Appendix A

ND SOYBEAN COUNCIL COVER SHEET – FY 2022
(Required for all Research Funding Requests)

Name of Organization: North Dakota State University

Project Title: Field Validation of Mineral N Cycling from Mixed Crop Residues in Long-term No-till Systems *(This is a request for a funding match for a proposal submitted to SBARE)*

Principle Investigator Name: Larry Cihacek **Title:** Professor
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Department: NDSU School of Natural Resource Sciences – Soil Science

Research Funding Request: $ 3872.00

Authorized Institution Representative: Jill Mackenzie
Title: Award and Program Officer

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Authorized Institution Representative Signature: Jill Mackenzie Digitally signed by Jill Mackenzie Date: 2020.10.29 10:24:26 -05'00' Date: _____

Principle Investigator Signature: _____ **Date:** 10/28/2020

Signature(s) of Co-investigators:

_____ Date: _____ _____ Date: _____

_____ Date: _____ _____ Date: _____

Non-Technical Summary 250 Words Maximum:

Recent research by Chatterjee et al. (2015) and Aher et al. (2016) have shown that significant levels of crop residues can accumulate in crop rotations in which high residue crops such as wheat or corn are frequent component crops. This residue accumulation is partly due to the relatively cool climate in the northern Great Plains of the U.S. High residue producing crops often have high N requirements. N fertilizer is a major input in the cost of crop production but little information is available in the literature about the rate of N mineralization and the N contribution of residue decomposition to the N requirements of subsequent grain crops in long-term no-till culture. We have just completed laboratory research that shows that most crop residues after harvest have wide C:N ratios which encourage N immobilization rather than N mineralization. We have also noted that adding a high N-mineralizing cover crop such as forage radish may negate the immobilization through supplementing microbial N needs during the rapid growth phase of crop development. Since this previous work was done under optimum laboratory temperature and moisture conditions, we need to validate our findings under field conditions. Knowledge of the mechanisms of N cycling from post-harvest crop residues in combination with effects of cover crops in long-term no-till culture will information growers on improved decisions about the most efficient use of their fertilizer N applications.

Objectives:
The objective of this research is to:

(a) evaluate and validate our laboratory research on N-mineralization/immobilization processes in a field environment; and

(b) determine how varying temperature and moisture conditions in a field environment affect crop residue decomposition and N mineralization under a no-till culture.

Project Deliverables:

Plan of work:

This study will utilize a total of 42 microplots installed in the field using PVC piping rings (30 cm in diameter and 21 cm in depth) to take our previous research into a field environment. These rings will be pushed vertically into the soil, with the bottom of the PVC tube left open, to eliminate soil disturbance. Three replicates will be established for the experiment (n=28 samples for each replicate). Each replicate will include two crop residue application methods (surface or mixed in the soil) and two fertilizer treatment methods (0 or 30 lb N/acre) with seven crop residue treatments. Residue treatments for each experiment tube will rotate each year to mimic cropping systems of the northern region (Table 1).

Table 1. Crop residue treatments and their rotations for corn (C), soybean (S), spring wheat (SW), radish (R) with 30% incorporation and the bare, unamended soil control alone over three-year study period.

Year/ Cycle	Crop Residue Treatment Rotations						
1st	C	S	SW/R	S/R	C	SW	Control
2nd	SW	C	S/R	C	SW/R	S	Control
3rd	S	SW	C	SW/R	S/R	C	Control

The crop residue will be collected the fall prior to year 1 of the study (Fall 2020) and analyzed in the lab to determine nitrogen content, C:N ratio, lignin, and cellulose composition. Chemical analysis for the soil itself will be conducted prior to year 1 sample collections to determine the soil organic matter, nitrogen availability, and soil pH.

Time domain reflectometer (5TM) sensors (n=14) will be installed for each sampling replicate to monitor soil moisture and temperature. Sensors will be installed horizontally through the side of the tube at 5 cm below the soil surface. Sampling rings that include mixed residue application (n=14) will be prepared by mixing the initial crop residue treatment with the soil using a hand trowel after ring installation in the field to a 5 cm soil depth. A surface application of 75 g of crop residue, simulating no-till will be manually applied to the soil surface. Treatments that include the 30 lb N/acre fertilizer application will be injected as an ammonium nitrate solution at the 5 cm soil depth. Moisture and temperature will be continuously monitored throughout the growing and non-growing season to capture the effect of freeze and thaw on soil dynamics for the designated tube samples. Soil samples will be manually collected every three weeks from selected microplots using a soil probe tube at the 5 cm soil depth. For the samples that include a surface application of crop residue, the surface residue will be removed by hand and then the sample will be taken. Soil samples will be gathered from post spring thaw (mid-April) through post-harvest (mid-October) for the region. The total number of handheld soil samples that will be collected as a part of the experiment is 2,268 or 756 per year (9 collection points/year *84 samples). For each collection period, samples will be collected from the field, transferred to a cooler, and transported to the lab. Samples with moisture and temperature sensors will be divided into halves in the laboratory. One half will be analyzed for PLFA analysis to analyze the microbial community. The other half and remaining soil samples without moisture and temperature data, will be air dried then analyzed in the lab for NO_3-N mineralization. For the nitrate analysis, NO_3-N will be extracted from the soil and distilled, using the methods of Keeney and Bremner (1972). Soil moisture and temperature data will be analyzed using average daily readings from the samples to examine any variances in crop residue application and/or crop rotations with and without cover crop. These findings will then be cross referenced with soil health data (PFLA), soil nitrate (mineralization/immobilization), and C:N ratios to provide a broader understanding of field management practices and mitigations that may be beneficial for

