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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:	EFFECT OF 5-YEAR DIVERSE CROP ROTATION WITH NO-TILL VS. CORN-SOYBEAN ROTATION WITH CONVENTIONAL TILLAGE ON CROP NITROGEN REQUIREMENTS AND CYCLING
Application ID:	3453
Submission Date:	10/14/2024 12:49 PM

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Application Details

Proposal Title

EFFECT OF 5-YEAR DIVERSE CROP ROTATION WITH NO-TILL VS. CORN-SOYBEAN ROTATION WITH

Proposal Abstract

The use of nitrogen (N) fertilizer is critical for optimizing crop yield. However, determining the proper N fertilizer application rate is quite challenging as the amount needed is influenced by many factors. Two of these factors are tillage and crop rotation. The SDSU Southeast Research farm recently purchased a new plot of land that was managed with conventional tillage and a corn-soybean rotation. One piece of the land will remain in conventional tillage with a corn-soybean rotation while the remainder will be transitioned to no-till and a five-year stacked crop rotation (corn-corn-soybean-hybrid rye with cover crop-soybean). The objective is to determine the effect of this transition compared to the area remaining in conventional tillage and corn-soybean rotation on N fertilizer requirements, crop yields, and N cycling tests.

2025 Total Budget Request

75,297

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.

EFFECT OF 5-YEAR DIVERSE CROP ROTATION WITH NO-TILL VS. CORN-SOYBEAN ROTATION WITH CONVENTIONAL TILLAGE ON CROP NITROGEN REQUIREMENTS AND CYCLING

PI: Jason Clark, Soil Fertility Extension Specialist and Associate Professor, SDSU, Department of Agronomy, Horticulture & Plant Science, jason.d.clark@sdstate.edu, (801) 644-4857
Co-PIs: Peter Sexton, Cropping Systems; Vander Nunes, Soil Science, and Sarah Sellars, Ag Economics

Summary

The use of nitrogen (N) fertilizer is critical for optimizing crop yield. However, determining the proper N fertilizer application rate is quite challenging as the amount needed is influenced by many factors. Two of these factors are tillage and crop rotation. The SDSU Southeast Research farm recently purchased a new plot of land that was managed with conventional tillage and a corn-soybean rotation. One piece of the land will remain in conventional tillage with a corn-soybean rotation while the remainder will be transitioned to no-till and a five-year stacked crop rotation (corn-corn-soybean-hybrid rye with cover crop-soybean). It is unknown how this management transition will affect the N fertilizer needed to optimize the corn and small grain production in the new rotation or how the health of the soil will change over time. A federal NRCS project has been fully funded to evaluate the effect of this transition on soil health parameters. Thus, in this proposal we are seeking funding to look at the objective of determining the effect of this transition (no-till + 5-year rotation) compared to the area remaining in conventional tillage and corn-soybean rotation on N fertilizer requirements, crop yields, and N cycling tests. Information from this project will be included in soil fertility extension presentations and in improving the corn N fertilizer rate recommendation. A three-year project is proposed with an annual budget for 2025 of $75,297.

Goal and Objectives

The goal of this project is to determine the effect of changing from a conventional crop management system to a soil health focused management system on N cycling and crop production. The specific objective is to determine the effect of changing from conventional tillage and a corn-soybean rotation to no-till and a five-year crop rotation on N fertilizer requirements, crop yields, and N cycling tests.

Justification

Nitrogen is the nutrient that most often limits grain yield. In commercial agriculture, the two main sources of N for crops are derived from mineralization of soil organic matter and synthetic N fertilizers. The process of mineralization can contribute 20 to 100% of this yearly crop N requirement, with the remainder needing to be supplied by another source, such as synthetic fertilizers. However, predicting the amount of N that will be mineralized is challenging because this process is influenced by many factors. Two of these factors include tillage practice and crop rotation. Converting to no-till and diversifying crop rotations by including small grains and cover crops in the rotation has increased the overall health of soils and crop productivity but the effect this has on N cycling and N fertilizer requirements to economically optimize crop yields is still unclear. Recent research shows the variable effect transitioning to no-till from conventional tillage has on N fertilizer requirements for corn and small grains across the U.S. with no-till fields requiring the same amount of N to optimize yield or needing additional N (Basso &

Ritchie, 2005; Rasse & Smucker, 1999; Yost et al., 2012, 2013). Other research has clearly shown the effect of rotation on crop yield. For example, in Iowa, continuous corn required the most N followed by corn after soybean and then corn after alfalfa. However, in South Dakota's climate, the effect of transitioning from till to no-till and implementing a five-year rotation (corn-corn-soybean-hybrid rye with cover crop-soybean) on crop production, N requirements, and N cycling is unknown.

