TerraNu®

Chris Kniffen, Director of Research

2024 TerraNu trials were limited due to product availability, challenging planting conditions, and farm machine data limitations

Winter Wheat

Michigan and Wisconsin

Spring Wheat

North and South Dakota

Soybeans

North and South Dakota, Wisconsin

Corn

Iowa and Minnesota

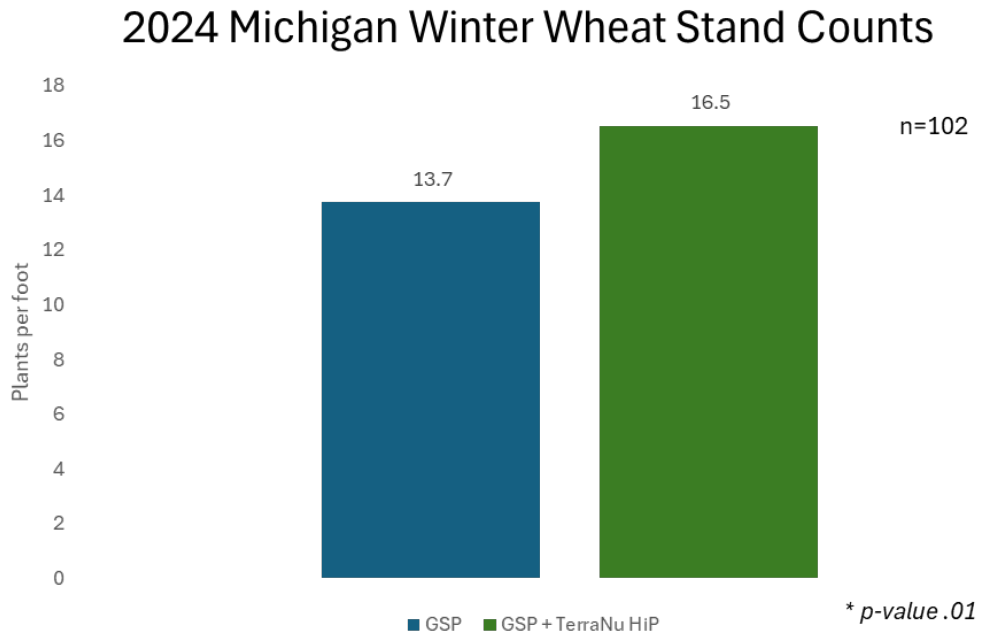
TERRANU

Spring data collection reported TerraNu increased stand counts 20% across all winter wheat trials in Michigan

Experimental Design

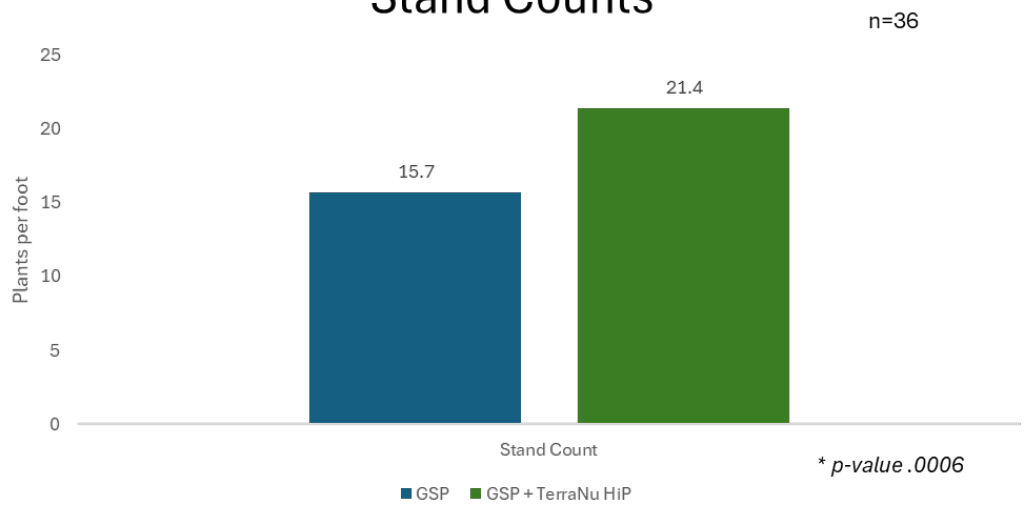
TerraNu HiP was applied as the treatment fertility program and compared to the following grower standard fertilizer programs:

COUNTY	TREATMENT	CONTROL
Huron	90 lbs/A TN HI-P	90 lbs/A MAP
Monroe	100 Lb/A TN HI-P GSP	GSP (7-13-37 Blended): 22 Lb/A Urea, 50 Lb/A MAP, 125 Lb/A Potash
Monroe	100 Lb/A TN HI-P + GSP	GSP (7-13-37 Blended): 22 Lb/A Urea, 50 Lb/A MAP, 125 Lb/A Potash
Tuscola	35 Lb/A TN HI-P	Seed Only
Tuscola	26 Lb/A TN HI-P	Seed Only

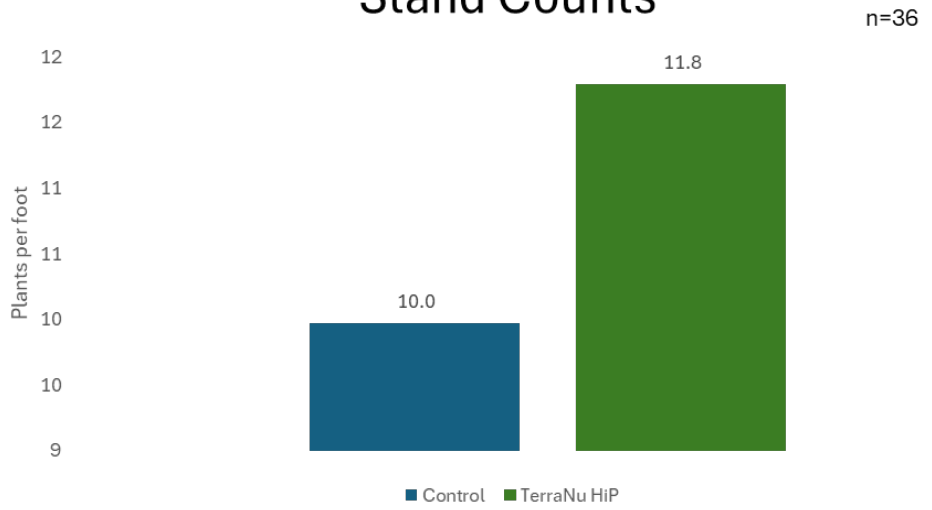


TerraNu HiP improved stands counts 18% when applied without fertilizer and 35% when applied with 7-13-37 dry fertilizer blend

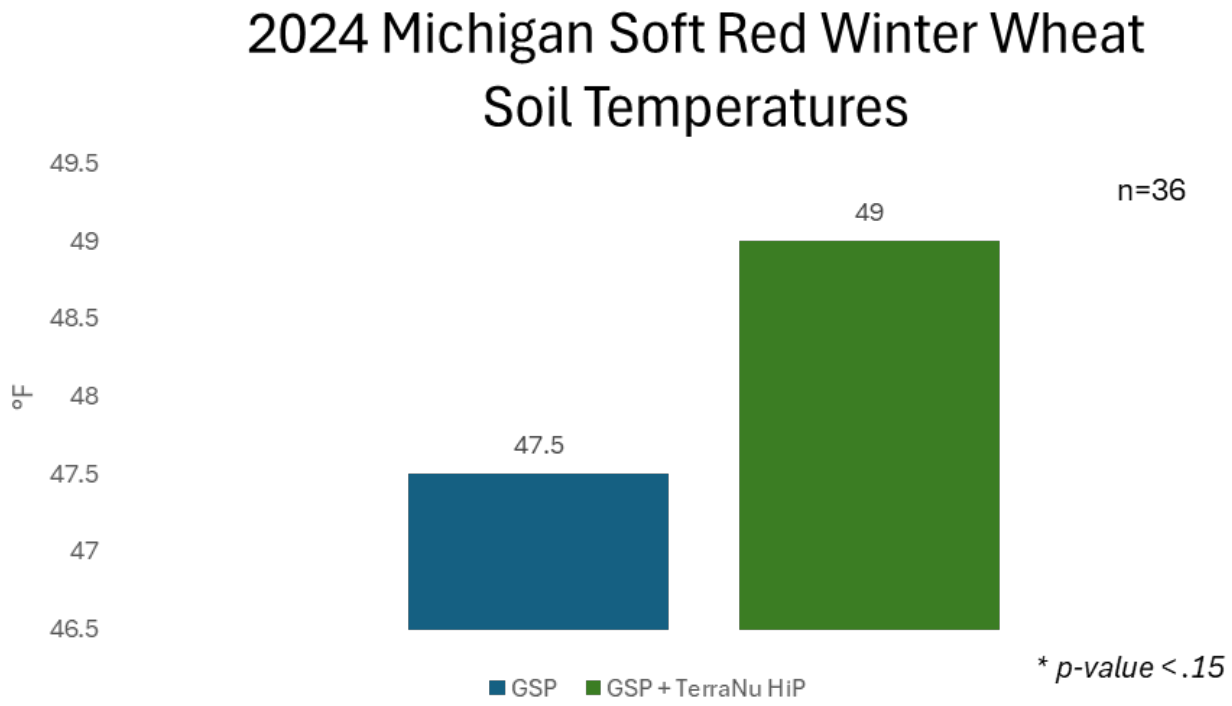
TerraNu HiP

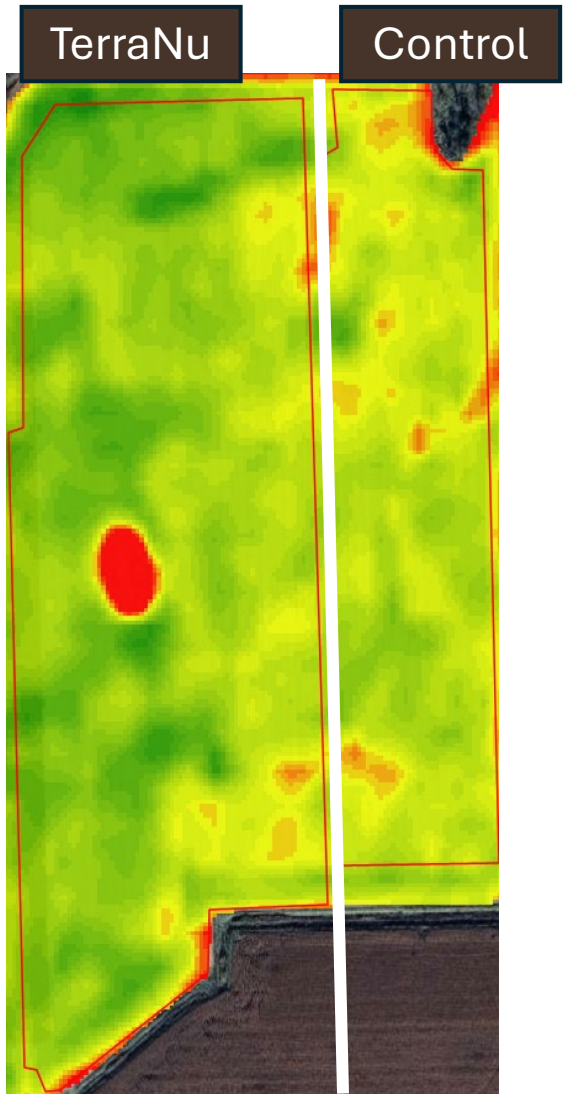


TerraNu HiP with 7-13-37



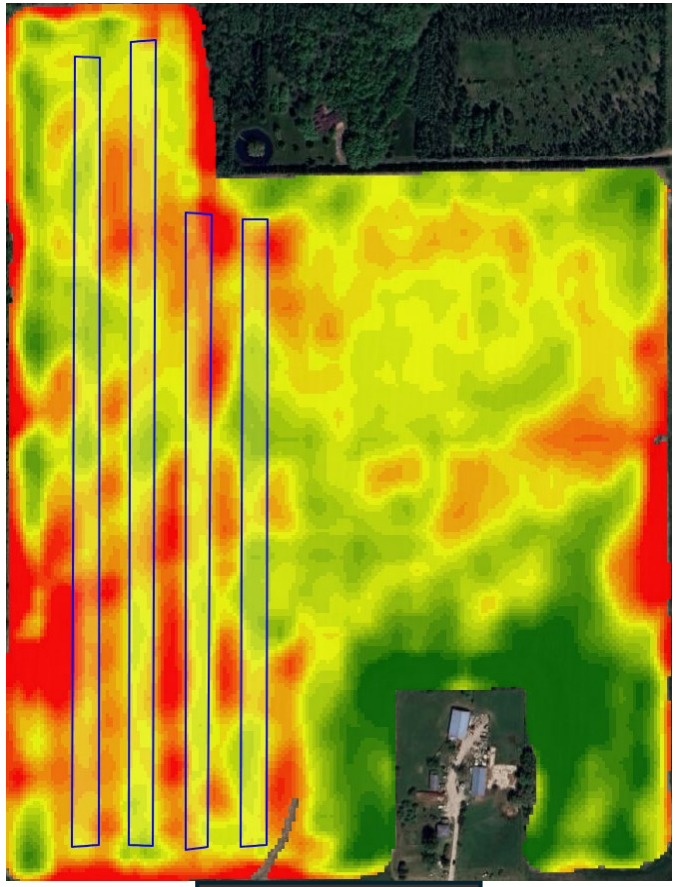
TerraNu HiP treatments reported a 2% increase in spring soil temperatures





