

The image features a background of a cornfield at sunset. The sky is a mix of orange, yellow, and blue, with some clouds. In the foreground, there are rows of green corn plants. The Koch logo is prominently displayed in the center, with the word 'KOCH' in a large, bold, white sans-serif font. A horizontal line is positioned below the logo. The background is overlaid with a semi-transparent blue geometric pattern consisting of various triangles and lines.

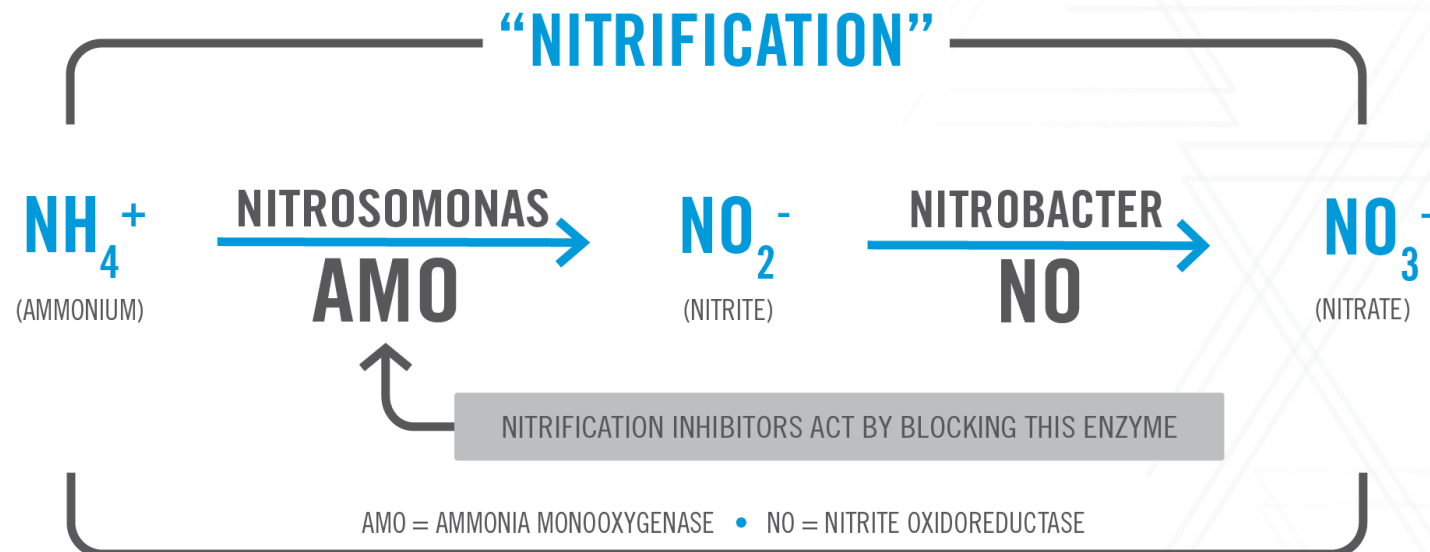
KOCHTM

AGRONOMIC SERVICES

**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.



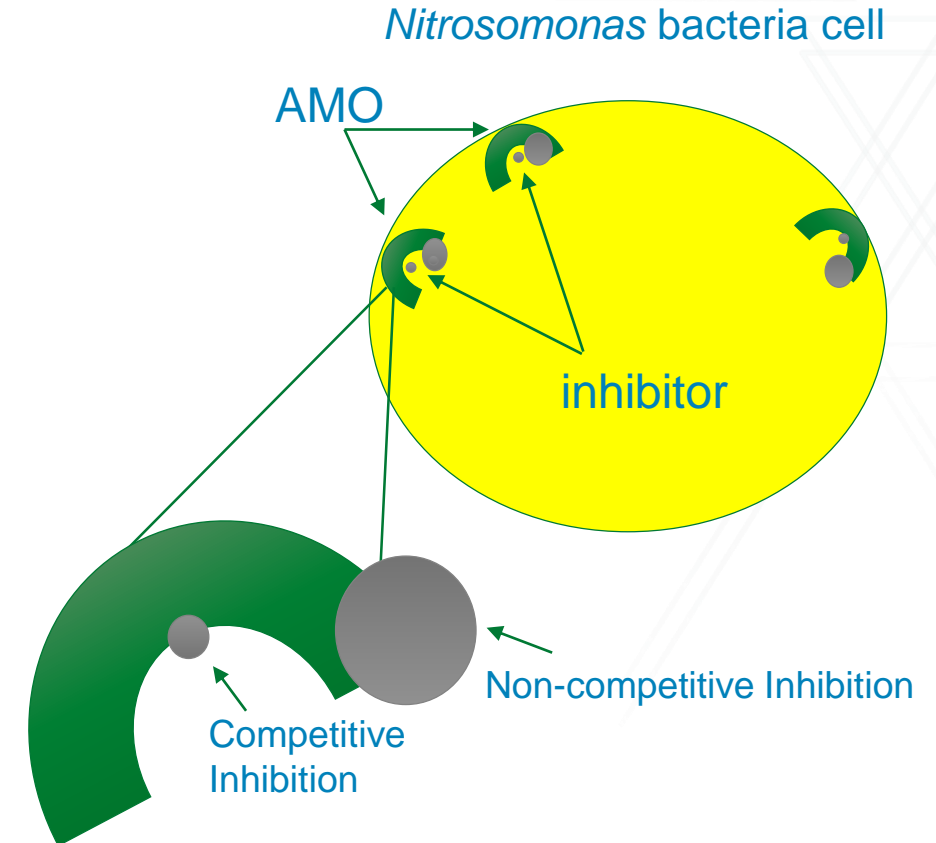
Source: Koch Agronomic Services

- 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

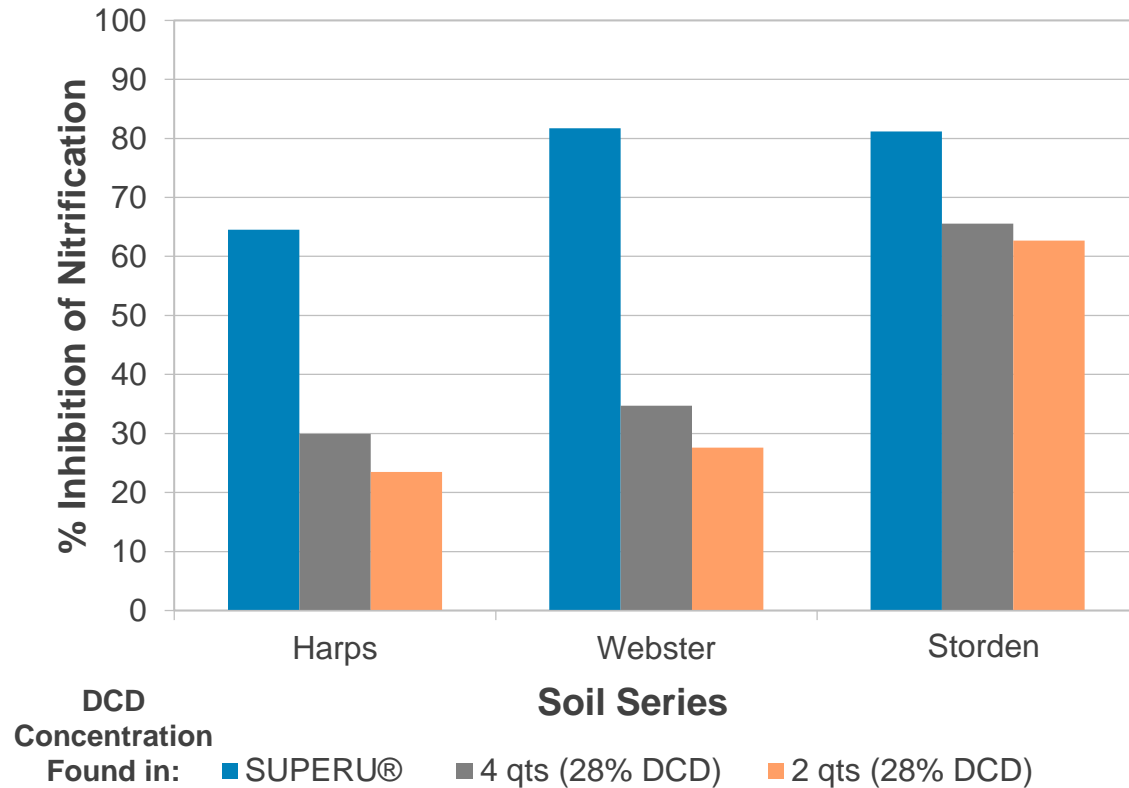
- The amount of DCD delivered by a product has a direct impact on how well a product will inhibit loss of nitrogen through nitrification.

