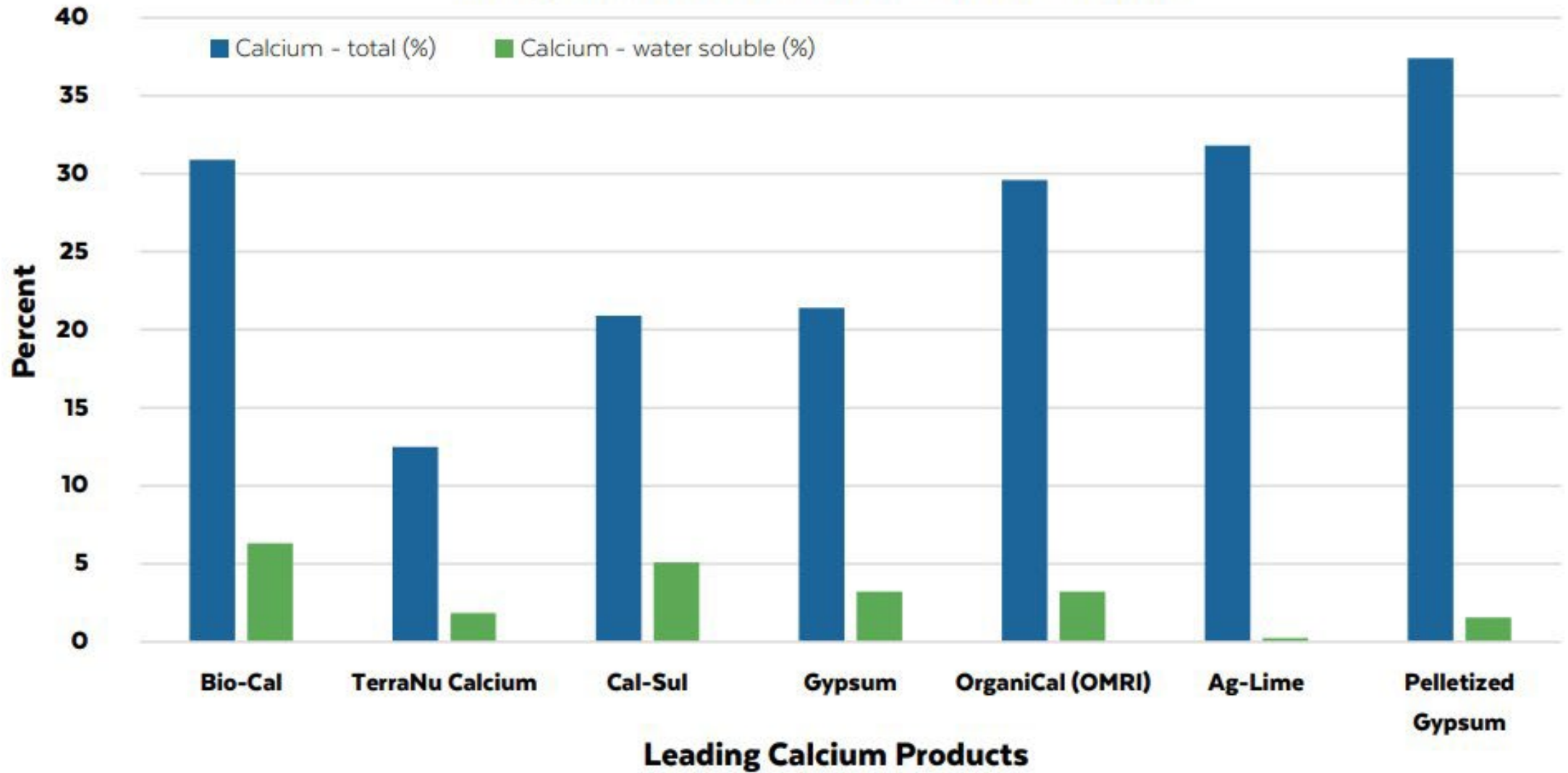


**Bio-Cal**<sup>®</sup>

Christopher Kniffen, Director of Research

## Analysis of Total vs. Water Soluble Calcium



# Bio-Cal Product Intro

- Proprietary, calcium-based soil amendment
- Formulated with five calcium sources that range from soluble to time-released
- Bio-Cal provides highly reactive, readily available calcium
- Bio-Cal acts as a catalyst in soil fertility programs, helping to mobilize nutrients, unlock soil potential and promote healthier and stronger crops
- Improves water infiltration, soil structure, and nutrient availability
- Enhances crop performance and optimizes manure efficiency



# Historically, Bio-Cal was positioned as a soil amendment for improving the quality of forages to supplement dairy rations

Observational improvements in plant health, standability, and yield were common when Bio-Cal was applied to forages.

**"Calcium is the trucker of all minerals"**

Data gaps limited confidence in the products performance when applied to row crops as the short-term performance was often overshadowed by uncontrolled variables influencing yield.



# **We questioned if a deeper understanding of Bio-Cal mode of action would increase the product's use cases and success**

Observational experience and basic soil science concepts of cation selectivity suggested the Bio-Cal mode of action and performance may be not fully realized when limited to forages.

Questioned if increasing the soluble fraction of calcium in the soil, via Bio-Cal, improves the porosity of the soil and the availability of sulfur as observed by many of our customers.

Also hypothesized that Bio-Cal functions as soil nutrient mobilizer. When positioned correctly, Bio-Cal improves the availability of potassium via cation displacement on the soil colloid.

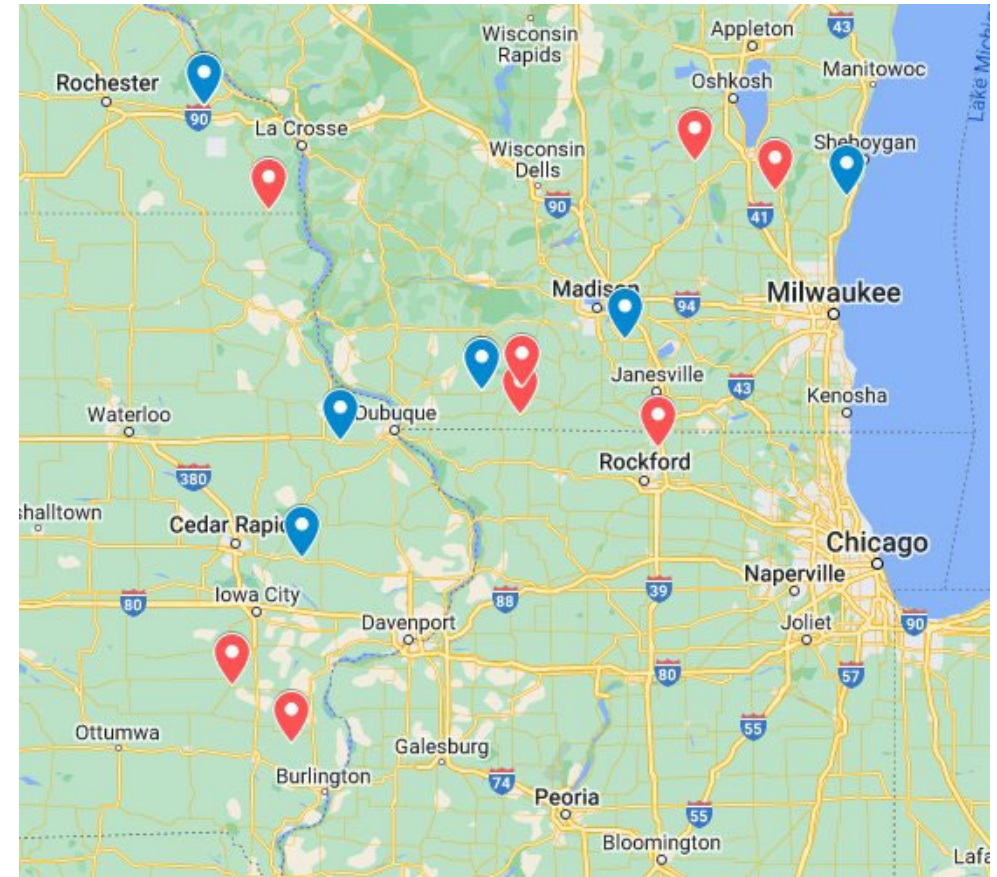


**Bio-Cal**<sup>®</sup>

# Bio-Cal / OrganiCal Trial Site Locations 2023 - 2024

## 2024 Site Description

- 10 trial locations
- 34 experimental sites (fields)
- 54 soil types
  - Silt loam – Clay
- Corn, Soybeans, and Alfalfa
- Manure and dry fertilizer nutrient management systems
- Mean application rate: 500 pounds/acre Bio-Cal



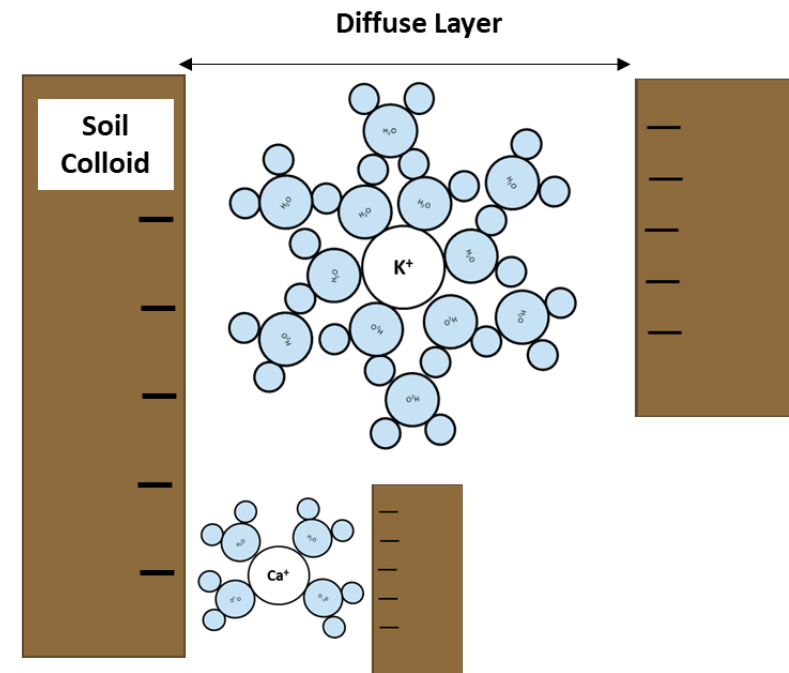
Each Bio-Cal farm trial location  
Blue = 2023, Red = 2024

# Question: Will increasing the soluble fraction of calcium in the soil, via Bio-Cal, improve the porosity of the soil and the availability of biologically mediated nutrients