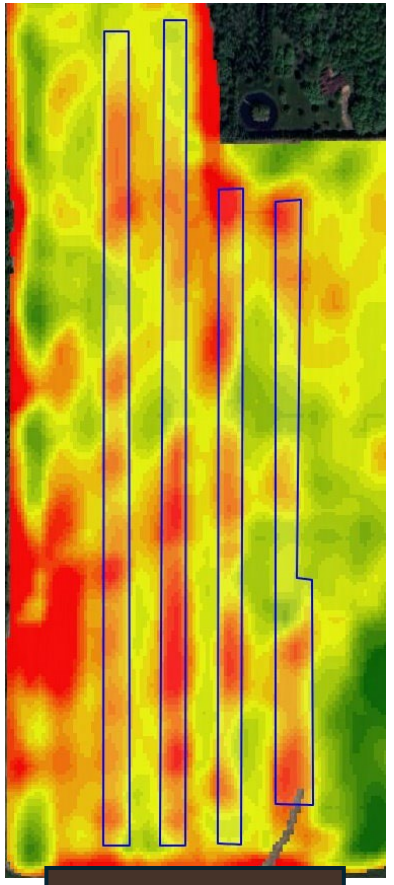
NDVI Imagery from March 3rd, 2024

Improved standability and early season plant health was observed in the Wisconsin winter wheat with TerraNu



TerraNu

NDVI Imagery from April 14, 2024

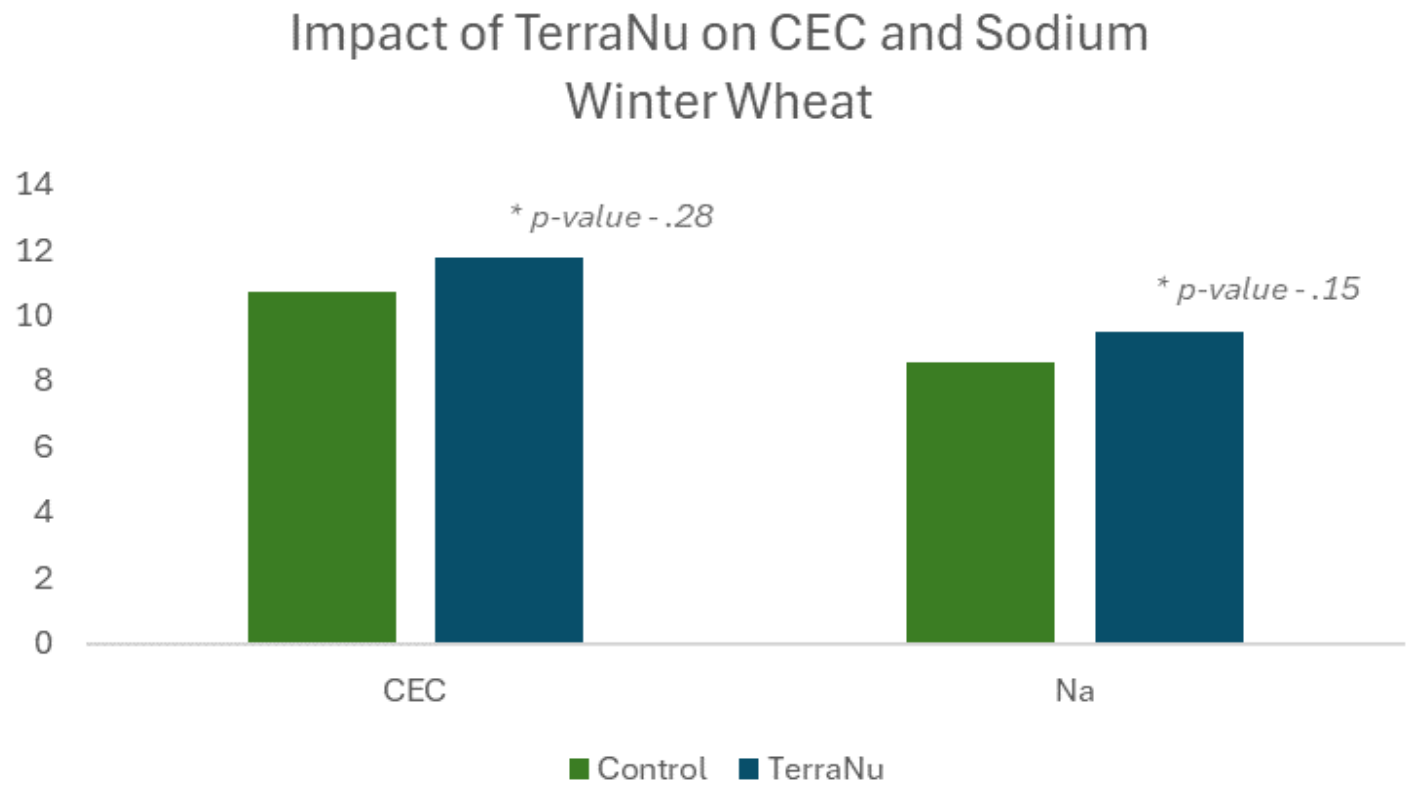


Control

TERRANU®

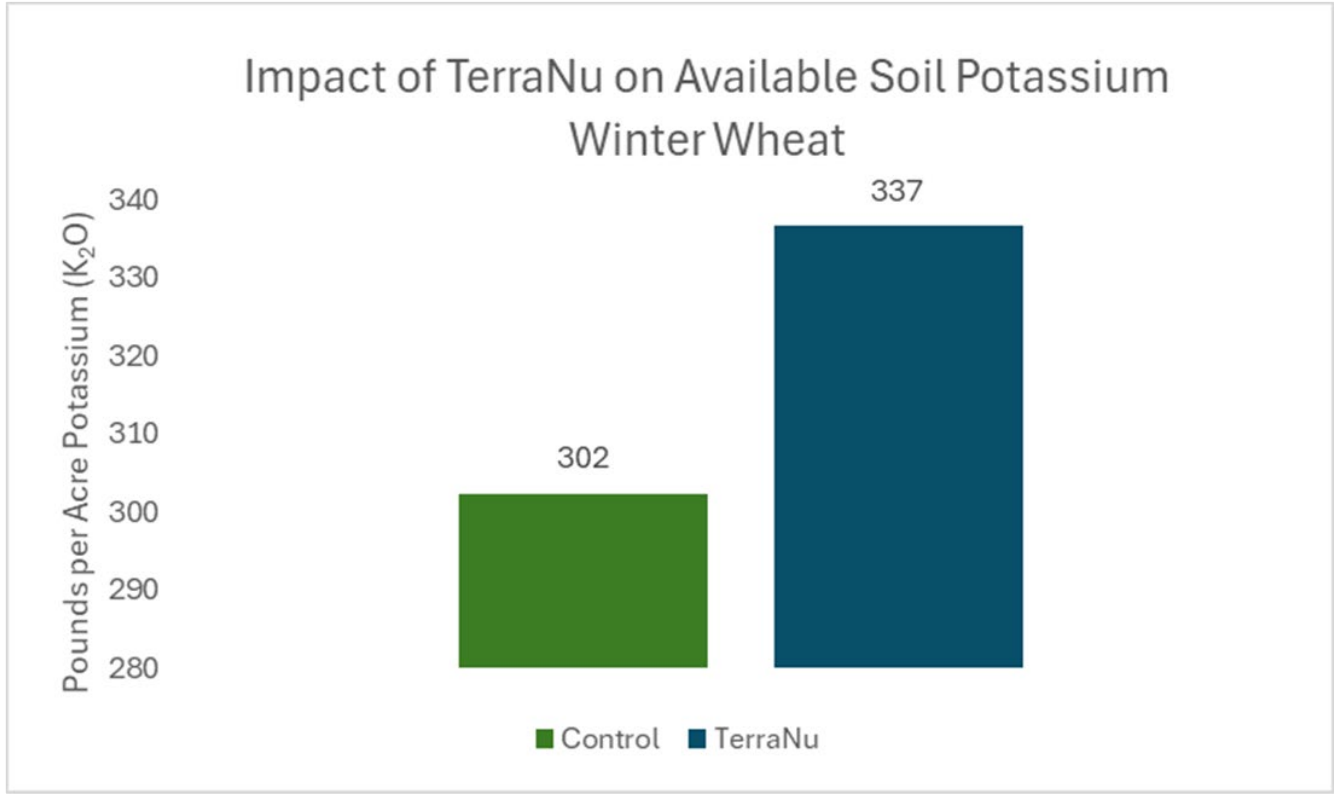
Mid-season soil tests report TerraNu HiP increased mid-season CEC and the availability of exchangeable cations

- Soil organic carbon is widely accepted as a charged complex which aids in the retention and availability of soil nutrients.
- TerraNu applications reported increases in mid-season CEC across all winter wheat trials (132 samples)



TerraNu increased available soil potassium 11% for a 35 pound per acre increase in soil K_2O

- Potassium "tie-ups" with clay complexes present a current nutrient loss pathway observed in many cropping systems.
- The use of TerraNu increased soil CEC and potassium, suggesting carbon functions as a buffer mechanism, improving the mobility and availability of potassium



