

## Report Status: Approved as of 08/17/2022

### Contributing Organizations

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University of Nebraska Lincoln

### Executive Summary

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#### Overview

The Institute of Agriculture and Natural Resources (IANR) is a part of the University of Nebraska-Lincoln and encompasses the three-part mission of teaching, research, and extension. Strategic planning is integral to IANR's function as a land-grant institution, and it prides itself on working as an integrated inclusive environment across the three mission areas. IANR strives to combine research, teaching and extension in a transdisciplinary, collaborative and inclusive environment that encourages creativity and innovation from across the University and private enterprise to ensure Nebraska's competitiveness in addressing global challenges and wicked problems. Six communities of practice were formed in 2011. Faculty from across IANR's departments and academic centers focused on areas of relevance and strengths that the institution as a whole could build upon. That type of bold collaboration and transdisciplinary thinking is propelling Nebraska forward. We are striving to excel and achieve excellence across these communities of practice and invite collaborators and learners to become part of the conversation. We welcome feedback, ideas, engagement, and support in our ongoing endeavor to make IANR a global leader in these key areas.

Communities of Practice:

- Computational Sciences
- Drivers of Economic Vitality for Nebraska
- Healthy Humans
- Healthy Systems for Agricultural Production and Natural Resources
- Science Literacy
- Stress Biology

To ensure that IANR's priorities reflect the needs of the state's residents we are continuously engaging in strategic and dynamic discussions between IANR and our stakeholders in the state. In 2018, strategic discussions moved to a new, higher plane as Vision for 2025 was implemented to ensure Nebraska's competitiveness in addressing global challenges. This visioning process was created to determine how IANR will contribute to the critical need of doubling the world's food supply to feed over 9 billion people; address climate change, weather extremes (e.g., floods and droughts) and environmental stresses (biotic and abiotic); respond to the increasing need for renewable energy sources; and consider how to help increase economic income opportunities for communities and thus the long-term economic growth and prosperity for Nebraska. In Nebraska, one in four jobs is directly tied to agriculture or agribusiness, and the state strives to increase job opportunities in this field of expertise. IANR informs and engages partners and clientele in our focus areas of IANR are food, fuel, water, landscapes, and people.

These five focus areas are representative of the societal challenge areas of the National Institute of Food and Agriculture (NIFA). For example, in the Nebraska planning process "food" represents the continuum of food from farm to fork, which included production, food security and hunger, childhood obesity, nutrition and food safety, and science/food literacy. Resilient Food Production and Ecological Systems represents the productivity, resilience and sustainability of all of our agro-ecosystems and natural resources. Water is highlighted because of its importance to our agro-ecosystems and natural resources in Nebraska. Fostering Healthy and Productive People represents the well-being of children, youth, and families as they interact with their environment.

The Future of Rural Communities is a crosscutting thread in each of these five focus areas. In 2019, the IANR Vice Chancellor challenged all the Institute's rural community resources to explore how we could deepen our commitment, better articulate with

how we work with rural communities and expand our impact. The importance was highlighted in 2020 by the launch of the Rural Prosperity Nebraska, an IANR and Extension led initiative that combines the strength of campus-based theory with community-based practice. Agricultural producers and other stakeholders have faced significant environmental and economic challenges in recent years including flooding, wildfires, extreme weather events, and a pandemic, have taken their toll on Nebraskans and their communities. Research-based information from across multiple disciplines is helping producers mitigate weather extremes, reduce input costs, increase efficiencies, improve productivity, resiliency and sustainability of farm operations. Agricultural System Economist educators are serving to enhance our capacity to complete this work.

The Agricultural Research Division (ARD) is supporting critical research and infrastructure to address these emerging issues and challenges, and Nebraska Extension served as a key statewide collaborator during the historic flooding response and recovery efforts that commenced in 2019 and continued in 2020.

The COVID-19 pandemic has brought unprecedented change to Nebraska and the world. Just as Nebraskans turned to Extension during the 2019 floods to cope with uncertainty, challenge and recovery, they reached out to Extension again in 2020 to help navigate the pandemic. In 2021, Nebraska Extension engaged in "Reimagining Extension," a process that is moving innovations realized during the pandemic forward while leaving behind less effective and impactful programming. Whether in person or virtual, Nebraska Extension has stood steadfast in our commitment to Nebraskans to deliver on our mission of sharing research-based solutions using innovative approaches and timely delivery. Similarly, ARD co-sponsored wide array of research projects to address the COVID-19 ranging from vaccine development to societal impacts.

IANR combines research, teaching and extension in a multidisciplinary, collaborative environment that encourages transdisciplinary efforts from across the University and private enterprise; to ensure Nebraska's competitiveness in addressing prevalent, current and emerging global challenges.

