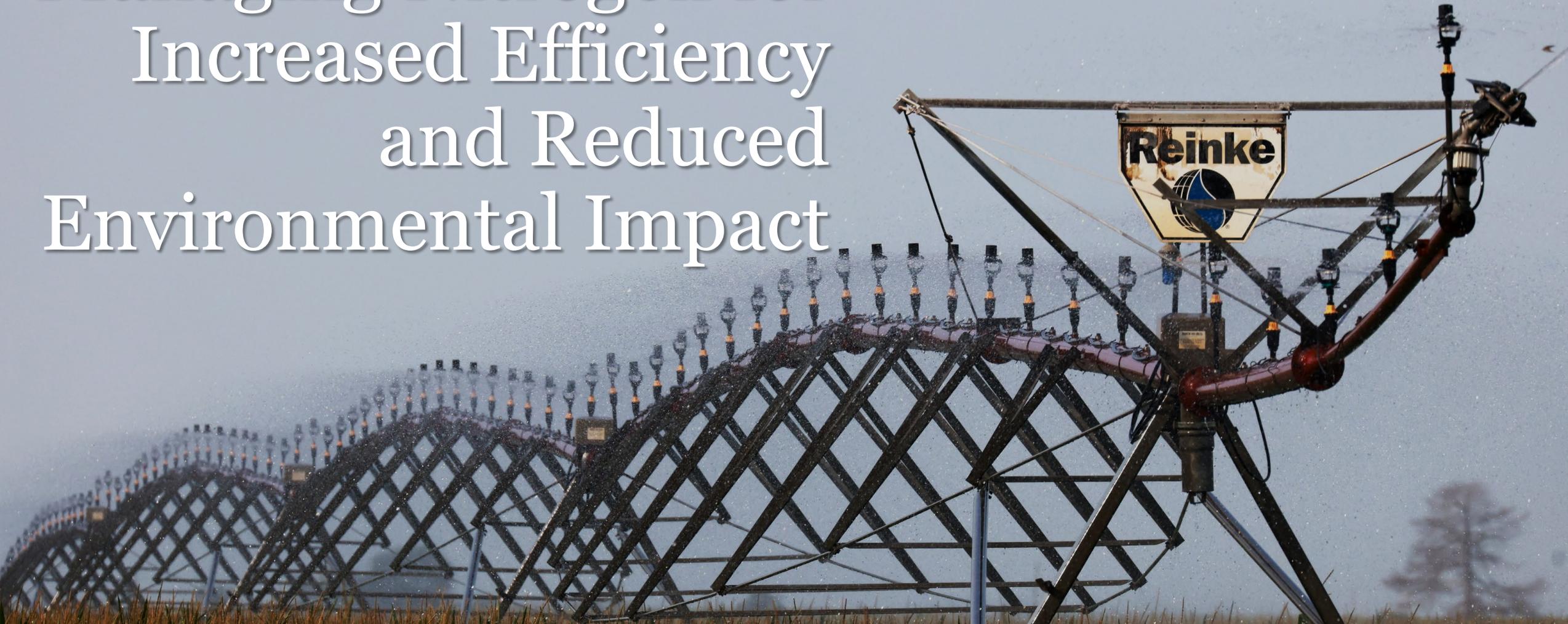
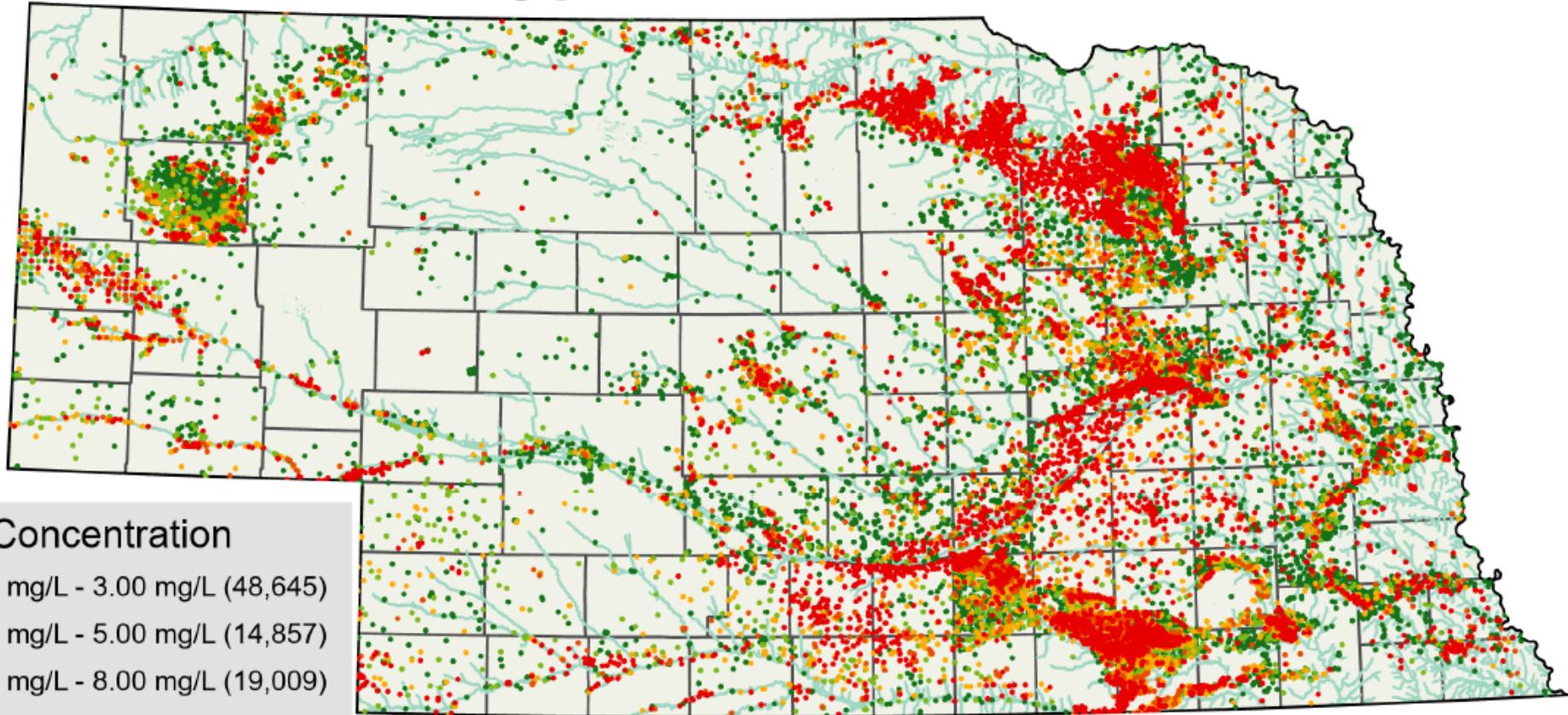