	CEC	K_2O	Na
Control	10.7	302.4	8.6
TerraNu	11.7	336.6	9.5
% Change	9%	11%	11%

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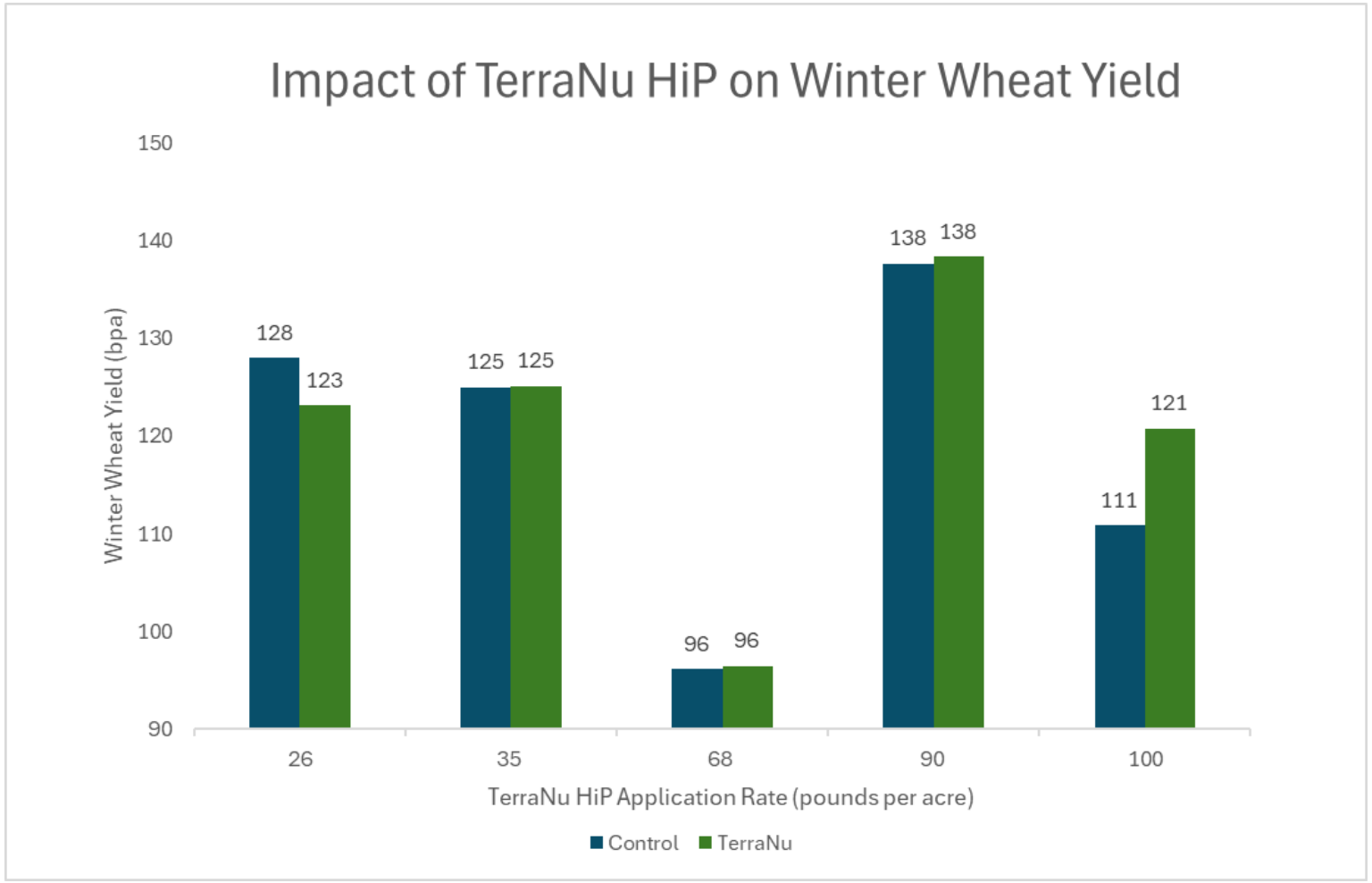
Favorable growing conditions spring of 2024 promoted winter wheat yields exceeding historical averages



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Spring Wheat trials in North Dakota and South Dakota

North Dakota

TerraNu Vs. MESZ

- 80 lbs/ac TN HI-P
- 100 lbs /ac MESZ

TerraNu vs. Chicken Compost Blend

- 75 lbs/ac TN HI-P

TerraNu vs. MAP

- 75 lbs/ac TN HI-P

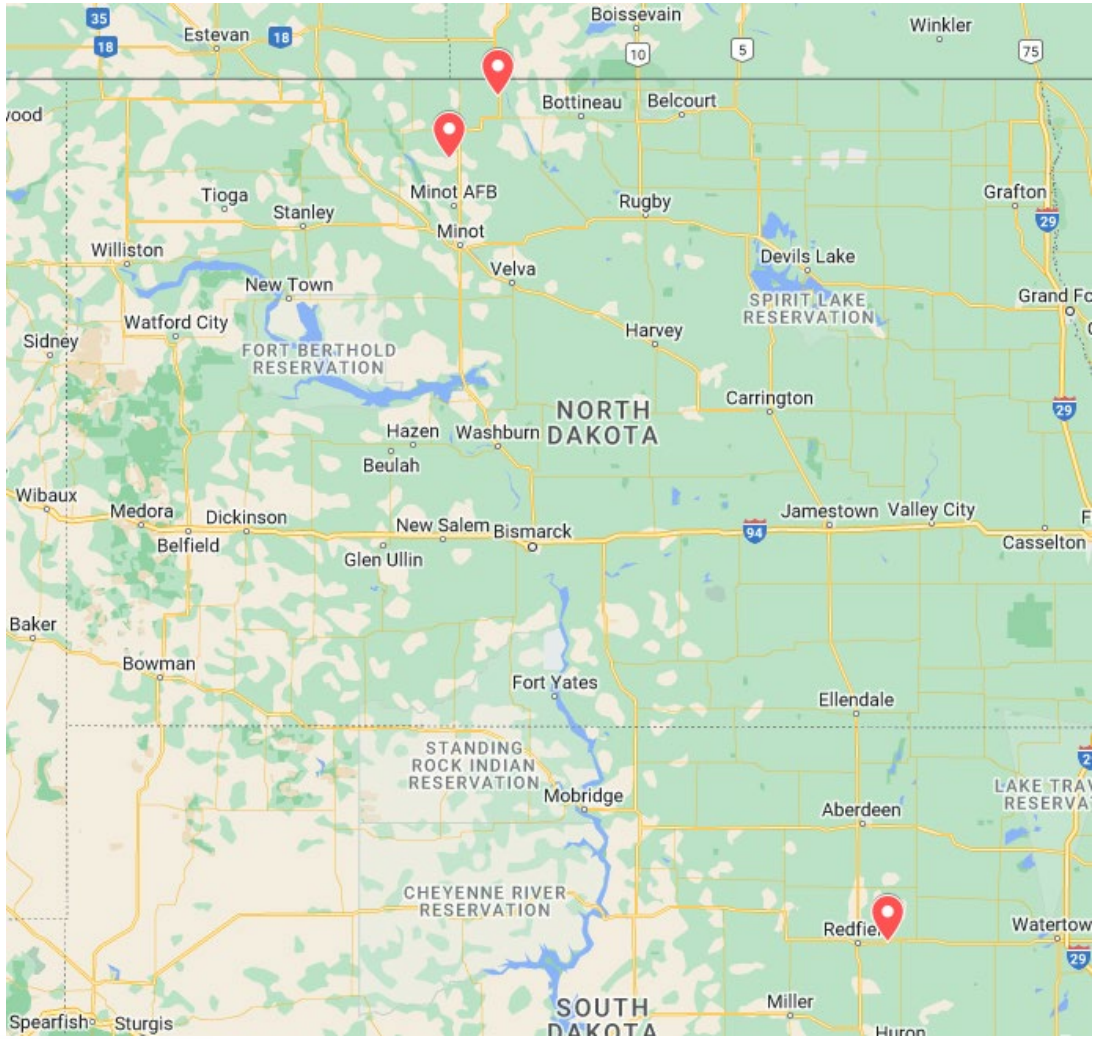
TerraNu vs. Control

- 75 lba/ac TN HI-P

South Dakota

TerraNu Blend Broadcast vs. GSP

- 138 lb/ac TerraNu
  - 60% TN HI-P, 40% TN Calcium



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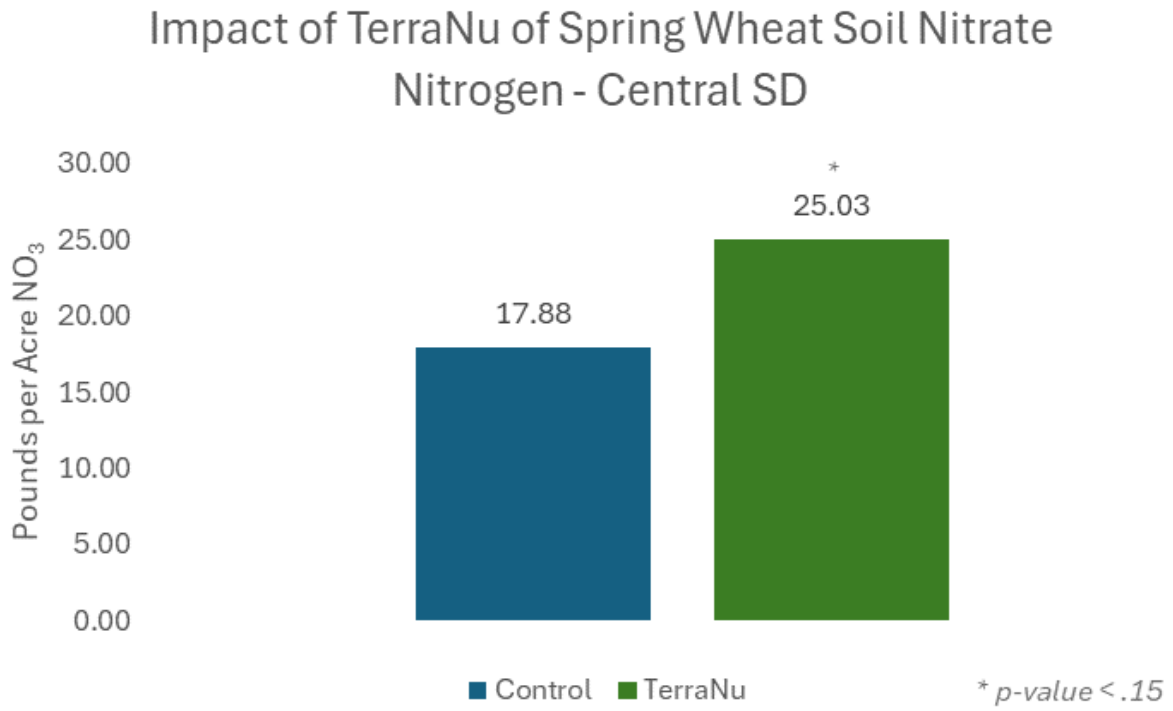
Spring Wheat in Central South Dakota reported an increase in soil nitrate nitrogen with a modest reduction in soil pH

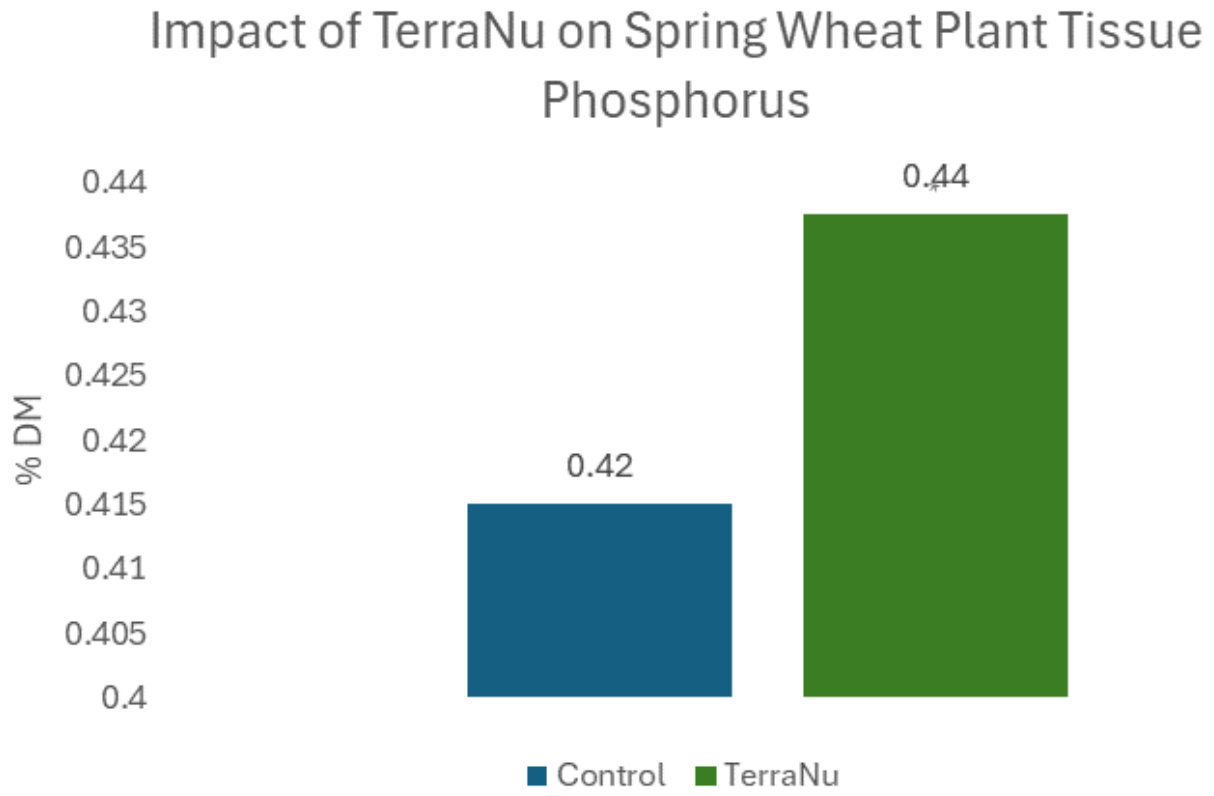
While not reported due to lower confidence in the data, a 3-4% reduction in soil pH was observed in soil samples collected from the experimental site in central SD.

