Indiana (Purdue University Main Campus) Annual Report - FY2021

Report Status: Approved as of 07/08/2022

Contributing Organizations

Purdue University Main Campus

Executive Summary

Overview

At Purdue University in West Lafayette, Indiana, administrative leadership is provided by the College of Agriculture's Senior Associate Dean for Research, and the Senior Associate Dean and Director for Extension.

Research and Extension efforts involve faculty, specialists, and staff in three colleges associated with the West Lafayette campus: 1) Agriculture, 2) Veterinary Medicine, and 3) Health and Human Sciences. Across Indiana, there are 92 County Extension offices, and based on population, staffed by educators representing one or more of the four program areas: 4-H Youth Development, Agriculture and Natural Resources, Community Development, and Health and Human Sciences. Coordination, collaboration, and integration of research and Extension activities among and between faculty, specialists, and educators happens routinely, and when appropriate, at the eight Purdue Agricultural Centers across Indiana. Program impacts shared in this report highlight the PAC Field Day events.

Purdue University's Next Moves initiatives include research prioritities that are leveraging USDA and other funding to address critical societal issues. In Plant Sciences 2.0, research is focusing on developing plants with enhanced nutritional and sustainability attributes, managing forests, and mitigating wildfires and diseases. In the Purdue Applied Research Initiatives (PARI), the focus is on science, technology, engineering and math (STEM) for the adoption of emerging technologies for agriculture, health systems, and energy. Digital Innovation in Agri-Food Systems Laboratory (DIAL), a component of PARI, is focused on digital solutions to pressing industry challenges across the food-agriculture sector. DIAL Fellows are tasked with formulating new solutions to vetted problems and creating high-value startup companies for the agri-food industry.

Extension efforts to diversify and expand audiences across Indiana include workforce development and health programs and resources available in Spanish and English, Spanish-based 4-H clubs, programs, and activities, and agriculture programs for non-traditional farmers - small-scale, urban, beginning, military veterans, and women. Program impacts shared in this report include ServSafe, Indiana Small Farm Conference, and three beginning farmer programs. Virtual and hybrid program delivery during pandemic challenges expanded the reach of Extension programs. Virtual program impacts shared in this report include the Vegetable Farming Webinar Series, Grow Your Farm Operation, So, You Inherited a Farm, Now What?, and Core Cover Crops and Soil Health Systems Training.

This report focuses on these critical issues: 1) childhood obesity, 2) climate change, 3) food safety, 4) global food security and hunger, 5) human, family, and community health and well-being, 6) natural resources and the environment, and 7) sustainable energy. In next's year's report, updated critical issues will be launched that incorporate priorities of the College of Agriculture's Strategic Plan 2021-2026, National Institute of Food and Agriculture (NIFA), Research, Education and Economic Goals of USDA (REE), Agriculture and Food Research initiative (AFRI), and Foundation for Food & Agriculture Research (FFAR).

Critical Issue: Childhood obesity

Purdue's College of Health and Human Sciences conducts a variety of studies on human obesity and co-morbidities, ranging from basic research on metabolism and related molecular pathways to dietary intake and behavioral determinants.

- "Fatty acid metabolism in obesity and metabolic dysfunction" addresses the metabolic benefits of reducing transport of free fatty acids in plasma. The results may impact the public by providing new treatments or prevention approaches for metabolic disease.

Nothing significant to report for Extension.

Critical Issue: Climate change

The Purdue research community is rapidly growing and evolving to tackle the climate crisis. The Purdue Office for the Executive Vice President for Research and Partnerships recently announced the formation on a new research institute focused on the environment, climate change, and global sustainability. Purdue College of Agriculture's climate change research is centered on climate-smart agricultural practices that conserve natural resources and reduce greenhouse gas emissions, including those that can be adopted for crop and animal production.

- "Cover crop and drainage management systems impacts on crop production, soil health, N cycling and water quality" investigated adaptive agriculture management practices that improve sustainability and resilience. Dissemination of the research in this project informs the public of the impact of cover crops on sustainable corn and soybean production and downstream water quality. Further, the studies demonstrate the cost and potential benefits/risk that are associated with cover crop adoption.

Extension is building capacity in climate science and training turfgrass practitioners in climate-durable insect management.

- Purdue Extension and the North Central Climate Collaborative (NC3) opportunities are building climate change expertise in Extension personnel to enhance delivery of educational programs to those in agriculture and the community.
- Turfgrass IPM supports workforce development via continuing certification hours, increases knowledge of climate-durable turfgrass insect management, and places timely, accessible, science-based diagnostic and decision-making tools in the hands of turfgrass practitioners.

Critical Issue: Food Safety

Research on Food Safety remains a central focus in Purdue's College of Agriculture. Purdue maintains a USDA ARS-funded Center of Food Safety Engineering and a USAID Food Safety Innovation Lab. Purdue's research cuts across technologies for pathogen detection, risk analysis, and the development of interventions and food safety programming.

- "Foodborne pathogen infection, pathogenesis and probiotic bacteria-based prevention strategy" elucidated the molecular pathways that are regulated by biofilm-forming *Listeria monocytogenes* cells during infection. Further, the use of an engineered probiotic strain to prevent disease in high-risk populations demonstrated promising results.
- "Engineering for food safety and quality" is a multi-state project focused on solving issues in extraction of bioactive compounds, cleaning and sanitizing in food processing operations using less chemicals and water using microbubble technology, thermal properties of food at elevated processing temperatures, and textural modifications of pea protein using new treatment and technology.

Purdue Extension provides workforce development training in safe food preparation and handling, and for safe vegetable production.

- ServSafe training (in Spanish and English) and exam proctor-only activities contribute to the knowledge and certification needed for adults working in the restaurant and food service industry.
- The Vegetable Farming webinar series delivered information to those interested in safe vegetable production, and encouraged adoption of recommended practices/technologies for horticulture and the environment. Previous year's attendees adopted practices that had resulted in conservation of resources and increased yields.

Critical Issue: Global food security and hunger

Purdue College of Agriculture's main focus is centered on food security. Investigators within the College study a broad cross-section of basic and applied approaches to improve the production of row crops, specialty crops, and livestock. Some notable areas of focus include pathogen detection and management, precision farming using digital tools, economic analysis of factors influencing production and agricultural sales, plant genetics and genomics, and optimizing management practices for increased production.

- "Multi-faceted Approaches to Detect, Monitor, and Manage Field Crop Diseases in Indiana" sought to provide timely detection and management options for new, emerging, and annual field crop diseases. Results from this study have led to better knowledge of crop disease location and severity maps as well as integrated field management guidance to better protect the food supply.
- "The economics of digital agriculture" is studying the value of agricultural technology adoption and data usage on farm profitability. Commercial farmers benefit from these activities as they are able to understand the potential efficiency gains available from adopting advanced precision farming systems.
- "The role of epigenetic factors in antifungal drug resistance" has identified a set of molecular factors that plays a direct role in regulating drug resistance. This knowledge will provide insight into novel targets for future antifungal treatments of agricultural commodities.

- “Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises” is focused on understanding the physiology of dairy animals to better meet animal needs in order to improve production and health while utilizing less resources.

Purdue Extension provides training and resources for crop, livestock, and small-scale farmers.

- Extension partners with the Purdue Agricultural Centers for events that contribute valuable and practical information for farmers and ranchers across Indiana. These informative opportunities, provide practical, useful, helpful and valuable tools and resources for learning, feature knowledgeable, amazing, enthusiastic, and excellent experts, are enjoyable events, and support and enhance networking and connections among farmers.
- Indiana Small Farm Conference is reaching its goals contributing to knowledge, networking, and adoption of practices for small-scale farming operators and enthusiasts across the state. Previous participants who intended to adopt practices, did adopt practices for farming, producing crops, raising livestock, sustainable practices and technologies, and business practices.

Purdue Extension teaches about meat processing in facing pandemic challenges.

- Boilermaker Butcher Block contributed to increased knowledge and confidence for those interested in processing meat for themselves, their farm, or their processing facility, to increase meat processing during pandemic challenges of supply chain availability and costs.

Purdue Extension helps beginning farmers.

- With the information from Grow Your Farm Operation virtual series, beginning farmers across Indiana increased their knowledge of farm financials, commodity marketing, and legal issues for managing their operations.
- The virtual Beginning Farmer program helped new farmers create a farm plan and business plan, analyze potential markets and farm finances, and developed connections with farmers and producers.
- So, You Inherited a Farm, Now What? helped Indiana families prepare for the next generation to take on the farm operation. As one participant stated “We had inherited the farm several years before I attended the seminar. The result was that many of the topics discussed were ones we had already addressed or had already researched. The seminar did give me some resources for future reference and did hammer home the importance of communication and family cohesiveness.”

Critical Issue: Human, family, and community health and well-being

Purdue is conducting active research in all three colleges that address various societal challenges important to human, family, and community health & well-being. Although not exhaustive, some key areas of focus include nutrition and behavioral health, rural health, vaccine development, substance abuse and cancer research.

- “Broadly Protective Vaccines against Emerging Influenza Viruses” is seeking to develop new strategies to confer protection against a range of influenza viruses. Although, at this stage, the public isn’t directly benefiting but the research, this line of investigation offers the potential for new and improved vaccines against the flu.
- “Examining Substance Use among Young Indiana Adolescents” is timely given data suggesting an increase in early substance use as a result of COVID-19 stressors. A new community partner and partner network were established along with initial data on factors influencing youth substance use. Additionally, the project will provide insight on needs, stressors, and coping mechanisms of families experiencing housing insecurity as a result of the pandemic.

Extension promotes health through coalitions, provides positive youth development, and helps community leaders plan and collaborate.

- Purdue Extension, in 76 of the 92 Indiana counties, played a major role in connecting communities through local coalitions and partnerships which positively impact policies, systems, and environments to support the health of all throughout the state.
- Indiana 4-H contributed to positive youth development, to growth in personal and social skills, to gains in knowledge and skills, and to positive attitudes through civic engagement, healthy living, animal science, science and engineering, and college and career readiness programs.
- Extension’s American Citizen Planner – Indiana prepared individuals with knowledge and resources to make decisions, work with policies, and improve engagement in local planning for communities to collaborate and protect watersheds.

Critical Issue: Natural resources and the environment

Purdue's College of Agriculture, particularly the department of Forestry and Natural Resources, conducts a variety of studies on the sustainable use of natural resources (soil, water, forest systems, etc.), and wildlife, fisheries, and aquatic sciences. Plant Sciences 2.0, a component of Next Moves, includes funds to support a new initiative on Digital Forestry.

- "Beneficial Use of Residuals to Improve Soil Health and Protect Public, and Ecosystem Health" is addressing polyfluorinated alkyl substances (PFAS) occurrence and fate in biosolids and land-applied biosolids and mitigation of PFAS mobility from biosolids. The information provided by our activities have improved our understanding of PFS occurrence in our waste-derived soil amendments, what happens to PFAS in waste solids during municipal treatment or once applied to soils, and potential biosolids management strategies for minimizing PFAS leaching while still being able to take advantage of the multiple carbon and nutrient benefits provided by land application of biosolids.

Purdue Extension prepared the public for the 17-year cicada emergence.

- Coordinated and multidisciplinary efforts for the 17-Year Cicada provided helpful insect, tree, and shrub information, resources, and education reaching thousands across Indiana.

Purdue Extension addresses conservation across natural resources and audiences to leverage impact across Indiana.

- Learn-N-Burn Prescribed Fire Workshop helped landowners learn how to conduct prescribed fires for conserving grasslands.
- By partnering with the State Parks, Purdue Extension leveraged the ability to share information and actions for improving water quality, and habitat for hellbenders, other amphibians and aquatic life across Indiana.
- Tree and Shrub ID Webinars and Tree ID Field Programs helped increased the knowledge of Indiana Conservation Partnership employees who will use that for instruction and engagement with their clients across Indiana.
- Conservation Tree Planting increased knowledge of landowners planning conservation tree plantings and connected them to Indiana Department of Natural Resources professional foresters available to help them.
- Working together, Purdue Extension, Indiana Conservation Partnership, and the Conservation Cropping Systems Initiative, provided effective training for conservation professionals to help Indiana farmers implement conservation practices for improved on-farm sustainability by increasing soil health, reducing total nutrient, herbicide, and insecticide applications, increasing resilience to extreme weather events, and producing more steady and predictable yields.

Critical Issue: Sustainable energy

Purdue research covers sustainable energy topics ranging from biofuels, value-added products, and energy-efficient solutions to agricultural machines.

- "Design heterologous metabolic pathways to assimilate carbon sources derived from agricultural byproducts" is addressing essential issues in optimizing microbial strains with desired phenotypes for bioconversion in fermentation sciences and synthetic biology. Thus, the platform generates value-added chemicals and chemical precursors for industrial processes.

Purdue Extension efforts related to sustainable energy help Indiana communities plan for use of sustainable energy resources and technologies to help protect the environment.

- Purdue Extension Land Use Team provides research-based resources and educational programs, including the bi-annual Land-Use Summit, to inform and support land use and renewable energy planning for Indiana professionals, government officials, citizen planners, and residents.

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

None

Highlighted Results by Project or Program

Critical Issue

Childhood obesity

Fatty acid metabolism in obesity and metabolic dysfunction

Project Director

Gregory Henderson

Organization

Purdue University Main Campus

Accession Number

1022890

Fatty acid metabolism in obesity and metabolic dysfunction

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

The project addresses the metabolic benefits of reducing transport of free fatty acids in plasma. The studies use albumin-deficient mice to understand the metabolic benefits of reducing the flow of free fatty acids from adipose tissue to the liver.

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.

We have characterized the albumin knockout mouse model. We discovered that this mouse model exhibits improved insulin sensitivity and reduced liver fat content. We also observed changes in gene expression in adipose tissue and liver that can explain how glucose metabolism is altered in this mouse mode. The results have implications for potential avenues to prevent diabetes in obese individuals.

