North Dakota (North Dakota State University Main Campus) Annual Report - FY2021

Report Status: Approved as of 07/08/2022

Contributing Organizations

North Dakota State University Main Campus

Executive Summary

Overview

NDSU Extension

Our Team

- Extension Agents are local educators who serve all 53 counties in the state and the four Native American reservations. They are the local face of Extension. Based on their knowledge of county issues and the input they receive from citizens at the local level, our agents deliver educational programs to meet the needs of the people and communities in the counties they serve.
- Specialists have technical expertise in their discipline, and develop and lead programs on issues of statewide concern. They are integral in supporting Extension agents with research-based information. Many specialists are based on the NDSU campus and usually hold faculty positions in the College of Agriculture, Food Systems, and Natural Resources; or the College of Human Sciences and Education. Others are based off campus at Research Extension Centers across the state. Several specialists have joint research and/or teaching appointments.
- Support staff are a part of all Extension offices and usually are the first point of contact for the public. The support staff maintains offices and help deliver high-quality information and educational programs to the public. Communication staff members help prepare and deliver educational materials through print, audio, video, graphics, social media platforms, mobile apps and computer technology.

We provide timely, accurate, research-based information. Input from local citizens about their needs and concerns is a vital part of how we develop educational programs. Extension program teams help guide the program development process. These teams consist of county-based Extension agents and Extension specialists. The teams also include Agricultural Experiment Station scientists at the NDSU main campus and Research Extension Centers. Many teams also involve representation from the public, including government agency members and clientele. The program teams are:

- Crop Management
- Farm Business Management
- 4-H Youth Development
- Horticulture and Forestry
- Human Development and Family Science
- Leadership and Civic Engagement
- Livestock Management
- Natural Resource Management
- Nutrition, Food Safety and Health
- Personal and Family Finance

ND AES

Cropping systems

Controlling from persistent weeds kochie, water hemp, wild oak, and foxtail reduces yields in important rotations, and the challenge has been exasperated by drought and excess water and herbicide resistance. Additionally weeds that have never been in North Dakota are being detected and control will be a challenge. Several herbicide approaches have been studied. Also, use of sensor and precision

technologies were explored, along with non-chemical tactics.

The NDAES maintains a strong public breeding program to support varieties that can grow in our climate, and greatly benefit the producer. The North Dakota growing season is highly variable, and the breeding programs contribute to the strong resiliency traits needed in response to shifting climates. Breeding programs are also supported by pathology programs that help promote disease-resistant varieties. Genetic tools and precision technologies, like high-throughput genotyping, contributed to variety selection to make competitive cultivar advancements for soybean, beans, potatoes, hard red spring wheat, and durum.

Natural Resources

Anthropogenic change impacts the natural resources that are important for the health of natural and agricultural systems. North Dakota is a resource-rich state and improving provisioning that benefits ecosystems and agriculture are important research contributions by the NDAES. Research contributions were made towards improving water quality and crop production, restoring agricultural productivity and native species in land impacted by oil spills and mining activities, assessing soil degradation, and improving urban stormwater management using native grassland species.

Livestock systems

The NDAES scientist contributed to the livestock industry from the conception of the animal, pregnancy health, improving animal nutrition and welfare, and increased meat quality outcomes. This wholistic approach is supported by advance molecular techniques and technologies.

Agriculture Economics

Historically, North Dakota's farmers have implemented highly diverse crop rotations because of the short and variable growing seasons of the state. However, agricultural land use has shifted, with rotation diversity decreasing, and corn-soybean rotations becoming more common. The NDAES scientist contributed to understanding the drivers behind land use decisions from the perspective of economics and climate.

Critical Issue: 4-H, Youth Development

Youth in North Dakota are reached in a variety of ways, in traditional 4-H clubs, afterschool activities, school-based enrichment programs, camping experiences, and more. In the previous year, youth took part in many educational programs. Two main areas of focus for North Dakota were childhood obesity and leadership development skills. A mixture of face-to-face, online, and hybrid programs were delivered across the state.

Childhood Obesity

Many programs were delivered to youth and their families to address the component of childhood obesity. County Extension agents delivered programs such as *Kids Baking School, Kids Cooking School, On the Move to Gardening Fun, On the Move to Food Adventures, On the Move Junior, On the Move to Stronger Bodies,* and *On the Move to Better Health*. These programs address healthy eating and physical activity habits in youth. Participants in these programs increase their knowledge and healthy behaviors as a result of participaing.

Youth Leadership Development

There are a number of opportunities for youth in North Dakota to develop their leadership skills and for them to become more active in their communities and throughout the state. These include our state and local amassador programs, Extension Youth Conference held every year on the North Dakota State University campus, Leadership Awareness Weekend (LAW), and service learning projects. Programs to teach skills include *Youth Lead Local* and *Building Tomorrow's Leaders*. Youth learn how to move beyond their individual self-interest and to be committed to the well-being of a larger group. Youth learn about civic affairs and begin to develop decision-making skills and a sense of understanding and confidence in relating and connecting to other people.

Critical Issue: Agriculture Economics

Agents planned and collaborated with specialists and other agents to conduct local and regional producer meetings on market situation and outlook and related price risk management strategies NDSU Extension provided crop and livestock producers, marketing clubs, agribusinesses, public agencies, Extension Agents, Farm Business Management Instructors, popular press, college students, and other

interested parties with a better understanding of current supply and demand factors and geo-political forces affecting crop and livestock prices. Provided a basic understanding of alternative marketing tools, and price risk management tools. Information was disseminated on which tools can be used to balance risk exposure and pricing opportunities, and when it may be most appropriate to utilize them.

Critical Issue: Community Vitality

Educational programs to build leadership capacity in communities were conducted. These programs included *Rural Leadership North Dakota, Lead Local, Soil and Water Conservation Leadership Academy* and *Growing Leaders Short Course.* Additionally, science-based informaiton was disseminated through social media, our website, news articles, Extension publications, and podcasts. Participants gained knowedge and increased their understanding of how touse ethical values to lead consistently, how to resolve conflict in groups, how to work well with others, their own individual strengths and weaknesses, basic meeting management, responsibilities as a member of a board, council or committee, and how to serve as an effective team member.

Critical Issue: Cropping Systems

Soil salinity and sodicity create extremely undesirable growth environment for plants and microbes. Saline soil conditions do not allow plant roots to uptake water even under moist soil condition. Whereas, pure sodic soils have extremely poor physical conditions (poor soil structure) with dense soil layers, resulting in very slow permeability of water and air through the soil profile. Managing salinity will require practices that will reduce evaporation by establishing salt-tolerant annual crops based on soil results, lowering groundwater depths, improving soil structure and water movement by reducing tillage and planting cover crops under decent rain events. Soil sodicity remediation will require addition of soil amendments that add calcium followed by salinity remediation practices.

The following activities were conducted in the past year to address the issue:

- Conducted trainings for the Extension agents and provide them the most updated information and scientific data to spread the word out and to be the "go to person/source".
- In coordination with the Extension agents began building long-term relationships with the stakeholders based on mutual trust and respect.
- Strengthened working relationship among with Extension agents and rest of the specialists.
- Established close relationship with soil conservation districts, NRCS personnel and water boards to coordinate soil health tours and workshops demonstrating practices which results in healthier soils.
- Helped Extension agents with generating resources like County-based demonstrations, power points, publications, pictures and any other tool to address area specific needs.
- Provided practical and cost effective solutions to stakeholders in coordination with the Extension agents.

Because of the activities conducted, stakeholders knowledge increased. They know the differences between soil salinity and sodicity and how these issues affect plants and soils. They understand the importance of sampling and testing unproductive arels for salinity and sodicity along wtith remedial options.

Critical Issue: Human Development and Education

Chronic Disease Prevention

According to the North Dakota Diabetes Prevention and Control Program's 2018 Diabetes Burden report, approximately 54,000 North Dakota adults are living with diagnosed diabetes. An additional 17,000 have undiagnosed diabetes. Between 80-90% of individuals who have type 2 diabetes are overweight or obese. It is estimated that 34% of the total population has prediabetes (198,000 individuals). Fifteen to 30 percent of people with prediabetes will develop type 2 diabetes within 5 years.

Participants learned the importance of self-monitoring, goal setting related to eating from the five food groups throughout the day, including but not limited to (a) cutting back on foods high in solid fats and added sugars; (b) increasing intake of fruits and vegetables; and (c) understand the importance of a healthy eating style for a lifetime.Participants also learned that increased physical activity and reduced sedentary behavior is a part of a healthy lifestyle. Studies for the National Diabetes Prevention Program found that moderate weight loss of 5-7% and increased physical activity to 150 minutes per week reduced the incidence of type 2 diabetes by 58% or 71% for individuals over the age of 60. NDSU increased partnerships across the state to train additional lifestyle coaches, and increased the number of educational programs delivered across the state.

Healthy Aging

NDSU provided evidence-based programs to older adults (*Stepping On, Powerful Tools for Caregivers,* and *Tai Ji Quan: Moving for Better Balance*). Participants gained knowledge and learned tools for taking care of themselves. The follwoing knoweledge and skills were addressed in programming:

- Improved balance and strength
- Home modifications
- Community safety
- Vision
- Medication review
- Safe footwear
- Sleep
- Reducing stress
- Changing negative self-talk
- Communicating feelings and needs of others
- Setting limits and asking for healp
- Dealing with emotions, such as anger, guilt and depression
- Making tough caregiving decisions
- Locating helpful resources
- Postural stability
- Awareness and mindful control of body positioning in space
- Functional walking
- Movement symmetry and coordination
- Range of motion around the ankle and hip joints.
- Lower-extremity muscle strength

Critical Issue: Livestock Systems

Meat Quality

Specialists provided education to county Extension agents for helping connect producers with consumers. NDSU provided custom-exempt, state inspected, federally inspected processing plant resources for Extension agents.

Manure and Nutrient Management

Assessment information was gathered through several stakeholders including producers, Extension agents and specialists and state and local agencies such as local NRCS and 319 watershed coordinators and the North Dakota Department of Environmental Quality, Division of Water Quality. Workshops, webinars, and producer meetings were held to provide educaiton on these issues.

Critical Issue: Natural Resources

Extension hosted discussions, developed publicaitons, and held workshops and field tours. Agents and specialists got a better understanding of landowners top concerns related to energy devleopment. Landowners increased their knowledge and understanding of the environmental impacs to energy development. They were taugh the best grazing management practices to restore range and pasture health.

Merit and Scientific Peer Review Processes

Updates

None

Stakeholder Input

Actions to seek stakeholder input that encouraged their participation with a brief explanation

None

Methods to identify individuals and groups and brief explanation

None

Methods for collecting stakeholder input and brief explanation

None

A statement of how the input will be considered and brief explanation of what you learned from your stakeholders

Local advisory councils provide input and feedback to county Extension agents on what educational programming is needed. County Commissioners are consulted when positions become vacant to determine if the position should be reassigned to a different content expertise. Participants and potential participants were surveyed to gather feedback on educational programs and their needs as well.

During 2021, State Board of Higher Education (SBARE) solicited feedback from hundreds of North Dakota stakeholders including citizens, policy makers, industry, commodity representatives, etc. and summarized the needs for the NDAES. Priority needs included support for plant protection and production, including agronomics, and viral and bacterial diseases. Priorities were also to support the operations in the NDAES to help scientist concentrate on research and to facilitate connections between main station and branch station research. Data science and research in climate smart agriculture were also areas of priorities determined by SBARE.

Highlighted Results by Project or Program

Critical Issue

4-H, Youth Development

4-H and Youth Development
Project Director
Ona Vig
Organization
North Dakota State University Main Campus
Accession Number
7000062

⭐ Childhood Obesity

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

More than 30% of North Dakota children 2 to 5 years o are considered overweight or obese (with a body mass index for their age above the 85th percentile). According to the Youth Behavior Risk Surveillance Survey (2015), 42% of North Dakota students in grades nine to 12 consumed vegetables less than one time daily, 75% of adolescents were not physically active at least 60 minutes per day, and about 12% were not physically active 60 minutes on at least one day during the seven days prior to the survey.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

On the Move Junior is a five-week school-based curriculum for second-graders. It is based on MyPlate, the current icon for nutrition, and includes children's storybooks and hands-on activities. The curriculum aims to improve the variety of healthful foods, especially fruits and vegetables, that children consume. It also aims to improve fitness habits. Parents receive newsletters and participate in goal setting and other family-based activities. In 2020, some classes participated virtually.

Briefly describe how your target audience benefited from your project's activities.

Participants improved their knowledge of nutritional recommendations as shown by test scores.

- 79% ate more fruit

- 63% ate more vegetables

- 76% tried a new food

- 67% tried different colored fruit

- 81% engaged in more exercise

According to survey results, 77% of parents read the weekly newsletter. Parents reported that their children asked questions about food (59%), offered help with food preparation (45%), requested healthful snacks (50%) and tried a new food (41%).

Briefly describe how the broader public benefited from your project's activities.

Improving health behaviors can increase quality of life and save millions of dollars in collective health-care costs for North Dakotans throughout their lifetime and lowering the cost of public provided healthcare.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Garden-Robinson, J. (2021). COVID-19 and Children: Stop the Spread of Germs. Journal of Nutrition Education and Behavior 53(9): 816.

Critical Issue

Agriculture Economics

Historical and Future Impacts on North Dakota major annual crops affected by climate cycles, climate volatility and climate change

Project Director

David Roberts

Organization

North Dakota State University Main Campus

Accession Number

1017947

⭐ **Historical and Future Impacts on North Dakota major annual crops affected by climate cycles, climate volatility and climate change**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The issue addressed by this project is rapidly changing agricultural land uses, specifically a large increase in the amount of corn and soybean planted in North Dakota since the mid-1990s. I seek to identify the primary economic and climate drivers that have occasioned this change.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Objective1: To develop spatially distributed panel data models that quantify the effects of climate change and climatevolatility on rapid historical changes in farmers' standard crop selections throughout North Dakota.

I have continued to work with a former graduate student, Eugene Nuworsu, to complete a study of changing crop-selection patterns in North
Dakota and their effects on North Dakota's local weather and microclimates. The preliminary results of this work provide strong statistical evidence that farmers' aggregate crop selections have impacts on local weather. Specifically, during the growing season (June, July, August, and September) an increase in the planted area of corn within each 16 km2 cross-section of North Dakota affects rainfall and temperature patterns. These effects are estimated using crop acreage data from the Cropland Data Layers produced by USDDA-NASS and temperature and precipitation data produced by the PRISM Climate Group at Oregon State University. Effects of each additional hectare of corn area on precipitation within each 16 km2 crosssection include: a) a statistically discernible June rainfall increase of 0.10 to 0.80 thousandths of a centimeter per additional hectare for all cross-sections with planted corn areas of 2,250 to 8,000 hectares, b) a statistically significant decrease in July rainfall of 0.40 to 0.50 thousandths of a centimeter per hectare for all cross-sections, c) a statistically significant decrease in July rainfall of 0.40 to 0.50 thousandths of a centimeter per hectare for all cross-sections, d) no statistically discenible impact of seasonal corn plantings on Agust rainfall within any cross-section, and e) a a statistically discernible September rainfall increase of 0.10 to 0.70 thousandths of a centimeter per additional hectare for all cross-sections with planted corn areas of 3,000 to 8,000 hectares. The planted areas of corn in adjacent 16 km2 cross-sections have additional impacts (typically of the same direction as the effects of each cross-section's own corn plantings) on precipitation in their neghboring cross-sections, thus intensifying these first-order effects on rainfall, though these neighbor impacts have yet to be fully quantified. Areas planted to corn also tend to lead statistically discernible increases temperature Comparative statics will be applied to the
entirety of the state to determine the net effect of rising corn area planted from 1998 to present by use of spatial econometric methods. Contirbutors to this effort include Eugene Nuworsu (a former graduate student, now studying at Purdue) and myself as co-lead authors, Jianglong Zhang (professor atmospheric science at UND), and Bob Hearne (professor of Agribusiness & Applied Economics at NDSU). Ultimately, these results indicate that a) agricultural policies and international trade policies that affect farmers' aggregate crop selections through the price mechanism have effects on localized temperature variations over both time and space, and b) the price mechanism (via subsidies or other incentives) could potentially be used to incentivize farmers to select specific crops to assist in local climate management for the benefit of farmers and the community at large. I continue to be cautious in publication of these results due to the complex nature of the dataset. Spatially and temporally collinear variables are both present; while this econometric problem does not not result in biased parameter estimates, it may
inflate the estimated standard errors for those parameters. The preliminary results of this work are compatible with earlier work by Starr, Zhang, Reid, and Roberts (2020) in the journal Remote Sensing.

Objective 2: To forecast potential spatially distributed changes in crop selection that may result from farmers' autonomous responses to a range of future climate scenarios in North Dakota.

I have continued to work with Bayarbat Badarch (former graduate student and current farm management instructor at LRSC) to quantify the impacts of precipitation and temparature variations on the yield frontiers (or maximum yield potentials) for corn, hard red spring wheat, and soybean within North Dakota, and for corn in the greater Northern Great Plains. Collinearity of temperatures and precipitation levels over the
months of the growing season and accross the cross-sectional units. We are currently seeking the best method to deal with these econometric/statistical problems in the dataset. One possible option is to use principal components regression to reduce the dimensionality of the temperature and precipitation data while retaining as much explanatory power as possible. We are currently assessing this option, among others, such as correlated components. Preliminary results indicate that monthly temperatures and precipitation levels during the growing-season (which are not controlled by farm managers) are the inputs that most limit the maximum yield potential within North Dakota. Various models used to date indicate a 1% increase in growing-season temperatures may increase the maximum frontier yield by between 2% and 42%. These results depend heavily on which temperature data are used (monthly averages, seasonal averages, monthly averages of daily highs and lows, etcetera. This should not be surprising, since the timing of heat, light, and rainfall patterns is important to crop plants' productivity. Principal components analysis will assist us in developing more certainty about the effects of these variables on the future productivity of current North Dakota crops.

Briefly describe how your target audience benefited from your project's activities.