Increases in soil nitrate nitrogen were observed with confidence from the samples collected.



TERRANU®

Along with the uplift in nitrate nitrogen, TerraNu reported increased phosphorus in plant tissue and plant health in Spring Wheat in South Dakota



South Dakota Spring Wheat

Ascend-SD (1.9M Bu/A population)

138 lb/ac TerraNu Blend

60% TN HI-P, 40% TN Calcium

High Phos in field so hasn't applied Phos for four years (20 ppm Olson).

High Magnesium led to inclusion of TN Calcium and Micro's

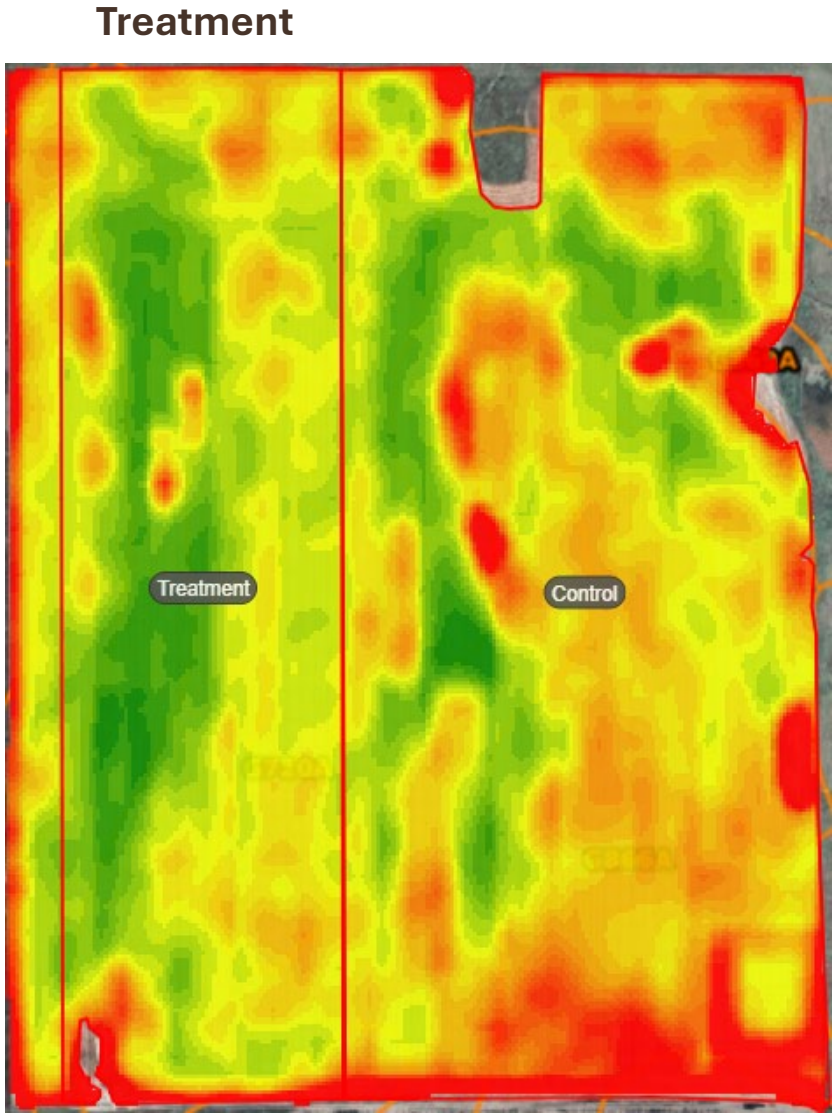
Yield goal – average 75

6.7 pH / 19.8 CEC

21.8 ppm Phosphorus

18.7% Magnesium Base Saturation

- 445.58 ppm Magnesium
- 226.6 ppm Potassium



NDVI Imagery from June 13th, 2024

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South Dakota Spring Wheat

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Control

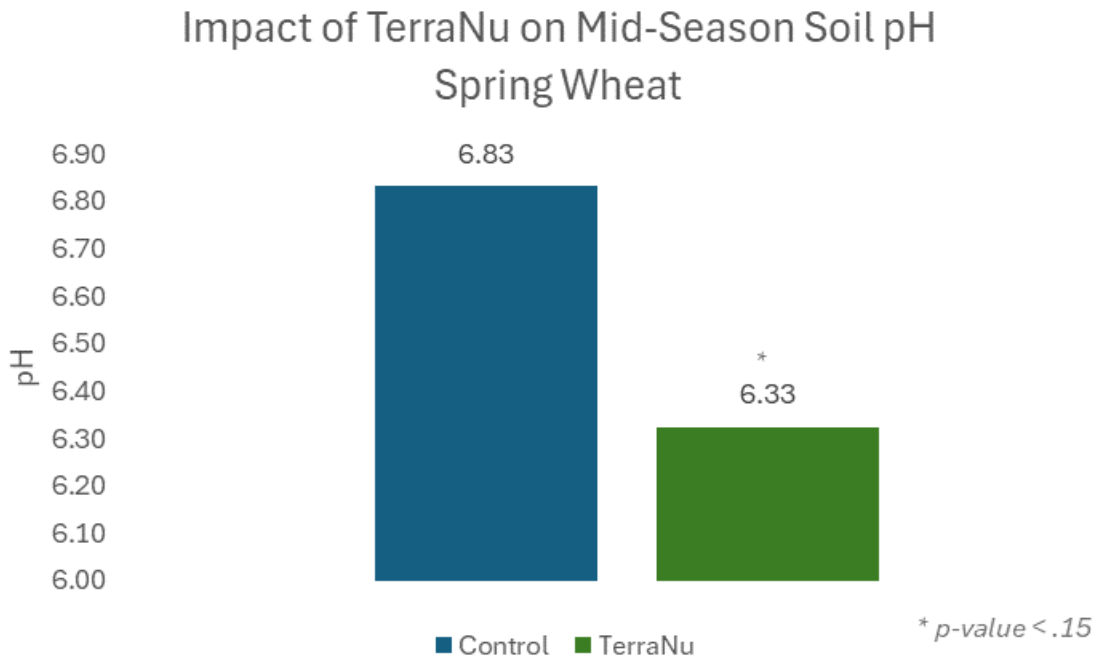
TERRANU®

Spring Wheat trials in central North Dakota reported reductions in mid-season soil pH

A reduction in mid-season soil pH was observed in central ND when TerraNu HiP was applied at planting with spring wheat

Reductions in pH are favorable for certain cropping systems and alkaline soils.

Neutral to acidic soil systems may require adjustments to fertilizer blends to de-risk over acidification of the rhizosphere



North Dakota Spring Wheat

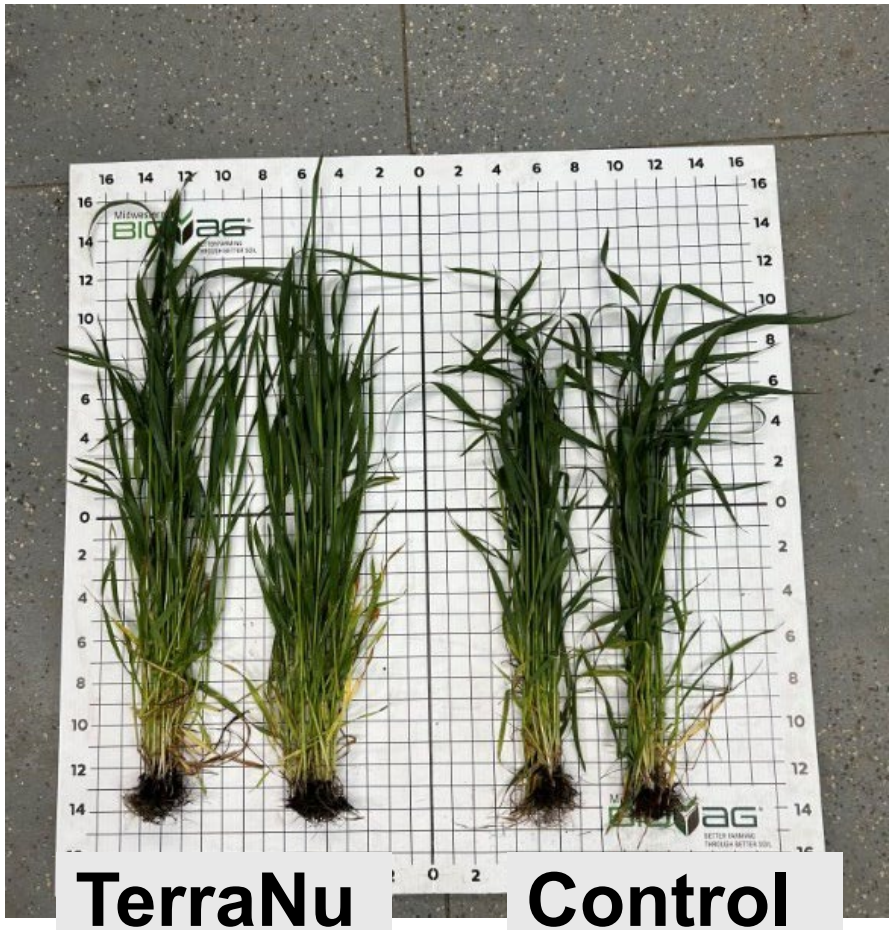
TerraNu Vs. MESZ

- 80 lbs/ac TN HI-P
  - 8-30-4-3.5S
- 100 lbs /ac MESZ
  - 12-40-0-10S-1Zn

Trial reported early season emergence in plant health

Yield reporting early season uplifts – yield losses were reported under treatment