producers with a long-term, no-till cropping system and to validate the results of our previous laboratory research. This appears to be an approach that has not been previously reported in the literature in studying N cycling from residues in relation to actual temperature and moisture conditions.

References:

Aher, G., L. J. Cihacek, and K. Cooper. 2016. An evaluation of C and N of fresh and aged crop residue from mixed long-term no-till cropping systems. Journal of Plant Nutrition (DOI:10.1080/01904167.2016.1201505, Published online: 26 Jul 2016).

Bremner, J. M. 1965. Inorganic forms of nitrogen. pp. 1179-1237. *In C.* A. Black (ed.) Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Agron. 9. ASA, Madison, WI.

Chatterjee, A., K. Cooper, A. Klaustermeier, R. Awale, and L. J. Cihacek. 2016. Does crop species diversity influence soil carbon and nitrogen pools? Agron J. 108: 427-432.

Cihacek, L. J., and R. Alghamdi. 2020. N mineralization dynamics in no-till crop residues in the Northern Plains. Great Plains Soil Fertility Conference Proceedings. March 10-11, 2020. Denver, CO.

Franzen, D. W., G. Endres, R. Ashley, J. Starica, J. Lukach, and K. McKay. 2011. Revising nitrogen recommendations for wheat in response to the need for support of variable-Rate nitrogen application. J. Agric. Sci. Tech. 1:89-95.

Stanford, G., and S. J. Smith. 1972. Nitrogen mineralization potentials of soils. Soil Sci. Soc. Amer. Proc. 36:465-472.

Benefit to ND Soybean Farmers:

Most soybean growers grow the soybean in rotation combinations with other crops (spring wheat, corn) as a means of providing crop diversity to control weeds, insects and diseases as well as providing an N credit for their subsequent crop's fertility needs. Our research shows that heavy crop residue accumulation in long-term no-till culture may be responsible for N immobilization in subsequent crops. Soybean can lend itself to seeding a fall cover crop after harvest that may help offset N immobilization and mitigate the immobilization by the residue. However, soil moisture and temperature are variables that cannot be controlled under field conditions. This work will provide a clearer picture of how the crop cam be managed to improve N availability to subsequent crops.

Appendix B
PROJECT BUDGET FORM
ND Soybean Council

Project Title: Field Validation of Mineral N Cycling from Mixed Crop Residues in Long-term No-till Systems

Proposing Organization: North Dakota State University
PROPOSED BUDGET SUMMARAY

- Supplemental detail may be required on items of $5,000 or more

Salaries:	
• Principle Investigator if **NOT a salaried position**:	$
• Professional Staff:	$
• Graduate Research Assistant:	$
• Under Graduate Students	$1000.00
• Technical Support:	$
• Fringe Benefits	$100.00
Total: Salaries and Fringe Benefits	**$1100.00**

Operating Costs:	
• Land Rent/Leases:	$
• Postage/Shipping:	$
• Printing:	$
• Repairs:	$
• Signs: (Agronomic Plots Only)	$
• Operating Fees: (Greenhouse, Soil Testing etc.)	$
• Field Supplies:	$
• Other: Data Loggers, temperature/moisture sensors, supplies	$2772.00
Total Supplies:	**$2772.00**

Travel:	
• Domestic:	$
• International:	$
Total Travel	**$0**

Note:

- **Domestic and international travel is RESTRICTED and exceeding allocated travel budget requires prior written approval from NDSC.**
- **NDSC will allow up to $1000 per grant for expenses to regional, national or international conferences when NDSC funded research will be presented. NDSC will also need a copy of the presentation and agenda for the conference.**

Total Requested:
Salaries $1100.00 + Supplies $ 2772.00 + Travel $ 0 = Total $ 3872.00

Project Leader/ Principle Investigator
Typed Name: Larry Cihacek Signature: Larry Cihacek Date: 10/28/2020

Authorized Organizational Representative
Typed Name: Amy Scott Signature: Jill Mackenzie Digitally signed by Jill Mackenzie Date: 2020.10.29 10:24:50 -05'00' Date: