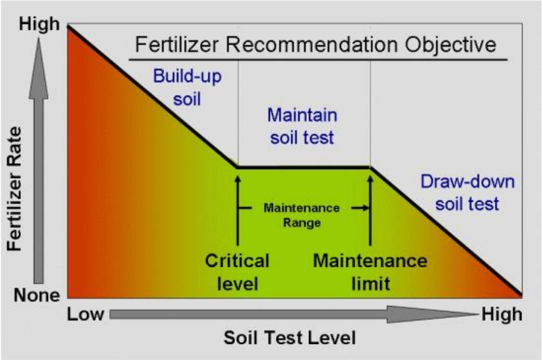
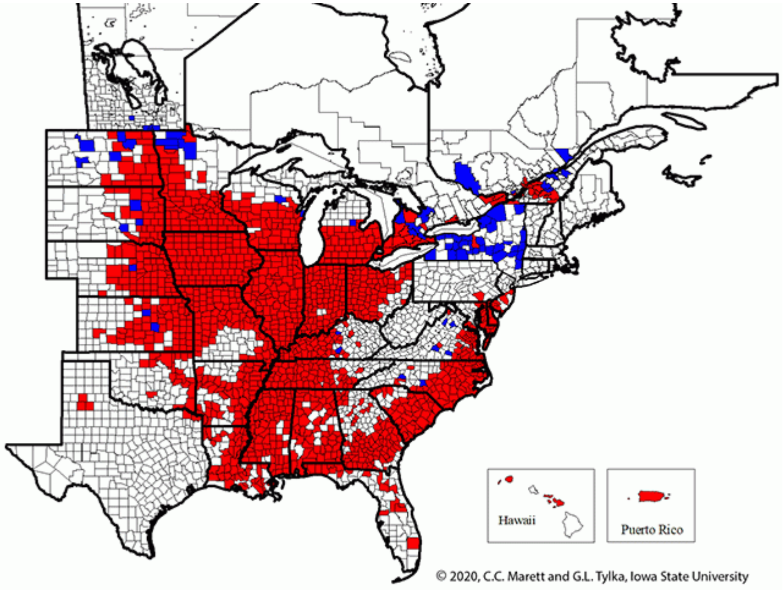
AGVISE Demonstration Project Update



Vitosh et al. (1995)

- Agvise Seminars
- January 3-5, 2023
- Brent Jaenisch, Ph.D.



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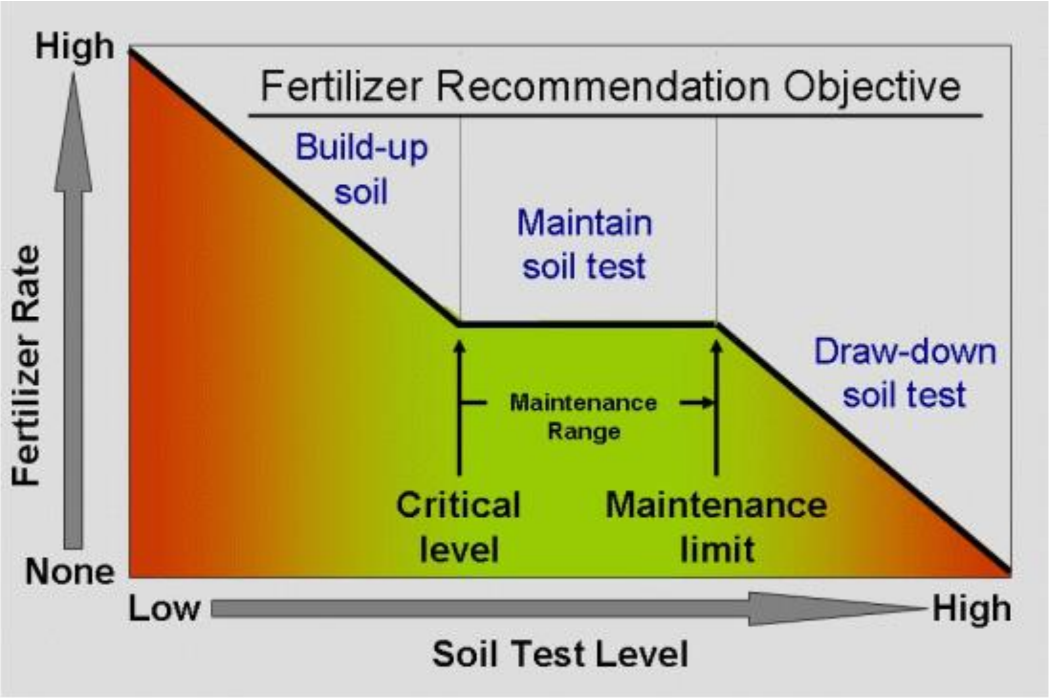
Outline

- Increasing soil test P and K values
- Decreasing soil pH with elemental sulfur
- SCN Project
- Summary

SCN-resistant soybean variety on left and SCN-susceptible variety on right.

Background – Why build soil test P and K values?

- Reduce fertilizer rates when prices are high
- Risk management



Vitosh et al. (1995)

Questions from growers about P

- Can you actually increase soil test phosphorus on high pH and calcareous soils?
    - We know high pH and calcium carbonate do increase phosphorus fixation.
- How much P does it actually take to move these soil test numbers in our upper Midwest soils?

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Questions from growers about K

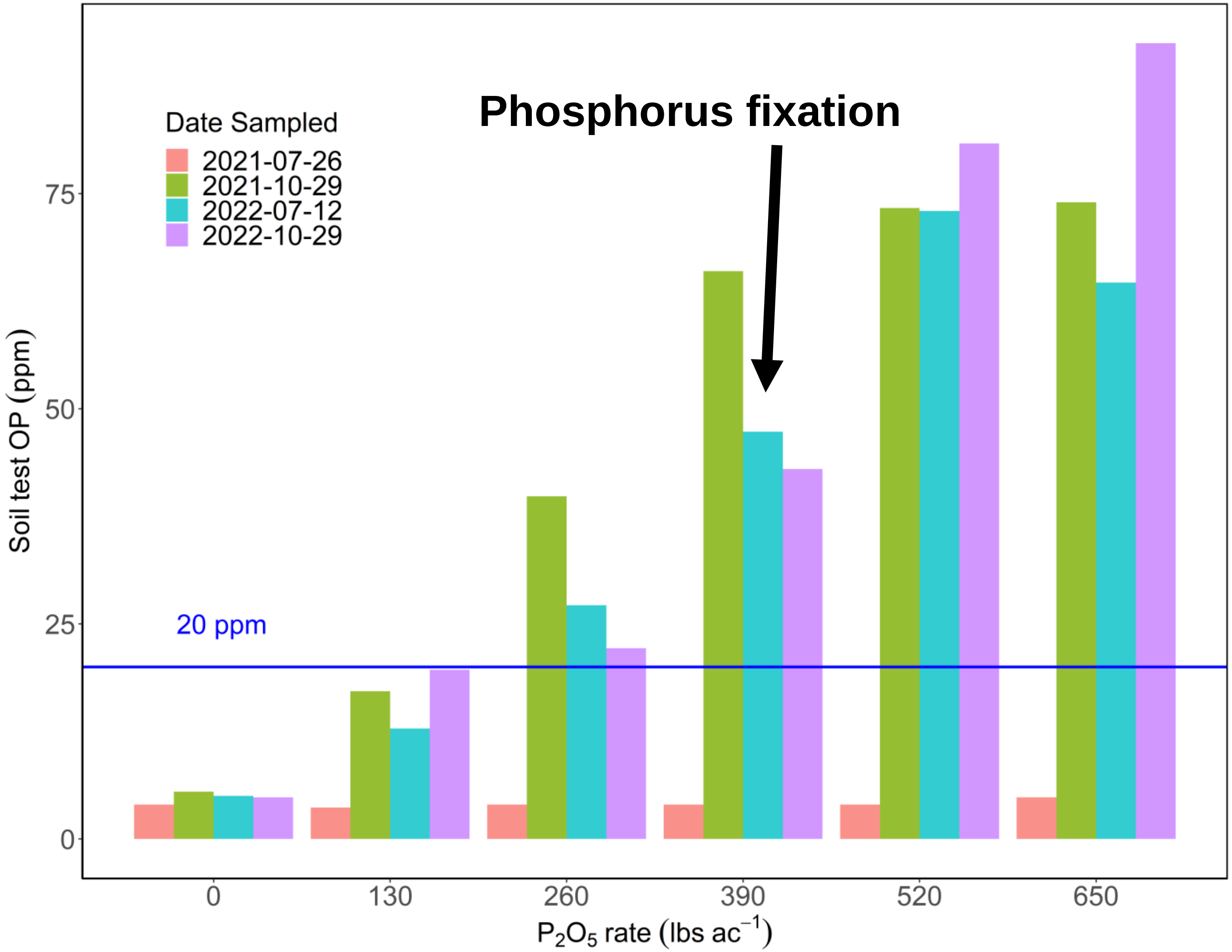
- Are you able to increase potassium saturation (%K) or base cation saturation ratios?
  - We know soils with high clay content have higher K buffering capacity.
  - We know soils with high pH, calcium carbonate, or salinity have inflated CECs and screwy BS calculations.
  - We know %K saturation is not important for soil potassium availability or crop uptake, so why do we still keep getting these questions?
- How much K does it actually take to move these soil test numbers in our upper Midwest soils?