Through the dedicated and innovative research of our ARD community across IANR, we continue to build on our strengths to support new technologies and discoveries, translate basic to applied science, and use transdisciplinary systems approach to address complex problems related to the grand challenges of global food security, resilience and healthy humans under changing climate and declining natural resources. Across the broadly diverse expertise of our Faculty, and through their strong collaborative spirit and the support of our Stakeholders, we are effectively applying Team Science 'from Healthy Fields and Landscapes to Healthy Communities'. We understand that Big Data is key for solving many of these complex problems and for moving IANR to the next frontier in research, discovery, innovation, and impact. ARD is being instrumental in contributing to IANR and UNL's efforts in developing the foundation for "Big Data" architecture in agriculture. IANR is also committed to creating a diverse, equitable and inclusive environment and has created an IANR task force to address this issue, and faculty participate in a campus wide effort to address this at the UNL and community levels. We continue to build partnerships with our tribal, black, and Hispanic communities in Nebraska and our faculty are increasing their engagement with historically black colleges outside of Nebraska.

Engagement with Nebraska government leaders, stakeholders, representatives of organizations, faculty and students/youth continue. Listening sessions, surveys, departmental reviews, and input from advisory groups maintain public involvement which are critical to this vision's success. IANR identified eleven engagement zones in 2019 and hired engagement zone coordinators in 2020 to elevate engagement internally and externally. Engagement zone coordinators (EZC) will foster employee success in Extension programming, build strong stakeholder engagement and connect local people to the University of Nebraska-Lincoln. A twel h, campus-based EZC was hired in early 2022.

In addition to focusing on priority areas, IANR strived to meet the needs of its Nebraska citizens through engagement in internationally recognized science and education. This mission is being met by: advancing knowledge along a continuum from fundamental research to application; engaging learners in education that addresses the current and emerging needs of the state's residents; and teaching tomorrow's professionals through formal and nonformal learning settings. The ongoing cultivation of public-public and public-private partnerships helps make our mission achievable.

In 2020, UNL underwent a process to identify the university's grand challenges – major societal issues that can be solved only through interdisciplinary collaboration. Eight grand challenges were identified and IANR is at the epicenter of several including:

- Anti-racism and racial equity
- Climate resilience
- Community and economic vitality
- Early childhood education and development

- Health equity
- Quantum science and engineering
- Science, engineering, and technology for society
- Sustainable food and water security

The importance of integrated mission is evident in our scholarly output and discoveries, patents, broader impacts, the continued upward trajectory of grant/contract dollars received, the high-quality publications and profile of our community, the rigor/impact of educational programs delivered in both formal and nonformal settings, and in the placement of graduates in careers.

#### **Critical Issue: Fostering Healthy and Productive People**

The delivery of the co-created Nebraska Extension CHIME program focuses on supporting the emotional well-being of early childhood professionals. Since 2020, CHIME has been delivered to 276 early childhood educators (providers, teachers, home visitors). Self-report surveys and written journal feedback suggest that CHIME is associated with a decrease in emotion dysregulation, workplace exhaustion and increase in being more engaged and present as an early childhood educator. The community engaged participatory research approach continues to support our progress in obtaining positive and meaningful impacts to improve the wellbeing of early childhood educators.

Early childhood professionals and teachers self-reported that they learned ways to decrease their emotion dysregulation. They also shared that learning about mindfulness and compassion benefited them personally with their own families and professionally, such as feeling less stresses and more connected in with their co-workers. They also reported being more present as an early childhood educator and more engaged with the children in their care.

The broader public benefits from the activities to deliver CHIME as supporting the wellbeing of educators supports young children in receiving positive and responsive care. Such care supports young children and their families receiving educational supports and early care environments that are critically important for setting up young children on positive trajectory for success.

#### **Critical Issue: Resilient Food Production and Ecological Systems**

There is a critical need for professional development programs for our Extension Educators to bring greater value to the clientele that they serve in the crops. TAPS provides that capacity building. In addition TAPS is an avenue to bring research-based information to clientele through the use of a model that allows for testing and monitoring management strategies imposed by producers on a level playing field and results shared using a number of engagement platforms.

TAPS participants fill out end of season surveys and at the end of the 2019 competitions, 100% of respondents changed the way they think about one or more of the tools, methods or technologies that they have the opportunity to use in the TAPS program. Sixty percent are already starting to adopt one or more lessons on their own operations that they learned during their participation in the program.

With having 5 years of data, people have the ability to benchmark their decisions and results with the others throughout the program.

Participants also can connect with other producers, industry professionals and university employees and build peer to peer networks.

Throughout the five years of the program, several communication methods have been established. Not only are numerous presentations done on the program throughout the year, but the TAPS program also has a footprint in print, audio and visual media. Over 600 people follow the program on Twitter, which averages over 10 tweets a month receiving an average of over 2,000 impressions each. A digital newsletter was developed three years ago which now has 267 subscribers.

### **Merit and Scientific Peer Review Processes**

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#### **Updates**

Interdisciplinary extension issue teams, comprising of faculty representing interest groups (beef systems; water and integrated cropping systems; 4-H youth development; early childhood; food, nutrition and health; community environment; rural prosperity

nebraska; reaching one, reaching all; disaster education; and global engagement), update their team plans annually using stakeholder input and evaluation results from delivered programs.