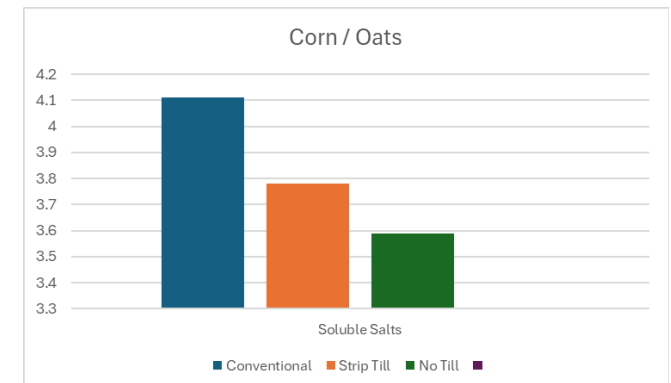
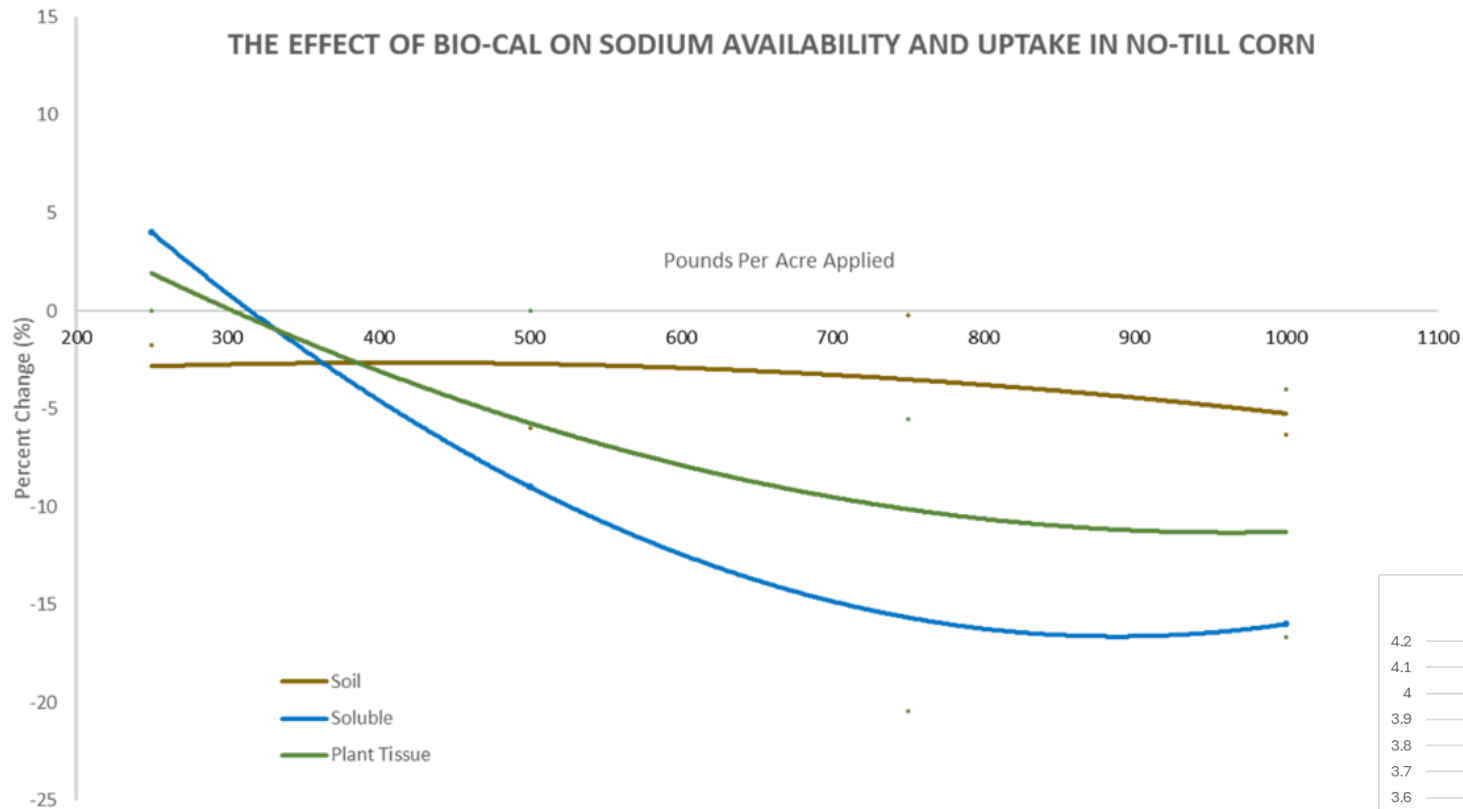
Preliminary evidence suggests that soil dispersion / compaction to be influenced by soluble ions in soil solution.

Higher concentrations of monovalent Sodium and Potassium increase compaction and shrink well

Soluble minerals can increase or decrease the distance between soil particles (colloids)



# 2023 Bio-Cal trials reported soluble salt management results enriching No-Till farming practices goals of soil health



**Bio-Cal**<sup>®</sup>



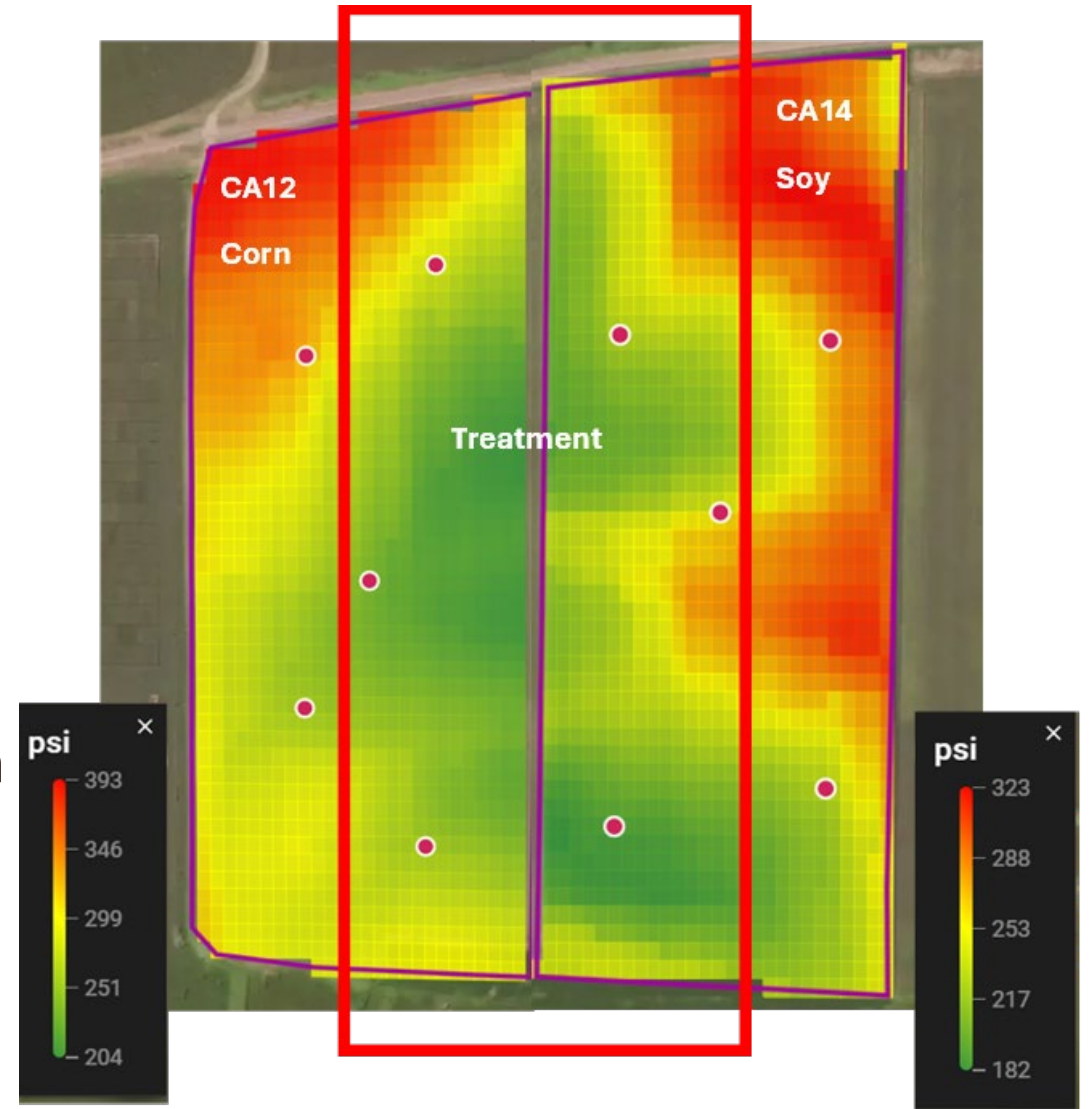


# EARTHOPTICS

"This precision soil mapping system and methodology precisely identifies the areas and depths where each individual field is compacted and quantifies the extent of the compaction.

Using this data, growers are provided with a customized tillage prescription that can be adjusted to their preferences, including compaction threshold, max tillage depth and specific crop."

- Earth Optics (<https://earthoptics.com/platform-products/tillmapper>)

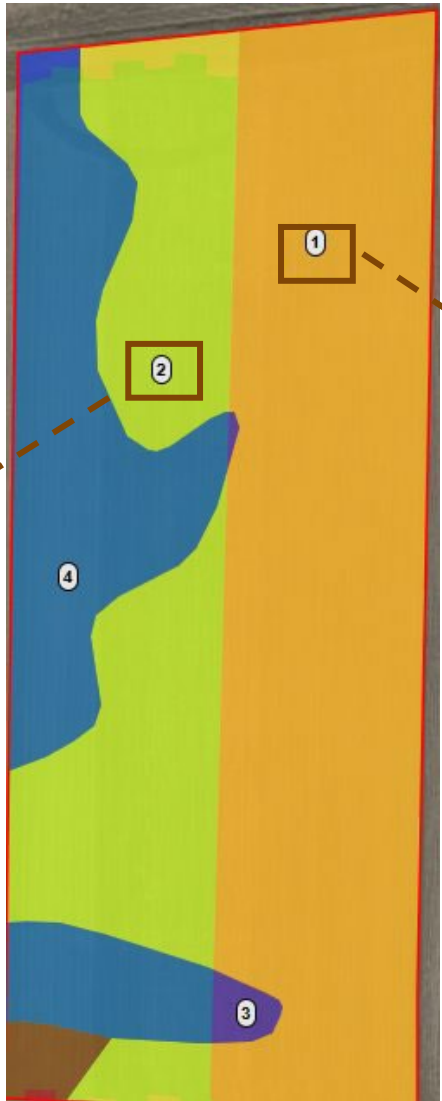


## Bio-Cal®

500 lbs/ac Bio-Cal



Soil Monolith pulled from Point 2 on July 1st, 2024.



