

Investigating Sulfur Use Efficiency in Perennial Ground Cover Corn Cropping Systems

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Introduction

Sustainable agriculture is vital for meeting global food needs while protecting the environment. Effective nutrient management plays a key role in enhancing crop yields, maintaining soil health, and reducing environmental impacts. Sulfur is particularly important, as it supports energy production from sunlight and improves nitrogen uptake, resulting in higher yields and better grain quality. Due to mandated emissions reductions from power plants and industrial sources, there has been a significant decrease in total SO₂ emissions in the US between 1970 and 2023, causing an imbalance in the nutrient ratios between nitrogen and sulfur. Cover cropping helps prevent nutrient loss, and using perennial grasses as groundcover presents a cost-effective, low-labor alternative to traditional annual cover crops. Our objective is to deliver accurate insights into nutrient dynamics—particularly sulfur—in perennial groundcover systems to advance sustainable farming practices.

Objectives

1. Evaluate the influence of perennial groundcover on corn sulfur uptake
2. Determine how the absence of nitrogen fertilizer impacts corn sulfur uptake in PGC Corn Cropping Systems
3. Assess the effect of PGC and Nitrogen Fertilizer on Corn Nitrogen:Sulfur ratio and grain yield

Methods

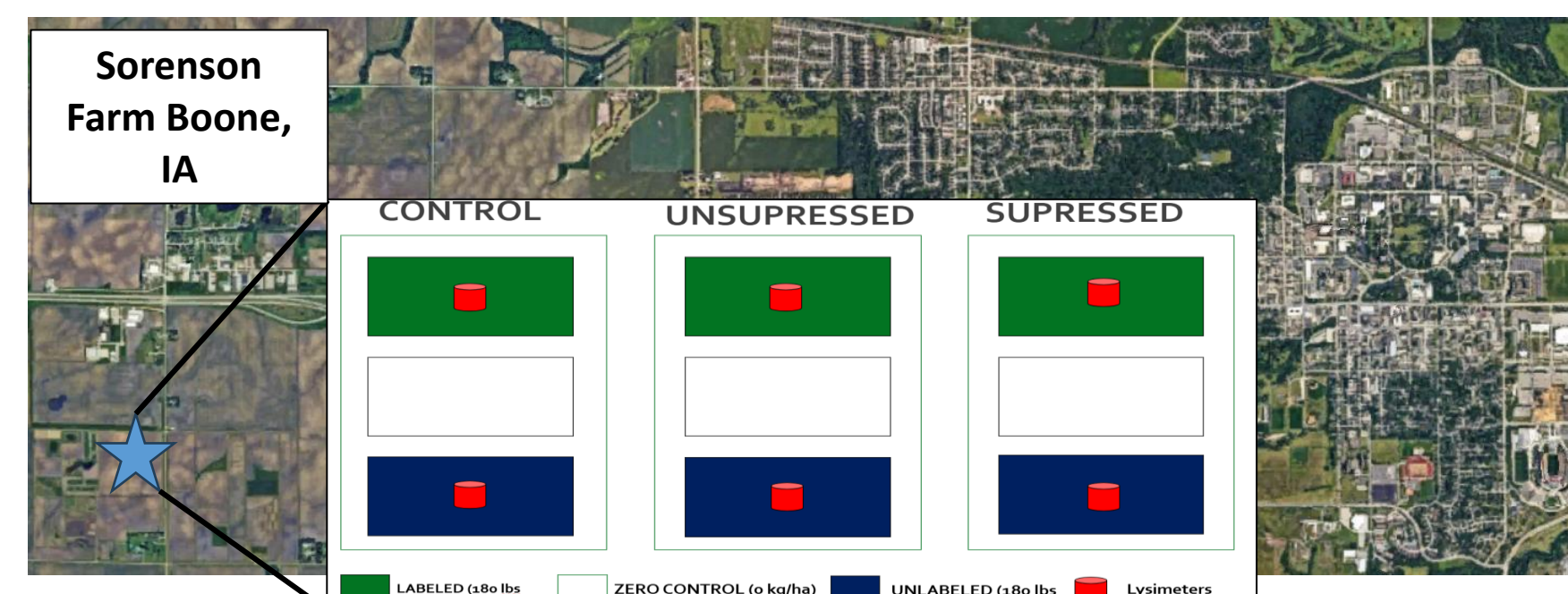


Figure 1. Research location and experimental design showing main plot and subplot treatments



Figure 2. Representation of corn growth stages at which plant and soil samples were collected