My target audience during this reporting period consisted only of the graduate students I supervised. They each learned some spatial econometrics techniques, among other new quantitative research skills, and both students completed their degrees during this reporting period.

Briefly describe how the broader public benefited from your project's activities.

Nothing to report.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

I plan to submit at least two manuscripts for publication during FY 2022. These will result from my work with Dr. Bayarbat Badarch and Mr. Eugene Nuworsu. There may be more than two manuscripts because the results are very dense.

Critical Issue

Community Vitality

Community Vitality
Project Director
Ona Vig
Organization
North Dakota State University Main Campus
Accession Number
7000065

Community Vitality

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

During the 2015 NDSU Extension Community forums, participants identified the lack of civic engagement across the state as a critical issue. Gaps have existed in participation and commitment at the local level. Multiple ballots for elected officials have gone unfilled in North Dakota in recent elections.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

With more than 8300 organization in North Dakota, one in every 24 people over the age of 18 must step up and serve. Small towns are counting on it. They need people to run for the school board, volunteer for the local ambulance service and serve on nonprofits supporting their local community. Positive changes in communities happen when adults and youth are engaged civically as volunteers and leaders. Successful community involvement and volunteerism hinges on the development of leadership skills and mentoring.

Briefly describe how your target audience benefited from your project's activities.

Based on surveys of program participants:

- All participants indicated that they learend at least a little from the workshops.

- 97% understand their responsibilities as a member of a board, council or committee.

- 100% can develop a meeting agenda using the components of an effective meeting.

- 98% can run a meeting using parliamentary proceedure.

- 98% are comfortable making a motion in a meeting.

- 100% can model effective ways to deal with group conflict.

- 100% use ethical values to lead consistently.

- 98% are aware of North Dakota open meeting laws.

- 100% recognize their individual strengths and weaknesses.

- 100% can lead with a clear plan and a set of defined goals.

- 100% understand how to work well with others.

- 100% felt prepared to serve in a leadership role.

Briefly describe how the broader public benefited from your project's activities.

Leaders and volunteers step up to fill 8314 volunteer organization's needs and run for office on local, regional and state levels.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Hoffman, M. S. (2021). Beginner's Guide to Grant Writing Overview. Presenter for North Dakota Main Street Initiatives Professional Development Series. North Dakota Main Street Initiatives

Critical Issue

Cropping Systems

Cropping Systems
Project Director
Ona Vig
Organization
North Dakota State University Main Campus
Accession Number

⭐ **Soybean Cyst Nematode**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Soybean Cyst Nematode (SCN) causes approximately $1.5B dollars in losses to the US soybean crop annually. The nematode continues to spread in North Dakota and losses continue to climb as the nematode adapts to management tools (such as genetic resistance). The situation is too large and complex for one organization to address alone.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

NDSU Extension leads a national public-private partnership, known as **'The SCN Coalition',** whose mission is to address the SCN crisis. The SCN Coalition includes dozens of Universities, companies, and soybean checkoff organizations. The SCN Coalition developed a national media campaign with the objectives of increasing *awareness* and *active management* of the nematode among soybean growers. Between 2018 and 2022, outputs included (but were not limited too):

- *28.1M potential impressions in the ag media*

- *16.4% total share of online discussion of SCN*

- *2.7M views of 'Let's Talk Todes' video series*

Briefly describe how your target audience benefited from your project's activities.

The Impacts of the SCN Coalition were measured by conducting surveys of approximately 1,000 soybean growers in 17 states in 2015 and 2020.

SCN Coalition message recall among growers:

- 76% recalled *"rotate to non-host crop"*

- 66% recalled *"consider a nematode-protectant seed treatment"*

- 65% recalled *"rotate resistant varieties"*

- 55% recalled *"actively manage SCN"*

Soybean growers reported statistically significant increases (>5%) in multiple management practices from 2015 to 2020:

- 18% increase: using a nematode-protectant seed treatment

- 10% increase: rotating sources of genetic resistance to SCN

- 7% increase: planting SCN resistant soybeans

- 6% increase: rotating to non-host crops

Economic Impact:

Surveyed growers reported capturing an additional 5.1 bushels per acre by managing SCN, adding $48.45 per acre to their bottom line (based on the average price of soybeans, $9.50/bu., at the time the 2020 survey was conducted). Depending on the tool(s) growers use, 6% to 18% more are actively managing SCN than in 2015. *That's tens of thousands of growers, millions of acres and hundreds of millions of dollars.*

Briefly describe how the broader public benefited from your project's activities.

Protecting soybeans from new and emerging diseases helps protect the nation's food supply, keeps more money in hands of North Dakota growers and strengthens our local economy.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Chowdury, I. A., Yan, G., Plaisance, A. and Markell, S. 2021. Characterization of virulence phenotypes of soybean cyst nematode (Heterodera glycines) populations in North Dakota. Phytopathology 111:2100-2109.

Bradley, C., Allen, T., Sisson, A., Bergstrom, G., Bissonnette, K., Bond, J., Byamukama, E., Chilvers, M., Collins, A., Damicone, J., Dorrance, A., DuFault, N., Esker, P., Faske, T., Fiorellino, N., Giesler, L., Hartman, G., Hollier, C., Isakeit, T., Jackson, T., Jardine, D., Kelly, H., Kemerait, R., Kleczewski, N., Koehler, A., Kratochvil, R., Kurle, J., Malvick, D., Markell, S., Mehl, H., Mehl, K., Mueller, D., Mueller, J., Nelson, B., Overstreet, C., Padgett, B., Price III, P., Sikora, E., Small, I., Smith, D., Spurlock, T., Tande, C., Telenko, D., Tenuta, A., Thiessen, L., Warner, F., Wiebold, B. and Wise, K. 2021. Soybean yield loss estimates due to diseases in the United States and Ontario, Canada from 2015 to 2019. Plant Health Progress 22:483-495.

Chowdhury, I. A., Yan, G., and Markell, S. 20XX. Soybean cyst nematode (SCN). North Dakota Extension Publication PPXXXX (In press).

Kandel, H., Miranda, C., Markell, S., deplazes, C., Ostlie, M., Schatz, B., Endres, G., Aberle, E., Indergaard, T., Burgard, H., Hafnes, M., Cooper, K., Eslinger, H., Nelson S., Eriksmoen, E., Kraklau, A., Hansen, J., Hanson, B., Henry, L., Faul, J., Rickertsen J., Wells, M., Bergman, J., Pradhan, G., Wahlstrom C., Jacobs, J., Turnquist, A., Tjelde, T., Landeis K., Seykora, M., and Zimprich, B. 2021. North Dakota soybean variety trial results for 2021 and selection guide. North Dakota Extension Publication A843-21.

Markell, S. 2021. It's and excellent time to scout soybeans for diseases to protect your yield in the future!

Markell, S. 2021. Soybean disease resources. NDSU Extension Crop and Pest Report No. 17 Pp 7. Pp. 6-7.

Markell, S. 2021. Soybean cyst nematode (SCN). NDSU Extension Crop and Pest Report No. 17 Pp 11-12.

Markell, S. 2021. 2021 Soybean cyst nematode (SCN) sampling program. NDSU Extension Crop and Pest Report No. 17 Pp 12-14.

Markell, S. 2021. How to sample for soybean cyst nematode (SCN). NDSU Extension Crop and Pest Report No. 17 Pp 15-16.

Markell, S. 2021. It's a great time to sample for soybean cyst nematode (SCN). NDSU Extension Crop and Pest Report No. 19 Pp 11.

Markell, S. 2021. Most wanted list! North Dakota Soybean Grower Magazine. 10(4):26.

Markell, S. 2021. Sample dry edible beans for soybean cyst nematode. NDSU Extension Crop and Pest Report. No. 18. Pp3.

[Applications of sensors and precision agriculture technologies in support of site-specific weed management and high throughput phenotyping](#)
Project Director
Joao Paulo Flores
Organization
North Dakota State University Main Campus

⭐ **Applications of sensors and precision agriculture technologies in support of site-specific weed management and high throughput phenotyping**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

A common agronomic practice for weed management in corn is to make two herbicide applications during the growing season. The first one is commonly done pre-emergence or early post-emergence, and the second usually takes place around the V4-V6 stage of corn. The cost of the second herbicide application (product + application) is usually around $15-20/ac. Using UAS imagery one can create weed control prescription maps, which can be loaded into sprayers to implement site-specific weed control (SSWC). This approach could save corn growers in ND as much as $5-7 million annually, with as little as a 10% reduction in applied acres. SSWC could make the management of resistant weeds more affordable as well, since it would target the application of more expensive herbicide mixtures to a much smaller acreage.

Another topic addressed on this project phenotyping in crop breeding programs. Traditionally, plant breeding is a time-consuming process, that involves many (usually thousands) plots across several locations. Information on agronomic traits such as stand establishment, flowering date, plant maturity, plant height, canopy coverage, and disease infestation could be collected more quickly and reliably with properly calibrated remote sensing methods, such as UAS imagery. Some of those measurements can be subjective and prone to human error due to fatigue or previous plot influence. This project will deploy a variety of sensors, remote sensing techniques, image analysis software, and GIS tools, to develop (semi)automatic computerized solutions to collect and extract data related to agronomic traits of interest from field and greenhouse trials to improve efficiencies of plant breeding programs. This can lead to reduced labor expense, more efficient culling of detrimental lines, retention of more lines with strong potential, more accurate data, and decreased time to release new crop varieties.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

After three growing seasons, in 2021 for the first time we were able to implement the full workflow proposed on the project, from UAS image collection to spraying the weeds in the field based on a prescription map, created from the UAS imagery, which was uploaded to a commercial size sprayer. The preliminary results showed that the sprayer followed the prescription map fairly well. What we did not know at that point was that during the process of exporting the prescription map from AgSMS software to the sprayer's computer cab unwanted changes were made to original prescription map, which made very difficult for us to make an accurate comparison between the site-specific control and the conventional (blanket application) chemical weed control treatments. Besides the challenges and issues faced this past growing season, I believe we finished the season with some positive outcomes: 1) we were able for the first time to implement the whole workflow from data collection to field weed control, which makes this research project pretty unique, since I am not aware of any similar reports in the literature; 2) the graduate student working on the project developed a very efficient method to identify corn rows based on the UAS imagery, which is helpful for a quick turnaround between image collection and having the prescription map ready to spray; 3) we learned about the issues related to the use of AgSMS when exporting the prescription map to the sprayer's cab computer and we were to identify a work around that, so we can correct that for the 2022 growing season; 4) although the results were not the ones expected, the project yield results that were used by a graduate student to successfully defend this MS thesis.

Regarding implementing high throughput phenotyping on some of NDSU's plant breeding programs, we have established collaborations with soybean, barley, dry edible beans, potatoes, and pulse crops breeders. As part of those collaborations, we continue to build team (graduate students) and hardware (UASs, sensors, phenotyping robots) capacities to further develop our capabilities to support plant breeding efforts by implementing high throughput phenotyping approaches to some of the programs listed above. In addition, we have been working close with plant breeders to identify the specific traits that they are interested on, so we can better deploy our resources to support measurements of such traits of interest.

Briefly describe how your target audience benefited from your project's activities.

The benefits from the study that focused on site-specific weed management are hard to measure because the data were compromised by unwanted changes that were made by the software used to create the prescription map loaded into to the computer on the sprayer. Those changes caused some of the parts of the field that we had set to "no-spray" to be sprayed, and vice-versa, which made very hard to accurately assess the efficacy of our site-specific weed control approach. We have identified a workaround solution for that issue, which will be implemented as we continue to work on this project . One thing

that I can say is that there is interested out there for the approach that we are using on this study to achieve site-specific weed control. My former graduate student (Ranjan Sapkota) presented the results of this study on a national conference, and he had two companies reaching out to him regarding the topic. In addition, Ranjan mentioned to me that there was a lot of interest from companies that he was interviewing with for the kind work he was doing during his MS project.

Regarding the high throughput phenotyping (HTP) part of this project, plant breeders have demonstrated great interest on the data been collected by the UAS and some of the traits that we can extract from the imagery. Although some very good correlations have been found between some wheat traits and yield have been found in the past, it seems that was not the case for last year. So, more data needs to be collected for one to make a better assessment of such practices and sensors when applied to HTP. One the aspects that one of my graduate (Diego Gris) looked at on his thesis project was the comparison regarding potential savings (men hours) from a HTP versus a manual traits measurement approach. The results showed that there are potential for saving potential for savings when using HTP especially when the numbers of plots evaluated increase. That could translate into a lot of time and financial savings for some plant breeding programs.

Briefly describe how the broader public benefited from your project's activities.

At this point I would say that there was not broader public benefit from the research activities carried out last year. Those benefits will take some time to be realized on both topics under this project.

Site-specific weed control in corn can lead to big financial savings in chemical application and have and environmental impact as well, since would be less chemical being applied to the soil, decreasing the risk of water contamination. There are some issues that need to be overcame for one fully realize such benefits, such as ways to scale the approach proposed on this project to larger acreage.

Regarding high throughput phenotyping (HTP), the broader public will take longer to realize from our project activities, since the focus of this part of the project is focused on the plant breeding programs at NDSU. The benefit to the general would come if we can when plant breeding programs would release more productive or more disease or drought resistant cultivars and/or hybrids.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Although we had some setbacks with the site-specific weed control (SSWC) study, we will apply the 2021 season learnt lessons on this coming growing season to successfully implement our SSWC in corn. In addition, we will be looking on both some prescription map parameters and sprayer operation conditions to evaluate how those variables can affect chemical accuracy placement when implement SSWC. Furthermore, we are collaborating with other research across NDSU to improve our approach to identify the corn rows and plants, and to look at the economics of the proposed SSWC approach.

Imaging technologies in precision agriculture can be used to address crop and livestock production issues in North Dakota

Project Director
XIN SUN
Organization
North Dakota State University Main Campus
Accession Number
1024616

⭐ **Imaging technologies in precision agriculture can be used to address crop and livestock production issues in North Dakota**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project aimed to help improve crop and livestock production in the state of North Dakota by using Precision Agriculture image processing technologies. More specifically, for livestock production, using video, and thermal image technologies to study the relationship between beef cattle temperament and beef quality. In addition, for crop production, use thermal,

visible/near-infrared (NIR), and hyperspectral sensing and analysis methods for weed species and herbicide resistance identification and mapping.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

In the year 2021, for crop production, my team have developed three different versions of robotic platforms to collect different weed species data in the field. We worked at three different locations (Carrington, Casselton and Grand Farm) across the North Dakota state to collect the more distributed data. In the future, more weed species and crop (soybean and corn) imagery data such as color, thermal and multispectral images will be collected to validate the robotic platform weed identification algorithms. At the end of this project, we hope a smart spraying system based on robotic technology will be built to target spray the weed. For livestock production, we have collected and analyzed thermal and video data of the beef cattle and worked out an equation to correlate the imaging technology and beef cattle temperament. Based on this research, we discovered that image technology can be a potential research tool for weed identification and livestock temperament monitoring. More results will be available after further data analysis based on these projects.

Briefly describe how your target audience benefited from your project's activities.

Farmers for crop production could benefit through this project effort to identify weed targets more specifically and save 60-70% of herbicide usage for crop spraying applications. Ranchers for livestock production could benefit through this project by using image technologies to monitor beef cattle temperament, as a result, could prouce higher quality beef product by manage the temperament for beef catle production.

Briefly describe how the broader public benefited from your project's activities.

The broader public could benefit from the reduced usage of herbicide spraying on the crop area, farmers can provide healthier crop products to the end-users, more importantly, this project has the great potential contribution to the environment for the earth. For livestock, this project could potentially contribte the effort to anliaml wealfare, as well as providing higherquality of beef products for the geneal consumers.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

We have published 12 journal articles and abstracts related to this project topic in the year 2021 (Detail publications are listed below).

1. Costa, C., Zhang, Y., Howatt, K., Ram, B., Stenger, J., Nowatzki, J., Bajwa, S. G., & **Sun, X*.** (2022). Palmer amaranth (amaranthus palmeri s. Watson) and soybean (glycine max l.) classification in greenhouse using hyperspectral imaging and chemometrics methods. *Journal of the ASABE (former Transactions of the ASABE)*, 65(1): 179-188. doi: https://doi.org/10.13031/ja.14321.

2. Eide, A., Zhang, Y., Koparan, C., Stenger, J., Ostlie, M., Howatt, K., Bajwa, S., & **Sun, X***. (2021). Image based thermal sensing for glyphosate resistant weed identification in greenhouse conditions. *Computers and Electronics in Agriculture*, 188, p.106348. doi: https://doi.org/10.1016/j.compag.2021.106348.

3. Chen, X., Ogdahl, W., Hanna, L.L.H., Dahlen, C.R., Riley, D.G., Wagner, S.A., Berg, E.P., & **Sun, X***. (2021). Evaluation of beef cattle temperament by eye temperature using infrared thermography technology. *Computers and Electronics in Agriculture*, 188, p.106321. doi: https://doi.org/10.1016/j.compag.2021.106321.

4. Eide, A., Koparan, C., Zhang, Y, Ostlie, M., Howatt, K., **Sun, X***. (2021). UAV-Assisted Thermal Infrared and Multispectral Imaging of Weed Canopies for Glyphosate Resistance Detection. *Remote Sensing*, 13(22): 4606. doi: https://doi.org/10.3390/rs13224606.

5. Delavarpour, N., Koparan, C., Nowatzki, J., Bajwa, S., & **Sun, X***. (2021). Review article - A Technical Study on UAV Characteristics for Precision Agriculture Applications and Associated Practical Challenges. *Remote Sensing*, 13, 1204. doi: https://doi.org/10.3390/rs13061204.

6. Ram, B., Ahmed, M. R., Koparan, C., & **Sun, X**. Field application of hyperspectral imaging for weed identification. 2021 Annual International Meeting (AIM) of the American Society of Agricultural and Biological Engineers (ASABE), Virtual.

7. GC, S., Zhang, Y., Koparan, C., Ahmed, M. R., Howatt, K., & **Sun, X.** Weed Identification Using Deep Learning Convolutional Neural Network. 2021 Annual International Meeting (AIM) of the American Society of Agricultural and Biological Engineers (ASABE), Virtual.

