Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-204

Proposal Title: Developing Smart-N App to Reduce Corn Nitrogen Pollution

Project Manager Information

Name: Yuxin Miao

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: Precision N management technologies can reduce N pollution of water resources. Developing a mobile App will support Minnesota corn growers to adopt precision N management technologies and protect water resources.

Funds Requested: $248,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Water Resources (B)

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

This project will target the unimproved water quality challenge of high nitrate concentration and loads due to mismanaged nitrogen (N) fertilizer application in corn fields, focusing on seamless bridging of novel technologies and corn growers with a precision corn N management mobile App.

High nitrate concentration and loads have not been significantly reduced in surface and ground waters of Minnesota over the last 20 years (MDA, 2016; MPCA, 2018). Corn cropping systems have been identified as a dominant non-point source of nitrate loads to surface and ground waters. Precision agriculture technologies have been demonstrated to effectively reduce N fertilizer input and nitrate loss by matching N supply and crop demand in both space and time. However, the adoption rate of precision corn N management is low in Minnesota.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

In this project, we propose to develop a smart mobile App of precision corn N management for real-time N deficiency diagnosis and in-season management recommendations to support corn growers. This smart App will build a pipeline between mature precision N management strategies developed at the Precision Agriculture Center, University of Minnesota (UMN), in-season dataflow, and corn growers. We will fully leverage publicly and privately available datasets related to soil and landscape factors, weather conditions, crop management practices, proximal and remote sensing, and computational resources at the UMN Supercomputer Institute. This App will be open to interested corn growers, farm advisors, crop consultants, and other agricultural professionals in the state of Minnesota.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

1). The wide adoption of the Smart-N App developed in this project will significantly decrease N fertilizer application for corn production and reduce nitrate loads to surface and ground waters, thus protecting the precious water resources in Minnesota;
2). The developed Smart-N App will facilitate seamless novel knowledge and technology transfer to corn growers from the Precision Agriculture Center, UMN.

Activities and Milestones

Activity 1: Develop and test smart-N mobile App for real-time corn precision N management

Activity Budget: $110,000

Activity Description:

A backend server will be hosted at the Precision Agriculture Center, UMN. It builds linkages between App users (i.e., corn growers) and databases at the Minnesota Supercomputing Institute. The results of real-time N stress diagnosis and fertilizer recommendation will be generated and reviewed first by precision agriculture scientists, and then be accessible to the registered corn growers. Four tasks include:

1.Smart-N App design and development at the client/corn-grower side and host server side. It includes a friendly wireframe for corn growers, backend construction, and a series of application programming interfaces (APIs) developed for data processing and N recommendations.

2. Data preprocessing and server-side database preparation. We will utilize computing clusters to process data on agronomic practices, soil, weather, remote sensing, historic management and yield, modeling, analysis, and summary for a specific corn field. The server-side database will provide connections with corn growers through APIs.

3. Decision tool assembly for precision real-time N deficiency diagnosis and fertilizer recommendations at specific times, locations, and rates.

4. Smart-N App performance tests on both the client and host server sides, and App release. We will continually test and improve the App based on feedback from corn growers.

Activity Milestones:

Description	Completion Date
Backend database and processing support pipeline	2021-10-31
Online N diagnosis and recommendation decision tool	2022-02-28
Smart precision corn N management mobile App test version release	2022-03-31

Activity 2: Evaluating the smart mobile App for precision N stress diagnosis and N management recommendation in corn fields

Activity Budget: $138,000

Activity Description:

We will evaluate the smart-N App in at least 50 corn fields of Minnesota in 2022. The selected corn fields will cover a range of landscapes with and without sub-surface drainage, across the entire corn growing area of Minnesota. Yield, economic, and environmental benefits of precision N management under the smart-N App will be compared with traditional N management practices. At UMN, we will simplify the procedures of N stress diagnosis and in-season N recommendation and demonstrate the App to collaborating corn growers through workshops, precision field-days, and online training. Specific work plans include:

1. Identifying interested corn growers for precision N management using the smart-N App;

2. Training corn growers for App registration, installation, application, data/results access, and queries, questions, and feedback submission;

3. Organizing field databases including location, weather, soils, historic agronomic management practices, and remote sensing data on a host server;

4. On-farm application of proximal and remote sensing tools for corn N stress diagnosis and making real-time in-season N recommendations;

5. Post-application monitoring of corn growth and development at each field using remote sensing technologies;
6. Final comparison and evaluation of App-based precision N management with farmer's existing practices.