Bio-Cal Trial Soil Sample Locations with Zone Split.

Omission Strip

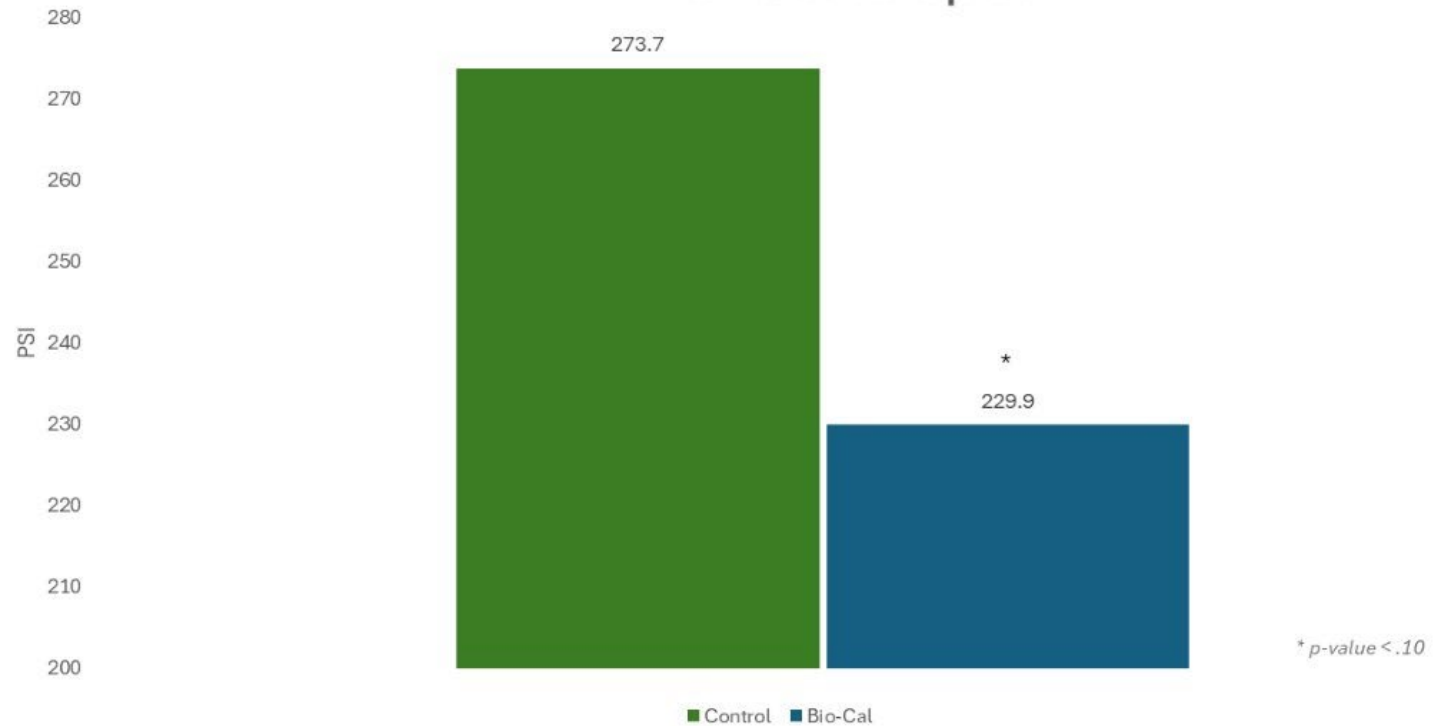


Soil Monolith pulled from Point 1 on July 1st, 2024.

# Bio-Cal Decreased Spring Soil Compaction 19% in Multi-Year No-Till Corn / Soy Trials - Southeastern MN

Pre-plant soil compaction was reduced **44 PSI** in Bio-Cal treatments

## Impact of Bio-Cal on Soil Compaction 6" Soil Depth

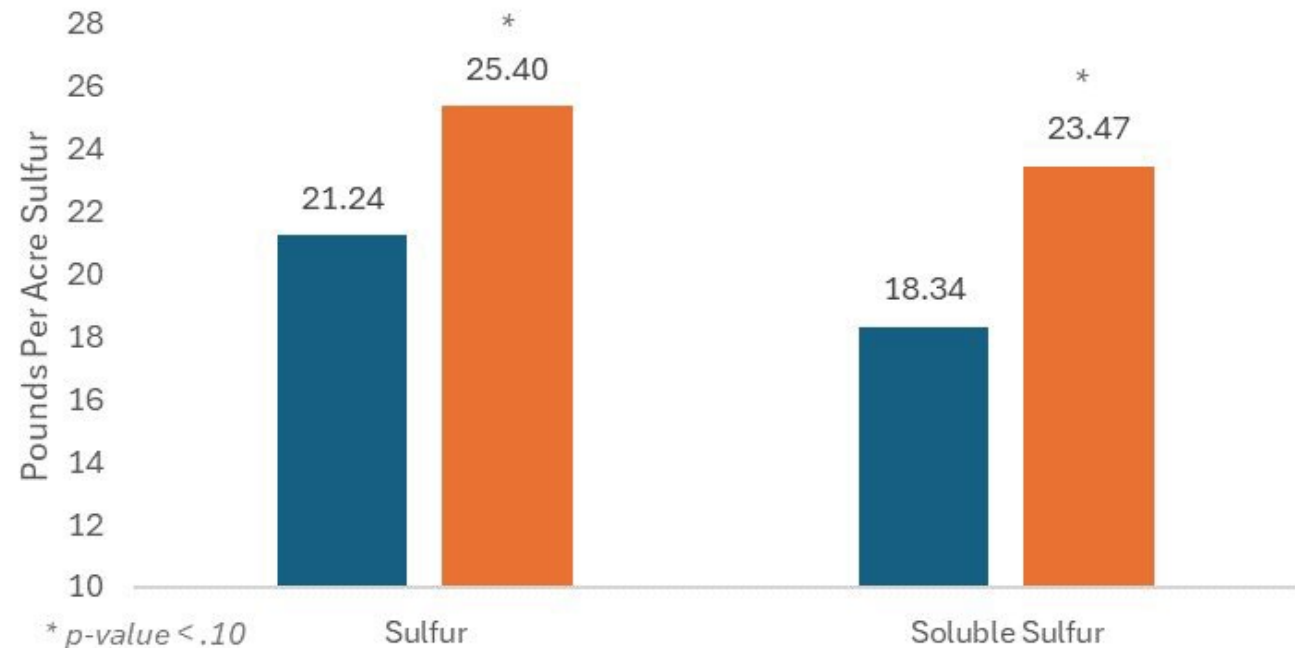


# Improvements in soil sulfur availability confirm the impact of improved porosity, via Bio-Cal, and improved soil oxidation and sulfur cycling