# Managing Nitrogen for Increased Efficiency and Reduced Environmental Impact



Richard B. Ferguson, PhD  
Department of Agronomy and Horticulture

# 119,683 Nitrate Well Samples from the Nebraska Groundwater Quality Clearinghouse: All Well Types 2003-2019

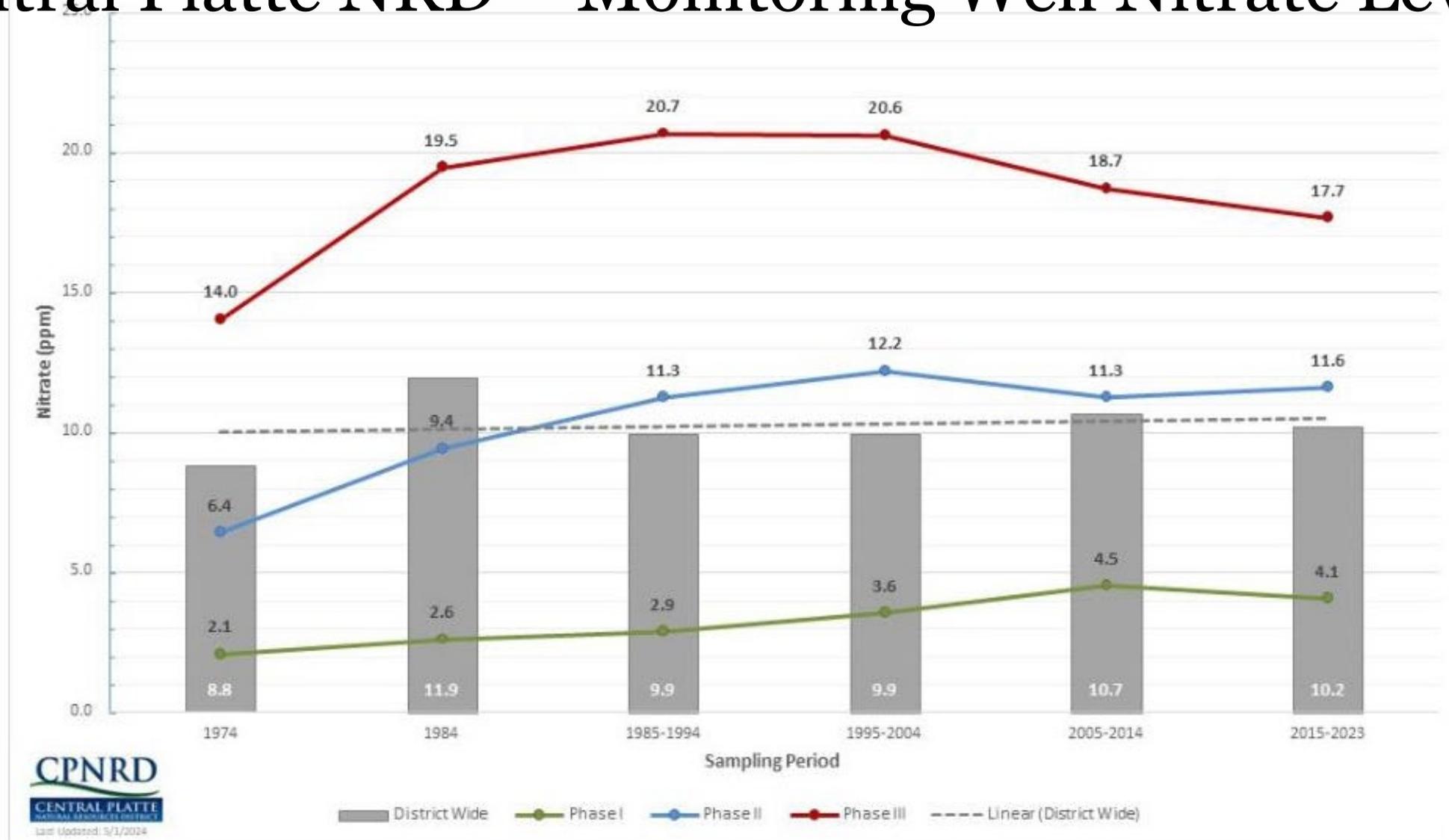


## Nitrate Concentration

- 0.00 mg/L - 3.00 mg/L (48,645)
- 3.01 mg/L - 5.00 mg/L (14,857)
- 5.01 mg/L - 8.00 mg/L (19,009)
- 8.01 mg/L - 10.00 mg/L (9,892)
- > 10 mg/L (27,550)

Credits: NDEE Drinking Water and Groundwater Division  
Name: NAD 1983 State Plane Nebraska FIPS 2,600 Feet  
Datum: North American 1983  
Projection: Lambert Conformal Conic

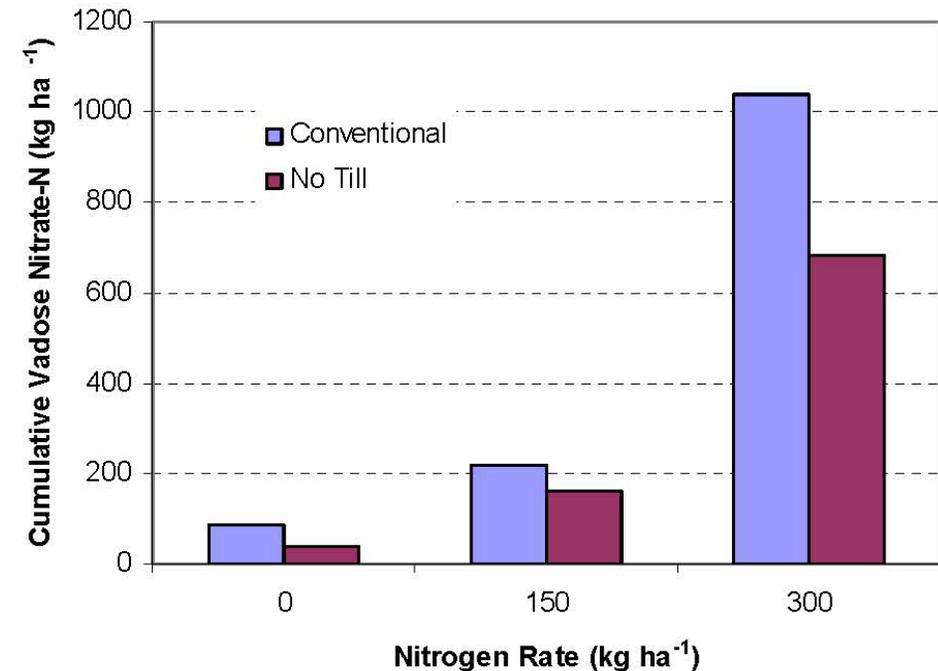
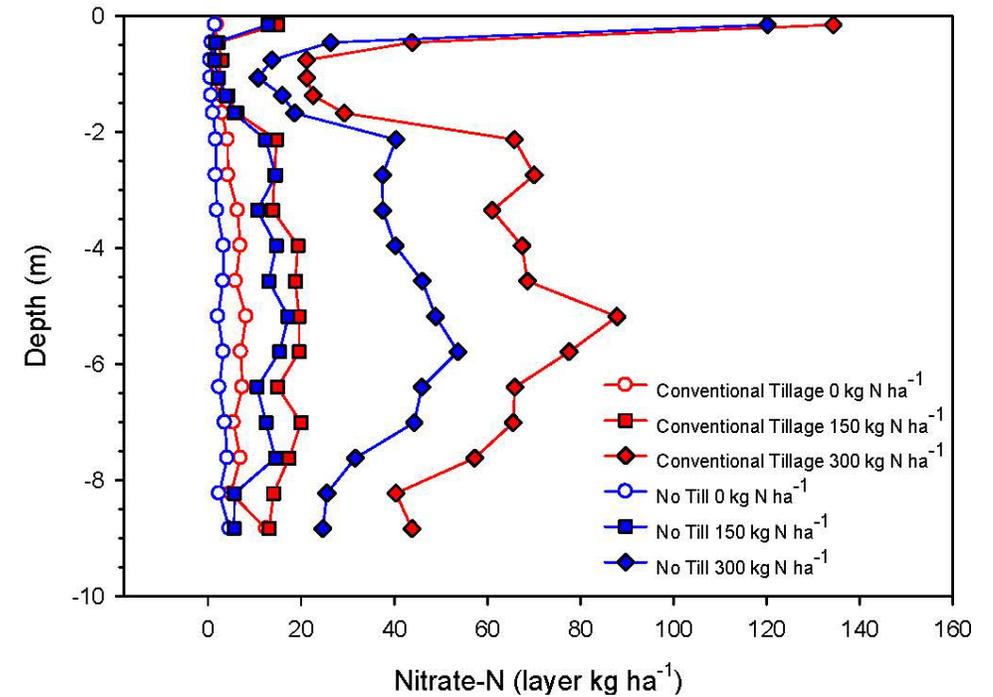
# Central Platte NRD – Monitoring Well Nitrate Levels