-1.44 bpa



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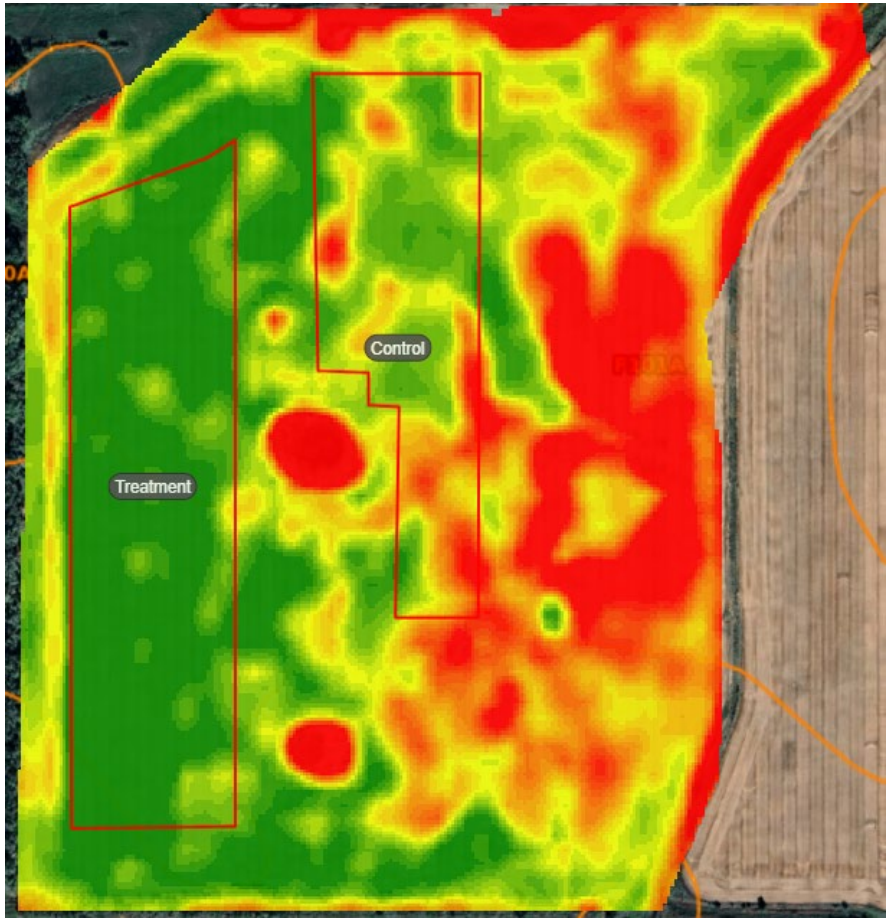
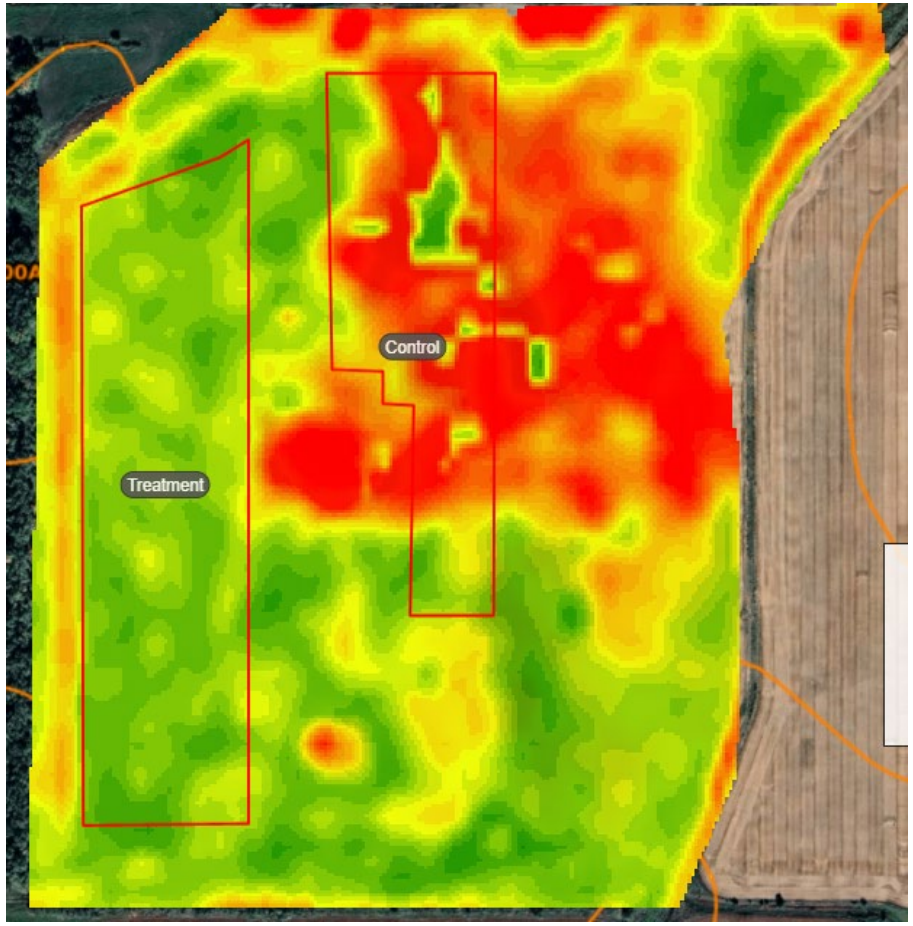
June 27th, 2024

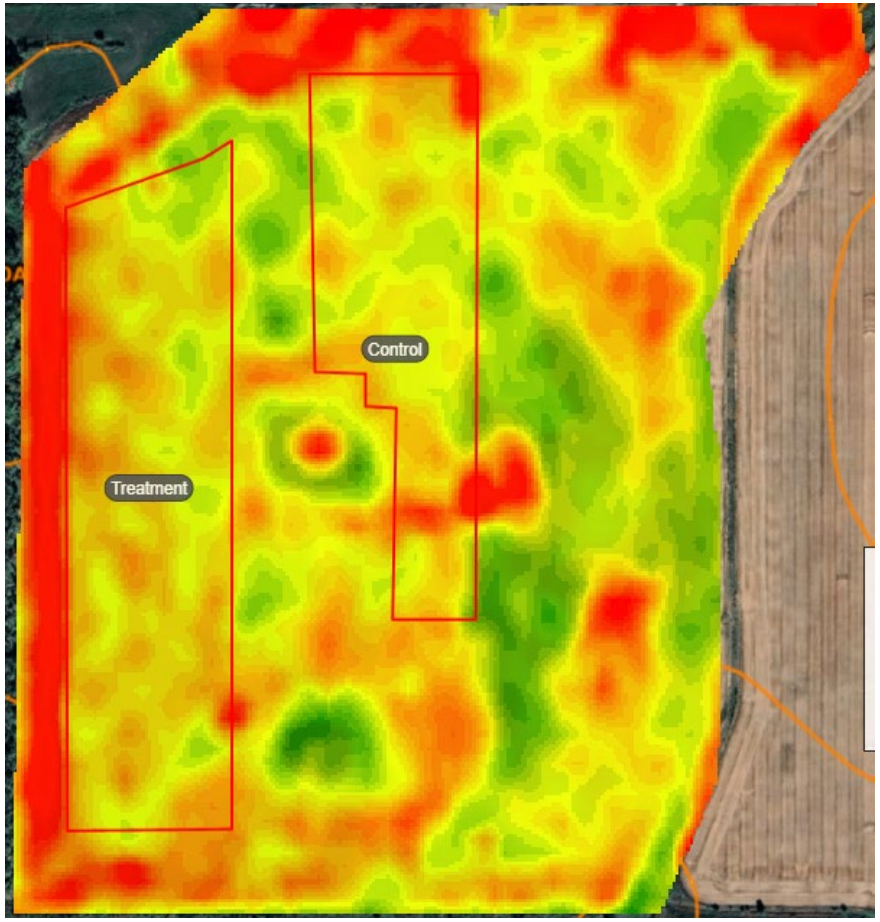


NDVI July 1st, 2024

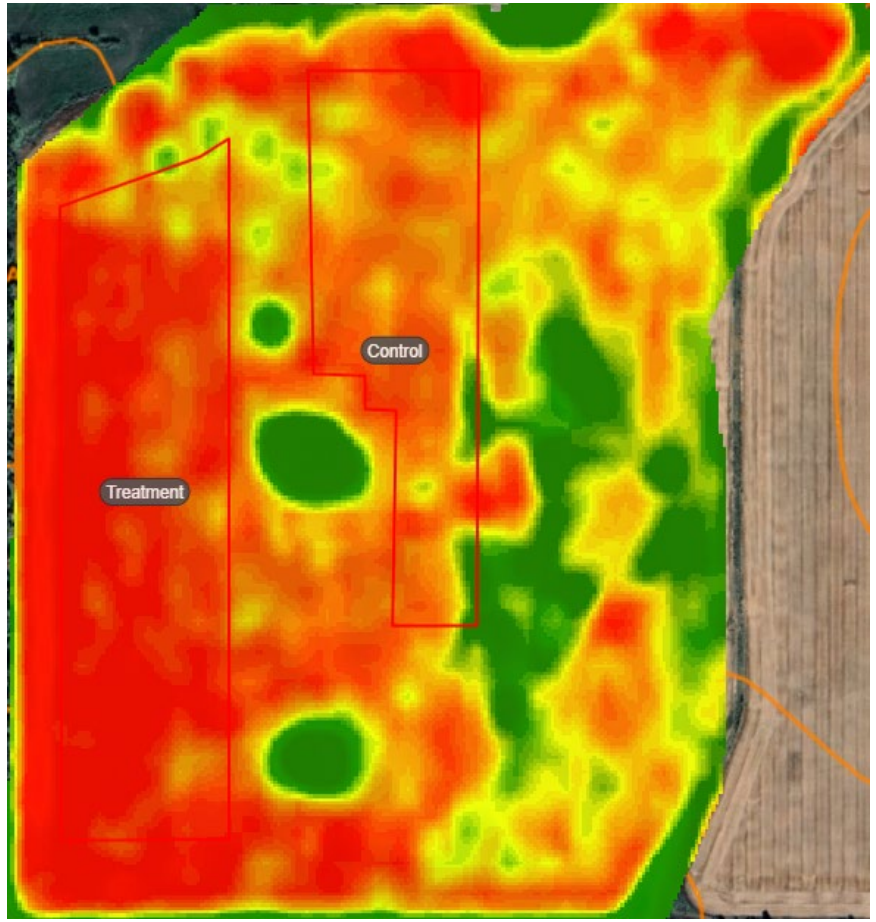


NDVI July 16th, 2024

TERRANU



NDVI August 3rd, 2024



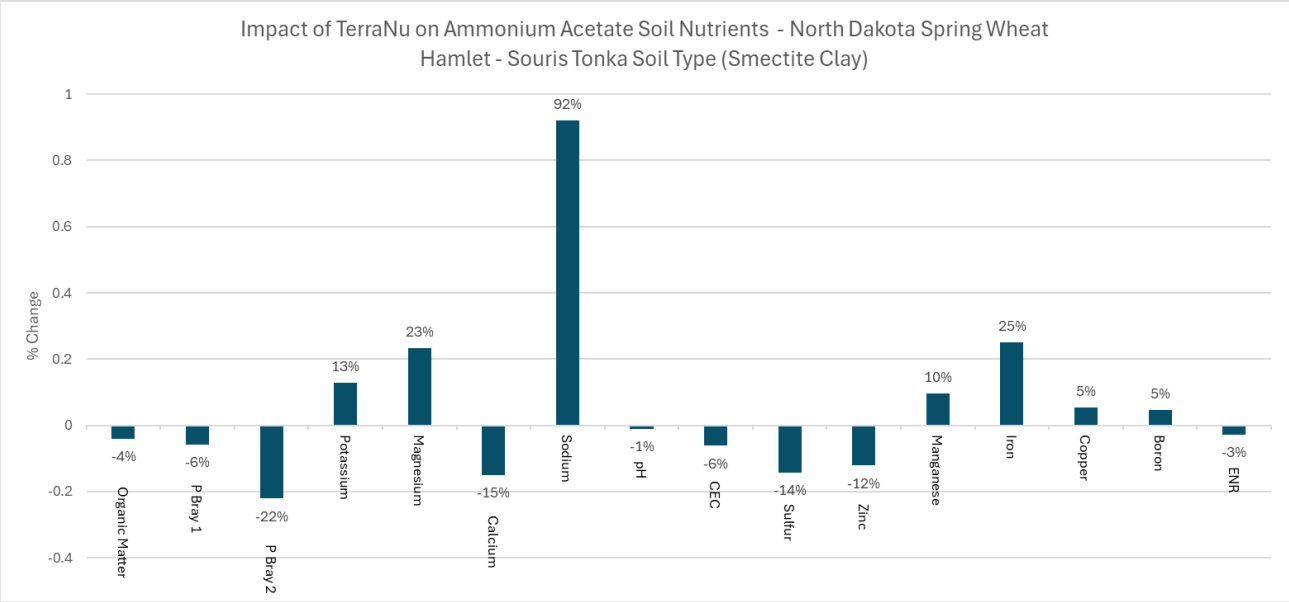
NDVI August 18th, 2024

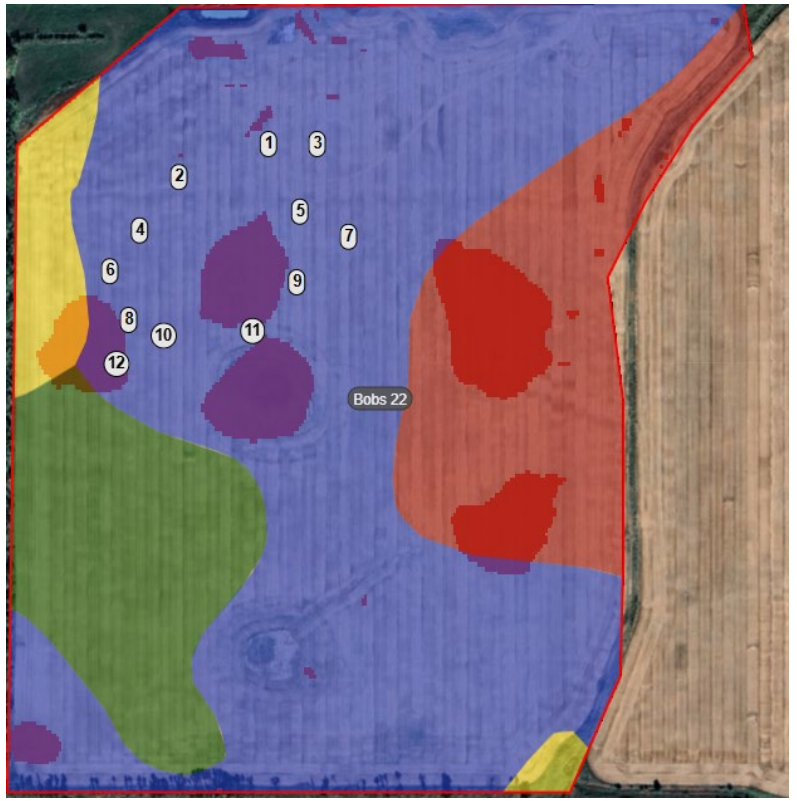
TERRANU

TerraNu yields likely impacted by topography, parent clay mineralogy (smectite clays), and potassium / sodium interactions