8. Ahmed, M. R., Yu Zhang, Ram, B., Eide, A., & **Sun, X**. Weed identification using hyperspectral imaging technology under greenhouse environment. 2021 Annual International Meeting (AIM) of the American Society of Agricultural and Biological Engineers (ASABE), Virtual.

9. Zhang, Y., GC, Sunil., Ahmed, M. R., Costa, Cristiano., Eide, A., Ram, B., Koparan, C., & **Sun, X**. A Field Based Multifunctional High Throughput Crop Phenotyping Platform. 2021 Annual International Meeting (AIM) of the American Society of Agricultural and Biological Engineers (ASABE), Virtual.

10. Eide, A.de, Zhang, Y., Ostlie, M., Howatt, K., & **Sun, X.** Validation of Image-Based Thermal & Multispectral Sensing Technology for Glyphosate-Resistant Weed Identification. 2021 Annual International Meeting (AIM) of the American Society of Agricultural and Biological Engineers (ASABE), Virtual.

11. Koparan, C., Ram, B., Betitame, K., Zhang, Y., & **Sun, X.** Evaluation of a Spraying UAV for Precision Weed Management. 2021 Annual International Meeting (AIM) of the American Society of Agricultural and Biological Engineers (ASABE), Virtual.

12. Betitame, K., Ostlie, M., Koparan, C., & **Sun, X**. Evaluation of Dicamba Drift Injury on Soybean using Unmanned Aerial Vehicle (UAV). 2021 Annual International Meeting (AIM) of the American Society of Agricultural and Biological Engineers (ASABE), Virtual.

Breeding Phaseolus Beans for Resilience, Sustainable Production, and Enhanced Nutritional Value
Project Director
J Osorno
Organization
North Dakota State University Main Campus
Accession Number
1024107

Breeding Phaseolus Beans for Resilience, Sustainable Production, and Enhanced Nutritional Value

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Several biotic and abiotic stresses affecting dry bean production in the US are common across different regions. This multistate platform facilitates collaborative research and breeding efforts among public dry bean scientists at universities and federal agencies to solve some of these common production constraints. Information, data, and germplasm exchange among breeding programs is critical for continued progress and this project allows for this in a very easy way by sharing all these resources across locations in an almost unrestricted manner. In addition, these resources are also shared with private stakeholders who may be interested in some of these resources.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The 2021 growing season in the region was very unusual given the extreme drought conditions that affected most crops grown. The usually-heavy rainfalls during late May and June were replaced by very mild showers in most cases. July, August, and September were drier than normal and few showers now at the end of the season. In spite of this, seed yields at most testing locations has been higher than expected. One entire breeding nursery (and ~15% of another one) were lost due to dicamba drift. Another location was lost due to compaction plus Fusarium wilt, which is well-known to occur under these conditions. ND Twilight is a newly released black bean with high seed yield, earliness, intermediate resistance to common bacterial blight, and complete resistance to bean rust. Preliminary data suggests that the resistance may be different from the already known-genes.

Regarding the W4150 collaborative trials and nurseries, ~1800 early generation breeding lines were grown in Puerto Rico as part of our collaborative winter nurseries. In North Dakota, some of the CDBN entries were lost due to dicamba drift/damage. Contrastingly, the MRPN was a very good trial and preliminary results show good seed yields in spite of being a dry/hot year. A manuscript using historical CDBN data was selected as 1 of 3 "editor's choice" for the Genetics journal. Overall, this study demonstrate that statistical genomics approaches can be used on Multi-Environment Trial (MET) phenotypic data to discover significant genetic effects and to define genomic regions associated with crop improvement.

A new pulse pathologist has been hired at NDSU. This is very strategic position since there is no other public university with a pathologist devoted to pulses only. There are new InDel and KASP markers (under validation) for the rust genes Ur-5 and Ur-11. As part of our collaborative work on white mold using a MAGIC population, ~30 resistant lines have been identified along with some known and new genomic regions associate with resistance. Collaborative research has shown that slow darkening pintos offer higher iron bioavailability and faster cooking time than regular darkening pintos. New published research has shown that breeding populations can be used with a dual purpose of genetic improvement as well as mapping.

A new atlas of RLK and RLP proteins across 5 legume species is now available. A new reference genome is available in phytozome: black bean line 5-593. Dr. Mark Bassett, University of Florida, developed a large set of backcross introgression lines using the black seeded, purple flower breeding line 5-593 (PI 608674) as the recurrent parent and donor lines with alleles that affect flower and seed coat and color and pattern. 5-593 is dominant allele for all but one of the genes controlling seed coat color and pattern. The 5-593 genotype for these genes is: T P [C r] J G B V Rk Gy sal. This genotype is currently being used to continue the understanding of the gene interactions among gene controlling seed coat color.

Briefly describe how your target audience benefited from your project's activities.

The collaborative research work done through the W4150 multistate project allows for significant progress towards disease resistance (i.e. white mold, rust, root rots, etc.), agronomic performance, and overall breeding efforts such as germplasm exchange and collaborative nurseries. In addition, the new genomic tools being developed (markers, sequences, genetic studies, etc.) are useful tools to improve breeding efficiencies within the breeding programs.

Briefly describe how the broader public benefited from your project's activities.

The W-4150 project produced several short-term outcomes benefitting stakeholders in the bean industry, among them:

In Michigan, 20% of the black bean acreage is grown by Zenith, which allows for direct harvesting, reducing grower costs. The estimated increase in value is $5 million per year based on a 10% yield advantage and time and equipment savings.

About 8% of great northern bean acreage in western Nebraska and the surrounding area is planted with 'Panhandle Pride'; more seed of 'Coyne' and 'Panhandle Pride' will be available in 2021. About 1,200 dry bean producers in western Nebraska and eastern Colorado have access to dry bean varieties with multiple disease resistance and drought/heat tolerance, enabling them to reduce production costs and increase net income.

Based on the 2020 annual dry bean grower's survey in the Northharvest region (ND+MN), NDSU dry bean varieties represented ~48% , ~50%, and ~15% of the area grown with black, great northern, and pinto beans, respectively. When translated to farm gate value of production (assuming an average price of $45 per hundredweight across market classes), it shows that just with the 2020 harvest, NDSU dry bean varieties contributed to generate approximately $133 million USD to dry bean growers in the region. This represents a net return of ~$887 USD per every dollar invested in the NDSU dry bean breeding program. The additional economic impact is also made to the rest of the food chain (elevators, wholesale buyers/brokers, packers, processors, etc.).

Approximately six years ago, the NDSU dry bean breeding program was one of the first to release a slow darkening (SD) pinto variety, which was considered a game-changer at that time. Today, it is estimated that SD pintos are ~35-40% of the total pinto acreage in North Dakota and it's expected to increase for 2021. During the 2020 growing season, ND Palomino, the SD variety released by NDSU, was grown in ~35% of the fields grown with SD pintos in the state. In addition, new collaborative research has shown that SD pintos cook faster than regular darkening pintos. They offer higher iron bioavailability than regular darkening pintos despite having similar iron seed content. These new findings offer exciting marketing opportunities for SD pintos, especially in developing countries where cooking time (energy) and human nutrition are important issues.

Oregon State University release (2018) 'Patron', a virus-resistant and high yielding Peruano type yellow seeded bean, was commercially grown in Idaho and Wyoming in 2019 and 2020.

Releases:

Michigan: Produced foundation seed and certified seed for four Michigan State University released cultivars: 'Adams' (high-yielding, upright, full-season black bean with anthracnose resistance and acceptable canning quality), 'Charro' (high-yielding, upright, full-season pinto bean with excellent canning quality), 'Eiger' (high-yielding, upright, full-season great northern bean with anthracnose resistance and acceptable canning quality), and 'Yellowstone' (determinate, virus resistant yellow bean with highly desirable vibrant dry seed coat color). Additionally, produced foundation and certified seed of two new varieties with excellent canning quality and uniform maturity, 'Zenith' (a high-yielding, disease-resistant, upright full-season black bean with superior color retention following canning) and 'Alpena' (an upright navy bean with natural dry down at maturity).

Nebraska: 'Kikatiti,' a pinto bean cultivar with high yield potential and multiple disease resistance developed by the dry bean breeding program at the University of Nebraska, Agricultural Research Division, was co-released with the Sokoine University of Agriculture in Morogoro, Tanzania in 2020. It will positively impact dry bean production in Tanzania.

North Dakota: North Dakota State University has released seven cultivars for the North Dakota/Minnesota region since 2014. Releases in 2019 include 'ND Falcon' (pinto with rust and soybean cist nematode resistance and good agronomic performance), 'ND Pegasus' (upright high yielding great northern with excellent seed quality and good white mold tolerance), and 'ND Whitetail' (high yielding white kidney with a high bacterial disease and white mold resistance). Efforts are underway to develop a replacement for 'Eclipse' (released in 2005), the region's most important black bean cultivar. In 2020, ND Twilight black bean was released with rust resistance, high seed yield, and early maturity.

Puerto Rico: 'Bella' (white bean) and 'Hermosa' (black bean), cultivars with resistance to major Caribbean bean diseases and superior performance in low N soils were released. TARS-LH1, a broadly adapted pinto bean germplasm with resistance to leafhoppers and E. krameri and E. fabae, was released collaborating with Michigan. Two lines produced through the shuttle breeding process, SB-DT2 (pinto) and SB-DT3 (small red), will be released as sources of drought tolerance and multiple disease resistance.

Washington: 'USDA-Basin' pinto bean and 'USDA Diamondback' slow darkening pinto bean. 'USDA Rattler' (PT11-13-31), a new pinto cultivar with drought and low fertility tolerance, and the I and bc-3 genes for BCMV resistance and Ur-3 and Ur-11 genes for rust resistance were released. Two RILs from the Rojo/CAL 143 population with HBB4.1, HBB5.1, and Pse-2 for resistance to halo blight, QTL for rust resistance, protected I gene, and moderate resistance to Angular leaf spot (ALS, Pseudocercospora griseola) are pending release.

California: five heirloom-like common bean cultivars have now been published in the Journal of Plant Registrations. There has been interest in California and other states to test these varieties, and a seed distribution/sale mechanism has been put in place via a California grower.

Durum Wheat Improvement
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E Elias

Organization

North Dakota State University Main Campus

Accession Number

1024693

⭐ Durum Wheat Improvement

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The primary goal of the breeding program is to develop improved durum wheat germplasm for characteristics such as grain yield, maturity, height, pest resistance, and quality. Breeding for disease resistance to Fusarium head blight (FHB), rusts, and tan spot are some of the major objectives of the breeding program because of their impact on durum wheat.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

To achieve our objectives, a pedigree breeding method in combination with emerging new technologies were used to develop195 new segregating populations. The breeding methods used involve the evaluation and selection of parents for good agronomic traits, good level of disease resistance, and high quality. The selected parents are hybridized to provide useful gene recombinations for selection. Approximately 75% of the crosses made are single crosses involving only elite adapted parents. The remainder of the crosses involve one parent that may be considered "exotic" but possesses desirable genes. During the reporting period, 29,569 F3-F5 new lines were evaluated for agronomic traits such as plant height and spike appearance and quality traits such as gluten strength. We evaluated 2,247 advanced experimental lines for agronomic, disease resistance and quality in preliminary, advanced, and elite yield trials grown at four locations in North Dakota.   Sixty-eight new populations were developed specifically for FHB resistance. A total of 3,200 lines were evaluated for FHB resistance in greenhouses. 5,600 lines were evaluated for FHB resistance in the FHB screening nursery at Prosper, ND. In the same reported period, 2,300 lines were evaluated for FHB in the field screening nursery at Langdon, ND. 2,852 and 1,260 lines were sent to the winter nurseries in New Zealand and Yuma, AZ, respectively. We continued the work on transferring FHB resistance from Sumai 3, Tunisian resistant lines, Langdon *dicoccoides* 3A and 7A substitution lines, *T. dicoccum*, and *T. carthlicum*, PI 277012 to durum wheat. In the same reporting period, 195 new populations were developed for low cadmium (Cd) uptake. 434 lines were tested phenotypically for Cd uptake. 4,147 lines were genotyped for Cd uptake at the USDA genotyping laboratory in Fargo, ND. These activities help me develop durum wheat germplasm that is resistant to diseases and has good agronomic and quality traits. Such germplasm maximizes the economic return to the producers and provides excellent quality durum wheat to the national pasta industry and international export market.

Briefly describe how your target audience benefited from your project's activities.

My target audience includes durum producers, millers and the pasta industry. I gave presentations at the Research Center's field days to producers. I gave presentations to the North Dakota Wheat Commission and the Northern Crops Institute. As for economic impact, based on the last five year's average, North Dakota produced 54% of the durum in the United States with $208 million direct economic value to ND producers annually. Over 90% of the ND durum acreage is sown with varieties developed at NDSU. The durum project at NDSU has $187.2 million direct economic impact on the state's economy annually. Two low cadmium varieties ND Grano and ND Riveland with high yield potential were released in 2017. In 2020, we released the durum variety ND Stanley because of its high yield and quality. If the new varieties replace 50% of the acreage and provide 2% increase in yield it will add approximately 2.0 million dollars to North Dakota producers annually.

Briefly describe how the broader public benefited from your project's activities.

NDSU durum germplasm has been used as hallmark material in breeding programs nationally and worldwide for high yield and excellent quality. Most, if not all, producers in North Dakota use varieties produced by the NDSU durum breeding program. For every one dollar direct impact on North Dakota producers, there is a two dollar impact on the state economy. Durum Project impact is not limited only to North Dakota producers, but also local and national millers and pasta manufacturers benefit from the breeding program. These benefits extend to a wide variety of local and national commercial and industrial businesses. Training M.S. and Ph.D. students is another benefit of the durum wheat breeding program.

Exploiting Advances in Technologies to Refresh Potato Improvement and Cultivar Development for North Dakota and the Northern Plains

Project Director

Asunta Thompson

Organization

North Dakota State University Main Campus

Accession Number

1024354

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Potato is an important horticultural crop in North Dakota, Minnesota and the north central region of the US and Canada. It is a nutrient dense food with convenient, quick, and simple meal prep options. Potato breeding and cultivar development are long-term processes, hampered by tetraploid genetics and high heterozygosity, vegetative propagation, susceptibility to many biotic and abiotic stressors, in addition to stringent market specifications. This project addresses the need by producers and the industry for economically and environmentally sustainable cultivars across market types.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

To address the shortcomings of industry standard cultivars and the needs of North Dakota and Northern Plains potato producers and industry, two research objectives were established: 1) identify, develop, and release potato cultivars and germplasm adapted to ND and the northern plains, with improved agronomic, quality, and nutritional attributes; and 2) improve breeding and assessment efficiency by adopting and/or developing new breeding technologies and strategies.

To address the objectives, the potato breeding program conducted potato research and production in the greenhouse, field, and laboratory in 2020 and 2021. Per the reporting dates, harvest of field trials, grading and assessment of yield attributes, and quality evaluations from the field and storage were completed for the 2020 research trials. Based on these assessments, including specific gravity, chip or French fry quality, and internal and external defects, selections across market types were identified as outstanding. ND050032-4Russ, ND060735-4Russ, ND113100-1Russ, ND12241YB-2Russ, ND1412Y-5Russ, ND14110B-1Russ, amongst others were identified as notable dual-purpose russets progressing through the breeding pipeline. Promising fresh market selections included ND081571-2R, ND081571-3R, ND102663B-3R, ND102990B-2R, ND113091B-2RY, ND113207-1R, ND1232B-2RY, ND1241-1Y and ND1243-1PY; ND13106-1R is a red-skinned fingerling with pink flesh, while ND1243-1PY has purple skin and yellow flesh. Outstanding chip processing selections included ND7519-1, ND7799c-1, ND102642C-2, ND113307C-3, ND1221-1, ND1241-1Y, ND12180ABC-8, ND13220C-3, ND13228AB-3 (chips from 3.3C), and others. ND1241-1Y is unique in that it is also dual-purpose, an exceptional chip processing selection with potential to be an excellent fresh market offering in the yellow sector.

During winter/spring 2021, 70 parental genotypes were used to create 321 new families. Parental germplasm included named cultivars and advancing selections from NDSU, USDA-ARS Prosser/Aberdeen, Michigan State University, and University of Maine. In addition to early maturity, emphasis was placed on introgression of resistance to disease and insect pests, and improvement of processing (frozen and chip) and fresh market quality attributes. One-third of the new families included a Potato Virus Y (PVY) resistant parent and about 10% included a nematode/corky ringspot resistant parent. Seedling tubers were produced in the greenhouse year-round for planting in the single-hill nursery. In 2021, 42,544 single hills were grown in the seedling nursery, with 28,943 from NDSU representing 157 families; the remaining single hills were received from collaborators in ID, ME and TX. Five hundred thirteen selections were made, with 353 as NDSU seedlings and 160 from out-of-state collaborators. Unselected seedling tubers were shared with the potato breeding programs in ID, ME, MN, OR and TX. In maintenance lots, 570 second year selections were grown, with 124 retained, 151 third year selections were evaluated with 83 selected, and 319 fourth year and older genotypes produced with 188 retained for continuation, in the breeding pipeline. Specific gravity of all was determined, each selection was photographed using a light box, and russet and chip processing selections were sampled for out of the field chip processing evaluation, and chip processing following eight weeks storage at 3.3C and 5.5C. Several mapping populations (4X) were produced, including a number segregating for skin set, an important attribute for minimizing storage losses due to disease and reducing marketing options due to unattractiveness. About 0.2 ha of increase lots of promising advancing selections was also entered into certification. The seedling nursery, clone maintenance and increase lots were grown at Baker, MN.

