Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 096-B**

Protecting Ground Water from Nitrogen in Potato Production

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 798,070

Proposed Project Time Period for the Funding Requested: June 30, 2023 (4 yrs)

Summary:

Complementary approaches to limiting nitrogen leaching into ground water from potato production: 1. integrate potato into a rotation with a deep rooted perennial 2. breed potatoes which require less nitrogen.

Name: Laura Shannon

Sponsoring Organization: U of MN

Title: Assistant Professor

Department:

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St. Paul MN 55108

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Location

Region: Central, Northwest

County Name: Becker, Cass, Clay, Hubbard, Kittson, Marshall, Morrison, Polk, Red Lake, Sherburne, Todd, Wadena

City / Township:

Alternate Text for Visual:

A comparion of Kernza and potato root structure that highlights the comparative ability of these two crops to hold soil in plae and limit nitrogen leaching

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Protecting Ground Water from Nitrogen in Potato Production

I. PROJECT STATEMENT

Potatoes are a crucial and expanding component of the Minnesota economy. The high drainage sandy soils in central Minnesota are particularly suited to potato production. However, these soils have a limited capacity to hold water or nitrogen (N). Therefore, potatoes are heavily fertilized with N and irrigated on sandy soils. The combination of the shallow root system of potatoes, with their limited ability to absorb N, and the low water holding capacity of the sandy soil results in high rates of N leaching into ground water. N leaching poses both environmental and human health risks, and sandy soil in Minnesota is particularly vulnerable to leaching.

We propose a two-pronged solution for sustainable potato production that protects the water and soil resource base. First, we will evaluate an alternate crop rotation system in which potatoes are rotated with a deep-rooted perennial wheatgrass (Kernza). Kernza has the ability to scavenge N from the soil following potato harvest and, therefore reduce or eliminate N leaching into ground water. Second, we aim to reduce the amount of N applied to potato fields by identifying and developing potato varieties that require less fertilizer. All proposed Activities will take place in Becker, MN.

Kernza is a perennial wheatgrass with a rooting depth of 10ft or more and the potential to produce profitable grain yields from minimal inputs. We propose to replace the traditional four-year corn-soybean-wheat-potato rotation with a rotation of one year of potato followed by three years of perennial Kernza. We hypothesize that the three year Kernza rotation will reduce N leaching by minimizing soil disturbance and extracting excess soil N left behind by potato to support growth of the harvestable perennial grain.

A complementary approach is a reduction of the total amount of N added to the system. Some potato varieties require less N. However, the ability to maintain yield with reduced fertilizer inputs (N use efficiency or NUE), has not been assessed in the majority of potato varieties. Instead, growers often apply uniformly high rates of N to all varieties. Identifying and developing varieties that require less fertilizer and sharing those results with growers will reduce total N added to the central sands. Identifying the genetic basis of NUE will allow us to breed varieties that require even less N.

Integrating potato varieties with minimal fertilizer requirements into a cropping system with Kernza, a deep-rooted perennial wheatgrass, will make the Minnesota potato industry more sustainable while protecting the water supply and the soil resource base on the central sand plains of Minnesota

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Evaluate the benefits of a Kernza/potato rotation on Central Minnesota sandy soils in terms of nitrogen leaching and potato productivity. ENRTF BUDGET: $ 481,660

We will compare a four-year Kernza/potato rotation (three years of perennial Kernza between potato years) to a four-year corn-soy-wheat-potato rotation. We will assess the ability of Kernza to uptake excess N from potato production and minimize leaching as well as the effects of Kernza rotation on potato yield and quality.

Outcome	Completion Date
1. Evaluation of the effects of a Potato-Kernza rotation on nitrogen leaching and excess nitrogen remaining in the soil.	***11/1/2022***
2. Evaluation of the effect of a –Potato-Kernza rotation on the productivity of both crops	***11/1/2022***

Activity 2: Determine the nitrogen use efficiency of the ten most commonly grown potato varieties on Minnesota sandy soils ENRTF BUDGET: $ 133,343

We will explore the N requirements of Minnesota's ten most commonly grown potato varieties. This study will allow us to make recommendations as to which varieties require less added fertilizer in sandy soils. These results will be shared directly with Minnesota growers through Area II and North Plains Potato Grower

Association (NPPGA) research reporting meetings and field days.