Trials reported yield losses (-1.44, -4.81) with TerraNu in 2024 North Dakota spring wheat trials

Sensitivities to soil type and drainage





Impact of TerraNu on ND Soil Types

Soil Type	pH	Magnesium	Sodium
Hamlet - Souris Tonka Loam	-4%	23%	92%
Glyndon Loam	-6%	28%	192%
Swenoda Fine Sandy Loam	-30%	-30%	-42%

TERRANU®

Agronomic management of sodium / potassium / carbon critical to crop production in western high plains

Salinity Impacts on Wheat

- Reduced leaf chlorophyll
- Decreased photosynthetic rate / stomatal conductance
- Decreased leaf water content
- Reduce root and shoot growth

(Photo courtesy of Boomer Patterson, Bottineau)

https://www.ndsu.edu/agriculture/sites/default/files/2023-10/sf1881.pdf

TerraNu soybean trials reported yield losses in trials with TerraNu HiP and Ignite

South Dakota

TerraNu Blend vs. No Fertilizer **(+7.17 bpa)**

- 75 lbs/ac 2-10-22-5S TerraNu Blend

South Dakota

TerraNu Blend vs. GSP **(- 7.01 bpa)**

- 75 lbs/ac 2-10-22-5S TerraNu Blend
- 75 lbs/ac GSP (AMS, MAP, Potash)

Minnesota

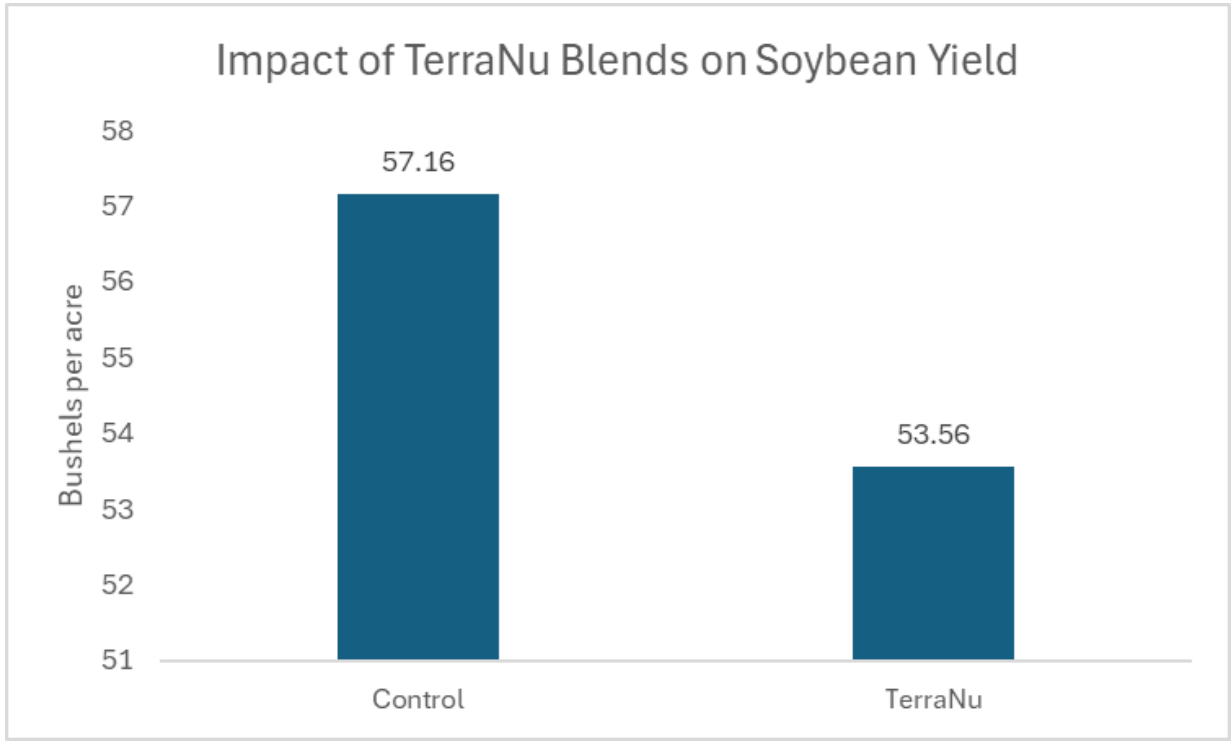
TerraNu Ignite vs. GSP **(+.11 bpa)**

- 160 lbs/ac Ignite
- 180 lbs/ac GSP (AMS, DAP, Potash, Zn)

North Dakota

TerraNu Blend vs. GSP **(- 12.06 bpa)**

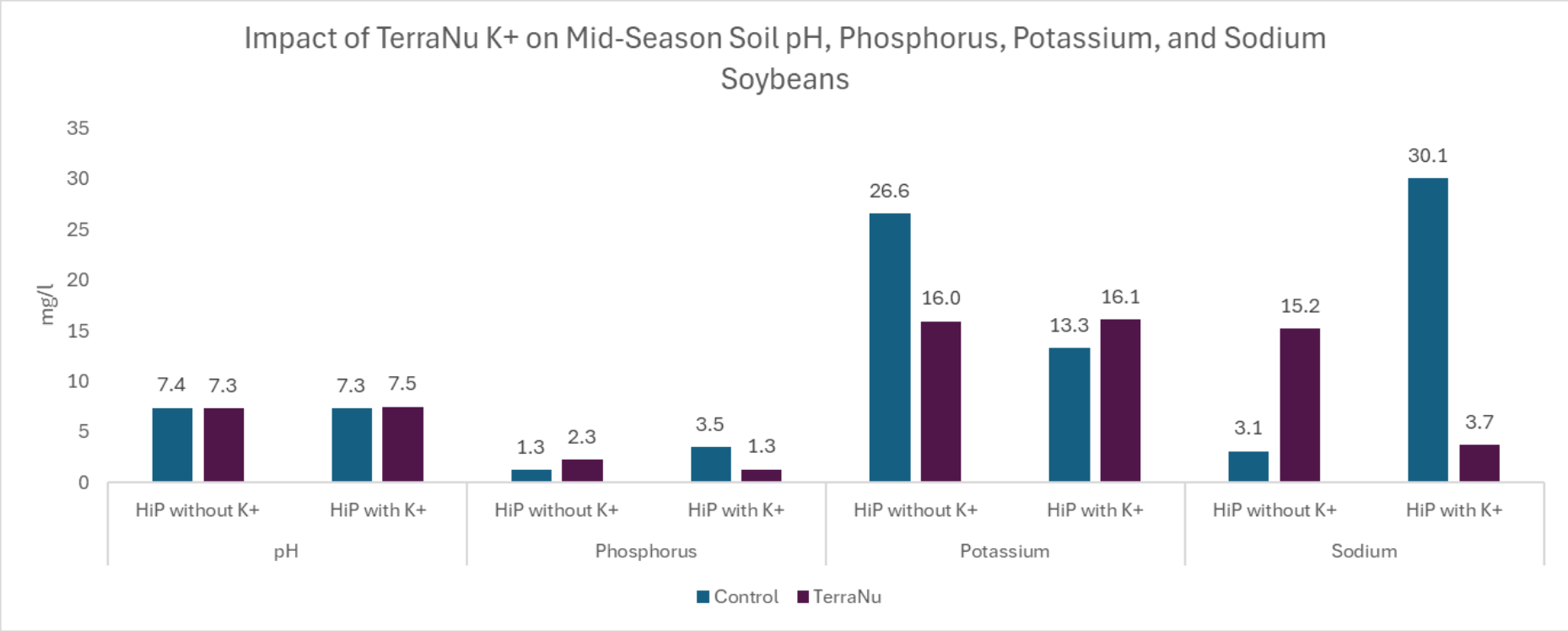
- 70 lbs/ac TN Blend



TERRANU®

Mid-Season SPE soil analysis suggests yield loss in Soybean trials may be mitigated with the inclusion of K+

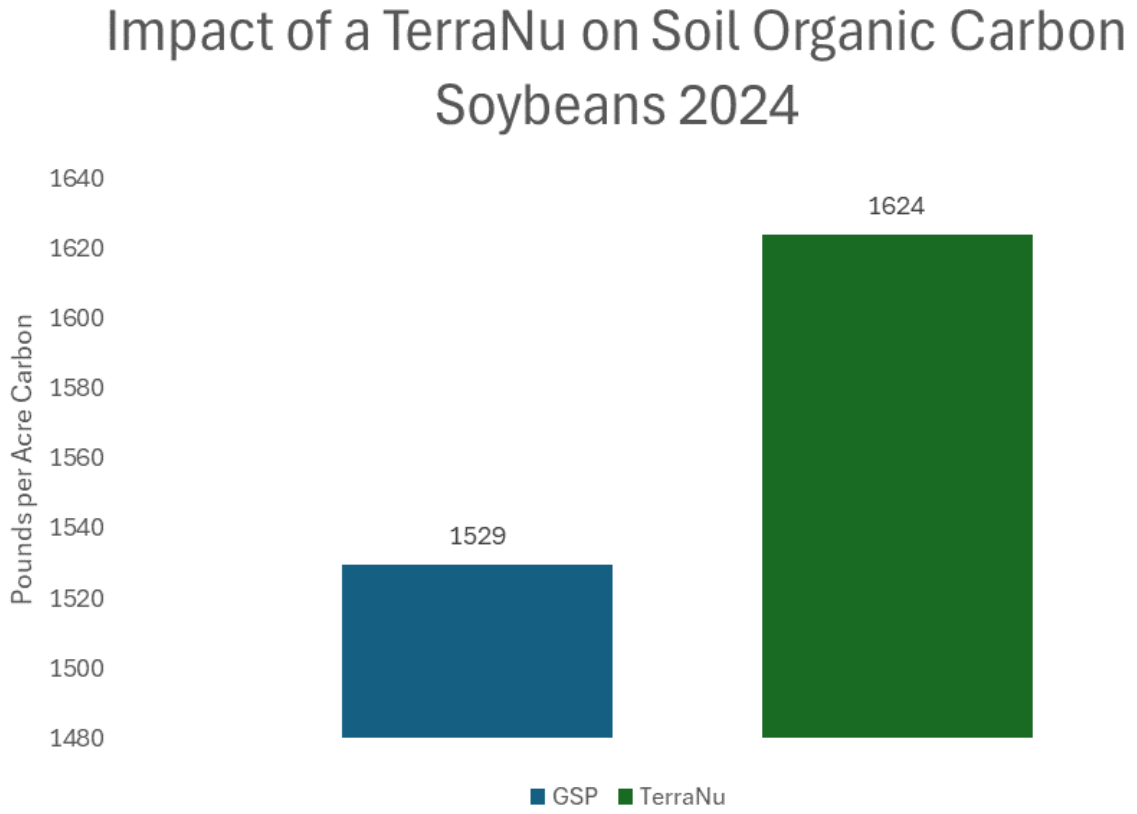
TerraNu blends without the inclusion of K+ reported increases in soluble sodium and reductions in soluble potassium



TERRANU®

TerraNu blends with the inclusion of K+ increased soil organic carbon 95 pounds per acre in Wisconsin soybean trials