Faculty members (either as individuals or teams) who hold research appointment in ARD, each has an active peer-reviewed research project in their area of expertise. The peer review process for research projects includes the Unit and (if applicable) Research and Extension Center head, at least two faculty members with relevant expertise, and an Associate Dean of ARD. Following the review and acceptable revisions (if necessary), the project is approved by ARD and is forwarded to USDA-NIFA for inclusion in the REEport database.

Academic units (subject matter departments and research, extension and education centers) complete a comprehensive five-year review to ensure program quality and relevance. Teams of three to six external panel members and two or three faculty panel members from other academic units conduct these reviews. The review team assesses the work of the academic unit to ensure that programmatic efforts and research are relevant and focus on Nebraska, national and global most critical needs. The review team completes its assessment with the development of a report that helps the administrative unit focus its work for the next five years. It is the responsibility of the IANR Deans to assist the unit administrator and faculty to accomplish the goals identified by the unit, as a follow-up to the review process.

Another review process, which combines merit and peer review, is the annual review of more than 100 research and extension proposals by state commodity check-off boards. Proposals selected for funding address the current and emerging issues facing our stakeholders and clearly communicate the research's relevance to user needs.

Stakeholder input remains key to IANR success throughout the process mentioned above.

## Stakeholder Input

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

Ongoing input from stakeholder groups, e.g. advocacy, advisory, and commodity groups, keeps extension, research and teaching team plans current. Ongoing relationships with stakeholder groups such as the Agriculture Builders of Nebraska (ABN) and Family, Youth and Community Partners (FYCP), Nebraska Association of County Extension Boards (NACEB), along with listening sessions led by IANR personnel and extension board reviews of local and regional programs, ensure that critical needs are addressed. The accuracy of the team's plans is verified using the following methods:

- Extension Issue Teams and Interest Groups meet regularly to assess their goals and progress made toward achieving them. These interdisciplinary teams include both faculty of academic departments who understand long-term trends and faculty located in extension offices who see, on a daily basis, the needs of Nebraska residents. Many of these faculty members of academic departments have joint research and extension appointments and can represent fundamental as well as applied research and extension education plans.

Issue teams and Interest Groups;

- o Use frequent phone and/or video conferencing to stay on track.
- o Consult with subject-matter department administrators annually to ensure that the Team's and Group's goals are congruent with university department research and extension goals.
- o Engage with their stakeholders to garner input to determine future plans.
- o Refine programs to ensure that content goals support needs identified by stakeholders and demographic trends.
- o Are coached by members of the Extension Leadership Team to enhance sharing and collaboration efforts.
- o Additionally, extension-developed 'Impact at a Glance' publications are used by stakeholders to tell others of the impact/public value of extension and then seek input for programmatic direction. (Go to: <https://extension.unl.edu/impact/> to see "Impacting All of Nebraska" impact summaries). These annual impact reports are developed and are available online, which helps stakeholders understand the value of and differences being made by today's extension/research programs. Impact reports are given to decision-makers and extension board members to help guide their advocacy efforts on behalf of IANR at the local, regional, and national levels.

- Agricultural Research Division faculty currently participating in multistate projects receive research funding through the multistate research component of the Capacity Funds. These projects are selected and approved by regional director associations because they are high priority needs identified for multistate activity.

## **Methods to identify individuals and groups and brief explanation**

Nebraska is a state in which the public is very engaged with its university. Research and extension's strategic relationships with local, state, and federal decision-makers is valued. Advocacy groups, advisory groups for subject matter, departments, research and extension centers, and extension boards are utilized to gather input. Farm organizations and industries related to agriculture routinely are at the planning table. Below are examples of how research and extension addressed the needs of underserved and underrepresented populations.