Activity Milestones:

Description	Completion Date
Identify 50 corn fields across Minnesota	2021-11-30
Database for all selected corn fields	2022-01-31
Workshop/training of smart mobile App for corn growers	2022-03-31
Updated smart-N mobile App release at Precision Agriculture Center	2022-05-31
On-farm testing of the smart mobile App-based precision N management	2022-12-31
Updated smart-N mobile App release at Precision Agriculture Center	2023-05-31
Final project report	2023-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Shujiang Kang	University of Minnesota	Senior agriculture modeling and data analytic scientist at Precision Agriculture Center, UMN, will provide support on database development, big-data analytics, and development of the smart mobile precision N management App.	Yes
Jeffrey A. Coulter	University of Minnesota	Professor and UMN Extension Specialist of corn-based cropping systems, will develop the extension plans for this project, identify and train interested growers and their advisors about this technology at workshops, field days, and online programs, and write online extension articles.	Yes
David J. Mulla	University of Minnesota	Professor, W. E. Larson Endowed Chair of Soil and Water Resources, and Director of the Precision Agriculture Center, UMN, will guide real-time corn N deficiency diagnosis and in-season N fertilizer recommendations.	No

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

The long-term goal of this project is to develop a fully interactive open platform of mobile App for all corn growers in Minnesota, producing corn on over seven million acres of the state. It will be available on the website of Precision Agriculture Center. We will work with UMN Extension, the Minnesota Corn Growers Association (MCGA), the Minnesota Agricultural Fertilizer Research and Education Council (AFREC), and the Minnesota Department of Agriculture (MDA) to fully use available resources and support to improve and disseminate the smart corn precision N management mobile App and educate MN corn growers for new technology application.

Project Manager and Organization Qualifications

Project Manager Name: Yuxin Miao

Job Title: Assistant Professor, Associate Director

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Yuxin Miao will lead and manage the project. He is an Assistant Professor of Precision Agriculture and Nutrient Management in the Department of Soil, Water and Climate, and Associate Director of the Precision Agriculture Center (PAC), UMN. Dr. Miao is an internationally recognized expert on precision agriculture and nutrient management. His research aims to develop integrated precision nutrient and crop management systems for food security and sustainable development. A combination of field measurements, active canopy sensors, UAV and aerial as well satellite remote sensing, crop growth modelling, geospatial analysis, machine learning, management zone delineation and other new technologies are used to develop innovative nutrient and crop management solutions to improve crop yield, quality, nutrient use efficiency, and economic returns, and protect the environment. He was the recipient of the Pierre C. Robert Precision Agriculture Young Scientist Award from International Society of Precision Agriculture (ISPA) in 2012, and the Outstanding Chinese Alumni Award of UMN in 2014. He has been serving as Country Representative at ISPA. He is the funding leader of the ISPA Precision Nitrogen Management Community. He has published over 130 journal articles, conference papers and book chapters. He has worked on different crops (wheat, corn, rice and potato) and different scales of farming systems. He is serving as Associate Editor for several international journals, including Precision Agriculture, Remote Sensing, and Agronomy Journal. Dr. Miao has extensive experience in precision N management and on-farm collaboration with corn growers on precision agriculture technology applications. Dr. Miao has extensive experience managing budgets and personnel in academic settings.

Organization: U of MN - College of Food, Agriculture and Natural Resource Sciences

Organization Description:
The College of Food, Agricultural and Natural Resource Sciences (CFANS) of UMN is the leading college in the state for agricultural research, education, extension and outreach, with deep expertise in disseminating research to the agricultural community.