- TerraNu K+ blends on soybean trials applied 38.3 pounds per acre carbon
- Soil organic carbon uplift was observed in the water extractable organic carbon fraction of the soil
- Mid-season water extractable soil organic carbon increased 2.5X with TerraNu



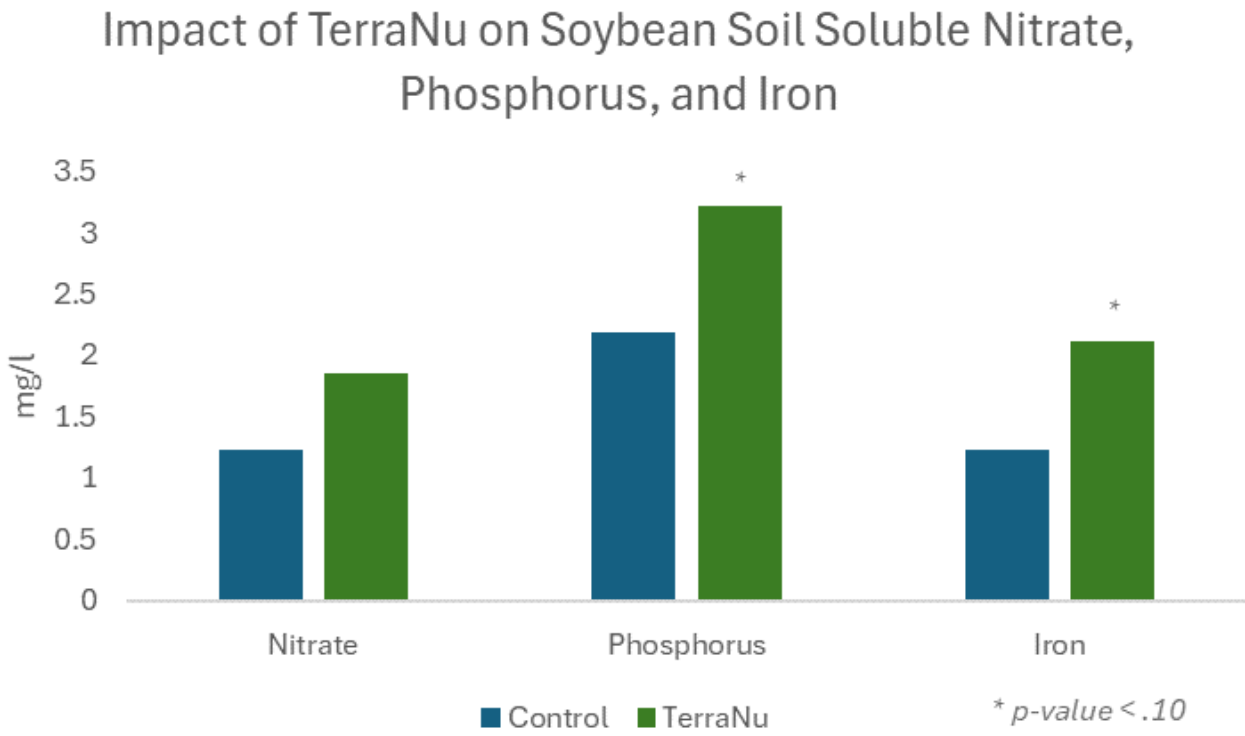
TERRANU®

Soybean trials in South Dakota also reported increases in soil nitrate nitrogen, phosphorus, and iron

TerraNu reported no observed change in soil pH in the South Dakota trials

Nitrate nitrogen **increased 50%** under treatment with TerraNu

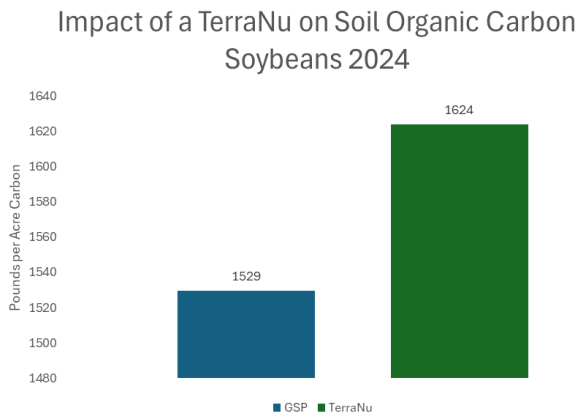
Phosphorus and Iron reported **increases of 47% and 72%** in 95% of the samples collected.

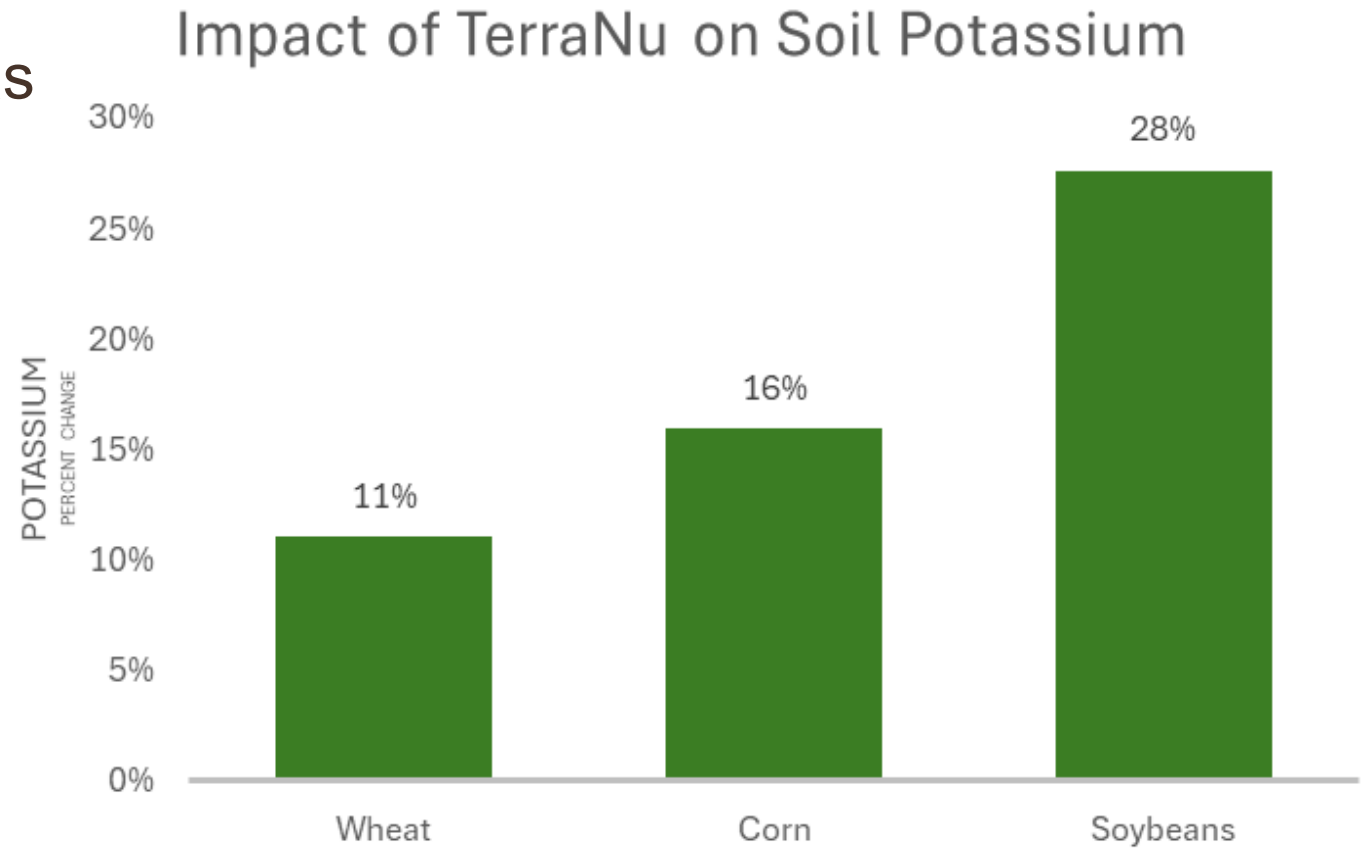


TERRANU®

TerraNu reported increases in winter wheat, corn, and soybean mid-season soil potassium

Uplifts in potassium availability increased as more carbon was applied as part of the trial's fertilizer program





TERRANU®

TerraNu Corn trials reported strongest uplifts observed with inclusion of K+ and complete fertilizer blends

South Dakota

- TerraNu Blend vs. GSP
  - TN Calcium and MicroPack

Iowa

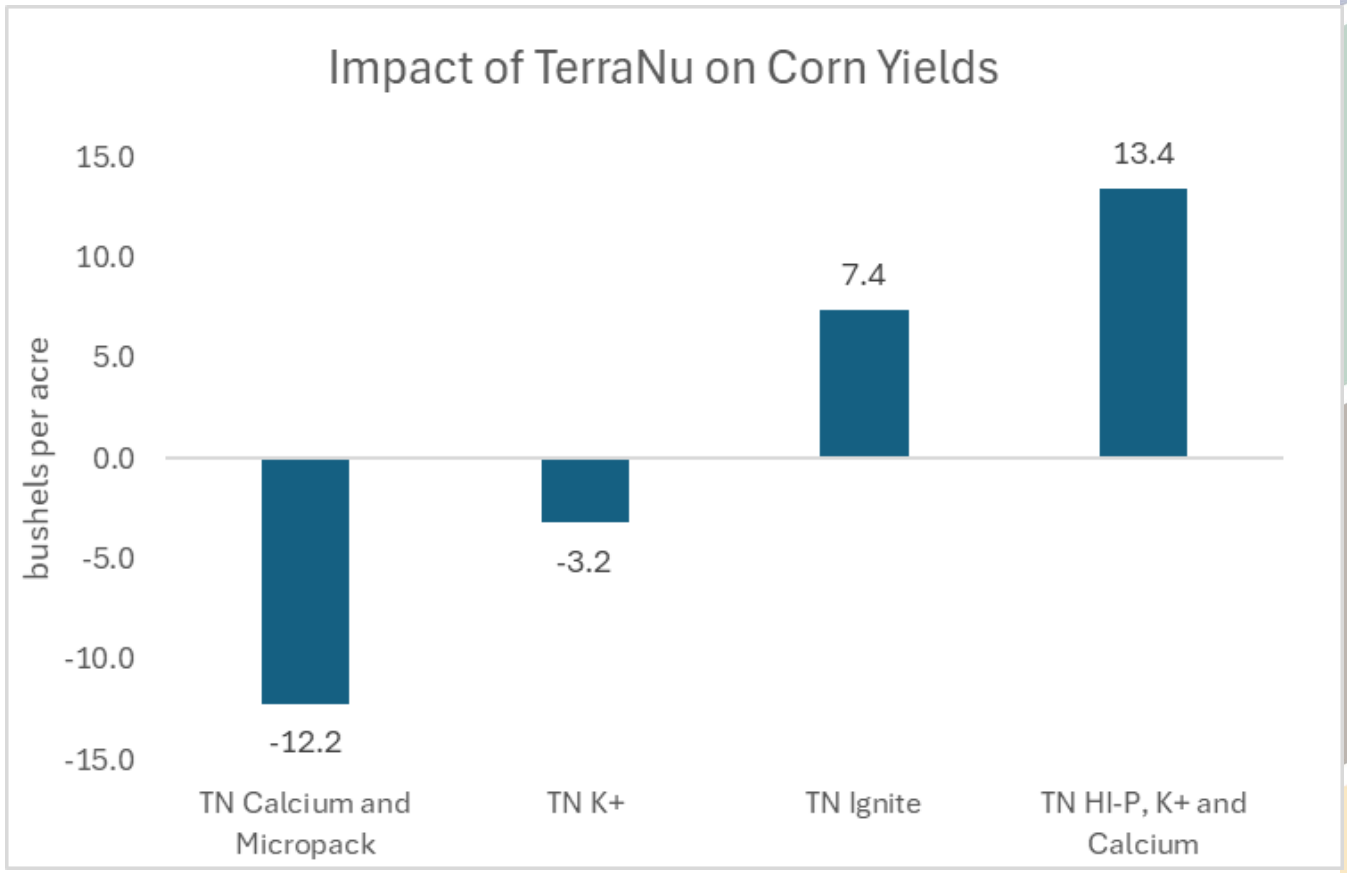
- TerraNu K+ vs. MOP
  - 100 lbs/ac TerraNu K+

