Table of Contents

Application Summary

Competition Details

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Category:	SDAES
Award Cycle:	2020
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Application Information

Submitted By:	Jason Clark
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Application Title:	Combining Soil fertility and Soil Health to improve Corn Potassium, Phosphorus, and Sulfur Fertilizer Recommendations
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Personal Details

Applicant First Name:	Jason
Applicant Last Name:	Clark
Applicant Degree(s):	M.S. in Plant Science, PhD. in Soil Nutrient Manag
Email Address:	Jason.D.Clark@sdstate.edu
Phone Number:	(801) 644-4857
Primary Organization:	Plant Science
Primary Appointment Title:	Assistant Professor, Soil Fertility Extension Specialist
Contact Person's Name:	
Contact Person's Email Address:	
Contact Person's Phone Number:	

Co-Applicant(s)

Name	Email	Affiliation
Anthony Bly	anthony.bly@sdstate.edu	SDSU
David Karki	david.karki@sdstate.edu	SDSU
David Clay	david.clay@sdstate.edu	SDSU

Application Details

Proposal Title

Combining Soil fertility and Soil Health to improve Corn Potassium, Phosphorus, and Sulfur Fertilizer

Recommendations

Proposal Abstract

Much of the data used to create the soil fertility recommendations for South Dakota in the South Dakota Fertilizer Recommendations Guide and Corn Best Management Practices manual is decades old. Over the past decade, more acres have been planted to corn and soybean creating a shift in crop rotations and yields have increased due to better genetics and improved agronomic practices, removing more nutrients from the soil. Further, soil health practices such as no-till, cover crops, and more diverse rotations are being promoted to improve soil structure, organic matter, nutrient cycling, and the overall health of the soils. There is also a growing interest in measuring these improvements by completing soil health tests. However, a strong connection between soil health measurements and crop yield and nutrient recommendations has not been made to aid producers in making management decisions. This project will address these issues by making the connections between traditional soil fertility tests, soil health tests, and nutrient recommendations. The information from this project will be used to help update current nutrient management recommendations based on measured soil properties and specific management practices. The annual budget of this two-year project is $53,606 for 2020 and $57,276 for 2021.

2020 Total Budget Request

53,606

External Peer Reviewer 1

Bijesh Maharjan, 308-632-1372, bmaharjan@unl.edu

External Peer Reviewer 2

Kurt Steinke, ksteinke@msu.edu, 517-353-0271

External Peer Reviewer 3

Antonio Mallarino, apmallar@iastate.edu, 515-294-6200

Combining Soil fertility and Soil Health to improve Corn Potassium, Phosphorus, and Sulfur Fertilizer Recommendations

PI: Jason Clark, Soil Fertility Extension Specialist, SDSU Department of Agronomy, Horticulture & Plant Science (AHPS), jason.d.clark@sdstate.edu, (801) 644-4857
Co-PIs: Anthony Bly, David Karki, and David Clay SDSU AHPS Department

Summary
Much of the data used to create the soil fertility recommendations for South Dakota in the South Dakota Fertilizer Recommendations Guide and Corn Best Management Practices manual is decades old. Over the past decade, more acres have been planted to corn and soybean creating a shift in crop rotations and yields have increased due to better genetics and improved agronomic practices, removing more nutrients from the soil. Further, soil health practices such as no-till, cover crops, and more diverse rotations are being promoted to improve soil structure, organic matter, nutrient cycling, and the overall health of the soils. There is also a growing interest in measuring these improvements by completing soil health tests. However, a strong connection between soil health measurements and crop yield and nutrient recommendations has not been made to aid producers in making management decisions. This project will address these issues by making the connections between traditional soil fertility tests, soil health tests, and nutrient recommendations. The information from this project will be used to help update current nutrient management recommendations based on measured soil properties and specific management practices. The annual budget of this two-year project is $53,606 for 2020 and $57,276 for 2021.