Work Plan

This study will take place at the SDSU Southeast Research Farm near Beresford, SD. Two sets of N rate response studies will be established in adjacent fields. The first set will be established in a field that has been historically managed utilizing conventional tillage and a corn-soybean rotation (control). The field will be divided into two blocks where corn and soybean will be grown in rotation with both crops present each year. The second set will be established on a newly purchased ¼ section of land that was previously managed using a corn-soybean rotation with conventional tillage. However, in 2024 this land was transitioned to no-till and a five-year soil health focused rotation (corn-corn-soybean-hybrid rye with cover crop-soybean) was started. The ¼ section was divided into five quadrants to allow every crop in the five-year rotation to be present each year (Figure 1). In 2025 an area will be determined where the long-term N rate response studies will be located within each block of the control (conventional tillage and corn-soybean rotation) and within each of the newly transitioned no-till and five-year rotation quadrants. The experimental design will be a randomized complete block arrangement with four replications. Each experimental unit will be approximately 15 ft. wide and 50 ft. long. For corn, N fertilizer treatments will consist of six rates that will be applied before planting ranging from 0 to 200 lbs. N/ac in 40 lb. increments. For hybrid rye, 30 lbs. N/ac will be applied in the fall prior to planting with the remainder of the six total N rates (0-150 lbs. N/ac in 30 lb. increments) applied once the ground thaws in mid-March the following spring. Two split applications for both corn and hybrid rye will also be evaluated at a total N rate of 80 and 120 lbs. N/ac for corn and 60 and 120 lbs. N/ac for hybrid rye. For corn, the split applications will occur in spring before planting and then at the V6 or V10 development stage. For hybrid rye, 30 lbs. N/ac will be applied in the fall and then the remaining of the total rate will be split between after the ground thaws (mid-March) and then early- or late-April. The same N fertilizer treatment will be applied every year to each experimental unit except when soybean is grown when no N fertilizer will be applied. These treatments will allow us to determine the effect of transitioning to no-till and this five-year rotation have on the N fertilizer rate needed to optimize yield for each crop in the rotation every year and how that may change as the number of years in no-till and this

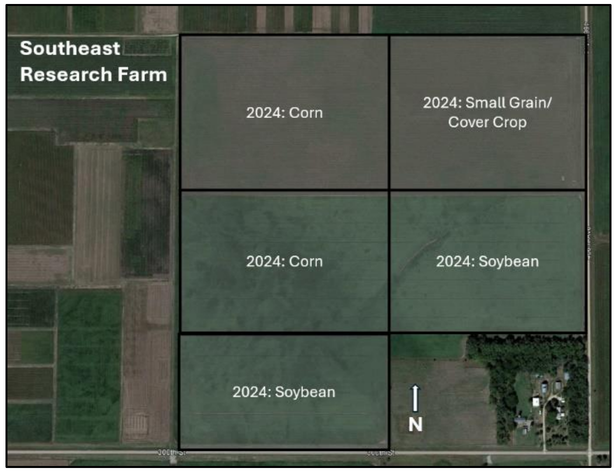

Figure 1. Map of new ¼ section of land that was transitioned from conventional tillage to no-till management and a corn-soybean rotation to a five-year soil health rotation of corn-corn-soybean-hybrid rye/cover crop-soybean.

five-year rotation increases. The economics of the two management practices over time will be compared and the economically optimal nitrogen rate for both practices will be calculated.

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. Air temperature, precipitation, and other weather conditions will be monitored daily with a nearby weather station.