Minnesota

- TerraNu Ignite vs. GSP

Illionis

- TerraNu Blend vs. GSP
  - **With K+**



TERRANU®

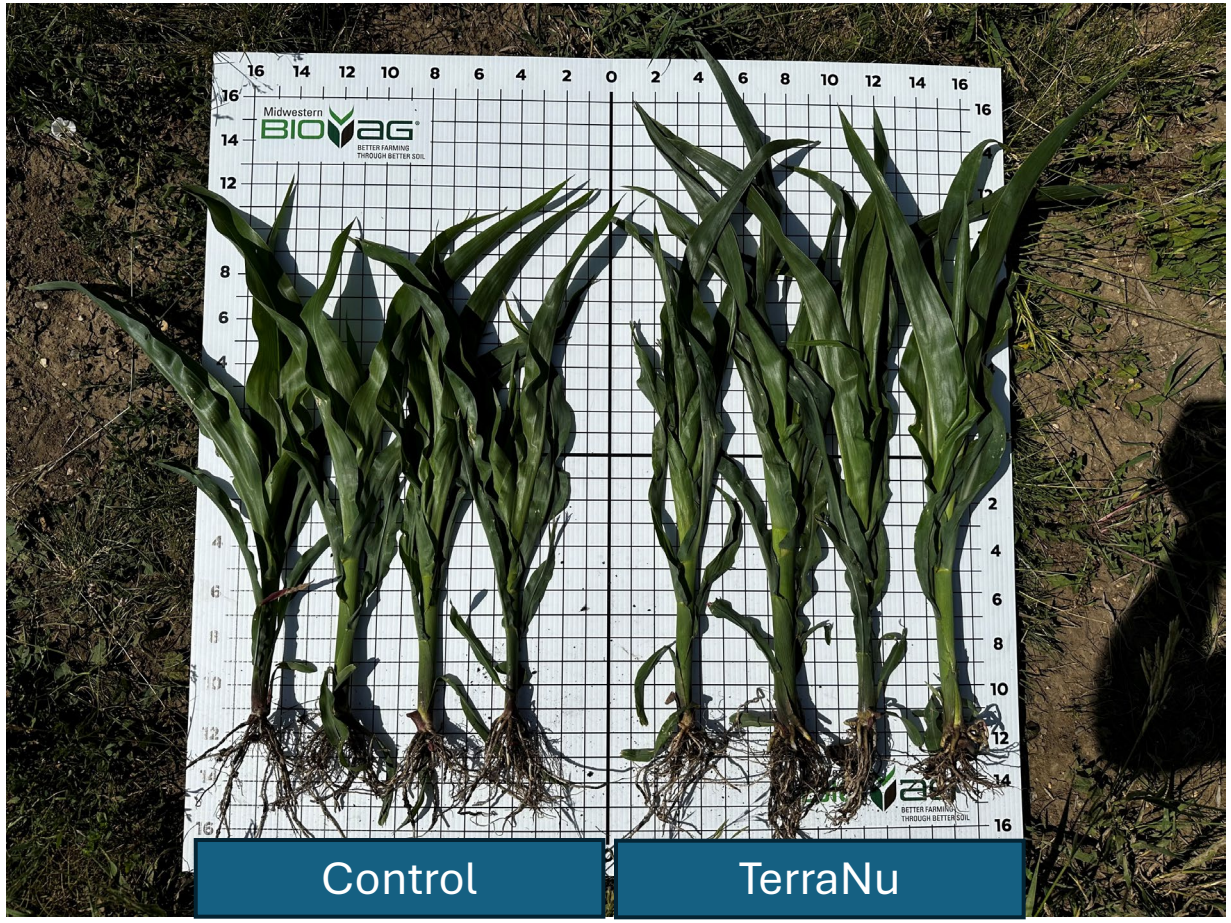
Corn Trials in SD reported early season uplifts in phosphorus and potassium – but also limitations in Nitrogen and Sulfur

Grower Standard

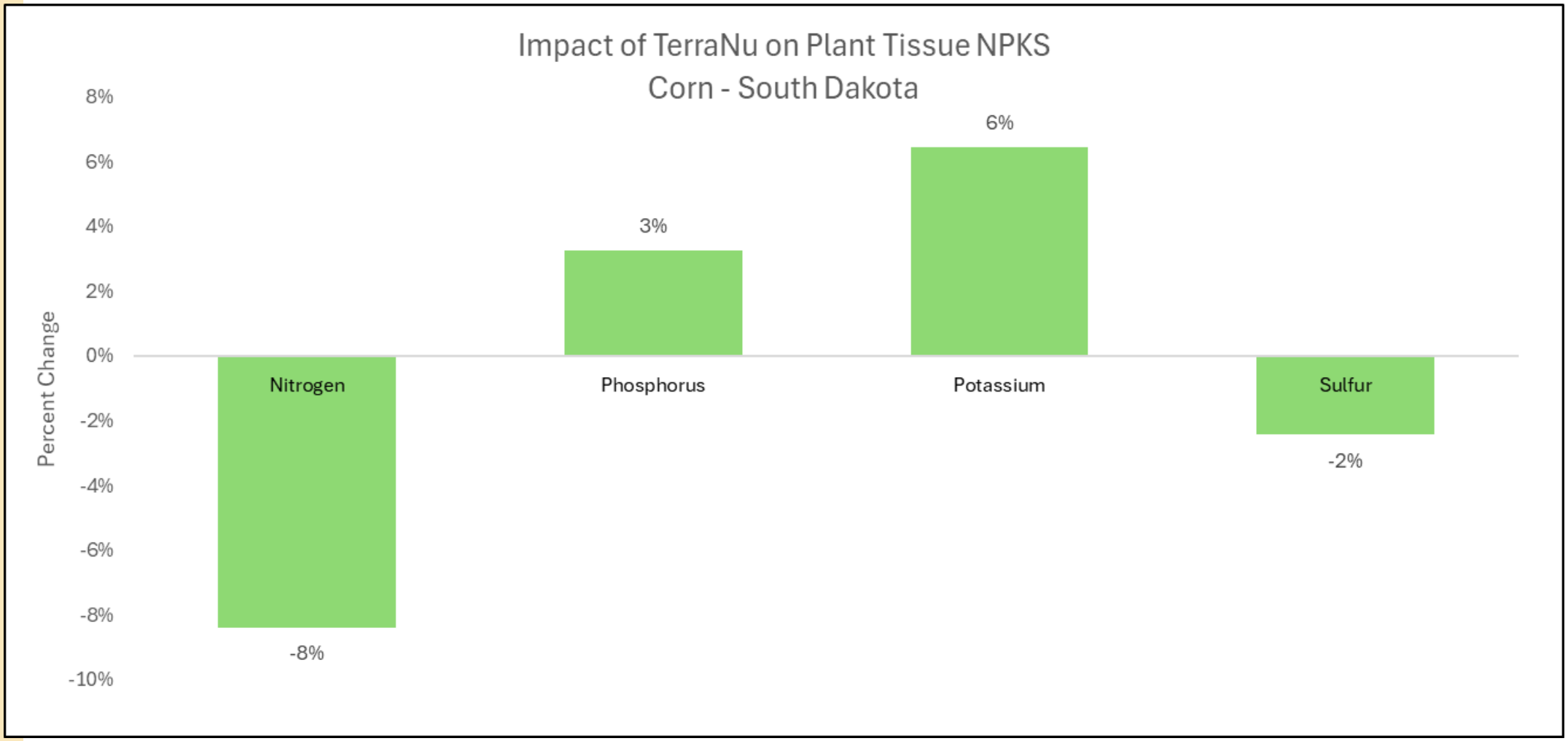
- 20-30 gal/ac UAN
- 250 lbs/ac fertilizer blend (AMS, MAP, Potash)

TerraNu Blend

- 20-30 gal/ac UAN
- 200 Lb/A TN Blend 4-19-11-6S
  - 10% SOP (20 Lb/A)
  - 10% MAP (20 Lb/A)
  - 5% TN MicroPack (10 Lb/A)
  - 20% TN Calcium (40 Lb/A)



TERRANU®


Impact of TerraNu on Plant Tissue NPKS
Corn - South Dakota
Percent Change
8%
6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
Nitrogen
-8%
Phosphorus
3%
Potassium
6%
Sulfur
-2%

TERRANU®

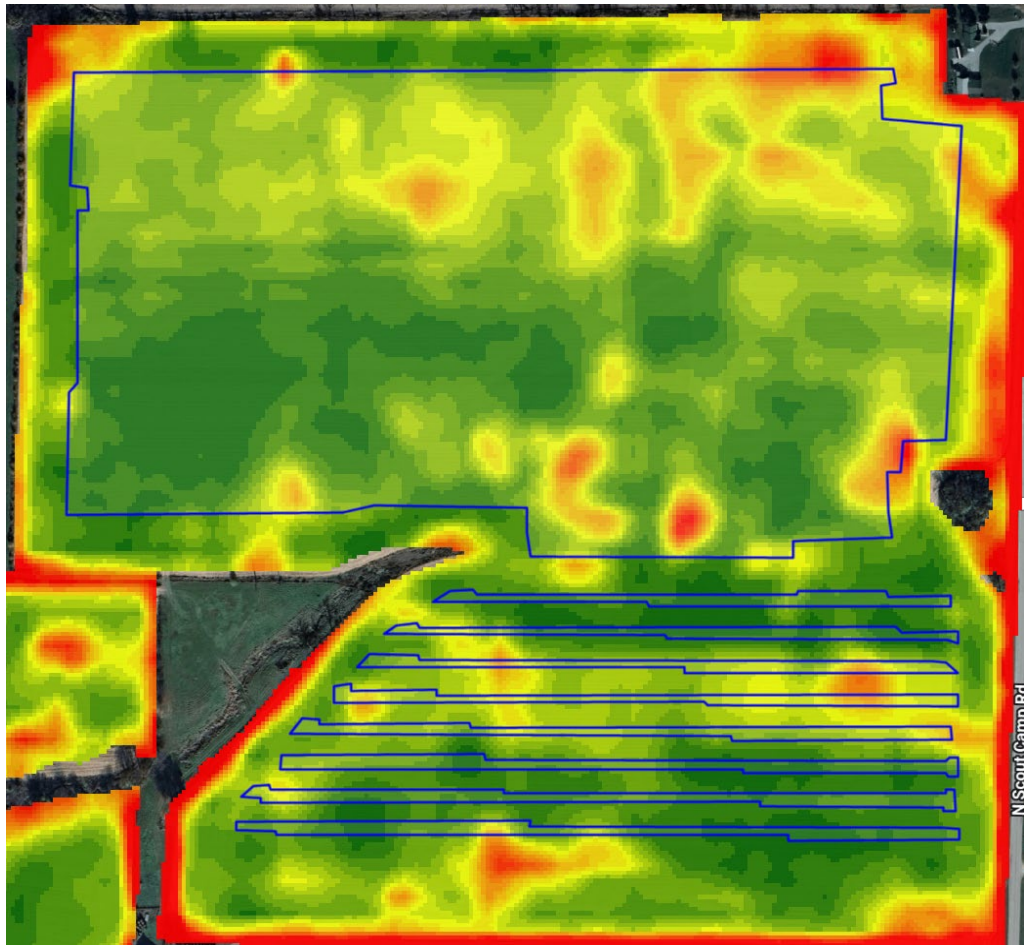
TerraNu complete fertilizer blends increased both yield 13.4 bushels per acre and crude protein 7% in Illinois corn trials

Grower Standard Program

- 100 Lbs of ESN (Urea)
- 50 Lbs/A DAP
- 150 Lbs/A 0-0-60
- 50 Lbs/A SO4
- 3 Lbs/A Zinc Sulfate
- 5 Lbs/A Copper Sulfate

TerraNu Blend

- 100 Lbs/A ESN (Urea)
- 50 Lbs/A TN HiP
- 150 Lbs/A TN K+
- 43 Lbs/A TN Calcium
- 3 Lbs/A Zinc Sulfate
- 7 Lbs/A Copper Sulfate



NDVI Imagery from June 25th, 2024

TERRANU