The Impact of DCD and NBPT Concentration on Nitrification and Volatilization
Understanding Nitrification

• Ammonia rapidly converts to ammonium when it combines with water in the soil.

• Ammonium is held by the soil, compared to nitrate which moves freely with soil water.

• In saturated soils nitrate can also denitrify (converted to nitrogen gas and lost from the soil).

• *Nitrosomonas* and *Nitrobacter* bacteria convert ammonium to nitrate.

• Nitrification inhibitors slow the conversion of ammonium to nitrate by inhibiting AMO enzyme, which is found within the *Nitrosomonas* bacteria.

• Nitrification inhibitors reduce leaching and denitrification loss potential.
How Nitrification Inhibition Works

There are two ways to inhibit nitrification through interactions with the AMO enzyme:

1. **Competitive inhibition**: The inhibitor molecule will compete with ammonia to occupy AMO’s active site. By blocking the active site, it slows the conversion of ammonium to nitrate preventing loss of nitrates.
   - DCD is a competitive inhibitor.

2. **Non-competitive inhibition**: The inhibitor can temporarily inactivate the AMO enzyme by altering the shape of the active site.
The Impact of DCD Concentration

• The amount of DCD delivered by a product has a direct impact on how well a product will inhibit loss of nitrogen through nitrification.

Comparison of DCD Concentration:

<table>
<thead>
<tr>
<th>DCD Concentration</th>
<th>DCD (PPM)</th>
<th>Nitrogen Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPERU® Fertilizer</td>
<td>8,500</td>
<td>Urea</td>
</tr>
<tr>
<td>AGROTAI® PLUS SC Nitrogen Stabilizer</td>
<td>6,080</td>
<td>UAN</td>
</tr>
<tr>
<td>4 qt/ton, 28% DCD</td>
<td>1,323</td>
<td>UAN &amp; Urea</td>
</tr>
<tr>
<td>2 qt/ton, 28% DCD</td>
<td>662</td>
<td>UAN &amp; Urea</td>
</tr>
</tbody>
</table>
This data is derived from a lab study. SUPERU and AGROTAIN PLUS SC rates were calculated based on label concentration to get equivalent rates. G. W. McCarty & J. M. Bremner (1989) Laboratory evaluation of dicyandiamide as a soil nitrification inhibitor, Communications in Soil Science and Plant Analysis, 20:19-20, 2049-2065, DOI: 10.1080/00103628909368200

- The DCD concentration in SUPERU provided more than three times the protection against nitrification compared to a 2 qt/ton 28% concentration product after 42 days when averaged across the soils.

- The DCD concentration in SUPERU provided twice as much protection against nitrification as 2 qt/ton of a 28% concentration product when averaged across the three soils tested.
DCD Concentration Advantage of SUPERU®

- Research shows the concentration of DCD in the soil has a direct influence on the percent of nitrification. Higher concentrations of DCD equate to higher percentage of nitrification inhibition.
- The individual markers indicate the level of DCD delivered by the different products.

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The DCD concentration in AGROTAIN PLUS SC provided twice as much protection against nitrification as 2 qt/ton of a 28% concentration product when averaged across the three soils tested.

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Enzymes are proteins that facilitate chemical reactions.

Urea hydrolysis increases soil pH in a localized zone around the urea dissolution microsite.

As localized pH increases, the gaseous ammonia form is favored, which is susceptible to atmospheric loss.

Ammonia volatilization is the loss of nitrogen to the atmosphere as ammonia gas (NH₃).

Once dissolved in water, urea is converted to ammonium bicarbonate.

The naturally-occurring enzyme, urease, speeds urea breakdown to ammonia (NH₃) and CO₂.

Enzymes are proteins that facilitate chemical reactions.

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As localized pH increases, the gaseous ammonia form is favored, which is susceptible to atmospheric loss.
How Urease Inhibitors Work

• NBPT slows the conversion of urea by competing with urea for the active site of the urease enzyme.
• Slowing the conversion allows time for the urea to be incorporated by rainfall or other means.
• Nitrogen loss is minimized resulting in optimized yield and ROI.

Source: Koch Agronomic Services
What Agronomists Need to Know About Nitrogen Enhancers and Stabilizers – MAC 2016*

• Rates used in successful nitrification inhibition range from 1 to 5 % of N in mix as DCD

• Needs to be added at >1% of total N content of fertilizer needing protection

What agronomists need to know about nitrogen enhancers and stabilizers
Dr. Fabián Fernández, Department of Soil, Water and Climate, University of Minnesota

The Impact of NBPT and DCD Concentration

• The amount of NBPT and DCD delivered by a product has a direct impact on how well a product will inhibit loss of nitrogen through nitrification and ammonia volatilization.