Long-term phosphorus and potassium fertilizer rate trial

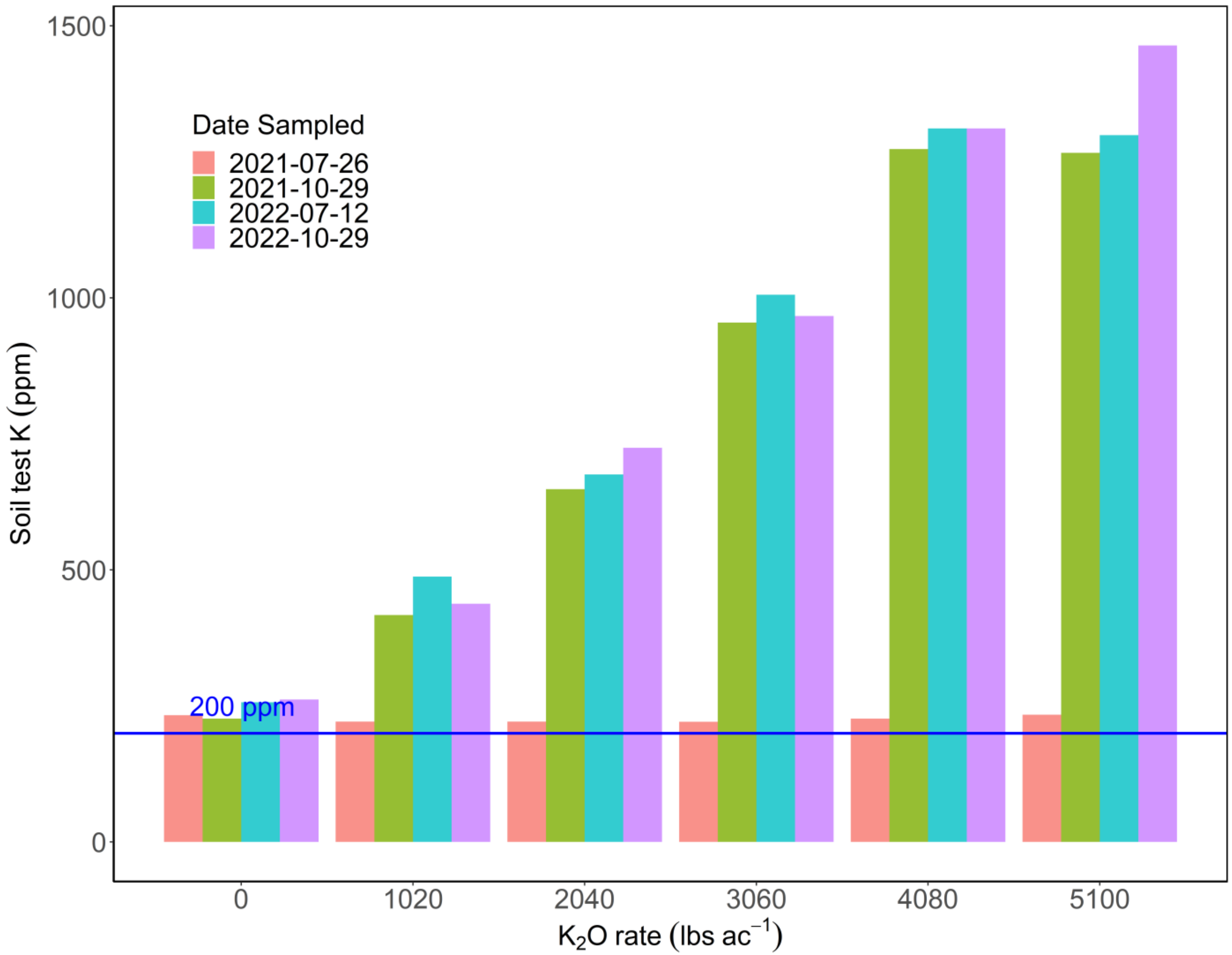
- **Site:** Northwood, ND
  - Bearden silty clay loam
  - Soil pH: 7.9
  - Carbonate: 4.5% CCE
  - Initial soil test OP: 4 ppm
  - Initial soil test K: 226 ppm
  - Initial %K: 1.1%
- **Treatments:**
  - 0 to 1,250 lb/acre MAP (11-52-0)
  - 0 to 8,500 lb/acre potash (0-0-60)
  - rototilled to 6 inches after application

Trial initiated: September 1, 2021

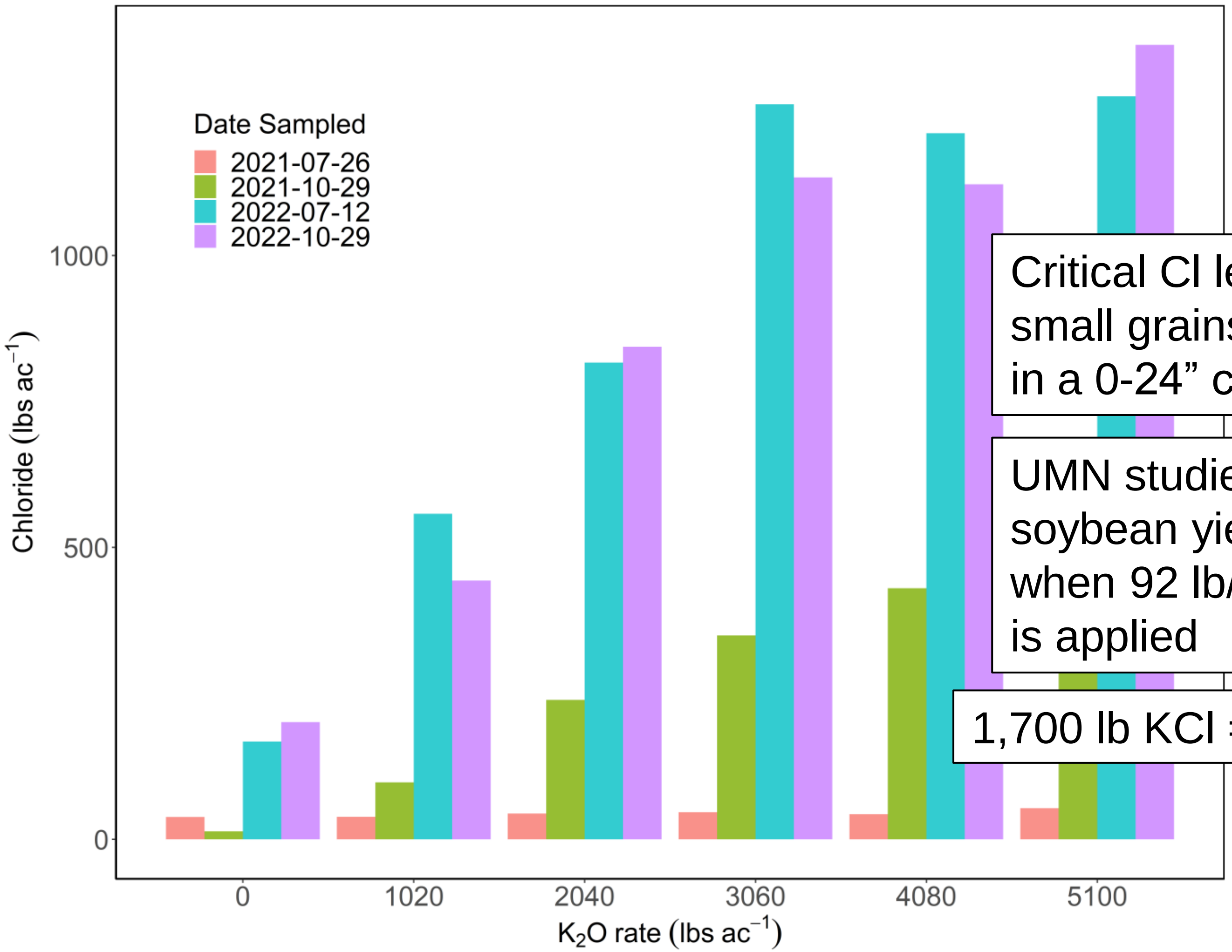
Building soil test phosphorus



Building soil test potassium



Effect of potash rate on soil chloride (lb/acre) October 29, 2022

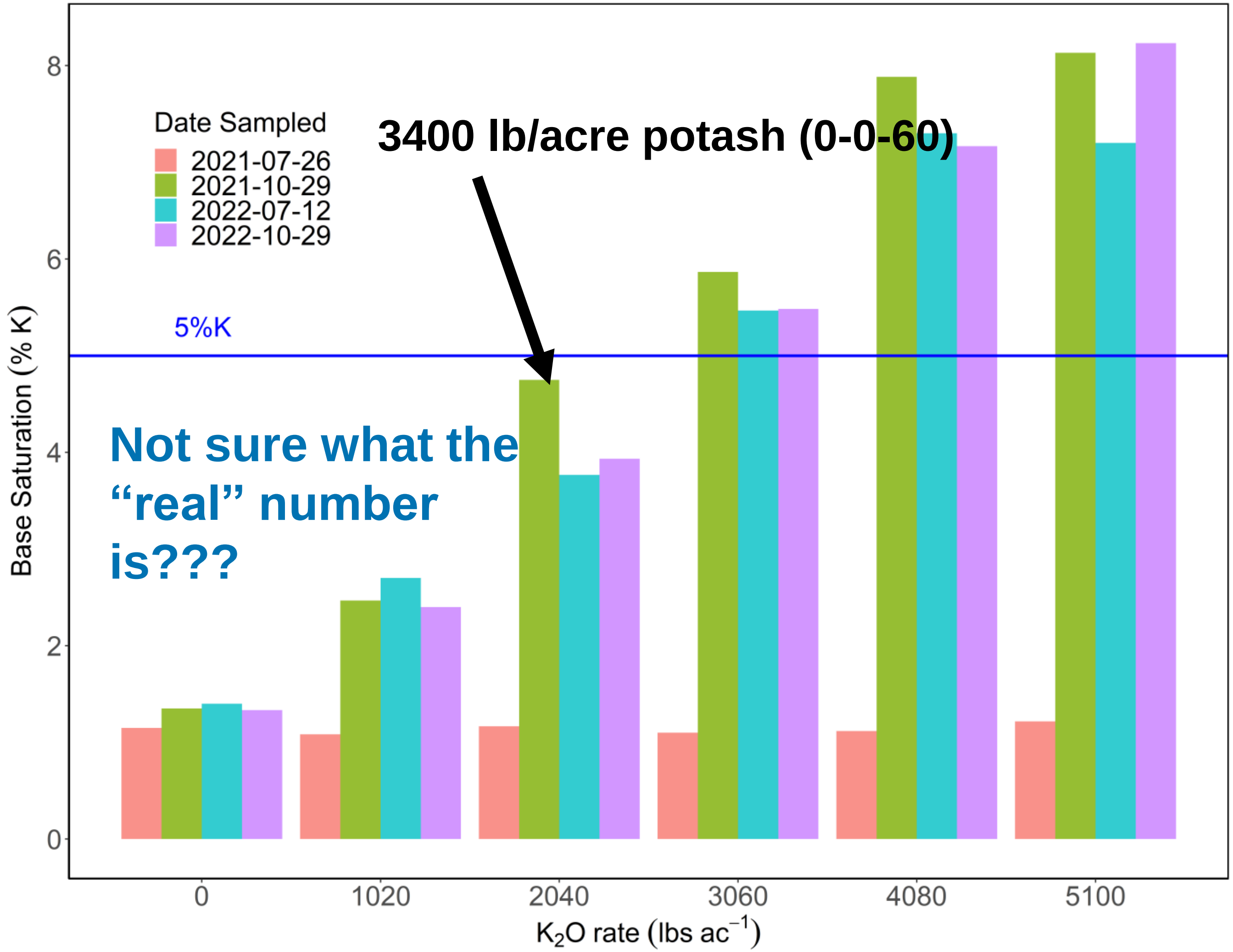


Critical Cl level for small grains = 40 lb/A in a 0-24” core

UMN studies show soybean yield loss when 92 lb/A chloride is applied

1,700 lb KCl = 782 lb Cl

Building potassium base saturation



Soil buffering capacity, so far

Soil buffering capacity (building factor) describes how much added nutrient (fertilizer) is required to increase the soil test level. Factors include soil pH, soil texture, mineralogy, carbonate, and others.

Bearden silty clay loam, pH 7.9, 4.5% CCE.