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

The results were disseminated to the scientific community through abstract presentations at conferences and through a peer-reviewed journal article.

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

Ultimately the results may impact public health by leading to new treatment approaches for diabetes and fatty liver disease.

Critical Issue

Climate change

Cover crop and drainage management systems impacts on crop production, soil health, N cycling and water quality.

Project Director

Shalamar Armstrong

Organization

Purdue University Main Campus
Accession Number
1013636

2021 Cover Crop, Soil Health, and Water Quality Progress Report

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

The long-term goal of this project is to identify and investigate adaptive agriculture management practices that improve the sustainability and resilience of cropping systems to be climate smart through increased soil health, water quality, and crop production. Particular emphasis will be placed on integrating cover crops into corn-soybean cropping systems and managing drained agricultural lands for water quality and crop productivity.

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.

We achieved serval major activities that allowed for significant progress toward completing the research objectives. The first is implementation of five field experiments across Indiana and Illinois that investigated the inclusion of over wintering legumes as an alternative to cereal rye before corn (NCSARE funded project). Results from this study revealed that Balansa clover survived the midwestern winter and produced 1000-4000 lb/A of above ground biomass and 115-200 lb/A of nitrogen. Corn grown in Balansa clover treatments resulted in equal corn yield relative to the non-cover crop control and both were significantly greater than the cereal treatment at lower N rate. The second was the start of a national cover crop project (over 15 states involved) that quantified the potential cover crop nitrogen fertilizer credit for corn (USDA CAP GRANT). Similar results were observed where hairy vetch resulted in equal yield to the control and both were significantly greater relative to the cereal rye treatment. Both of the forementioned studies and results produced data that was presented regionally, nationally, and internationally to address farmer questions about cover crop species and reduced fertilizer inputs to increase their profit margin.

As for the water quality aspects of the projects, results from the 35-yr tile drainage/water quality study at the Southeast Purdue Agricultural Center (SEPAC) were published in the Journal of Environmental Quality (listed below). Nitrate-N concentrations and loads were reduced by use of cover crops and changes in fertilizer N rates over the 35-yr period. Drain-flow volumes and nitrate loads were greater for greater drainage intensity plots (narrower drain spacings) than for lower drainage intensity plots (wider drain spacings). During Years 16-31, when the nitrate-N concentrations were relatively stable in the 4 to 9 mg/liter range, annual nitrate-N loads were linearly correlated with annual flow volumes. The results underscore the interacting effects of drainage design, crop management, and weather in determining the magnitude of N loss from drained agricultural fields. Long-term data on crop yields are being prepared for manuscript submission. All data on water flow, nitrate-N, and crop yield are also being prepared for publication as a database.

Cover crops impact on nitrate loss via tile-drainage is scalable to the watershed level (Central IL location). After a successful aerial application of cover crops in the fall of 2020 on 449 acres (49% of the treatment watershed), we observed a reduction in tile-drainage water NO3-N concentration for the cover crop watershed relative to the reference (control) watershed. This reduction in tile-drainage water NO3-N concentration is consistent with our observation from previous years of 2018-2020. Furthermore, when considering NO3-N load, the total mass of NO3-N per 1000 gallons of drainage water, cover crop adoption resulted in a 33% reduction relative to the reference watershed in 2021, which is consistent with the 39% reduction of the previous 3 years. These observations demonstrate the ability of cover crops to interact and scavenge soil nitrate from the residual and legacy N pools that would otherwise be susceptible to being lost via tile-drainage. Once soil nitrate is scavenged, the cover crop assimilates the nitrate into its organic structure securing it from possibility of leaching and denitrification.

Tile drainage site (Central IL location) in 2021 was characterized by warmer and dryer conditions relative to the 30-year average. Dryer conditions significantly reduce the tile drainage volumes and total nitrate loss. Cumulative nitrate load and flow weighted nitrate concentrations have been updated (partial water quality analysis to 5/25/21; 6 of 8 events completed, no events in July-October) and the trend of cover crops significantly reducing N loss and concentration continued. Over a 6-year period cover crops reduced the flow weighted nitrate-N concentration by 37.5% and was equal to the zero control, where no nitrogen fertilizer was added. Additionally, when considering nitrate load over the same 6 years cover crops reduced the mass of nitrate-N loss by 43 and 46% relative to the control and zero control treatments. Another significant observation is the change in the rate nitrate-N loading over time. When considering the zero-control treatment, we observed that the rate of nitrate-N loss decreased significantly over time, where over a six-year period the rate of loss was 34.3 lbs A-1yr-1, which was 66% higher relative to the rate of loss over the last 3 year at 12 lbs A-1yr-1. For the non-cover crop control and the cover crop treatment we observed a 21 and 16% reduction in the rate of nitrate-N loss, respectively, when comparing the 6- and 3-year

time periods. One implication of the zero control observation is that the rate of loss from the legacy N pool begins to decline after approximately 3 years following tile drainage installation in high organic matter soil (3.4%). Another implication is that cover crops maintained a 47% lower rate of nitrate loss consistent across the 6-year period relative to the N fertilized treatment without cover. Thus, we hypothesize that consecutive cover crop adoption of cereal rye will result in significant greater nitrate loss reductions, especially if the fertilizer N rate remains constant.

The plot scale Central IL data was used calibrate and validate a novel Cover Crop Decision Support Tool (https://farmdocdaily.illinois.edu/2020/10/introducing-the-cover-crop-decision-support-tool.html). This tool was created through a collaboration with U of I and Purdue University. The tool allows farmers to model and visualize the growth, nitrate loss reduction, and residue decay of a cereal rye cover crop on their land. The goal of the tool is to help cereal rye adopting farmers predict changes in management. Additionally, all Central IL sites were used to develop a Cover Crop Guide (https://www.illinoisnrec.org/wp-content/uploads/2021/12/2021-NREC-Cover-Crop-Guide_Dec2021.pdf).

All of the forementioned studies and results produced data that were presented regionally, nationally, and internationally to address farmer questions about the performance cover crops and their impact of the agronomics, environmental footprint, and economics of their cropping systems

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

Farmers, conservation agency staff, Extension educators, independent crop advisors, agricultural industry personnel (sales and technical staff, company agronomists), regulatory agencies, NGOs, landowners, and other scientists. All of the studies will take place in Indiana and Illinois, but we collaborate closely with scientists throughout the Corn Belt. The practical results of the research will be applicable to much of the Corn Belt and the target audiences are primarily from this region. Scientific results are more broadly useful across a wider range of geographies.

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

Distribution of the result from the research in this project informs the public of the impact of cover crops on sustainable corn and soybean production and downstream water quality. Further the studies, demonstrate the cost and potential benefits/risk that are associated with cover crop adoption.

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.

N/A

Addressing Climate Change with Conservation Strategies and Technologies for Sustaining Economic Vitality

Project Director
Julie Huetteman
Organization
Purdue University Main Campus
Accession Number
7001747

Building Climate Expertise in Extension

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

Climate change has become a primary topic of discussion and research in the agricultural sector and among agricultural producers. Extension professionals in the North Central Region (NCR) are well situated to be purveyors of climate science relating to agriculture and production systems.

Loy et al. (2013) show that about two-thirds of farmers in the U.S. Corn Belt believe climate change is occurring, due to either human or natural causes, or both. Only 40% believe human causes can be attributed. The National Climate Assessment (NCA, 2018) and Intergovernmental Panel on Climate Change (IPCC, 2014) both detailed strong agreement, and high likelihood, of

human-caused climate change globally, which is not consistent with farmer beliefs.

Most Extension and Agriculture advisors do not have educational backgrounds in meteorology or climatology. This may be the root of their discomfort with the topic, as Wilke et al. (2015) found in surveys of agriculture advisors. In general, Extension and Agriculture advisors have similar climate change beliefs as the producers they serve.

USDA and other federal agencies are studying climate change and its impacts on all sectors of the economy (agriculture, energy, commerce, transportation, etc.), and making strides to follow the President's Climate Action Plan (2013). Many federal agencies established regional centers to address concerns at local or regional scales. USDA's Regional Climate Hubs are among those groups, and focus on using Extension to provide knowledge and advice to agriculture producers. Three USDA Regional Climate Hubs are active in the NCR. For these reasons, it is important Extension professionals become familiar, and comfortable, with climate science pertaining to agriculture production.

NCR SARE has been a benefactor to climate curriculum in the past (ENC11-127, ENC12-136). Research and training opportunities provide Extension Educators with basic knowledge, and allow some to specialize programming to address climate change issues.

In 2017, the North Central Climate Collaborative (NC3) was established as an initiative with Extension Educator and/or Specialist representation in all 12 states. This group provided regional in-person trainings to other Educators and provided webinars on climate change and agriculture topics every other month. In months when webinars were not provided, the team met to discuss issues impacting the states and opportunities for the region. The NC3 received funding in past efforts through the North Central Region Water Network.

Within the NC3, expertise varies greatly. All Educators have some expertise in agriculture, although some are more versed in livestock, field crop, or horticulture than others. All Educators have a basic understanding of climate change principles. This project endeavors to identify and analyze gaps in advanced knowledge of climate change and agricultural principles, and to address them creating state or regional Specialists in climate change and sustainable 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.

Ongoing webinars are held on climate and climate change projects. A three-day virtual conference "Advanced Climate Change Topics: North Central Climate 201" was held on in-depth topics: new climate "normals", climate projections and models, climate assessments, National Weather Service Climate Projection Center Outlooks, climate justice, community climate risk and planning, climate indicators on agriculture, adaptation through conservation, and climate's impact on habitat, conservation, wildlife and fisheries.

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

Webinar results have favorable responses. Almost all survey respondents show knowledge gained, with over 90% intending to initiate action or share information. Over 600 people have attended a webinar since October 2019.

The 430 registrants of the North Central Climate 201 Conference were sent a post-survey via email. Of 29 who responded, they indicated they work in Extension (20.0%), State or Federal Agencies (17.1%), Local government (17.1%), or the USDA (14.3%). All indicated they work in states across the Midwest and beyond.

Respondents indicated they most valued the speaker and presentation about climate justice, stating: "Wonderfully presented and full of information I plan to use." "Being an EPA employee working with smaller rural communities, climate justice has signi?cant overlap with environmental justice which is an EPA Focus. It helps to better understand that overlap." "As an agency employee, we slip easily into acronyms and jargon. It's good to be pushed toward engaging the public, and the speaker provided good suggestions on how to do this e?ectively." "This was new information for me and provided information that I could incorporate into my work." "It had a lot of useful information that I can use in my climate presentations to make them more e?ective."

As a result of attending, most (82.4%) felt somewhat, or much more, comfortable doing climate-related education. They reported increased awareness about people located in other states who are working on climate issues, and on where to find information and resources about climate. They also reported increased understanding of climate research and outreach happening across the region.

Respondents reported they expect to use information they learned for their professional development, regulation / policy discussions, community planning, and educational curricula. For actions, respondents indicated, as a result of the conference, they would use more climate information in their work, do more climate-related programs, make updates to existing climate-related programs, and recommend changes to agricultural operations.

Despite the conference being virtual, over half (55.2%) felt they developed connections/contacts with out-of-state experts they could consult with about climate questions.

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

Extension's North Central Climate Collaborative (NC3) opportunities are building climate change expertise in Extension personnel to enhance delivery of educational programs to those in agriculture and the community.

Turfgrass Practitioners Earn Continuing Certification Hours for Climate-Durable Integrated Pest Management (IPM)

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

Managed turfgrass covers more than 20 million hectares of U.S. land and generates more than $40 billion in annual economic activity, making it one of the fastest growing agriculture segments. Insect management represents a significant portion of efforts by turfgrass and landscape professionals, homeowners, and property managers to produce functional, aesthetically acceptable, and environmentally and economically sustainable turf. However, potential environmental and human impacts associated with turfgrass management have garnered scrutiny from regulatory agencies, environmental organizations, and local governments.

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.

Purdue Extension's Turfgrass Integrated Pest Management (IPM) integrates applied research and extension on biology, ecology and management of insects in turfgrass environments. The program addresses very important challenges facing the industry through translational science supporting development and implementation of sustainable, climate-durable, insect management strategies that stand up to Indiana and Midwestern climate change effects – warmer, wetter, and increased frequency of extreme precipitation events.

Extension programs are delivered, and materials, training tools, mobile apps (e.g., TurfDoctor for homeowners and land managers to diagnose and address common turfgrass problems), websites, Extension publications, bulletins, newsletters, and social media created, distributed, and posted. Research activities examine biological and chemical treatments for efficacy and climate durability for preventing turfgrass insects.

Turfgrass IPM serves a large and varied group of Indiana stakeholders, including leadership and staff for 550 golf courses, 600 professional lawn care businesses, 20 sod producers, hundreds of athletic fields (university, high school, and municipal), grounds managers for schools, parks, cemeteries, and hospitals, professional and semi-professional sports teams, product manufacturers, and distributors. All efforts enhance certification and training opportunities for turfgrass industry practitioners. The Turfgrass IPM Correspondence and Online Course addresses cool- and warm- season turf grass, chemical pesticides and the environment, equipment and calibration, and management of weeds, diseases, insects, and vertebrate pests, and is designed for turf professionals, golf course groundskeepers, landscape pest management professionals, chemical industry personnel, lawn care applicators, commercial sod growers, and sports turfgrass managers.

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

The turfgrass IPM research efforts provide the backbone for in-person and remote-learning sessions reaching 850 individuals who completed Commercial Applicator Category 3b Turf Management continuing certification hours. In the last year, digital Extension materials were accessed by over 19,000 individuals, the TurfDoctor mobile app was downloaded to 530 new devices, and 12 students enrolled in the Turfgrass IPM online course.