Comparison of NBPT and DCD Concentration:

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<th>NBPT (PPM)</th>
<th>DCD (PPM)</th>
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<tr>
<td>SUPERU® Fertilizer</td>
<td>600</td>
<td>8,500</td>
</tr>
<tr>
<td>AGROTAIIN® Nitrogen Stabilizer</td>
<td>665</td>
<td>-</td>
</tr>
<tr>
<td>17% NBPT and 25% DCD Product</td>
<td>600</td>
<td>870</td>
</tr>
</tbody>
</table>
• With conditions favorable for volatilization, AGROTAIN® and SUPERU® with their higher NBPT concentrations, outperformed the 17% NBPT and 25% DCD product.

The underlying data was provided by the University of Alberta under a Research Trial Financial Support Agreement with Koch Agronomic Services, LLC and neither the University of Alberta, nor the individual researchers referenced, endorse or recommend any product or service.
Canola response to spring deep banded urea and fall broadcast of urea, urea treated with AGROTAIN® stabilizer, SUPERU® fertilizer and a 17% NBPT and 25% DCD product.
Canola Yield Response – 2018 University of Alberta Ellerslie Site

- With 8.2 inches of precipitation from fertilizer application to seeding and with growing season precipitation at 6.5 inches, this made for ideal conditions for leaching and denitrification losses.

- SUPERU, with its higher concentration of DCD provided a yield advantage over the lower rate DCD product.

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DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®

Canola Yield Response - 2018 Wheatland Conservation Area (Swift Current)

- Dry conditions resulted in the increased yield advantage of the 70 percent of the recommended SUPERU® application rate.

Source: Bryan Nebo, 2018. Wheatland Conservation Area
- Yield averaged across nitrogen rates (84 and 120 lbs N/a)
- Fertilizer Applied: Nov. 3, 2017
- Canola Planted: May 21, 2018
- Canola Harvested: Sept. 10, 2018
- LSD (.05): 4.3 bushels

The underlying data was provided by Wheatland Conservation Area (WCA) under a Research Trial Financial Support Agreement with Koch Agronomic Services, LLC and neither WCA, nor the individual researchers referenced, endorse or recommend any product or service. Neon™ is a registered trademark of Eco Agro Resources, LLC.
DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®

- Drier than normal conditions in 2017 led to higher volatilization losses.
- AGROTAIN at the recommended rate, with its higher concentration of NBPT, outperformed the lower rate NBPT product.

Source: Steven Shirtliffe, 2017. University of Saskatchewan
Yield averaged across nitrogen rates (70 and 100 lbs N/a)
Fertilizer Applied: Nov. 5, 2016
Canola Planted: May 15, 2017
Canola Harvested: Sept. 15, 2017
LSD (.05): 4.6 bushels
• With deep banding as the reference, treating nitrogen with SUPERU® and AGROTAIN® for broadcast applications provided similar yield advantages.
• The low-rate product did not provide the yield advantage compared to AGROTAIN® and SUPERU® with their higher concentrations of active ingredients.

Source: Steven Shirtliffe, 2018. University of Saskatchewan
• Yield averaged across nitrogen rates (70 and 100 lbs N/a)
• Fertilizer Applied: Oct. 20, 2017
• Canola Planting: June 12, 2018
• Canola Harvested: August 20, 2018
• LSD (.05): 5.0 bushels
The site experienced increased precipitation compared to the other sites, creating the risk of denitrification, although not as significant as it would have been had the products been applied in the fall (missed the losses from snowmelt).

SUPERU provided a higher yield advantage compared to the 17% NBPT and 25% DCD product with the lower DCD concentration.
DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®

- Drier than normal conditions in 2017 led to increased volatilization losses. AGROTAIN® was able to provide a yield advantage compared to the 17% NBPT and 25% DCD product.
DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®

The underlying data was provided by University of Alberta, Northeastern Agricultural Research Foundation, Wheatland Conservation Area and Indian Head Agricultural Research Foundation under separate Research Trial Financial Support Agreement with Koch Agronomic Services, LLC. Neither the organizations or universities, nor the individual researchers referenced, endorse or recommend any product or service. This study was conducted at sites in Saskatchewan and Alberta.

- On average, the 17% NBPT and 25% DCD product performed as well as AGROTAIN which shows the DCD concentration in the 17% NBPT and 25% DCD product, may be too low to protect against losses to leaching and denitrification.

- Average results across four sites in 2018 (AB and SK)
- Nitrogen applied at rate recommended for each site
- Bars followed by the same letter are not significantly different at 95% probability.