Parameter	General range	Unit	Oct. 2021 (2 months)	July 2022 (10 months)	Oct. 2022 (14 months)
Soil test P (Olsen)	15-20 lb/ 1 ppm	P_2O_5	7.2 lb/ppm	8.1 lb/ppm	9.3 lb/ppm
Soil test K	5-10 lb/ 1 ppm	K_2O	4.2 lb/ppm	4.4 lb/ppm	4.2 lb/ppm
K saturation	soil dependent	K_2O	660 lb/%	770 lb/%	772 lb/%

Phosphorus fixation is occurring. Soil test P will decline, resulting in the buffering capacity to increase over time and approach the expected range of 15-20 lb/ppm. Potassium sits close to the expected range of 5-10 lb/ppm.

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Excessive Potash Fertilization Negatively Impacted Corn Growth and Grain Yield in Eastern South Dakota

Andrew Ahlersmeyer[1], Jason Clark[2]

[1]M.S. Student, South Dakota State University

[2]Assistant Professor and Extension Soil Fertility Specialist, South Dakota State University

South Dakota
State University

Objectives

1. **Investigate the negative implications of this practice on corn growth and yield**
2. **Provide possible explanations for this occurrence**

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Materials and Methods

- Soil samples were collected prior to treatment application
  - Various physical, chemical, and biological parameters tested
  - Sample depths of 0-10, 0-15, 15-30, and 30-60 cm
- Treatments of potash (0-0-60) were manually broadcast applied prior to VE
  - Conventional and excessive rates
- Response parameters:
  - V6 stand estimates, vegetative K content, and dry matter
  - NDVI imagery (Brookings-2022)
  - Grain yield
- Statistics analyzed in Excel and R

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5

Materials and Methods

Conventional K Rates

Applied as part of the primary potassium rate study

- 0 kg K_2O ha^{-1}
- 34 kg K_2O ha^{-1}
- 67 kg K_2O ha^{-1}
- 101 kg K_2O ha^{-1}
- 134 kg K_2O ha^{-1}
- 168 kg K_2O ha^{-1}

Excessive K Rates

Applied to increase base saturation K to 40 and 70 g kg^{-1}

Yankton-2021

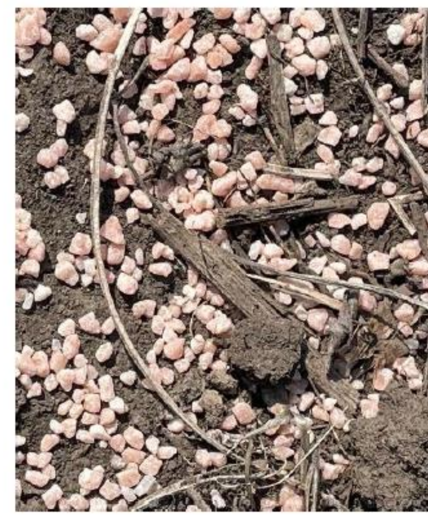
- 1434 kg K_2O ha^{-1}
- 2509 kg K_2O ha^{-1}

Brookings-2022

- 1553 kg K_2O ha^{-1}
- 2718 kg K_2O ha^{-1}

Minnehaha-2022

- 1493 kg K_2O ha^{-1}
- 2613 kg K_2O ha^{-1}



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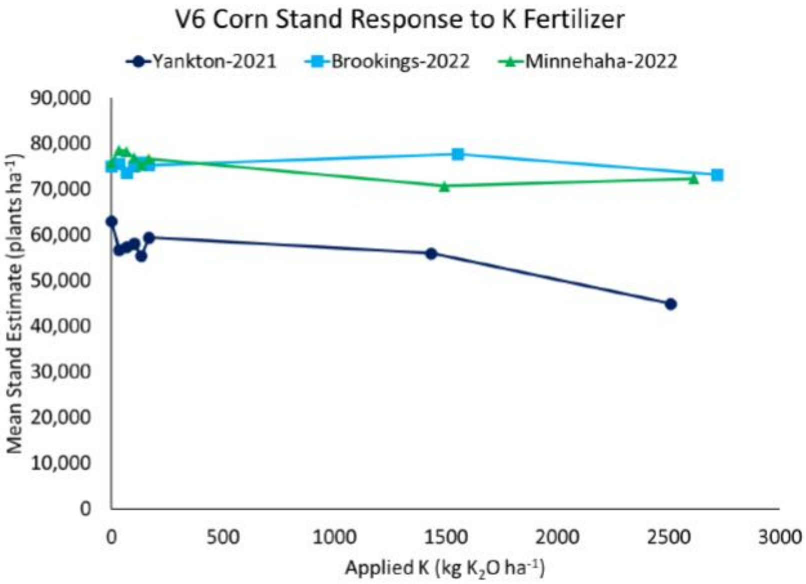
V6 Stand Estimates



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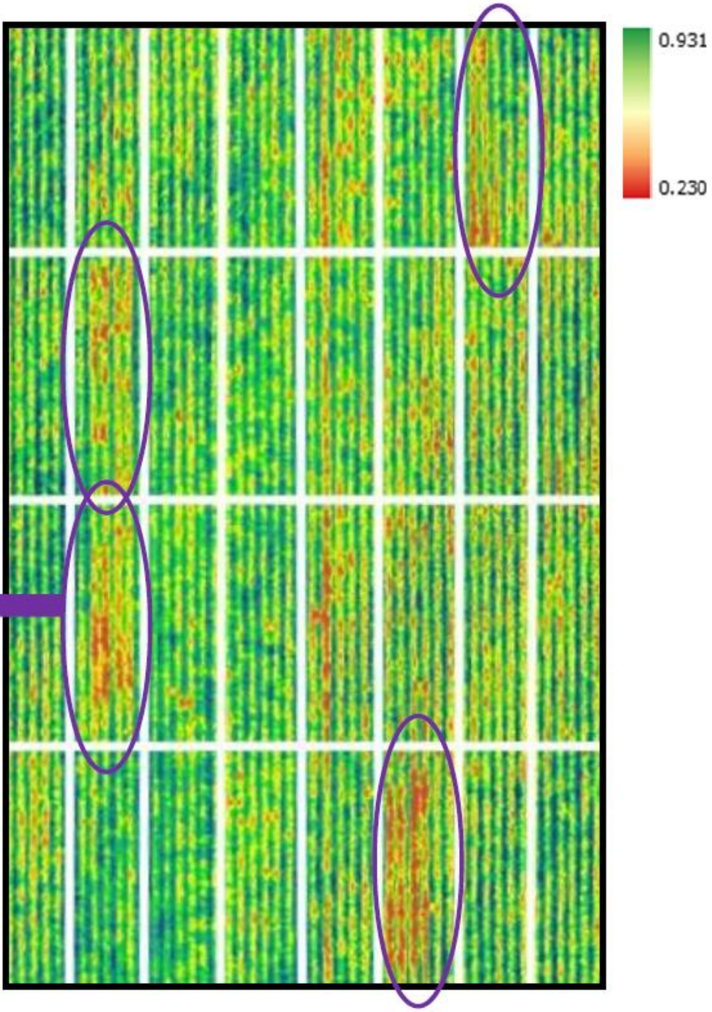
NDVI Imagery

Circled plots:
2718 kg K_2O ha^{-1}



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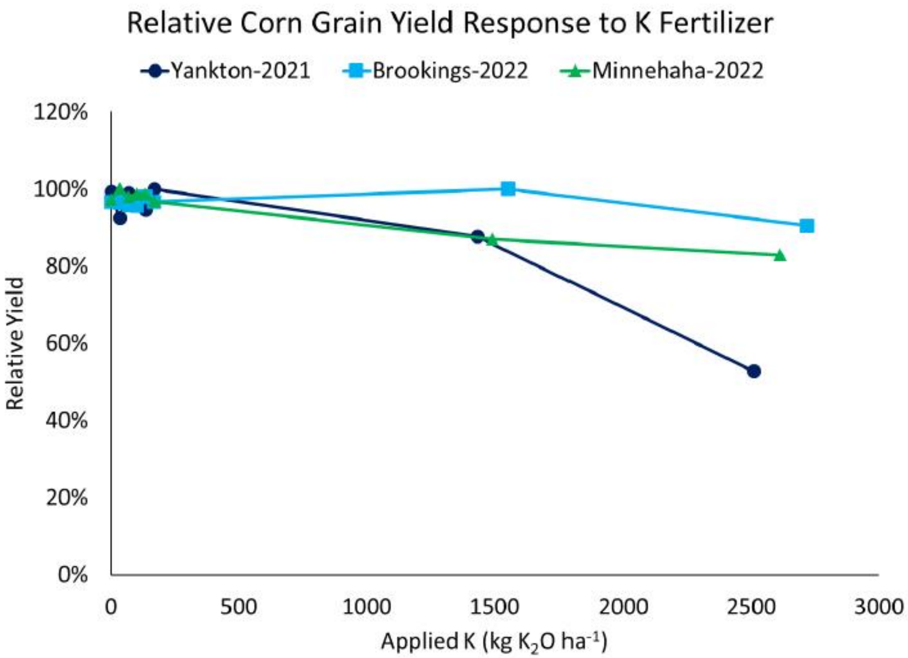
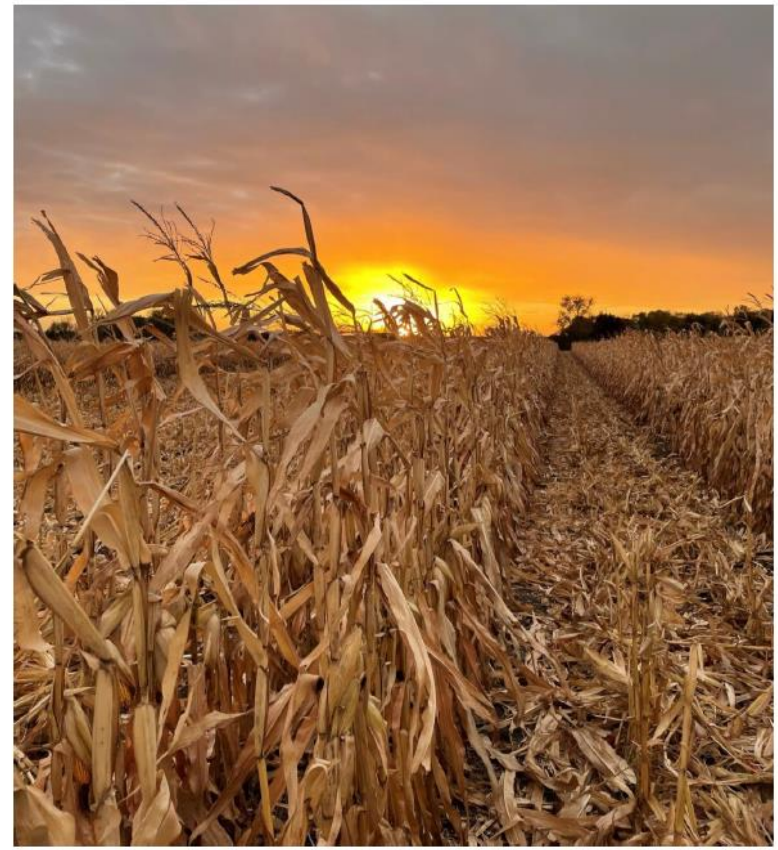
Grain Yield





