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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:	COMBINING SOIL FERTILITY AND BIOLOGICAL MEASUREMENTS TO IMPROVE CORN N RATE RECOMMENDATIONS: Year 2
Application ID:	3452
Submission Date:	10/14/2024 12:39 PM

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Application Details

Proposal Title

COMBINING SOIL FERTILITY AND BIOLOGICAL MEASUREMENTS TO IMPROVE CORN N RATE

Proposal Abstract

The use of nitrogen (N) fertilizer is critical for optimizing corn yield. However, improper applications can create environmental issues and reduce grower profits. The N cycle is largely affected by biological processes. Therefore, the inclusion of biological soil tests alone or in combination with other soil chemical and physical properties may enable us to improve the accuracy of estimating corn N fertilizer needs. The objectives of this project are to determine the accuracy of corn N fertilizer rate predictions when including soil chemical, physical, and biological properties into the model and to create a decision tool that estimates corn N rate requirements. Information from this project will be included in soil fertility extension presentations and in improving the corn N fertilizer rate recommendation.

2025 Total Budget Request

100,214

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.

COMBINING SOIL FERTILITY AND BIOLOGICAL MEASUREMENTS TO IMPROVE CORN N RATE RECOMMENDATIONS: Year 2

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Summary
The use of nitrogen (N) fertilizer is critical for optimizing corn yield. However, improper applications can create environmental issues and reduce grower profits. The N cycle is largely affected by biological processes. Therefore, the inclusion of biological soil tests alone or in combination with other soil chemical and physical properties may enable us to improve the accuracy of estimating corn N fertilizer needs. From 2018-2021, 28 corn N response trials in central and eastern South Dakota showed some soil tests measuring biological processes were related to corn N requirements (acid citrate extractable protein test, water extractable total C, silt to sand ratio, organic C, and water extractable and H3A extractable NO_3–N). However, additional N fertilizer rate studies are needed to test these new relationships and create a decision tool that incorporates these tests into the N rate recommendation. Thus, the objectives of this project are to determine the accuracy of corn N fertilizer rate predictions when including soil chemical, physical, and biological properties into the model and to create a decision tool that estimates corn N rate requirements. Information from this project will be included in soil fertility extension presentations and in improving the corn N fertilizer rate recommendation. A second year is proposed with an annual budget for 2025 of $100,214.

Goal and Objectives
The goal of this project is to increase the accuracy of the field-to-field N rate recommendation for corn in SD. The objectives of the project are 1) determine the accuracy of corn N fertilizer rate predictions when including soil chemical (i.e., soil N levels), physical (e.g., soil texture), and biological properties into the model and 2) create a decision tool that estimates corn N rate requirements using the best combination of soil chemical, physical, and biological properties.

Justification
The use of nitrogen (N) fertilizer is important for maximizing corn yield, but improper applications can reduce fertilizer efficiency, create environmental issues, and reduce grower profits. One way to improve the accuracy of corn fertilizer-N rate guidelines is to improve soil testing and its use in making management decisions. To be most effective in improving N rate guidelines, soil tests will likely need to account for both plant-available inorganic N and N that will be mineralized during the growing season. To this point much research has been completed in using inorganic soil N to improve N rate recommendation accuracy. Since 20% to 100% of N needed by corn to obtain optimal growth can be supplied by mineralization processes, including biological soil tests along with inorganic N soil tests has the potential to improve upon current N rate guidelines. Recent research has shown that improvements in soil biological health improve corn yield potential. One soil test that has shown some promise in being used to improve corn N rate guidelines is the soil respiration or flush of CO_2 after rewetting test. In recent SD studies,

soil health tests like the acid citrate extractable (ACE) protein test had a good relationship with corn N requirements ($R^2 = 0.34$). Other soil tests that had a good relationship with corn N requirement were water extractable total C ($R^2 = 0.20$), silt to sand ratio and organic C ($R^2 = 0.19$), and water extractable and H3A extractable NO_3–N ($R^2 = 0.17$). However, additional N fertilizer rate studies are needed to test these new relationships and create a decision tool that incorporates these tests into the N rate recommendation.