Field research trials were conducted at multiple locations in 2021; irrigated sites included Oakes, Larimore and Inkster, ND, and Park Rapids, MN. Trials at the Oakes Research Extension Center (OREC) included a processing trial with 13 selections compared to processing industry standards and a fresh market trial evaluating 10 advancing red and yellow skinned selections compared to standards. Processing genotypes were predominantly second- and third- year materials, providing our first look at quality and yield performance. As in 2020, standout in the fresh market trial was ND1241-1Y, a round yellow which retained its shape unlike many yellows which develop points when exposed to heat stress. Trials at the Larimore site included a processing trial with 16 advancing russet/long white selections compared to industry standards, the National French Fry Processing trial (NFPT), a preliminary processing trial (unreplicated) included 81 russet/long white-skinned genotypes and industry standards, the North Central Regional Genomic Selection Trials, and several agronomic trials. Dual-purpose russet standouts included ND1412Y-5Russ and ND1413YB-1Russ, in addition to previous NDSU releases Dakota Russet, Dakota Trailblazer and Russet Norkotah (this cultivar does not process into French fries and is limited to fresh consumption). A processing trial with 9 entries, including ND12154AB-2Russ, a common scab screening trial with 68 entries across market types, and the replicated *Verticillium* wilt resistance screening trial (25 genotypes across market types conducted in collaboration with Dr. Julie Pasche's program) were conducted at Park Rapids. ND12154AB-2Russ performed very well in processing trials in ND and MN, and combines early bulking with attractive tuber type and good processing qualities.

Non-irrigated research sites were at Crystal, Hoople, and Fargo, ND. All sites suffered from heat and the lack of timely rains during the 2021 growing season. The Crystal fresh market trial had 30 entries, including 24 advancing red, yellow and purple skinned selections compared to six fresh market standards; standouts included ND081571-2R, ND113207-1R, ND1232-1RY, ND1232-2RY, ND1241-1Y, and ND1243-PY. Yields at Crystal were extremely low with a very small tuber size profile due to the environmental conditions. Similarly, the preliminary fresh market trial (replicated) yields and tuber size profiles were small and a few of the selections produced a propensity of heat runners. Chip processing trials were located north of Hoople near the Crystal location; trials included the advanced chip processing trial, the National Chip Processing Trial (NCPT), and preliminary chip processing trial. Yields were slightly better (they were green dug later in September, rather than vine desiccation in early September) than the fresh market trial. Standouts based on yield and quality attributes in the chip processing trial were ND13220C-3 (nearly twice the yield of all other selections), ND7519-1, ND7799c-1, Dakota Pearl and Dakota Crisp. ND13220C-3 is advancing in the national trialing efforts in 2022. Several selections that performed well in the preliminary trial will be entered into Tier 1 of the 2022 National Chip Processing Trial. Two trials were grown on the NDSU campus-Fargo Main Station, an herbicide sensitivity trial, in collaboration with Drs. Hatterman-Valenti and Flores, focused on rapid phenotyping and an organic demonstration trial of 16 specialty selections compared to All Blue, French Fingerling, Red Norland and Yukon Gold. While Colorado Potato Beetles were not an issue in the organic trial in 2021, grasshoppers plagued the plot causing significant defoliation, providing valuable information in this demonstration.

NDSU has released 27 cultivars; the most recent was Dakota Dawn (ATND99331-2PintoY) in May 2021, the first specialty cultivar release from NDSU. ND1241-1Y and ND113207-1R will be presented for pre-release consideration in 2022, and the cold-chipping selection ND7519-1 will be considered for release in 2022. Several breeding lines may be considered for germplasm releases in breeding for cold-sweetening resistance and resistance to Colorado Potato beetle.

Briefly describe how your target audience benefited from your project's activities.

The target audience of certified seed and commercial potato producers, potato industry personnel, urban agriculturalists, consumers and students benefit from the development of economically and environmentally sustainable cultivars that incorporate disease, pest and stress resistance, the need for reduced inputs of water and fertilizer, and that possess enhanced quality and nutritional attributes including limited waste and improved flavor. Our hybridizing and research efforts are focused at incorporating and assessing these traits. As examples, drought conditions in 2021 allowed assessment of yield potential with minimal water and evaluation of value-added products when produced under stress conditions.

Briefly describe how the broader public benefited from your project's activities.

Dakota Dawn, evaluated as ATND99331-2PintoY, was released in 2021. It had been evaluated in North Dakota since its selection in 2002. It was predominantly trialed in the northern Red River Valley primarily in the Crystal/Hoople area and was included in the North Central Regional Potato Variety Trial. Grower and packing evaluations have not occurred due to the specialty nature of the selection, despite displaying it at the National Potato Council's Potato Expo and at other venues since 2011. However, culinary artists have taken note of the interesting appearance and delicious flavor and are pursuing production and utilization.

Nonchemical weed management tactics to benefit annual and perennial grain crop production systems

Project Director

Greta Gramig

Organization

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Accession Number

1024696

⭐ **Nonchemical weed management tactics to benefit annual and perennial grain crop production systems**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project addresses challenges associated with achieving acceptable nonchemical weed management in both organic grain and perennial flax production systems. Objective 1 focuses specifically on perennial creeping weed management in organic grain production systems, which is one of the most critical problems that farmers face in these systems. Objective 2 is focused on developing nonchemical weed management approaches for a new crop, perennial flax, with potential to provide valuable nutrients (omega-3 fatty acids) while increasing operational flexibility for farmers and improving soil quality.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Objective 1: During 2021, we conducted field studies to address Project Objective 1. These studies aim to compare 3 different cropping sequences in terms of creeping perennial weed management. This study year, 2021, was the third year in a four year sequence, and included yellowsweet clover (which had been undersown in wheat during 2020), a nine-species cover crop mixture, and perennial alfalfa. Within each cropping sequence treatment, we evaluated weed community density and composition to provide information about the relative efficacy of each cropping sequence for suppressing weeds, particularly creeping perennial weeds. Research results indicated that Canada thistle was better suppressed by alfalfa than yellow sweetclover. Perennial sow thistle density was also reduced under alfalfa. Field bindweed density had been similar among cropping sequences until a large increase occurring in 2021 within the two cropping sequences composed of annual crops and cover crops. This increase in field bindweed within treatments likely resulted from poor spring wheat establishment at one study site. In contrast, alfalfa reduced field bindweed density after two years. Extensive site prep through fertilization and tillage was conducted in fall of 2021 in preparation for the fourth year of the study in which all plots will be planted to hard red spring wheat.

Objective 2: Given the difficulties establishing perennial intercrop species in perennial flax stands in the 2020 season, we decided to explore more direct weed control through the application of flame weeding. Initial greenhouse trials of flame weeding using a hand torch had mixed but promising results. Three growth stages of perennial flax were treated alongside a broadleaf (kochia, *Bassia scoparia*) and grass (wild proso millet, *Panicum* miliaceum) weed species. The three growth stages of flax ranged in relative maturity with the youngest stage being seed germinating below the soil surface and oldest stage being flax with multiple true leaves. We noted good weed control in the greenhouse trial, especially among the broadleaf weeds. Perennial flax suffered high injury and mortality among the older two stages, while the youngest stage was minimally if at all affected by flame weeding. Older stage flax that survived flame weeding show a marked recovery response, initiating new growth within 7-14 days. Given these results, we determined that flame weeding in the field could potentially be effective if we could get the timing right. Additionally, we suspected that flax injured by flaming in the field may exhibit a stronger recovery response as they would not be limited in rooting depth and would have had a longer time to establish.

Flame weeding in the field was assessed on perennial flax that was dormant seeded at the 4x rate on 30" rows across four replicates of seven treatments on 10x20' plots at each site (Absaraka ND and Comstock MN). The treatments for this study consisted of six flame weeding regimes varying in early and late season actions as well as weedy check plot. The Absaraka site was treated with flame weeding first on May 18, 2021. We treated the plots in the evening so as to avoid morning dew, which can reduce the efficacy of flame weeding. Unfortunately, the flax had emerged well before any weeds. This early emergence was likely due to the warmer conditions we experienced in the spring of 2021. Additionally, this was the first time we had frost seeded perennial flax, and we did not have a precise baseline for estimating emergence time. Flax was approximately 7-10 cm tall with multiple true leaves at the time of flaming. This was not ideal, as we experienced high mortality at this growth stage in the initial greenhouse trials. We still applied the treatments as we hypothesized that flax in the field may be more resilient to flame weeding injury, and that the result may differ from the greenhouse trial as we are using a more precise piece of equipment.

Following our initial flaming application at the Absaraka site, we noted 60-90% flax mortality. Unfortunately, we also had little to no effect on weeds from the initial flaming application. The intense drought conditions of summer 2021 likely compounded the injury to flax and impeded recovery. We determined that a second flaming application would likely totally eliminate flax from the field, so we decided to not flame at all at the Comstock site.

Given this unfortunate early result, we adjusted our approach to incorporate a new spread of flaming and tillage combination treatments on extra plots that had received no prior treatment. These additional plots were seeding at the same timing, spacing, and rate as the previously treated plots. We evaluated additional methods of mechanical weed management for these treatments, as well as scaling down our flame weeding to the use of a handheld light duty flamer. This second treatment scheme represents a more intensive, modified approach to using flame weeding with extra emphasis on reducing flax injury. These treatments were applied at both the Comstock and Absaraka sites. Initial observational data supports good control of winter annual weeds and little to no flax mortality.

Briefly describe how your target audience benefited from your project's activities.

The target audiences for this project are farmers who are interested in nonchemical weed management and agricultural scientists who do research about this topic. Both project objectives (1 and 2) include on-farm research sites, and the farmers who own these farm sites benefited from seeing how the approaches we investigated worked on their farm. We also presented results at two NDSU field days attended by farmers, and those attendees benefitted from hearing about our results and experiences. Scientists involved in nonchemical weed management research benefitted from learning about our project results and experiences at a scientific conference (ASA-CSSA-SSSA Conference) at which we presented results from studies connected to both project objectives.

Briefly describe how the broader public benefited from your project's activities.

The broader public is interested in supporting agricultural methods that provide desired foods while also protecting the environmental and enhancing the sustainability of agroecosystems. Both projective objectives seek to develop weed management approaches that are less reliant on synthetic herbicides. Both project objectives also have potential to develop crop management approaches that could enhance soil quality and enhance soil carbon sequestration by reducing tillage and increasing vegetative coverage (cover crops, perennial crops) throughout the year. These project goals and outcomes benefit the broader public by providing research results that will help to sustain agricultural production needed to ensure adequate food supply while also enhancing long-term sustainability of agricultural production.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Major changes/problems: During May 2021, the research specialist who provided technical assistance for both project objectives resigned, and as of March 2022, has not yet been replaced. This unfortunate circumstance led to some delays in activities as well as adjustments to planned activities. Severe drought conditions across the field study areas produced negative impacts on all the field studies, although some sites were more severely impacted than others. The main consequence was a loss of some crops that led to missing or reduced amounts of data collected.

Opportunities for training: This project has provided training for two undergraduate students and two graduate students during 2021.

Results dissemination: Results from both project objectives were presented at the NDSU Carrington Research Extension Center Field Day (July 2021), NDSU Horticultural Research Field Day (August 2021) and the ASA-CSSA-SSSA Conference (November 2021).

New goals for next reporting period:

Objective 1: The final study year (2022) will allow us to make a more balanced comparison of the cumulative effects of all sequences on perennial weeds as every plot will be sown to hard red spring wheat. Wheat sown in the plots that were previously alfalfa will likely benefit from the reduced weed density and increased soil nitrogen.

Objective 2: Despite the difficulties faced in the first year of utilizing flame weeding in perennial flax, we feel that there is still an optimal way to incorporate flame weeding as part of an integrated weed management plan for the crop. We believe that second year perennial flax may be more resilient to flaming injury. To explore this idea, we plan to apply flame using the AFI

flamer again splitting the treatments up further to include reduced application dosage as well as thermal shielding manipulation. The hand flamer + tillage treatment set will be repeated again in 2022. We also established a fall seeded plot of perennial flax inter-cropped with winter wheat and rye to begin exploring this approach to weed management as well.

[Characterization and utilization of Fusarium head blight resistance in wheat](#)

Project Director
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⭐ Characterization and utilization of Fusarium head blight resistance in wheat

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In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Fusarium head blight (FHB) caused by Fusarium species is a devastating wheat disease in North Dakota and many other regions of the world. The disease not only causes significant yield losses, but also produces mycotoxins in grains that can harm the health of humans and animals. We are addressing the issue through identification of genes for resistance to the disease and deploy them in spring wheat and durum wheat.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The general goals of this project are to characterize new sources of Fusarium head blight (FHB) resistance in spring wheat and durum wheat at genetic and molecular level and to introgress the gene loci conferring FHB resistance into adapted wheat germplasm. The specific research objectives are: 1. Identify and map novel quantitative trait loci (QTL) for resistance to FHB and deoxynivalenol (DON) accumulation. 2. Develop adapted wheat germplasm with improved FHB resistance. 3. Isolate and functionally characterize the major QTL for FHB resistance in the wheat line PI 277012. We conducted the following research activities to achieve the goals and objectives of the project in 2021:

1. To identify QTL for FHB resistance in the emmer wheat (*Triticum turgidum* L. subsp. *dicoccum*) accession PI 254188, we conduced genetic analysis of a mapping population derived from the cross between PI 254188 and durum cultivar Divide. To our surprise, one major effect gene (*Qfhb.ndwp-2A-2*) conferring FHB resistance was detected on chromosome 2A of the susceptible parent Divide, while another minor effect gene (*Qfhb.ndwp-5A-3*) found on chromosome 5A of the resistant PI 254188. Our hypothesis is that the major QTL for FHB resistance on 2A of Divide might have been suppressed by other genetic factors in the durum wheat genetic background. Further research is needed to find out the genetic factors suppressing the FHB resistance gene in durum wheat.

2. To clone the gene (*Qfhb.rwg-5A.2*) for FHB resistance on chromosome 5A, we sequenced the whole genome of the wheat line PI 277012 using the PacBio HiFi sequencing technology. A total of 11,754,213 HiFi reads (equivalent to ~13x genome coverage) were generated and assembled into 5,827 contigs with N50=9.1 Mb and covering 14.3 Gb (84%) of the wheat genome. Using sequences of markers mapped to the *Qfhb.rwg-5A.2* region as queries, we identified a genome sequence containing the target FHB resistance QTL. With the whole genome sequences, we developed additional SNP markers for *Qfhb.rwg-5A.2.* These SNP markers were converted into PCR-based markers for fine mapping and introgression of the QTL. We also screened EMS mutants generated from PI 277012 and identified mutant lines that were much more susceptible to FHB than the wild type parent PI 277012. These mutants will be used to validate the candidate genes for FHB resistance.

3. Several studies discovered that the wheat gene *TaHRC* at the *Fhb1* locus (conferring FHB resistance) is involved in susceptibility/resistance to FHB. Mutation or deletion of functional *TaHRC* in wheat could lead to improved FHB resistance. We developed transgenic corn plants with gene editing machinery for targeting TaHRC. Using pollens of the transgenic corn

plants to cross with an FHB susceptible wheat variety (Dayn), we obtained three haploid plants with mutations and deletions at the *TaHRC* gene, and produced doubled haploid plants from them. Further studies are required to assess the FHB resistance of the doubled haploid plants.

4. The *Fhb1* gene from Sumai3 and *Qfhb.rwg-5A.2* from PI 277012 confer major effect resistance to FHB. To introduce them into elite spring wheat and durum wheat cultivars, we used wheat cultivar Alsen as the donor of *Fhb1* and wheat line GP112 as the donor of *Qfhb.rwg-5A.2* to cross with 11 spring wheat cultivars (Glenn, Alsen, ND VitPro, ND828, Linkert, Lang-MN, MN10201, Surpass, SD4539, WA8283, and Dayn) and two durum wheat varieties (ND Grano and ND Riveland). Five runs of backcrosses and marker-assisted selection have been performed to generate wheat lines carrying the FHB resistance gene (*Fhb1* or *Qfhb.rwg-5A.2*) plus having agronomic traits similar to their respective parents. We will continue the backcrossing and selection process until the seventh generation to obtain near-isogenic lines, which are 99.6% genetical identical to the parents but carry the targeted FHB resistance gene. FHB resistant durum wheat lines have also been developed from the cross between durum cultivar Joppa and an FHB resistant durum wheat line derived from the cross between PI 254188 and Divide.

Briefly describe how your target audience benefited from your project's activities.

Our target audience include: 1. Wheat breeders and geneticists; 2. Wheat growers; 3. Plant pathologists; 4. Extension agents. Our research activities have led to identification of new FHB resistance genes and DNA markers, development of new resources and tools for isolation and manipulation of genes responsible for FHB resistance or susceptibility to FHB, and generation of elite germplasm with improved FHB resistance for spring wheat and durum wheat breeding programs. All target audience can benefit from the outcomes of this research project. For example, the FHB resistance genes we identified and DNA markers we developed will be used by wheat breeders and geneticists to develop FHB resistant wheat varieties in breeding programs. Availability of FHB resistant wheat varieties will help plant pathologists, extension agents, and wheat growers to combat this devastating disease, reduce the yield and economic losses caused by the disease, and ultimately gain a better profit in wheat production. In addition, the genome sequences and gene editing technology developed in this project can be used for cloning other genes of interest in wheat.

Briefly describe how the broader public benefited from your project's activities.

Wheat is a world-wide grown crop providing 15% of the world's calorie intake. However, diseases such as FHB significantly reduce yield and quality of the crop. Use of host resistance is the most effective and environmentally sound approach to control the disease. Our research activities will facilitate mitigation of the impact of the disease and ensure food safety and security locally and globally.

Biology and Management of Potato and Sugarbeet Diseases

Project Director

Gary Secor

Organization

North Dakota State University Main Campus

Accession Number

1019384

⭐ Biology and managment of potato and sugarbeet diseases

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Potato plants and tubers are susceptible to numerous diseases that impact yield and quality resulting in decreased profits for producers. Understanding and managing potato diseases is critical for production of a healthy and profitable potato crop and to reduce risk of crop failure. The Red River Valley region of ND and MN is the leading producer of sugar beets in the USA. The most important disease of sugar beet is Cercospora leaf spot that causes severe loss of sugar in the field. Managing leaf spot results in critical to continued profitable production of sugar beets in our area.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Identification of tactics for managing blemish diseases of table potatoes helps potato producers reduce losses due to poor quality and increases profitability. Identification of new potato varieties with increased resistance to disease such as dry rot and soft rot reduces production losses resulting in a more sustainable and competitive market presence and reduced input costs. Basic research for understanding Cercospora leaf spot disease and understanding fungicide resistance has led to alternate cultural management strategies and development of disease forecasting systems to accommodate new information about Cercospora spore production and spread.