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Conclusions

- In addition to being uneconomical, these excessive potash rates:
  - Reduced early season corn stands at all sites
  - Reduced corn dry matter at all sites
  - Reduced corn vegetative K content at two of three sites
  - Reduced final grain yield at all sites
- Likely due to a combination of factors, including:
  - Inadequate precipitation during V stages at Yankton and Minnehaha sites
  - Excessive salts from high rates of potash

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Quick observations

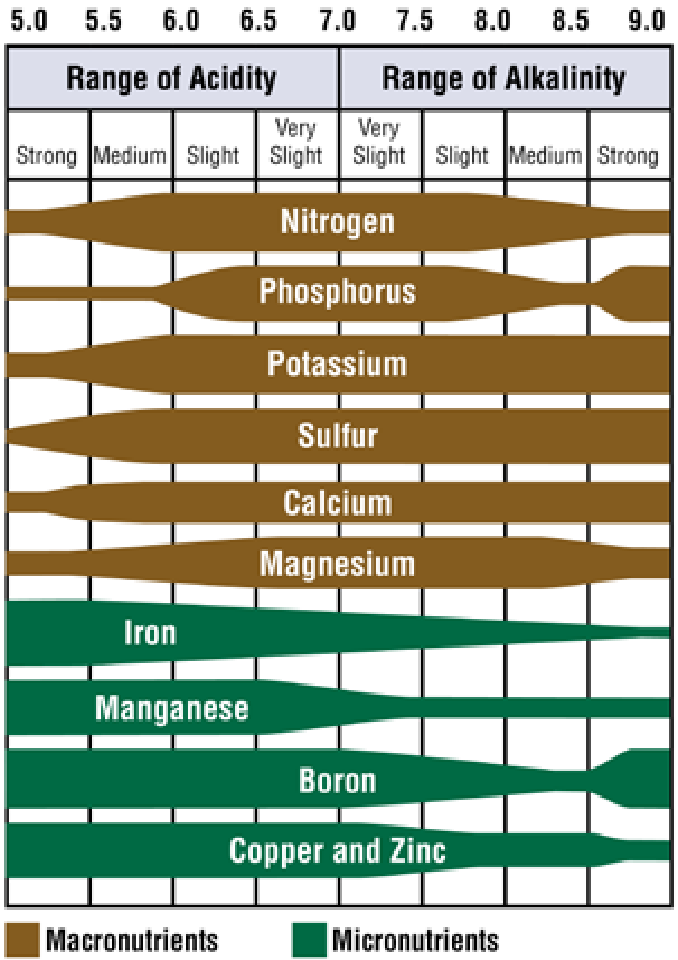
Phosphorus

- Soil test P increased quickly from “fresh” P
- Phosphorus fixation is occurring and decreasing soil test P

Potassium

- Soil test K increased with increasing rate
- %K increased to 4-8% when high rates of K were applied
  - 3,400 – 8,500 lbs./ acre potash
- 100 years worth of K

Soil pH



Purdue Extension publication ID - 179

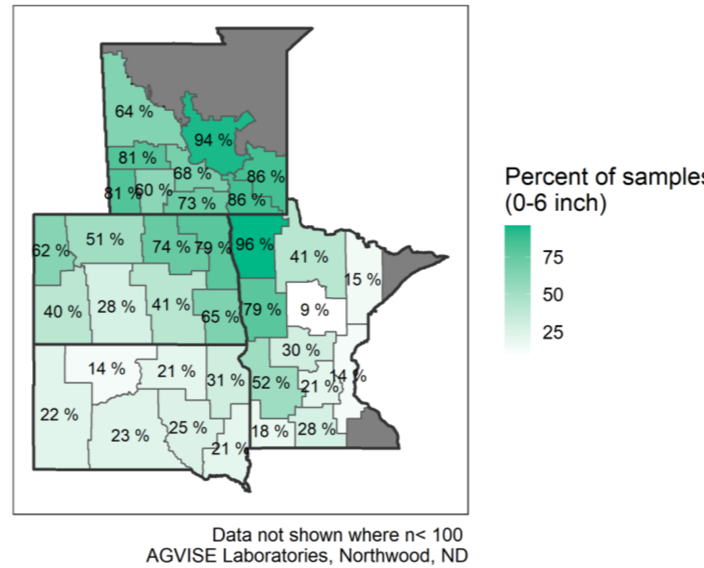
Atrazine carryover at pH > 6.8

Purdue Extension publication ID – 2018.13

Is there an easy way to lower high pH?

- Soils in the Northern Great Plains often have soils with high pH (>7.3)
  - Soils with free calcium carbonate ($CaCO_3$) will have a pH buffered around 8
- Soil pH controls availability of plant nutrients
  - Lowering soil pH may increase nutrient availability
- Elemental sulfur often marketed as an “easy solution” to reduce pH

Soil samples with soil pH above 7.3 in 2020



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Picture from: https://www.amazon.com/Walts-Elemental-Sulfur-Pellets-10/dp/B016YYNMB4

Soil pH

Table 3-3 Soil Acidity Produced by N and S Fertilizers

Fertilizer Source	*Soil Reaction*	*mole H^+/ mole N+S*	*$CaCO_3$ Equiv.**
Anhydrous ammonia	$NH_3 + 2O_2 \rightarrow H^+ + NO_3^- + H_2O$	1	3.6
Urea	$(NH_2)_2CO + 4O_2 \rightarrow 2NO_3^- + 2H^+ + CO_2 + H_2O$	1	3.6
Ammonium nitrate	$NH_4NO_3 + 2O_2 \rightarrow 2NO_3^- + 2H^+ + H_2O$	1	3.6
Ammonium sulfate	$(NH_4)_2SO_4 + 4O_2 \rightarrow 2NO_3^- + 4H^+ + SO_4^{-2} + H_2O$	2	7.2
Monoammonium phosphate	$NH_4H_2PO_4 + O_2 \rightarrow 2NO_3^- + 2H^+ + H_2PO_4^- + H_2O$	2	7.2
Diammonium phosphate	$(NH_4)_2HPO_4 + O_2 \rightarrow 2NO_3^- + 3H^+ + H_2PO_4^- + H_2O$	1.5	5.4
Elemental S	$2S + 3O_2 + 2H_2O \rightleftarrows 2SO_4^{-2} + 4H^+$	2	7.2
Ammonium thiosulfate	$(NH_4)_2S_2O_3 + 6O_2 \rightarrow 2SO_4^{-2} + 2NO_3^- + 6H^+ + H_2O$	1.5	5.4

*$CaCO_3$ equivalent → lbs $CaCO_3$ required per lbs N applied to neutralize acidity in the fertilizer.

SOURCE: Adams, 1984, *Soil Acidity and Liming*, No. 12, p. 234, ASA.

Table 3-3 shows the theoretical quantity of $CaCO_3$ needed to neutralize the acidity produced per unit of N or S fertilizer applied. For example with $(NH_4)_2SO_4$, 7.2 lbs $CaCO_3$ are needed to neutralize the H^+ produced per lb of N applied. The method used to determine the $CaCO_3$ equivalent for $(NH_4)_2SO_4$ is as follows:

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The science behind lowering pH with elemental sulfur

- High pH soils have “free lime” ($CaCO_3$)
- Free lime must be neutralized before pH can be reduced
- When S^0 is applied to soil, it is oxidized by soil bacteria (*Thiobacillus*). Thus, forming sulfuric acid

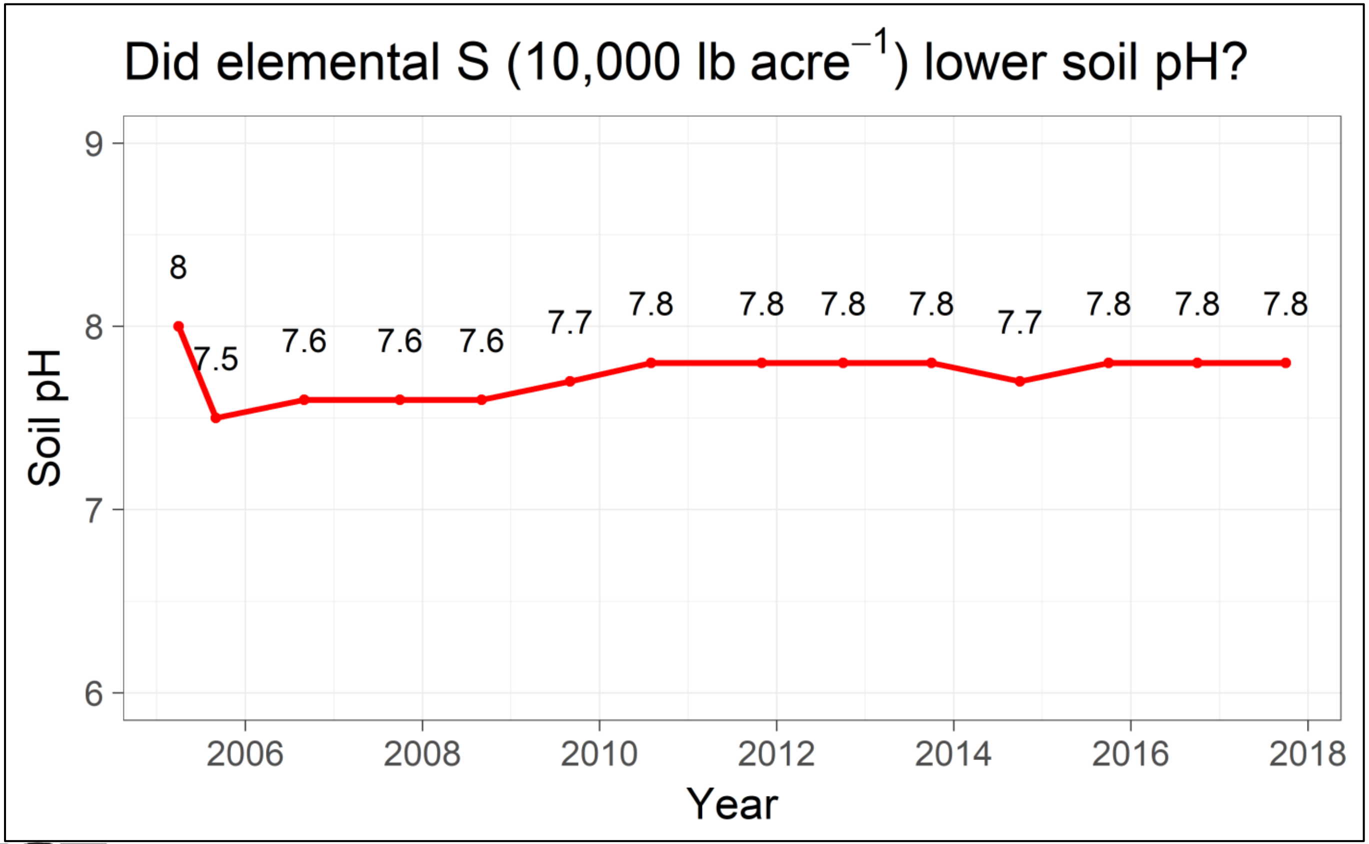
- Sulfuric acid produces H^+ ions, which can neutralize free lime in the soil
- Any other form of sulfur fertilizer (e.g. gypsum) is the sulfate form of sulfur and CAN NOT neutralize free lime

I only need about 100 lb/A elemental sulfur, right?