Available soil sulfur increased **20%**

Soluble soil sulfur increased **28%**

Impact of Bio-Cal on Soil Sulfur Availability  
2023 - 2024

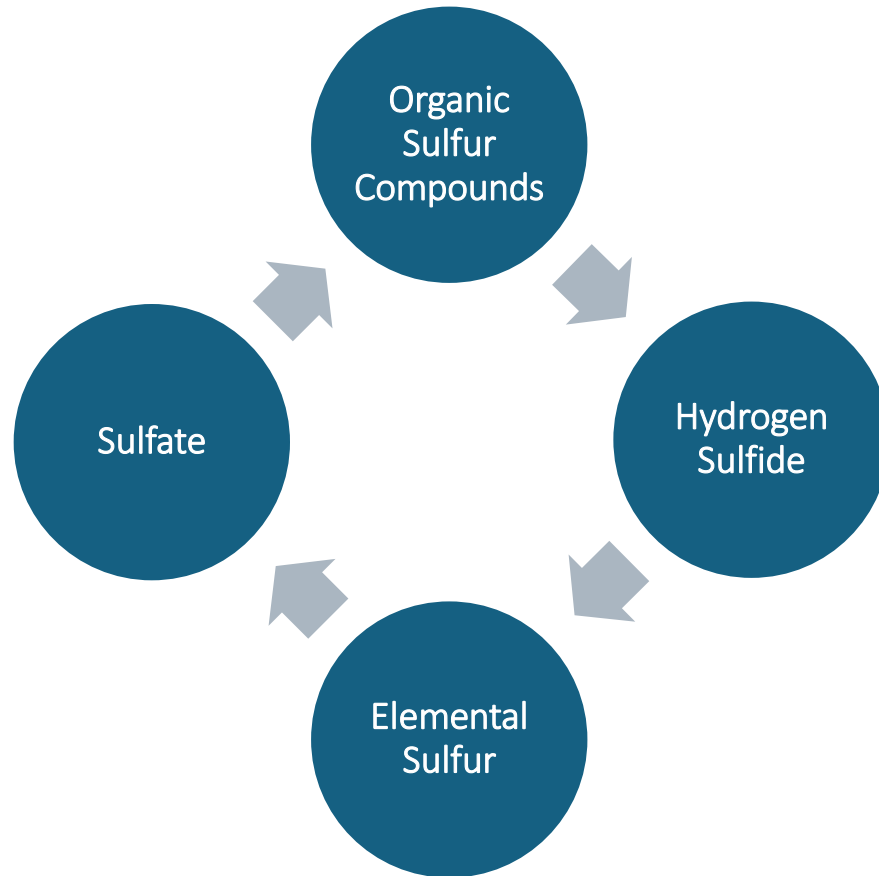


**Bio-Cal**<sup>®</sup>

Sample size – 349

Sample collection – early/mid season

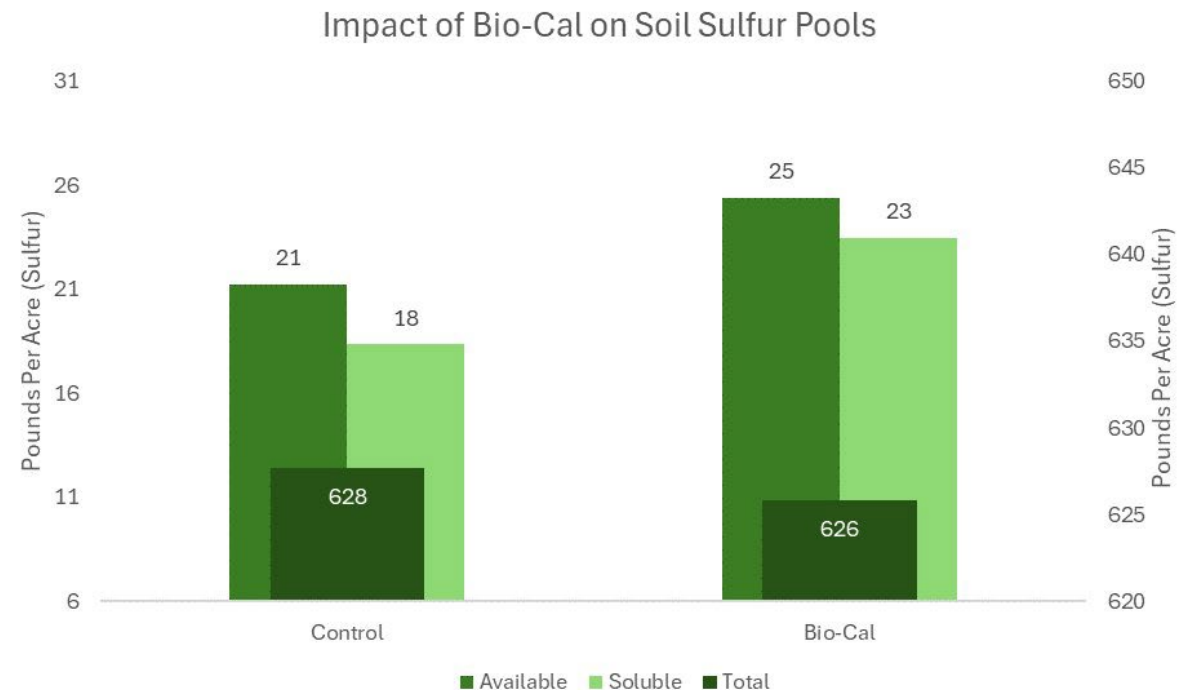
# Sulfur plant availability is directly correlated to the porosity and governed by reduction - oxidation reactions



# Total Sulfur Pools Remain Consistent Suggesting Bio-Cal Improved the Availability and Solubility of Soil Sulfur

## Discussion

- Total sulfur pools remain unchanged by addition of Bio-Cal
- Bio-Cal increased available and soluble sulfur pools **20% and 28%**, respectively
- Increases in available and soluble sulfur pools suggest Bio-Cal is enhancing the availability of soil sulfur



# Bio-Cal, when compared to traditional calcium / sulfur inputs, reported increased sulfur availability despite lower applied rates of sulfur with Bio-Cal

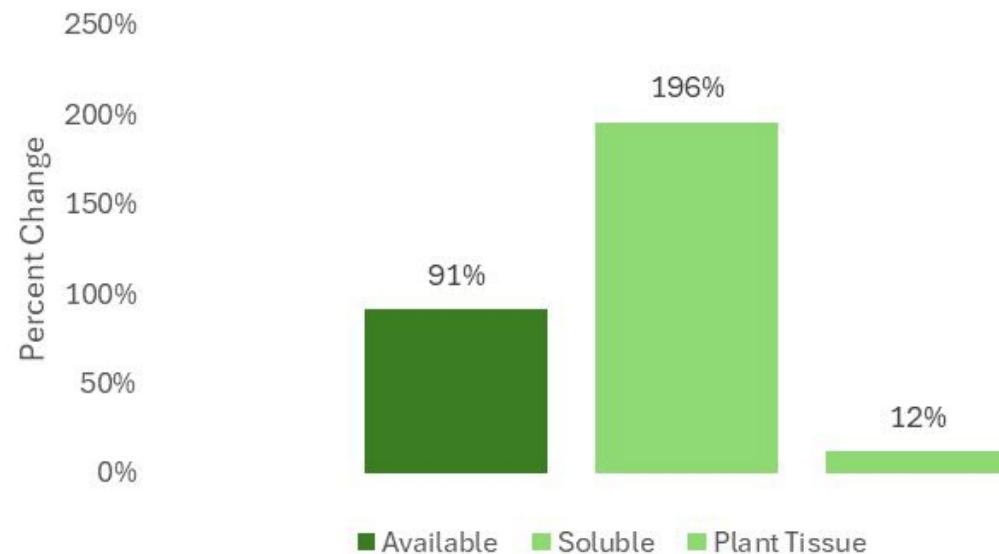
## Experimental Design

- Bio-Cal and Cal-Sul were applied at general application rates
  - Bio-Cal – 472 pounds
  - Cal-Sul – 200 pounds

## Results

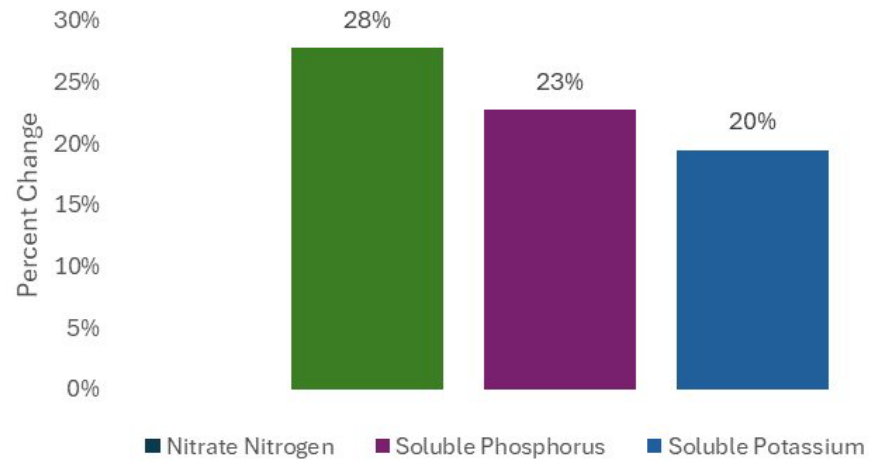
- Cal-Sul treatment applied 24.5 pounds per acre more sulfur per acre than Bio-Cal, yet reported lower levels of available, soluble, and plant tissue sulfur

Reported changes in Sulfur Availability and Uptake when treated with Bio-Cal versus Cal-Sul

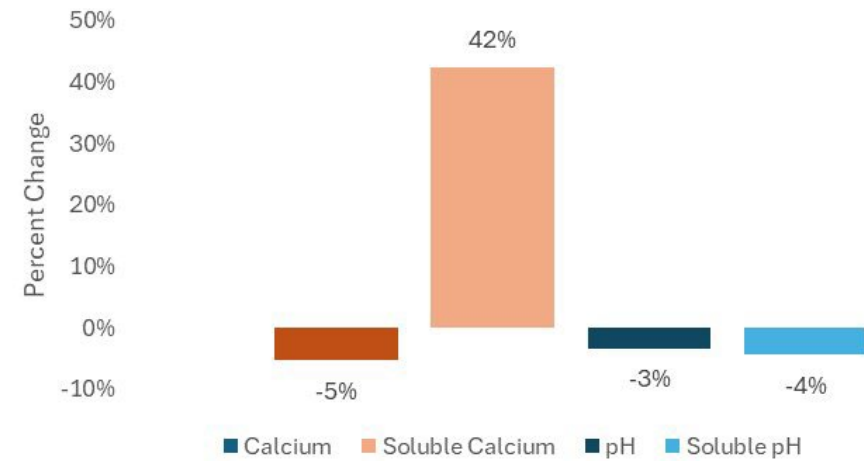


# Bio-Cal and Cal-Sul also reported Improved NPK Availability, Calcium Solubility and Performance than Cal-Sul

Reported changes in soluble NPK when treated with Bio-Cal versus Cal-Sul



Reported changes in Calcium and pH when treated with Bio-Cal versus Cal-Sul



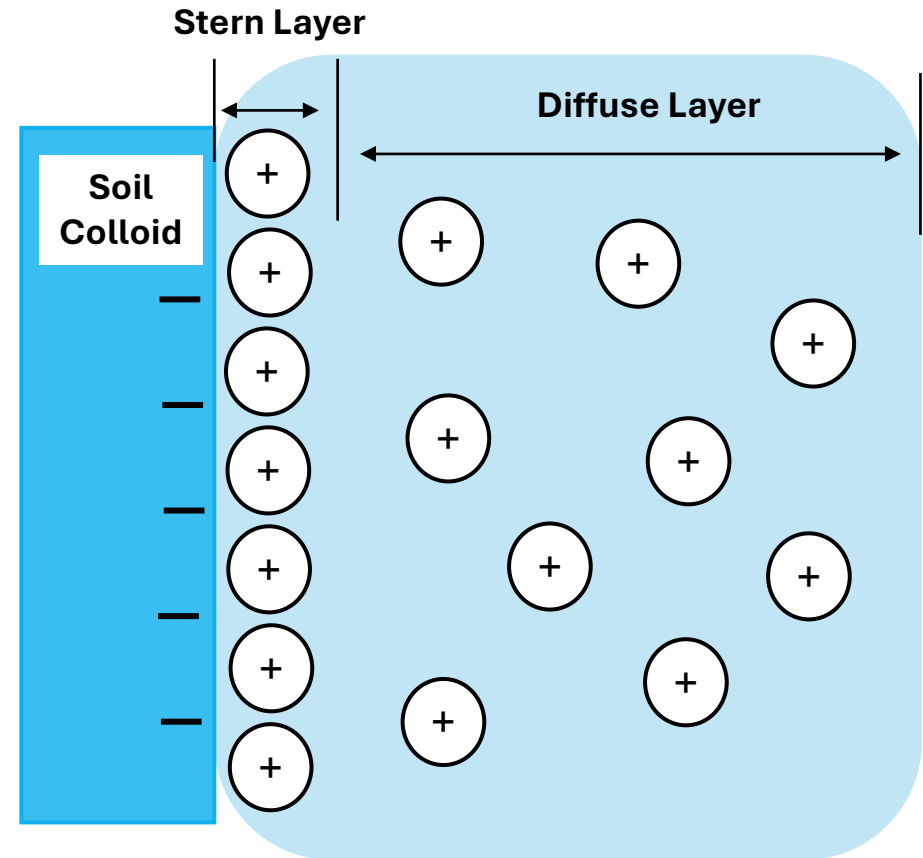


# Question: Does Bio-Cal increase the availability and mobility of additional plant nutrients

Soils will always work to reach equilibrium

Increasing soluble divalent cation such as calcium  $2+$  will naturally displace two monovalent cation potassium or sodium ions  $1+$

In soils where potassium is present yet fixed or "tied up" to the soil colloid, saturating the soil solution with soluble calcium should logically increase the availability of potassium for plant uptake.