Briefly describe how your target audience benefited from your project's activities.

We developed a procedure to screen potato seed lots for the presence of Dickeya soft rot bacteria to insure planting of cleaner seed for increased production due to reduced emergence losses. We demonstrated that Dickeya soft rot bacteria are not spread during the cutting and handling of seed potatoes, but are readily spread from infected seed to progeny tubers in field soil moisture.

Tested 550 field isolates of *Cercospora beticola*, the most important cause of leaf spot of sugar beet, collected from sugar beet fields in ND and MN for sensitivity to six fungicides. Data used by the sugar beet industry to develop disease control recommendations that is used by 2650 farmers that plant 450,000 acres of sugar beets in our region . Determined that Cercospora beticola spores are produced earlier than previously reported, germinate at temperatures lower than previously reported and infect sugar beet plants earlier than previously reported. Developed an early forecasting model for Cercospora leaf spot of sugar beet.

Briefly describe how the broader public benefited from your project's activities.

Public consumers benefits from our work by a reliable supply of fresh market potatoes with higher quality and reduced blemishes in the market. Managing potato disease results in a stable and abundant supply of potatoes that consumers can reliably purchase at a reasonable price. Managing sugar beet leaf spot disease results in a stable supply of white sugar that is used by the general public for food production.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Opportunities continue for international collaborative research and educational programs with scientists in Chile for potatoes and beets. This information is distributed in scientific publications, scientific conferences, commodity group meeings and to stakeholders by personal meeitngs and emails

Genetic Research to Improve Weed Control
Project Director
M Christoffers
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North Dakota State University Main Campus
Accession Number
1020629

⭐ Genetic Research to Improve Weed Control

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Control of herbicide-resistant weeds is estimated to cost $10 to $40 more per acre than standard weed control. In comparison, proactive resistance management strategies are estimated to provide long-term annual economic returns of $20 to $50 per acre. The weed genetics project is developing tools to both facilitate proactive resistance management through genetic diagnostics and to mitigate resistance using emerging genetic technologies.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

This project previously established laboratory-grown waterhemp tissue culture cell lines on solid growth media and in liquid suspension cultures. By demonstrating their response to herbicides, the suitability of these cell lines for herbicide resistance research was confirmed. The major achievement during the current reporting period was the successful development of a protocol to remove the cell walls of living waterhemp cells grown in liquid culture, generating what are called protoplasts (plant cells without cell walls). Six different protocols were tested, but only one produced waterhemp protoplasts. The successful protocol consistently produced protoplasts that were about 72-78% viable, which is sufficient for subsequent experimentation. Inserting genetic material into these protoplasts (transformation), is now being studied. The development of this waterhemp tissue culture and transformation system will facilitate research to determine the feasibility of gene editing strategies as genetic biocontrol methods to mitigate herbicide resistance in waterhemp.

Briefly describe how your target audience benefited from your project's activities.

Herbicide-resistant weeds are a major problem in agricultural crop production. As of March 2022, there were 266 weed species with documented herbicide resistance globally, covering 164 different herbicides and a majority of herbicide sites-of-action. In the U.S., waterhemp is particularly problematic due to prolific seed production and its ability to develop multiple resistance to different herbicide sites-of-action. Producers are in need of new tools to manage waterhemp and other herbicide-resistant weeds, and this project is furthering that goal by developing a tissue culture system to investigate new genetic biocontrol methods under laboratory conditions. This tissue culture system has potential to help other weed scientists achieve their research goals as well.

Briefly describe how the broader public benefited from your project's activities.

It is beneficial to the public for weed research to be carried out under conditions that minimize negative environmental impacts. When doing research in weed genetics, it is important to minimize the possibility of seeds or pollen escaping laboratory or greenhouse containment. Our work to establish a tissue culture system for waterhemp research benefits the public by providing a system where this weed can be studied without the production of seeds or pollen, thereby minimizing escape and potential risks to the environment.

Soybean Breeding and Cultivar Selection

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⭐ **Soybean Breeding and Cultivar Selection**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Soybean now become the number one crop in North Dakota. According to USDA stats, 7,250,000 acres of soybean were planted in 2021. There are many farmers that want to grow soybean, but may not be familiar with it or may not to take the risk of buying expensive name brand seed every year. The NDSU soybean breeding program assists these farmers by providing knowledge they need to produce soybean on their farms. This comes in various forms such as direct consultation, conducting public tests of soybean varieties from various companies. The breeding program also produces NDSU soybean varieties which offer competitive yields of private companies at a reasonable price.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The two objectives of this project are:

1. Develop superior soybean cultivars and improved germplasm for North Dakota.

During this reporting period, 75 new cross combinations were made in the soybean breeding program. These crosses included goals to increase yield for both the glyphosate tolerant and conventional projects across all maturity groups in North Dakota. In addition, there are cross combinations made to stack disease resistances to major diseases in North Dakota such as soybean cyst nematode (SCN) tolerance with soybean sudden death (SDS) tolerance. Also introduced was a specialty premium soybean oil trait, high oleic oil, which would allow North Dakota farmers access to a high value oilseed. To select for the progeny lines with the desired characteristics, we use markers to select for traits that we can: SCN, SDS, and high oleic at the F3 generation. We then grow out the selected progeny and test for maturity and yield. The F5 stage is the important generation where we first select for maturity and yield. This year, 8,000 F5 lines were evaluated, and 1,500 lines were selected for advancement to yield trials in 2022 across all projects. In 2021, we tested 886 glyphosate tolerant and conventional experimental lines in our first-year yield tests at two locations (a third location was lost to drought). 98 of these lines were selected for advancement to second year tests in 2022. We also tested 43 conventional lines and 67 glyphosate tolerant lines in the second-year yield tests and selected 24 lines to 2022 3rd year testing. The 3rd year tests were grown in 12 locations and there were 65 lines tested of which 19 were advanced to 4th year testing in 2022. 4th year tests in 2021 were grown in 12 locations had 20 lines total. From the results of the 4th year tests, 2 lines will be pre-released meaning their data will be disseminated to a selection committee, and it will be decided if these lines will be valuable to North Dakota. We did have several locations of lost data due to the drought in 2021, however we were able to salvage useful data through two methods 1) the numerous locations allow for non-useful data to be discarded without affecting statistical results 2) the use of spatial analysis statistics allowed us to remove some the environmental effect of the drought so we could ascertain true yield potential.

1. To test both public and private soybean cultivars and provide growers information that will aid them in identifying the best cultivar for their farm.

In 2021 an electronic submission form was created to facilitate ease of order entry. As much as I would like every farmer to grow only NDSU soybean varieties, it is a competitive market and farmers appreciate having an objective side by side comparison of commercial varieties grown in the same environments to understand yield performance. Two yield tests were conducted. The first was a GMO only test that contained all lines with Xtend, Enlist, and RR2 varieties. The second test contains all non-GMO or "conventional" varieties. These tests are also divided into central and southern tests. The central tests are near Fargo and were planted in Arthur and Hatton. The southern tests are south of Fargo and were planted at Lisbon and Milnor. In the GMO central tests: 30 lines were entered. In the GMO southern tests: 38 lines were entered. In the conventional central tests: 16 lines were entered and in the conventional southern tests: 19 lines were entered. All these locations were planted and maintained by the NDSU soybean breeding program and were harvested the first week of October 2021. Data were analyzed and published in the A843 publication in November 2021. This publication can also be found here: https://www.ndsu.edu/agriculture/sites/default/files/2022-01/a843_soybean_2021.pdf

Briefly describe how your target audience benefited from your project's activities.

This project's target audience are the soybean growers of North Dakota, seed producers and distributors, and commercial soybean seed companies. In January 2021, NDSU released two new soybean varieties: ND21008GT20 and ND2108GT73. ND21008GT20 is a glyphosate tolerant soybean cultivar that is meant to be grown by the northern border of North Dakota. It jas excellent resistance to iron deficiency chlorosis; a condition that can be devastating to soybean yields. ND2108GT73 is a glyphosate tolerant soybean cultivar that is meant to be grown by the southern border of North Dakota. This cultivar is the first NDSU released variety that is glyphosate tolerant for that growing region of the state. In addition, I also provide expert advice about soybean varieties at field days throughout the state, over the telephone and email communication. I also organize and host a soybean symposium which showcases soybean research occurring at NDSU which is relevant to the target audience.

The NDSU soybean breeding program also completed its annual testing of private company varieties. Most farmers find this information invaluable because it is an objective, side-by-side comparison of the most current commercially available crops. They are tested for yield in an environment that farmers are familiar with and they utilize this information to help them make educated choices for the seed they will grow the following season. The results are publicly available in the A-843 publication and online at https://www.ndsu.edu/agriculture/sites/default/files/2022-01/a843_soybean_2021.pdf

Briefly describe how the broader public benefited from your project's activities.

NDSU soybean varieties have been successful. In 2021, across all NDSU soybean varieties, 132,284 1 acre seeding rate units were sold. Assuming all the units were planted as labeled 132,284 acres of 7,250,000 total acres is 1.8% of a very competitive market. Averaged across 3 years, from 2019-2021 the market share was 2.4%. One variety, ND17009GT, which was released in

2017 has been very popular with farmers.

In addition to directly benefitting North Dakota farmers/growers/producers, the NDSU soybean program also provides educational services to school and 4H groups. We also participate in NDSU field days as a chance to teach people who may not be familiar with soybean the opportunity to learn more and ask questions. We pride ourselves on providing agricultural education to all who are interested.

<div style="border: 1px solid orange;">Closing Out (end date 09/07/2023)</div>

Annual weed control in small grain crop rotations

Project Director
K Howatt
Organization
North Dakota State University Main Campus
Accession Number
1016190

⭐ **Annual weed control in small grain crop rotations**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Weed presence in North Dakota cropland is a persistent issue with negative economic implications that elicits many consultation calls and leads to initiation of several research trials. In addition to general weed pressure, weeds such as kochia, waterhemp, wild oat, and green foxtail with specific resistance traits present difficult weed control scenarios within certain crops. Control with herbicides also might be affected by new application technologies aimed at limiting off-target movement. And crops grown on few acres, such as mustard or buckwheat, and new crops, such as industrial hemp lack chemical options to control weeds. Improving control of weeds throughout the season and finding weed management options for low-acreage crops would mitigate lost revenue and reduce infestation in other crops of the rotation by limiting weed seed return to the soil.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Several Group 4 herbicides are already registered in small grains, each with specific benefits and often with some limitation. The herbicides 2,4-D and MCPA at 4 to 8 oz ae/A have been long-standing staples for broadleaf weed control in wheat and barley but are ineffective for control of kochia (up to 40% control in trial near Dazey, ND, which is a key weed concern in the Plains and Western United States. Clopyralid at 1.5 oz ae/A provides excellent control of composite (Canada thistle) and legume (black medic) weeds, but has not controlled kochia or many other broadleaf weeds in several trials near Fargo, Valley City, Prosper, and Rogers, North Dakota. Fluroxypyr at 2 oz ae/A provided excellent control of kochia but lacks general broadleaf activity. A trial near Valley City, ND, indicated that 1.3 to 1.5 oz/A fluroxypyr was sufficient to control kochia that was 4 to 6 inches tall in premixes that included bromoxynil, but alone this rate allowed survival of some kochia plants. Dicamba is good on kochia but weak on mustards and often causes injury to small grains. Because of the potential for crop response, dicamba is seldom used at rate higher than 1 oz ae/A in North Dakota. At this rate, kochia control in trials near Fargo and Valley City has been 80 to 85%.

Dichlorprop-p at 8 to 16 oz ae/A in wheat has demonstrated excellent kochia activity (90 to 98% control) and also provides control of many other broadleaf weeds in greenhouse and field trials. For North Dakota geography, dichlorprop-p at 8 oz/A is a strong broadleaf herbicide and the premix with bromoxynil at rate near 5 oz ae/A, Group 5, aids resistance management as well as broadening and enhancing weed control to achieve greater than 90% control of most broadleaf weeds. In addition, we have not observed injury to small grains from dichlorprop-p at 16 oz/A that has resulted from use of dicamba, 2,4-D, or MCPA at lower rates.

Another issue of concern is antagonism of Group 1 grass herbicides when mixed with broadleaf herbicides. In field experiments near Fargo, control of yellow foxtail and wild oat with fenoxaprop at 1.32 oz ai/A has been reduced by as much as 22 percentage points when applied in mixtures with 2,4-D, dicamba, thifensulfuron, or tribenuron. Fenoxaprop activity was not less when dichlorprop-p was added at 8 oz ae/A compared with fenoxaprop alone.

Resistance profiles of several kochia, wild oat, and foxtail samples were generated in greenhouse experiments to characterize response across several herbicide options. Seed sources were submitted or collected from fields suspected of containing resistant biotypes. This information was valuable for generating acceptable and appropriate prescriptive control measures for mitigation of resistance.

Weeds resulted in approximately 30% less seed yield in industrial hemp compared with hand-weeded alternative in trials near Casselton, Fargo, Hillsboro, and Prosper. Herbicides were investigated for use in industrial hemp in greenhouse and field experiments. Pre-emergence options were identified and are under continued evaluation to encourage registrant interest. Post emergence alternatives do not have support from various registrants because of crop injury level often exceeds 15%. Since post emergence herbicides for broadleaf weed control do not appear likely, repeat application of pre-emergence herbicides identified several potential programs. Trifluralin at 16 oz ai/A pre-emergence followed by S-metolachlor at 30 oz ai/A or dimethenamid-p at 19 oz ai/A early post emergence resulted in less than 5% injury across four cultivars at Fargo, Carrington, and Langdon, ND. Substituting acetochlor at 24 oz ai/A or pyroxasulfone at 4 oz ai/A in the early post emergence application resulted in as much as 15% marginal necrosis of exposed leaves. Herbicides did not result in damage to subsequent leaf development. At this time, most of the registrants are apprehensive to enter the hemp herbicide market even though initial research indicated excellent crop tolerance, manageable weed control, and vegetation and seed samples did not contain detectable herbicide concentration. Several control options were identified to control volunteer hemp in small grains, corn, soybean, dry bean, sunflower, potato, and edible legumes.

Briefly describe how your target audience benefited from your project's activities.

Specific target audiences included crop producers in North Dakota and bordering regions, North Dakota Advanced Crop Advisors, Certified Crop Advisors, undergraduate students, graduate students, area crop consultants and agronomists, county extension agents, peer institution researchers and instructors, industry representatives, professional society members, and private landowners.

Target audiences received information from field and greenhouse experiments for the purpose of gaining knowledge and improving understanding of weed management in cereal grains and oilseed crops. Main objectives and other information included maximizing control of grass weeds in small grain cereal crops, facilitating effective management of herbicide-resistant weeds, discussing the function and benefit of adjuvant components, evaluating effect of droplet size and pulse-width modulation technology on efficacy of herbicides, discussing and demonstrating dicamba off-target movement and determining the effect of dicamba damage on susceptible crops, and documentation of industrial hemp response to herbicides for weed control in crop or control of volunteers the following season.

Information and results of research were used in several venues to educate clients for more appropriate decision making with the end goal of improved weed control and greater profitability. Research results were used in classroom-type settings and for instruction aid to better prepare our future professionals. Research results and consulting cases were used to provide tangible examples related to discussion topics. Field examples also were used to construct learning exercises to refine diagnostic skills. Effort in classroom curriculum development facilitated incorporation of more diagnostic exercises, self-directed learning opportunities, and formative assessments.

The primary indirect dissemination of information was through the North Dakota Weed Control Guide, which was co-authored by several researchers in North Dakota to distribute recommendations based on research information and experiences through approximately 15,000 distributed copies annually, and the content is available online.

Professional society membership and peers received presentations of key research findings, and subsequent discussions and collaborative work broaden our greater understanding of the science. Presentations to local land managers, agronomists, and crop consultants address specific questions from the clientele to aid their efforts and improve their success.

Briefly describe how the broader public benefited from your project's activities.

Information from this project's activities improved the efficiency of weed control as well as identified greater options for weed control in certain crops. This is, at times, a slow process as the registration process can require several years of research, testing, and residue analysis. At times, the discoveries meet greater obstacles than can be overcome, such as environmental concerns or economic unviability.

Some private individuals are reached directly through project activities. Several of those who benefit from this project's activities in turn directly interact with many private individuals. This dramatically expands the scope of benefit in the region. Improved weed control increases profits and farm receipts. Better land management also increases the land value and

professional expertise of clientele which garners increased value of service provided and aids in retention of clients. This all leads to greater stability and economic security of our rural farm economy, which also supports the region's urban business districts.

Reduced off-target movement improves quality of life in areas adjacent to crop production and non-crop areas where weed control with herbicides is more accurately, appropriately, and safely achieved through guidance and information provided by this project. Improved aesthetics can also be achieved by reducing the presence of weeds. Commodities are cleaner, which increases revenue for the production chain and results in better end-use products.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Classroom and outreach interactions were greatly hindered by pandemic restrictions but still directly reached more than 500 individuals. Personal interactions were reduced to limit the risk of spreading disease.

NDSU Weed Science hosted the North Central Collegiate Weed Science competition. This brought about 150 people to campus for training and competition.

Events included co-coordinating the Wild World of Weeds Workshop for about 275 participants and presenting research at Extension events to reach about 200 individuals. Participation in annual Weed Science Society meetings enabled dissemination of results as well as professional training.

The data of nonconfidential work are included in a database available to researchers and the public for review and query. This database is directly used by 10 individuals to assist research development, but information can be solicited by anyone. The database covers North Dakota field research spanning approximately 50 years.

Research reports are prepared for cooperators and industry partners. Web access to these reports (http://www.ag.ndsu.edu/weeds/nd-weed-control-research) has allowed broader access to weed science research in North Dakota with questions about information in the reports coming from across the United States and Canada.

