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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:	Field Monitoring of Precision Controlled Drainage for Water Quality and Yield Improvement- Phase 2
Application ID:	3444
Submission Date:	10/10/2024 9:24 PM

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Application Details

Proposal Title

Field Monitoring of Precision Controlled Drainage for Water Quality and Yield Improvement- Phase 2

Proposal Abstract

This request is for Phase 2 of the planned multi-year study. This phase will focus on collecting a full season of water flow data and preparing for expansion of the project to cooperator sites. Nutrient loss contributes to economic loss for producers and potential negative downstream water quality impacts. Commercially available systems allow for remote control through a smart phone but management still does not account for field, crop, or future weather conditions. Two AgriDrain Automated Controlled Drainage systems were installed at the South East Research Farm in 2023. Yield, water quantity, and water quality will be compared to two manually controlled drainage plots and two free drainage plots. Monitoring in this second phase with fully established instrumentation will allow us to capture the dynamics during the spring melt/thaw and the rest of the season. Plans will be developed for Phase 3 to include precision CD testing in cooperator fields.

2025 Total Budget Request

60,713

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.

Field Monitoring of Precision Controlled Drainage for Water Quality and Yield Improvement- Phase 2

PI – Todd P Trooien, Agricultural and Biosystems Engineering, SDSU.
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Collaborators – Sushant Mehan, Agricultural and Biosystems Engineering, SDSU
John McMaine, Biosystems and Agricultural Engineering, University of Kentucky.
Ali Nafchi, Agronomy, Horticulture, and Plant Science, SDSU.
Kristopher Osterloh, Agronomy Horticulture, Plant Science, SDSU.

Summary – This request is for Phase 2 of the planned multi-year study. This year will focus on collecting a full season of water flow data and preparing for expansion of the project to cooperator sites. Nutrient loss contributes to economic loss for producers and potential negative downstream water quality impacts. One path of soluble nutrient loss (nitrate) from fields is through subsurface drainage. Current CD management recommends adding or removing stop logs two or three times per year without regard to field conditions. Commercially available systems allow for remote control through a smart phone but management still does not account for field, crop, or future weather conditions. Two AgriDrain Automated Controlled Drainage systems were installed at the South East Research Farm in 2023. Yield, water quantity, and water quality will be compared to two manually controlled drainage plots and two free drainage plots. Monitoring in this second phase with fully established instrumentation will allow us to capture the dynamics during the spring melt/thaw as well as the rest of the season. Also, plans will be developed for Phase 3 to include precision CD testing in cooperator fields.

Goals and Objectives – Goal – Evaluate plot-scale precision controlled drainage systems that will allow farmers to optimize water retention based on soil moisture and crop water needs. Specific objectives:

1. Evaluate the performance of a plot-scale precision controlled drainage system.
2. Demonstrate the technology and process in field days.

Justification Statement – Tile drainage continues to increase in South Dakota. During years that experience intermittent dry periods, an opportunity exists to use controlled drainage to hold back timely rains for use by the crop. The reduction in annual nitrate-N load with controlled drainage (CD) ranged from 3.7 to 19.1 kg-N ha^{-1} (Helmers et al., 2010). Unlike other conservation drainage practices, CD has also shown the potential to increase yield by up to 4 to 10% (Youssef et al., 2023) by holding more water in the field when needed. Precision controlled drainage reduces the potential risk of mismanagement. By optimizing how much water is held back, agricultural fields can more effectively use available water and nutrients and reduce the amount of nutrients that go downstream.

Work Plan – This project will be broken into two steps: (1) conduct plot scale field research and (2) communicate results to stakeholders.

1) The first step of the project is to compare three treatments: automated or precision controlled drainage; manually controlled drainage; and free drainage. There will be two replications for each treatment. Plots were established and systems were installed at the South East Research Farm in 2023 and 2024. The two automated controlled drainage systems were provided to SDSU at cost and represent a significant value of up to around $10,000 to the project. Beginning in spring, water grab samples will be collected weekly from each control structure and analyzed for nitrate and ortho-phosphate concentrations. Flow will be measured continuously and logged every five minutes using a weir inside the control structure and radar to measure water level.