The Precision Agriculture Center (PAC) was established in 1995 as the world's first center for precision agricultural research, education and extension, housed in CFANS of UMN. Precision agriculture was developed at UMN in the early 1980s. The center was the organizer of the International Conference on Precision Agriculture for many years, and founded the Precision Agriculture journal. The Center provides a platform for exploring new digital agriculture frontiers on production, environment, and sustainability of various cropping systems. It is forging interdisciplinary research collaborations across disciplines and growers, both within and beyond UMN. The PAC has been focusing on precision N management strategies and technologies, involving proximal, UAV, aerial and satellite remote sensing technologies, crop growth modeling, slow release fertilizers, machine learning and artificial intelligence, soil-landscape analysis, management zone delineation strategies, and soil sensing.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
PI		Yuxin Miao, Will lead and coordinate the project			36.5%	0.2		$27,846
Co-PI, Professor and Extension Scientist		Jeffrey A. Coulter, will lead and coordinate extension and training			36.5%	0.06		$7,000
Co-PI, research scientist		Shujiang, Kang, will develop the App and coordinate on-farm evaluation			36.5%	1		$88,725
Graduate Assistant		Will compile the database, conduct on-farm evaluation experiments, and analyze the data			46%	1		$49,149
Part-time Computer Software and App developer, temp-casual appointment		will work on App design, coding, and testing			8%	0.5		$40,000
							Sub Total	**$212,720**
Contracts and Services								
consulting fee	Professional or Technical Service Contract	Crop Consultants to help communicate this project to corn growers, identify corn growers for on-farm trials, and facilitate data collection from these corn growers				0		$2,580
							Sub Total	**$2,580**
Equipment, Tools, and Supplies								
	Tools and Supplies	Sampling bags, 500	for collecting ground truth samples					$500
	Tools and Supplies	Batteries for GPS, UAV, and Sensors, 10	For field data collection					$100

							Sub Total	**$600**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	traveling to farmer fields not known yet using university fleet services vehicle, covering mileage, lodging and meals, 20 trips in two years	to implement on-farm trials and collect sensor data and ground truthing data					$4,000
	Miles/ Meals/ Lodging	4 in-state nutrient management related conferences at locations not determined yet, covering mileage, lodging and meals	to present project progress and promote the adoption of the App					$1,000
							Sub Total	**$5,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	2 annual nitrogen use efficiency network meetings organized in different states not determined yet, covering mileage, lodging, meals and incidentals, 2 people for each conference	to present project progress and receive feedback and advice	X				$1,000
	Conference Registration Miles/ Meals/ Lodging	2 annual American Society of Agronomy conferences at cities not determined yet, covering registration, abstract fee, air ticket, lodging, meals and incidentals,1 person for each conference in each year, each conference costs about $2,000	to present project progress, share the results with wider audiences, and receive feedback and advice for improvement	X				$4,000
							Sub Total	**$5,000**
Printing and Publication								
	Printing	Training Materials and Handouts, 100 copies	for organizing training workshops and providing training materials to grower and crop consultant participants					$1,000

	Publication	Publication fees for research and extension papers, 3 papers in total	for wider dissemination of project results					$3,000
							Sub Total	**$4,000**
Other Expenses								
		Pix4D Software License, 1 licence, $500/year, 2 years	for UAV image processing and analysis					$1,000
		ENVI Remote Sensing Image Analysis Software License, 1 licence	for analysis of satellite and UAV images					$2,100
		On-farm Trial Fee, 50 corn fields, $300/field	Compensation to cooperating growers participating in on-farm trial					$15,000
							Sub Total	**$18,100**
							Grand Total	**$248,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	2 annual nitrogen use efficiency network meetings organized in different states not determined yet, covering mileage, lodging, meals and incidentals, 2 people for each conference	Nitrogen use efficiency network meeting is organized each summer by different universities in the mid-west to share latest research progress on N management research and development, and it is important for us to share the project progress with peers in other states for better outreach and also for their suggestions to improve the App development for Minnesota.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	2 annual American Society of Agronomy conferences at cities not determined yet, covering registration, abstract fee, air ticket, lodging, meals and incidentals,1 person for each conference in each year, each conference costs about $2,000	The American Society of Agronomy Annul Meeting is organized together with Crop Science Society of America (CSSA) and Soil Science Society of America (SSSA) each year in different cities of US. It is attended by several thousands of people each year. It is a great opportunity not only to share our research progress, but also a great opportunity to learn the latest advances and technologies by researchers from around the world to improve our research in Minnesota.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Attachments

Required Attachments

Visual Component

File: 072e24ad-174.docx

Alternate Text for Visual Component

Visual Description of the Development of Smart-N APP to Reduce Nitrogen Loss and Improve Water Quality

Optional Attachments

Support Letter or Other

Title	File
Support Letter from Minnesota Corn Growers Association	efe1cbb4-b58.pdf
Support Letter from Minnesota Department of Agriculture	dc685882-bf7.pdf
Support Letter from Agricultural Fertilizer Research and Education Council	86686393-d1a.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

Yes,

- Patent, Copyright, or Royalty Potential
- Potential revenue generated or net income from the sale of products or assets developed or acquired with ENRTF funding

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Development of Smart-N App (SNAP) to Reduce Nitrogen Loss and Improve Water Quality