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

Turfgrass IPM supports workforce development via continuing certification hours, increases knowledge of climate-durable turfgrass insect management, and places timely, accessible, science-based diagnostic and decision-making tools in the hands of turfgrass practitioners.

Critical Issue

Food Safety

Engineering for food safety and quality

Project Director

Dharmendra Mishra

Organization

Purdue University Main Campus

Accession Number

1023114

Engineering for food safety and quality

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

Our project is focused on solving issues in extraction of bioactive compounds, cleaning and sanitizing in food processing operations using less chemicals and water using microbubble technology, thermal properties of food at elevated processing temperatures, and textural modifications of pea protein using new treatment and technology.

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.

For the bioactive compound extraction, seven laboratories from different universities across the US collaborated to conduct a comprehensive comparative study on different technologies for bioactives extraction. Researchers found emerging ways to extract bioactives from food processing by-products and reuse them in other foods, which capture value that would otherwise be lost and reduce food waste. For the cleaning methods, we have continued to advance the understanding of the physics of cleaning microbubbles. Combining experimental observations and high-fidelity computer simulations, we investigated the influence of contaminants on the fluid dynamics of cleaning microbubbles, and their potential impact on the removal of soiling material from food processing surfaces. With regards to the plant-based protein, our lab has conducted experiments trying to answer two questions. The first is, how do temperatures below 0°C change the structure of protein for food applications. We have found that proteins treated with combinations of ethanol, shear forces (like from a blender), and temperatures of -10°C significantly alter the structure of a commercial pea protein isolate. It was found these modified proteins had favorable characteristics for forming emulsions, and they also formed unique gels. This suggests that these treatments may lead to unique textures in food products. The other major objective has been modeling protein structure to demonstrate how these changes occur and find relationships between these bioinformatic models and physical properties. It was found that correlations between models and various physical properties that impact gels and emulsions exists. This means that bioinformatics has the potential to be used a screening tool to identify plant-based proteins for specific food applications. For the food thermal properties, a complimentary experimental design used to enhance the number of parameters that could be estimated from a single experiment.

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

The results of this project can potentially serve as a guide to select technologies for bioactives extraction from fruit and vegetables. As a result of our project's activities, we published a peer-reviewed article ("Active motion of contaminated microbubbles". Chemical Engineering Science, 238, 116574, 2021) and presented preliminary findings in the Annual Conference of the American Institute of Chemical Engineers (2021 AIChE Annual Meeting, Boston, MA). Our results advance food and chemical engineers' ability to predict the dynamics of microbubbles for improved cleaning performance and has the potential to benefit the public by reducing chemical and water use in food processing. Our work in cold denaturation has led to three peer-review publications, and a fourth manuscript is under review. The publication of such work allows for the dissemination of information for others to build on. This work has also been disseminated through 6 conference posters and presentations at the Institute of Food Technologists, Cereals & Grains, and the American Society of Baking's annual

conferences. The work has also led to 12 articles in magazines that are tailored towards the Baking Industry, which are shared through the magazine's websites and print publications, as well as on personal social media accounts. In this way, our target audience has full access to our ideas through a variety of media and formats. The thermal properties of food project resulted in two peer-reviewed publications and several talks at conferences and meetings.

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

More efficient utilization of agricultural wastes and by-products for production of high-value food, nutraceutical, and cosmetic products can develop a sustainable circular bioeconomy. Training of over 250 food industry professionals and regulatory inspectors in the area of commercial food manufacturing. The broader public benefits from contributions at conferences such as the Institute of Food Technologists, as well as the social media posts that we create for our work. This leads to education about topics such as plant-based protein and makes our group a point of contact for those who might have questions.

Closing Out (end date 09/07/2023)

Foodborne pathogen infection, pathogenesis and probiotic bacteria-based prevention strategy

Project Director

Arun Bhunia

Organization

Purdue University Main Campus

Accession Number

1016249

Pathogenesis of biofilm-forming L. monocytogenes and prevention using bioengineered probiotics

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

Listeria monocytogenes forms biofilms on food processing environment and host and serves as a major source for foodborne outbreaks. However, very little is known about the pathogenicity of biofilm-forming cells, thus, we investigated the contribution of LAP and InlA during the gastrointestinal phase of infection in a mouse model. Furthermore, the molecular and immunological basis of *Lm*-induced epithelial barrier dysfunction facilitating *Lm* passage through the intestinal epithelial barrier and the fetoplacental barrier was also investigated. In addition, we also examined if a bioengineered *Lactobacillus casei* probiotic (BLP) expressing LAP from nonpathogenic *Listeria* (*L. innocua*) could protect against *Lm* infection in mice and pregnant guineapig models.

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.

Specific Objective 1

In biofilms, *Lm* sessile cells express reduced levels of the *lap*, *inlA, hly*, *prfA*, and *sigB* and show reduced adhesion, invasion, translocation, and cytotoxicity in the cell culture model than the planktonic cells. Oral challenge of mice with food, clinical, or murinized-InlA (InlAm) strains revealed that at 12 and 24 h post-infection (hpi), *Lm* burdens are lower in tissues of mice infected with sessile cells than those infected with planktonic cells. However, these differences are negligible at 48 hpi. Besides, the expressions of *inlA* and *lap* mRNA in sessile *Lm* from intestinal content are about 6.0- and 280-fold higher than the sessile inoculum, respectively, suggesting sessile *Lm* can still upregulate virulence genes shortly after ingestion (12 h). Similarly, exposure to simulated gastric fluid (SGF, pH 3) and intestinal fluid (SIF, pH 7) for 13 h shows an equal reduction in sessile and planktonic cell counts but induces LAP and InlA expression and pathogenic phenotypes. Our data show that the virulence of biofilm-isolated *Lm* is temporarily attenuated and can be upregulated in mice during the early stage (12–24 hpi) but fully restored at a later stage (48 hpi) of infection. Our study further demonstrates that in vitro cell culture assay is unreliable; therefore, an animal model is essential for studying the pathogenesis of biofilm-isolated bacteria.

Specific Objective 2

Our bioengineered probiotic *Lactobacillus casei* (BLP) expressing LAP from a non-pathogenic *Listeria innocua* and a pathogenic *Lm* colonized the intestine, reduced *Lm* mucosal colonization and systemic dissemination, and protected mice and guineapig fetuses from lethal *Lm* infection. The BLP competitively excluded *Lm* by occupying the surface presented LAP receptor, heat shock protein 60 and ameliorated the *Lm*-induced intestinal barrier dysfunction by blocking the nuclear factor-

κB and myosin light chain kinase-mediated redistribution of the major epithelial junctional proteins. Additionally, the BLP increased intestinal immunomodulatory functions by recruiting regulatory T cells, dendritic cells and natural killer cells. BLP also exerted an anti-inflammatory response in both mice and pregnant guinea pigs. Engineering a probiotic strain with an adhesion protein from a non-pathogenic bacterium to make receptor-specific epithelial contact provides a new paradigm to exclude pathogens and amplify its inherent health benefits. These data highlight the potential for the prevention of listeriosis and fetoplacental transmission of *Lm* by LAP-expressing BLP during pregnancy.

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

The research findings were published in peer-reviewed journals to share with other researchers. Besides, a non-technical summary of research findings was published as a blog in Nature Portfolio Microbiology Community and Research Feature.

Key points:

Our data show that the virulence of biofilm-isolated *Listeria monocytogenes* is temporarily attenuated and can be upregulated in mice during the early stage (12–24 h) of infection but fully restored at a later stage (48 h) of infection. Our study further demonstrates that in vitro cell culture assay is unreliable; therefore, an animal model is essential for studying the pathogenesis of biofilm-isolated bacteria.

Engineering a probiotic strain with an adhesion protein from a non-pathogenic bacterium to make receptor-specific epithelial contact provides a new paradigm to exclude pathogens and amplify its inherent health benefits. These data highlight the potential for the prevention of listeriosis and fetoplacental transmission of *Listeria monocytogenes* by LAP-expressing BLP during pregnancy.

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

Knowledge of biofilm-forming cells is equally pathogenic as planktonic cells will provide heightened awareness of proper sanitization of processing plants, aseptic processing and packaging to avoid Listeria contamination.

Bioengineered probiotics have the potential to prevent listeriosis in high-risk populations including pregnant and elderly individuals.

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.

Journal Articles

1. Zhu, X-Y., Bai, X., Liu, D., **Bhunia, A.K.**, and Zhao, Z-M. 2020. Detection of *Listeria monocytogenes* in milk using a laser light scattering sensor system. Lasers in Engineering 47:203-219

2. Drolia, R., Amalaradjou, M.A.R., Ryan, V.E., Tenguria, S., Liu, D., Bai., X., Xu, L., Singh, A.K., Cox, A.D., Bernal-Crespo, V., Schaber, J.A., Applegate, B.M., Vemulapalli, R., and **Bhunia, A.K.** 2020. Receptor-targeted engineered probiotics mitigate lethal *Listeria* infection. Nat. Commun. 11:6344.

3. Bai, X., Liu, D., Xu, L., Drolia, R., Gallina, L.F., Cox, A.D., and **Bhunia, A.K.** 2021. Biofilm-isolated *Listeria monocytogenes* exhibits reduced systemic dissemination at the early (12-24 h) stage of infection in a mouse model. Npj Biofilm & Microbiome 7:18.

4. Ryan, V.E., Taylor W. Bailey, Liu, D., T.W., Vemulapalli, T., Cooper, B., Cox, A.D., and **Bhunia, A.K.** 2021. *Listeria* adhesion protein-expressing bioengineered probiotics prevent fetoplacental transmission of *Listeria monocytogenes* in a pregnant guinea pig model. Microb. Pathog. 151:104752

5. Xu, L, Bai, X., and **Bhunia, A.K.** 2021. Current State of Biosensors Development and their Application in Foodborne Pathogen Detection. J. Food Protect. 84 (7):1213-1227 (Invited).

6. Lopes-Luz, L., Mendonça, M., Fogaça, M.B., Kipnis, A., **Bhunia, A.K.**, and Bührer-Sékula, S. 2021. *Listeria monocytogenes*: Review of pathogenesis and virulence determinants-targeted immunological assays. Crit. Rev. Microbiol. 47(5):647-666.

7. Fogaça, M.B.T, **Bhunia, A.K.**, Lopes-Luz, L., Pontes de Almeida, E.P.R., Vieira, J.D.G., and Buhrer-Sékula, S. 2021. Antibody- and Nucleic Acid-based Lateral Flow Immunoassay for *Listeria monocytogenes* Detection. Anal. Bioanal. Chem. 413: 4161-4180 (May 28, 2021)

8. Bai, X., Nakatsu, C.H., and **Bhunia, A.K.** 2021. Bacterial Biofilms and Their Implications in Pathogenesis and Food Safety. Foods 10(9): 2117.

9. **Bhunia, A.K.** 2021. Food safety concerns of biofilm-forming zoonotic bacterial pathogens. Indian J. Anim. Health 60(2):44-51 (Invited Review Article)

Conference Abstracts

1. Drolia, R., Tenguria, S., Liu, DL., Cox, A., & Bhunia, A.K. 2021. Listeria Adhesion Protein Promotes Listeria monocytogenes Translocation across the Intestinal Barrier in Internalin A–Permissive Gerbil Model, Indiana ASM Branch Meeting (Virtual)

2. Tenguria, S., D. Liu, R. Drolia, M. Samaddar, L. Xu, X. Bai, N. Gallina, J. A. Schaber, A. D. Cox, and A. K. Bhunia. 2021. Gastroenteritis Caused by *Listeria monocytogenes* at a High Infectious Dose. Indiana ASM Branch Meeting (Virtual)

Patents

Bhunia, A.K., Drolia, R., Amalaradjou, M.A.R., and Koo, O.K. **2021**. Bioengineered Lactobacillus probiotics and the uses thereof. Application No. 16/458, 243. Patent No. 11090357; Issue date August 17, 2021

Blog

1. Do Not Let Biofilm-Forming Pathogens Misguide You about Their Infectivity (Nature Portfolio)

2. Epithelial Cell Contact is Critical for Probiotic Action (Nature Portfolio)

3. How do Listeria bacteria move from the intestine to other areas of the body? (Research Features)

Focusing on Safe Food Production, Handling, and Serving

Project Director
Julie Huetteman
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Accession Number
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Purdue Extension Encourages Practices for Safe and Effective Vegetable Production

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

Specialty crop growers face difficulties with insects, diseases, and weeds. They may have unique growing scenarios with greenhouses, fields, and high tunnels. Crops vary in nutrient requirements, equipment needs, and handling for food safety. Vegetable farming is diverse by nature and it can be difficult to stay on top of the most recent research and recommendations.

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 annual Indiana Horticultural Conference has been an important resource for vegetable growers across the state. With the uncertainty of the pandemic, Purdue Extension Specialists and Educators teamed up to offer a Vegetable Farming webinar series. The series provided 2 hours of instruction every Wednesday for the month of February.

Numerous topics and tips relevant to vegetable growers were presented, providing attendees with the most current research-based information on pest control, soil health and nutrient management, food safety for fresh produce, and production methods. There were 420 registered across all four webinar sessions. The majority of registrants were non-Hispanic (82.3%) and male (52.6%).

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

A post-survey was completed by 74 survey respondents across all sessions. Most respondents (78.9%) indicated, as a result of the Vegetable Farming webinar series, they learned something they didn't know before. Respondents indicated they plan to adopt recommended food and farm safety/security practices (29.6%) and recommended assessments of critical control points for contamination - chemical, physical, and/or biological (25.4%). Respondents indicated they plan to adopt recommended practices/technologies for horticulture and the environment (43.7%), increased yields (43.7%), increased efficiencies (35.2%), and conservation of resources (35.2%).