Goals and Objectives
The goal of this project is to update P, K, and S recommendations in South Dakota under different management practices. The specific objectives of this project are 1) Determine corn yield and nutrient uptake response to added P, K, and S fertilizers under various soil fertility and soil health conditions, and 2) Identify soil health measurements that can alone or in combination with traditional soil fertility measurements be used to improve P, K, and S fertilizer recommendations.

Justification
Soil fertility recommendations for corn in South Dakota in the current Fertilizer Recommendations Guide (EC750) and the Corn Best Management Practices manual are based on the relationship between standardized soil fertility laboratory tests and crops yields when fertilizers are applied. However, the data used to develop the recommendations in these guides have not been updated for many years. Since the acquisition of the data used to create the guidelines, reporting of P, K, and S deficiency symptoms have been increasing in various parts of the state, depending on soil and management practices. For example, corn's response to K fertilizer has varied depending on landscape position and soil electrical conductivity in South Dakota. However, these factors are not included in K recommendations. Current and on-going research is needed to reevaluate South Dakota's current P, K, and S guidelines and update them to provide producers with the ability to make precision nutrient recommendations based on soil properties, management practices, and weather conditions.

In addition to the need to update current nutrient recommendations, there has also recently been a large interest to improve the health of our soils. The majority of soil health research has focused on determining how different cropping systems and land uses affect the indices used to determine soil health. However, there is little research in relating measurements of soil health to crop yield, fertilizer applications, and other management decisions. In general, soil samples collected to assess soil health and those to aid in making fertilizer decisions are seen as separate assessments. However, soil biological processes play a large role in nutrient cycling, which affects soil fertility tests. Research is needed to determine the potential for soil health tests combined with traditional soil fertility tests to improve the accuracy of nutrient recommendations. The establishment of relationships between soil health measurements and fertilizer needs of crops will also help promote the measurement of soil health as well as soil health practices that can improve grower profits.

Work Plan:

Field Experiment

We propose a two-year project that includes 8-10 locations annually throughout the eastern and central South Dakota where P, K, and S deficiency is most common. Research will take place on producer's fields with up to five experimental areas within each field to capture field variability. Fields will be selected across a range of management practices that are common in South Dakota. These sites will be identified through SDSU Extension, agricultural co-ops, and commercial and private agronomists. Historic crop management information such as weather, crop rotation, tillage type, cover crop usage, manure application, previous yields, soil type, field slope, tiling, irrigation, and other fertilizer additions will be collected for each field. There will be omission sites determined in each field that consist of areas where producers have strategically excluded P, K, and S fertilizer applications from their normal operations. These omission sites will be a minimum of approximately 60' x 40' or the width of the producer's equipment. These 60' x 40' omission sites will be subdivided into 6 20' x 20' quadrants. Six fertilizer treatments will be evaluated (1, P; 2, K; 3, S; 4, P and K; 5, P, K, and S, and 6, no P, K, and S). All other fertilizers needed will be applied by the cooperating producer following university recommendation guidelines. By conducting this study in several sites within fields that vary in management practices and soil properties, we will be able to determine under what soil properties corn nutrient uptake and grain yield is improved by application of P, K, and S fertilizers. In the 2019 growing season we have already implemented this study on 6 fields and are currently working to finish gathering harvest data for the 2019 growing season. Results from this study will guide future studies regarding the establishment of precision fertilizer rate recommendations based on measured soil properties and specific management practices, which will improve upon the current recommendation that primarily varies by crop yield.