# 90% of the samples collected from 2023 and 2024 Bio-Cal trials reported improved potassium availability

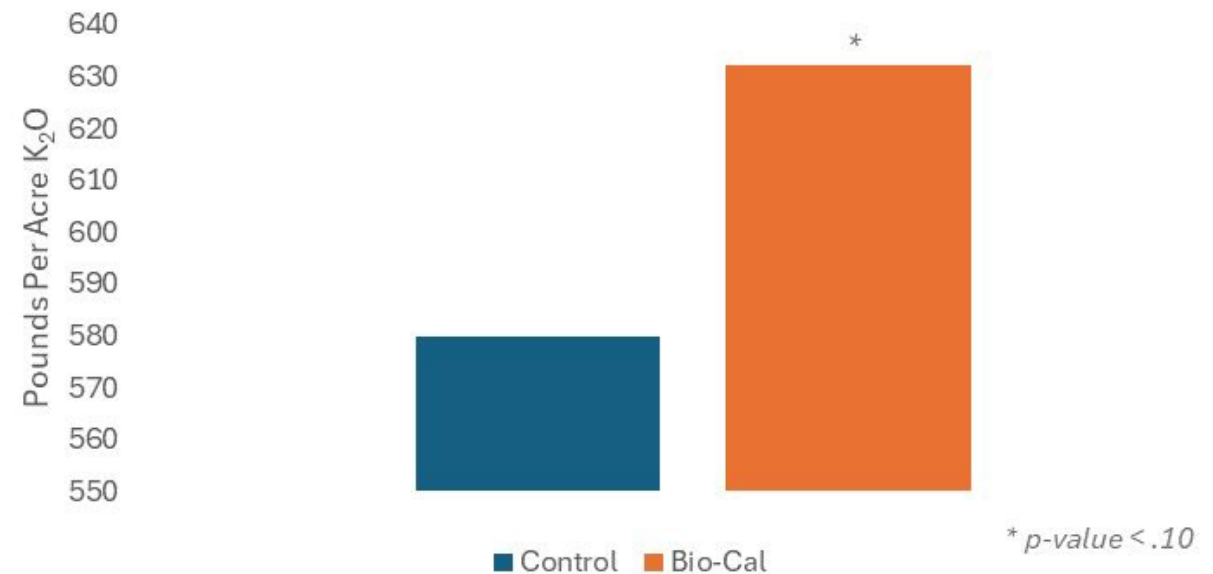
**9% increase**  
in soil potassium (lbs/ac)

**10% increase**  
in base saturation K%

**52 pounds per acre K<sub>2</sub>O uplift**

- \$18.20 per acre potash (MOP)
- \$48.10 per acre (SOP)

Impact of Bio-Cal on Soil Potassium Availability  
2023-2024



Sample size – 377  
Sample collection – early/mid season

# Fundamental concepts in cation selectivity suggest results observed in salinity, potassium, and sulfur management may be transferred to high magnesium soil

Current best management practices for high magnesium soil management are limited to:

- Farming around the problem
- Tillage
- No-till practices



**Control**



**Bio-Cal**

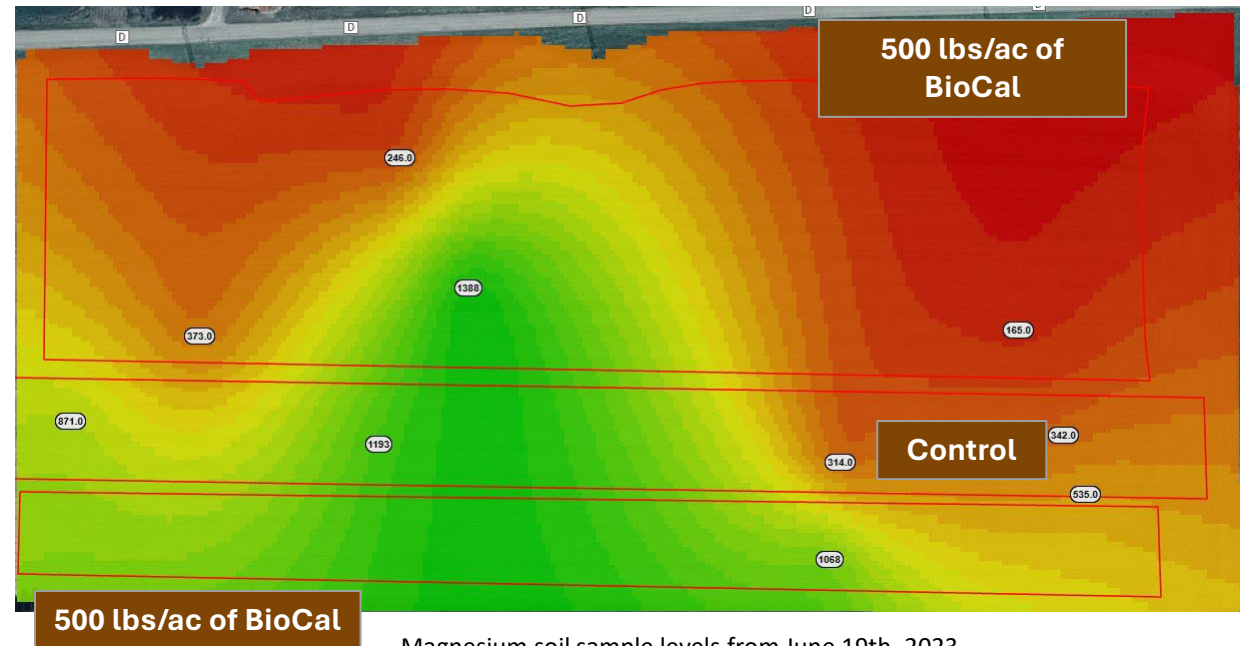
2023 field samples from Wisconsin trial on high magnesium soils

**Bio-Cal**<sup>®</sup>

# Multi-Year Bio-Cal Trial reported Reduced Soil Magnesium on a dolomitic parent material – SC Wisconsin

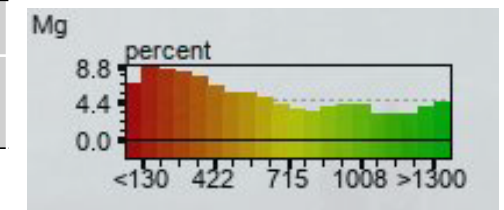
## Site Selection

- Bio-Cal was applied in consecutive years on a dolomitic parent material loess silt loam
- Primary concerns to address were salinity and magnesium
- Continuous Corn – No Till Rotation



Magnesium soil sample levels from June 19th, 2023.

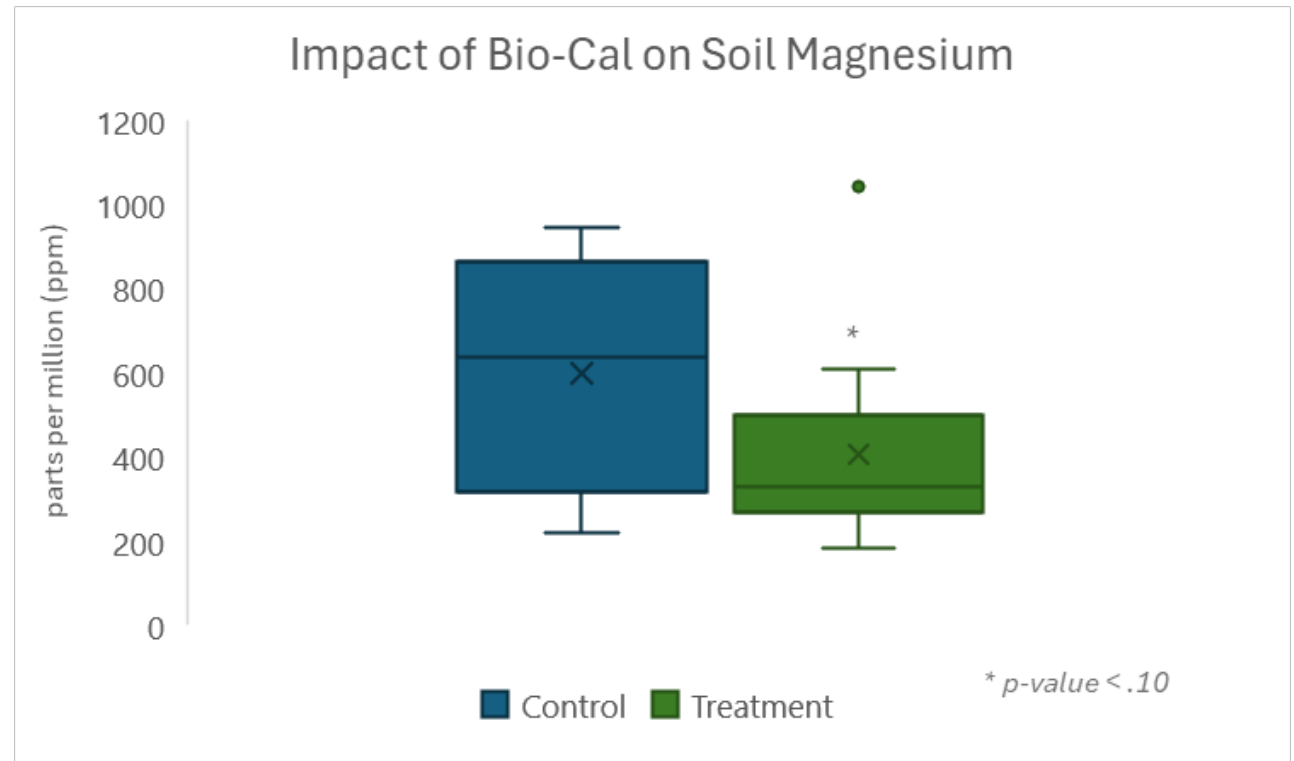
Soil Type	Soluble Cations (percent total)			
	Calcium	Magnesium	Potassium	Sodium
Total	37%	28%	18%	17%
Ideal	55-60%	18-20%	9-10%	.8-2%



