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Application Summary

Competition Details

Competition Title:	2025 South Dakota Nutrient Research and Education Council Invited Proposals
Category:	SDAES
Cycle:	2025
Submission Deadline:	10/15/2024 5:00 PM

Application Information

Application Title:	Tillage Effects on Liming Efficiency in Acidified Topsoil (Year 2)
Application ID:	3449
Submission Date:	10/14/2024 10:38 AM

Personal Details

Applicant First Name:	Kristopher
Applicant Last Name:	Osterloh
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Contact Person's Phone Number:	

Co-Applicant(s)

Name	Email	Affiliation
Peter Kovacs	peter.kovacs@sdstate.edu	SDSU, CAFES, AHPS Dept

Application Details

Proposal Title

Tillage Effects on Liming Efficiency in Acidified Topsoil (Year 2)

Proposal Abstract

Agriculturally productive surface soils across much of the midwestern corn belt are becoming acidified through the use of nitrogen fertilizers. These soils are glacially derived, typically including loess, till, outwash, and/or alluvium that is naturally basic or neutral from inherited calcium carbonate. Application of lime can help to raise pH and counteract the acidification caused by nitrogen application, but that practice is not always used consistently to maintain soil pH. As a result, surface soils have become acidified over the last 30-50 years. Many factors influence the amount of acidification occurring, including initial calcium carbonate levels, type and amount of Nitrogen fertilizer applied, crop rotation, and soil type. Preliminary data shows an increase in acidity of up to an entire pH unit (ie. going from pH 7.0 to 6.0 or lower) within 25-30 years. Even with increases in nitrogen use efficiency and precision agriculture techniques, acidified soils will need to be neutralized over time to maintain economically sustainable productivity. Liming applications are typically applied at the surface and worked into soil to ensure their utility throughout the entire surface soil depth. This practice conflicts with the soil health principle of minimizing disturbance.

We propose to continue our multi-year study to assess the impact of liming practices across different tillage types. This study includes chisel tillage, strip till, and no-till systems with 5 different levels of liming applications. All treatments were in a corn system with a nitrogen application for year 1. We plan to rotate to soybeans for year 2. We hypothesize that strip till and no-till systems will have reduced efficiency of lime applications in increasing soil pH. In strip-till systems, soil pH will only increase in the areas where tillage is occurring. No-till systems will have a vertical stratification of effects, where only the near-surface soil is impacted by liming application. We hypothesize that both strip-till and no-till systems will see a reduced impact of higher liming rates compared to chisel till systems. Full yield, biomass, and soils data from year 1 will be available in the Fall.

2025 Total Budget Request

93,241

Acknowledgment

Acknowledgement of Terms and Conditions

[Acknowledged] I have read and agree to abide by the South Dakota Nutrient Research and Education Council Terms and Conditions attached to this RFP.

Title: Tillage Effects on Liming Efficiency in Acidified Topsoil (Year 2)

Co-PI: Kristopher Osterloh, Department of Agronomy, Horticulture, and Plant Science, South Dakota State University (SDSU). Email: Kristopher.Osterloh@sdstate.edu

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Summary: Agriculturally productive surface soils across much of the midwestern corn belt are becoming acidified through the use of nitrogen fertilizers. These soils are glacially derived, typically including loess, till, outwash, and/or alluvium that is naturally basic or neutral from inherited calcium carbonate. Application of lime can help to raise pH and counteract the acidification caused by nitrogen application, but that practice is not always used consistently to maintain soil pH. As a result, surface soils have become acidified over the last 30-50 years. Many factors influence the amount of acidification occurring, including initial calcium carbonate levels, type and amount of Nitrogen fertilizer applied, crop rotation, and soil type. Preliminary data shows an increase in acidity of up to an entire pH unit (ie. going from pH 7.0 to 6.0 or lower) within 25-30 years. Even with increases in nitrogen use efficiency and precision agriculture techniques, acidified soils will need to be neutralized over time to maintain economically sustainable productivity. Liming applications are typically applied at the surface and worked into soil to ensure their utility throughout the entire surface soil depth. This practice conflicts with the soil health principle of minimizing disturbance.

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Goals and Objectives: With this project, we aim to understand the effect of tillage practices on the ability of liming agents to neutralize acidified surface soils and will evaluate the following objectives:

- Assess the impact of tillage on the vertical and spatial distribution of liming effects.
- Assess the impact of tillage on liming rate efficiency.
- Assess the grain yield and nutrient uptake impact of liming

Justification Statement: Soil acidification is a slow and natural process in pedogenesis, which can be accelerated or decelerated in agricultural systems. Accelerated soil acidification can come from a number of processes including (i) increased H^+ secretion by plants to uptake additional cations, (ii) removal of alkalinity in agricultural products, (iii) mineralization of organic matter, nitrification of ammonium, and leaching of the resulting nitrate, and (iv) inputs of acidifying NH^{+}_{4}-based fertilizers (Sumner and Noble, 2003). Although corn, soybeans, and many agricultural cash crops prefer slightly acid soils (6.0-6.8), too much acidity can reduce yields, detrimentally affect nutrient availability, decrease beneficial soil microbial activity, and eventually cause toxicity to plants (Franzmeier et al., 2016). Liming with calcium or magnesium carbonate are the most common ways to decrease acidity and raise soil pH. Liming also provides plant essential nutrients and increases the uptake of other nutrients, making it a beneficial management strategy for many producers.