# South Central Ag Lab Long-Term N Management Study

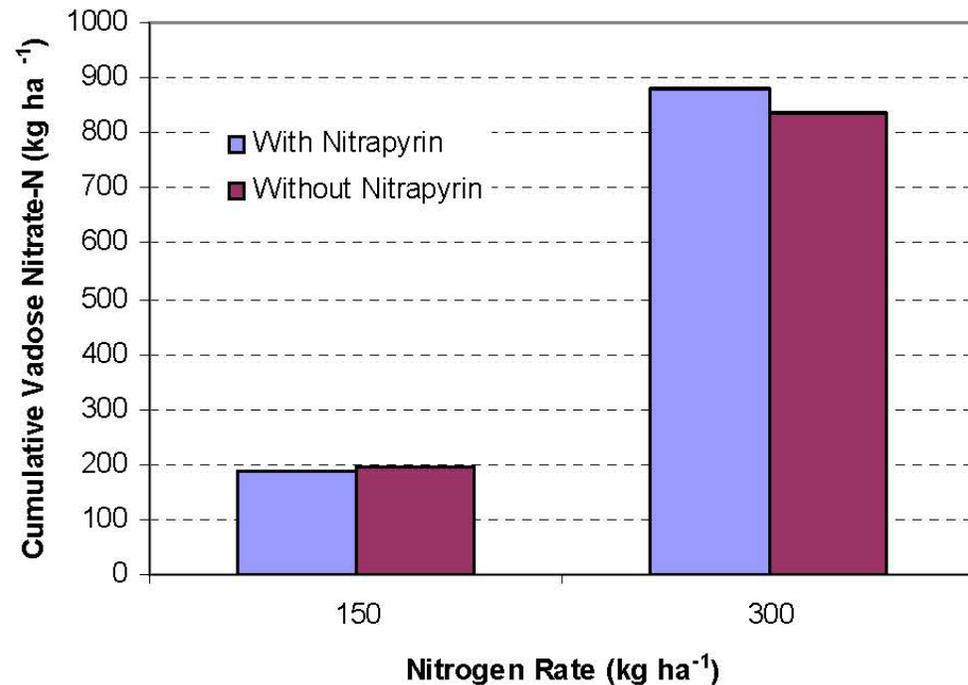
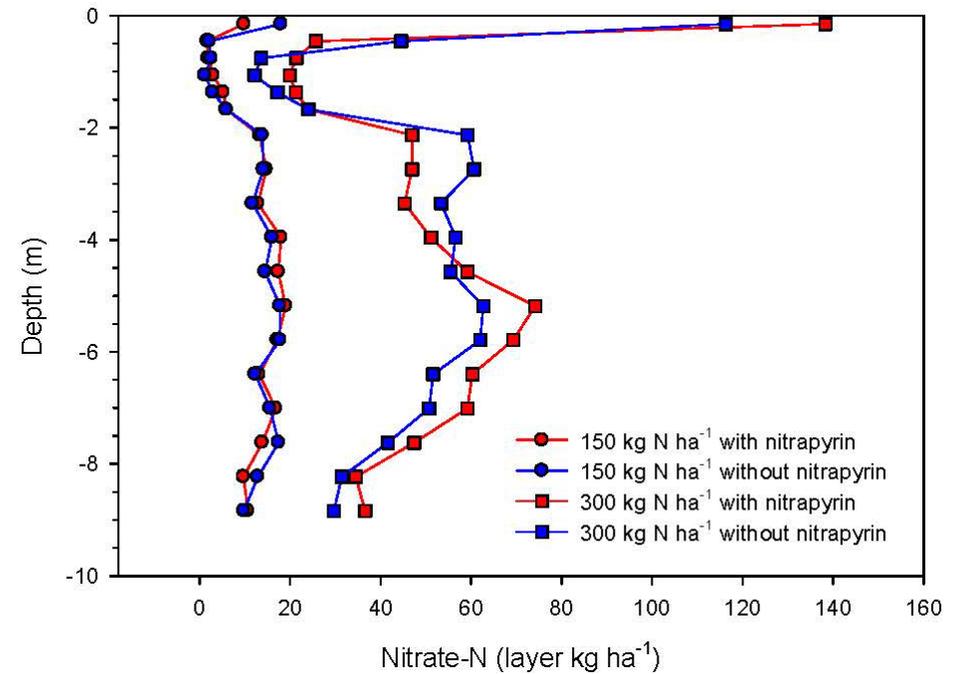
- Started 1986 – continuous irrigated corn, preplant  $\text{NH}_3$
- Treatments include N rate (0, 75, 150 and 300 kg N/ha)
- Tillage (conventional chisel/disk, no-till)
- Nitrification inhibitor