AGVISE Demonstration 2005-2017

Soil had 1.5% CCE, starting pH was 8

Elemental S applied in 2005

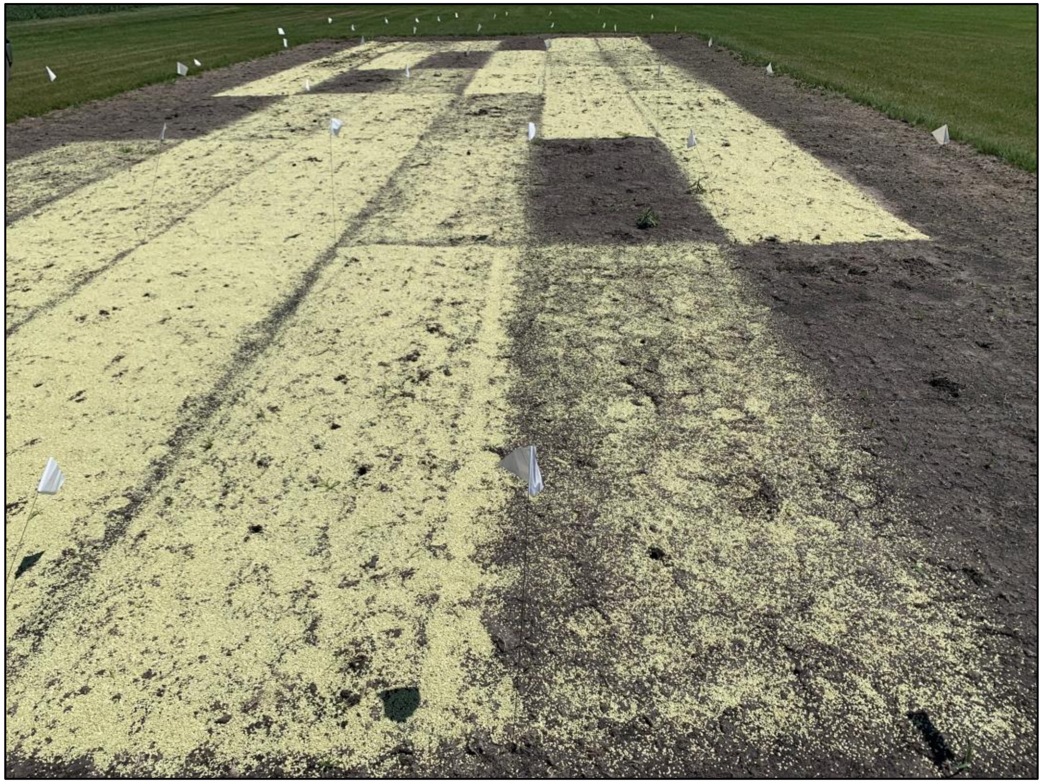


Again starting in 2020, with higher rates!

Objective: evaluate long-term effectiveness of elemental S as a soil amendment to reduce soil pH on a calcareous Northern Plains soil.

Site: Northwood, ND Bearden silty clay loam, soil pH 8.0, average **CCE: 4.5%**

Treatments: 0 to 40,000 lbs/A elemental sulfur, tilled to 6” after application



It takes about 3.2 tons elemental sulfur/acre to neutralize 1% CCE in soil

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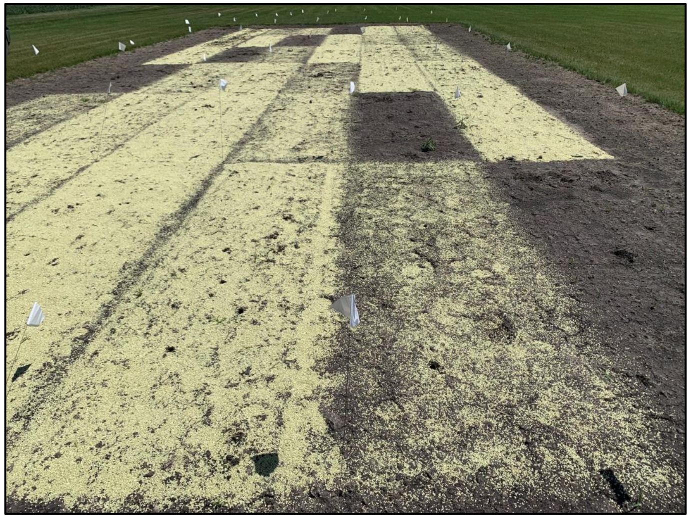
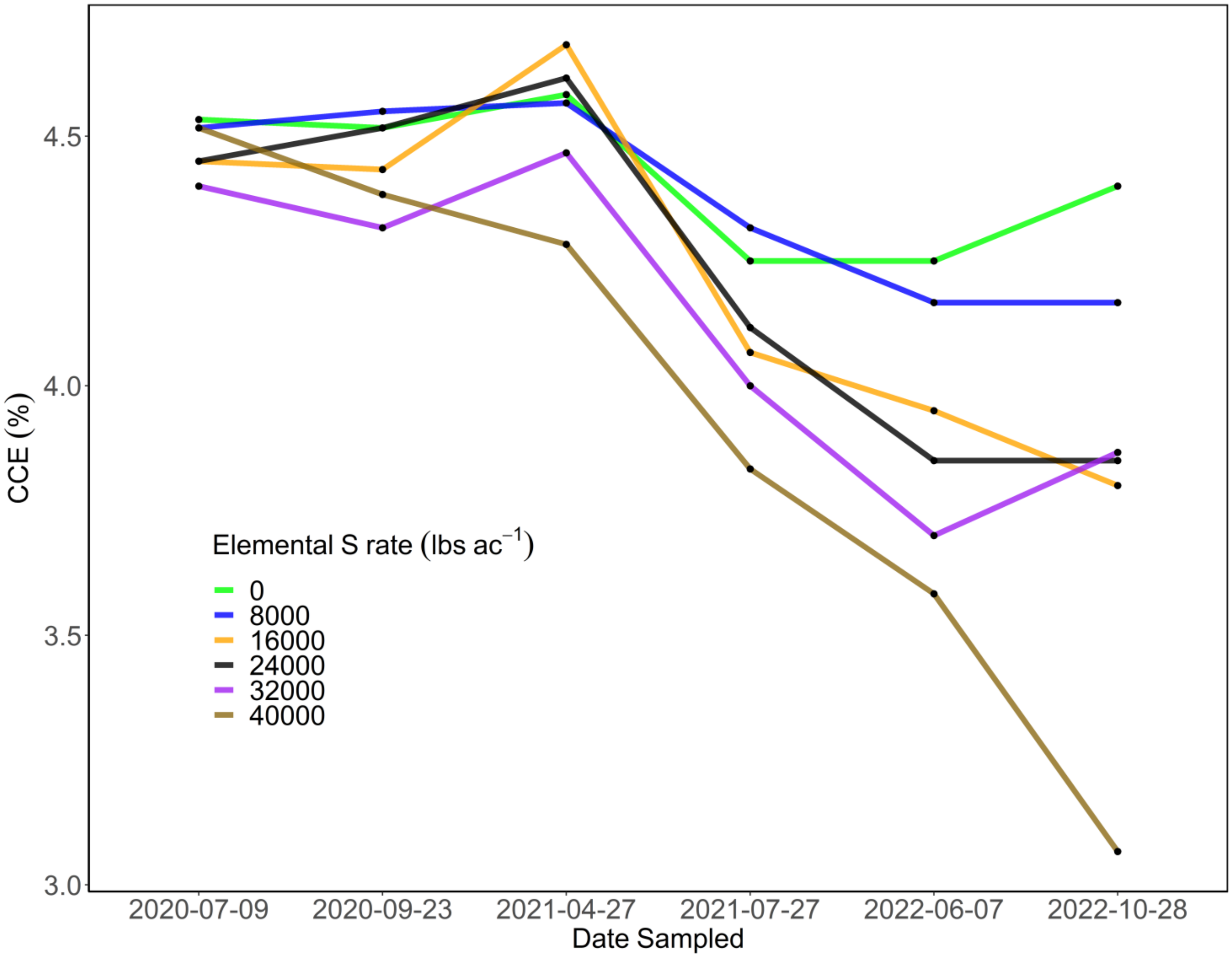
Sampling almost 2 years later…