# Bio-Cal reduced Soil Magnesium 32 % in 90% of the sample points collected spring 2024

## Results

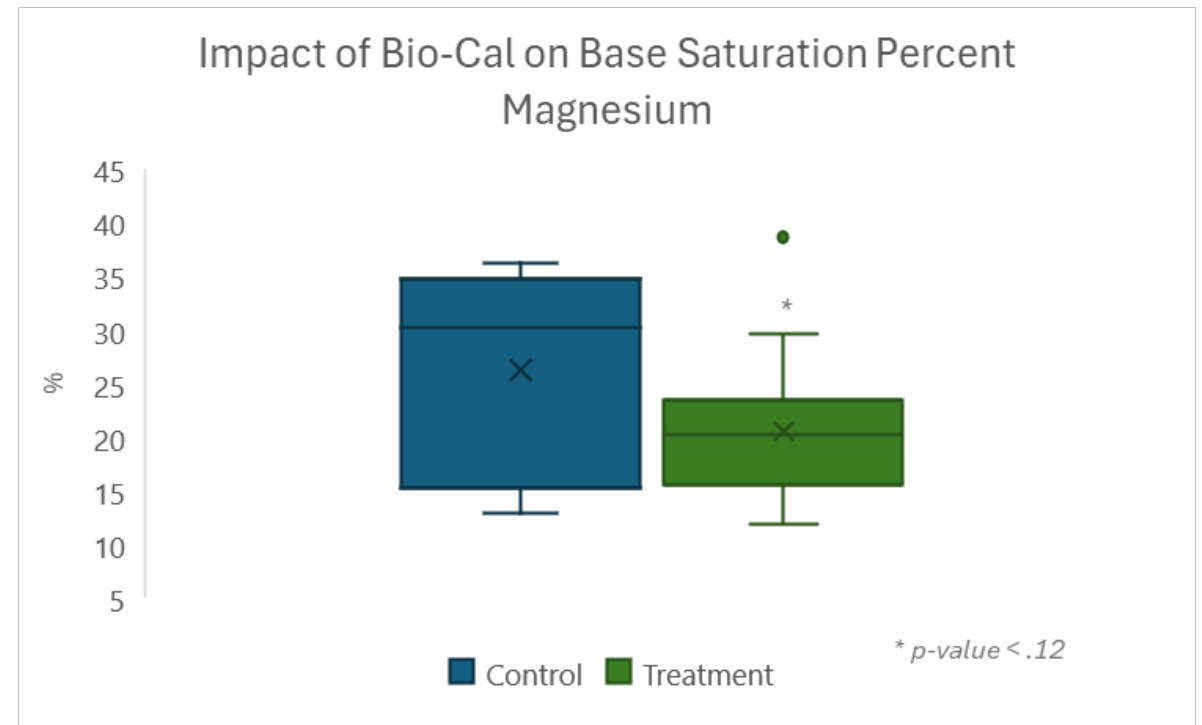
- Bio-Cal reduced soil magnesium levels 32% compared to the control treatment zones
- The 32% reduction in soil magnesium levels equated to 386 pounds per acre of magnesium that was impacted by the application of Bio-Cal



# Base Saturation Percentage of Magnesium was also reduced 21% - no other cation base saturation percentages were impacted

## Discussion

- Base Saturation Magnesium was reduced 5.66 percentage points
  - (26% Mg – 20% Mg)
- The reported 21% reduction in Magnesium base saturation percentages was only observed for Magnesium.
- All other cations were not impacted by Bio-Cal



# Bio-Cal reductions in soil magnesium and improvements in soil tilth, can be missed due to underlying nutrient limitations and soil moisture

Potassium deficiencies are often the yield limiting factor preventing uplifts with Bio-Cal in high moisture years

Drought years' experience higher frequencies of shrink / swell and the results of Bio-Cal are typically expressed more dramatically

Bio-Cal Agronomic Considerations:

- Sensitivities to low soil pH
- Potassium

**2023**

<b>Control</b>	<b>213.07</b>	bu/ac
<b>Treatment</b>	<b>217.09</b>	bu/ac

**+4.02**

**2024**

<b>Control</b>	<b>233.77</b>	bu/ac
<b>Treatment</b>	<b>234.94</b>	bu/ac

**+1.17**







# Due to the high salinity concerns with manure - we questioned the impact of Bio-Cal on manure use efficiency

## Experimental Design

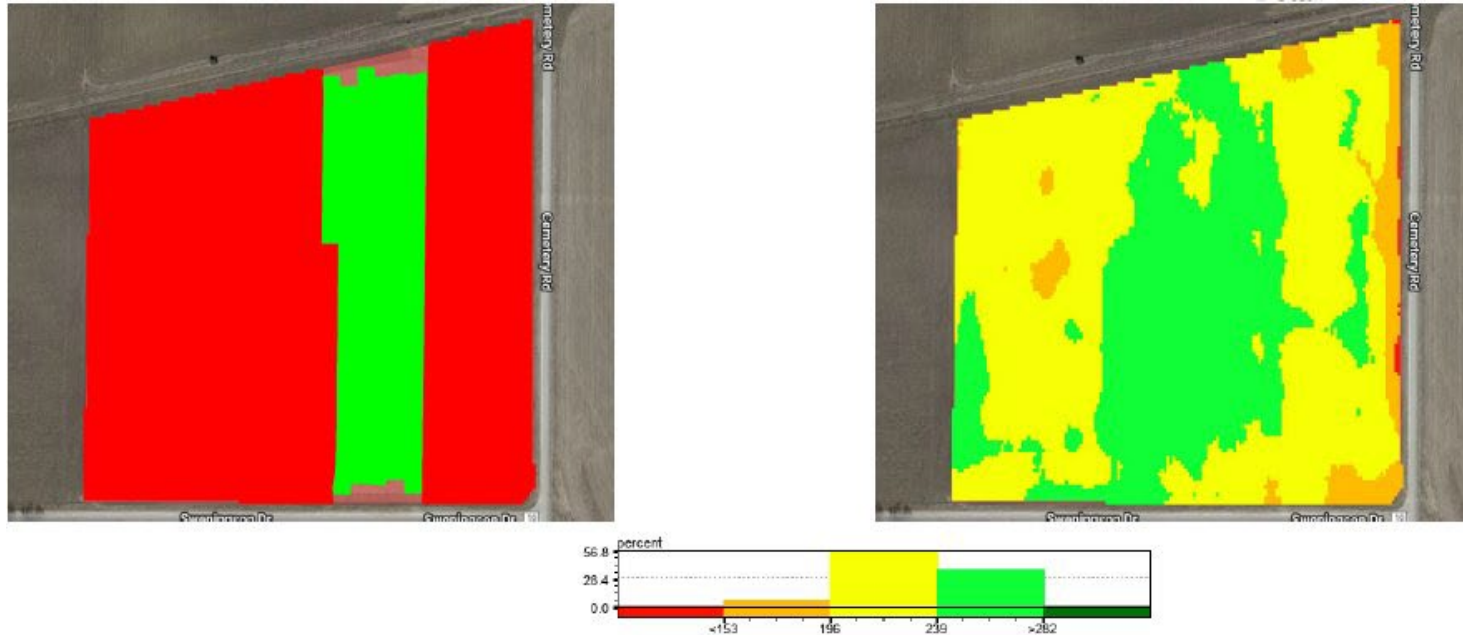
- Bio-Cal applied two consecutive years
  - 500 pounds per acre
- Corn / Soy Rotation
- Multiple nutrient management strategies
  - 15,000 gallons per acre dairy manure
  - 5 ton per acre dry bed pack and potash (110 pounds per acre)
  - 148 pounds per acre potash
  - LIF starter and control
- No-Till / Conventional Tillage



Bio-Cal treatments outlined in blue

# 2023

## Bio-Cal increased corn yields 16.88 bushels per acre - Winona, Minnesota



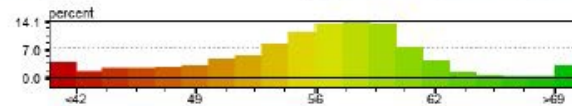
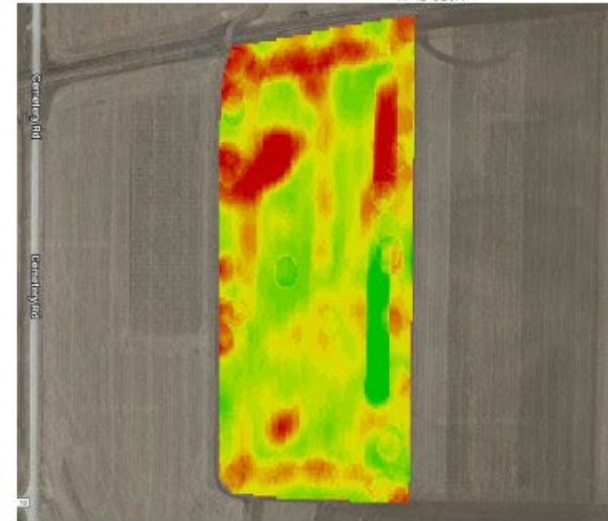
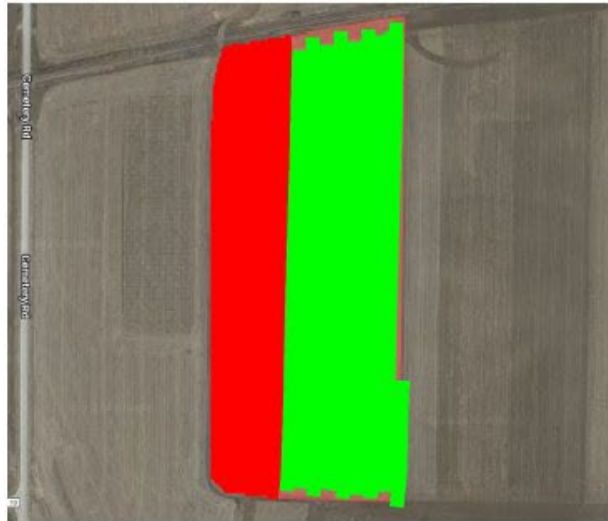
Total Harvested Acres: 37.27  
Whole Field Yield Average: 230.86

Zone No.	Mgmt Zone Name	Range	Zone Name	Data	Avg Moisture%	Avg Yield	HarvestAcres	Area
Zone 1	BIO-GEL Trial 1.26	Min - Max	1	None	23.28	227.72 bu/ac	29.08	29.11
Zone 2	BIO-GEL Trial 1.26	Min - Max	2	None	24.47	244.60 bu/ac	7.45	7.47



# 2023

## Bio-Cal increased soybean yields 3.16 bushels per acre



Total Harvested Acres: 25.98  
 Whole Field Yield Average: 55.57

Zone No.	Mgmt Zone Name	Range	Zone Name	Data	Avg Moisture%	Avg Yield	HarvestAcres	Area
Zone 1	BIO-CAL Trial 1.26	Min - Max	1	None	10.33	53.63 bu/ac	9.85	9.87
Zone 2	BIO-CAL Trial 1.26	Min - Max	2	None	10.77	56.79 bu/ac	15.25	15.52



# Bio-Cal increased corn silage ROI

## - Winona, MN

BIO-CAL CORN SILAGE ROI				Control	Bio-Cal	
Pounds Per Acre - Applied				0	500	1000
Milk 2006 Non-Processed				3403	3428	3582
Average Corn Silage Yield (Dry Matter Tons Per Acre)	10			-	-	-
Pounds Per Acre - Milk				34030	34280	35820
Milk Revenue	\$0.20			\$6,806.00	\$6,856.00	\$7,164.00
BIO-CAL Cost (per acre)	\$0.05			\$0.00	\$22.50	\$45.00
BIO-CAL ROI				-	1	7