Soil and Plant Sampling

In early spring of each year, the omission sites within a field will be soil sampled following a standardized protocol. The protocol includes obtaining GPS coordinates and soil profile physical and chemical characteristics (0–48-in. depth by soil horizon) (Kitchen et al., 2017), traditional soil fertility (0–6-in. depth) measurements (Denning et al., 2012), and soil biology measurements (0–2 and 2–6-in. depth) (USDA-NRCS, 2018). These soil samples will be obtained within each omission site and analyzed for the measurements indicated in table 1. Whole plant samples will be collected from each quadrant within each omission site near the V6 corn development stage

by clipping 8 plants at ground level. At maturity, corn ears will be hand-harvest from 12 ft. of four adjacent rows in each plot. Plant and grain samples will be dried to constant mass. Corn ears will be shelled and the final grain yield will be adjusted to 15.5% moisture. Whole plant and grain samples will be ground to pass a 0.08 in. sieve and then analyzed for nutrient uptake such as N, P, K, S, etc. (Table 1). These analyses will be used to determine the effect of P, K, and S fertilization on nutrient uptake and grain yield relative to the check plot.

Table 1. Proposed soil and plant measurements.

Traditional Soil Fertility Measurements (0-6")	**Soil Profile Characterization (0-48" by soil horizon)**	**Soil Biology (0-2" and 2-6")**	**Nutrient Content (V6 and R6)**
Organic matter	Bulk Density	pH	Nitrogen
pH	Texture	Total Nitrogen	Phosphorus
Buffer pH	Electrical conductivity	Soil Organic Carbon	Potassium
Sodium	pH	Potentially Mineralizable N	Calcium
Phosphorus	Total Nitrogen	Aggregate Stability	Magnesium
Potassium	Soil Organic Carbon	ACE Protein	Sulfur
Calcium	Phosphorus	Enzyme (NPSC)	Zinc
Magnesium	Potassium	Respiration (Cornell method)	Iron
Sulfur	Sulfate-Sulfur	Active Carbon (POXC)	Manganese
Soluble Salts		Electrical conductivity	Copper
Nitrate-Nitrogen			Boron
Cation Exchange Capacity			Molybdenum

Data from this study will be combined with other similar studies that are being conducted in Missouri, Iowa, and Nebraska with Newell Kitchen, a USDA-ARS Scientist at the University of Missouri as the lead investigator. This study will also be combined with another study already funded by the Nutrient Research and Education Council to increase the number of study locations evaluating the response of corn yield to P and K, but also include S. By completing this project and combining it with other projects, we increase the number of study locations, the access to equipment and labor, reduce costs with an in-kind contribution of approximately $8,000 annually from completing soil health analyses at USDA-ARS laboratories, and reduce other laboratory analysis costs by 35% from receiving bulk rate discounts. Data collected from all of the states will be combined, resulting in a large and powerful dataset. This dataset will be used to evaluate the influence of soil health practices on measurements of soil fertility and evaluate the accuracy of current P, K, and S fertilizer recommendations.

Evaluation

The response of grain yield and nutrient uptake when P, K, and S fertilizers are applied relative to the check will be analyzed at each omission site and then combined within South Dakota and again across the region (South Dakota, Iowa, Nebraska, and Missouri). In total over the 3 years (which includes data from the 2019 growing season), hundreds of these monitoring sites will be combined across the region and the relationships between crop responses and soil fertility, soil health, landscape, weather, and management factors will be determined utilizing traditional and advanced multi-variate data analysis techniques. This type of analysis will help us understand

crop responses to P, K, and S fertilizers as a function of soil fertility, soil health, landscape, and management factors. The success of this proposal will be measured in three ways: 1) the determination of soil fertility, soil health, and other management practices where current P, K, and S fertilizer recommendations need to be updated, 2) the identification of soil health measurements that can be used to determine soil fertility and crop responses to fertilizers, and 3) identification of when traditional soil fertilizer recommendations can be modified using soil health measurements such as soil test critical values increasing/decreasing depending on the level of a soil health measurement.

The results from this study will be shared annually with the cooperating producers, agronomists, and other individual producers. This study will also be the basis of Extension programming (presentations and fact sheets) regarding nutrient recommendations and the effect of soil properties and soil health on these nutrient recommendations. One presentation regarding this work has already been given to farmers and agronomists based on data from the 2019 growing season.