August 2020

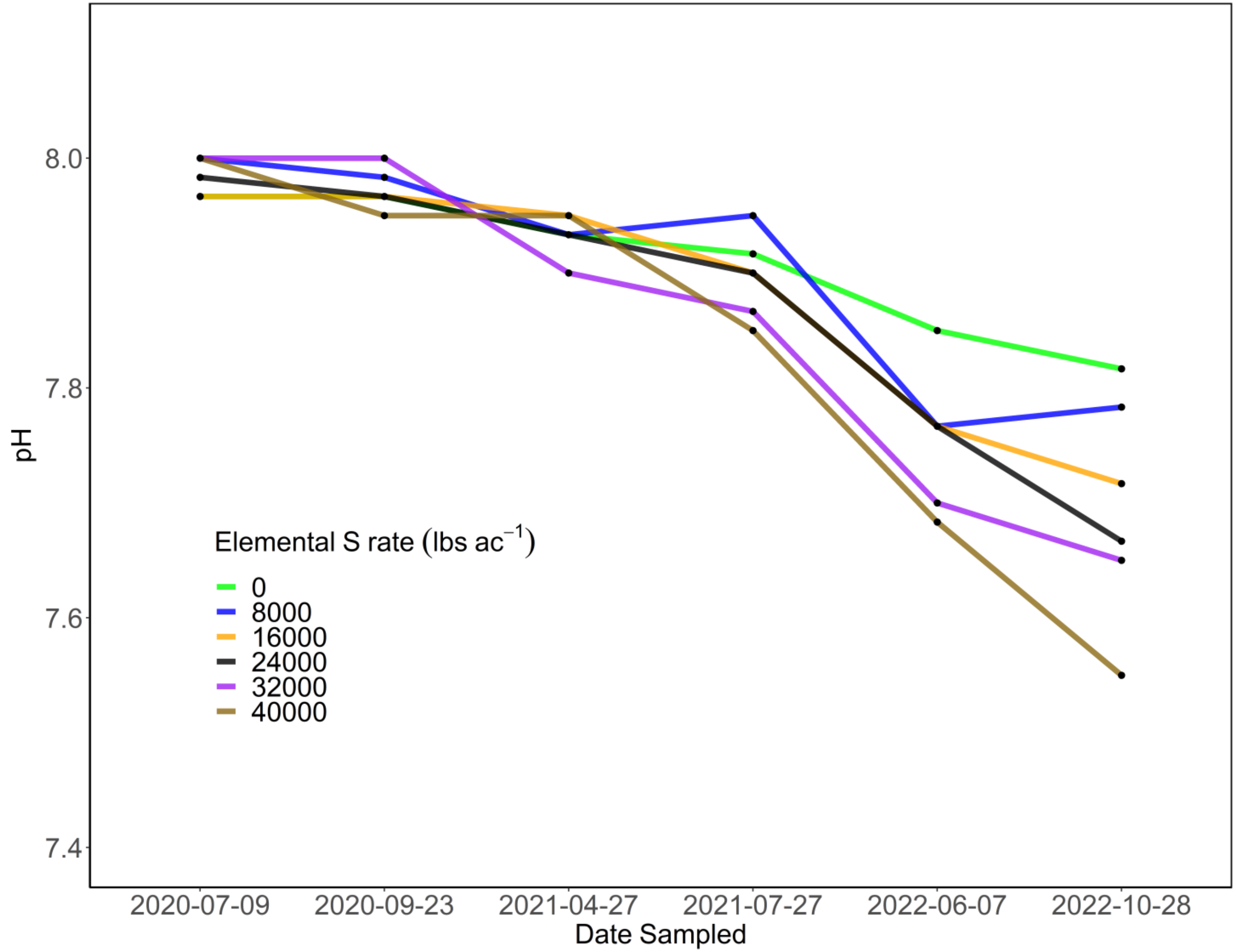
June 2022

% CCE



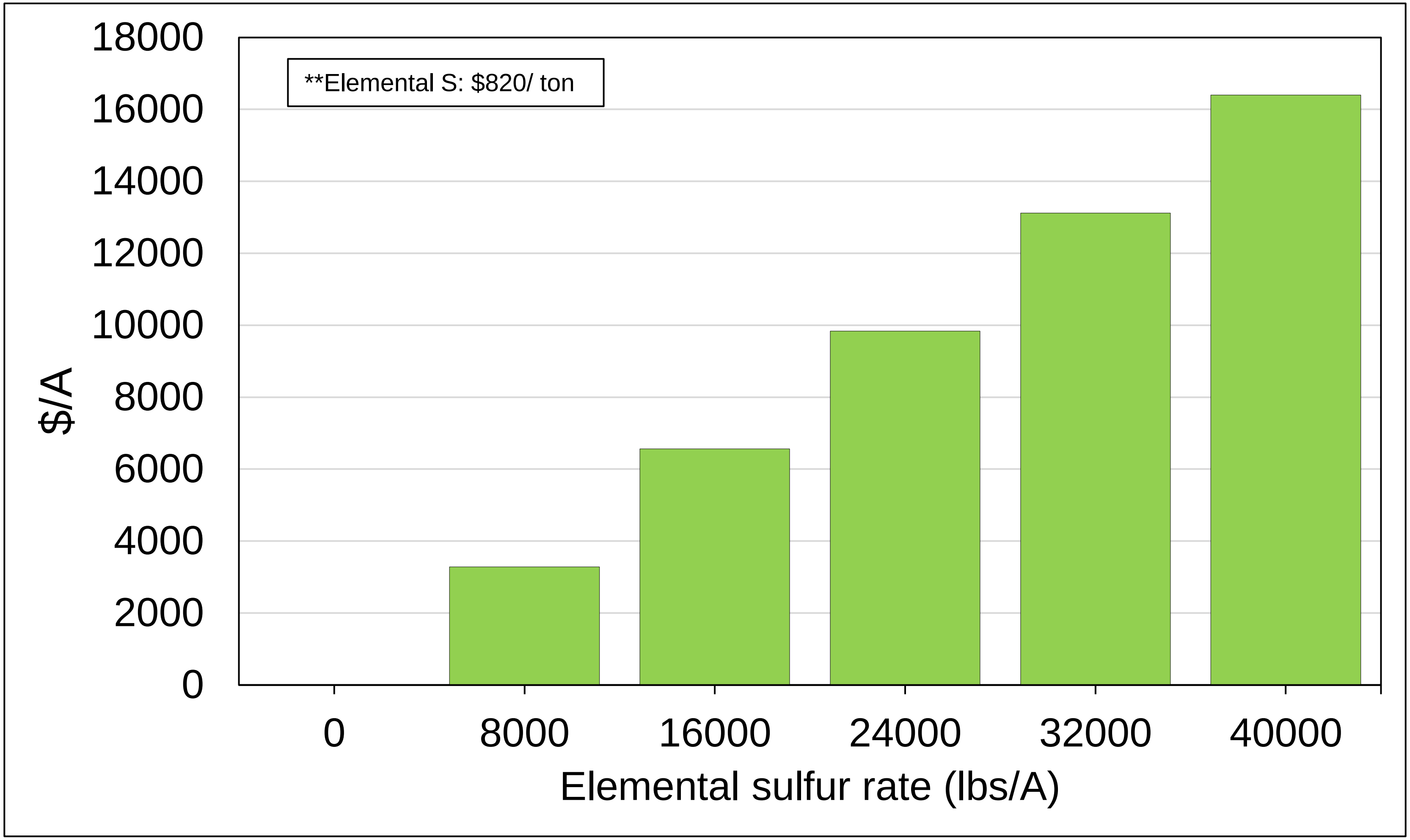
CCE (%)
4.5
4.0
3.5
3.0
Elemental S rate (lbs ac^{-1})
0
8000
16000
24000
32000
40000
2020-07-09
2020-09-23
2021-04-27
2021-07-27
2022-06-07
2022-10-28
Date Sampled

Soil pH



8.0
7.8
7.6
7.4
pH
Elemental S rate (lbs ac^{-1})
0
8000
16000
24000
32000
40000
2020-07-09
2020-09-23
2021-04-27
2021-07-27
2022-06-07
2022-10-28
Date Sampled

Cost



**Price: Personal Communication in Fall 2022

Conclusion

- The process that turns elemental sulfur into sulfuric acid is biology driven; dry conditions in 2020 through 2021 slowed down any CCE% neutralization.
- Applying enough elemental sulfur to neutralize CCE and reduce pH is impractical on a field scale

There is no quick, easy solution to reducing soil pH in the northern Great Plains/Prairie Provinces

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Agvise SCN Project with Clyde Tiffany

Introduction-SCN

- Annual losses of $1.5 billion
- Main source of resistance is PI 88788
    - 95% contain this resistance
- Capacity to survive long term without soybeans
- First reported
    - MN-1978
    - SD- 1995
    - ND-2003
    - Manitoba-2019

Courtesy: Mike Janssen

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IOWA STATE UNIVERSITY
Extension and Outreach

Integrated Crop Management

Greg Tylka *Professor*

Dr. Greg Tylka is a professor in the Department of Plant Pathology and Microbiology at Iowa State University with extension and research responsibilities for management of plant-parasitic nematodes. The focus of Dr. Tylka's research program at Iowa State University is primarily the soybean cyst n...

Income in SCN-infested Fields Can Be $200 Per Acre Less With PI 88788 Than With Peking Resistance

January 9, 2020

The results of a field experiment conducted in 2019 with the soybean cyst nematode (SCN) in southeast Iowa were dramatic and alarming. The data illustrate what likely could occur in SCN-infested fields throughout the state in future years.