Work Plan

Six study locations on farmer's fields will be chosen each year of this three-year proposal. Study locations will vary in management practices that are common for South Dakota (i.e. conventional and no tillage and with and without cover crops). Sites will be determined by working with farmers and agronomists. Nitrogen rate treatments will include 6 N rates applied before planting ranging from 0 to 200 lbs N ac^{-1} in 40 lb increments. Two split application timings where ~25% of the total N is applied at planting and the remainder at V6 or V10 at two N rates will also be evaluated. Air temperature, precipitation, and other weather conditions will be monitored daily with a nearby weather station. Every year soil cores (0–6 in.) will be taken from each replication and analyzed for phosphorous (P), potassium (K), pH, and organic matter. Nutrient and pH deficiencies will be corrected before planting each year and pre- and post-emergent herbicides will be used for weed control as needed.

Data Collection

Every year soil cores (0–6 and 6-24 in.) will be taken from each replication before planting and fertilization, sealed in a plastic bag, and stored in coolers with ice until they can be processed. Soil samples will be analyzed for soil chemical, physical, and biological properties (e.g., acid citrate extractable protein, water extractable and H3A extractable NO3–N, water extractable total C, organic C, Haney, enzymes, and silt to sand ratio. The relationship between these soil measurements and the response of corn grain yield and nutrient uptake to N fertilization and fertilizer-N required to obtain maximum yield will be determined. Testing soils for measurements of soil fertility and health will enable us to identify which measurements alone and together relate to fertilizer-N requirement of corn and can be used to improve our current fertilizer-N recommendations. Soil analysis methods will follow standard protocols (Denning et al., 2012; USDA-NRCS, 2018).

At two of the research sites, we will include obtaining soil samples from the single and two split N applications at a traditionally low and optimal fertilizer-N rate at the V6 and V10 corn development stages (0–24 in. in 12-in. increments) before split N applications are applied and after harvest (0–36 in. depth in 12-in. increments). These samples will allow us to track the availability of inorganic N to corn when fertilizer-N was applied as a single or split application during the growing season and the amount remaining at the end of the season that may be lost due to leaching or volatilization in central and eastern SD soils.

At four of the research sites, we will sample whole corn plants from the single and two split N applications at a traditionally low and optimal fertilizer N rate at the V6, V10, and R6 corn development stages. Obtaining plant samples will allow us to track the uptake of N by the plant and determine under what soil and weather conditions throughout central and eastern SD split N

applications lessen corn fertilizer-N requirement and improve fertilizer-N use efficiency. Plant samples will be collected by clipping 6 plants at ground level. For the R6 sampling, ears will be removed and measured separately from the above ground vegetative matter (stover). Plant materials will be dried in a forced air oven (140^{o}F) until constant mass and weighed to determine dry matter yield. Ears will be shelled, and dry weights of grain and cob samples measured. Harvest grain yield will be calculated by harvesting the center two rows of each plot area and adjusting grain weight to 15.5%. Nitrogen concentration of the grain and vegetative matter will be measured after samples are ground to pass through a 0.08 in. sieve using the Dumas combustion method (Bremner, 1996). These analyses will be used to determine the effect of fertilizer N on uptake of N.

Evaluation

The response of grain yield and nutrient uptake to fertilizer-N rates will be evaluated. Several models will be used to evaluate the response of corn to fertilizer N including linear, quadratic, linear-plateau, and quadratic plateau models. The optimal and economic optimal N rate for corn grain yield will be calculated. The optimal N rate being the N rate at which there is no longer an increase in corn production with additional fertilizer N. The economic optimal N rate is when the increase in crop yield from applying fertilizer N no longer pays for the cost of applying more fertilizer. All results will be input into the corn nitrogen response database which currently totals 53 locations. Traditional soil fertility information along with newer soil health/biological tests measured at each site will be evaluated for their relationship with corn N requirement and corn yield alone and in combination with each other. This information will also be evaluated using newer machine learning techniques to determine if they can be used to improve the accuracy of corn N rate guidelines over the currently used yield goal and maximum return to N approaches.

Information from this project will be used to improve N fertilizer guidelines for corn that reduces the potential for under- or over-application of N fertilizer and thus increases profitability and decreases potential negative environmental effects associated with over-application of N fertilizer. Results will be communicated at various field days, extension, and CCA events. As the project and data analysis progresses, updates will be provided through the SDSU Extension website as well. Two of the three project leaders have extension appointments, which will also help to communicate the updates and results of the project to producers, crop advisors, and other stakeholders.