- Agricultural Research Division research programs related to human nutrition and healthy lifestyles were highlighted under the federal goals and key themes. The research results feed science-based information directly into Nebraska Extension programs that target underserved and underrepresented populations.
- Nebraska Extension built a strong partnership with Little Priest Tribal College and Nebraska Indian Community College and has a Tribal Extension Educator with statewide responsibilities. Through this partnership, Native American teens have become more involved in outside activities and interact with youth and adults outside their schools. The University of Nebraska–Lincoln Native American Coalition (NAC) builds relationships and partnerships between the Nebraska Extension and Native American communities and organizations. The work of NAC is to help Nebraska Extension staff work more effectively with Native American communities, to build bridges between tribal and non-tribal communities, to facilitate community development and leadership in Native communities and to bring Native American traditional worldviews, languages, cultures and histories to the University of Nebraska and non-tribal communities.
- The Expanded Food and Nutrition Program (EFNEP) and the Supplemental Nutrition Assistance Program-Education (SNAP-Ed) supports Nebraska Extension's efforts to address health equity. Low-income families and youth (many are from the underrepresented populations) are engaged in direct education, virtual on-line experiences and community based efforts to improve their diets, improve their nutrition practices, stretch their food dollars further, handle food more safely, and increase their physical activity level. SNAP-Ed also implements Policy, Systems, and Environmental (PSE) change strategies in schools, communities and childcare settings to modify the environment to make healthy choices practical and available to all community members.
- The College of Education and Human Sciences, extension and the Nebraska Department of Education have undertaken a programmatic effort with targeted school districts to address needs of first generation families. Programs focused on early childhood development, social-emotional health and rural wellness are a result of continued collaborations between the college and extension.
- An extension educator addressed the needs of Hispanic and Native American youth in Scotts Bluff County. This program engages middle and high school youth in a school and community-based programs. Coalitions of Hispanic and Native American individuals contributed to the success of this youth program. An extension educator in northeast Nebraska connected Nebraska Extension youth development programs with Hispanic and Native American families in this region. A recent extension educator hire will focus on rural prosperity needs for Hispanic people.
- Ongoing efforts to recruit and retain a more diverse pool of faculty that can serve as a gateway into underserved and underrepresented populations are underway.
- In 2013, IANR participated in a Civil Rights Review through USDA NIFA and developed and started several new initiatives to improve connections with underserved audiences. One direct outcome is a \$100,000 extension-funded competitive grant program for proposals that reach new audiences. A summary of our commitment to a diverse faculty and diversity of audiences reached by our education programs is found at: <https://ianr.unl.edu/diversity>
- In 2019, IANR hosted rural community prosperity listening sessions where Nebraskans were invited to share experiences in rural community development and explore how the university can be most effective in strengthening the economic prosperity and vitality of rural communities.

Nebraska Extension is committed to ensuring access and opportunity for all Nebraskans to receive, and benefit from, our programming. We demonstrate excellence in valuing everyone as an important member of the communities that we already serve and those we seek to serve. Nebraska Extension offers "Navigating Difference (ND) Multicultural and Diversity Training and Intercultural Development Inventory (IDI)" professional development to faculty, staff and community members.

In 2021, IANR faculty were required to share how their work is leading to a more inclusive work environment in their annual report.

## **Methods for collecting stakeholder input and brief explanation**

In 2018, Nebraska Extension launched the Extension 2025 Strategic Priorities Planning Process. Nebraska Extension partnered with the University's Bureau of Sociological Research to conduct a statewide random survey of 10,000 Nebraskans to determine how Nebraska Extension could most effectively meet their needs. This survey data is being used to determine program areas,

staffing patterns, and programmatic outcomes. This data was supplemented by statewide stakeholder listening sessions designed to help identify extension programming priorities for the next five years.

The Nebraska Association of County Extension Boards (NACEB) engaged in a NextGEN NACEB initiative in 2018 designed to strengthen their relationships with extension and to enhance advocacy efforts for both extension and IANR. This effort included 10 face-to-face stakeholder engagement meetings throughout the state and an online engagement opportunity for extension board members.

Additionally, there was an ongoing effort by extension boards to talk one-on-one with their neighbors and colleagues about needs within their geographic regions.

Extension is a partner with the 1994 land-grant institutions in our state. Extension and the Nebraska Indian Community College (NICC) have had a continuous partnership to support the implementation and management of tribal college extension programs in three different NICC communities. IANR extension faculty who work routinely with the tribal colleges serve as a conduit to move content and planning information between these entities. Research opportunities are being explored with these colleges.

The Nebraska Panhandle has both recent and longtime Hispanic residents. An extension educator in the Scottsbluff area works with audiences and local planning groups to ensure a cross-cultural understanding. The program is in three parts: history of Mexican people in the Panhandle, cross-cultural communications, and formal education for audiences working with English language learners. This workshop is presented for public school educators, health professionals, students in education, health and human services employees, community leaders, chambers of commerce members, and companies. This is just one example of extension's engagement as a teacher for other organizations that seek increased understanding and involvement with all of our state's residents. In addition, Nebraska has worked to increase the number of extension educators who can focus on diverse youth audiences. For example, a Spanish-speaking 4-H educator works specifically with underserved audiences in northeast Nebraska. Several bilingual Spanish speaking faculty and staff were hired in 2021.

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

Input from stakeholders is used to identify emerging issues for both research and extension, and to help set priorities. Stakeholders are invited to provide input during the selection of administrators; for example, stakeholders serve as members of search committees for unit administrators, deans, vice chancellors, etc. Local stakeholders are invited to interview extension educators for positions located in their geographic regions.

Stakeholders expect IANR and its divisions of research, extension, and teaching to remain focused on critical issues facing Nebraska. They expect the land-grant institution to do cutting-edge work that is well regarded by the academy, has global impact, and is of value to Nebraska's residents and economy. Stakeholders recognize that programming priorities must be established. During 2015, 18 extension issue teams were developed from the direction of our stakeholders to address the issues and needs of Nebraskans. In addition, 9 interest groups were formed under these issue teams to directly develop research-based programs and information that will positively impact these stakeholders, allowing them to make informed decisions relevant to these issues. These issue teams and interest groups were active through 2021. New and innovative collaborative team models are in developmental stages within IANR.