Comparison of DCD Concentration:

DCD Concentration	DCD (PPM)	Nitrogen Source
SUPERU[®] Fertilizer	8,500	Urea
AGROTAIN[®] PLUS SC Nitrogen Stabilizer	6,080	UAN
4 qt/ton, 28% DCD	1,323	UAN & Urea
2 qt/ton, 28% DCD	662	UAN & Urea

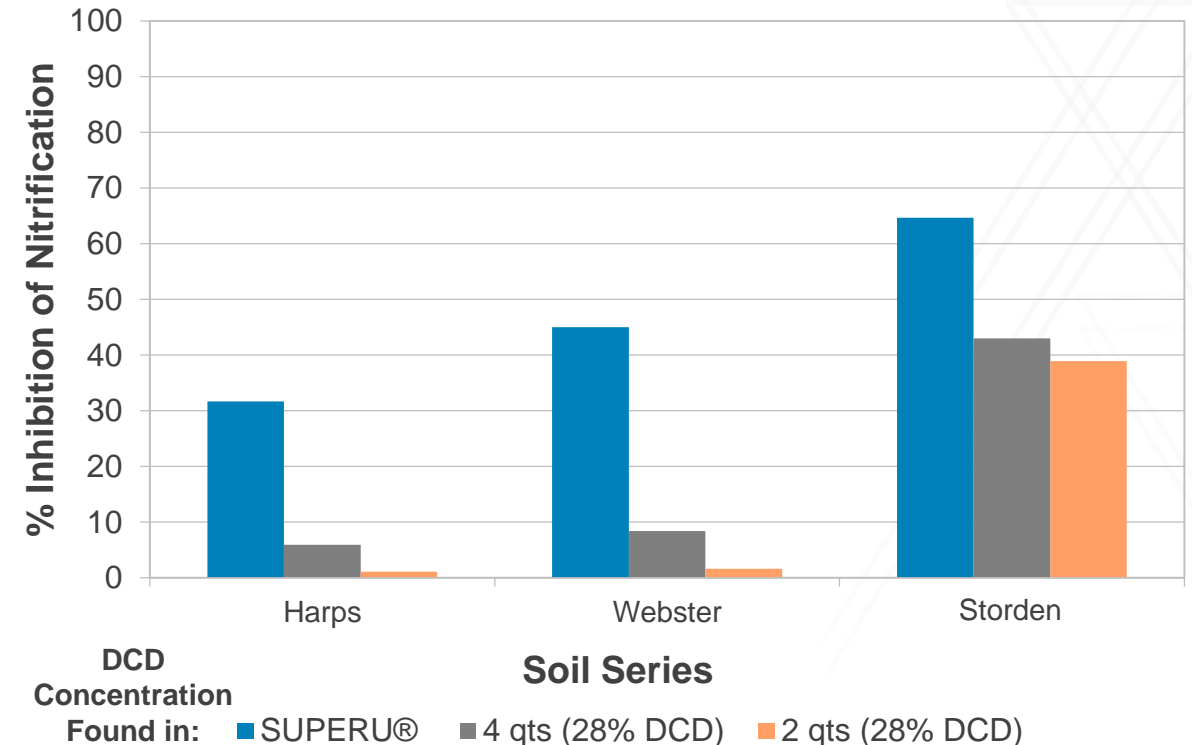
DCD Concentration Advantage of SUPERU®

21 Day Incubation (68°F/20°C)



- 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.

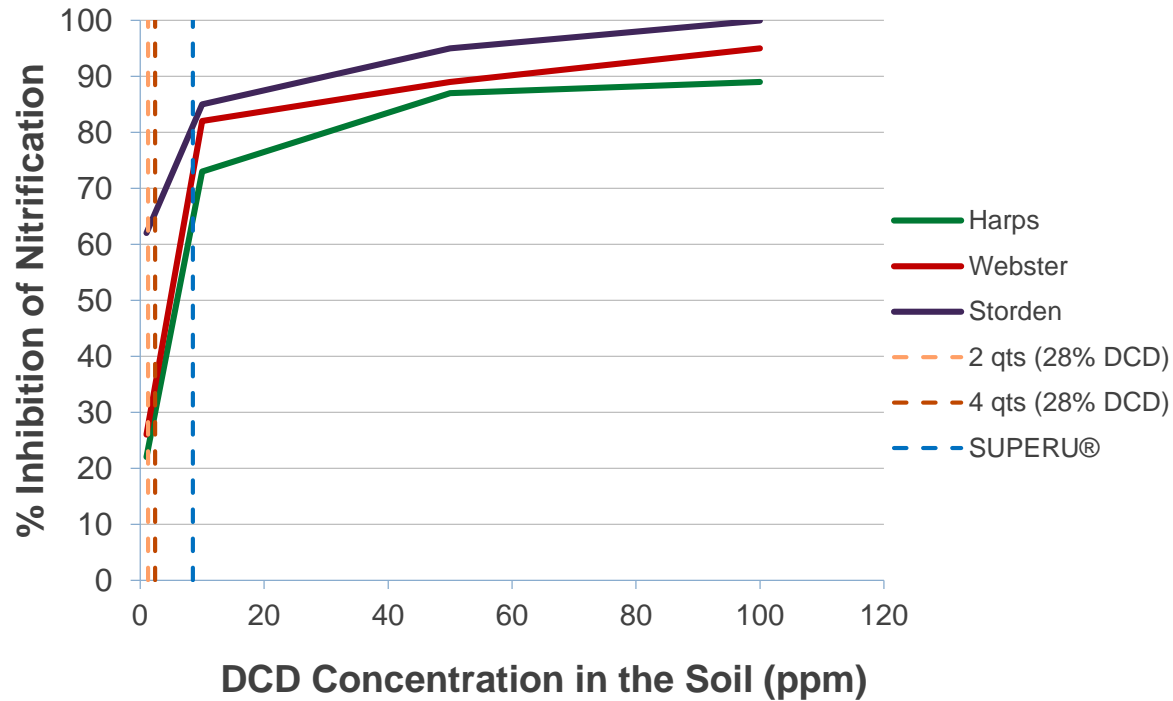
42 Day Incubation (68°F/20°C)



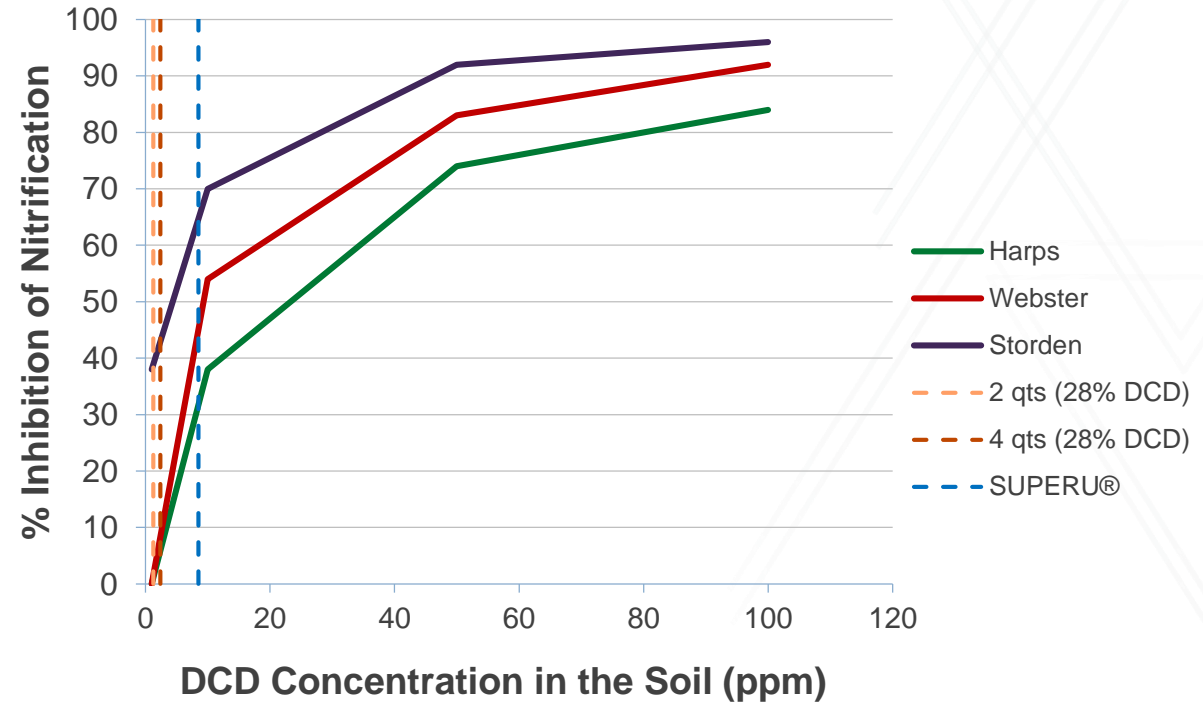
- The DCD concentration in SUPERU provided more than three times the protection against nitrification compared to a 2 qt/ton 28% concentration product after 42 days when averaged across the soils.