Outcome	Completion Date
1. Develop nitrogen recommendations for the ten most commonly grown potato varieties for production on the central sand plain of Minnesota.	*11/1/2021*

Activity 3: Elucidate the genetic architecture of nitrogen use efficiency (NUE) in potato to inform breeding efforts. **ENRTF BUDGET: $ 183,067**

We will identify regions of the potato genome that contribute to distinct mechanisms of NUE in potato and use that information to combine those mechanisms in a single new variety using a traditional breeding approach.

Outcome	Completion Date
1. Identification of genomic regions implicated in different types of NUE in potato, in order to inform breeding of more nitrogen efficient potatoes	*12/31/2022*
2. Evaluation of the feasibility of combining types of NUE in a single potato clone	*11/1/2022*

III. PROJECT PARTNERS:

A. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Dr. Thomas Michaels	Professor of Horticultural Science	UMN	Experimental design and data interpretation as it relates to sustainable food systems
Dr. Carl Rosen	Professor of Soil Science	UMN	Experimental design and data interpretation as it relates to soils
Dr. Laura Shannon	Assistant Professor of Potato Breeding and Genomics	UMN	Project design, management, and analysis as it relates to potato breeding and genetics
Dr. Donald Wyse	Professor/Head of Forever Green Institute	UMN	Experimental design and intrepretation as it relates to Kernza

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

The findings of this study will provide the groundwork for mitigating N leaching from potato production on sandy soils. The results of Activities 1 and 3 will be shared directly with Minnesota potato growers at the NPPGA and the Area II Growers Association at the annual field days and research reporting meetings. Furthermore, we will work with interested growers to implement and support potato-Kernza rotations in their fields.

The results of Activity 2 will contribute to our efforts to breed an N efficient potato. As part of Activity 2 we will develop N efficient germplasm to use in the UMN breeding program and methods to efficiently screen existing germplasm for NUE genetic potential. These will be shared with other potato breeders to encourage breeding for NUE. We believe the results of this work will be pivotal in attracting future funding for breeding nitrogen efficient potatoes from industry groups (including: Potatoes USA, the Area II potato growers, and NPPGA) and the USDA and MDA specialty crop initiatives.

V. TIME LINE REQUIREMENTS: This will be a three-and-a-half-year study to allow for a complete Kernza/potato rotation. Kernza is a perennial crop which provides maximum environmental benefits when maintained for three years. Three years between potato plantings also mitigates the risk of soil disease. Therefore, the ideal design for a Kernza-potato rotation is three years Kernza, one year potato, and our experiment examines the entire rotation.