## **Highlighted Results by Project or Program**

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Critical Issue

### **Fostering Healthy and Productive People**

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#### **[Cultivating Healthy Intentional Mindful Educators \(CHIME\)](#)**

Project Director

Linda Tempel

Organization

University of Nebraska Lincoln

**Cultivating Healthy Intentional Mindful Educators (CHIME)**

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

Stress among early childhood educators (teachers, providers) creates challenges for staffing the workforce, with high turnover rates potentially reducing the availability of experienced early childhood professionals and compromising the stability of children's care. Presently, professional development opportunities to support early childhood educators working do not always explicitly address the emotional well-being of educators. There is thus a critical need for professional development programs that facilitate the emotional well-being of early childhood educators and, ultimately, their ability to provide responsive, sensitive, inclusive environments for children. By positively impacting educator's wellbeing, CHIME promotes educator's sensitivity, responsiveness, and the capacity to scaffold children's social-emotional learning and strengthens partnerships with families.

**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 delivery of the co-created Nebraska Extension CHIME program focuses on supporting the emotional well-being of early childhood professionals. Since 2020, CHIME has been delivered to 276 early childhood educators (providers, teachers, home visitors). Self-report surveys and written journal feedback suggest that CHIME is associated with a decrease in emotion dysregulation, workplace exhaustion and increase in being more engaged and present as an early childhood educator. The community engaged participatory research approach continues to support our progress in obtaining positive and meaningful impacts to improve the wellbeing of early childhood educators.

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

Early childhood professionals and teachers self-reported that they learned ways to decrease their emotion dysregulation. They also shared that learning about mindfulness and compassion benefited them personally with their own families and professionally, such as feeling less stresses and more connected in with their co-workers. They also reported being more present as an early childhood educator and more engaged with the children in their care.

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

The broader public benefits from the activities to deliver CHIME as supporting the wellbeing of educators supports young children in receiving positive and responsive care. Such care supports young children and their families receiving educational supports and early care environments that are critically important for setting up young children on positive trajectory for success.

**Identification of health beneficial bioactive compounds in maize and discovery of the genes underlying their variation**

Project Director

Toshihiro Obata

Organization

University of Nebraska Lincoln

Accession Number

1021844

**Identification of health beneficial bioactive compounds in maize and discovery of the genes underlying their variation**

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

Corn is the primary crop product in the US, especially in the Corn Belt states, including Nebraska. Although the majority of corn is used for feeding livestock or for industrial usage, corn-derived foods, such as popcorn, cornbread, and a variety of Mexican foods, are intimately involved in the daily diet, and their nutritional values affect our health and wellness. Recent researches indicated that corn proteins are digested in the gut and small intestine to be turned into bioactive peptides with beneficial health effects. Additionally, phytochemical composition in corn is altered during gastrointestinal digestion and exerts bioactivity in the digestive tract. Identification of these chemicals naturally occurring from corn diet via human metabolism will enhance the beneficial health effects of corn-derived diets. Obesity-induced metabolic disorders constitute a significant threat of the health and wellness of the US citizens, and chronic inflammatory conditions are responsible for the progression of the disease.

In this project, the relationship between chemicals in maize grains digested in the gastrointestinal tract and antiinflammatory activity in cultured intestinal cells will be analyzed to identify bioactive compounds with beneficial health effects. The maize genes responsible for the availability of these bioactive compounds will be determined to be used as markers for future maize improvement through breeding. These results are expected to improve the beneficial health effects of corn products, both nationally and globally.

**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 bioactive peptides and phytochemicals in maize grains exhibiting anti-inflammatory activity in gastrointestinal tract Maize inbred lines will be selected to maximize the diversity in phytochemical compositions and amino acid sequences of peptides derived from major storage proteins. Experimental systems and materials to analyze the genetic diversity of the health-beneficial bioactivities of maize kernels have been established in this reporting period. The newly developed semi-high-throughput digestion system simulating human gastrointestinal (GI) digestion enables three times faster sample processing for the 300 genotypes in the maize population panel. The newly established cell culture systems are suitable for confirming the bioactivities in the cells closely related to normal human intestinal cells. These accomplishments prepare us to perform chemical profiling and bioactivity assays for the GI-digested kernels of all 300 genotypes. Genetic diversity information is essential to identify genes and compounds related to the antioxidant and anti-inflammatory activities in GI-digested maize kernels by quantitative genetics approaches and regression analysis. Identification of bioactive compounds will elucidate the biochemical basis underlying the health-beneficial activities. The scientific evidence will improve the consumers' perception of corn-derived diets and their consumption. The genes responsible for the bioactivities can be genetic markers for marker-assisted breeding of maize cultivars with enhanced health benefits. This can improve the health outcomes of consumers and commercial values of dietary corn. Potential health and commercial impacts can be enormous since health benefits are the major concern of consumers today, and nearly 60 million US individuals suffer from chronic metabolic disorders.