DCD Concentration Advantage of SUPERU®

Nitrification after 21 Days
(68°F/20°C)



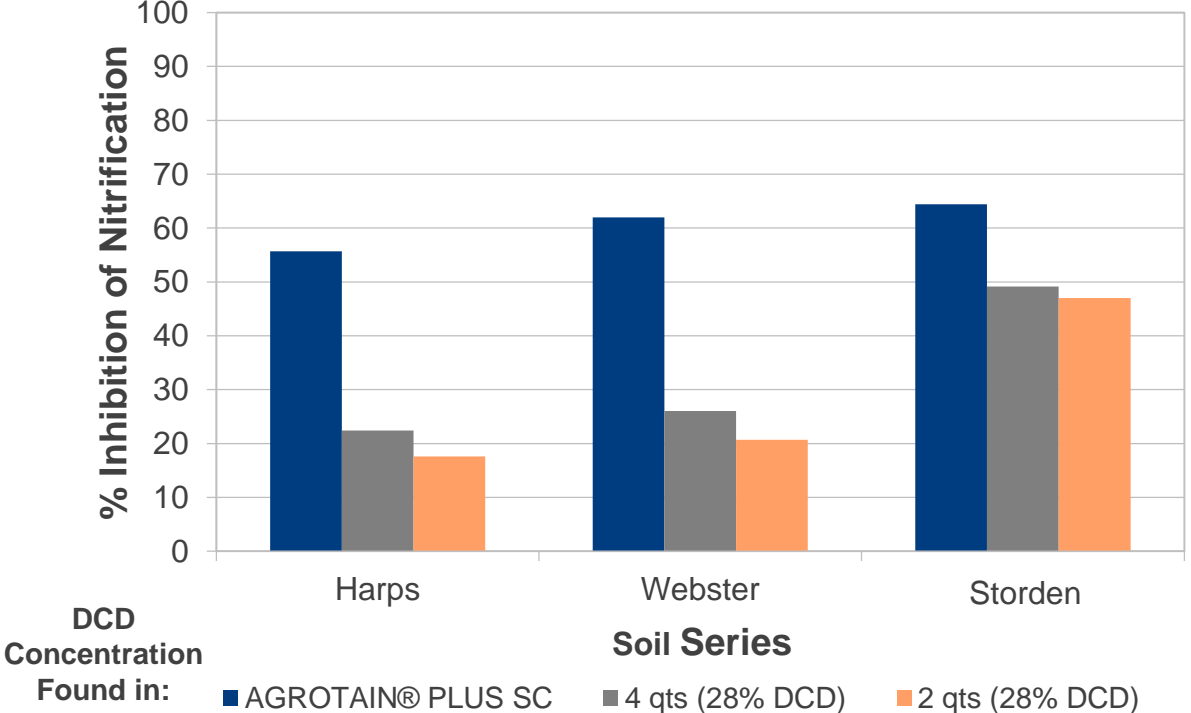
Nitrification after 42 Days
(68°F/20°C)



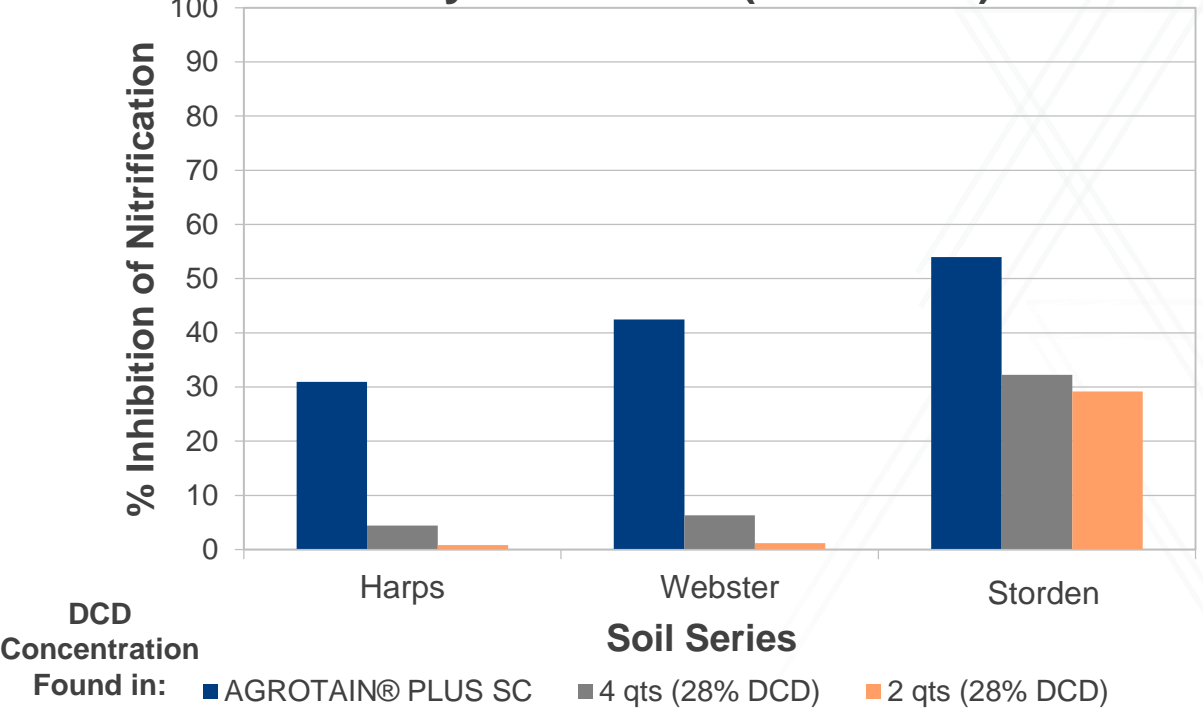
- Research shows the concentration of DCD in the soil has a direct influence on the percent of nitrification. Higher concentrations of DCD equate to higher percentage of nitrification inhibition.
- The individual markers indicate the level of DCD delivered by the different products.

DCD Concentration Advantage of AGROTAIN® PLUS SC

21 Day Incubation (68°F/20°C)



42 Day Incubation (68°F/20°C)



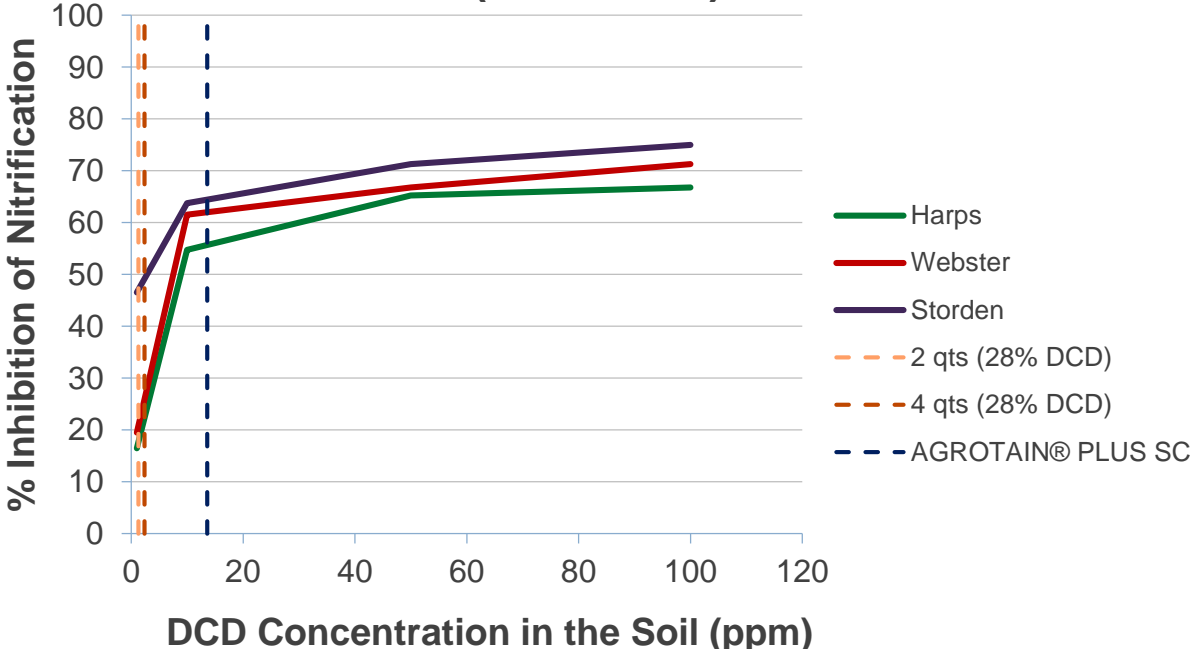
- The DCD concentration in AGROTAIN PLUS SC provided twice as much protection against nitrification as 2 qt/ton of a 28% concentration product when averaged across the three soils tested.