Research is published in graduate student theses and professional society journals. In addition, abstracts have been published through the Weed Science Society of America and Western Society of Weed Science.

Many presentations, volunteered and requested, have disseminated results to growers, consultants, industry representatives, and peer academicians.

Critical Issue

Human Development and Education

Human Development and Education
Project Director
Ona Vig
Organization
North Dakota State University Main Campus
Accession Number
7000063

⭐ Caregiving

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Parent Education
Parent education and support is key to developing healthy children and families. Some families struggle with abuse or neglect and require ongoing educational support. A partnership between NDSU Extension and the ND Department of Human

Services-Children and Family Services provides a system of parent education delivery for each of the seven regions in the state (ND Parent Education Network).

- During FFY 2020, a total of 6,141 children received a child maltreatment investigation in ND.

- Of children assessed, 27% (*N*=1,657) were substantiated as victims of child maltreatment.

- These assessments represent 1,657 children who were victims of child abuse and neglect and 1,200 caregivers who were the subjects of these assessments.

Older Adult Caregiving

The vast majority of older North Dakotans want to stay living in their home as they age. In AARP's 2020 survey of North Dakota adults, in the past two years, one quarter (26%) of North Dakota residents age 45+ are currently providing unpaid help to an adult relative or friend. These family caregivers provide a range of daily activities, such as transportation, personal care, managing finances, grocery shopping, and much more. Caregiving can be a rewarding experience but can also be filled with enormous physical, emotional, and financial challenges. It is essential for caregivers to maintain their own health and well-being while managing caregiving responsibilities. Yet, most caregivers receive little or no training to care for themselves.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Parent Education

NDSU Extension works in partnership with the ND Department of Human Services to provide prevention education programs that address child abuse and neglect. NDSU Extension collaborates with schools, social services, non-profits and local agencies to develop and implement a variety of parent education programs. These programs target primary prevention education work at the community level while also supporting and teaming, as requested, to support the intervention work of social service agencies.

Parents who participate obtain knowledge and skills to create safe, stable and nurturing relationships with their children. From October 1, 2020 - September 30, 2021, seven parent and family resource centers participating in the ND Parent Education Network provided 1,838 parents and other adults with the knowledge and skills to create healthy relationships with their children. A total of 1,220 hours of direct parent education and support were provided in classes and meetings. Region 3 was without a coordinator for this time period. The ongoing Covid-19 pandemic required our parent educators to deliver a majority of classes using online platforms.

Older Adult Caregiving

The *Powerful Tools for Caregivers* (PTC) *Program* is a national evidence-based program which was brought to North Dakota by the NDSU Extension. Extension Family & Community Wellness Agents, along with many local community leaders, have been trained as Class Leaders to offer 6-week workshops to two audiences: family caregivers caring for adults with chronic illness and family caregivers of children with special needs. In response to COVID-19 classes have been offered online.

Briefly describe how your target audience benefited from your project's activities.

Parent Education

Based on participant feedback, the following impacts were reported:

- When having a family dispute, after participation those resolving the issue constructively increased from 66.4% to 93.3% of participants.

- In working through family stresses, after participation those working together positively increased from 77.7% to 93.4% of individuals.

- Following participation, adult participants who reported losing control during child discipline decreased from 28.3% to just 5.6% of participants.

- After participation, parents spending time with children in activities the child enjoys increased from 80.6% to 95.5% of participants.

- With regard to thinking that children misbehave just to upset them, after participation adults who made this judgment decreased from 30.2% to 11.9% of parents involved.

Older Adult Caregiving

Participants who completed the PTC workshop evaluations reported improvements in the following areas:

- 49 percent increase in their confidence in asking for help with tasks needed for caregiving.

- 43 percent increase in understanding that emotions are a normal response to caregiving.

- 49 percent increase in finding positive ways to cope with the stress of caregiving.

- 58 percent increase in their ability to find caregiving resources in their area.

Survey results indicated participants' plans to use newly learned "tools" in the future:

- 86 percent plan to use Action Plans

- 88 percent plan to use Positive Self Talk

- 80 percent plan to use relaxation tools

- 82 percent plan to use "I" messages

- 70 percent plan to use long range goal setting

Briefly describe how the broader public benefited from your project's activities.

Parent Education

Communities with parents who exercise poor parenting skills are at potential risk for negative outcomes, including school failure and juvenile criminal activity such as vandalism or gang association (National Clearinghouse on Child Abuse and Neglect). The cost-benefit of programs that include parenting education components results in reduced expenditures for school remedial services, criminal justice and child welfare.

Older Adult Caregiving

Improving the health and well-being of family caregivers can save North Dakotans money by helping them keep their loved ones at home longer and delaying more costly levels of care. Aging in community preserves quality of life for residents and saves money for taxpayers.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Brotherson, S. E., & Hoffman, M. S. (2020). The history and usage of parenting newsletter interventions in family life education. Education Sciences, 10(11), Article 326. https://doi.org/10.3390/educsci10110326

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Diabetes Prevention

According to the Centers for Disease Control and Prevention, 96 million Americans have prediabetes. Having prediabetes puts an individual at greater risk of developing type 2 diabetes, which is the most expensive chronic condition in our Nation. In North Dakota, approximately $832 million is spent on diagnosed diabetes costs, $423 million of which is from indirect costs such as absenteeism and the inability to work.

Expanded Food and Nutrition Educaiton Program

Obesity, poor nutrition, and limited physical activity are significant health concerns. According to the U.S. Centers for Disease Control and Prevention (CDC), North Dakota's adult obesity rate is 33.1 percent. Additionally, 10.5 percent of North Dakota youth, 10-17, are overweight or obese. Poor health disproportionately affects minority and low-income populations. Certain populations, including women and children of low-income status, have higher rates of obesity (NHANES). Obese children are more likely to become obese adults with an increased risk for chronic disease and higher health care costs. Parents/caregivers can influence the opportunities and preference for healthy behaviors in their children.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Diabetes Prevention

Extension has been a leader in diabetes prevention across the state for a number of years. Our team of educators has made prevention a priority. Program delivery options have expanded from in-person to distance learning, to hybrid online-distance programs. Community partners continue to look to Extension to train new lifestyle coaches and to provide technical assistance on data entry, program delivery, and recognition requirements.

Expanded Food and Nutrition Educaiton Program

Through education, the program seeks to support participants' efforts toward self-sufficiency, nutritional health, and well-being. EFNEP serves families with limited resources in four urban areas and on two reservations in North Dakota.

The program targets low-income adults with children in the household and school-aged youth from low-income households. Adult programming focuses on cultivating positive nutrition, food safety, physical activity and food resource management practices through a series of classes. Youth programming provides age-appropriate lessons to teach youth to build healthier eating and physical activity habits.

Briefly describe how your target audience benefited from your project's activities.

Diabetes Prevention

During 2021, Eligible participants lost an average of 10.5 pounds. n average, participants reported completing between 170 and 230 minutes of physical activity weekly.

Expanded Food and Nutrition Educaiton Program

Educators adapted and found creative ways to offer resources and remote programming in some locations.

- 92% of adult graduates improved one or more nutrition practices

- 76% of adult graduates improved one or more food resource management practices

- 46% of adult graduates improved one or more food safety practices

- 96% of 3rd-5th graders improved one or more nutrition practices

- 79% of 6th-8th graders adopted or improved physical activity behaviors

Studies have shown three to ten dollars in health care savings for every dollar invested in EFNEP.

Briefly describe how the broader public benefited from your project's activities.

Diabetes Prevention
Prevention of diabetes impacts a community's economy by reducing healthcare expenditures for individuals, creates opportunities for health savings, and increases productivity both by improving the quality of life for effected individuals and reducing the loss of productivity due to illness and disability.

Expanded Food and Nutrition Educaiton Program
Low-income parents/caregivers who participate in EFNEP gain valuable skills to feed their families healthfully and economically, which not only benefits them but all of North Dakota by decreasing the need for public assistance and the collective health care costs of poor nutrition.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Garden-Robinson, J., West, R., Coleman, S., Ingham, B., McGarry, J. & Nwadike, L. (2021). Organizing Extension Family and Consumer Sciences Groups Around a Common Topic: Lessons Learned and Best Practices. Journal of the National Extension Association of Family and Consumer Sciences.

Smith, N. & Stankiewicz, J. (2021). PSE Guidebook. NDSU Extension.

Johnke, K. & Stankiewicz, J. (June 2021). Growing and Go!-ing Together: Local Food Opportunities, Dakota Rural Health Conference.

⭐ Healthy Aging

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Falls are the leading cause of both fatal and nonfatal injuries among older adults. Twenty to thirty percent of people who fall suffer moderate to severe injuries that may make it difficult to get around or live independently, increasing the risk of early death. In 2019, falls were the second leading cause of injury-related deaths in North Dakota, and the leading cause of injury-related deaths in individuals over the age of 65. A total of 437 ND residents died due to falls from 2015 through 2019, an average of 87 deaths per year.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

NDSU Extension is partnering with community organizations to conduct *Stepping On* falls prevention workshops. *Stepping On* is a national evidence-based program designed to help older adults take control of their fall risks, explore coping behaviors, and use safety strategies in everyday life. Participants meet for 2 hours per week for 7 weeks, plus a 3-month follow-up session. There are 31 Stepping On certified facilitators offering workshops in North Dakota.

Tai Ji Quan: Moving for Better Balance (TJQMBB) is a national evidence-based program which was NDSU Extension implemented in 2021. The TJQMBB program is designed to improve strength, balance, mobility and daily function, reducing participants' risk of falling. Because of the unique, recreation-like format, the program may be especially appropriate for individuals who are not receptive to "traditional" falls prevention classes. Extension Family & Community Wellness Agents, along with their local community partners, have been trained as class leaders to offer classes.

Briefly describe how your target audience benefited from your project's activities.

Participants ranged in age from 48 to 93 years, with an average age of 79 years. They reported:

- Their knowledge about the importance of balance and strength exercises for preventing falls increased 63 percent

- Their confidence in applying safe strategies in mobility situations increased 52 percent

- Their understanding of the relation between medications and falls increased by 69 percent

- Overall, 79 percent of participants reported learning a significant or great extent from the program to prevent falls.

In a follow-up survey three months after the workshop, participants reported positive changes in behavior, such as:

- 50 percent exercise routinely

- 95 percent had assessed their home environment for safety hazards

- 95 percent had practiced techniques for safe transfers, standing, walking, and climbing curbs and stairs

- 65 percent had used ways to learn about side effects of medications

Participants who completed the TJQMBB workshop evaluations reported improvements in the following areas:

- 33 percent increase indicated that they recognize more ways to reduce falls.

- 19 percent increase in their confidence in taking time to socialize more with others.

- 33 percent increase in recognizing their concern about falling interfered with their normal social activities with family, friends, neighbors, or groups.

- 25 percent felt more flexible in their movements.

Survey results indicated participants' actions (since the program began) to reduce their chance of a fall:

- *60 percent indicated that they improved overall in the activities of their daily living*

- 20 percent talked to a family member or friend about how they can reduce their risk of falling

- 13 percent had their medications reviewed by a health care provider or pharmacist

- 23 percent had their vision checked

- 10 percent have made safety modifications in their home, such as installing grab bars or securing loose rugs, to reduce their risk of falling

Briefly describe how the broader public benefited from your project's activities.

Reducing the risk of falls can increase older adults' quality of life and save thousands of dollars in health-care and long-term care costs for North Dakotans.

Livestock Systems

Livestock Systems

Project Director

Ona Vig

Organization

North Dakota State University Main Campus

Accession Number

7000060

⭐ **Manure and Nutrient Management**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

While both raw and composted manure benefit soil health and crop production, there are benefits to creating and land-applying composted manure over raw manure. Product uniformity, volume, weed seed, pathogen and parasite reduction and nutrient stability are just a few of the benefits. However, composting manure in Minnesota and North Dakota have yet to gain popularity.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

NDSU Extension partnered with the University of Minnesota Extension with the original plan of holding four workshops in two years (two each in ND and MN). When implications from the COVID-19 pandemic ensued, we changed our plans to host an online workshop in 2020 and were able to continue with two in-person workshops in 2021.

The online workshop consisted of 13 videos that were sent to registrants 2 weeks before an online, live discussion was held in August 2020 with the presentation team as well as 3 producer cooperators. One of the videos consisted of on-farm interviews with each of our producer cooperators in an effort to showcase to registrants the ability to manage compost differently with similar results. The videos are still available and have been viewed collectively 1,845 times.

The in-person workshops were held in July and August of 2021. Each workshop covered the same material as the online workshop and all three producer cooperators attended each event. The producer cooperators were responsible for helping attendees with the compost diagnostics activity as well as answering questions during a panel discussion.

Briefly describe how your target audience benefited from your project's activities.

Two compost-related publications for producers were created for use while at the compost rows:

- Manure Composting Quick Guide

- Common Manure Composting Problems and Their Solutions

Online Workshop

- 180 people registered for the online workshop and 50 joined the live discussion with presenters and producer cooperators

- 43 responded to the immediate follow-up survey where
  - 76% thought the self-paced format was excellent

  - 64% thought the amount of material was excellent

- 62% thought the topics covered were excellent

  - 15 months after the online workshop, 21 people participated in a follow-up survey and as a result of the workshop, **58% reported they had altered their manure composting practices**.

  - When asked what manure composting change(s) they made, **58% reported they improved their operations** adding,
    - "I have more confidence in my ability to compost successfully and have a better understanding of the environmental impacts of composting."

    - "I no longer have to pay someone to haul away our waste"

    - "Although not composting on a commercial level, I manage several community gardens where large volumes of biomass are accumulated. After learning additional techniques, my piles were hotter and decomposed more quickly. The key? More moisture!

In-person Workshops

  - 31 people attended the in-person workshops in ND and MN, of which 10 participated in a 4-month follow-up survey
    - 67% of those who made changes as a result of the workshop stated **they started composting manure**

  - 100% of those who did not make changes were either agency or university Extension/research personnel who reported the workshops impacted them, their work, and/or their relationship with their clients by:
    - "Allowing me to be more educated about manure composting so that when producers inquire about composting I am able to give them accurate information."

    - "Using workshop information to inform clients of another manure handling method to consider; composting."

Briefly describe how the broader public benefited from your project's activities.

Composting is a process producers in all sectors of agriculture can use, whether they raise livestock, crops, vegetables or companion animals. Composting creates a stable, nutrient rich product which can prevent surface water pollution while also being beneficial for plant growth.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Keena, M. A., & Augustin, C. (2021). Nutrient Characteristics of Solid Beef Manure in North Dakota. North Dakota State University, NM2007.

Keena, M. A. (2021). Solid Manure Sampling for Nutrient Management Planning. North Dakota State University, NM1259, revised.

Keena, M.A. (2021). Manure Spreader Calibration For Nutrient Management Planning. North Dakota State University, NM1418, revised.

Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation
Project Director
Kasey Maddock Carlin
Organization

North Dakota State University Main Campus

Accession Number

1025800

⭐ **Nothing Significant to Report**

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

One of the problems encountered during fiscal year 2021 was the delay in receiving reagents and supplies to complete proposed research, which may have been due to the continued pandemic. Much of the analysis that was to be completed in 2021 was delayed significantly due to shipping delays. Due to inabilities to recieve needed supplies, the labatory analysis was shifted towards the end of the fiscal year and has not been fully completed or the statistical analysis has not been completed on the data produced. However, training on laboratory techniques was given to two Ph.D. students who completed procedures in western blotting and oxidation analysis. We have made significant progress towards the completion of data collection and will have a full report for 2022.

Factors influencing skeletal muscle metabolism and ultrastructure: Implications on meat palatability

Project Director

Kasey Maddock Carlin

Organization

North Dakota State University Main Campus

Accession Number

1022303

⭐ **Factors influencing skeletal muscle metabolism and ultrastructure: Implications on meat palatability**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

As we manage livestock to improve growth efficiencies, carcasses have changed in terms of overall weight, size, and composition resulting in greater production of meat. Beta-adrenergic agonists such as ractopamine hydrochloride are often utilized in finishing diets of cattle to repartition growth towards greater lean and less fat while maintaining or improving feed efficiency. This alteration of growth has been shown to have negative implications on meat tenderness and marbling. Palatability traits (tenderness, juiciness, and color) have been identified as being the main factors driving consumers decision to continue to purchase red meat. Current methods of categorizing meat quality and our understanding what drives differences in meat palatability traits are lacking. Therefore, the overall goal of this research is to understand how meat palatability attributes (tenderness, juiciness, and color) are influenced by postmortem skeletal muscle metabolism and ultrastructure changes during storage and aging from cattle that have differences in efficiencies.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Preliminary results for study1 indicate that while supplementation with ractopamine hydrochloride (280 mg/d/steer) during the last 28 days of feeding increased gain:feed in steers compared to controls, there was not differences in hot carcass weights or dressing percentage. There was a decrease in marbling score and increase in loin muscle area. There was not a difference observed in tenderness or cook loss. Characterization of fiber types indicate a shift of muscle fiber types in the semitendinosus muscle towards type II fibers, which are more glycolytic and have a different ability to maintain energy during cell death. Results for project 2 show that protein degradation in postmortem muscle was influenced by carass size where the longissimus muscle had less degradation of troponin-T during aging and the semimembranosus muscle had more degradation of troponin-T as carcass weight increased, but differences did not correlate to temperture or pH measurements.

Briefly describe how your target audience benefited from your project's activities.

The greatest benefit of this research is towards the research audience who are studying how the increases in growth efficiency and the increased carcass size in beef cattle changes muscle metabolism and meat quality. This information will help develop hypothesis driven research that will answer best practices for developing optimum meat quality in these larger, more efficiently grown carcasses.

Briefly describe how the broader public benefited from your project's activities.

The broader public benefits from this research as it will direct research towards best practices and methodologies to ensure a access to high quality beef that has best outcomes for palatability and shelf life.