About one-fifth of respondents reported they had attended the previous year's in-person conference. Since that event, they had adopted recommended practices for farming, producing crops, and sustainable practices and technologies (69.2%). As a result of those adopted practices, they experienced conservation of resources (53.8%) and increased yields (46.2%).

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

The Vegetable Farming webinar series was an effective event for delivering information to those interested in safe vegetable production, and for encouraging adoption of recommended practices/technologies for horticulture and the environment. Previous year's attendees adopted practices that had resulted in conservation of resources and increased yields.

ServSafe Contributes to Certification for Adults in the Restaurant and Food Service Industry

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

Foodborne illness is a common, costly yet preventable public health problem. CDC estimates that one in six Americans get sick from contaminated foods or beverages and 3,000 die each year. The U.S. Department of Agriculture (USDA) estimates that foodborne illnesses cost $15.6 billion each year. Reducing foodborne illness by 10% would keep five-million Americans from getting sick each year. Preventing a single fatal case of E. coli infection would save an estimated $7 million.

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.

Purdue Food Safety and Purdue Extension collaborate with the National Restaurant Association to offer ServSafe in Spanish and English for food safety management certification and provide education and training materials for staff and volunteers in the restaurant and food service industry. Extension Educators are certified to provide training by completing the exam at a proctored site, two tutorials, and two online exams, to become a certified instructor and exam proctor.

Face-to-face ServSafe training and exam proctoring were put on hold for part of the year during the pandemic. Proctoring exams could continue as needed but were required to follow Purdue Extension safety guidelines. For the year there were proctor-only events, training with exam events, and hybrid events which had training plus proctor-only participants. A total of

25 counties were involved in ServSafe activities. There were 124 sessions (96 proctor only, 28 training and hybrid events) for over 286 hours of instruction. A total of 405 direct contacts participated in training or proctoring activities.

During the pandemic limitations, there were 54 proctor-only events held for 141 participants. With the return to in-person activities, there were 42 proctor-only events held for 75 participants, and 28 training and hybrid (training with addition of proctor-only) events held for 189 participants. Of the 264 participants who attended training or took the exam without training, there were 148 who completed the post-survey for a response rate of 56.1%. Three-quarters (74.1%) were training participants. There were 16 Counties that incorporated the post-survey with training and proctor-only events. These evaluation-participating Counties had 26 unique National Restaurant Association-assigned exam numbers for events.

Post-survey participants reported their race, ethnicity, gender and age. Most were non-Hispanic (79.5%), female (78.4%), 49 years and younger (74.0%), and White (73.2%).

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

There were 223 ServSafe training and proctor-only participants who passed (minimum score of 75%) the certification exam. Post-survey respondents indicated they learned “a lot” about: monitoring time and temperature, and the flow of food: service (holding and serving).

Over half indicated they would adopt these practices at work: assess areas for activities that risk microbial contamination (64.5%), use proper time and temperature controls (60.7%), and take steps to reduce cross contamination risks (52.3%). Over half (63.3%) indicated they already do the recommended handwashing practices. Nearly half indicated this was their first time to attend training (45.6%), or take the exam (46.9%).

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

Purdue Extension ServSafe training via Spanish and English and exam proctor-only activities contribute to the knowledge and certification needed for adults working in the restaurant and food service industry.

Critical Issue

Global food security and hunger

Methods to Monitor and Improve US Food Security and Dietary Intake

Project Director

Heather Eicher-Miller

Organization

Purdue University Main Campus

Accession Number

1019736

Methods to Monitor and Improve US Food Security and Dietary Intake

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

Our project addresses U.S. food insecurity, or the limited access of enough foods for a active, healthy diet. About 11% of U.S. households were food insecure in 2020. We focus on the dietary intake of food insecure groups in the U.S. and how they may not be meeting recommendations both for food group intake, nutrient intake, and overall dietary quality. We are also interested in understanding how these dietary shortfalls or excesses may be linked with chronic health outcomes and how we may intervene to improve food security, diet and health. We are also interested in understanding how curent programs, like the Supplemental Nutrition Assistance Program-Education (SNAP-Ed), SNAP, and food pantries may be helping to address needs or how they could be improved to better address food security, diet and health among low-resource groups.

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.

During this reporting period we have made progress according to the project plan.

Objective 1: We have evaluated the dietary impacts of the SNAP-Ed program. We carried out a randomized trial of SNAP-Ed eligible women in Indiana (n=97), and found that this nutrition education intervention program did not improve dietary outcomes after 1-yearfollow up except for dietary intake of vitamin D. The overall dietary quality among the entire group of Indiana SNAP-Ed eligible women was very low, less than 50 out of 100 (a score of F). This finding lies in contrast to the finding of a previous randomized controlled trial that found an improvement in food security. We have a paper currently under review that documents these findings. We will follow to investigate and better understand the reasons for this. We also continue to evaluate the ways that diet has been assessed in this program to demonstrate impact.

Objective 2: We have created temporal dietary patterns using a data-driven machine learning approach. The patterns we discovered are linked with indicators of obesity, meaning they are meaningful predictors to health. We continue to evaluate these patterns by visualizing the energy and timing of the participants with similar patterns and to describe the patterns using simple energy and time cut-offs. We will further test the translation of the patterns using the cut-offs by imposing these cut-offs on the energy and timing data to re-classify the patterns and then test the new cut-off derived patterns against obesity outcomes. This work is currently being prepared for presentation at a conference and will demonstrate validity of the data-driven patterns. We will continue to work on this project and publish results.

Objective 3: We have evaluated the dietary contributions of food pantry client diets from various sources including the grocery store, restaurants, food pantry, and others and found that the contributions of food pantries are reletively high in dietary quality compared with the other sources. However, there were some gaps where the contributions could be improved, especially with regard to nutrients like sodium, consumed in excess. These results can be used to improve the food offerings at food pantries and provide nutrition education to clients. THis work has recently been published. We will follow this work by evaluating the cost or value of the foods obtained by dietary quality and work to fulfill the goals of this objective.

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

Our target audience is the low-income and food insecure U.S. population.

Regarding objective 1, our evaluation of the SNAP-Ed program and the diet and health of the group targeted by this program has informed the curriculum and programmatic efforts of the program. This program is provided to about 20,000 individuals in Indiana each year. However, our work has a national relevance that also impacts and has improved the evidence base of this program which is relevant for future funding and policy changes.

Regarding objective 2, our discovery of the importance of time in dietary patterns and potentially lifestyle patterns will inform future interventions to create an evidence base for the role of timing of dietary intake and other behaviors. Such information may potentially be included in future national dietary guidance and have broad relevance for the target population and general population as adaptation of healthful temporal dietary patterns may prevent obesity and other chronic health outcomes.

Regarding objective 3, determining the dietary intake of food pantry clients, contributions from food pantries, and potential for interventions can inform optimization of resources for food pantry clients including the improvement of the food environment in food pantries, provision of nutrition education, and attention of food pantry volunteers and staff to the dietary needs of clients. This resource may be improved to better serve the needs of food pantry clients on the basis of the information we discover in this project.

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

The project activities have benefited the broader public by providing education on diet, health and programs regarding food insecurity in the US. Specifically, we have delivered education to academic, professional, and lay audiences regarding the discoveries resulting from the research in our projects. I have provided several invited lectures to both academic and professional audiences, we have published papers disseminating the information, and also presented our work at conferences. Further, our work is disseminated to lay audiences through the website and newsletter for Indiana's Emergency Food Resource Network, an outreach of my laboratory. We create bi-monthly newsletter featuring our research and others relevant to the volunteers and staff of food pantries that is delivered electronically to emergency food providers and affiliated organizations througohout the state. The newsletter is student written and edited.

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.

There have been no major changes or problems during this reporting period. We will continue to progress on the objectives according to the project plans.

Improving integrated pest management strategies in horticultural crop systems in Indiana

Project Director
Elizabeth Long
Organization
Purdue University Main Campus
Accession Number
1022384

Progress towards understanding the activity and damage potential of important insect pests in specialty crop production

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

This project addresses insect pest management challenges faced by producers of specialty crops in Indiana and the surrounding north-central region. Special attention is focused on commercial tree and small fruit systems, including apples, grapes, blueberries, and brambles; commercial vegetable systems (carrots and parsley); and commercial mint and CBD hemp production systems. Current and emerging invasive insects like the Asiatic garden beetle, brown marmorated stink bug, spotted-wing dropsophila, and spotted lanternfly are also addressed in the applied research and extension efforts of this project.

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 activities in fiscal year 2021 included applied research and extension efforts to 1) monitor key pest insects in horticultural crop production systems, 2) characterize beneficial insect communities in these systems, and 3) evaluate the efficacy of insecticides and predatory insects against key pests in these systems.

Towards item #1 above, we made significant progress towards identifying and monitoring the occurrence of the invasive Asiatic garden beetle in commerical mint production in Indiana. We were able to monitor three fields in the spring and fall to determine that densities of this insect pest are highest in the fall and that densities greater than 6 grubs/square foot are enough to cause economic loss (decline in mint productivity) for producers. This threshold is preliminary as it is based on 1 year of data so far, but it represents an important and novel finding for mint growers because there is no current economic threshold for this insect in commercial mint production in the midwest, where it is a key pest.

Towards item #2, we made significant progress towards characterizing insect communities commonly observed on CBD hemp in outdoor and indoor production systems. We were able to scout three CBD hemp sites in Indiana (two outdoor growing sites and 1 high tunnel growing site) twice a month from June to August in 2021 and observe patterns in the identity and occurrence of potential pest and beneficial insects observed throughout the season. The most common potential pest insects we observed on CBD hemp plants at all sites were aphids, leaf hoppers, and whiteflies. The most common beneficial insects and arthropods we observed were lady beetles, hover fly larvae, minute pirate bugs, aphid lion larvae, and jumping spiders. We also observed a diversity of insects including bees, beetles, grasshoppers, and flies that appeared to be "visitors" to hemp - not feeding or causing damage, just resting on plants. These findings are meaningful and novel for hemp producers in Indiana because this is still a new crop in Indiana that we do not have much experience with. There are limited chemical tools for use on hemp in Indiana, so concerns about the identity and need to manage potential insect pests is a high priority for hemp growers. Our findings provide a baseline for the types of insects observed on hemp in indoor and outdoor production, as well as guidance for growers on what a particular insect is and whether it is likely to be a pest, beneficial, or just a visitor.

Towards item #3, we made preliminary progress towards evaluating the efficacy of soil-applied, systemic insecticides (neonicotinoids and diamides) and insect-parasitic nematodes against grubs of the invasive Asiatic garden beetle (AGB) in mint. In greenhouse trials, we have evaluated the survival and behavior of AGB grubs when they are exposed to insecticides and insect-parasitic nematodes when these products are applied to the soil of mint plants infested with known numbers of AGB grubs. We have observed that insecticides do not necessarily kill AGB grubs; however, exposure to insecticides seems to intoxicate the grubs making them "sick" so they are less active and unable to feed normally. This reduction in feeding seems to translate into less damage to mint plant roots, which is a surprising and exciting finding: killing the grubs would be great, but stopping the feeding is the real goal, so reductions in feeding caused by insecticide application is still a success towards improving management. In contrast, insect-parasitic nematodes were more successful in killing AGB grubs relatively quickly; however, grubs continue to feed on mint roots until they actually die from infection by these beneficial nematodes. Taken together, these results are meaningful and novel for mint growers because this suggests that an integrated management approach, using insecticides and insect-parasitic nematodes together, has the potential to significantly improve suppression of Asiatic garden beetle populations in commercial mint fields.

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

The target audience for this project are specialty crop producers, stakeholders, extension educators, and extension specialists in the north central region of the US. Our preliminary Asiatic garden beetle grub density-threshold represents an important and novel finding for mint growers because there is no current economic threshold for this insect in commercial mint in the midwest, where it is a key pest of peppermint and spearmint production. Our summer-long insect survey efforts in CBD hemp are meaningful and novel for hemp producers in Indiana because this is still a new crop in Indiana that growers and IPM specialists have little experience with. Because there are limited chemical tools for use on hemp in Indiana, growers have a lot of concerns about the identity and need to manage potential insect pests. Our findings provide a baseline for the types of insects observed on hemp in indoor and outdoor production, as well as guidance for growers on what a particular insect is and whether it is likely to be a pest, beneficial, or just a visitor. Our efficacy trials with insecticides and insect-parasitic nematodes are meaningful and novel for mint growers because this suggests that an integrated management approach, using insecticides and insect-parasitic nematodes together, has the potential to significantly improve suppression of Asiatic garden beetle populations in commercial mint fields.

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

This project benefits the broader public by contributing to the continued productivity and sustainability of specialty crop production, a key grand challenge that will continue to be critical for our planet as we strive to feed more people a healthy diet. We are illustrating the importance of applied research and extension for understanding how we approach pest management challenges in real-world specialty crop production systems, providing transparency in the research process, and the importance of partnership with growers and stakeholders in the industry to carry out rigorous research that is important for the sustainability of specialty crop production.

Evaluation of mushroom products in antibiotic-free swine diets

Project Director
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Purdue University Main Campus
Accession Number
1021926

Evaluation of mushroom products in antibiotic-free swine diets - second year update

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

Antibiotics are an important aspect of animal health for disease treatment and prevention. However, antimicrobials used in swine production are under growing scrutiny due to concerns of antibiotic resistant pathogens that may impact both human and animal health and the future effectiveness of antibiotics in treating diseases. This project is focusing on the role that mushroom products can play to aid pig's growth performance and immune function in antibiotic-free swine diets.

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.