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

The target audience of this project are food and nutritional scientists, plant biochemists, plant geneticists, corn breeders, farmers in the US, and developing countries, consumers, and the general public.

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

The health beneficial effects of protein derived peptides and phytochemicals are emerging topics having great potential to improve our understanding of food functions and nutrition. The combination of food science, metabolomics, and quantitative genetics will have significant impacts on the research field of food and nutritional science, biochemistry, and genetics. The project will investigate novel traits of maize grains, which can be the potential selection target of maize germplasms with health beneficial biological activities above and beyond the nutritional value. The project will also provide biochemical and genetic markers that have the potential to be used for marker assisted breeding. Once the maize varieties with high health beneficial effects were generated, they will improve commercial values and public perception of corn-derived food products. They will also improve nutritional values and food security, especially in developing countries.

**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 had planned to analyze a smaller set of maize inbreds due to the limited capacity of the regular GI digestion workflow to process a large number of samples. We changed the plan to analyze the entire set of inbreds in the genetic diversity panel since it is now feasible by the semi-high-throughput GI-digestion system developed in this reporting period. The larger dataset will improve the detection power and reliability of the correlation and quantitative genetics analysis, which is the key to identifying the genetic and chemical factors associated with the bioactivities.

Critical Issue

## Resilient Food Production and Ecological Systems

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### Testing Agriculture Performance Solutions – TAPS

Project Director

Linda Tempel

Organization

University of Nebraska Lincoln

Accession Number

7000159



### Testing Agriculture Performance Solutions - TAPS

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

The TAPS program is aimed at assisting producers understand and improve their nitrogen and irrigation use efficiency through the use of farm management competitions. TAPS also helps competitors track their cost of production, marketing and ultimately, profitability.

#### **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.**

There is a critical need for professional development programs for our Extension Educators to bring greater value to the clientele that they serve in the crops. TAPS provides that capacity building. In addition TAPS is an avenue to bring researchbased information to clientele through the use of a model that allows for testing and monitoring management strategies imposed by producers on a level playing field and results shared using a number of engagement platforms.

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

TAPS participants fill out end of season surveys and at the end of the 2019 competitions, 100% of respondents changed the way they think about one or more of the tools, methods or technologies that they have the opportunity to use in the TAPS program. Sixty percent are already starting to adopt one or more lessons on their own operations that they learned during their participation in the program. With having 5 years of data, people have the ability to benchmark their decisions and results with the others throughout the program. Participants also can connect with other producers, industry professionals and university employees and build peer to peer networks.

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

Throughout the five years of the program, several communication methods have been established. Not only are numerous presentations done on the program throughout the year, but the TAPS program also has a footprint in print, audio and visual media. Over 600 people follow the program on Twitter, which averages over 10 tweets a month receiving an average of over 2,000 impressions each. A digital newsletter was developed three years ago which now has 267 subscribers.

**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 major changes we have had to make are how we are working with industry partners. In the TAPS program, participants get to use the latest in technology at no charge to them. This allows them to test these products and platforms before adopting them on their operations.

Throughout each season, participants are invited to attend different TAPS events. Some of these events offer in-person training and education from both university officials but also from the technology partners. The technology companies also provide different levels of training throughout the season via webinars, etc. The TAPS team is also co-developing high school level curriculum with ag teachers, focused on the six management decisions the TAPS participants decide, to be offered to high school students, community colleges and beyond.

An annual report is published every year following the competitions and made available online. We also present the data and results at a number of events including but not limited to, American Society of Agronomy annual meetings, other state's events and countries (in person and virtually), as requested.

We are in the planning stages with multiple states as they develop a TAPS program in their region. A colleague at Oklahoma

State University has already had 3 successful years of running a TAPS program in both sprinkler corn and cotton production. We will continue to look for opportunities to expand TAPS in Nebraska, as well as throughout other states and possibly internationally.

Peer-reviewed publication (full-text citation)

Burr, C.A., D. Rudnick, M. Stockton, R. Tigner, and K. Rhoades. 2020. Engaging Farmers and the Agriculture Industry Through the Testing Agricultural Performance Solutions Program. Journal of Extension. V58-5a3. <https://joe.org/joe/2020october/a3.php>

Rudnick, D.R., M. Stockton, S. Taghvaeian, J. Warren, M.D. Dukes, A. Kremen, C.G. Henry, J. Aguilar, B. Ortiz, A. Andales, C.A. Burr, X. Qiao, W. Liang, S. Walthour, S.H. Amosson, and K. Welch. 2020. Innovative extension methods to promote irrigation management. Transactions of the ASABE 63(5): 1549-1558. <https://doi.org/10.13031/trans.13929>

### [Establishment of the soybean single cell transcriptome atlas.](#)

Project Director

Marc Libault

Organization

University of Nebraska Lincoln

Accession Number

1022556



### **Establishment of the soybean single cell transcriptome atlas**

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

The transcriptome of each soybean cell is unique, depending on cell type (i.e., cell fate determination), cell state (i.e., cell differentiation stage, age, degree of elongation, and functional status, and environmental factors (e.g., photoperiod affects plant transcriptomes [48]). Taking advantage of existing soybean genomic resources, the expertise of the PI in single cell/nucleus genomics, we propose to apply snRNA-seq technology to analyze soybean cell-type gene expression across organs and establish the first single cell transcriptome atlas. Specifically, we propose to:

Objective 1 (Years 1-3): Establish the transcriptomic signature of each soybean cell-types.