Vadose zone sampling conducted 2006

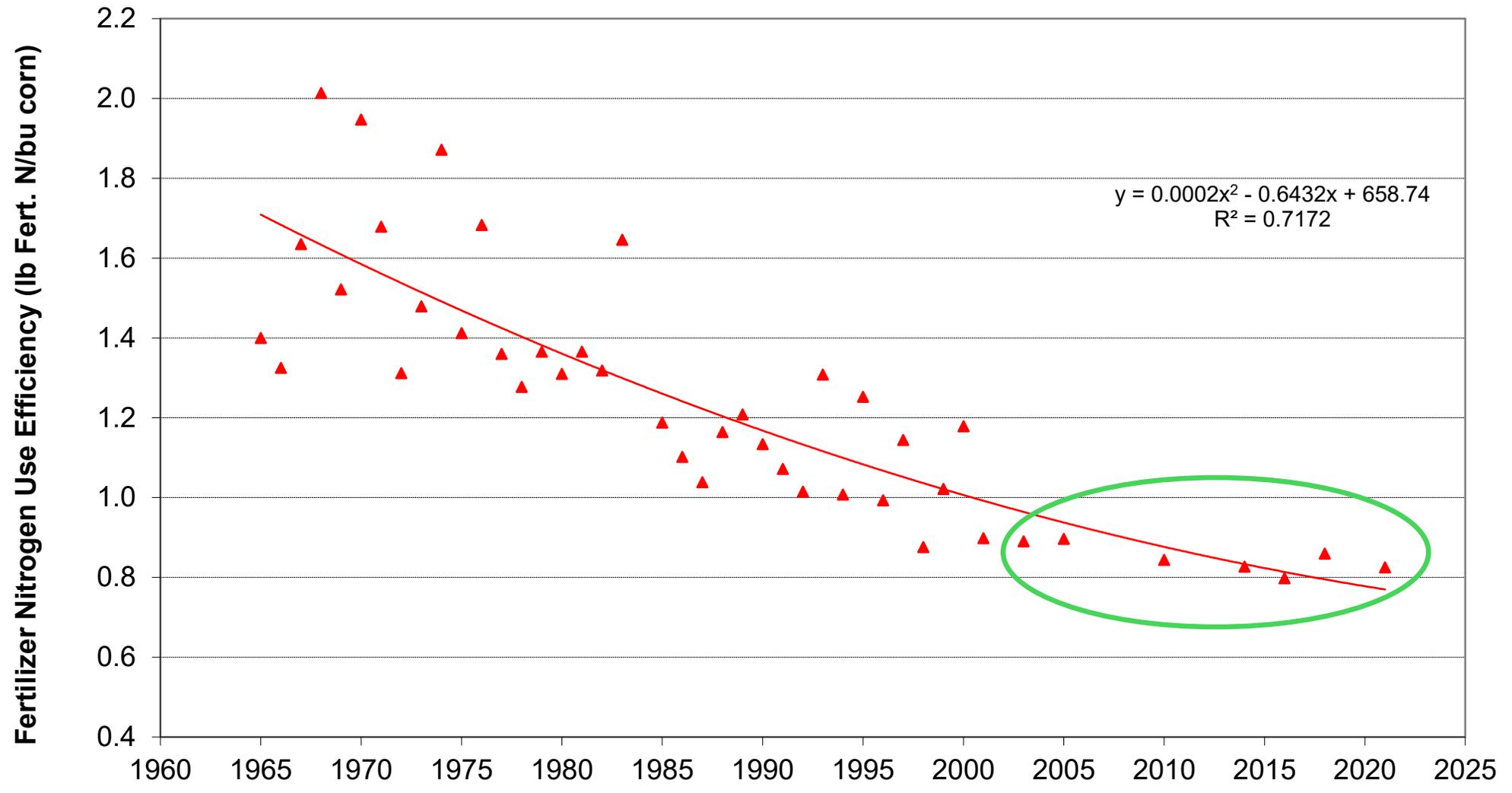


# South Central Ag Lab Long-Term N Management Study

- No significant effect of nitrification inhibitor on vadose zone nitrate



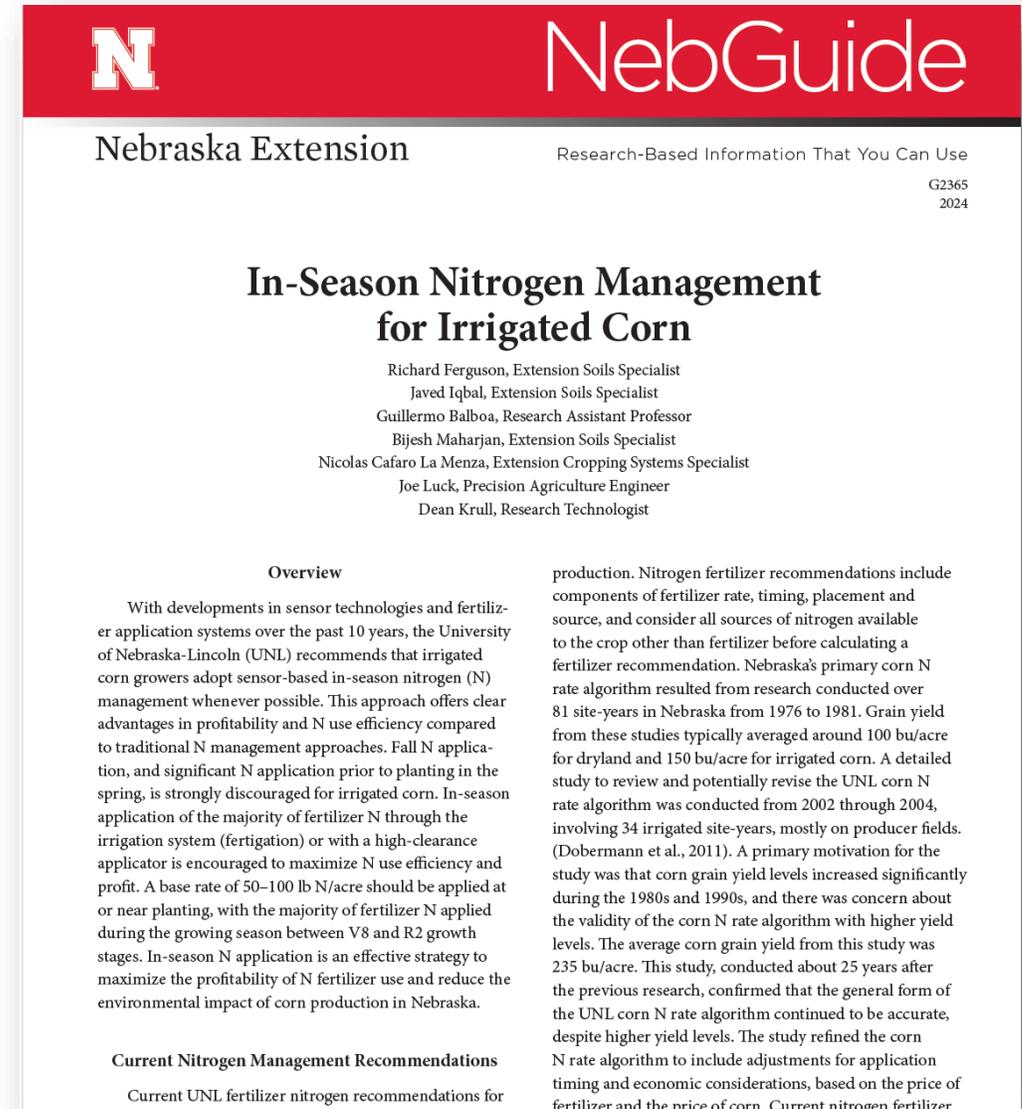
# Fertilizer Nitrogen Use Efficiency for Corn Production in Nebraska



# In-Season N Management for Irrigated Corn

## G2365

- Fall and significant pre-plant N application is not recommended. Apply 60% or more of total N in-season.
- Apply a base N rate of 50-100 lb/acre at or just before planting.
- Manage in-season N using satellite or high-clearance applicator sensors.
- Target application between V8 and R2 growth stages.



The image shows the cover of a NebGuide document. At the top, there is a red header with a white 'N' logo on the left and the word 'NebGuide' in white on the right. Below the header, the text 'Nebraska Extension' is on the left and 'Research-Based Information That You Can Use' is on the right. The document title 'In-Season Nitrogen Management for Irrigated Corn' is centered. Below the title, a list of authors is provided: Richard Ferguson, Javed Iqbal, Guillermo Balboa, Bijesh Maharjan, Nicolas Cafaro La Menza, Joe Luck, and Dean Krull. The document is identified as G2365, 2024. The main content area is divided into two columns. The left column has an 'Overview' section, and the right column has a section on 'production'. At the bottom, there is a section for 'Current Nitrogen Management Recommendations'.