Swine production is moving further away from antibiotics, following the trend of consumer desires. Antibiotics are an important aspect of swine production for disease prevention and treatment. Antimicrobials used in feed for the post-weaning pig, such as Carbadox are under heavy scrutiny due to the growing concerns of antibiotic resistant pathogens. The effects of feeding Carbadox to nursery pigs has traditionally shown improved growth performance and feed efficiency compared to pigs fed diets without antimicrobial agents. This has led to research in alternatives to antibiotics like Carbadox due to industry concern over potential monetary losses. One of these possible alternatives is a Chinese herbal mushroom blend of Cordyceps Militaris and Cordyceps Sinensis. These mushrooms have long been used by the Chinese as a human health promoting additive. The particular compound, Cordycepin, found in these mushrooms is currently being studied for it's antimicrobial and antiviral characteristics Based on our first study with this mushroom showing positive results, a dose titration study was conducted to refine the levels to feed to nursery pigs.

One-hundred sixty weanling pigs (18.8 d of age) weighing an average of 13.1 lb were used in a 35 day growth trial. Growth performance was analyzed using body weight (BW), average daily gain (ADG), average daily feed intake (ADFI), and feed conversion as feed-to-gain (F:G). Pigs were allotted by BW with 5 or 6 pigs per pen. There were 5 dietary treatments:, a negative control diet without a feed antimicrobial (but did contain pharmalogical levels of ZnO and CuSo; a positive control diet containing 55 ppm carbadox, , 300 or 600 ppm mushroom powder, and a step down treatment containing 900, 900, 450, 300, 150 ppm mushroom powder weeks 1 to 5, respectively. The 300 ppm mushroom dose was the level that provided a partial positive response in the first study reported last year.

During Phase one of the trial (d 0 to7) there was a tendency for a linear reduction in BW ($P < 0.07$) as the mushroom concentration increased in the diet (Table 2). During Phase 2 (d 7-14) there was a trend for a cubic mushroom response ($P < 0.07$) in ADFI and ADG ($P<0.11$), resulting in a cubic mushroom response in BW at d 14 of age ($P < 0.04$). These cubic responses were caused by the pigs fed the 300 ppm dose having an 8.7**%** increase in ADG and 9.8**%** increase in ADFI above the 0 ppm negative control followed by the lowestADG and ADFI at the 600 ppm level and the 900 ppm dose having a partial recovery of the pig growth performance. Phase 3 (d 14-21) showed no statistical differences in performance among treatments ($P > 0.10$). During the first week of Phase 4 (d 21 to 28), pigs fed carbadox had improved ADG ($P < 0.04$) and increased feed efficiency ($P < 0.02$) over pigs fed the negative control. There was also a tendency for a linear increase in ADG ($P<0.10$) and improvement in feed efficiency ($P < 0.08$) as mushroom concentration increased to 600 ppm. During the second week of Phase 4 (d 28 to 35) there was a tendency for cubic ADFI response ($P < 0.10$) for mushroom inclusion with a 13**%** increase in ADFI at the lowest 150 ppm inclusion followed by a 10.7**%** decrease in ADFI at the 300 ppm level and ADFI then increasing at the 600 ppm level, close to the negative control. Overall (d 0 to 35) pigs fed the 300 ppm diet tended ($P < 0.10$) to have better feed efficiency compared to those fed the step-down mushroom treatment. However, there were no other dietary treatment effects for the overall nursery study.

Carbadox has been well documented in its effects in post-weaning performance. Most industry professionals tend to use some form of antimicrobial in the post-weaning diet. In this current study, Carbadox primarily only improved pig growth performance during Phase 4, the last 2 weeks of the study, resulting in about a 1.1 lb heavier pig over the negative control. It should be also noted the growth performance of pigs in general was very good in this study and is likely related to the small response to the antimicrobial and mushroom product.

It is worth noting that the heaviest pigs in this study were fed the constant level of 300 ppm mushroom (41.6 lb) similar to the Carbadox (41.5 lb) fed pigs. It is also notable that as the mushroom level declined to 150 ppm the last week of the study, the greatest growth performance of all treatments was observed for these pigs. This may indicate with the poorer growth performance earlier in the study by pigs fed 600 and 900 ppm mushroom powder may indicate that these levels may have been too high and may require future evaluation below 300 ppm. Inclusion, the 300 ppm mushroom and step-down treatments were both comparable in results to Carbadox. Therefore, mushroom powder could serve as a possible antimicrobial replacement to Carbadox.

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

Pork producers, nutritionists, and veterinarians are being informed of the potential mushroom products might play in nursery pig diets and may help with producing pigs on antibiotic free diets. As we refine the dosing and durations of these products we can also discuss their economic importance and potentials. When considering the economics of feeding this human grade mushroom product, the 300 ppm mushroom product is slightly more expensive at $35/ton compared $26/ton for the antimicrobial carbadox treatment. However, when feeding the 150 ppm level at the end of the study feed costs were less than the carbadox positive control. So refining a lower dose titration may make the economics more positive for this future antibiotic alternative in pig diets.

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

The public benefit is related to the continued research into opportunities for animal agriculture to reduce their reliance on the use of antibiotics at critically stressful time periods like weaning of a piglet. If we can reduce antibiotic use it may help prevent antibiotic resistance, benefitting both humans and animals.

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 were able to continue with the training of 1 masters student on this project along with 4 new undergraduate students learning about the research process and rigor. Next year we will continue with the evaluation of mushroom products for the nursery pig.

Development and Protection Assessment of Fusobacterial Outer Membrane Protein against Bovine Liver Abscesses

Project Director
Sanjeev Narayanan
Organization
Purdue University Main Campus
Accession Number
1021337

Development and Protection Assessment of Fusobacterial Outer Membrane Protein against Bovine Liver Abscesses

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

Liver abscess is the result of necrotic infections caused by the opportunistic anaerobic pathogen, *Fusobacterium necrophorum* (T. G. Nagaraja, Narayanan, Stewart, & Chengappa, 2005). The rate of incidence of liver abscess in US feedlot is 10-20% annually and affects the economy of feedlot industry (McCoy, O'Quinn, Schwandt, Reinhardt, & Thomson, 2017). According to National Beef Quality Audits 2016, the rate of liver condemnation is 30.8%. Liver abscess results in approximately 50% of liver condemnation in USA(Harris et al., 2018). In severe cases and during trimming, the rupture of abscessed liver needs the entire carcass to be condemned. This contributes to the significant economic loss to the feedlot industry. National Beef Quality Audits summary mentioned "It is evident further improvement is needed with liver condemnation and carcasses with bruising". So far, the antibiotic prophylaxis has been effective in reducing the severity of the disease(Tiruvoor G. Nagaraja, Sun, Wallace, Kemp, & Parrott, 1999). However, the prognosis of liver abscess is poor, and it is late until identified. There is a surge in antibiotic resistance and is inevitable process. Therefore, our **long-term research goal** is to develop vaccines, to minimize or eliminate the use of in-feed antibiotics to prevent or reduce liver abscesses in feedlot cattle.

According to US Feed Additive Compendium (2012) and FDA US Food and Drug Administration 2018, five antimicrobials (bacitracin, chlortetracycline, oxytetracycline, tylosin and virginiamycin) have approval to use to prevent liver abscess in cattle (Bakkelund et al., 2018). However, among these Tylosin has been most effective in reduction but does not completely prevent liver abscess (Tiruvoor G. Nagaraja et al., 1999). There is increased concern among Public Health regarding the use of antibiotics for growth promotion in food animals and increased demand of "No Added Antibiotics" food supply among consumers. Consequently, FDA's Veterinary Feed Directives 2015 has outlined the need of Veterinary authorization and supervision to use the antibiotics in the animal feed. Likewise, the center of Veterinary Medicine of FDA has issued three documents, 'Guidance for Industry' (GFI#152, #209 and #213)- 2017 to implement the changes which make the medically important antibiotics use illegal for production purposes and requirement of authorization from the licensed veterinarians to use them for treatment. These restrictions in cattle farming will likely lead to higher incidence of liver abscess and so in the economy. Hence, a **vaccine that prevents or lowers the incidence and severity of liver abscesses in feedlot cattle will be an appealing alternative to antibiotic supplements.**

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.

Liver abscesses are very common and is the cause of 20.7% of liver condemnation according to 2016 National Beef Quality Audit (Harris et al., 2018). Antibiotic administration is the mainstay to treat these infections, but antibiotic-resistance is unavoidable. Thus, a vaccine could be the best alternative prophylaxis. In most Gram-negative pathogenesis, bacterial attachment to the host cell is a crucial step, therefore Outer Membrane Proteins (OMPs) is an active study area for vaccine development. Our project is aimed towards developing an effective and efficacious vaccine that will prevent infection by most strains of Fusobacterium, the most likely bacterium that causes liver abscesses.

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

F. necrophorum is a Gram-negative anaerobe that causes liver abscesses, necrotic laryngitis (calf diphtheria), foot rot and foot abscesses in cattle. Liver abscesses in beef cattle can average from 12 to 32% in most feedlots. The primary pathogen that causes liver abscesses in cattle is *F. necrophorum* bacterium. The infections by this bacterium in cattle lead to liver condemnation, reduced feed intake, reduced weight gain, and reduced feed efficiency. These strict anaerobes gain access through breaks in forestomach and reach liver through blood to cause abscesses. Until now, use of antibiotic feed additives has reduced the incidence of liver abscesses, however, their usage is discouraged, and in some situations prohibited. The best alternative is to develop a potent vaccine that effectively prevent liver abscesses. An effective vaccine will replace antibiotic tylosin that is currently used in the feedlot industry to control liver abscesses. Hence, with the increased efforts to develop an efficacious vaccine, we have studied two antigens, leukotoxin and OMPs of *F. necrophorum*. In this project, we will evaluate various OMPs present on the surface of *F. necrophorum* that plays an essential role in host cell infection. These proteins, singly or in combination, can serve as a potent vaccine(s) against liver abscesses in feedlot cattle. Vaccine developed in this project could be tested in the future for its ability to provide protection against foot rot, foot abscesses and other infections (metritis in dairy cows) caused by *F. necrophorum*.

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

The National Beef Quality Report 2016 has reported liver abscess rate of 20.7% causing to the liver condemnation. This will affect the feedlot economy and, directly and indirectly affect the consumers. Use of antibiotic feed additives have reduced the incidence of liver abscesses until now, however, their usage is deterred, and in some situations prohibited according to FDA's Veterinary Feed Directive 2015 and FDA's Guidance for industry 2017. The best alternative is to develop a potent vaccine that effectively prevent liver abscesses. An effective vaccine will replace antibiotic tylosin that is currently used in the feedlot industry to control liver abscesses. In addition, this will meet the increasing demand in the domestic consumer market for antibiotic-free organic and natural beef.

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.

A graduate student (Ms. Bista) worked on this project continuously and is responsible for the updates and progress made, and deserves credit for identifying protein targets for vaccine. A post doctoreal research associate (Dr. Hassan) contributed by working on proposals. Dr. Deepti Pillai, Assistant Professor contributed to dissemination of results.

- **Poster presentation**
  Bista, P.K.,*; Jung, H.; Pillai, D.; and Narayanan, S. April 13, 2021. Outer membrane proteins of *Fusobacterium necrophorum*: Potential vaccine candidates. 2021 PVM Research Day, College of Veterinary Medicine, Purdue University, West Lafayette. – Awarded 2nd position

Bista, P.K.,*; Pillai, D.; and Narayanan, S. Dec 3-7 2021. Outer membrane proteins as potential vaccine candidates against *Fusobacterium necrophorum* infections. Conference of Research Workers in Animal Diseases (CRWAD 2021), Chicago, IL. – Awarded 1st position

- **Seminar Presentation**
  Bista, P.K.*, Pillai, D.; and Narayanan, S. March 23, 2021. Potential candidates for vaccine development against *Fusobacterium necrophorum*. CPB697 Research Seminar, Purdue University.

Project Director
Andrea Liceaga
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Purdue University Main Campus
Accession Number
1019794

2021 progress report

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

This project looks at the study of emerging protein sources (e.g., edible insects, chia seeds, canary seeds) to meet global food/protein demand towards the year 2050. The recent COVID-19 pandemic drastically affected food-supply chains worldwide, showing the vulnerability of food security. The need to consider alternative protein sources that can help alleviate global food shortage problems should be prioritized.

Some of these emerging proteins require less resources (e.g., land, water, etc.) than conventional/traditional proteins, making them more sustainable alternatives.

By application of physical and/or chemical processes such as enzymatic proteolysis, microwave heatng, etc., we can modify the physico-chemical structure of these proteins and make them more functional towards food technology applications, as well as increase their biological activity towards human health.

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 activities in this project allowed us to identify potential proteins that meet the criteria listed above. For example, we identified edible insects as one of the major alternative protein sources due to their sustainability and high protein quality. Activities allowed us to extract the protein from edible insect species (i.e., crickets) farmed in the U.S.A. and process them into powders with improved techno-functional properties that will allow them to be used in food and beverage formulations. We also looked at studying the health benefits of the cricket protein & peptides by specifically evaluating their anti-hypertensive, anti-inflammatory and anti-diabetic activities as well as their allergenicity.

We applied optimization methods to extract and hydrolyze protein from canary seeds to develop peptides with anti-hypertensive, anti-diabetic, and anti-obesity properties. Activities such as in vitro evaluation of the inhibition of enzymes associated with chronic disease (e.g., pancreatic lipase, angiotensin converting enzyme, dipeptidyl-4). Other activities included the use of in vivo studies using *Caenorhabditis elegans* and mice models to evaluate the role of these bioactive peptides in preventing oxidative stress and obesity, respectively.

As emerging proteins become more adopted in our diet, concerns persist on their safety in terms of triggering allergic reactions. For example, edible insects are considered a promising protein source and several processing methods are commonly used to improve their functionality in foods and sensory quality. However, their allergenicity remains mostly unexplored. Dr. Liceaga's team has extracted edible cricket tropomyosin, a major insect pan-allergen, to study the effects processing on its immunoreactivity. Using immunoinformatics, her team predicted 31 epitope regions, while proteomic analysis suggested decreased amounts of intact epitope regions in microwave-heated and protease-treated crickets.

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

The target audience benefited from novel information generated from this research in terms of fomenting the study of emerging, sustainable protein sources in food formulation and therapeutic applications in order to advance food security and human health towards the year 2050. Her activities have contributed to the development of efficient techniques to extract the protein from emerging protein sources (e.g., edible insects and novel plant crops such as canary seeds and chia seeds), improve their techno-functional properties for food and beverage formulation, and study their allergenicity and biological activity towards human health.

Audience has received this information in the form of several peer-reviewed scientific publications, conference presentation, radio and newspaper interviews.

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

Broader public will benefit by having access to new protein sources that contain high-quality protein (including all essential amino acids), are palatable (compared to traditional proteins) and posses added health benefits (beyond basic nutrition) such as therapeutic application in prevention of chronic disease. This information has been disseminated via public radio interviews as short communication/press releases through the College of Agriculture as well as local and national newspapers. Another example of the benefits from this project's activities includes the studying of the effects of processing methods on immunoreactivity of these emerging proteins, which will benefit the broader public by providing them with hypo-allergenic, sustainable proteins.

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.

Some of the publications related to this project-fiscal year 2021 include:

1. Urbizo-Reyes, U., Reddivari, L., Kim, K-H., Anderson, J.M., Liceaga, A.M. (2021). Enzyme kinetics, molecular docking, and *in silico* characterization of canary seed (*Phalaris canariensis* L.) peptides with ACE and pancreatic lipase inhibitory activity. *Journal of Functional Foods*, 88, 104892.

2. Hall, F. and Liceaga, A. M. (2021). Isolation and proteomic characterization of tropomyosin extracted from edible insect protein. Food Chemistry- Molecular Sciences, 3, 100049.

3. Nino, M. C., Reddivari, L., Ferruzzi, M. G., & Liceaga, A. M. (2021). Targeted Phenolic Characterization and Antioxidant Bioactivity of Extracts from Edible Acheta domesticus. *Foods*, *10*(10), 2295.

4. Liceaga, A.M., Aguilar-Toala, J.E., Vallejo-Cordoba, B., González-Córdova, A.F., Hernández-Mendoza, A. (2021). Protein from Insects as an Alternative Protein Source. *Annual Review of Food Science and Technology, 13*.

5. Malm, M.G and Liceaga, A.M. (2021). Physicochemical properties of chitosan from two Commonly reared edible cricket species, and its application as a hypolipidemic and antimicrobial agent. *Polysaccharides,* 2, 339-353.

Closing Out (end date 09/07/2023)

The economics of digital agriculture

Project Director
Nathan DeLay
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Accession Number
1019254

Report 2021

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

Effects of data usage and precision agriculture technology adoption on farm profitability remain unclear. Efforts in 2021 were directed at better understanding the economic value of farm data and precision farming 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.

During 2021, I engaged in several research projects directed toward the goals of understanding data and technology value in agriculture. The first was a Purdue AgSEED funded grant to estimate the value of farm data to producers in farmland transactions. Data is often collected by farmer-tenants who use the data to make better management decisions. However, when farmland changes hands, this data rarely remains with the land. The benefits of this data collection are lost for future producers. The value of the data may be capitalized into the farmland asset if it were retained with the landowner and offered to new tenants. To estimate farmers' willingness-to-pay (WTP) for farm data in farmland transactions, I and colleagues developed a survey instrument that presented fictional farm fields to producers with different attributes (including the transfer of farm data) and asked them to state the maximum amount they would pay to rent each field. Surveys were sent out to 5,000 farm addresses in the summer of 2021 and returned throughout the fall. Academic and extension output are currently. being created based on the results. Myself, colleagues, and my graduate assistant also made use of USDA Agricultural Resource Management Survey (ARMS) data to document trends in precision agriculture adoption and estimate the efficiency gains associated with adoption. Several academic papers came out of these efforts along with multiple extension presentations. I also began work on a project to estimate the impact of rural broadband availability on technology adoption among farms. This work will be ongoing through 2022.

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

The target audience (primarily commercial farmers) benefited from these activities by seeing the potential efficiency gains available to them by adopting advanced precision farming systems. This is beneficial for the purposes of benchmarking and forecasting changes in the agricultural industry. Agribusiness stakeholders benefited from these efforts by seeing where commercial producers are heading in terms of data and technology.

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

The public benefits from these activities by better understanding the farming sector and how technology and data are used to raise the food and fiber they consume.

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.

Over the next year, I will continue to research data usage and technology adoption. I will expand my research program to include the effects of rural broadband on technology usage and productivity.

Closing Out (end date 09/07/2023)

Multi-faceted Approaches to Detect, Monitor, and Manage Field Crop Diseases in Indiana

Project Director
Darcy Telenko
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1019253

Multi-faceted Approaches to Detect, Monitor, and Manage Field Crop Diseases in Indiana

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

Both established and new field crop diseases continue to threaten corn, soybean, and wheat production in Indiana. Favorable environmental conditions, such as seen in 2018, can create disease epidemics that lead to significant economic loss and threaten U.S. food security. In soybean, a number of endemic diseases, such as frogeye leafspot (*Cercospora sojinia*), sudden death syndrome (*Fusarium virguiliforme*), stem canker (*Diaporthe spp.*), and many others threaten production in Indiana. In corn, in addition to endemic diseases such as grey leaf spot and northern corn leaf blight, two new diseases pose significant risk. These include tar spot confirmed in Indiana in 2015, and bacteria leaf streak not currently confirmed in Indiana, but found in surrounding states. In 2018, an outbreak of tar spot occurred in Northern Indiana causing losses up to 60 bu/A (personal communication). Bacterial leaf streak may also have significant impacts, particularly in the specialty corn

production. Therefore, the overarching goal of this research program is to provide timely field crop disease detection and management options for new, emerging, and annual field crop diseases. Approaches will include sentinel disease monitoring plots, replicated field experiments, and greenhouse and laboratory experiments.

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 overarching goal of this research program is to provide timely field crop disease detection and management options for new, emerging, and annual plant pathogens. This will include the identification, characterization and development of effective disease management tools in corn, soybean, and wheat. In addition, this research will support Extension outreach activities aimed at increasing the profitability of field crop production systems and providing independent information to Indiana farms about best management options to improve disease control and seed quality.

- Objective 1: Identify, document, and confirm the distribution of field crop diseases in Indiana to advance the understanding of disease potential and improve disease control methods.

- Objective 2: Assess fungicide efficacy and application timing for management of field crop diseases throughout Indiana and evaluate baseline sensitivities and/or development of fungicide resistance.

- Objective 3: Evaluate the integrated management options for the major field crops diseases in Indiana.

Objective 1: A disease survey using a multiscale approach to determine the occurrence and severity of field crops in Indiana was intitiated in May 2021. While working closely with the Purdue Plant Pest Diagnostic lab (PPDL) to make sure all positive field crop disease samples received are documented. Those that were positive for tar spot of corn and frogeye leaf spot of soybean samples were preserved for future population research and fungicide sensitivity testing. In addition, ten corn and soybean sentinel plots were established at five Purdue Agricultural Centers (PACs) for disease detection and monitoring. These included Davis (DPAC), Northeast (NEPAC), Southeast (SEPAC), Feldon (FPAC), and Throckmorton (TPAC). The sentinel plots allowed us to monitor and detect the first appearance of field crop diseases across an array of environments throughout Indiana. The plots were planted at each research station at the end of May or early June with a susceptible variety/hybrid and were monitored weekly for diseases during the growing season. Corn and soybean plants showing disease symptoms were collected and documented. This enabled our ability to monitor and detect the first appearance of endemic diseases and their development, but also capture the potential risk of other disease threats not currently in Indiana. A statewide survey was conducted at the end of the season to determine the distribution and severity of tar spot and southern rust of corn. During the survey fields in Indiana were scouted for tar spot in all 92 Indiana counties.This resulted in the confirmation of tar spot in 82 counties in Indiana, 4 new counties for 2021, but also enabled the mapping of risk based on severity. The survey resulted in southern rust being documented in 73 counties.

Objective 2: Eight fungicide efficacy trials were established during the 2021 growing season (two wheat, five corn, and three soybean). These trials were located in three locations in Indiana - ACRE, PPAC and SWPAC - in order to assess fungicide efficacy in the different regions in Indiana. These trials included nine fungicide programs in wheat, 12-14 fungicide programs in soybean, and 6-12 in-furrow and foliar fungicide programs in corn. Each trial was a randomized complete block design with four replications. In general, field crop fungicide trials relied on on natural infestation for most foliar pathogens, when appropriate pathogen infected sorghum will be used to inoculate plots for soil-borne pathogen assessment. Disease data collection has be completed on these trials and the trials were included in the annual research summary.

In addtion, research has documented the expanded distribution of fungicide resistance to the quinone outside inhibitor (QoI) class of fungicides in *Cercospora sojina* (frogeye leaf spot) in Indiana from four to 29 counties, and developed baseline sensitivity of the population to the demethylation inhibitors (DMI) class of fungicides for future fungicide resistance monitoring.

Objective 3: Three field trials evaluting integrated management of soybean sudden death syndrome (*Fusarium virguliforme*) and two trials evaluating integrated management of tar spot of corn (*Phyllachora maydis*) were intitated in 2021. The trials were established at either ACRE or PPAC. Plots were 4-row (10-ft) by 30-ft long. The two center rows will be used for evaluation and yield. Data collection thus far has included scoring agronomic characteristics and disease ratings (incidence and severity). For all field trials -yield will be collected and data analysis completed this winter. The results from

these trials will help determine the impact of implementing these on improved production, profitability and future success. Successful strategies will then be shared through outreach activites such as Extension presentations, print and digital publications, and Extension outreach materials.

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

Since October 1, 2020, Forty-six presentations were made at workshops, conferences, field days, county Extension meetings to over 6,223 participants to Indiana, national, and international audiences that included farmers, agricultural industry personell, crop advisors, Extension Educators, students, and research colleagues. In a 2021 survey at winter meetings

Knowledge gained from field research and surveys has been shared with Indiana corn growers. This new research is critical in helping guide farmers to implement best disease management practices. . In completed post-presentation surveys (n=111), 62% reported they have changed disease management practices, such as adding fungicide applications for tar spot, scouting, vigilance, and greater awareness of the disease. The adoption of tools and practices include identifying tar spot (71%), scouting regularly (61%), and monitoring annual disease maps (45%). As a result, **79% realized protected or increased yield on their farm, estimating up to 80 bushels per acre, with most reporting 1 to 20 bushels.** Based on what they learned, 73% reported they will increase scouting, increase use of fungicides, and use tools such as Tar Spotter App, models, and efficacy tables next year.

In addion, the survey found that 96.9% have learned something new and o**ver 97% of participants credited Purdue Extension in providing useful and valuable disease management information for their farms**. Of the resources that Dr. Telenko has created 63.5% find useful in-person or virtual presentations, 52.9% disease distribution and activity maps, 51.8% fungicide efficacy tables, 47.1% articles in Pest & Crop Newsletter, 28.2% annual applied research publication, 18.8% field crop pathology Extension website, 12.9% social media posts. Efforts contributed to new knowledge, tools, and practices to address field crop disease management, and continue to quickly and effectively distribute information and results for increased understanding of management options for corn growers.

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

The broader goal of of the project is to promote sustainable and economically sound disease management practices in Indiana field crops. To achieve this goal, an integrated Extension program that uses research-based information to address clientele needs in field crop diseases. This allows for the research to be relevant and applicable to protect food supply.

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.

COVID restrictions continued to limited the amount of training we could offer. We were able to have three undergraduate research interns assist in scouting and data collection during the implementation of this reserach and disease survey. They recieved training on plant disease identification in field crops (wheat, corn and soybean), scout field crops for disease, assisted with research trials and learn how to collect field research data. In addtion, one graduate student completed her degree (M.S.), and four graduate students (2 Ph.D. and 2 M.S.) have initiated their first and continued their second and third year of study in field crop pathology. Each graduate student is studying one pathosystem (tar spot of corn, sudden death syndrome of soybean, frogeye leaf spot of soybean, and white mold of soybean). Each student was able to present a poster at the national American Phytopathological Society annual meeting remotley during the summer of 2021.

Since October 1, 2020, Forty-six presentations were made at workshops, conferences, field days, county Extension meetings to over 6,223 participants to Indiana, national, and international audiences that included farmers, agricultural industry personell, crop advisors, Extension Educators, students, and research colleagues.

Extension publication: Telenko, D. E. P. 2021. Applied Research in Field Crop Pathology for Indiana 2020. BP-216-W. Purdue Extension.

During the next reporting period all field trials initiated in 2021 will have final yield collection and data analysis completed in the winter. These results will be combined with 2019, 2020 and 2021 data to deteremine impact of implementing disease management
tactics on improved field crop production, profitability and future success. Successful strategies will contine to be shared

through
outreach activities such as Extension and reserach presentation, print and digital publications, and Extension outreach materials. In addtion, mansucripts from the initial 3 years of reserch will be pursued, as appropriate. Year four will be initiated on the same objectives listed prior to continue to validate the findings from the first three years.

Closing Out (end date 09/07/2023)

Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

Project Director
Jacquelyn Boerman
Organization
Purdue University Main Campus
Accession Number
1017193

Management systems to improve the economic and environmental sustainability of dairy enterprises

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

We are trying to address nutritional and managment changes that allow for the continued improvement in production and efficiency in dairy calves and dairy cows. We are also trying to make better use of data collected on dairy farms to assist with decision making.

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. We have conducted two calf studies in the past year focused on the role of nutraceuticals on improving health, immunity, and gastrointestinal permeability. This represents our larger goal of judicious use of antibiotics in dairy cattle. We have also collected nasal samples on three commercial dairy farms for the development of a biosensor to detect the causative agent of bovine respiratory disease. Several publications are in progress related to these projects.

2. We have completed an animal study evaluating the effect of an amino acid product on lactating dairy cattle. The study has shown some positive results on amino acid bioavailability, milk fat production, and feed efficiency.

3. We have evaluated muscle mobilization during the peripartient period in two studies and it has resulted in multiple publications. The results have led to preliminary data for a federally funded grant evaluating the effects of amino acid supplementation in the pre-partum period on tissue mobilization post-partum.

4. We have spent the last 18 months developing the Purdue Precision Dairy Ecosystem collaborating with Hewlett Packard Enterprises, Agriculture Data Services (Purdue University) to automate data collection and integration from disparate data sources. This has required a considerable amount of data mapping, programming, and troubleshooting to achieve searchable databases using Jupyter notebooks. This has allowed for additional collaboration and we anticipate a considerable amount of research output from this effort.

5. We have worked on a collaborative project to develop a paper-based sensor to determine the causative agent of bovine respiratory disease in cattle. The goal is for this to be used cow side and supply veterinarians and farmers with information about what is causing the respiratory disease and if and which antibiotic are recommended.

6. We have worked on developing a video analytics system in a pen setting to identify, track and detect attributes of an animal's appearance and behavior. We have been able to predict bodyweight with a video-based system however, we continue to expand the complexity of where we are evaluating animals to try to make it more applicable for dairy farmers.

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

We have published a number of pieces on the physiological changes caused by disrupting the circadian rhythm of dairy cattle. We believe this can be applied to management of dairy cattle to optimize production and minimize health disorders. We have focused on reducing antibiotic usage in animals by evaluating nutraceuticals as a way to improve growth and immune function in dairy calves. Additionally, we have contributed to the development of a paper-based sensor that detects the causative agent for Bovine Respiratory Disease in dairy cattle. This paper-based sensor can be applied to other diseases and has the potential to aid in decision making on farm and reduce the use of antibiotics. We have developed an automated process to collect and integrate data from disparate data sources on farm which will ultimately allow us to answer more complex questions and provide producers with a more complete picture of their problem or question.

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

Our research focuses on understanding physiology of dairy animals to better meet their needs in order to improve production and animal health. Healthy, productive animals increases efficiency and utilizes less resources.

Genomic analysis of tomato genes that function in resistance to Ralstonia solanacearum

Project Director
Anjali Iyer-Pascuzzi
Organization
Purdue University Main Campus
Accession Number
1013630

Results from 2021

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

Bacterial wilt, caused by *R. solanacearum*, is one of the most destructive bacterial diseases of *Solanaceous* species worldwide. The best means of control is through host plant resistance, but the genes underlying resistance are largely unknown. This work aims to identify and understand mechanisms of resistance in plants to *R. solanacearum*. Our objectives are:

Objective 1: Identify genomic regions underlying resistance to *R. solanacearum* strain K60 in tomato.

Objective 2. Identify additional genes with roles in resistance using reverse genetics.

Objective 3: Identify new sources of resistance to US strains of *R. solanacearum* in tomato.

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: Identify genomic regions underlying resistance to *R. solanacearum* strain K60 in tomato. *R. solanacearum* strain K60 is a severe limiting factor to tomato production in the Southeastern United States. We have a mapping population of 188 recombinant inbred lines (RILs) derived from a cross between resistant Hawaii7996 (H7996) and West Virginia 700 (WV). We phenotyped these lines for resistance to *R. solanacearum* using image-based digital phenotyping and performed QTL mapping for aboveground plant wilting. We identified approximately 20 QTL for resistance to R. solanacearum, and several of these QTL had not previously been identified. We anticipate that these QTL may eventually be useful in a breeding program.

Objective 2. Identify additional genes with roles in resistance using reverse genetics. We have previously used RNA-seq analysis to identify genes differentially expressed in resistant and susceptible tomato roots at 24 and 48 hours post infection (hpi) with *R. solanacearum*. We hypothesize that genes strongly activated or repressed after infection have roles in plant defense. We have identified three mutants, each with defects in the auxin response pathway, that have enhanced resistance to *R. solanacearum*. We have also identified two mutants with defects in LRR-Kinases that have altered responses to *R. solanacearum*. We have identified several processes that are important for resistance to multiple strains of *R. solanacearum* in tomato. Finally, we identified the subcellular localization of *R. solanacearum* effector proteins in tomato.

Objective 3: Identify new sources of resistance to US strains of *R. solanacearum* in tomato.

We have identified one wild species, an *S. pimpinellifolium*, with high levels of resistance to *R. solanacearum*. We are currently examining additional tomato accessions to test for resistance.

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

The target audience is plant biologists and plant pathologists. Based on our work, they are able to develop new hypotheses for how *R. solanacearum* proteins function, compare *R. solanacearum* effectors to those of other phytopathogen, and develop new hypotheses for resistance.

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

R. solanacearum is a devastating pathogen of tomato. Understanding mechanisms of resistance will eventually provide the public with more resilient tomatoes.

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.

No changes in the approach.

Opportunities: Seven graduate (PhD) students were trained in 2021 in this work, along with two undergraduates. One postdoc was also trained in this work. Two PhD students and the postdoc gave seminars to the broader plant science community. The two PhD students gave oral presentations at the national American Phytopathology Society conference, and the postdoc gave a presentation at the Solanaceae seminear series at the University of Wisconsin. One graduate student conducted outreach at a community center in Indianapolis to engage high school students. All students attended seminars during 2021.

Links between plant fertility and disease and their impacts on crop yield

Project Director
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Organization
Purdue University Main Campus
Accession Number
1013614

Links between plant fertility and disease and their impacts on crop yield

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

In this project, we proposed to explore the link between fertility and infection and the role of MLO genes in these and other developmental processes important for crop yield. Our research has shown that pollination may use overlapping molecular pathways with pathogen infection, suggesting that using some genetic targets for engineering disease resistance may have unintended consequences of decreasing pollination success and ultimate plant yield. A better understanding of the links

between fertility and infection is critical in order to avoid potential yield losses as new disease resistant plant varieties are developed in response to ever increasing strains on world food security. In addition, MLO genes may be important targets for helping to optimize plant productivity in an ever-changing environment.

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 overall objective of this project is to determine if trade-offs exist between disease resistance and fertility and to explore the functions of MLO genes in plant development and response to stress.

Specific objective 1 is to determine if common molecular mechanisms are used for pollen tube reception and powdery mildew infection.

Our previous research showed that MILDEW RESISTANCE LOCUS-O (MLO) genes are involved in both powdery mildew infection and pollen tube reception during plant reproduction and that the receptor-like kinase FERONIA (FER) is also involved in both processes. In pollen tube reception, the MLO named NORTIA (NTA, also known as MLO7) is sequestered in the Golgi of the synergids until pollen tube arrival, upon which the NTA protein is trafficked to the filiform apparatus at the entry to the embryo sac. NTA accumulation at the filiform apparatus is dependent on FER activity. In the last year, we showed that constitutive accumulation of NTA at the filiform apparatus through a c-terminal domain swap with MLO1 is able to act independently from FER to promote pollen tube bursting and sperm delivery. We hypothesized that for every activity of FER in the plant (including powdery mildew infection) there is a downstream MLO that accumulates at the plasma membrane to boost the FER signal to the extracellular environment. MLO2 has already been shown to accumulate at the site of powdery mildew invasion, we are now testing whether this accumulation is dependent on FER and whether constitutive plasma membrane accumulation of MLO2 enhances powdery mildew infection. In crops, mycorrhizal associations have been shown to dependent on MLO proteins. Thus, understanding how to manipulate subcellular localization of MLO proteins could be used to enhance crop productivity.

Specific objective 2 is to determine the expression patterns of Arabidopsis thaliana MLO genes and to examine mutants in these genes for developmental and stress-related phenotypes.

The Arabidopsis MLO gene family has 15 members. For this objective, we fused each of the MLO promoter and coding regions to the GUS reporter and reintroduced them to Arabidopsis. We stained all stages of plant development for GUS activity in order to determine when and where the 15 genes are expressed during plant development. From these experiments, we determined that MLO15 might be an important regulator of root hair tip growth. Root hairs allow plants to absorb water and other nutrients from the soil and are thus important for plant fitness. FER is a major regulator of tip growth in root hairs. *fer* mutants have short, collapsed root hairs that are not functional. We showed that our constitutive plasma membrane-localized NTA (described in objective 1 results) could complement *fer* mutant root hair phenotypes, indicating that a FER/MLO module is also important for root hair tip growth. We are currently testing the hypothesis that MLO15 is the MLO that acts downstream of FER to promote root hair tip growth using insertion mutants and manipulation of MLO15's subcellular localization.

Specific objective 3 is to determine if phylogenetically-related maize MLO genes share common functions with their Arabidopsis counterparts, or if the function of MLO genes in grasses has diverged from that of dicots.

We chose to focus on objectives 1 and 2 since we first needed to establish more basic knowledge on MLO function in the easily transformable Arabidopsis system before moving into crop species such as maize.

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

Our main target audience is the scientific community that studies plant reproduction, development, and plant-pathogen interactions. We published a paper in Developmental Cell that describes the FER/MLO signaling module during pollination and potential implications in other aspects of plant growth and development.

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

Our project focused on the links between plant reproduction, plant disease resistance, and root development. Understanding these links is vital for for understanding how to improve crop growth and disease resistance without negative impacts on pollination and subsequent crop yield.

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 focused on the Arabidopsis part of the project instead of maize since we were able to make progress on understanding the molecular function of MLO proteins in the easier experimental system. This project will end in September, 2022. By then, we hope to understand the impact of MLO function on root hair development and the importance of this pathway in drought response in plants. This project helped train 2 graduate students and 1 postdoc in the last year and led to a publication in the journal Developmental Cell.

Signaling pathways controlling plant fertilization in tomato

Project Director
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1013606

"Signaling pathways controlling plant fertilization in tomato"

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

Seeds, the products of sexual plant reproduction in flowering plants, are critical factors in crop productivity. With the increase in the global demand for food and the emergence of new agricultural threats caused by climate change, there is an urgent need for rapid innovation in agricultural breeding practices to improve and stabilize seed quality and yields. Achieving *better* outcomes at this scale can be challenging without an in-depth knowledge of the molecular and cellular mechanisms regulating the process of double fertilization and seed development. The project's overall goal is to understand better fundamental processes that regulate the formation of a zygote and downstream mechanisms controlling seed development. This knowledge will allow us to explore new research discoveries to develop innovative breeding tools to improve productivity and the future of 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.

After the research impact of the pandemic during 2020, we made significant progress over the project during the current year. One of the main objectives of this proposal included the functional characterization of TETs and the identification of their interactors in male gametes of Arabidopsis thaliana. The description of the expression patterns of TETs in male and female gametes provided new hints about their functions. In male gametes, TETs seem to function as molecular organizers of signaling complexes and mediate cell-cell adhesion. In female gametes, these proteins may facilitate sperm-egg interactions and communication. We generated double and triple mutants using gene editing or insertional mutagenesis to determine their impact in double fertilization. However, the phenotypes affected early stages of gametophyte development, leading to complete sterility, and impairing further evaluation of their roles after double fertilization and seed development. The research strategy had to be reevaluated, and we are currently testing new promoters to regulate the expression of TETs in later states of sexual reproduction. We expect this new strategy be more productive and increase the chances of identifying phenotypes affecting fertilization and seed development contributing to the discovery of new gamete-specific promoters that can be used to manipulate gamete expression levels or drive gene editing at later stages of plant reproduction. In parallel, we performed a detailed analysis of TETs protein structure and identified several structural motifs that can be used to alter expression or subcellular localization. New mutants or transgenic lines are currently being generated or being analyzed.

We also identified a new sperm TET-interactor (DMP) in Arabidopsis thaliana which was functionally characterized and found to act as regulator of gamete interactions and double fertilization. Mutations in two homologous genes, both expressed in sperm cells, led to impaired sperm-egg interactions, endosperm polyspermy, and haploid induction. The molecular functions of these new factors are still unknown. The proteins do not contain any recognizable functional motifs. We generated overexpression lines and expressed the genes in plant vegetative tissues. Constitutive expression in planta did not reveal any visible phenotypes, suggesting cell type-specific functions (restricted to gametes). We performed a more profound structural analysis and used stable lines in Arabidopsis to purify the protein for activity assays. Preliminary data indicates that DMP factors require interactions with other partner proteins to be functional. We identified potential interactors (protein modifiers) expressed in sperm cells. We are currently analyzing their effects using T-DNA insertional lines and overexpression lines to determine the " activation " mechanism of DMP proteins in double fertilization. Because DMP proteins can induce sperm-mediated haploid induction, they are valuable candidates to be used as breeding tools to accelerate the fixation of desirable traits in new crop varieties or hybrids. The mutant progeny generates haploids and triploids at a frequency of 2.5% and 1%, respectively. These values are at the level of other known haploid inducers in monocot species. Using different strategies (chemical treatment, introduction of mutations regulating endosperm development, and altering the genetic background of the mother plant), succeeded in increasing haploid induction frequencies to 6-8%.

We generated the CRISPR/Cas9 lines for the DMP orthologue of Arabidopsis thaliana expressed in sperm cells of Solanum Lycopersicon (goals 2 and 3). We identified several edited lines and confirmed their phenotypes. Edited plants produced seed progeny according to the presence of haploids and triploids. Our goal is now to test small target molecules, synthetic peptides, or chemicals to target their functions to increase or improve the frequencies of haploid-induction in tomatoes. If successful, these results will open new perspectives for improving current haploid-induced based breeding approaches in other dicot crop species.