Data Collection

In the first year before planting and fertilizer application, soil samples will be obtained from each replication and after year one, three N rates will be sampled (0, 120, 200 lbs. Nac^{-1}) at the 0–6 and 6-24 in. depths. Before each split application is applied to the corn or hybrid rye, we will also obtain soil samples from the single and two split N application treatments at the traditionally lower than optimal N fertilizer rate (80 lbs. Nac^{-1}) at depths of 0–12 and 12-24 in. and after harvest at 0–12, 12–24, and 24–36 in. These samples will allow us to track the availability of inorganic N to corn and hybrid rye when N fertilizer 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. All these soil samples will be analyzed for nitrate-N and ammonium-N following methods described in NCERA-13 (2015).

Soil samples measuring soil health, nutrient cycling, and N mineralization will be obtained in mid-June (~V6 corn growth stage). These samples will be obtained from the typically optimal N rate (120 lbs. Nac^{-1} treatment) from the 0–6 in. depth. These tests include total and organic C, total N, aggregate stability, available water holding capacity, soil respiration, permanganate oxidizable C, ACE protein, N mineralization (new Illinois soil nitrogen test, Solvita SLAN, hot 2M KCl) and enzymes proteins related to carbon and nitrogen cycling.

Plant samples will be obtained in-season before each split application occurs and at plant maturity in the same treatments where soil samples will be obtained as explained previously. For corn at the V6 and V10 growth stage, 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). For hybrid rye, plant samples will be collected by clipping 11 yd of five rows. Plant materials will be dried in a forced air oven (140^{o}F) until constant mass and weighed to determine dry matter yield. Corn ears will be shelled, and dry weights of grain and cob samples measured. 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 track the uptake of N by the plant and determine the effect of tillage and rotation on N uptake by corn and hybrid rye. Harvest grain yield will be calculated by harvesting the center two rows of each corn plot and center 5 ft of each hybrid rye plot and adjusting grain weight to 15.5% for corn and 14% for hybrid rye.

Information from this project will be used to improve N fertilizer guidelines for corn and small grains being transitioned to no-till and a more diverse crop rotation. This information will help to reduce 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. Three of the 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

- Knowledge gained determining the effect of transitioning to no-till and this five-year rotation has on N fertilizer rate needed to optimize yield for each crop in the rotation every year.
    - Determination of how the above effects change as the number of years in no-till and this five-year rotation increases.
- Knowledge gained on the effect of tillage and crop rotation on soil health metrics and N mineralization metrics as the number of years increases in no-till and a five-year rotation.
    - Knowledge of the length of time it takes for differences in soil health and N mineralization to occur will be determined.
- Development of N fertilizer rate and timing recommendations for hybrid-rye.
- 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 over-application of N fertilizer.
- Update N fertilizer guidelines to include years in no-till with a five-year rotation.
- Extension programming (presentations and fact sheets) regarding the response of corn and hybrid rye to N fertilizer rates and timings.
- Training of graduate and undergraduate students in soil fertility.

Timeline

Table 1. Annual research activities for field studies.

Activity	**2025**				**2026**
	Jan-Mar.	**Apr-June**	**July-Sept**	**Oct-Dec**	**Jan-June**
Map 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 $75,297. 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: $75,297

Personnel and Fringe: $27,919

Jason Clark	$5,630	Provide oversight of the project and personnel throughout the year along with data collection, analysis, and update of fertilizer recommendations.
M.S. Student	$21,232	M.S. student to help in trial establishment, sample and data collection, data analysis, and interpretation and writing of results.
Fringe Benefits	$1,057	Fringe benefits for full- and part-time personnel.

Travel and Accommodations: $6,000

Costs of travel from Brookings to field research locations in Bereseford, SD. This includes approximately 11 trips to establish, maintain, and collect samples and travel to local, regional, and national extension and professional meetings for researchers and students to present results.

Materials & Supplies: $4,000

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: $29,700

$9,600 for soil physical, chemical, and biological measurements. These soil and plant analyses will be completed at labs within South Dakota State University and certified commercial laboratories.

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

$3,600 is budgeted for land rental and user fees of university research farm fields.

$12,000 is budgeted for user fees associated with equipment use of hydraulic soil sampler, tractors, fertilization equipment, planters, plant and soil processing equipment, and combine to mark out research areas, sample soil, establish treatments, plant, maintain crops and research areas, 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.

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