**N** NebGuide

Nebraska Extension Research-Based Information That You Can Use

G2365  
2024

### In-Season Nitrogen Management for Irrigated Corn

Richard Ferguson, Extension Soils Specialist  
Javed Iqbal, Extension Soils Specialist  
Guillermo Balboa, Research Assistant Professor  
Bijesh Maharjan, Extension Soils Specialist  
Nicolas Cafaro La Menza, Extension Cropping Systems Specialist  
Joe Luck, Precision Agriculture Engineer  
Dean Krull, Research Technologist

#### Overview

With developments in sensor technologies and fertilizer application systems over the past 10 years, the University of Nebraska-Lincoln (UNL) recommends that irrigated corn growers adopt sensor-based in-season nitrogen (N) management whenever possible. This approach offers clear advantages in profitability and N use efficiency compared to traditional N management approaches. Fall N application, and significant N application prior to planting in the spring, is strongly discouraged for irrigated corn. In-season application of the majority of fertilizer N through the irrigation system (fertigation) or with a high-clearance applicator is encouraged to maximize N use efficiency and profit. A base rate of 50–100 lb N/acre should be applied at or near planting, with the majority of fertilizer N applied during the growing season between V8 and R2 growth stages. In-season N application is an effective strategy to maximize the profitability of N fertilizer use and reduce the environmental impact of corn production in Nebraska.

#### Current Nitrogen Management Recommendations

Current UNL fertilizer nitrogen recommendations for

production. Nitrogen fertilizer recommendations include components of fertilizer rate, timing, placement and source, and consider all sources of nitrogen available to the crop other than fertilizer before calculating a fertilizer recommendation. Nebraska's primary corn N rate algorithm resulted from research conducted over 81 site-years in Nebraska from 1976 to 1981. Grain yield from these studies typically averaged around 100 bu/acre for dryland and 150 bu/acre for irrigated corn. A detailed study to review and potentially revise the UNL corn N rate algorithm was conducted from 2002 through 2004, involving 34 irrigated site-years, mostly on producer fields. (Dobermann et al., 2011). A primary motivation for the study was that corn grain yield levels increased significantly during the 1980s and 1990s, and there was concern about the validity of the corn N rate algorithm with higher yield levels. The average corn grain yield from this study was 235 bu/acre. This study, conducted about 25 years after the previous research, confirmed that the general form of the UNL corn N rate algorithm continued to be accurate, despite higher yield levels. The study refined the corn N rate algorithm to include adjustments for application timing and economic considerations, based on the price of fertilizer and the price of corn. Current nitrogen fertilizer



# Why Should Producers Adopt Sensor Based In-Season N Management?



1. We don't really *know* the economic optimum N rate (EONR).
2. The potential for N to be lost from the soil begins the moment fertilizer is applied.
3. To maximize profit.
4. To reduce environmental impact.

# Predicting EONR for Corn

University of Nebraska-Lincoln

**AGRITOOLS**

About Find An Answer Our People/ Locations Program Areas Careers Impact

## Corn Nitrogen Calculator

RESET ENTIRE FORM

Field #1

ADD NEW FIELD

Please Note: The accuracy of the recommendation you receive using this tool is dependent on the quality of the data you put in.

CURRENTLY EDITING:  
**Field #1**

Name Required  
Field #1

Size in Acres Required  
160 acres

Soil Texture  
Med./Fine

Expected Corn Value Required  
\$ 5.80 /bu

Yield Goal Required  
245 bu/acre

[How to Calculate A Yield Goal](#)

<https://agritools.unl.edu/tools/nitrogen>

Iowa State University

**N FACT**

Estimate your optimum N On-Farm Trials FAQ About Us Sign In

## Nitrogen Fertilizer Application Consultation Tool

Finding the nitrogen rate for your farm to maximize productivity, profitability, and environmental performance

This decision support tool leverages data from the Iowa Nitrogen Initiative on-farm nitrogen rate trials with cropping systems modeling. See the optimum nitrogen rate under different scenarios by selection location, anticipated crop year weather, residual soil nitrogen, crop rotation, planting date, and fertilizer/crop pricing.

Explore on-farm rate trials Discover your optimum N rate ↓

### Select Your Location ?

Choose the location of your field by clicking on the map. You can select a location based on county or by Major Land Resource Area (MLRA).

Counties  Regions

<https://n-fact.ag/start>



# Strategies to Predict Crop Nitrogen Need

Published online January 4, 2018

REVIEWS & INTERPRETATIONS

## Strengths and Limitations of Nitrogen Rate Recommendations for Corn and Opportunity

DOI: 10.1002/saj2.20539

Thomas F. Morris,\* T. Scott Murrell, Douglas B. John Grove, Quirine Ketterings, Peter M. Kyve, John J. Meisinger, Jeff Melkonian, Bianca N. Moeb, John E. Sawyer, Peter C. Scharf, Walter Smith, Jo

### ABSTRACT

Nitrogen fixation by the Haber-Bosch process has more than doubled the amount of fixed N on Earth, significantly influencing the global N cycle. Much of this fixed N is made into N fertilizer that is used to produce nearly half of the world's food. Too much of the N fertilizer pollutes air and water when it is lost from agroecosystems through volatilization, denitrification, leaching, and runoff. Most of the N fertilizer used in the United States is applied to corn (*Zea mays* L.), and the profitability and environmental footprint of corn production is directly tied to N fertilizer applications. Accurately predicting the amount of N needed by corn, however, has proven to be challenging because of the effects of rainfall, temperature, and interactions with soil properties on the N cycle. For this reason, improving N recommendations is critical for profitable corn production and for reducing N losses to the environment. The objectives of this paper were to review current methods for estimating N needs of corn by: (i) reviewing fundamental background information about how N recommendations are created; (ii) evaluating the performance, strengths, and limitations of systems and tools used for making N fertilizer recommendations; (iii) discussing how adaptive management principles and methods can improve recommendations; and (iv) providing a framework for improving N fertilizer rate recommendations.

### Core Ideas

- Nitrogen recommendations for individual corn fields are less accurate than desired.
- Nitrogen recommendations need improvement for economic and environmental reasons.
- A review of fundamental concepts will improve understanding about N recommendations.
- Examination of N recommendation systems, tests, and models will improve recommendations.

### ORIGINAL ARTICLE

Soil Fertility & Plant Nutrition

Soil Science Society of America Journal

## Combining corn N recommendation tools for an improved economical optimal nitrogen rate estimation

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### Correspondence

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### Abstract

Improving corn (*Zea mays* L.) nitrogen (N) rate fertilizer recommendation tools can improve farmers' profits and mitigate N pollution. Numerous approaches have been tested to improve these tools, but to date improvements for predicting economically optimum N rate (EONR) have been modest. This work's objective was to use ensemble learning to improve our estimation of EONR (for a single at-planting and split N application timing) by combining multiple corn N recommendation tools. The evaluation was conducted using 49 corn N response trials from eight states in the US Corn Belt and three growing seasons (2014–2016). Elastic net and decision tree approaches regressed EONR against three unique tools for each N application timing. Tools used in various combinations included a yield goal method, two soil nitrate tests (pre-plant and late season), a computer simulation crop model (Maize-N), and canopy reflectance sensing. Any combination of two or three N recommendation tools improved or maintained performance metrics ( $R^2$ , root-mean square error, and number of sites close to EONR). The best results for a single at-planting recommendation occurred when combining the three at-planting N recommendation tools (including interactions) with an elastic net regression model. This combined recommendation tool had a significant linear relationship with EONR ( $R^2 = 0.46$ ), an increase of 0.27 over the best tool evaluated alone. Combining multiple tools increased the implementation cost, but it did not reduce profitability and, sometimes, improved profitability. These results show tools can be combined to better match EONR, and thus could aid farmers in improving N management.