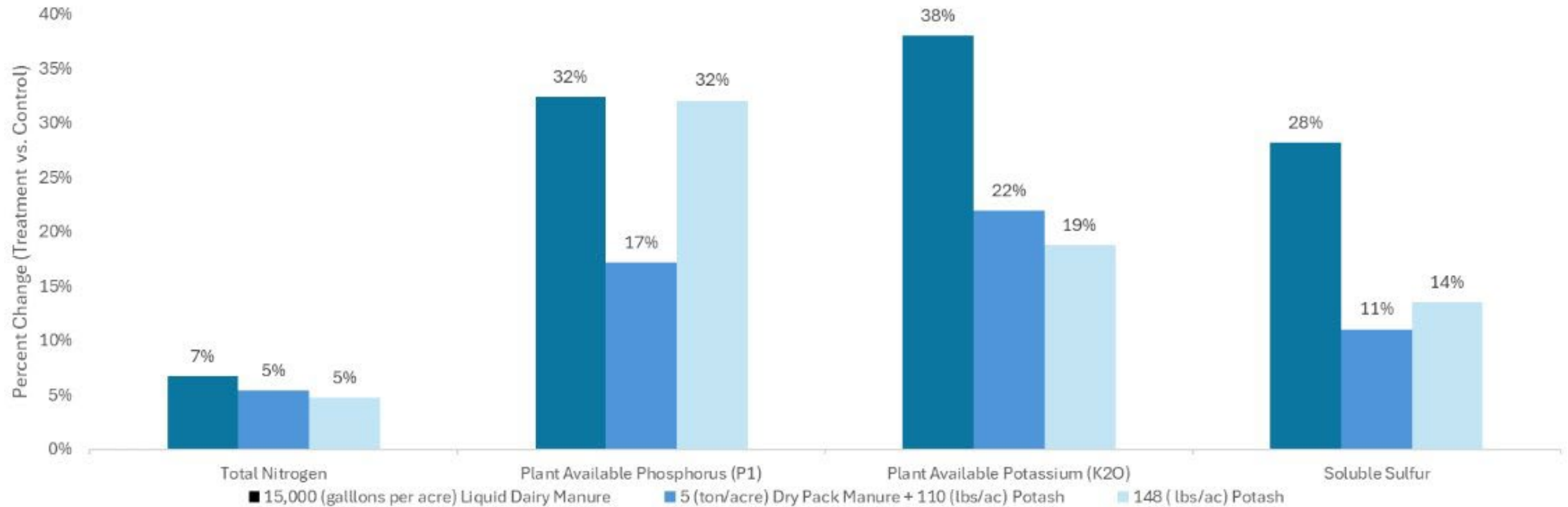
Potential Increased Revenue \$358 per acre

BIO-CAL CORN SILAGE ROI				Control	Bio-Cal	
Pounds Per Acre - Applied				0	500	1000
ISU Beef				298	289	310
Average Corn Silage Yield (Dry Matter Tons Per Acre)	10			-	-	-
Pounds Per Acre - Beef				2980	2890	3100
Beef Revenue (per pound)	\$2.75			\$8,195.00	\$7,947.50	\$8,525.00
BIO-CAL Cost (per acre)	\$0.05			\$0.00	\$22.50	\$45.00
BIO-CAL ROI				-	-12	6

Potential Increased Revenue \$330 per acre

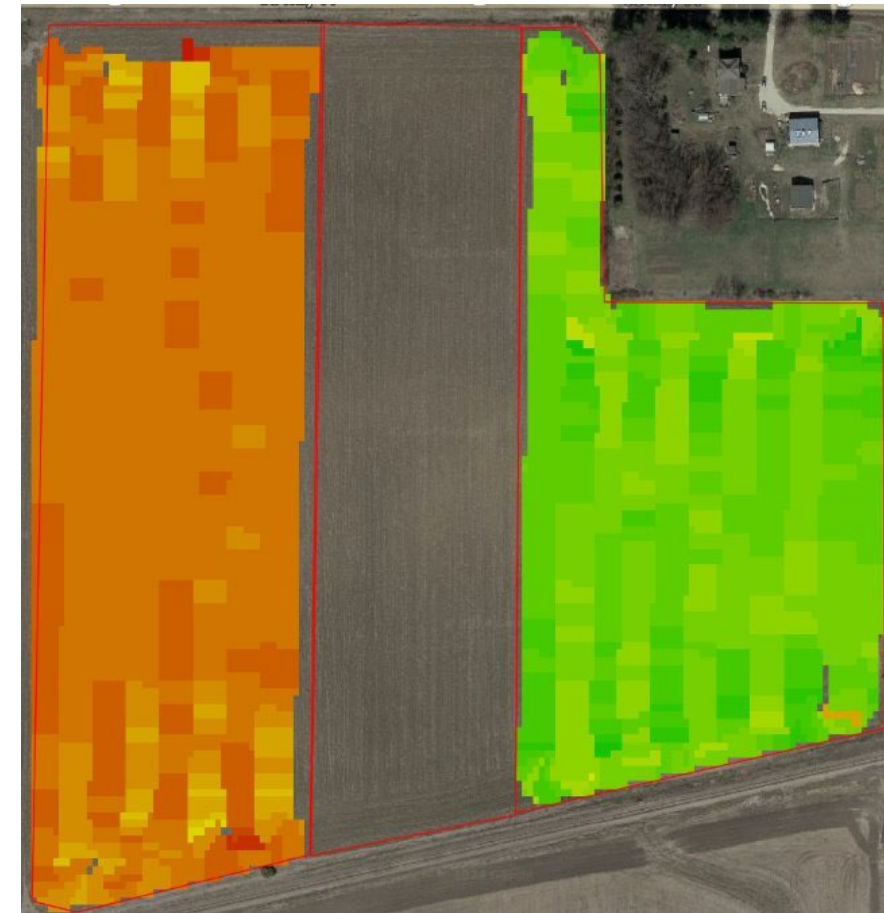
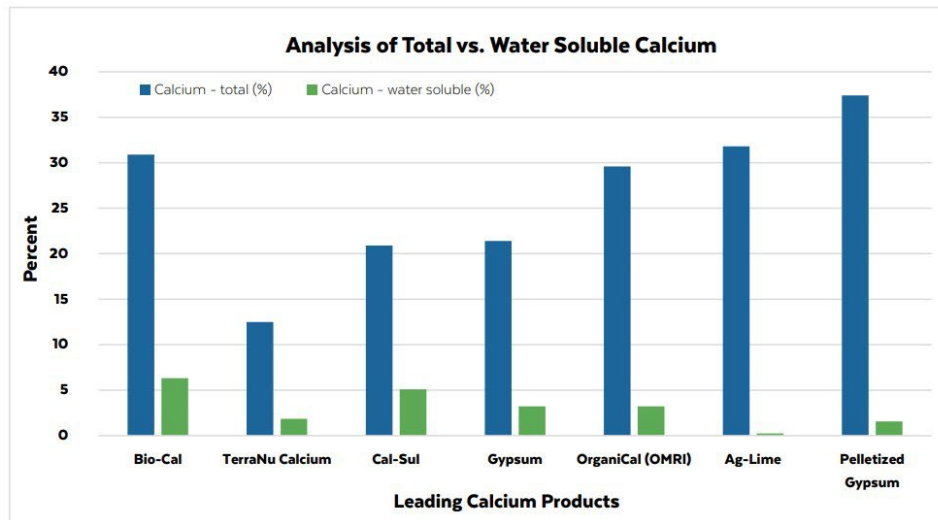
**Bio-Cal**<sup>®</sup>

## Comparative Impact of Bio-Cal and Nutrient Management Practices on Soil Macronutrient Availability for a Southeastern Minnesota Dairy Farm (2024)