- The DCD concentration in AGROTAIN PLUS SC 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.

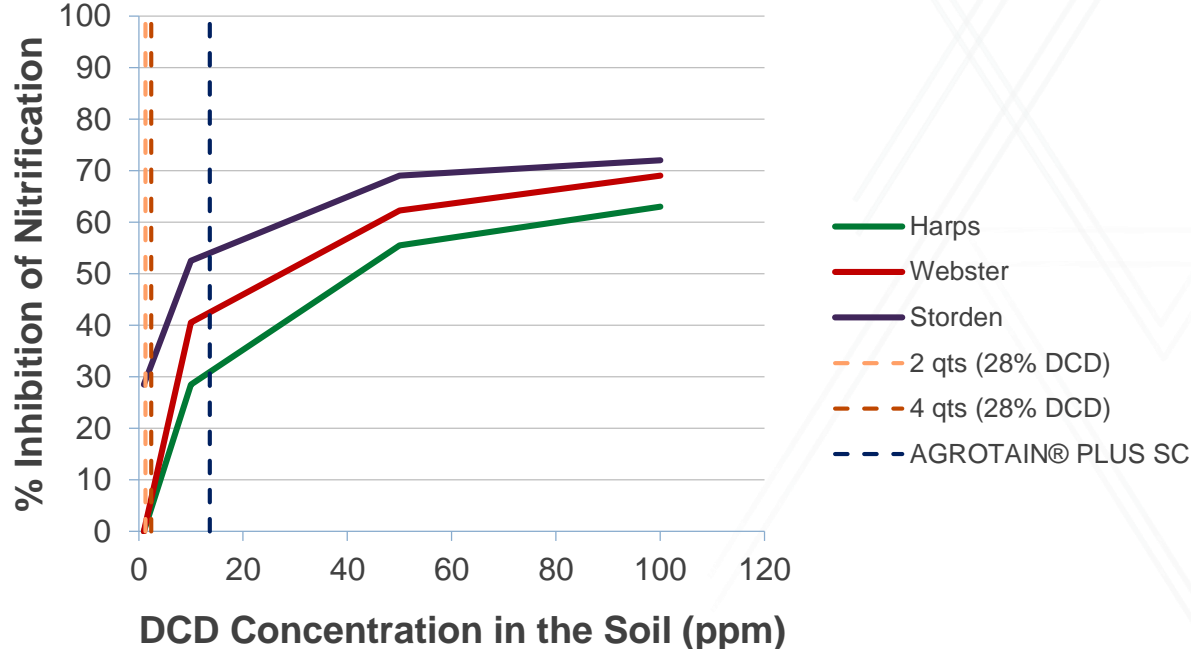
This data is derived from a lab study. SUPERU and AGROTAIN PLUS SC rates were calculated based on label concentration to get equivalent rates. G. W. McCarty & J. M. Bremner (1989) Laboratory evaluation of dicyandiamide as a soil nitrification inhibitor, Communications in Soil Science and Plant Analysis, 20:19-20, 2049-2065, DOI: 10.1080/00103628909368200

DCD Concentration Advantage of AGROTAIN® PLUS SC

Nitrification after 21 Days
(68°F/20°C)



Nitrification after 42 Days
(68°F/20°C)

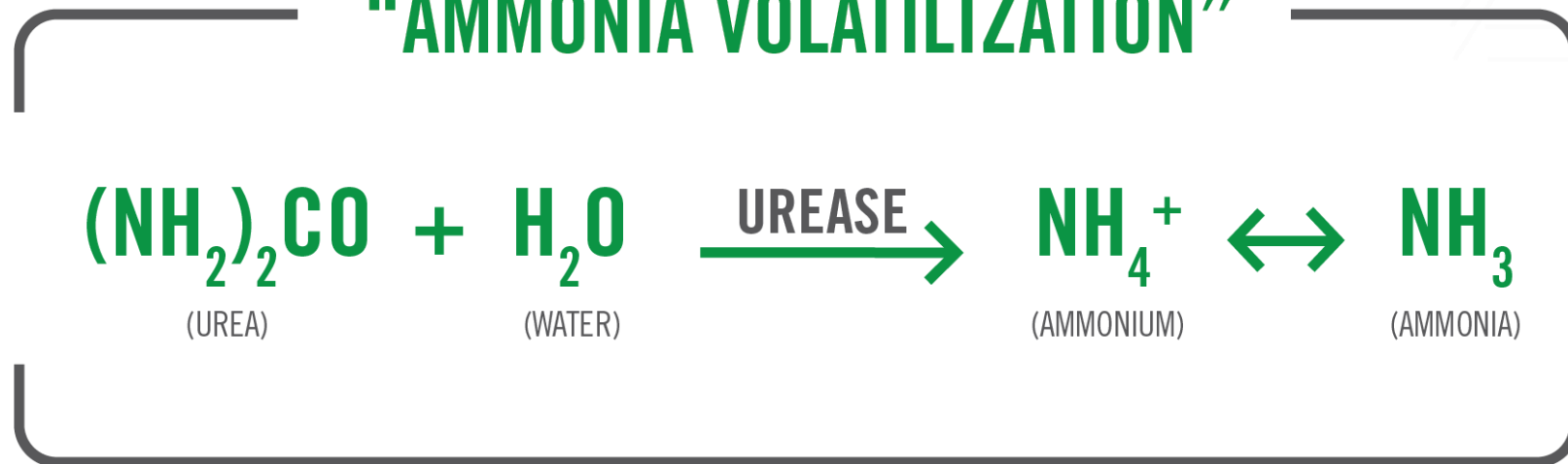


- Research shows the concentration of DCD in the soil has a direct influence on the percent of nitrification. Higher concentrations of DCD equate to higher percentage of nitrification inhibition.
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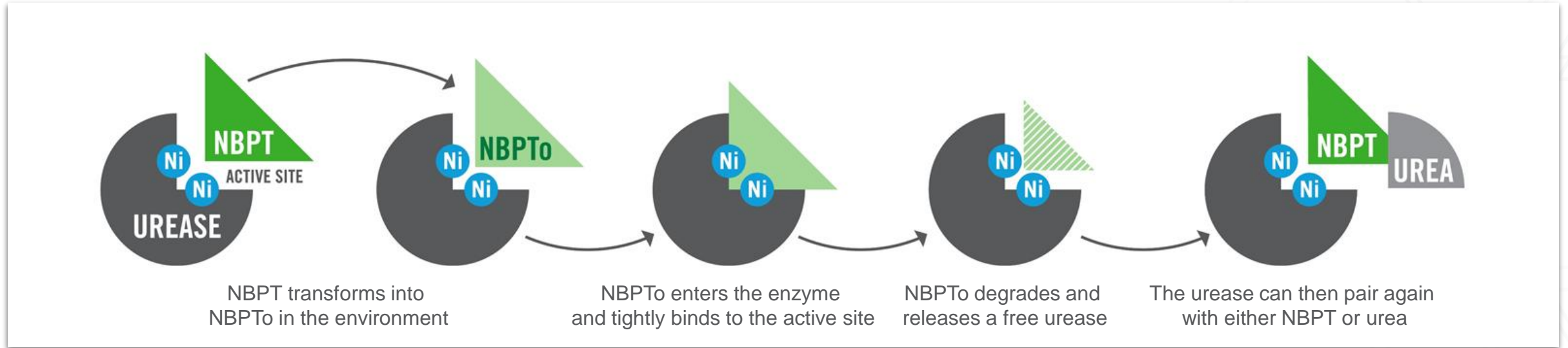
Understanding Ammonia Volatilization

“AMMONIA VOLATILIZATION”



- 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.
- 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

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.