Objective 2 (Years 2-4): Create the "Soybean Single Cell Types Transcriptome Atlas" to characterize cell-type-specific differentially expressed genes. To fulfill this second objective, we will utilize modern computational tools specifically developed to support the analysis of single cell transcriptomic datasets. The major outcome of this analysis will be the development of an online resource, the "Soybean Single Cell Types Transcriptome Atlas", to allow the scientific community to access and analyze the transcriptional pattern of the soybean genes.

Objective 3 (Years 3-5): Comprehensive analysis of the transcriptional regulation of the soybean root hair genes. The root hair cell plays a central role in the uptake of water and nutrients from the soil, and it is the first cell infected

by nitrogen fixing Bradyrhizobium diazoefficiens, soil bacteria involved in the nodulation process. In this third objective, we propose to characterize the dynamic regulation of the soybean root hair transcriptome during the lifetime of the cell (i.e., starting by its cellular differentiation, continuing with its typical polar elongation, and finishing with the gain of its biological functions). We also propose to reveal co-expressed gene modules which are composed of specialized genes essential for the establishment of the soybean root hair function. The characterization of the co-expressed gene modules will benefit from the current development of MiReN (Minimal Regulatory Network; [50]) by co-PI Saha, an optimization-based tool for transcriptomic datadriven discovery of global regulatory phenomena.

**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 transcriptome of each soybean cell is unique, depending on cell type (i.e., cell fate determination), cell state (i.e., cell differentiation stage, age, degree of elongation, and functional status, and environmental factors (e.g., photoperiod affects plant transcriptomes). Taking advantage of existing soybean genomic resources, the expertise of the PI in single cell/nucleus genomics, and preliminary results, we propose to apply snRNA-seq technology to analyze soybean cell-type gene expression across organs and establish the first single cell transcriptome atlas. To date, we worked on the establishment of the transcriptomic signature of each soybean cell-types. This was achieved upon isolation of soybean nuclei from various organs (i.e., root tip, mature root, nodules, true leaves, trifoliolate, shoot apical meristem, flower, green pods, and seeds (3 different stages of development) and their use to synthesize then sequence single nuclei RNA-seq libraries. As part of our analysis of the libraries, we initiated the bioinformatics analysis of the soybean single nuclei RNA-seq libraries. On average, we identified 1,000 to 3,000 expressed genes per nucleus with the strongest transcriptomic activity in the cells composing the developing seeds and pods. Using the 10x Genomics pipeline as well as the Seurat and Monocle computational tools, we processed the sequence reads to generate soybean single-nuclei transcriptomes, and to cluster the nuclei according to their transcriptomic profile. We are currently working on allocating a specific cell type name to each cluster of seed nuclei. Compared to the timeline of this project, we are ahead and hope to develop the first manuscript by the end of 2022.

We recently developed a new core facility at UNL (<https://biotech.unl.edu/single-cell-genomics>) with funding support from the Nebraska Research Initiative

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

During the past year, we communicated about this project with the following target audience: • Plant scientists from UNL, from various US institutions, and across the world. • UNL undergraduate students through teaching and research activities. • High school students who are working in the laboratory and high school teachers through our participation in conferences. You can find more details in our response to "How have the results been disseminated to communities of interest?". Besides, to allow researchers to benefit from our expertise in plant single-cell biology, we recently developed a new core facility at UNL (<https://biotech.unl.edu/single-cell-genomics>) with funding support from the Nebraska Research Initiative.

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

To date, the results of this project were shared with an international audience through the delivery of oral presentations in local, national, and international conferences (e.g., EMSL XChange Seminar Series10x, The First International Symposium on "Plant Single Cell Biology" Wuhan, Chine, Plant Biology 2021 Worldwide Summit (ASPB), by the South Dakota State University Department of Microbiology, the First Plant Cell Atlas Symposium, the MPlant Virtual Seminar) Besides, the PI participated in two events with Nebraska high schools [i.e., Nebraska Association of Teachers of Science (NATS) conference, October 7-9 Doane University; the 2021 Nebraska Research and Innovation Conference (NRIC), July 22- 23, Lincoln, NE] to share outreach opportunities associated with this project. The data generated by this HATCH project has been used to support the development of grant proposals. Notably, in 2021, an NSF-PGRP and a USDA-AFRI Foundational and Applied Science Program proposal focusing on deciphering the programs controlling the early stages of legume nodulation and lateral root emergence were awarded. We are also engaged in international collaboration as a project partner on a 2021 Thomas Jefferson Found call entitled "Towards a single-cell view of genetic reprogramming for nitrogen-fixing symbiosis in soyb

**[Improving accuracy and scaling out of yield forecasts across the Corn Belt](#)**

Project Director

Patricio Grassini



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

The proposed study builds on the existing Yield Forecasting Center (YFC) that will provide real-time, in-season corn yield forecasts for a minimum of 40 sites across the U.S. Corn Belt, located in the most important production areas. There are a number of scientific challenges associated with the yield forecasts, which we expect to address in this project, which will well help at upscaling of results from single locations to larger geographic regions and improving simulation of crop yields in extreme conditions.