Strategies to Improve Fertility and Pregnancy Outcomes in Ruminant Livestock

Project Director
Lawrence Reynolds
Organization
North Dakota State University Main Campus
Accession Number
1016901

⭐ **Strategies to Improve Fertility and Pregnancy Outcomes in Ruminant Livestock**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

In the U.S., agriculture accounts for 2 to 11% of gross state product in 23 states, and North Dakota and South Dakota are the top two, with 8 and 11%, respectively. Additionally, 60% of the value added annually to the U.S. economy from agricultural production can be accounted for by livestock and crops used for feed, and livestock production is critical to agricultural sustainability and food security. Maintenance of reproductively sound females is a primary expense in livestock production, and thus infertility (the inability to conceive, and establish and maintain a pregnancy) as well as poor pregnancy outcomes, as reflected by premature delivery and low birth weight, have a major impact on the efficiency of livestock production, and thus improvements in these critical reproductive parameters would have a major impact on the profitability of animal agriculture.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

To meet the long-term goal, **we have the following 3 Objectives** in which we are examining three critical areas that dramatically influence reproductive efficiency in livestock:

(**Objective 1**) Molecular regulation of fertility and early placental function, including the influence of differing levels (low, moderate and high) of maternal dietary intake; (**Objective 2**) The role of oviductal fluid in fertilization and early embryonic development, including the role of differing levels of maternal dietary intake; and(**Objective 3**) The role of placental steroids in fetal organ maturation and delivery, and thus in successful pregnancy outcome.

For all of the proposed studies, we are using either cattle or sheep. Additionally, we utilize a team-based approach involving intra- and extra-mural collaborators.

During this Reporting Period, we made progress primarily towards Objective 1, Molecular regulation of fertility and early placental function, including the influence of maternal dietary intake. **The 5 articles published demonstrated**:

1. dramatic effects of moderate maternal dietary restriction occurring the first 50 days of pregnancy in beef heifers on location and abundance of amino acid transporters in the placenta;

2. dramatic effects of moderate maternal dietary restriction occurring the first 50 days of pregnancy in beef heifers on gene expression in key metabolic tissues of the fetus (liver, muscle and cerebrum);

3. dramatic effects of vitamin and mineral supplementation of heifers during early pregnancy on maternal weight gain, maternal serum and allantoic fluid amino acid concentrations, and placental expression of energy metabolism and

4. effects of maternal nutrition and rumen-protected arginine supplementation during early pregnancy on systemic hemodynamics and circulating amino acids in pregnant ewes and their offspring. These data, taken together, demonstrate the importance of maternal nutrition during early pregnancy on fetal and placental development, as well as the long-term effects on the offspring.

Briefly describe how your target audience benefited from your project's activities.

The primary target audience reached was agricultural and biomedical scientists engaged in research related to fetility and pregnancy outcomes in livestock and other mammals including humans. Other target audiences included extension service personnel and graduate and undergraduate students, postdoctoral fellows and the general public. In one such example, one of the Co-PDs, Dr. Caton, was an invited plenary speaker at the annual meeting of the American Society of Animal Science, which includes animal scientists from throughout the U.S. and the worls, and published an invited review article based on the presentation (Caton JS, Crouse MS, Reynolds LP, Neville TL, Dahlen CR, Ward AK, Swanson KC. Maternal nutrition and programming of offspring energy requirements. Transl Anim Sci. 2019 Jun 25;3(3):976-990. doi: 10.1093/tas/txy127).

To disseminate the results of our studies, we have published not only review articles, but also journal articles and abstracts. In addition, the Participants have attended meetings and made presentations at those meetings. The project also has involved 1 undergraduate student, 5 graduate students and 2 postdoctoral fellows, all of whom have not only participated in the studies, but also have attended meetings, made presentations and published reviews, journal articles and/or abstracts.

The results of the proposed studies will dramatically improve our understanding of the mechanisms that determine fertility and pregnancy outcomes, and thus will potentially have a large economic impact on livestock production, which is a major component of agriculture in the state of North Dakota, and also will enable North Dakota to continue to provide the highest quality agricultural products to the world.

Briefly describe how the broader public benefited from your project's activities.

As already mentioned, the results of these studies will improve our understanding of the mechanisms determine fertility and pregnancy outcomes, and thus will potentially have a large economic impact on livestock production, which is a major component of agriculture in the state of North Dakota, and also will enable North Dakota to continue to provide the highest quality agricultural products to the world. These efforts, therefore, will contribute greatly to both food security and agricultural sustainability.

Additionally, because the studies involve undergraduate and graduate students and postdoctoral fellows, they are contributing to training the next generation of animal scientists, again helping to ensure both food security and agricultural sustainability.

Improving efficiency of nutrient use in ruminants
Project Director
Kendall Swanson
Organization
North Dakota State University Main Campus
Accession Number
1014684

⭐ Improving efficiency of nutrient use in ruminants

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Feed costs are a major component of overall production costs in cow/calf, growing, and finishing cattle systems. Improving the
efficiency of feed utilization or using lower cost feeds, therefore, can have dramatic effects on profitability and sustainability of
the beef industry.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Major goals were to: 1) Evaluate variation in efficiency of nutrient utilization and examine approaches to improve feed efficiency, 2) Better define
nutrient metabolism in visceral tissues as related to whole animal energy and protein efficiency, and 3) Assess alternative feeding programs to reduce feed costs in North Dakota and the Northern Great Plains. Research results indicate that 1) Heifer and cow size is an important factor influencing feed intake, body weight change, and calf weaning weight, 2) Changes in cow nutrition influences oxygen consumption and mitochondrial function in offspring, and 3) Hempseed cake may be a potential alternative feed source for use in finishing cattle diets.

Briefly describe how your target audience benefited from your project's activities.

This research is targeted to provide information to producers, industry personnel, and other scientists interested in beef cattle nutrition and physiology. This research is targeted to provide information to producers, industry personnel, and other scientists interested in beef cattle nutrition and physiology. Results are shared at presentations at national and international scientific meetings and to local producer groups, as well as through publication in Extension and scientific peer-reviewed articles.

Briefly describe how the broader public benefited from your project's activities.

Agricultural and livestock research is important for improving the sustainability and efficiency of food production. Improvements in feeding management have resulted in increased production with the use of less resources while maintaining or improving animal health and well-being. Besides providing knowledge for use by producers and industry personnel to improve productivity and efficiency, a primary benefit of my research program is training students and other personnel who are and will be important in the improvement of the agricultural industry and of human well-being and food security.

Critical Issue

Natural Resources

Natural Resources
Project Director
Ona Vig
Organization
North Dakota State University Main Campus
Accession Number
7000059

⭐ Land Reclamation and Remediation

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The leading industries in North Dakota are energy and agriculture. Development of energy and poor grazing management can have negative costs to lands used for agricultural production, recreation and the environment. Once the environment is compromised or lost, reclaiming the original environment can be difficult and costly. When the environment is impaired, landowners can incur losses to forage production, crop yields and water quality in addition to losing quality of life of factors like wildlife and aesthetics. The goal of reclamation and restoration is to reverse the impairment restoring factors such as the plant community, soil quality, water quality, and wildlife habitat.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

1) Extension hosted discussions, 2) Extension publications, 3) Development of Presentations, 4) Workshops and field tours. Organized and hosted ND Reclamation Webinar Series. The webinars featured 5 sessions with nine speakers and was attended by 188 participants in 5 countries and 12 states.

Briefly describe how your target audience benefited from your project's activities.

Surveys of participants revealed an increased knowledge of grassland reclamation (98%), pipeline reclamation (100%), innovative approaches to reclamation (98%), reclamation technology (93%) and cost-effective reclamation (96%). A total of 66 participants intended to make changes to their reclamation practices following the webinar series. Videos from the series were viewed 781 times.

- Outreach efforts have helped build relationships with oil and gas industry resulting in securing $1,497,697 to support research and Extension.

- Team formed to develop reclamation suitability ratings and disturbance response groups to improve reclamation success in ND.

Briefly describe how the broader public benefited from your project's activities.

Agricultural lands that have reduced productivity or have been removed from production due to oil and gas development and poor range and pasture management will be reclaimed restored. Returning these land to production will enhance food security. In addition, reclamation of these lands will improve ecological functions leading to enhanced biodiversity, wildlife habitat, air quality and water quality.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

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Applying soil micromorphologic techniques to assess soil health on the benchmark Barnes soils of eastern North Dakota

Project Director
David Hopkins
Organization
North Dakota State University Main Campus
Accession Number
1023185

⭐ **Applying soil micromorphologic techniques to assess soil health on the benchmark Barnes soils of eastern North Dakota**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This research will develop and apply soil micromorphologic techniques to assess soil health on the benchmark Barnes soils of eastern North Dakota. An ongoing study consisting of eight Barnes sites on cropland were sampled for micromorphology in 2017 and provide evidence of soil change in surface layers of these soils due to tillage erosion. A related 2019 project funded by the NRCS in North Dakota is focused on creating three sites for comparison that are located on native, non-cropped Barnes soil map units. By comparing the two forms of land use with high quality images and image analysis, a novel means to verify dynamic soil change can be developed.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Three Barnes reference sites (non-cropped, native landscapes) were selected with the assistance of NRCS soil scientists having extensive networks in the North Dakota soil health community. The reference sites were located and landowner permission obtained during this reporting period and reflect the full range of the Barnes soil series in central North Dakota from near the South Dakota border to the International boundary. The southern site in Dickey County was sampled on September 8, 2021 and the northern site in Rolette County, ND was sampled October, 16, 2021, beyond the current reporting period. The remaining reference site will be sampled in Wells County in April, 2022. The soil profiles were described, photographed, and samples taken by horizon to 50 cm depth. These soil samples were carefully wrapped and dried so that thin sections can be developed from them. That process is in its initial stages currently. Extensive training of an undergraduate research assistant was necessary and occurred during this reporting period; thin sections were developed on teaching samples with lower priority.

A Motic Easy-Scan digital scanner, purchased with departmental equipment funding, was installed in February, 2021 at the NDSU Advanced Imaging and Microscopy Core Laboratory. The PI was instructed in the use of this scanner and continued scanning some of the 256 thin sections from eight cropped sites sampled for micromorphologic analysis in the Barnes soil health project. Currently, 163 slides have been scanned on the Motic, representing about 64 percent completion. After careful consideration of thin section coverage, quality, and depth of sampling, it seems that 6 of the 8 sites will provide the sampling range for assessing micromorphologic evidence of soil change due to tillage.

Results from topsoil thin sections made in 2020 for a NRCS dynamic soil properties (DSP) study at the USDA-ARS-Northern Great Plains Research Laboratory in Mandan, ND were scanned on the Motic scanner and limited image analysis was performed on some images during this reporting period. The three sites in this study are on loessial soils and land management treatments vary between native pasture under low intensity grazing, no till crop/fallow continuous spring wheat, and an aspirational management program recently developed by the ARS. This is the first contract work undertaken in my lab and 30 polished thin sections from 90 slabs were prepared for three land use treatments.

A meeting was held in November, 2021 with a research specialist at the NDSU Electron Microscopy Core Laboratory to investigate using scanning electron microscopy to detect elemental changes or trends in the thin sections. Only one thin section was used in this testing, but the technique does permit elemental abundances to be determined for transects across thin sections. Such evidence will be useful to determine the effects of land management on soil characteristics that govern soil function. Additional work will be directed to this technique in the next reporting period.

Briefly describe how your target audience benefited from your project's activities.

A presentation "Micromorphology Project Update" on soil thin section interpretation from topsoils sampled during the NRCS dynamic soil properties project was delivered virtually to the North Dakota Cooperative Soil Survey Technical Planning Workshop in April 2021. The audience included soil scientists, soil conservationists, and other federal and state professionals involved in soil resources and conservation from both North Dakota and South Dakota. Participants were able to witness both the remarkable nature of the mineral and biologic features in high resolution thin section images, but were also exposed to ways that soil porosity can be quantified with image analysis techniques. Regardless of the constraints, micromorphology offers perhaps the best way to evaluate a soils spatial architecture, and to formulate and refine interpretations of soil function.

The PI was invited to central ND near Ellendale to discuss soil properties on sodium affected soils at a Field day "Digging for the Bottom Line" sponsored by North Dakota Pheasants Forever and the James River Soil Conservation District on September 7, 2021. Part of that presentation included large format posters of soil thin section images, including those from sodium affected soils, displayed in the farm shop.

Briefly describe how the broader public benefited from your project's activities.

While sampling the Barnes reference site north of Ellendale, a newspaper editor for the Dickey County Leader came to the ranch for an interview and photographs and we discussed the high quality of the Barnes soil on the native pasture as well as the tillage erosion problem in the state. Later, a front-page article titled "Area soil samples delight NDSU scientist" was published on September 30, 2021. This coverage helps producers understand the importance of maintaining soil quality on this benchmark North Dakota soil.

The PI sat in on the First Virtual Micromorphology Meeting (ViMi I) organized in Europe with 127 scientists and students participating representing 31 countries that was held on April 23, 2021. This activity is essentially part of the PI's professional development, as the science and art of soil micromorphology is considerably more advanced in Europe than North America. During one of the Breakout room sessions images of fungal sclerotia from a North Dakota thin section were shared with the audience and confirmed by a prominent Dutch micromorphologist.

An abstract titled "Value added pedology, a micromorphologic rewrite of a Natrudoll (Solonetz) case study in North Dakota, USA" was prepared for the 22nd World Congress of Soil Science and accepted for an oral presentation in August, 2022. Graduate students in a 2016 advanced soil genesis course made detailed observations of a 4 m trench face dug in a sodium affected soil. Students made a detailed map of the 1.5 m tall trench face, highlighting extreme short-order soil heterogeneity in horizon boundaries and thickness. They observed soil structure, clay coatings, and secondary minerals such as gypsum, and identified nine unique genetic horizons that met USDA taxonomic criteria for mollic, albic, glossic, natric, and calcic horizons. Samples collected for micromorphology after student field work was completed were used to create thin sections which were scanned on the Motic Easy-Scanner in spring, 2021. These thin section images provide compelling evidence for pedogenic processes, and will be analyzed more fully for the World Congress presentation.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

The project is in its early stages and the pandemic has reduced opportunities for student training and productivity. During this reporting period two undergraduates worked in the lab and one of them has now begun to impregnate soil samples and produce thin sections. This individual will work till at least May and hopefully good progress will be made on Barnes reference site samples. As a result of carefully reviewing the thin sections from the Barnes soil health study, only six of the eight sites appear to be valid for comparison with Barnes reference sites.

Land Management Strategies to Restore Species Diversity and Structural Heterogeneity in Novel Ecosystems

Project Director

Ryan Limb

Organization

North Dakota State University Main Campus

Accession Number

1019309

Land Management Strategies to Restore Species Diversity and Structural Heterogeneity in Novel Ecosystems

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Kentucky bluegrass invasion is threatening grassland ecosystems of the northern Great Plains. Given the loss of grasslands, and the economic costs of invasive species, it is especially important to study invasive species biology and ecology, and provide options to manage them and how to restore sited already invaded. At this time, there is a lack of empirical evidence to suggest how bluegrass-invaded communities respond to land management strategies in the northern Great Plains and how bluegrass responds to grazing after burning.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

In collaboration with faculty at the Central Grasslands Research Extension Center, four grassland management strategies were implemented on large-scale pastures to address real-world conditions and solutions. We examine alternatives to manual thatch removal in the form of conventional rangeland management techniques. To determine the effect of different management strategies on Kentucky bluegrass thatch, we measured plant community composition and thatch depth at multiple points across 12 different pastures invaded by Kentucky bluegrass in the Missouri Coteau region. Each pasture was managed with either patch-burn grazing, modified twice-over rotational grazing that was designed to create vegetation structure like that found in patch-burn systems by varying grazing intensity between patches, or season-long grazing. We found no difference in thatch depth between rotational and season-long grazing. However, pastures managed with patch-burn grazing had a thinner thatch layer than those managed with either rotational or season-long grazing. While thatch depth did vary between patches in our patch-burn and modified rotational pastures, it did not consistently vary with time since fire or grazing intensity. This suggests that a single fire can halt thatch accumulation for a number of years by removing dead plant biomass. Further, we found that in general management strategies that increased landscape level heterogeneity also increased plant diversity and available niche space. These results suggest that patch-burn grazing is an effective tool in reducing Kentucky bluegrass thatch accumulation and may lessen the impact of Kentucky bluegrass on prairies.

Briefly describe how your target audience benefited from your project's activities.

The main target audiences for this project include those interested in how to reclaim and restore rangeland landscapes. The audience may include but not lmited to farmers, ranchers, pracicing professionals, and state and federal agencies. Numerous traiing opportunities were offered this past reporting period including Extension Center field days, and local presentations. In attendance were ranchers, scientists, and state and federal land managers. During each training event, the fundamental principles of this project's objectives were discussed.

Briefly describe how the broader public benefited from your project's activities.

The broader audiences for this project include those interested in how to reclaim and restore rangeland landscapes across the Northern Great Plains and global grasslands in general. The audience may include but not lmited to scientists, practicing professionals state and federal agencies. Findings from this work was presented at two international professional society

symposiums. Further, graduate students published three abstracts, one dissertation and submitted two manuscripts for publication. Additionally, one manuscript was published in a peer-reviewed journal.

Closing Out (end date 09/07/2023)

Improvement of plant productivity potentials of highly disturbed soils

Project Director
Thomas DeSutter
Organization
North Dakota State University Main Campus
Accession Number
1015955

⭐ **Improvement of plant productivity potentials of highly disturbed soils**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Disturbed soils as a result of the extraction of oil, gas, and coal resources are needing to be improved so that these soils improve ecosystem services and agricultural revenues. This project addresses reclamation strategies and needs to improve soil function post-disturbances.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Superabsorbent polymers can be used to promote increased soil-water availability to plants but they can also improve soil physical properties. The major 2021 activity investigated the use of a superabsorbent polymer and how it impacted evaporation, water retention, freezing and thawing, liquid limit, bulk density, peak penetration resistance, and saturated hydraulic conductivity. The addition of the polymer appeared to have the potential to amplify the remediation of compacted soils as a result of freezing-thawing events. These results are significant since compaction of soil is a major obstacle to long-term plant establishment, reducing erosion, and the promotion of nutrient cycling.

Briefly describe how your target audience benefited from your project's activities.