*“Nitrogen recommendations for the foreseeable future in humid regions will poorly predict the needed for corn at individual fields.”*

*Individual corn N recommendation tools poorly estimated EONR ( $R^2 \leq 0.24$ ) across many US Midwest states.*

*Combining or “ensembling” two or more corn N recommendation tools improved EONR estimation ( $R^2 \leq 0.46$ ).*



# Uncertainty About the Economic Optimum Fertilizer N Rate (EONR)

- N rate prediction models are based on either past research and crop response (empirical) or simulation of soil, plant and weather processes (mechanistic), or a combination of the

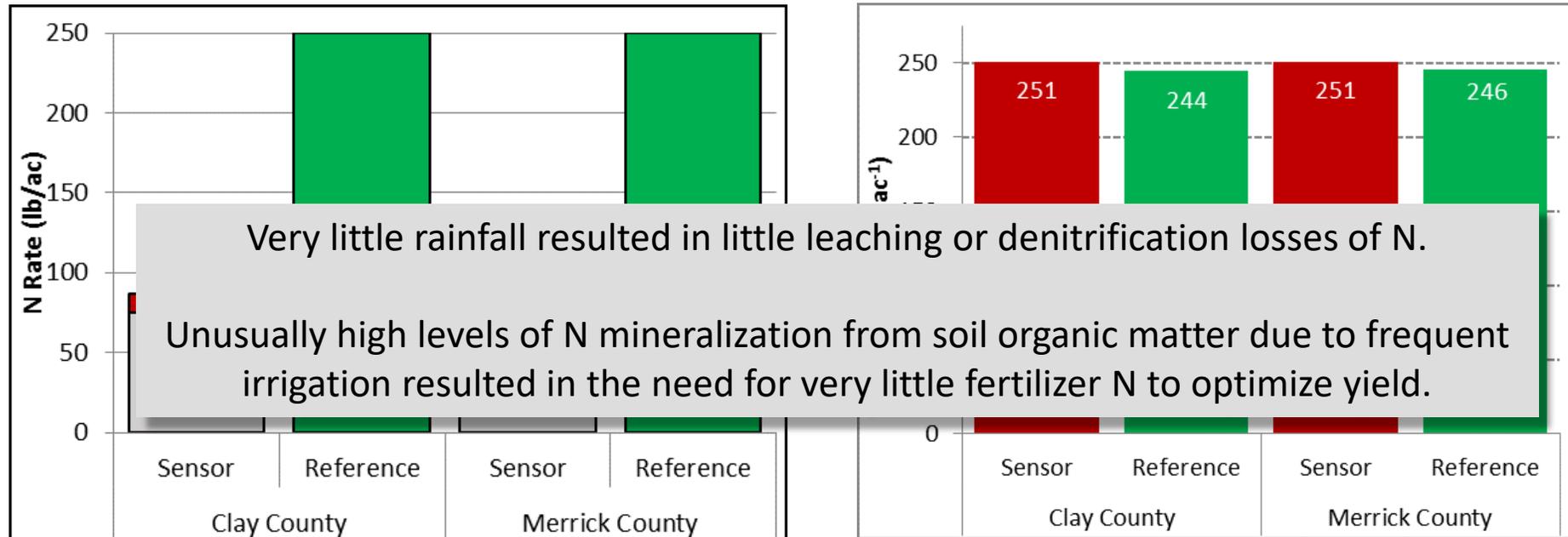
Predicted EONR will always have a range of uncertainty because each of the factors in the prediction model will have individual uncertainties.

- Irrigation water nitrate N
- Cover crops (either immobilization or mineralization)
- EONR will be influenced by N source, application timing and application method.



# Crop Canopy Sensors: Ability to Optimize N Rate for Local Conditions

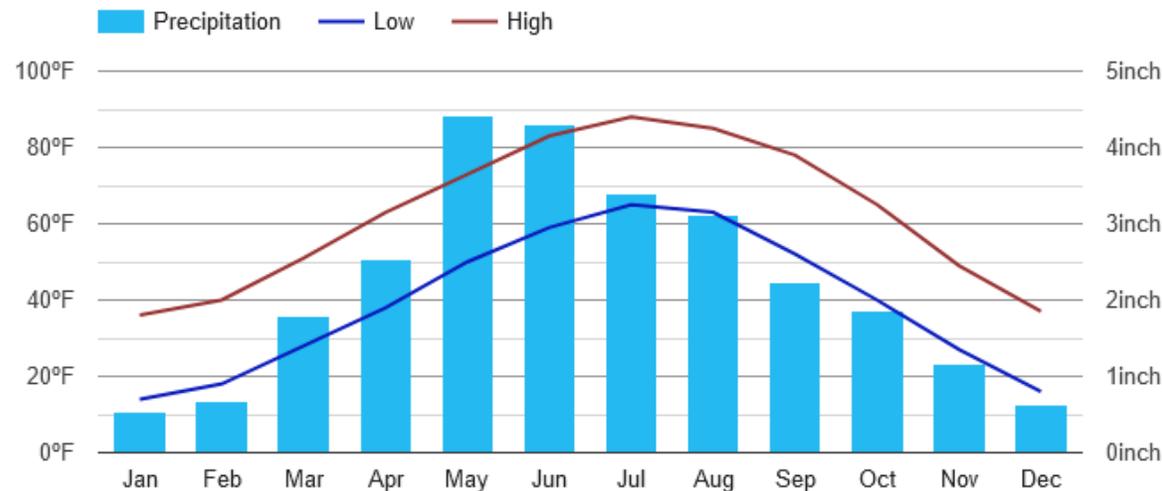
## 2012 Research



# Sensor-Based Fertigation

Allows the crop to inform us of the need for N according to weather, soil conditions and crop demand, accounting for variation in soil N mineralization due to moisture and temperature patterns. We do not have to predict the weather for each field, but react to it.

Avoids the presence of significant fertilizer nitrogen in the soil during the wettest time of the year, before the majority of crop N uptake occurs.