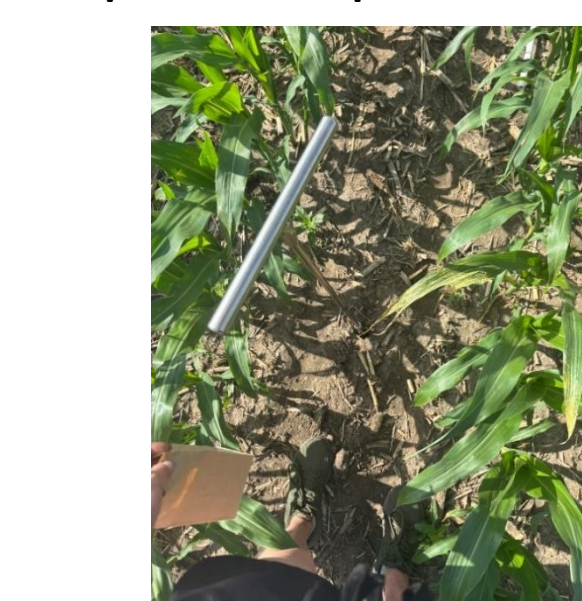


Figure 3. Corn and soil sampling at the V6 growth stage

- Sulfur fertilizer was applied at a rate of 28 kg ha⁻¹ using gypsum (0-0-17S)
- Plant samples from corn were collected at the V6, VT, and R6 growth stages from designated rows.
- The samples were oven dried and ground to .5mm.
- Plant tissue analysis was conducted using dry combustion on a ThermoFisher FlashSmart NCS Analyzer to determine %N and %S.
- Corn S uptake was determined by multiplying the %S at a given growth stage by the biomass at that growth stage.
- Statistical analysis was conducted using a mixed model ANOVA with treatment and subplot as fixed effects and replication as a random effect, followed by mean separation using Fisher's LSD test at a significance level of P<0.05.

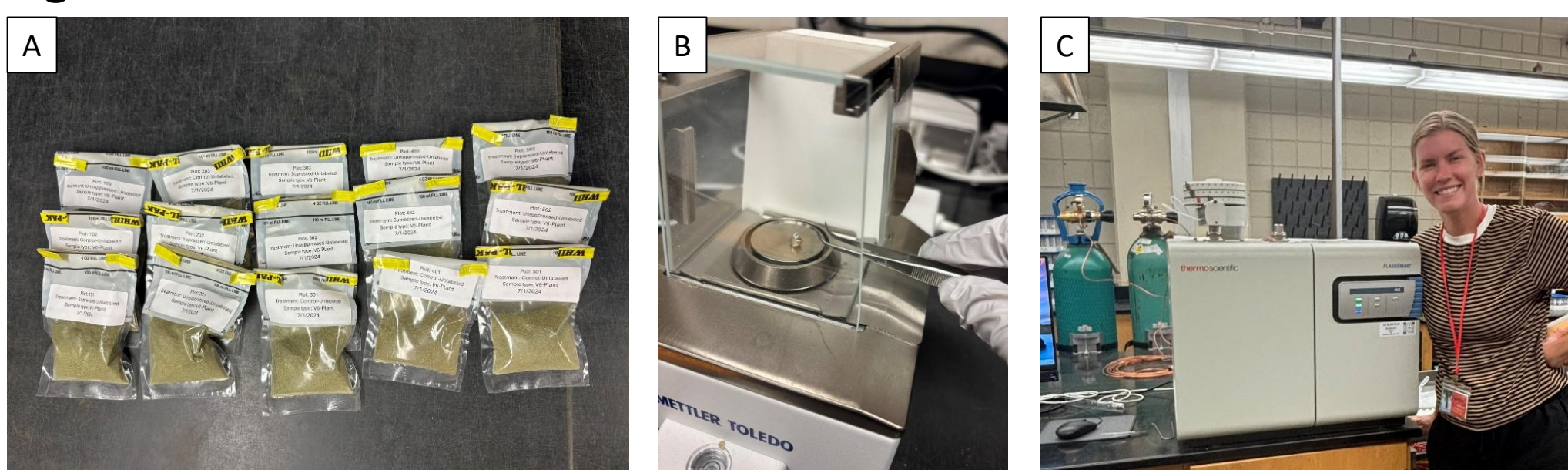


Figure 4. Processed stover samples (A), Weighing of plant samples (B), Flash Smart nutrient testing (C)

How does PGC influence corn sulfur uptake?

Classroom Applications

The research introduces students to the importance of data analysis and environmental impact assessment, encouraging critical thinking and problem-solving. These practices support NGSS-aligned learning and deepen understanding of ecology, biology, and sustainability.

These related activities support NGSS Crosscutting Concepts:

Patterns: Students identify observable trends in plant growth or soil changes, guiding them to ask questions and make predictions.

Cause and Effect: They investigate how specific choices—like watering frequency or ground cover type—impact plant health, drawing conclusions about what caused the outcomes they observe.

Scale, Proportion, and Quantity: Students measure time, water, or plant height, and discuss how small changes can scale up in real-world systems like farms or ecosystems.

Systems and System Models: By defining parts of a classroom plant system (e.g., soil, water, sun, plant), students learn how systems work together and how one change affects the whole.

Energy and Matter: Students can track how water moves through the system, how nutrients cycle, and how energy from the sun drives growth.

Structure and Function: Observing different types of leaves, roots, or soil textures shows how physical traits relate to performance in different conditions.