Across North Dakota, thousands of miles of pipelines are annually installed to support the transport of natural gas, crude oil, and subsequent waste products. In addition, hundreds of acres are annually reclaimed post extraction of coal. Our target audience now realizes the potential that superabsorbent polymers can have in the reclamation of these problem soil. Further field research is needed but the proof-of-concept for semi-arid compacted soils is realized.

Briefly describe how the broader public benefited from your project's activities.

In our lifetime the energy resources are limitless, which includes oil, gas, coal, thermal, and wind. The extraction of these resources does disturb soils, which are the lifeline for many farmers and ranchers of the state. The project's activities have provided researchers and reclamation specialists with a potential tool to combat one of soil disturbances greatest challenges, which is compaction. Superabsorbent polymers are non-caustic, inexpensive, and fundamentally safe to handle. Their potential use in problem soils offers another possibility for fully reclaiming highly disturbed soils.

Water management to improve water quality and crop productivity

Project Director
Xinhua Jia
Organization
North Dakota State University Main Campus
Accession Number
1017014

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

When the *Transforming Drainage* project was officially ended on April 30, 2021, we removed all the instruments from the fields and did not do any field experiments on drainage water management. Instead, our research involved using soil moisture sensors to automatically control a drip irrigation system for specialty crops, such as tomato and watermelon.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Irrigation scheduling is very important for irrigation water management. The methods for determining when to irrigate can be improved by using soil moisture sensors to automatically control when water is applied. In 2021, we tested an automatic controller (at five different soil water thresholds, or five different irrigation schedules for watermelon with and without clear plastic mulch. We found the irrigation scheduling at threshold level 7 (or at -55 kPa) under clear plastic mulch provided the highest yield, 36.9 kg/plant and 6 watermelons per plant, but the plot was only irrigated five times. Frequent irrigation with small amount did not lead to a higher yield, particularly for the clayey soil in this study.

Briefly describe how your target audience benefited from your project's activities.

The target audience are farmers, gardeners, researchers, students, staff, etc. They learned from our project that proper irrigation water management might change the water application, and improve the irrigation water productivity and water use efficiency.

Briefly describe how the broader public benefited from your project's activities.

The general public will benefit from this project because the information will be made available through publications, presentations, field tours, videos, and demonstrated using fresh watermelon samples.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Two new projects on sensor controlled automatic drip irrigation will be started in the next reporting period, but on different vegetables, different soils (loam and sandy soils), different irrigation schedule and different controllers.

Type	Projects / Programs
Projects / Programs without a Critical Issue	**4**

Breeding Improved Hard Spring Wheat Cultivars
Project Director
Andrew Green
Organization
North Dakota State University Main Campus
Accession Number
1015553

⭐ **Breeding Improved Hard Spring Wheat Cultivars**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

North Dakota plants around 6 million acres of spring wheat annually. Our program focuses on stable yield, genetic disease resistance to Bacterial leaf streak, Fusarium head blight, and rust diseases. Genetic disease resistance is preferred because it reduces crop inputs and can positively benefit soil and environmental health. We also strive to maintain and increase the

milling and baking quality of the varieties that we develop in order to maintain demand in both the domestic and international markets for North Dakota grown wheat. This value ensures competitive prices are paid to farmers who grow spring wheat.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Objective 1: Develop breeding germplasm and competitive varieties of hard red spring wheat adapted to the Northern Plains of the United States with superior disease resistance and improved end-use quality.

During the reporting period, 603 new crosses were made to develop new populations for the red wheat breeding program. The goals of these crosses are increasing grain yield, improving straw strength, disease resistance, and improved milling and baking quality. Each cross made has at least one parent which is moderately resistant to Fusarium head blight, and at least one parent must have acceptable end-use quality. During the same period, we evaluated 302 F2 populations and made selections based on plant appearance and disease resistance, and harvested a large sample of individual spikes. We evaluated 137 F3 populations in single spike rows across two locations which were harvested from F2 plots the previous year. We tested 122 F4 populations, and derived new experimental lines as homozygous plants from 113 F5 populations at three locations in ND. 3449 new experimental lines were tested in an observation nursery at Casselton, ND. These were also simultaneously screened for FHB resistance in a misted, inoculated nursery. Selected lines were bulk harvested and tested for end-use quality, kernel quality, leaf rust, and stem rust resistance. There were 278 second year yield trial (Y2) lines tested at four locations in North Dakota, 84 Y3 lines tested at nine locations in ND, and 40 Y4 lines tested in ten locations across ND. Due to the excessively dry conditions, we abandoned our Minot testing location, as well as around half of the experiment at Carrington. Data were collected and used from all other sites. We planted three inoculated FHB nurseries totaling 14,500 plots total, and 3,500 inoculated plots in one Bacterial leaf streak (BLS) nursery. Our program grew three breeder seed increases for potential new cultivars, each covering 1/3 acre. Two were harvested and advanced. Final evaluation was conducted for data to propose the release of a new wheat variety, which was tested as NDHRS16-14-126.

Objective 2: Develop experimental breeding germplasm of hard white spring wheat adapted to the Northern Plains of the United States with improved disease resistance and suitable end-use quality.

During the reporting period, 235 crosses were made in the white wheat breeding program. These are a combination of crosses between two white wheat lines as well as red wheat lines crossed with white wheat lines. In the case of red by white crosses, we rely on color sorting of bulk seed samples from earlier generations to isolate white seeded individuals for planting in the following season. We screened 249 F2 populations at two locations (Cass County ND and Adams County ND), and evaluated 18,640 F3 rows in Cass County which were derived from single spike selections in the previous year. We had 137 F4 and 120 F5 populations at two and three locations, respectively. White wheat first year yield lines are F5 derived and were increased in the New Zealand winter nursery for yield plot evaluation in 2021. We tested 1150 new lines at Casselton, ND. The Y2 trial was planted at four locations and contained 106 lines, and the Y3 had 36 entries, and was planted at nine locations. All of the white wheat breeding material is also screened in FHB and BLS nurseries. Milling and baking evaluation targets whole wheat flour products. Similar to the red wheat program, data were lost from Minot, ND due to drought, but other locations yielded useful results.

Briefly describe how your target audience benefited from your project's activities.

My project's target audience includes wheat growers, seed producers, representatives from the milling and baking industry, extension personnel, crop consultants, and private seed industry representatives. My interaction with them included speaking at in-person field days at Hettinger, Casselton, Langdon, and Thompson, ND in July, North Dakota Wheat Commission in March, and July, and the Wheat Quality Council tour in July, as well as virtual meetings with Crop Improvement District (5) in February, northeast area Extension personnel in February, and a Northern Crops Institute webinar presentation in October. I also reach stakeholders through regular email communication and phone calls pertaining to wheat varieties and data interpretation, and helping to prepare the Annual ND Spring Wheat Variety Trial Results and Selection Guide.

Briefly describe how the broader public benefited from your project's activities.

In 2021, 18% of spring wheat acreage in ND was planted to varieties developed at NDSU. Products from our breeding project are also used as crossing material by other breeding entities. The cash value of grain sales alone for spring wheat was around $1.38 billion in 2020 (the latest year with available data). Improved varieties released by our program have a direct economic impact on North Dakota. For example, remaining popular because of superior baking quality, 'Glenn' (released in 2005) was the leading NDSU developed variety sown in 2021, with an estimated 4.4% of North Dakota's 5.75 million acres of spring

wheat, according to USDA-NASS, 2021. 'ND Frohberg' (released in 2020) was released to replace 'Glenn' and can yield 5-10% more, with similar quality. Replacing even 50% of 'Glenn' acreage with 'ND Frohberg' would increase cash grain revenue to ND producers by an estimated $2.4 million.

Breeding and Genetics of Spring Barley for North Dakota

Project Director
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Accession Number
1020837

⭐ Breeding and Genetics of Spring Barley for North Dakota

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

North Dakota produces around 19% of all U.S. barley. Depending on the quality of the crop, up to 75% of the barley produced in the state is acceptable for production of malt. Barley not sold for malting purposes is fed to livestock on the farm, sold at a substantially lower price for feed, or used as seed. F actors that reduce the value of the crop are end-use quality attributes required by maltsters and brewers; and factors that reduce grain quality, including the mycotoxin deoxynivalenol (DON) and preharvest sprouting (PHS).

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Objective 1: To develop two-rowed malting barley (Hordeum vulgare L.) germplasm with improved Fusarium head blight resistance (FHB) that is acceptable to growers and those who process the grain.

Commercial barley cultivars, new cultivars, and promising advanced selections were evaluated at 6 locations in ND. In addition, off-station trials with new and check cultivars were conducted by ND Research Extension Centers across the state. Severe drought at our Minot and Nesson Valley locations resulted in trials from these locations being abandoned. Yields at our Williston, Osnabrock, Carrington, and Fargo locations were reduced due to drought; however, the quality of the data coming from these locations was acceptable. 17 6-rowed and 55 2-rowed experimental lines were grown and harvested at 4 ND locations in their 3rd or more years of yield trials. The USDA-ARS-CCRU in Madison, WI evaluated selected lines for malt quality and Dr. Tom Baldwin from the NDSU barley pathology project evaluated lines for resistance to spot and net blotch. 5 lines were submitted to the American Malting Barley Association's (AMBA) Pilot Scale Evaluation Program. 156 2-rowed lines were grown and harvested in the Intermediate Malting Barley Yield Trial at 4 locations in ND. Selected lines were evaluated for malt quality by the USDA-ARS-CCRU and for spot blotch and net blotch reactions in greenhouse tests conducted by Dr. Baldwin. 711 2-rowed experimental lines were grown and harvested in the Preliminary Malting Barley Yield Trial at 3 locations in ND. 7,020 F3 or F4 2-rowed barley head rows were grown at 1 ND location. 4,116 spikes from these head rows were selected and sown as head rows in in Yuma, AZ to increase seed for 2022 yield trials. Rows with acceptable straw strength, maturity, and uniformity will be harvested and advanced to the Preliminary Malting Barley Yield Trial. In summer, 45 2-rowed F2 populations were grown in one location and 40 2-rowed populations were selected for advancement. The 40 2-rowed F3 populations were sown in the Yuma, AZ winter nursery. Spikes from selected F3 populations will be harvested and advanced to the 2024 F4 short row nursery in ND. 45 2-rowed crosses were made in the 2021 spring greenhouse. F1 seed from these crosses was grown in the summer greenhouse and F2 populations were sown in October in the Arizona off-season nursery. Selected spikes will be advanced to the 2022 F3 short row nursery. 49 2-rowed crosses were made in the 2021 fall greenhouse. All crosses have the objective of combining favorable agronomic characteristics, disease resistance, and malt quality traits. All crosses made use at least 1 parent with FHB resistance.

Objective 2: To identify traits in which genomic selection can be successfully used to predict agronomic, disease resistance, and malt quality performance of NDSU breeding lines.

3,956 F3 bulks were genotyped using a SNP chip with 553 markers. Genomic selection (GS) of these bulks will be used to predict wort beta-glucan, yield, and heading date. These predictions will be used to identify up to 1,000 2-rowed lines from the 2021-2022 Arizona off-season nursery to advance to the 2022 PYT. Validation of GS for wort beta-glucan determined that genomic selection increased the number of PYT lines entered in the trial with acceptable values for this trait from 33% before

GS to nearly 85% using GS. We are collecting data on the remaining GS traits predicted to validate the efficacy of selection. Additionally, a new training population consisting of 254 lines was genotyped with the 50k iSelect SNP array for barley. Phenotypic data are being collected to develop new GS models and to design a new SNP chip for the breeding program. Agronomic data were collected on the training population in yield trial experiments conducted at 4 locations in 2020 and 3 locations in 2021. Malt data were collected on lines grown at 2 locations in 2020 and are being collected on lines grown at 2 locations in 2021. New GS models will be developed using these phenotype data.

Briefly describe how your target audience benefited from your project's activities.

My project's target audience includes barley growers, people in the malting and brewing industries and allied organizations, crop consultants, and extension personnel. Efforts to reach these audiences included presentations on the development of new barley varieties at the Grains for Brewing and Distilling Happy Hour in February (virtual), a field day at Carrington, ND in July, at the Northern Crops Institute Barley and Malt Short Course in October, and the Prairie Grains Conference in December. I also reached stakeholders through answering e-mails, phone calls, and office visit questions pertaining to barley cultivars and barley production from individuals in the target audience.

Briefly describe how the broader public benefited from your project's activities.

USDA-NASS determined through a survey in 2020 that 635,000 acres of barley was seeded in the upper Midwest U.S. region that includes Minnesota, North Dakota, and South Dakota. Based on a 2020 survey done by the American Malting Barley Association on barley varieties contracted for malting in this region, about 47% of the acres in North Dakota, 54% of the acres in Minnesota, and 100% of the acres in South Dakota sown to two-rowed barley were done so with varieties developed at NDSU. The two most popular NDSU two-rowed barley varieties were Pinnacle and ND Genesis. Changes in the malting and brewing industries in the US are resulting in an increased demand for two-rowed barley.

Exploring the nature of saline soils in North Dakota: their management with cover crops and their impacts on soil biology
Project Director
Caley Gasch
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1014648

⭐ **Exploring the nature of saline soils in North Dakota: their management with cover crops and their impacts on soil biology**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Naturally occuring saline soils are prevalent across the northern Great Plains, including in eastern North Dakota. Saline soils degrade croplands and reduce land profitability. This project aimes to understand the biological nature of saline soils and to evaluate the use of cover crops in mitigating negative effects of salinity.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

By working with full-production scale field trials and observations, we were able to compile a thorough understanding of the physical, chemical, and biological characteristics of saline soils. Across multiple field sites throughout eastern ND, we identified consistent patterns in soil measurements associated with saline soils, which provides us a clearer understanding of how saline soils cycle nutrients and water, and how what types of organisms inhabit these soils. We've learned that saline soils are distinctly different than their adjacent, productive, non-saline lands, and as such, should be candidate areas for alternative management considerations. Specifically, we recommend removing saline patches from cash crop production and eliminating fertilizer inputs in unproductive soils. This practice would yield both economic and environmental benefits. We also evaluated the use of a cereal rye cover crop in managing water within the soil profile, which is associated with salt

occurrence in the rooting zone. While cereal rye proves to be an effective water management tool (on par with other winter annual small grains), we did not observe strong improvment in soil properties or crop production for the duration of the study (5 years). Salinity management requires a long term commitment to water management and soil improvements.

Briefly describe how your target audience benefited from your project's activities.

We have been able to communicate the findings of this work through various extention and outreach outlets. Since this project focused on soil biological communities of saline soils and the use of cover crops in saline soils, most of these communications have provided education of the fundamental science of saline soils and their management. Additionally, we have been able to demonstrate field-level economic impacts of salinity to farmers and crop advisors, by applying an economic model across space. These efforts have received positive feedback from practitioners. In addition to helping practitioners to understand the origins and impacts of salinity, we have provided guidance and recommendations for alternative management of saline areas that improve the ecosystem's condition and the farm enterprise budgets.

Briefly describe how the broader public benefited from your project's activities.

This project will help practitioners (farmers and crop advisors) to be better stewards of soil and water resources. The health of the environment is directly related to the management of these natural resources, and can directly impact the health and quality of life of the general public. Ultimately, this work aims to understand potential sources of water contamination and soil loss and degradation, and to offer solutions for mitigating these problems. Clean air and water and productive soils benefit us all.

Methods to Increase Reproductive Efficiency in Cattle
Project Director
Carl Dahlen
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North Dakota State University Main Campus
Accession Number
1014153

★ Methods to Increase Reproductive Efficiency in Cattle

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Reproductive efficiency is paramount to profitability of cattle enterprises. In FY 2021 our main focus was on evaluating mechanisms that regulate reproductive processes impacting production efficiency in cattle. Our specific efforts involved understanding the impacts of nutrition on fetal development and sperm function and gene expression.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Feeding a vitamin/mineral supplement increased fetal liver Se, Cu, Mn, and Co concentrations; fetal muscle Se and Zn; and ALF Se and Co; while LG increased fetal liver Mo and Co concentrations and fetal muscle Zn at d 83 of gestation. Our results confirm that managerial decisions associated with vitamin and mineral supplementation and rate of gain can alter fetal reserves of trace elements during early pregnancy.

Pre-breeding and early gestation maternal micronutrient supplementation leads to the upregulation of genes acting on calcium homeostasis with a putative effect on placenta vascular function.

Maternal vitamin and mineral supplementation from pre-breeding to d 83 of gestation leads to upregulation of fetal hepatic genes acting on mineral homeostasis, lipid transport, and metabolism

We determined that colonization of pioneer fetal microbiota in fetal fluids with methanogenic archaea dominant species occurs during the first 12 weeks of gestation.

Our findings suggest diet-sensitive mechanisms between sperm function and gene expression. Epigenetics mechanisms through DNA methylation and histone modification seem to be altered in sperm via nutrition. Taken together, these results provide novel insights into the interplay between nutrition, epigenetics, and potential fertility in mature bulls.

Briefly describe how your target audience benefited from your project's activities.

Training sessions were held for beef producers, county, area, and state Extension personnel, veterinarians, allied industry personnel, media representatives, and other beef industry stakeholders.

Results of projects were used to develop curriculum in an undergraduate/graduate Physiology of Reproduction course and in other guest lectures for NDSU students. Producers, allied industry professionals, veterinarians, and Extension personnel were attendees of meetings, workshops, and field day demonstrations focusing on fertility and feeding projects. Written reports were published in newsletters, press releases, and popular press outlets

Briefly describe how the broader public benefited from your project's activities.

Work in previous years has provided beef cattle producers with science-based recommendations to enhance the reproductive efficiency of their operations. Work in the current FY provided undergraduate and graduate students, university personnel, industry personnel, and other industry stakeholders with information to enhance understanding of the role of nutrition during gestation and sperm development on reproductive and offspring outcomes. This knowledge can serve to enhance reproductive efficiency and other production outcomes. A better understanding of the biology related to production and reproduction metrics will allow for enhanced production of marketable beef per cow maintained which will ultimately contribute to an increased supply of beef available for consumption.