Grand Island average precipitation and temperatures



# Project SENSE

Sensors for Efficient Nitrogen Use and Stewardship of the Environment

2015-2022

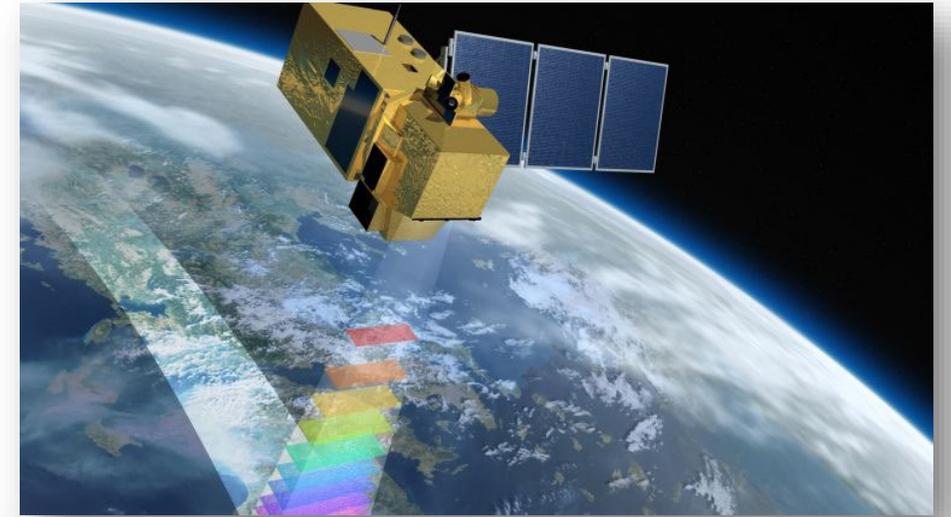


<b>Six Year Average</b>	<b>SENSE</b>	<b>Grower</b>
Total N rate (lb-N/acre)	158.9 B	191.9 A
Yield (bu/acre)	220.8 B	222.0 A
Fertilizer N Use Efficiency (lb-N/bu grain)	0.72 B	0.86 A
Partial Profitability (\$/acre) [@6.75/bu and \$1.00/lb-N]	\$1,331 A	\$1,307 B
Partial Profitability (\$/acre) [@3.15/bu and \$0.41/lb-N]	\$630 A	\$620 B

# Satellite Sensor-Based Fertigation Management

2021-2025

- Enabled due to the advent of satellite systems with frequent revisit times (as often as daily), good spatial resolution ( $\leq 10$  m), and required visible, red edge and NIR spectral bands.
- Uses the same concept of in-season, multispectral crop canopy sensing as Project SENSE, though with passive, satellite-based sensors rather than active, high clearance vehicle mounted sensors.
- Requires a base N rate of 50-100 lb N/acre at planting, along with reference blocks at higher and lower N rates than expected optimal N rate.
- Allows fertigation as often as needed between V8 and R2 growth stages.
- Requires use of an advisory service to provide access to satellite data and generate fertilizer recommendations.



**SENTINELAG** ABOUT PLATFORM RESOURCES CONTACT

SENTINEL (Sign-In) CSP PORTAL

## End the guesswork - let your crop guide your nitrogen plan.

Our platform's daily crop nitrogen measurements help you make timely, confident decisions that maximize the return of every dollar spent.

[See How It Works](#)

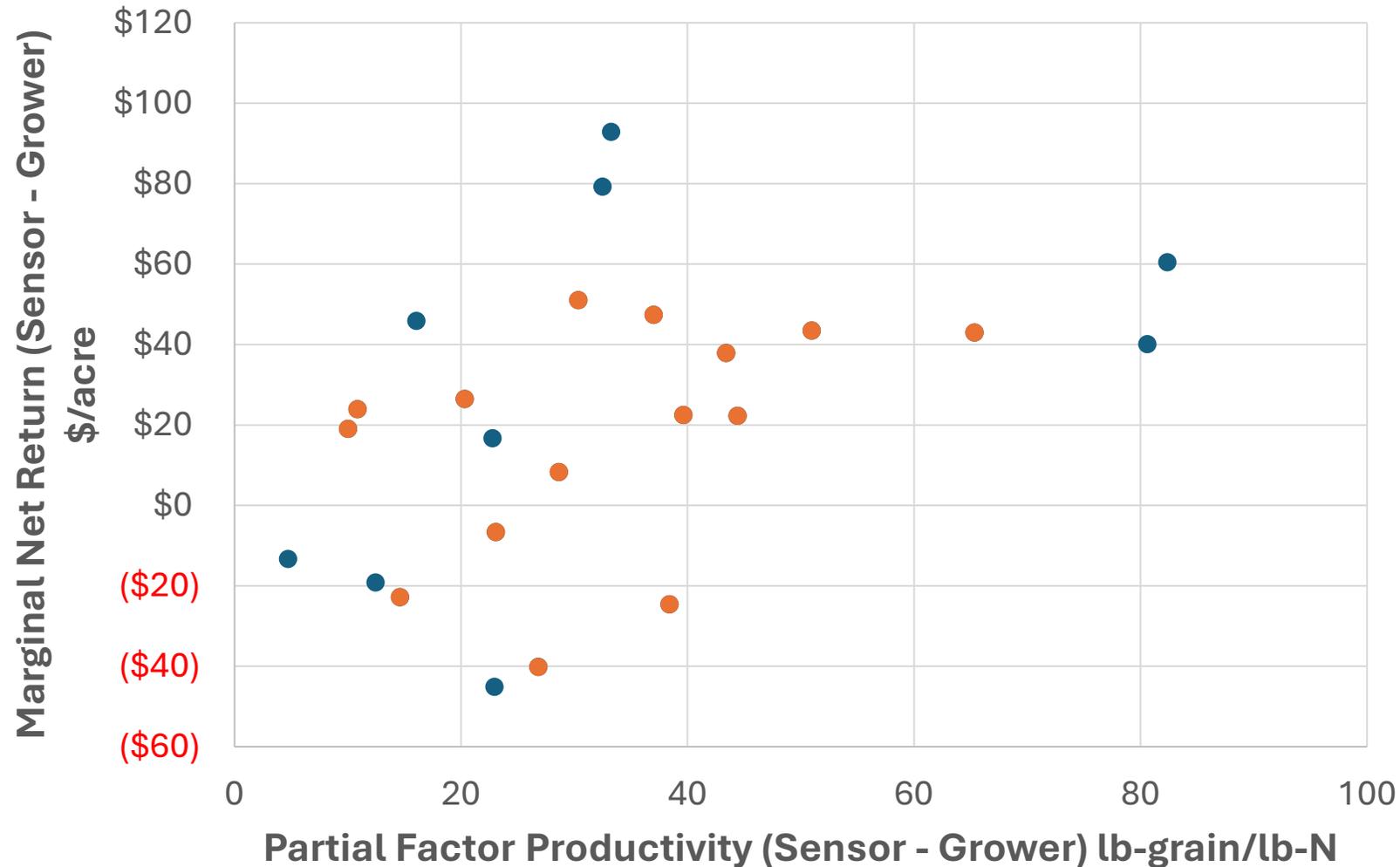
### Optimizing for your crop's potential - and your profit.

No more guessing if your crop is limited by nitrogen. No more being defined by a yield goal or by the accuracy of available nitrogen in a soil sample. Sentinel's platform lets



# Satellite Sensor-Based Fertigation Management 2021-2023

24 site-years



Average partial profit increased by \$24/acre compared to grower practice

Fertilizer nitrogen use efficiency improved to 0.6 lb fertilizer N/bu corn, compared to grower NUE of 0.84 lb fertilizer N/bu corn