Stability and Change: Students examine what helps a plant system remain stable or what causes it to change—like drought, overwatering, or poor soil quality.

These experiences give students an authentic opportunity to think like scientists—asking questions, analyzing data, and applying what they learn to real-world sustainability challenges—while building a strong foundation in science, environmental awareness, and critical thinking. It also helps students see the interconnectedness of natural systems and human activity. It empowers them to think about how humans influence global challenges like climate change, food security, and resource conservation, making science more relevant.

Results

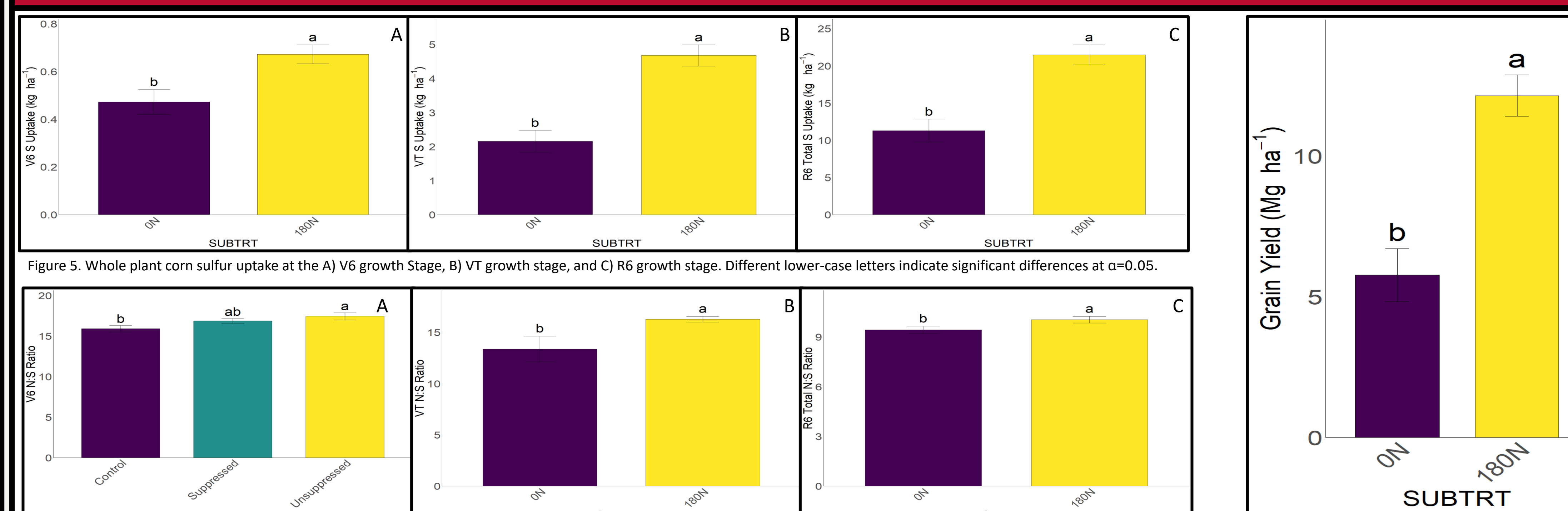


Figure 5. Whole plant corn sulfur uptake at the A) V6 growth stage, B) VT growth stage, and C) R6 growth stage. Different lower-case letters indicate significant differences at $\alpha=0.05$.
Figure 6. Whole plant corn N:S ratio at the A) V6 growth stage, B) VT growth stage, and C) R6 growth stage. Different lower-case letters indicate significant differences at $\alpha=0.05$.
Figure 6. Corn Grain Yield. Different lower-case letters indicate significant differences at $\alpha=0.05$.

Conclusion

1. We determined that PGC (suppressed or unsuppressed) did not influence corn sulfur uptake at any growth stage.
2. The presence of nitrogen fertilizer had the greatest influence on both corn S uptake, corn N:S ratio, and corn grain yield.
3. PGC treatment only significantly influenced corn N:S ratio at the V6 growth stage.
4. PGC treatment did not significantly influence corn grain yield.

Acknowledgements

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Future Collaborations

This project has taught me that research is a collaborative, ongoing process that requires patience, precision, and a clear purpose. I gained a deeper understanding of how scientific inquiry translates into meaningful real-world applications, especially in areas like sustainable agriculture and environmental responsibility. I also learned how important data collection, analysis, and adaptability are when working with living systems and natural variables.

By bringing the practices of the research team—such as forming hypotheses, collecting data, analyzing results, and drawing conclusions—into the classroom, students can engage in authentic STEM practices. I can use my experience to create hands-on labs, real-world problem-solving scenarios, and opportunities for students to connect with agricultural and environmental science careers. Programs through the ISU Outreach and Extension department, ISU WiSE Role Models, and state programs such as Iowa Learning Farms can help provide hands on learning experiences for my students. These opportunities reinforce the idea that science is not just about answers, but about asking questions and investigating the world.