibitor

\(\xrightarrow{}\) \(\text{NO}_3^-\) \(\rightleftharpoons\) \(\text{N}_2\text{O}\)

Nitrification
Mechanisms

Urea

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

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

Plant uptake

Denitrification

\[ \text{N}_2 \rightarrow \text{N}_2\text{O} \rightarrow \text{NO} \rightarrow \text{NO}_3^- \rightarrow \text{NO}_2^- \rightarrow \text{NH}_4^+ \rightarrow \text{Urea} \]
Polymer coated urea
Impacts of polymer coated urea

$\text{NH}_3$ ↓↓↓

$\text{N}_2\text{O}$ ↓↓△

$\text{NO}_3^-$ ▲▼

Yield ▲▲▼

Polymer coated urea: yield effects

Max = 159%
Median = 2%
Min = -26%
Average = 6%

58% positive response rate

146 observations. 20 published studies: Alberta, Saskatchewan, Manitoba, Montana, South/North Dakota, Nebraska, Minnesota
Polymer coated urea: Grain N concentration

- Max = 22%
- Median = 3%
- Min = -18%
- Average = 4%

59% positive response rate

146 observations. 20 published studies: Alberta, Saskatchewan, Manitoba, Montana, South/North Dakota, Nebraska, Minnesota
When polymer coated urea outperforms

Timing

Fall

Polymer coated urea better than urea

When polymer coated urea outperforms

**Timing**

〇 Fall
□ Spring

-30% -20% -10% 0% 10% 20% 30% 40%

Polymer coated urea better than urea

When polymer coated urea outperforms

Timing

-30% -20% -10% 0% 10% 20% 30% 40%

Fall

Spring

Placement

Banded

Polymer coated urea better than urea

When polymer coated urea outperforms

When polymer coated urea outperforms

Timing

- Fall
- Spring

Placement

- Banded
- Broadcast

Incorporated

Polymer coated urea better than urea

When polymer coated urea outperforms

Timing
- Fall
- Spring

Placement
- Banded
- Broadcast
- Seedrow

Polymer coated urea better than urea

Effects of placement: In the seedrow

Wheat yield (kg ha\(^{-1}\))

Fertilizer N rate

Effects of placement: In the seedrow

Wheat yield (kg ha\(^{-1}\)) vs. Fertilizer N rate

Polymer coated urea

Non-coated urea

Effects of placement: In the seedrow

Wheat yield (kg ha\(^{-1}\))

Fertilizer N rate

Toxicity mitigation near seed


Effects of placement: In the seedrow

Alternative to side-banded urea in fall and spring

- Non treated urea
- Polymer coated urea

Wheat yield (kg ha$^{-1}$) vs Fertilizer N rate


When polymer coated urea outperforms

Blending of polymer coated urea and non-coated urea may increase grain yield under high moisture conditions.

Differences across the topography

<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>Fall banded coated</td>
<td>2900</td>
<td>2660</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
Uurease inhibitor = UI
Nitrification inhibitor = NI
Both = DI
Urease and double inhibitors: Yield effects

Max = 159%
Median = 1%
Min = -44%
Average = 7%

56% positive response rate

69 observations. 20 published studies: Alberta, Saskatchewan, Manitoba, Montana, South/North Dakota, Nebraska, Minnesota
Polymer coated urea: Grain N concentration

Max = 14%
Median = 0%
Min = -18%
Average = 0%

47% positive response rate

69 observations. 20 published studies: Alberta, Saskatchewan, Manitoba, Montana, South/North Dakota, Nebraska, Minnesota
Effects of placement: In the seedrow

Polymer coated urea

Non-coated urea

Yield (kg ha\(^{-1}\))

Fertilizer N rate

Effects of placement: In the seedrow

Effects of timing: Fall vs Spring

Fertilizer recovered in grain (%)

- Late fall
- Winter
- Spring

Treating urea with urease inhibitor

Effects of timing: Fall vs Spring

Other studies:

Effects of timing: Fall vs Spring

Other studies:

Yields increased by 3 to 8% when treating fall broadcasted urea

Effects of timing: Fall vs Spring

Other studies:

Yields increased by 3 to 8% when treating fall broadcasted urea

Yields not affected (0 to -1%) when treating spring broadcasted urea

Combining urease and nitrification inhibitors

<table>
<thead>
<tr>
<th>Urease inhibitor</th>
<th>Yield relative to non-treated urea</th>
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<td>-1 to -7%</td>
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</table>

Winter wheat, Beiseker, Alberta: Jensen. 2007. Personal communication.
# Effect of combing with a nitrification inhibitor

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

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

- Consider modes of action [1]

Summary

• Consider modes of action [1]
• Consider timing and placement

Summary

• Consider modes of action [1]
• Consider timing and placement
  • Seed row placement
  • Fall application with high loss risk
  • Blending source in spring

Summary

• Consider modes of action [1]
• Variable effects on yields
  • Seed row placement
  • Fall application with high loss risk
  • Blending source in spring
    – Combining urease and nitrification inhibitors provide multiple modes of actions

Thank you

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