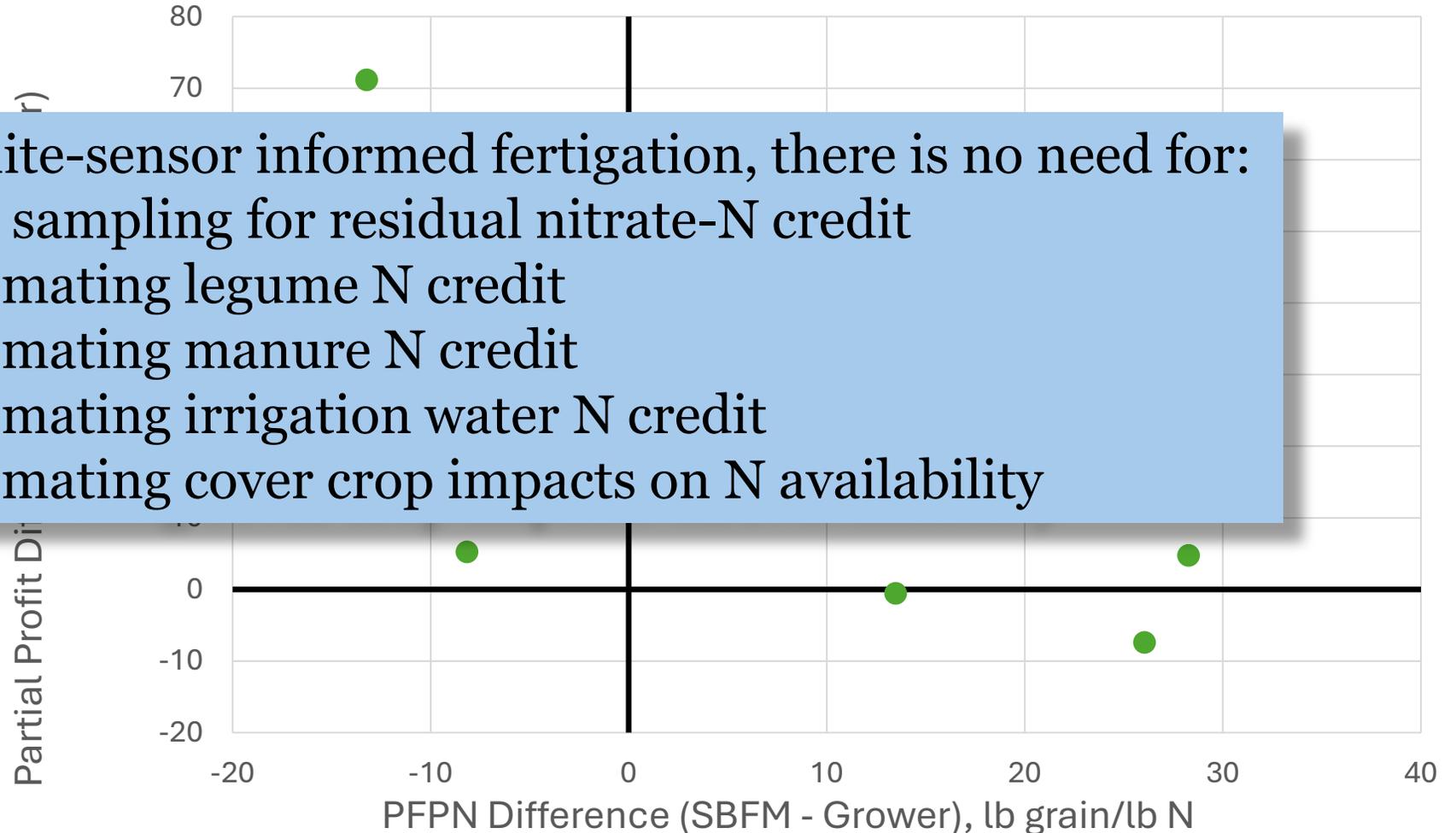


# 2024 Sensor-Based Fertigation Results

With satellite-sensor informed fertigation, there is no need for:  
Soil sampling for residual nitrate-N credit  
Estimating legume N credit  
Estimating manure N credit  
Estimating irrigation water N credit  
Estimating cover crop impacts on N availability

Corn \$4.35/bu, N \$0.50/lb

Average partial profit increased by \$21/acre compared to grower practice

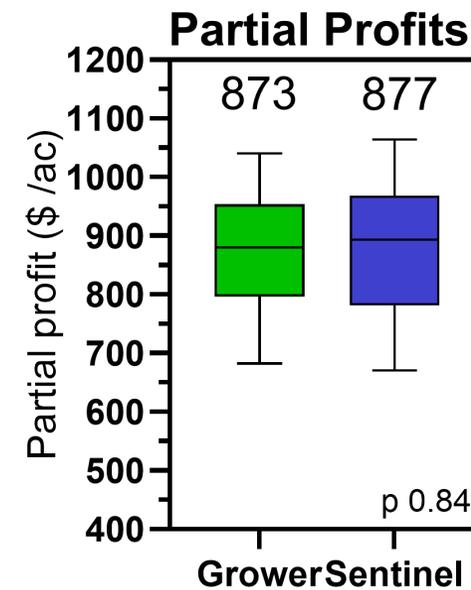
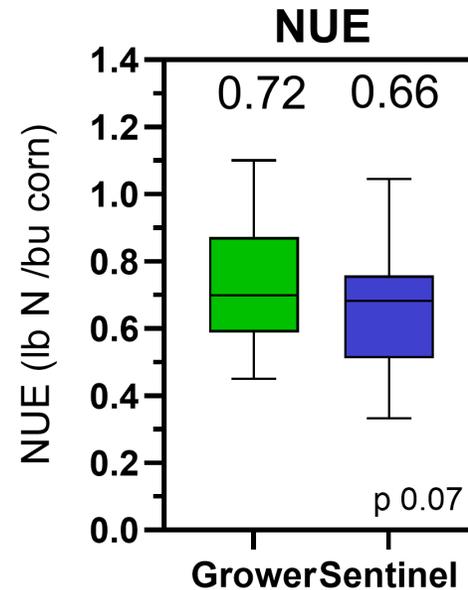
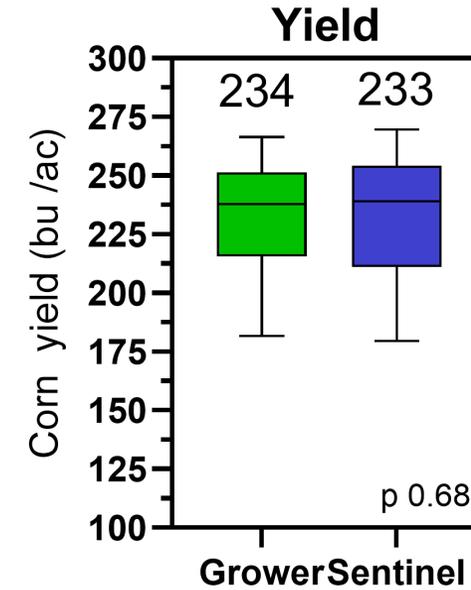
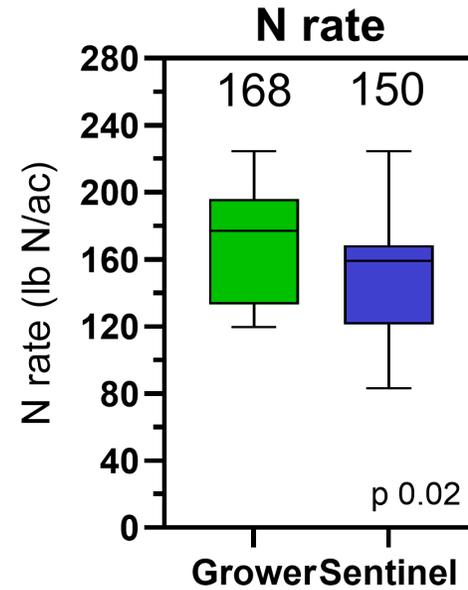


# 2025 Sensor-Based Fertigation Results

Average of Ten Locations

Corn price: 4.22 \$/bu

Nitrogen price: 0.70 \$/lb N



# Fertilizer Nitrogen Use Efficiency for Corn Production in Nebraska