2019 Proposal Budget Spreadsheet

Project Title: Protecting Ground Water from Nitrogen in Potato Production

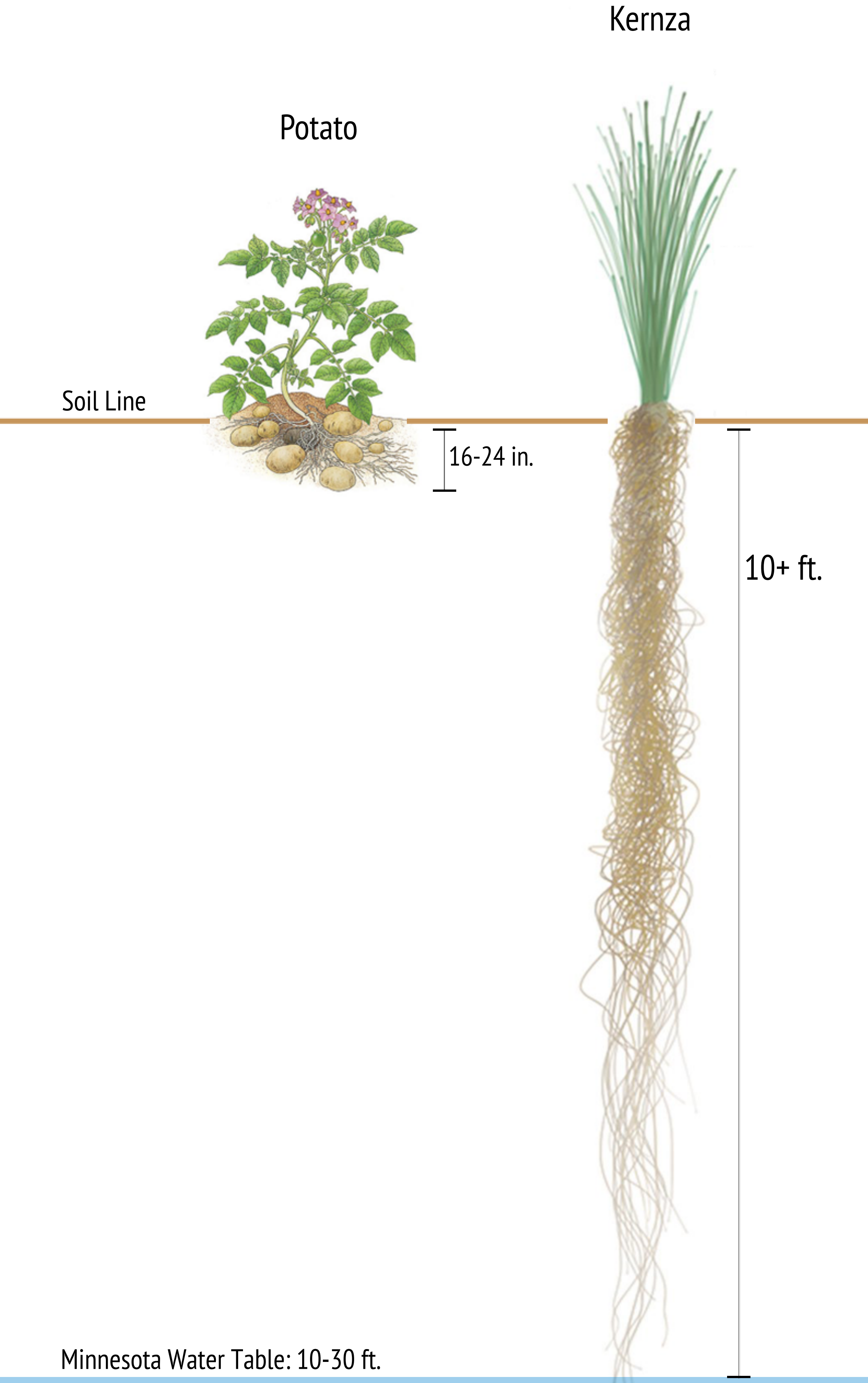
IV. TOTAL ENRTF REQUEST BUDGET 3.5 years

BUDGET ITEM (See "Guidance on Allowable Expenses")	**AMOUNT**
Personnel: PhD Student -- Carrying out research and analyzing data for all three activities, 50% appointment rate for 3.5 years (Year 1 salary: $25,168, fringe: $3,775, tuition: $16,145; Year 2 salary: $25,923, fringe: $3,888, tuition: $16,629; Year 3 salary: $26,701, fringe: $4,005, tuition: $17,128; Year 4 salary: $14,217, fringe: $2,133, tuition: $8,142) Total: $163,854 (56% salary, 44% benefits) **Researcher 1 (Potato breeding) -- Plant care and data collection across all three activities, 100% appointment rate for 3.5 years (Salary: $35,000, Fringe at 27.2%: 9,520 with a 3% cost of living increase per year) Total: $161,931 (78% salary, 22% benefits)** **Researcher 3 (Soil science) – Soil and water samples and measurements for Activity 1, 25% appointment rate for 3.5 years (Salary: $18,732, Fringe at 27.2%: $5,095 with a 3% cost of living increase per year) Total: $99,684 (78% salary, 22% benefits)** **Undergraduate field technicians (Soil Science)— Two per summer for water sample collection and analysis for Activity 1 (salary: 680 hours/summer x $12/hour x 4 years x 2 students/year, fringe: $0) Total: $65,280 (100% salary, 0% benefits)** **Undergraduate field technicians (Potato Breeding)—One per summer for plant care and phenotyping for activities 2 and 3 (salary: 680 hours/summer x $12/hour x 4 years, fringe: $0) Total: $32,640 (100% salary, 0% benefits)**	$ 523,389
Professional/Technical/Service Contracts: **Plant N measurements (160 samples/year x $11 per sample + 55 set up = $1815/ year x 4 years) = $7,260** **Soil N measurements (160 samples/year x $17.75/sample + $50 set up = $2,890/year x 4 years) = $11,560** **Water N measurements (2,400 samples per year x $14.50/sample + $55 set up = $34,855 x 4 years) = $139,420** **Genotyping (200 individuals/mapping population x 3 mapping populations x $50/individual) = $30,000**	$ 188,240
Equipment/Tools/Supplies: $3,300 genotyping supplies (Activity 3) $8,000 for soil lysimeters for measuring leaching (Activity 1) $16,000 soil testing supplies (Activity 1) $4000 field supplies (all activities)	$ 31,300
Acquisition (Fee Title or Permanent Easements):	$ -
Travel: Vehicle rental ($1,315/month x 7 months x 4 years)=$36,820 + (11,850 miles/year x 0.32/mile x 4 years) = $15,168 All travel costs are for research teams to travel back and forth from the Saint Paul campus to the research plots at Becker MN, the soil team and the potato breeding team will have to do this multiple times per week during the growing seasons	$ 51,988
Additional Budget Items: Space Rental at the Sand Planes Research and Outreach Center 2 acres in years 1 and 4 and 3 acres in years 2 and 3 at $275/acre =. $2,750, One year winter greenhouse growout space ($0.0288/day/sqft x 200 days x 70 sqft) = $403	$ 3,153
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 798,070