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
- http://umanitoba.ca/faculties/afs/agronomists_conf/proceedings_2016.html

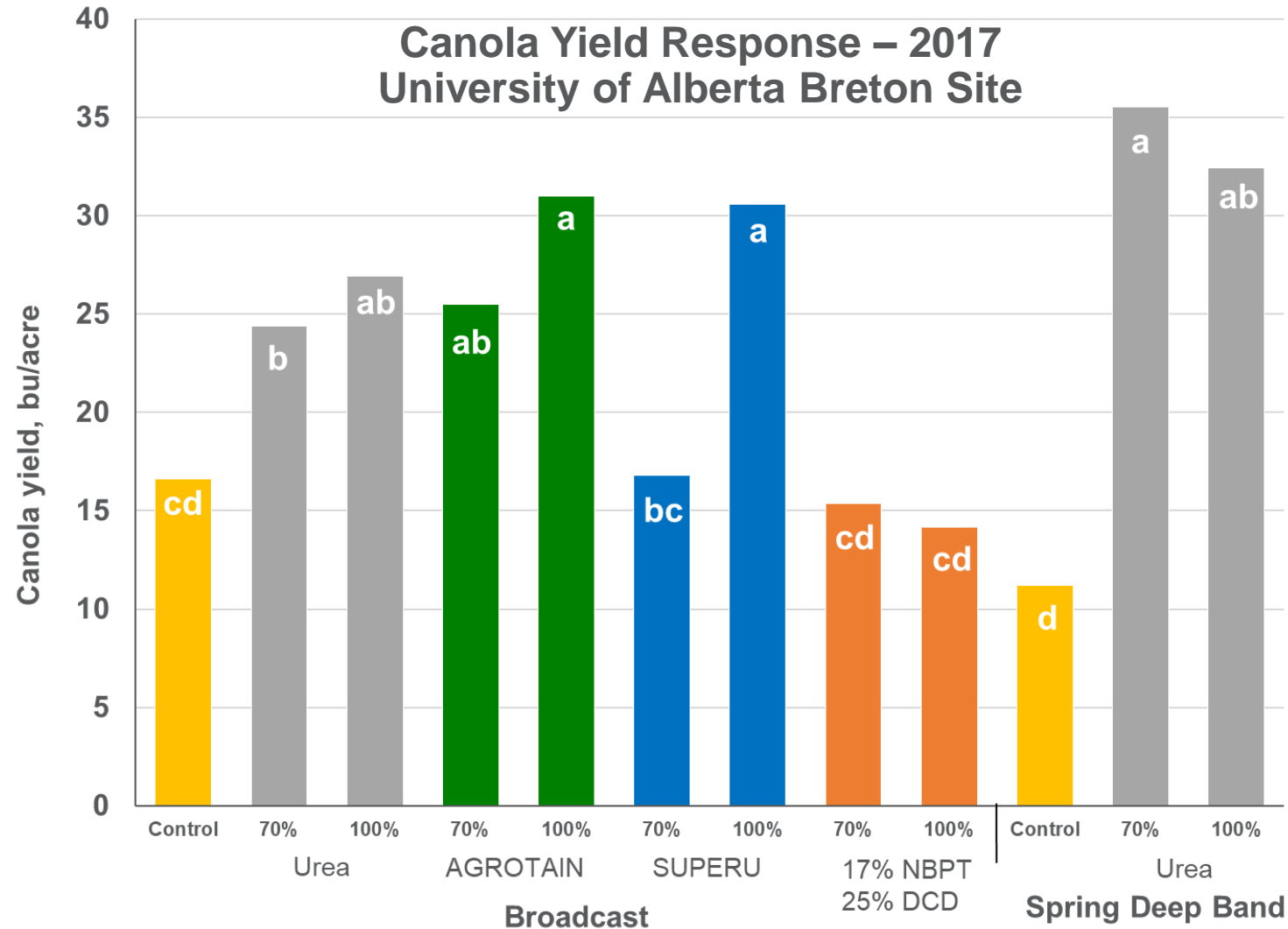
The Impact of NBPT and DCD Concentration

- 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:

NBPT and DCD Concentration	NBPT (PPM)	DCD (PPM)
SUPERU[®] Fertilizer	600	8,500
AGROTAIN[®] Nitrogen Stabilizer	665	-
17% NBPT and 25% DCD Product	600	870

DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®



- With conditions favorable for volatilization, AGROTAIN® and SUPERU® with their higher NBPT concentrations, outperformed the 17% NBPT and 25% DCD product.

- Source: Miles Dyck, 2017. University of Alberta
- Yield averaged across nitrogen rates (105 and 150 lbs N/a)
- Fertilizer applied Nov. 1, 2016
- Canola Planted: May 17, 2017
- Canola Harvested: Sept. 27, 2017
- LSD (.05): 6.02 bushels

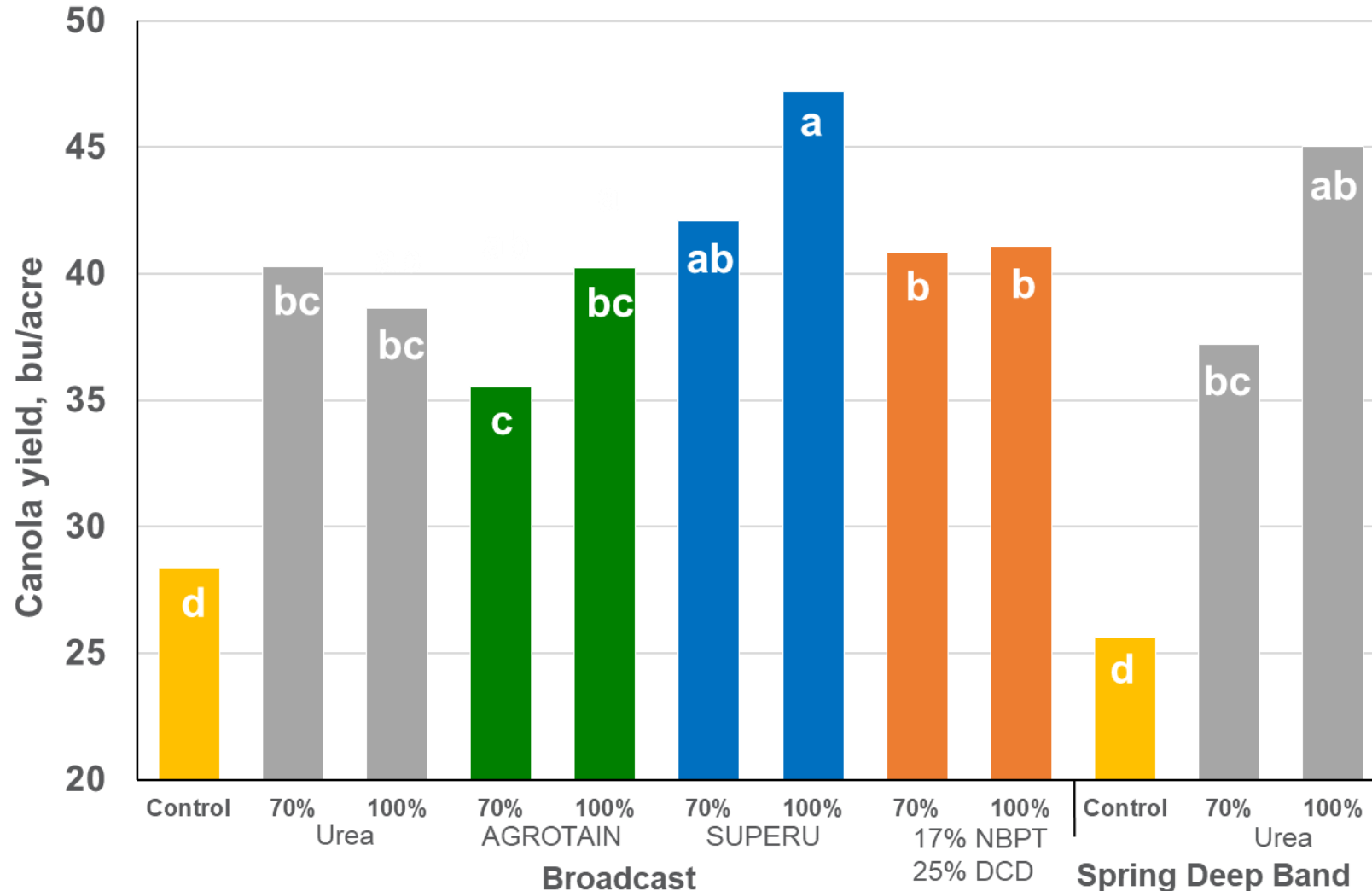
DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®



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.

DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®

Canola Yield Response – 2018 University of Alberta Ellerslie Site

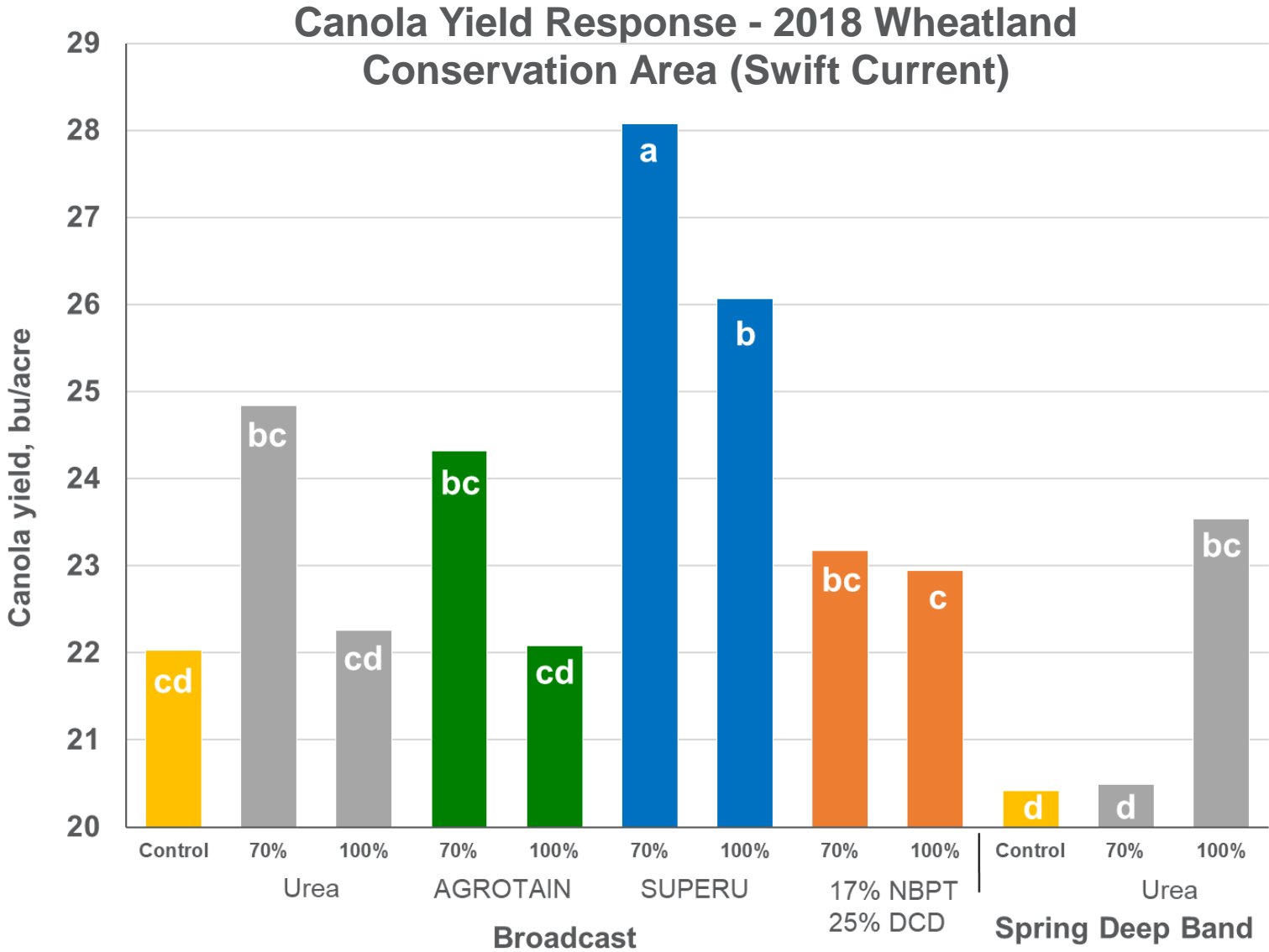


- With 8.2 inches of precipitation from fertilizer application to seeding and with growing season precipitation at 6.5 inches, this made for ideal conditions for leaching and denitrification losses.
- SUPERU, with its higher concentration of DCD provided a yield advantage over the lower rate DCD product.

• Source: Miles Dyck, 2018. University of Alberta
 • Yield averaged across nitrogen rates (105 and 150 lbs N/a)
 • Fertilizer applied Oct. 30, 2017
 • Canola harvested Oct. 16, 2018
 • LSD (.05): 5.7 bu

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.

DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®



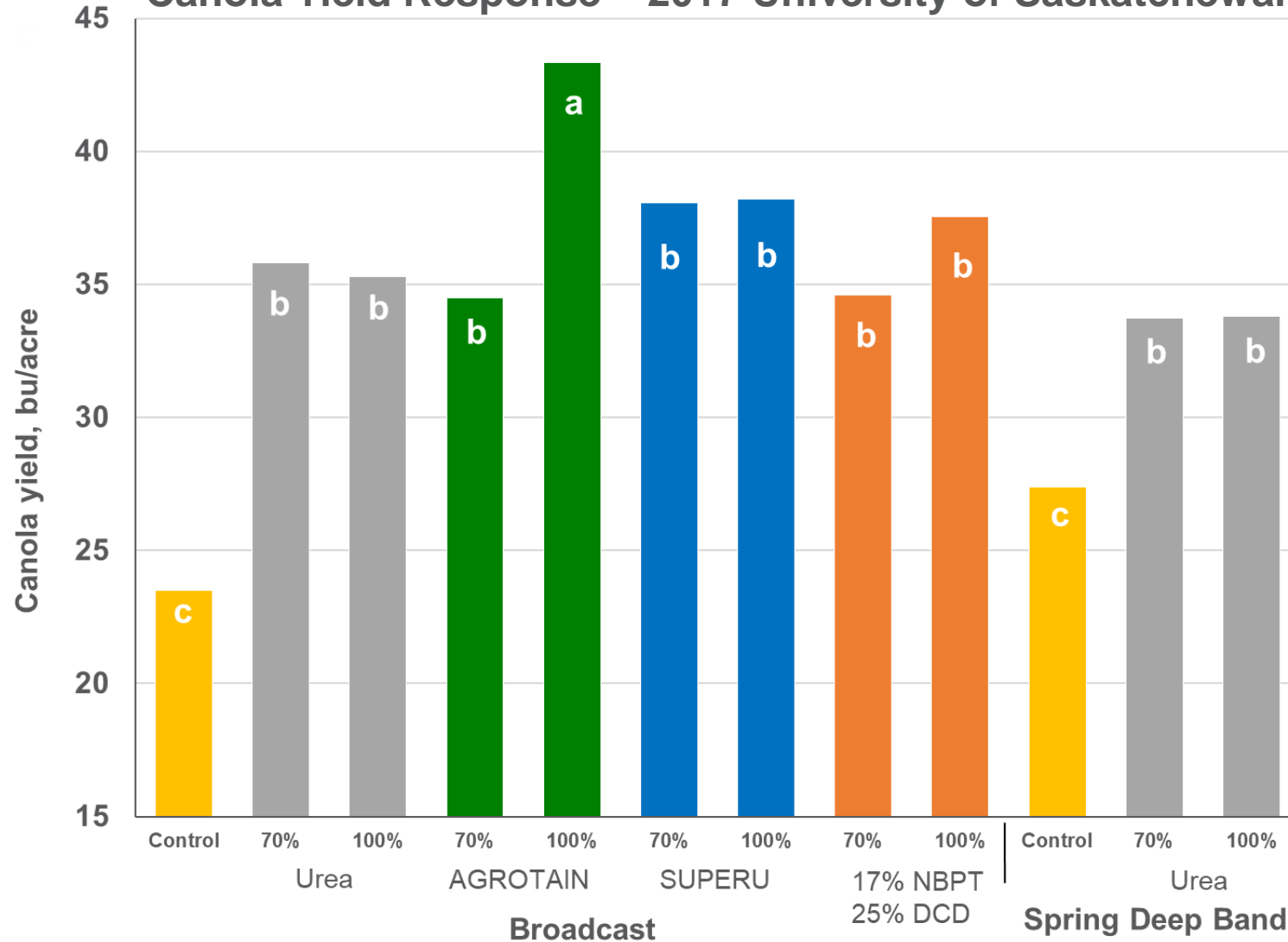
- Dry conditions resulted in the increased yield advantage of the 70 percent of the recommended SUPERU® application rate.