Potential Impacts:

- Creation of a N response curves for corn database that can be used to:
    - Identify new soil tests that can improve the accuracy of corn N rate guidelines.
    - Track N fertilizer requirements that optimize corn yield from year-to-year and how it varies across soil and weather conditions in South Dakota.
    - Evaluate current N recommendation guidelines and update where needed.
    - Compare the current N recommendation guidelines approach with approaches used in other states as well as create novel approaches.

- Improved N fertilizer guidelines for corn that reduces the potential for under- or over-application of N fertilizer and thus increases profitability and decreases potential negative environmental effects associated with over-application of N fertilizer.
- Increased knowledge regarding the variability of N fertilizer requirements across South Dakota.
- Greater understanding of the influence of soil properties and weather conditions affect on N fertilizer requirements for corn.
- Improved data processing and analysis techniques in the area of fertilizer recommendations.
- Extension programming (presentations and fact sheets) regarding the response of corn to N fertilizer rates and updated N fertilizer rate guidelines.
- Training of several undergraduate students in soil fertility.

Timeline:
We have constructed a database with 53 research sites throughout SD regarding N rate responses with soil health/biological measurement data. Data from this project will be added to this database each year. From this database we will be able to see trends over time, update recommendations as needed, and compare the current yield goal approach to N recommendations with other approaches. Data will be continuously analyzed throughout the three-year duration of this project.

Table 1. Annual research activities for field studies.

Activity	**2025**				**2026**
	Jan-Mar.	**Apr-June**	**July-Sept**	**Oct-Dec**	**Jan-June**
Determine field sites/soil sample collection	x	x	x	x	
Fertilization and crop planting		x			
Plant sampling		x	x	x	
Soil and plant sample analysis			x	x	x
Harvest			x	x	
Sample and Data Processing, report writing			x	x	x

Budget and Justification:
The budget of the project is $100,214. The cost will cover salaries for PIs, graduate student, and undergraduate student workers to help set up and maintain research sites, plant, apply fertilizer, collect data, process samples and data, and harvest. It will also cover the cost to travel to the research sites, purchase tools to mark and sample the plots, analyze collected samples, and pay land/equipment usage fees.

Total Project Budget: $100,214

Personnel and Fringe: $45,056

Jason Clark	$5,630	Provide oversight of the project and personnel throughout the year along with data collection, analysis, and update of corn N fertilizer recommendations.
Ph.D. Student	$27,195	Ph.D. student to help in trial establishment, sample and data collection, data analysis, and interpretation and writing of results.
Student help	$10,000	Undergraduate student wages to help aid in field and laboratory work.
Fringe Benefits	$3,231	Fringe benefits for full-time employees and undergraduate students.

Travel and Accommodations: $6,500

Costs of travel from Brookings to field research locations in western, central, and eastern SD. This includes approximately 8 trips to establish, maintain, and collect samples at each of the research sites and travel to local, regional, and national extension and professional meetings for researchers and students to present results.

Materials & Supplies: $4,200

Costs of materials and supplies (plot flags, plot stakes, bags, seed, fertilizer, harvest materials, hand tools, etc.) for implementing and assessing treatments at all sites. Cost also includes laboratory supplies (i.e. chemicals, pipettes, filters, etc.) and computer and software supplies for researchers to complete soil and plant nutrient and statistical analyses.

Contractual: $35,780

$12,000 for soil physical, chemical, and biological measurements at 6 locations (2 sites will have more in-depth soil sampling and analyses during the growing season). These soil and plant analyses will be completed at labs within South Dakota State University and certified commercial laboratories.

$3,000 for plant analysis in two locations. These plant analyses will be completed at labs within South Dakota State University and certified commercial laboratories.

$7,280 is budgeted for land rental and user fees of university research farms along with compensation for crop loss that may occur with crop stress from low fertilizer rates or other experimental cropping system treatments.

$12,000 is budgeted for user fees associated with equipment use of hydraulic soil sampler, combine, fertilization equipment, planters, tractors, and cover crop seeders to sample soil, establish treatments, plant, and harvest crops along with advertising for recruitment of employees and graduate students.

$1,500 is budgeted for registration cost for researchers to attend professional conferences.

Tuition Remission:

$7,678 is budgeted for tuition remission for the Ph.D. student in accordance with SDSU and the SD Board of Regents program.

References:

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