Specific objectives of this new project are:

1. Evaluation and improvement of model performance.
2. Comparison of yield forecasts based on historical weather versus forecasts made with NOAA and other seasonal climate predictions.
3. Determine frequency of water and temperature stress patterns for major climate-soil domains where maize and other crops are grown in the United States.
4. Mapping yield gaps (difference between actual and simulated yields) and understand their underpinning causes.
5. Assess climate change scenarios. YFC offers also a platform to forecasts crops yields in future climates.

**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 proposed study builds on the existing Yield Forecasting Center (YFC) that will provide real-time, in-season corn yield forecasts for a minimum of 40 sites across the U.S. Corn Belt, located in the most important production areas. There are a number of scientific challenges associated with the yield forecasts, which we expect to address in this project, which will well help at upscaling of results from single locations to larger geographic regions and improving simulation of crop yields in extreme conditions.

During 2021, we provided real-time yield forecasts and phenology every two weeks during the maize growing season for 40 locations in the US Corn Belt based on local measured weather, soil, and management data provided by the collaborators in each state. We put together a large team that consists of two UNL Extension Educators, five UNL faculties, 10 faculties from other U.S. universities (KS, IA, MN, IA, IL, OH, WI, MO, and MI), and one Post-Doctoral Research Associate (Dr Fatima Tenorio) and one graduate student (Mr Gonzalo Rizzo) under my supervision. Results relative to the specific goals of this project are listed below: (1 & 2) A well-validated maize simulation model was used to estimate yield potential for 41 locations across the US Corn Belt, including both irrigated and rainfed crops, during 2021. These 40 locations encompassed very favorable and adverse weather conditions for crop growth and yield. Simulations were based on measured weather data, dominant soil properties, and key management practices at each location (including sowing date, cultivar maturity, and plant population density). We were able to predict that 2021 was not going to be a record yield year as early as August and, instead, was going to be a moderately good year (but, again, not a record year). (3) This was completed working in collaboration with a group of researchers from Iowa State University (led by Dr Sotirios Archontoulis) and Kansas State University (led by Dr Romulo Lollato). See results in our previous 2020 report. Briefly, simulations were based on measured weather data and site-specific soil type and cropping systems. Environmental types were defined based on the level of water and heat stress during the critical period for yield determination of each crop. Frequency of environmental types were determined for each location and mapped. A publication reporting these results has been published in Agricultural and Forest Meteorology journal. (4) This was completed working in collaboration with a group of researchers from Iowa State University (led by Dr Sotirios Archontoulis) and Kansas State University (led by Dr Romulo Lollato). See results in our previous 2020 report. We are working on a publication derived from this work. (5) We have been working on this activity in collaboration with a group of researchers from Iowa State University (led by Dr Sotirios Archontoulis). Briefly, we have investigated how management practices can help mitigate the negative impact of climate change on crop yield using crop modeling coupled with experimental data. A publication is near to be submitted to Global Change Biology journal. Additionally, we have worked on a comparison of topdown and bottom-up spatial frameworks for yield gap analysis, which has been published as a journal article in

Nature Food. Likewise, we have worked on a publication on yield gaps in irrigated maize systems, which has been recently been accepted for publication in PNAS.

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

We have reached crop producers, crop consultants, ag industry professionals, ethanol plants, livestock operations and transportation companies

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

During 2021 season, we have released biweekly UNL CropWatch articles, including yield forecasts, real-time phenology, analysis of seasonal weather, and risk of early-killing frost. These UNL CropWatch articles received ca. 3,000 web views (verified with Google Analytics) and were often re-posted in farm and industry websites. I estimated the impact of YFC at a total of \$5 million, based on (i) a conservative figure about the impact of better-informed management, logistics, and marketing decisions (\$5/ac), (ii) number of attendees to the UNL CPPC and other extension venues, and number of recurrent web views, (iii) a conservative 10% adoption rate (i.e., 1 out of 10 farmers), and (iv) averages of corn acreage per producer and commodity prices retrieved from official statistics

**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.**

Follow-up activities related to each goal are listed below: (1 & 2) Performed corn yield forecasts for the 2022 crop season (3) Activity completed (4) Prepared and submit an article about yield gaps for maize, soybean, and wheat in the USA. (5) Get article published

Type

Projects / Programs

**Projects / Programs without a Critical Issue**

**0**

**Not Provided**