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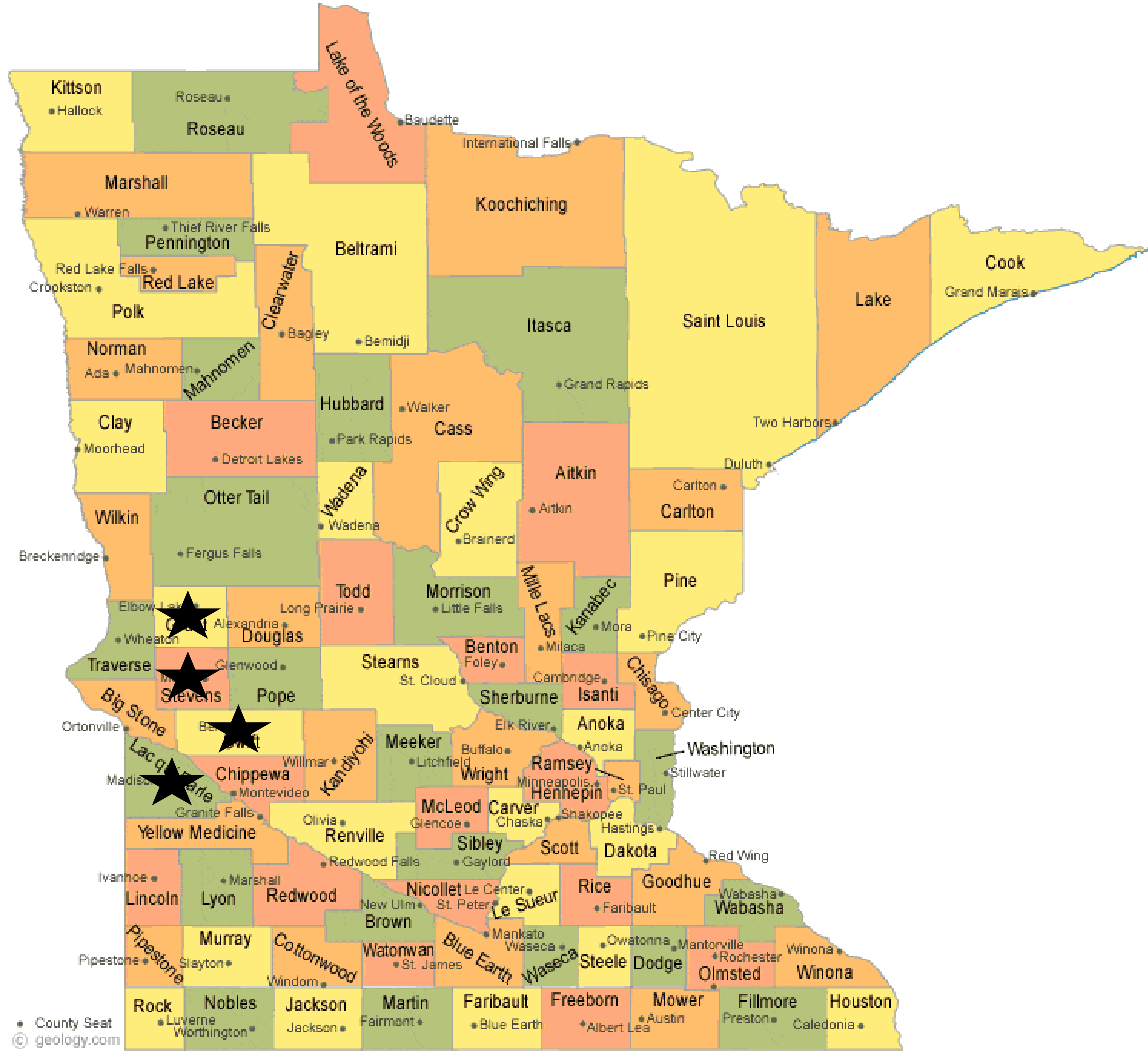
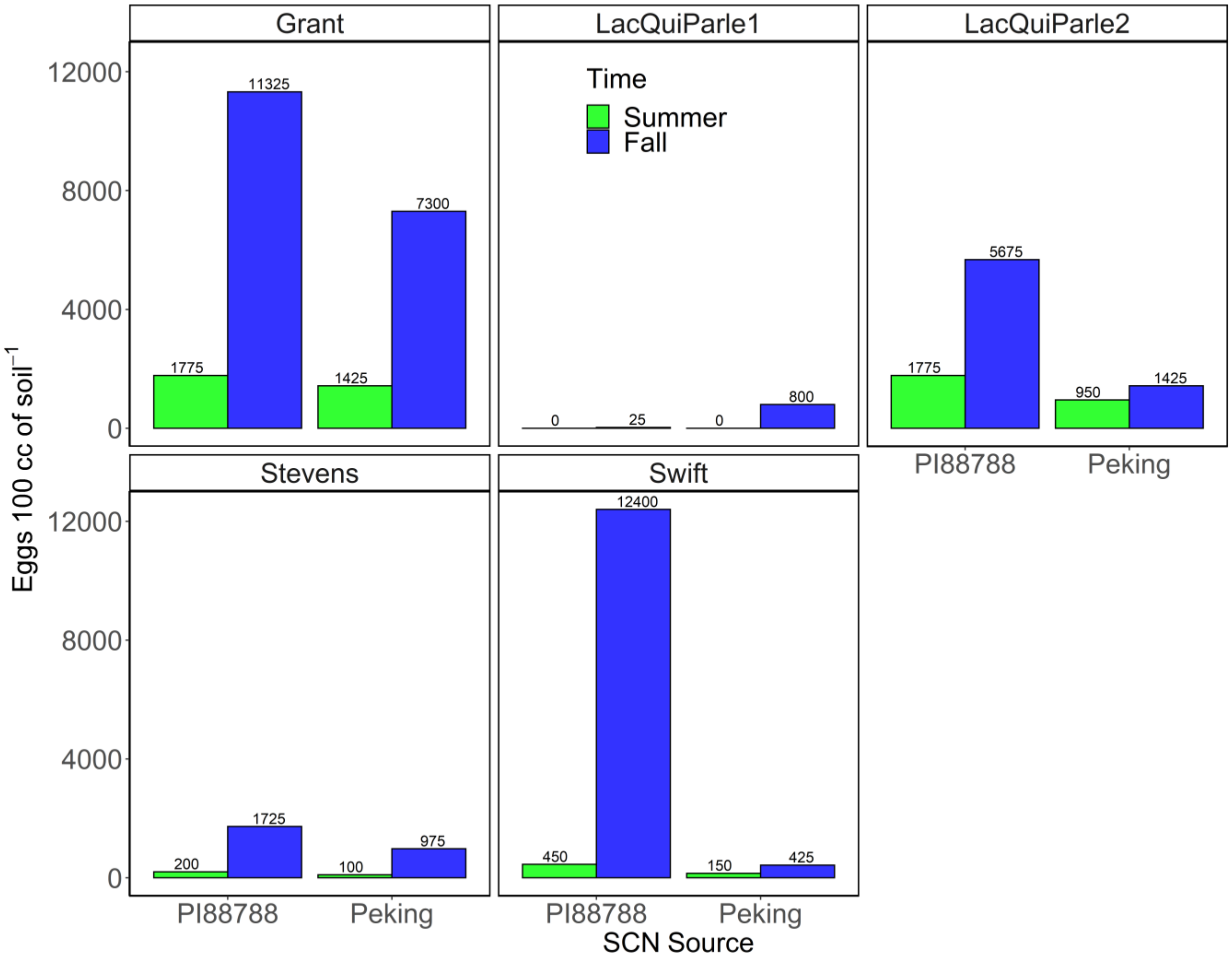
https://crops.extension.iastate.edu/cropnews/2020/01/income-scn-infested-fields-can-be-200-acre-less-pi-88788-peking-resistance

SCN Project

- Two different sources of resistance
  - PI 88788
  - Peking
- 2 years (2021, 2022)
- 11 locations
- SCN sampled:
  - June
  - Harvest
- Grain yield



SCN Egg Production in 2021



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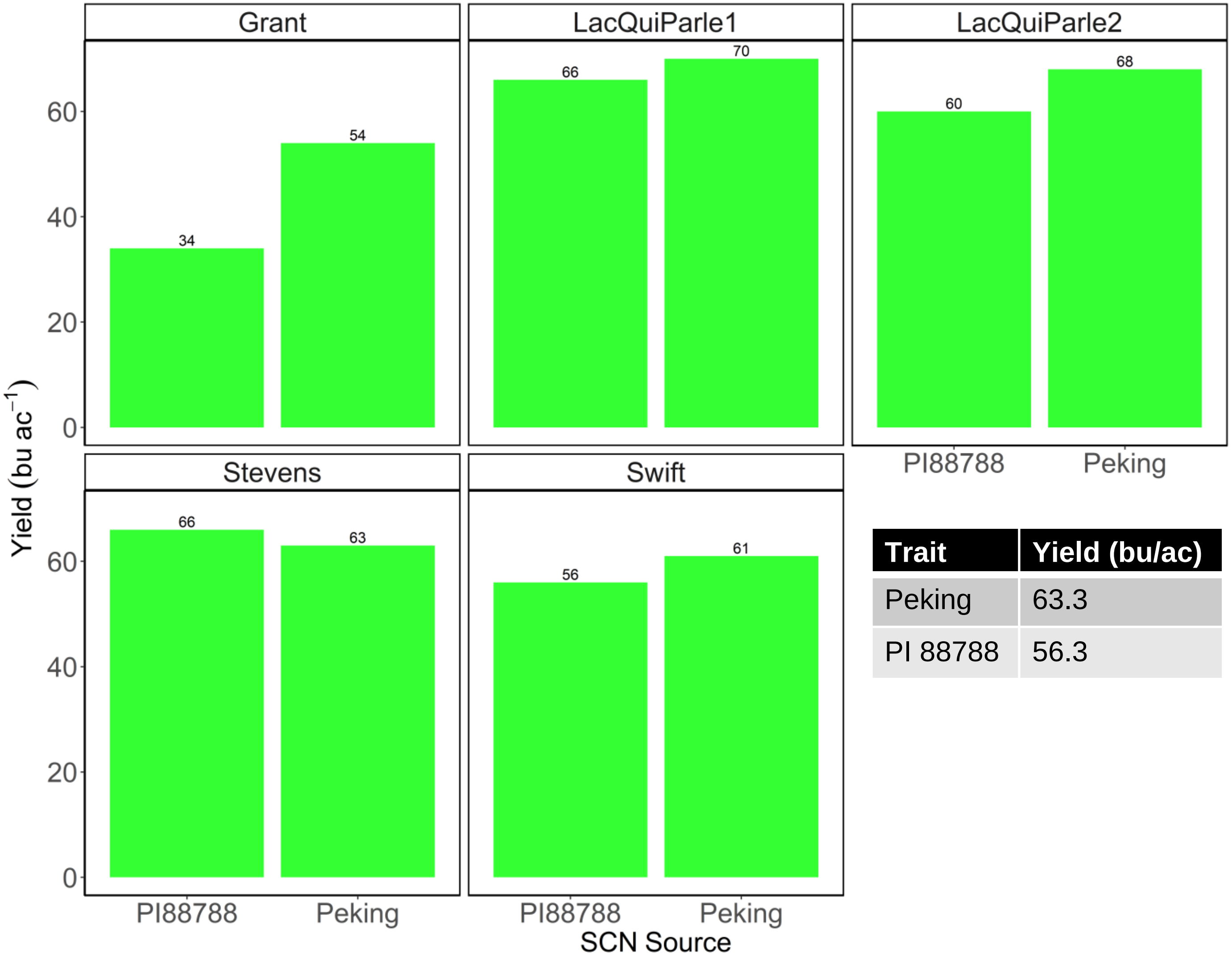
SCN Yield in 2021