Weekly concentration is multiplied by flow to determine the load (or mass) of nutrients leaving each system. Soil moisture will be measured with soil moisture probes that SDSU already owns (value of about $10000). In addition, crop yield will be measured for each plot.

2) The second step of the project, communication to stakeholder, will include multiple field days at different stages of the project, a fact sheet, and incorporation of the technology into a Precision Agriculture and Agricultural Systems Technology course, Climate Risk Management with Precision Ag (in which many students are future ag producers or advisors).

The simulation model DRAINMOD was calibrated during Phase 1. It can be used to simulate and compare other treatments if they are identified. No further comparisons are planned at this time but the calibrated model is a powerful tool that is readily available if further objectives are identified.

In preparation for a potentially expanded project commencing in 2026, cooperators will be sought during the summer and fall. Selection criteria will include a site with appropriate topography and access and willingness to cooperate in a research and extension project and approach.

Potential Impacts – Under ideal conditions, precision controlled drainage could reduce nutrient loss by 40-50% across hundreds of thousands of acres in South Dakota (and millions across the Midwest) while increasing yields across those acres by up to 15%. While yield benefit depends on rainfall amounts and timing (little benefit when it is excessively wet or excessively dry), it's likely that there is enough yield benefit for precision controlled drainage that it can pay for itself. If that proves to be true, then agricultural systems with precision controlled drainage could simultaneously produce more crop and reduce nutrient loading without needing to significantly alter in-field management.

This project provides an important transitional step in the overall process. While controlled drainage and remote controlled drainage systems are commercially available, these do not incorporate field information to determine water needs. This project will develop the mechanisms needed to control drainage based on field conditions. This project will meet important needs for South Dakota producers through reducing nutrient loss in tile drainage and improving crop yields, it also will lead to significant investment in South Dakota by federal grants to further develop and implement this technology.

Timeline - The experiment will be conducted and flow data and water quality samples will be collected during the entire frost-free period of 2025. Water quality sample analysis will begin when samples are available. Data analysis will commence as soon as water quality data are available. Field days or tours will take place at least once during the summer and at least once during the fall.

Searching for and recruiting cooperators for a potential expanded project at multiple locations will take place during most of the summer and fall.

Year 2	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25
Collect water quality samples												
Analyze data												
Recruit cooperators for expanded project												
Field day tour												

Project Budget

Total - $60,713
Travel - $5,000 for travel (50 trips at $0.5 per mile for 200 miles per round trip),
Contractual - $6,120 sample analysis (6 sampling points, $30 per sample, 34 samples at each point), $4,500 for plot fees (6 plots at $750 each), total of $10,620.
Other Personnel –
$6,180 for staff salary to assist with setup and maintenance. This is 10% time at $61,800 annual salary.
$23,859 for one PhD student at 49% time.
$1,920 for 96 hours (one day per week during the summer) of undergraduate student labor to train undergraduates in the project.
Fringe benefits – Total is $2,429. Fringe benefits for Other Personnel above is calculated based on 10% of time on the project at a rate of 15% plus an annual stipend of $12,444 for health and life. One percent fringe is calculated for students for a total of $258.
Publication fees - publication fees of $1,500 for page charges for one publication.
Tuition remission - $9205 for tuition remission

References:

Helmers, M.J., Abendroth, L., Reinhart, B., Chighladze, G., Pease, L., Bowling, L., Youssef, M., Ghane, E., Ahiablame, L., Brown, L. and Fausey, N., 2022. Impact of controlled drainage on subsurface drain flow and nitrate load: A synthesis of studies across the US Midwest and Southeast. *Agricultural Water Management*, *259*, p.107265.

Youssef, M.A., Strock, J., Bagheri, E., Reinhart, B.D., Abendroth, L.J., Chighladze, G., Ghane, E., Shedekar, V., Fausey, N.R., Frankenberger, J.R. and Helmers, M.J., 2023. Impact of controlled drainage on corn yield under varying precipitation patterns: A synthesis of studies across the US Midwest and Southeast. *Agricultural Water Management*, *275*, p.107993.