- 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®

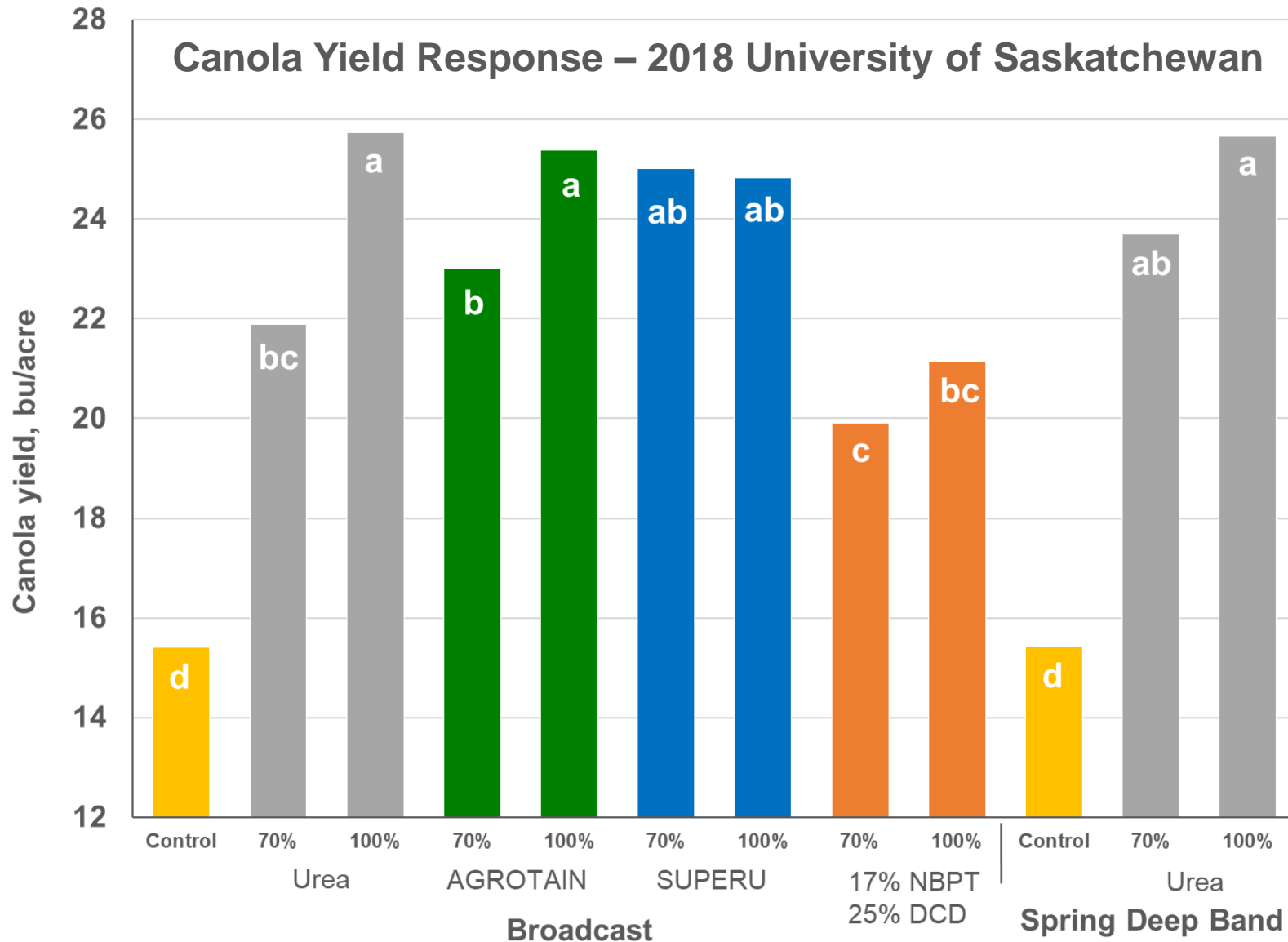
Canola Yield Response – 2017 University of Saskatchewan



- 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 Shirliffe, 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

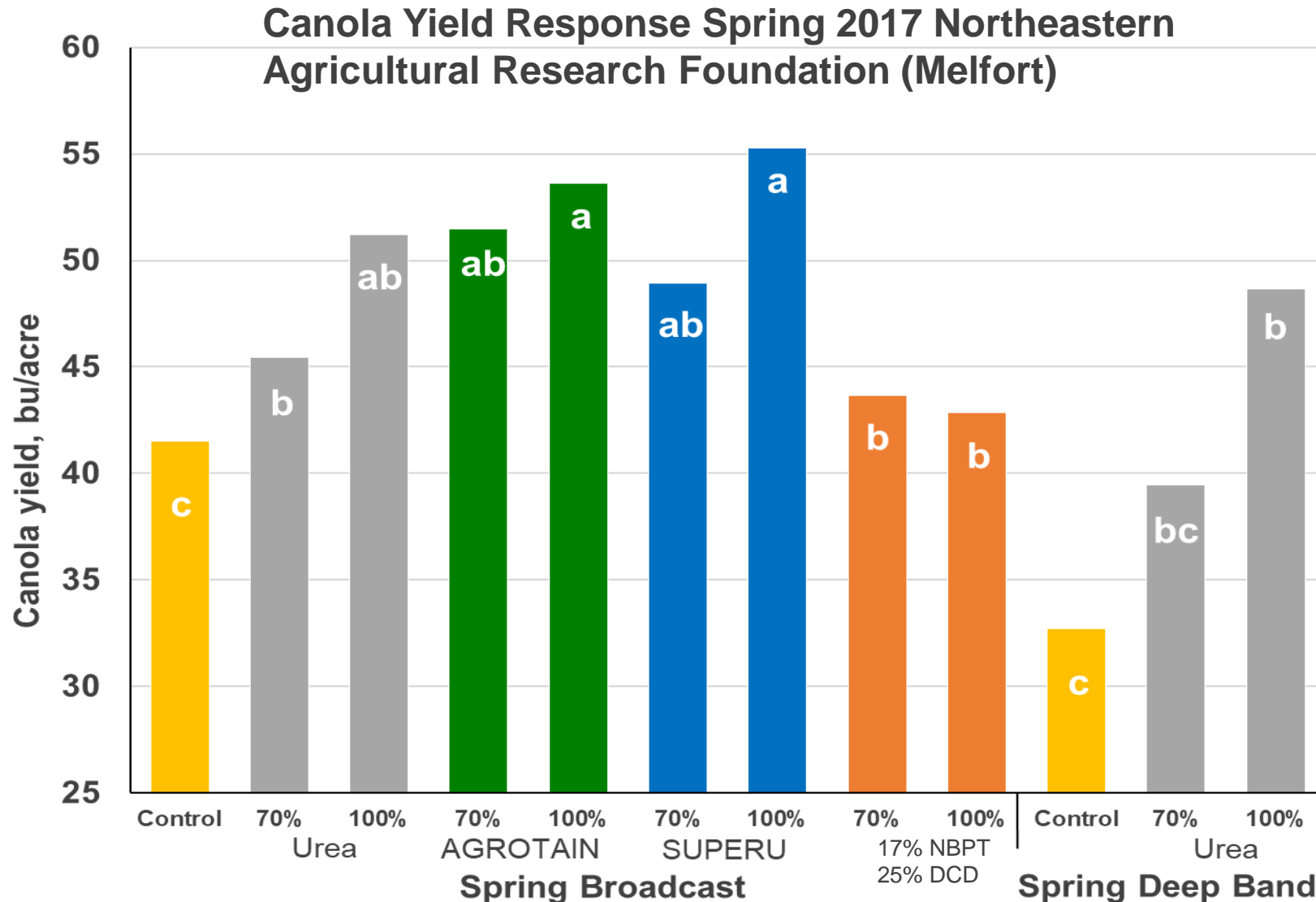
DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®



- 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.

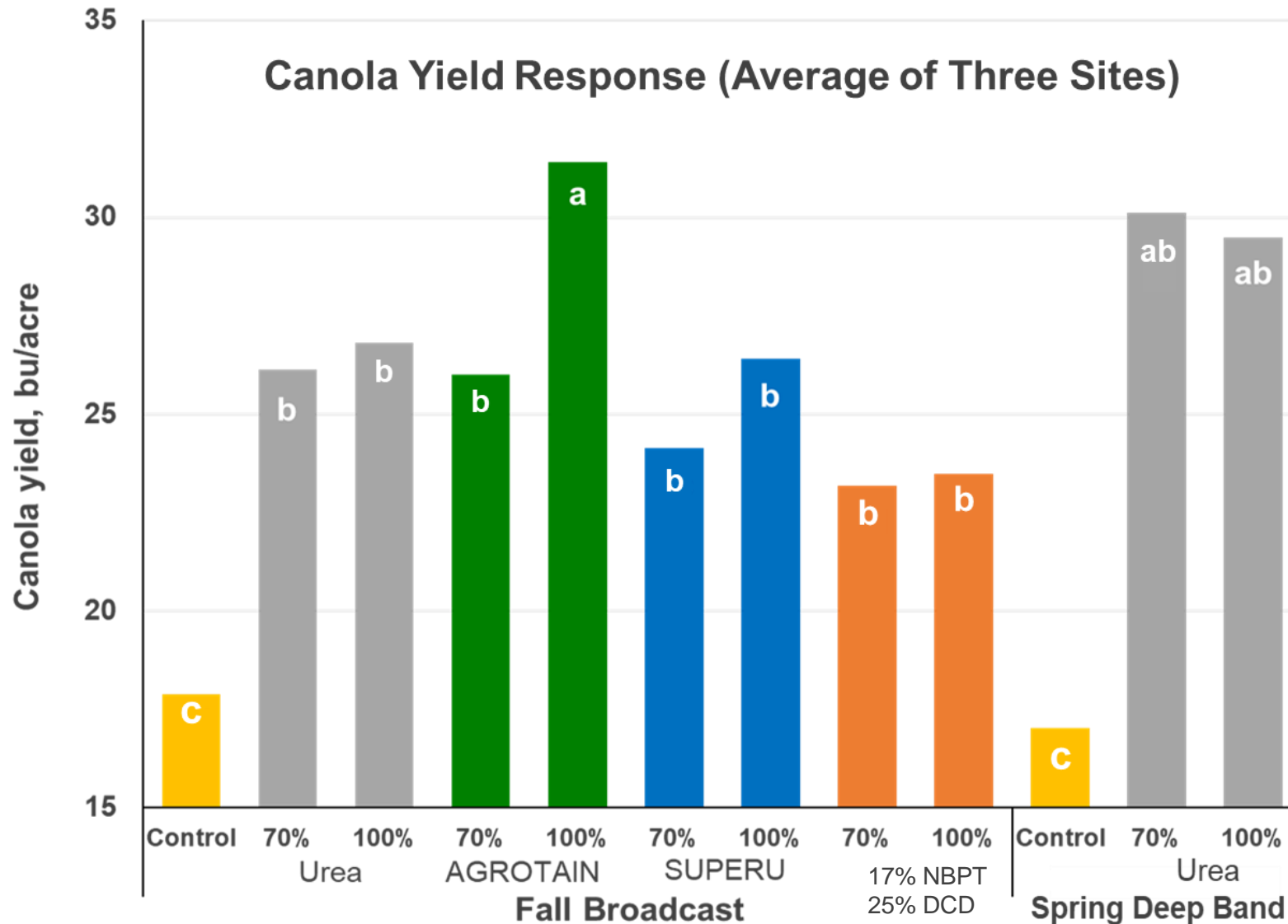
• Source: Steven Shirliffe, 2018. University of Saskatchewan
 • Yield averaged across nitrogen rates (70 and 100 lbs N/a)
 • Fertilizer Applied: Oct. 20, 2017
 • Canola Planting: June 12, 2018
 • Canola Harvested: August 20, 2018
 • LSD (.05): 5.0 bushels

DCD & NBPT Concentration Advantage of AGROTAIN® & SUPERU®



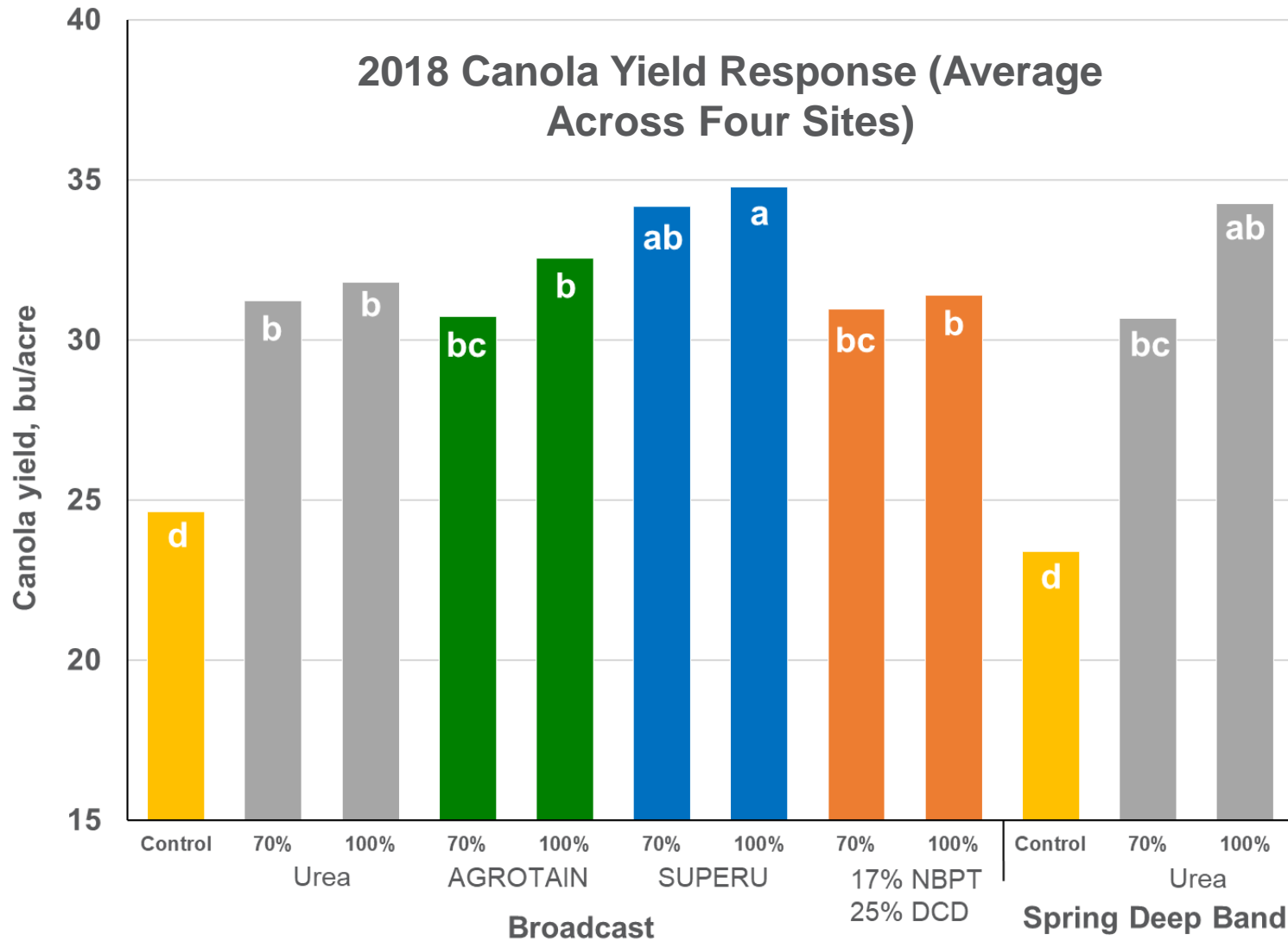
- The site experienced increased precipitation compared to the other sites, creating the risk of denitrification, although not as significant as it would have been had the products been applied in the fall (missed the losses from snowmelt).
- SUPERU provided a higher yield advantage compared to the 17% 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®



- 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.

The background of the image is a wide-angle photograph of a cornfield at sunset. The sky is a mix of orange, yellow, and blue, with wispy clouds. The corn plants in the foreground are green and appear to be in the early stages of growth. On the left side, there is a silhouette of a large tree. On the right side, there are faint, white geometric shapes (triangles and lines) overlaid on the image. The text 'K KOCH' is centered in the upper half of the image, with a horizontal line below it. The text 'AGRONOMIC SERVICES' is centered below the line. The text 'AGROTAIN®', 'SUPERU®', and '© 2017 Koch Agronomic Services, LLC.' is located at the bottom of the image.

K KOCH™

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