# Lastly, with the high level of total calcium in Bio-Cal we questioned the impact Bio-Cal has on soil pH

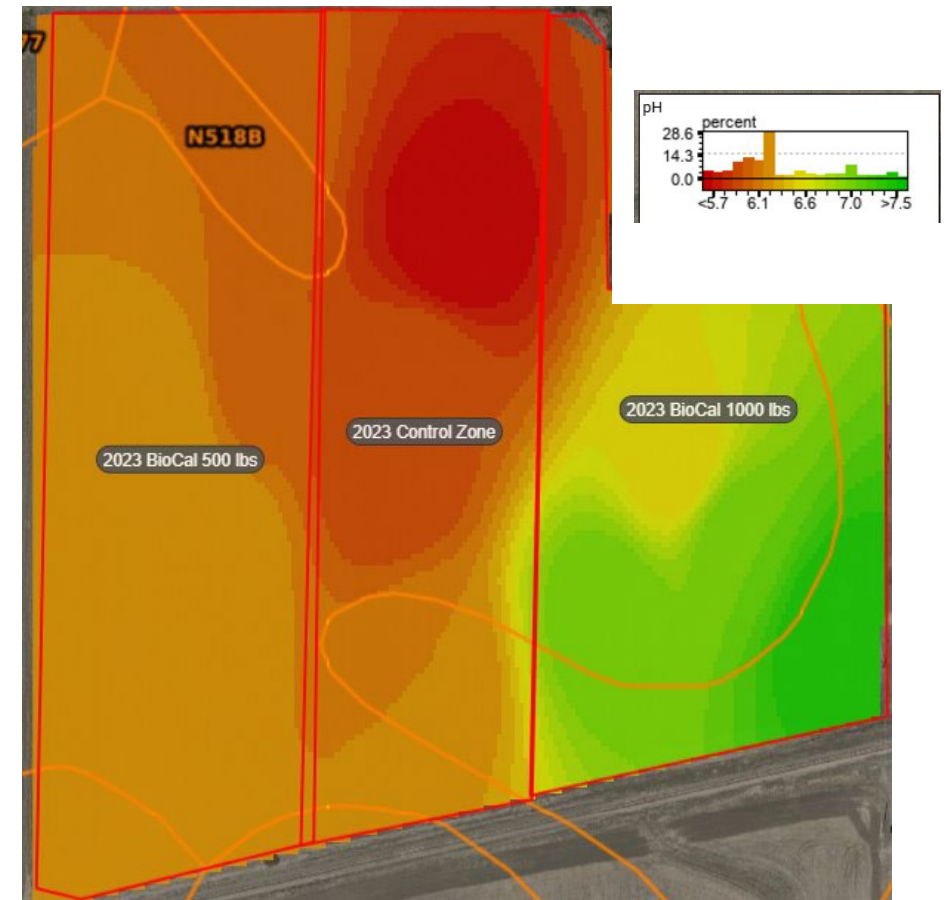
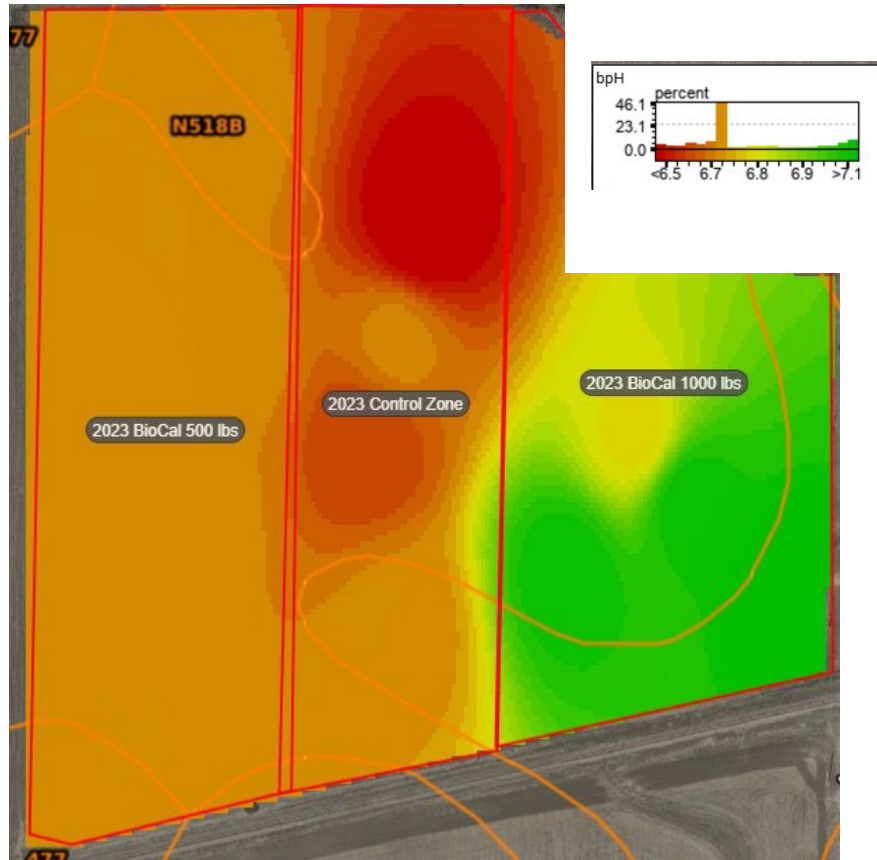
Sample ID: 2-BC	Lab Number: 70076386		
Moisture	8.5	%	
Calcium (total)	30.9	%	
Magnesium (total)	2.52	%	
Total neutralizing value (CaCO3 eq)	73.1	%	
ECCE	47.4	%	
% passing 4 sieve	96.4	%	
% passing 8 sieve	90.0	%	
% passing 60 sieve	46.9	%	
Calcium (water soluble)	63200	mg/L	



500 Bio-Cal

1000 Bio-Cal

# Bio-Cal Increased Mid-Season Soil pH and bpH as Application Rate Increased suggesting added value as a pH neutralizer



# OrganiCal™

Chris Kniffen, Director of Research



# OrganiCal™ performance was assessed on alfalfa production in Illinois

OrganiCal™ includes two calcium sources — finely ground gypsum and 300-mesh high calcium lime.

OrganiCal™ can improve multiple soil types. Sulfur and calcium can improve the soil structure of heavy soils, and humates can increase plant-available sulfur and calcium levels in light soils.

OrganiCal™ contains sulfate sulfur, which is necessary for plant protein formation.

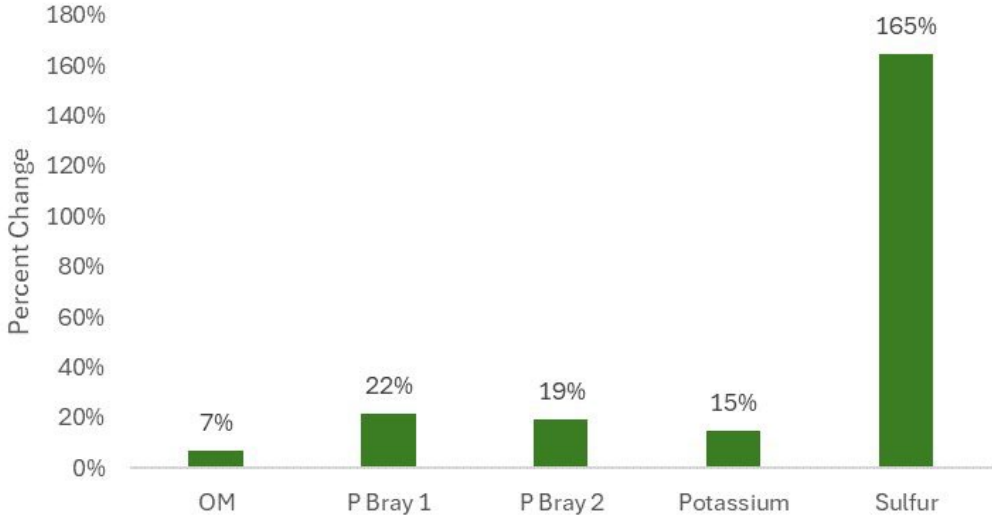
OrganiCal™ delivers the sulfur your crops need to help prevent sulfur deficiency

1000 pounds per acre OrganiCal™ was applied along with grower standard practice of 2 ton/acre chicken litter.

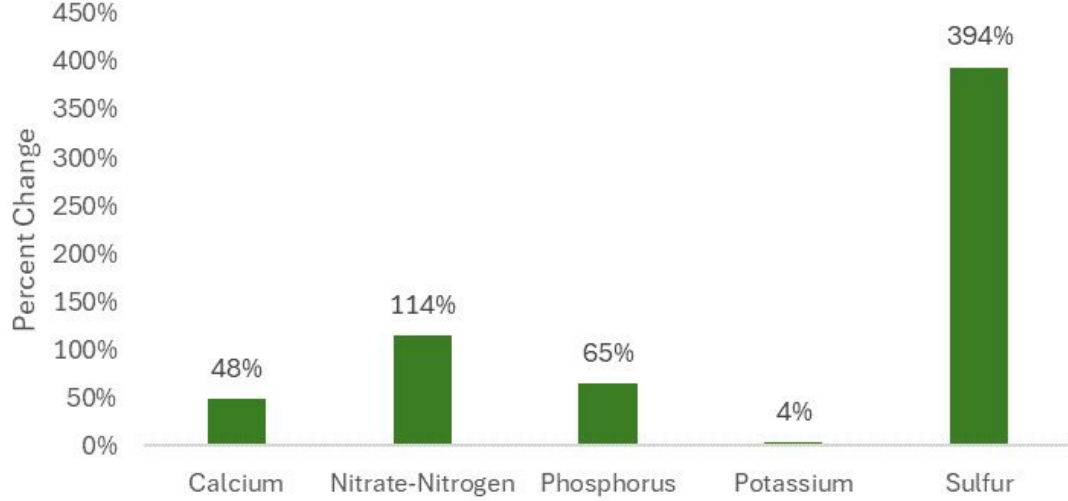


# OrganiCal™ increased plant available and soluble soil nutrients with the strongest uplift in reported in sulfur

Impact of OrganiCal on Plant Available Soil Nutrients

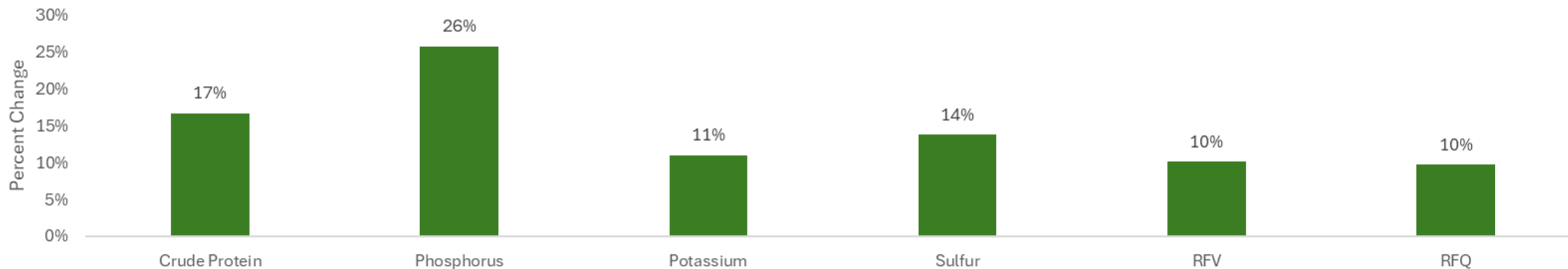


Impact of OrganiCal on Mid-Season Soluble Soil Nutrients



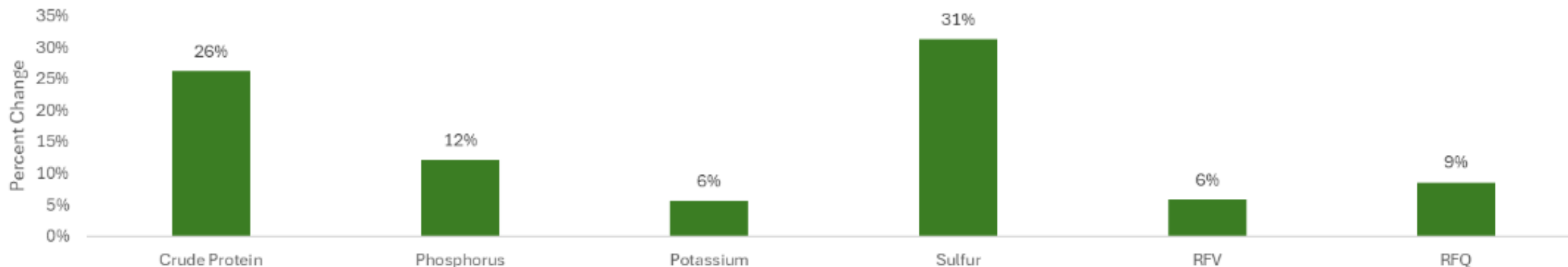
# Impact of OrganiCal on First Cutting Alfalfa

6/7/2024



# Impact of OrganiCal on Second Cutting Alfalfa

7/23/2024





First Cutting  
**Treatment (left) Control (right)**



Second Cutting  
**Treatment (left) Control (right)**