Trait	Yield (bu/ac)
Peking	63.3
PI 88788	56.3

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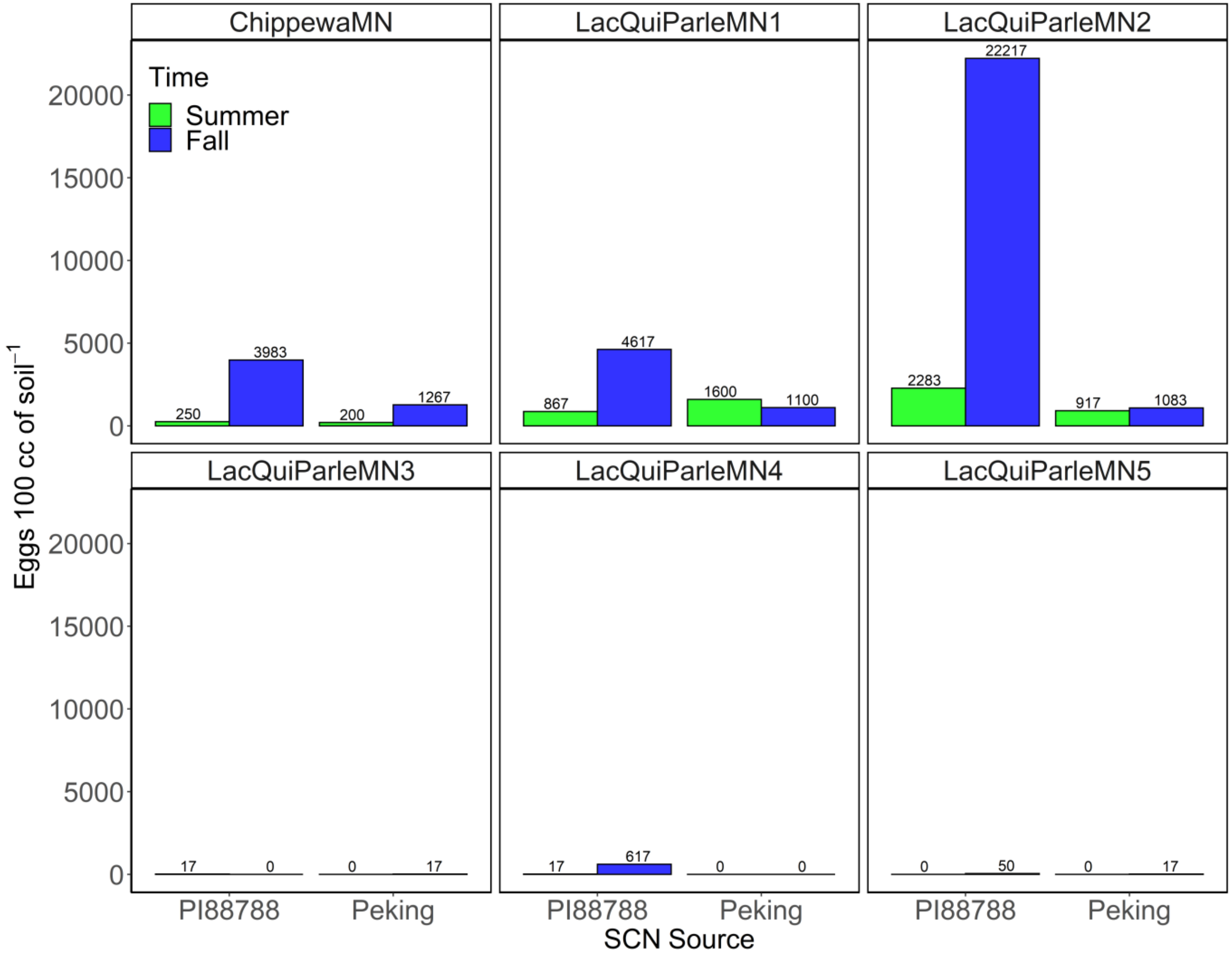
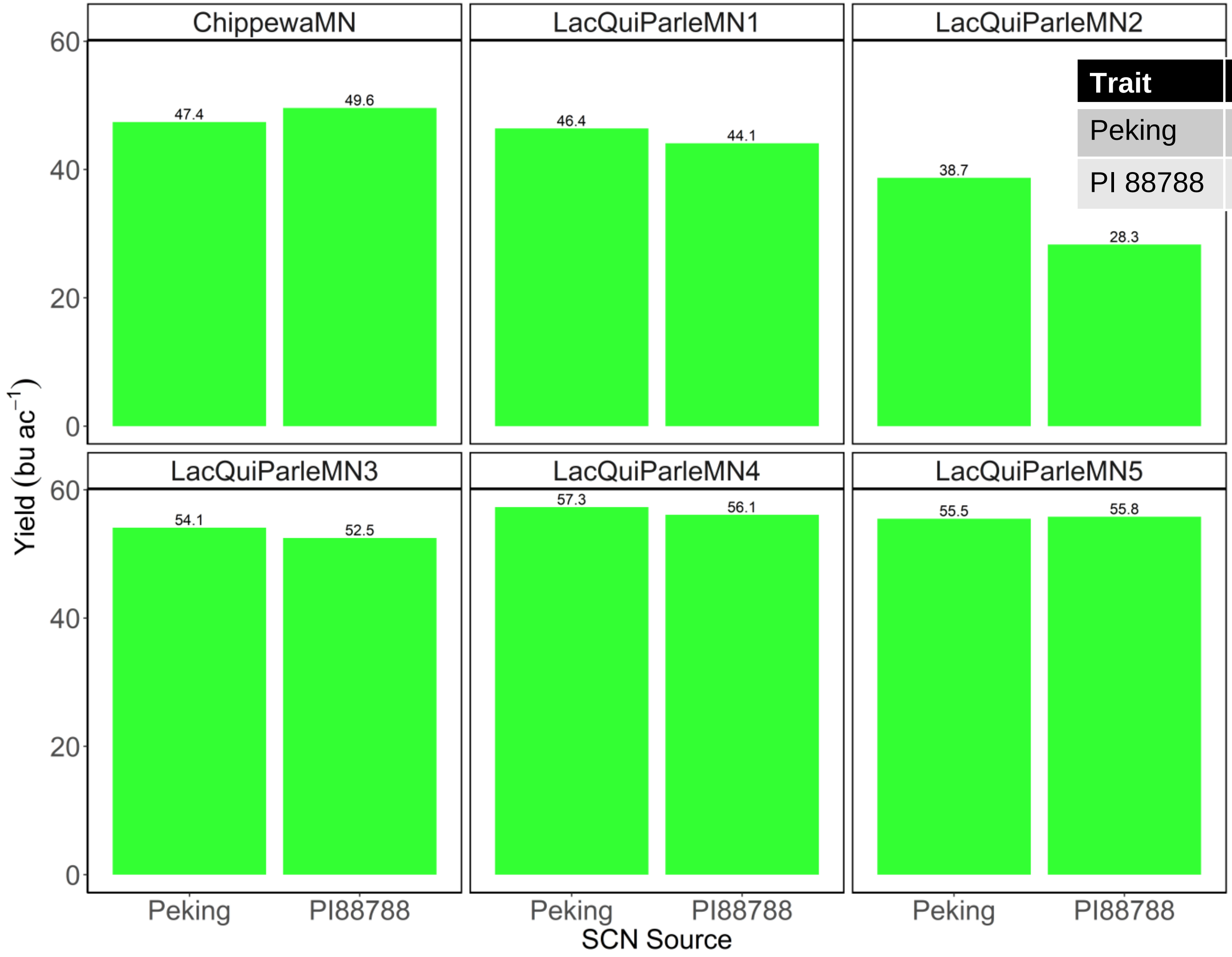
SCN Egg Production in 2022



SCN Yield in 2022



Trait	Yield (bu/ac)
Peking	50
PI 88788	47

2022 IDC Plot Observations

Dawson, MN

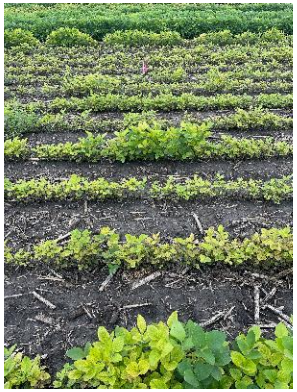
Sampled 7/12/2022

Analysis by AgVise Laboratories, Benson, MN

Sampled for SCN in two Varieties:

P18A73E: Peking

P17A87E: PI88788



	Good Area (No IDC)	Moderate IDC Symptoms	Severe IDC Symptoms
Nitrate Level (lb/A)	14.5	20.5	**78.5**
pH	7.8	8.0	8.0
Calcium Carbonate (%CCE)	0.4	3.3	**9.9**
Soluble Salts (dS/m)	0.305	0.345	**0.605**
SCN 7/12/2022 Avg. (Eggs/100cc)	525	675	**1475**
SCN 9/30/2022 (Eggs/100cc)	**Peking: 400/PI88788: 2,500**	**Peking: 2,500/PI88788: 10,400**	**Peking: 1,750/PI88788: 2,550**

Final Thoughts

- Sampling early and late season does provide useful information on SCN resistance
- SCN can reproduce in IDC soils
- Variety selection is key
  - Limited varieties
- Do NOT plant continuous soybeans

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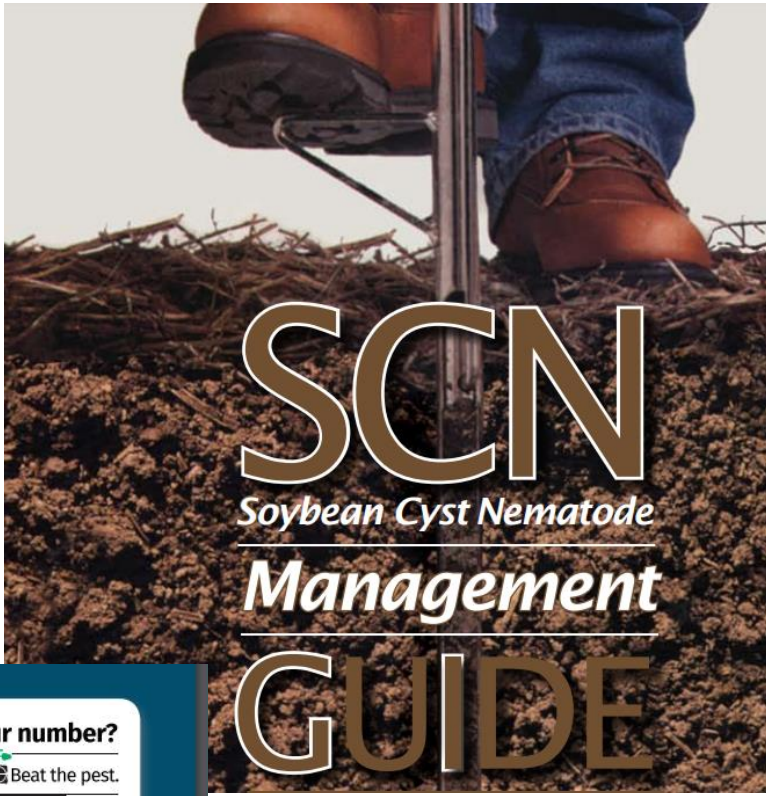
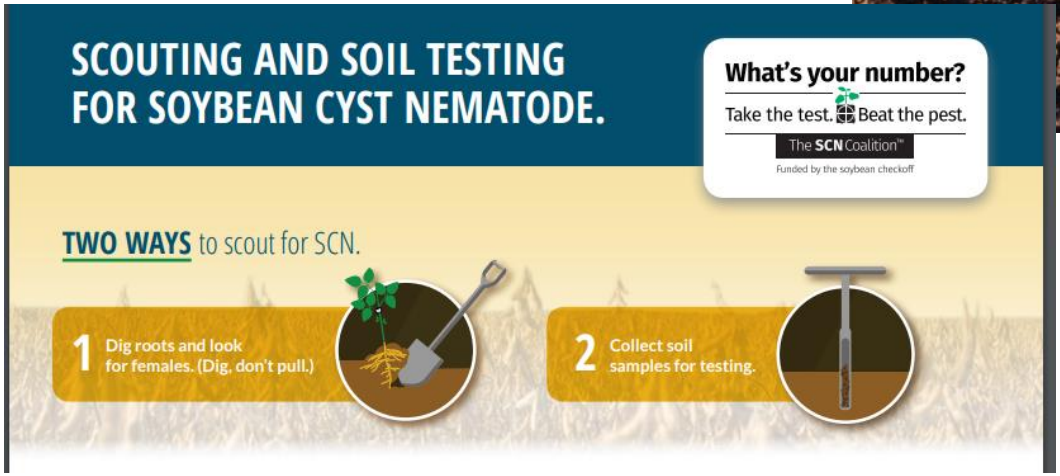
Going Forward: Start/Continue Sampling for SCN





Questions

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