Liming agents are not readily soluble, so when applying them it is recommended to use finer particle size materials and to incorporate it into the soil in order to maximize their efficiency and prevent wind/water loss. Mechanical mixing of the soil via tillage is incompatible with the soil health principles of minimizing disturbance and maximizing the presence of living roots. Many producers in South Dakota have switched to no-till systems. A 2017 survey ranked South Dakota #11 in the country with 52.3% of land being managed in no-till systems. In terms of total acres, South Dakota was ranked #6 with 7,656,188 acres in no-till systems; a 7.0% increase from 2012 (Myers and LaRosa, 2019). As the adoption of no-till and conservation tillage systems increase, these producers will also need to lime their fields periodically. Currently South Dakota lacks an assessment tool for how liming practices work within various conservation tillage operations.

Work Plan: This study will use a split-plot design with 3 different tillage types (chisel, strip till, and no-till), 5 application rates of lime (from 0 lbs/ac to up to 2 times of liming recommendation rate), and 4 replicates for a total of 60 plots. The tillage type will be the main plots and application rates will be the sub-plots. Lime was broadcast applied for the conventional and no-till treatments, and incorporated with tillage in the conventional plots prior to year 1 of the study. Lime was applied through the strip-till machine in the strip-till treatments. All plots will have the same management practices (besides the tillage and liming treatments). Weeds free growing environment will be provided through herbicide applications as needed. Current field sites are at the SDSU Southeast Research Farm (SERF) and the SDSU Aurora research farm. Liming applications are based on a target pH of 6.8.

Plant growth, plant biomass accumulation and nutrient accumulation at full pod stage (R6) in soybean will be used to assess the impact of liming on productivity.

Soil samples will be taken in each plot 3 times a year. Year 1 plots were sampled 3 times, Pre-planting, the V4 stage of corn growth, and post-harvest. In each plot we will take samples from within the crop row (or in the strip tilled area) and between rows. Cores will be pulled 7.5 and 15 (mid-row) inches away from corn rows to assess if liming material is moving laterally. Soil cores will be pulled and divided into the following sample depths: 0-5, 5-15, and 15-30 cm. Soils samples will be analyzed for pH; a composite sample will be pulled form each block for comprehensive basic nutrients.

Results from this project will be communicated at the international ASA, CSSA, SSSA meeting and published in a peer reviewed journal. Locally, we will disseminate results through SDSU extension publication, and South Dakota Soil Health Coalition Annual meeting and other extension meeting, by hosting a field day at the research site and also sharing results with other extension specialists and educators.

Potential Impact: We expect that this work will increase awareness of soil acidification, liming, and improve liming efficiency, reduce the negative impact of acidified topsoil, and help producers with management decisions related to liming their no-till fields. Fields that are under conservation tillage practices will remain minimally disturbed and will not need to be disturbed to incorporate liming material.

Timeline: This proposed 3-year project will be started in the spring of 2024 and end in the fall of 2026, with full results being published in early 2027. Preliminary results from year 1 will available in the winter of 2025.

	Year 2			
Task	Jan-Mar	April-June	July-Sept	Oct-Dec
Analysis of year 1 results	X			
Pre-plant sampling and design layout		X		
Liming application, fertilizer application, planting		X		
Initial soil analysis			X	
Harvest, yield, and biomass sampling			X	X
Post Harvest soil sampling				X
Initial data analysis				X

Project Budget: The projected total budget for this 3-year project is $277,615, with an annual budget of between $89,000 and $97,000. Our requested budget for 2024 is $91,0241

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Category	**Cost**	**Description**
Salaries and Wages	**$57,179**	
Kris Osterloh	$10,618	Principal investigator salary equivalent to 1% of 9-month contract and 1 month summer salary to provide supervision of the project.
Peter Kovacs	$12,337	Principal investigator salary equivalent to 1% of 9-month contract and 1 month summer salary to provide supervision of the project.
Graduate Student	$23,030	1 Masters student in Plant Science to conduct the project as their primary thesis topic
Undergraduate Student	$7,200	Wages for an undergraduate worker during the summer field and lab work. $18/hr. for a total of 400 hours.

Fringe Benefits	$3,994	Fringe benefits for student and faculty personnel as required by SDSU.
Travel	**$5,000**	Cost of South Dakota Fleet and Travel vehicles to be used by research personnel, graduate, and undergraduate students for collecting field data and soil samples. Costs of sending graduate student and PI's (partial) to the ASA-CSA-SSSA conference to present initial findings of year 1 and 2.
Other Direct Costs	**$31,062**	
Materials & Supplies	$5,000	Purchase of field and sampling supplies (i.e. sampling bags, gloves, labels, markers, soil probes, etc.). Further, cost includes laboratory supplies (i.e. chemicals reagents, pipettes, filters, etc.).
Contractual	$16,000	Contractual services to complete soil analyses, plant, and biomass sampling at a certified lab.
Publication	$2,000	Costs to publish results in an open source peer-reviewed journal.
Tuition	$8,062	Tuition remission for graduate student.
Total	**$93,241**	

References

Franzmeier, D. P., McFee, W. W., Graveel, J. G., & Kohnke, H. (2016). *Soil science simplified*. Waveland Press.

Myers, R., & LaRose, J. (2019). Adoption of soil health systems based on data from the 2017 US Census of Agriculture.

Sumner, M. E., & Noble, A. D. (2003). Soil acidification: the world story. *Handbook of soil acidity. New York: Marcel Dekker*, 1-28.