Potential Impacts:

- Improved P, K, and S fertilizer guidelines for corn that increase profitability and has the potential to extend to other nutrients and crops.
- Increased knowledge regarding the effect of improved soil health on soil fertility and fertilizer recommendations.
- Identification of soil health measurements that can be used to determine soil fertility and corn responses to fertilizers.
- Development of fertilizer recommendations that incorporate soil fertility, soil health, and other management practices.
- Identification of when traditional soil fertilizer recommendations can be modified using soil health measurements.
- Improved data processing and analysis techniques in the area of fertilizer recommendations.
- Extension programming (presentations and fact sheets) regarding the effect of improved soil health on soil fertility and fertilizer recommendations.
- Training of a graduate and several undergraduate students in soil fertility.

Timeline:

Table 2. Project work plan for year one of three-year project.

Activity	Mar-Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Soil Sampling									
Identification of 8 on-farm sites	X								
Soil fertility samples (0-6")	X								
Soil profile characterization	X								
Soil biology	X								
Veris Soil EC	X								
Plant Sampling									
Corn plant sampling			X			X	X		
Field Operations									
Fertilization	X	X							
Plant corn	X	X							
Harvest						X	X		
Sample and Data Processing									
Plant and soil processing and analyses	X	X	X	X	X	X	X	X	X
Build database							X	X	X
Share findings through Extension				X	X	X	X	X	X
Prepare reports as requested	X	X	X	X	X	X	X	X	X

Project Budget and Justification:

The laboratory work for the soil health analyses will be completed at the USDA-ARS research lab in Columbia, Missouri. Because of this collaboration with USDA-ARS personnel, we are able to reduce the laboratory costs of this project with an in-kind contribution of approximately $8,000 annually. Therefore, the annual budget of this two-year project is $53,606 for 2020 and $57,276 for 2021.

Table 3. Annual budget and justification.

Category	Year 1	Year 2	Description
Salaries and Wages			
Lab/field coordinator	$11,250	$11,588	Provide day to day oversight for the students conducting the experiments and technical support in laboratory analyses.
Student help	$5,100	$5,253	Undergraduate student wages to help in field and laboratory work.
Benefits	$4,256	$4,435	Fringe benefits for lab/field coordinator and student employees.
Total Salaries and Wages	**$20,606**	**$21,276**	
Travel	**$7,000**	**$7,000**	Cost of using South Dakota Fleet and Travel vehicles by research personnel, graduate, and undergraduate students to travel and move equipment to and from research sites to complete field work and sampling. Travel to local, regional, and national extension and professional meetings for researchers and the students to present results is also included.
Direct Costs			
Materials & Supplies	$6,000	$6,000	Purchase of field and sampling supplies (i.e. fertilizers, flags, stakes, sampling bags, disposable gloves, measuring tapes, labels, markers, plant cutter, soil probes, WD-40, ice packs, coolers, and other incidentals) needed to apply fertilizer treatments and collect and process plant and soil samples. Cost also includes laboratory supplies (i.e. chemicals, pipettes, filters, etc.) and computer and software for graduate student to complete soil and plant nutrient and statistical analysis).
Publications	-	$2,000	Cost of formatting and publishing of extension and scientific articles.
Contractual	$20,000	$21,000	Service costs are for processing and analysis of plant and soil samples (Table 1) by plant and soil testing labs. The costs of this project is reduced by an in-kind contribution of approximately $8,000 from USDA-ARS because the majority of the soil health analyses will be completed in their labs. By combining this project with those in three other states, costs for soil and plant sampling was reduced by 35% because of the large number of research samples being analyzed from this project. Other contractual costs consist of use of a hydraulic soil probe, lab equipment, crop destruction/cooperation fees, and statistical consulting fees.
Total Direct Costs	**$26,000**	**$29,000**	
Annual Total	**$53,606**	**$57,276**	

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