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period:	n/a	*n/a*
Other State $ To Be Applied To Project During Project Period:	n/a	*n/a*
In-kind Services To Be Applied To Project During Project Period:	n/a	*n/a*
Past and Current ENRTF Appropriation:	n/a	n/a
Other Funding History:	n/a	*n/a*

A comparison of Kernza and potato root structure that highlights the comparative ability of these two crops to hold soil in place and limit nitrogen leaching.



Proposal: Protecting ground water from nitrogen in potato production
Researchers: Shannon, Michaels, Rosen, and Wyse

Images:
Potato drawing from https://www2.klett.de/sixcms/list.php?page=infothek_artikel&extra=TERRA%20WZG-Online&artikel_id=89398&inhalt=klett71prod_1.c.130587.de
Kernza drawing from https://www.patagoniaprovisions.com/pages/long-root-ale

Protecting Ground Water from Nitrogen in Potato Production

Project Manager Qualifications: Dr. Laura Shannon, Ph.D. – Horticultural Science

Education and Training:

Degree	Major	Institution	Year
Ph.D.	Genetics	University of Wisconsin	2013
B.A.	Biology and Anthropology	Grinnell College	2007

Research and Professional Experience:

2017-Present Assistant Professor, Univ. of Minn., Department of Horticultural Science
2016-2017 Postdoctoral Researcher, Univ. of Wisc., Department of Horticulture
2013-2016 Postdoctoral Researcher, Cornell Univ., Department of Biomed. Science

Dr. Laura Shannon is an assistant professor of potato breeding, genetics and genomics at the University of Minnesota. Dr. Shannon is a geneticist by training and has carried out large scale genomic studies in three organisms (corn, dogs, and potatoes). The UMN potato breeding program has two pilot studies this summer looking at the prevalence of nitrogen use efficiency in the germplasm and so is familiar with the protocols involved and the feasibility of such studies. Additionally, these studies have been essential in identifying the parents for the proposed mapping experiments. Dr. Shannon and members of her lab will carry out the bulk of data collection and analysis. Specifically: making, genotyping and phenotyping the three mapping populations in activity 3, growing and phenotyping the potatoes in activities 1 and 2, and data analysis and outreach to growers for all three activities.

Potato Breeding, Genetics, and Genomics Lab – Department of Horticultural Science, University of Minnesota

The potato breeding, genetics and genomics lab at UMN is working to develop a better understanding of the potato genome in order to speed the release of new potato cultivars which require fewer inputs for Minnesota growers. The lab is growing, and currently consists of Dr. Shannon, Dr. Cari Schmitz Carley -- the breeding specialist, a tissue culture specialist, two graduate students, and four undergraduate interns. The potato breeding lab works closely with local grower's organizations, the potato entomologists, soil scientists, extension agents, and pathologists at the University of Minnesota and the other potato breeders in the North Central Region.