We are also testing a new methodology as a transient expression system that will verify the expression and function of gamete factors in pollen of crop species such as Solanum Lycopersicon. If successful, this strategy will allow us to evaluate *in vitro* functional alterations of specific sperm cell factors and ultimately determine their functions in double fertilization in a crop species instead of using Arabidopsis thaliana stable lines. This strategy will reduce the required time to test new functions or the effect of multiple factors in gamete function.

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

This past year Dr. Boavida was directly responsible for advising and supervising two graduate students (Ph.D.) and five undergraduate research projects. The students were trained in general laboratory techniques, plant biology, and genetics in model species and crop plants. Students presented their results in the Ag Undergraduate Research Symposium and Purdue Summer Virtual Research Symposium.

Information related to the project were disseminated to researchers through presentations in departmental seminars.

2021 "Sperm cell factors in plant fertilization: more than meets the eye." Arizona University, Department Seminar Series, April 28. *Invited seminar (Virtual)*.

2021 "Tearing down barriers in plant fertilization: New insights from sperm cell factors." Donald Danforth Plant Science Center, Scientific Seminar Series, March 24. *Invited seminar (Virtual)*.

As a result of the lab expertise and research, the PI was invited to join an International Research consortium (MAD) **(H2020-MSCA-RISE-2019)** – "Mechanisms of Apomictic Developments" – This Collaborative project involves 13 international research groups (France, Italy, US, Argentina, Australia, Belgium). Current collaboration with Lucia Colombo (female sporogenesis and gametogenesis, University of Milan) Silvina Pessino (apomixis, CONICET).

Three publications are currently in preparation for submission. A provisional utility patent is planned to be submitted exploring methodologies to increase haploid induction mechanism in crop species.

The PI contributes as an Ad-hoc Reviewer for European and National grant funding agencies and multiple international scientific journals**.** In addition, the PI is a Review Editor in *Frontiers in Plant Science* (section *Plant Cell Biology*) and is a member of the editorial board of *Scientific Reports*.

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

Research discoveries were disseminated or communicated via social media platforms (Twitter, Facebook, ResearchGate and lab webpage). The PI is currently developing and working in collaboration with AgIT, the Department, faculty, and undergraduate students to build a "Plant Digital Imaging Website" and launch a podcast aimed to promote Plant Science

educational engagement and support BPP educational and outreach activities.

Regular activities during Spring Fest were postponed in 2020/2021. Dr. Boavida's lab will resume the activities "The minuscule world of Pollen" and "Be(e) a pollinator" during the 2022 Spring Fest.

The function and regulation of STN kinases in plant photosynthesis

Project Director
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1013608

2021 Progress Report

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

Two serine/threonine protein kinases phosphorylate plant photosystem II (PSII) in light. Our project seeks to understand the consequence of this phosphorylation on PSII light harvesting function and light-induced turnover. We also examine how PSII kinases are regulated by light and redox signals.

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.

A pair of proteins known as state transition 7 and 8 (STN7 and STN8) phosphorylate the peripheral antenna and internal core proteins of PS II in light. When phosphorylation occurs on the peripheral antenna, the antenna moves towards the other photosystem, photosystem I (PS I), and shares some of the absorbed light energy in a balancing act known as state transitions. How core protein phosphorylation affects PS II function and turnover, in contrast, remains a critical knowledge gap in our understanding of PS II. The aim of our research is to test the hypothesis that core phosphorylation causes antenna and core disassembly to minimize the excitation pressure and facilitate the repair of damaged PS II. Our recent results show that phosphorylation is required for monomerization of the dimeric PSII cores. Our recent data also reveal a novel phosphoprotein in PSII called PsbL, which is likely to have some role in the disassembly of dimeric cores into monomeric cores. We are currently testing this possibility in the model plant *Arabidopsis thaliana*. Results from our lab also show a hitherto unappreciated role for damage in PSII disassembly. The light-induced damage to PSII usually manifests as oxidative modifications of key amino acid residues. Using mass spectrometry, we have mapped these modifications and our preliminary analysis shows that oxidative modifications of amino acids at the interface of key subunits likely drive the disassembly of PSII. In support of this hypothesis, we have recently demonstrated that incubation of thylakoids with H2O2 results in the disassembly of PSII. It is likely that the oxidative modifications function in concert with core phosphorylation for the controlled disassembly of PSII. Another key objective our project is to understand how light and redox signals regulate PSII kinases. Towards this objective, we have recently determined the redox potential of the lumenal and stromal thiol-disulfide switches in STN7. The redox potential of the stromal cysteines is consistent with it being reduced by the stromal reductant thioredoxin. We are currently testing this hypothesis with recombinant Arabidopsis STN7 and thioredoxin f proteins. Based on the redox properties of the STN7 cysteines, we have arrived at a regulatory scheme for this key regulatory protein of plant photosynthesis. We are drafting a manuscript to report these novel observations.

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

In photosynthetic community, our research advances the understanding of plant PSII structure and function. Our research has shown the requirement for core phosphorylation in the monomerization of PSII, identified a novel phosphoprotein in PSII, revealed a hitherto unrecognized role for damage in PSII disassembly, and proposed a new regulatory scheme for STN7 based on its thiol redox switches. Our results have been communicated to the photosynthetic community through publications, talks, and posters. Our project has also trained a postdoc, a graduate student, and two undergraduate research associates.

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

Our research has revealed new fundamental insights into PSII structure and function. This new knowledge created would inform the genetic engineering approaches to create a light tolerant PSII and thereby crop plants with high photosynthetic efficiency and productivity. Strategies to increase photosynthetic efficiency will be essential to address a looming agricultural crisis caused by climate change, population growth, loss of arable land, and increased mandate for biofuels.

Global Food Security and Hunger: Facing the Challenges of Sustainably Feeding a Growing Planet

Project Director

Julie Huetteman

Organization

Purdue University Main Campus

Accession Number

7000099

Beginning Farmers Create Plans, Analyze Finances, and Connect with Other Farmers

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

In Indiana, more than 23,000 farmers self-identified as beginning farmers, having less than 10 years of experience producing food, feed, fuel and/or fiber. These farmers were in rural and urban areas, were young or old, and often used a myriad of production systems. Numerous people who farm on small acreage lands struggle to make ends meet and often begin farming without spending intentional time understanding the realities of what it means to own (and be successful on) a farm or ranch. Beginning farmers need to better understand their goals and objectives, assets and challenges, and how to move forward, to address uncertainties and lead to better success.

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.

A seven-week virtual Beginning Farmer program was delivered to over 30 participants. The program covered topics to help aspiring and beginning farmers better define their objectives, understand their assets and challenges including issues related to land, finances and social capital, access and analyze markets and create action plans. In addition to instruction, participants had the opportunity to connect with a number of supporting agencies and interact directly with farmers to hear about their experiences developing and evolving their farms.

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

Program evaluation respondents indicated that, based on their participation in the program, they planned to apply the following practices: create a farm plan (29.2%), create a business plan (29.2%), analyze potential markets (20.8%), and analyze farm finances (20.8%). Additionally, 44% indicated that, as a result of attending the program, they developed relationships and connections with farmers, producers, participants and people interested in diversified farming and food systems.

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

The virtual Beginning Farmer program helped new farmers create a farm plan and business plan, analyze potential markets and farm finances, and developed connections with farmers and producers.

Beginning Farmers Learn to Grow Their Operations

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

The average age of Indiana farmers is increasing as documented by the USDA Census of Agriculture (55.5 years old in 2017 vs. 53.9 years old in 2012). Beginning farmers replacing retiring producers need additional knowledge to effectively manage agricultural production systems, understand risk management tools, and use business management skills.

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.

A statewide team of Purdue Extension Educators adapted an agronomic / farm management program from the University of Nebraska Extension, “Grow Your Farm Operation”, targeting farmers with less than five years of experience. The eight-session virtual series taught farm principles, including 1) Drones, yield maps and precision soil mapping, 2) Financial management of my farm business – how to manage your farm operation with resources, profit + loss reports, balance sheets, overall planning, 3) Corn, Beans, and Eyes in the Sky - Identifying Crop yield limiting factors, 4) Commodity Marketing – reading trend lines, basics and goals, 5) Integrated Pest Management – Weeds, Insects, and Plant Disease Management, 6) Communication – Conflict modes, learning how you and others handle conflict, 7) Legal Do's and Don’ts – 90 useful tips for risk management and planning, and 8) Diversification in farming operations– Farmers share how they diversified their operations. Twenty-four individuals across Indiana participated in the series.

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

Between 8 and 20 participants responded to on-screen polls during the virtual series. With average scores of 8.0 or higher (10-point scale) they indicated increased knowledge of: basic estate plans (8.83), financial threats from death taxes and nursing home care (8.75), farm rental contracts (8.75), succession planning (8.58), identifying corn yield limiting factors (8.5), establishing goals for marketing my grain (8.38), precision soil mapping (8.35), commodity futures and futures trading (8.13), soil measurement techniques (8.05), and maximizing corn plant populations (8.0).

Participants indicated they had gained at least one new idea to improve the financial management of their farm business (8.73), and overall management of their farm business (8.73). All respondents indicated they plan to learn the conflict styles of others and use different conflict-handling modes accordingly, and most (71.4%) better understand how to use all five conflict-handling modes in their business and family.

In a two-week follow-up survey, nine respondents indicated these sessions were the most useful: Commodity Marketing, Financial Management, and Legal Do's and Don’ts. Participants shared the benefit they experienced. Commodity Marketing “discussion of strategies on when to sell grain was useful.” In Commodity Marketing, “the presenter’s use of current ag charts was a great way to illustrate some fundamentals of grain market trends. This again was a session focused on mentoring me as a farmer though a specific task.” Financial Management “was one of the most beneficial sessions to me. I am trying to do a good job maintaining my financial records, and this helped me fill in the gaps in my process. This session was directly related to activities I am doing or need to do on the farm.” Legal Do’s & Don’ts “was one of the best. Would also have been good to focus on cash rent contracts, but these items were well integrated into the presentation. Not sure how he used random points to pull together such a wide range of details down to the farm level activity. Great presentation!” Legal Do’s & Don’ts “tips on estate planning were very helpful.”

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

With the information from Purdue Extension’s Grow Your Farm Operation virtual series, beginning farmers across Indiana increased their knowledge of farm financials, commodity marketing, and legal issues for managing their operations.

Butcher Basics Participants Learned Meat Processing During Pandemic-Induced Supply Crisis

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

The pandemic revealed and exacerbated supply chain management between meat animal production and meat harvest facilities. When large meat packing facilities were forced to halt production, producers had no outlet to harvest their meat animals. This placed an overwhelming demand and significant strain on smaller-scale meat processors. As a result, small-scale processors drastically increased their capacity, livestock and poultry producers moved to direct marketing, or others developed their own processing facilities. However, lack of skilled labor in meat science, food safety, and economic development limited these activities. Meat science education is generally not available outside of university settings. Lack of meat science education results in poorly prepared meat industry workers, inexperienced meat animal producers, and under-educated consumers in animal harvest, carcass fabrication, meat quality, and food safety.

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.

Purdue Extension and the Purdue Boilermaker Butcher Block developed an interactive, hands-on meat lab program. It included speaker presentations and videos on the science and procedures of harvest, food safety, fabrication, and processing of red meat and poultry species. The “Boiler Butcher Basics” series was implemented with two-day programs each for Beef, Pork, and Lamb/Goat, and a one-day program for Poultry.

In this hands-on training, participants learned how to:

- harvest meat animals (Beef, Pork, Lamb/Goat, and Poultry) for food production,
- execute proper carcass cutting techniques into wholesale and retail cuts,
- produce processed meat products (e.g., sausage, ground meats, bacon, jerky),

They learned about:

- biochemical reactions occurring during production,
- factors contributing to meat palatability and methods to enhance palatability,
- food safety hazards associated with meat products and the procedures to mitigate these hazards, and
- small business management fundamentals for meat processing.

Each session started with personal and food safety information in the classroom. Then participants went into the meat lab harvest floor where animals were harvested and processed. Carcasses were chilled, then later that day for poultry, or on the second day for all other species, participants completed fabrication, breaking the carcasses (or previously harvested carcasses) into cuts of meat, sausages, and ground meat.

Participants could choose which sessions to attend. A total of 47 participants took part in the series, and some attended multiple sessions, with: 12 attendees for Beef, 9 for Pork, 12 for Lamb/Goat, and 14 for Poultry. Participants were non-Hispanic (87.5%), White (82.6%), male (63.0%), and age 40-49 (30.4%). They reported attending to be able to have higher quality or healthier meat, to do meat processing for themselves, to add meat processing on their own farm, or to expand or increase production at existing processing facilities.

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

Participants completed pre- and post- surveys to report their knowledge of, and confidence to perform, animal harvest techniques, carcass processing techniques, food safety procedures, and species-specific processing (Beef, Pork, Lamb/Goat, and Poultry).

Participants rated their knowledge (0-Not Knowledgeable to 10-Extremely Knowledgeable) and their confidence to perform (0-Not Confident to 10-Extremely Confident) for these topics:

- General animal harvest techniques,
- General carcass processing techniques,
- Food safety procedures, and

- Species specifics.

Knowledge average scores increased for all topics: animal harvest techniques (93%), carcass processing techniques (104%), food safety procedures (97%), and species-specific (159%). Participant increases in knowledge ratings (10-point scale) varied from pre to post by species. Participants in the Beef session (pre 5.3-post 7.9) started with higher levels of knowledge and increased that rating over 2 points. Participants in all other species sessions started with ratings at 3 or 4 and increased by 3 to 5 points (Pork 4.4- 7.4, Lamb/Goat 3.4- 8.1, Poultry 3.0- 8.5).

Confidence to perform average scores increased for all topics: animal harvest techniques (81%), carcass processing techniques (81%), food safety procedures (83%), and species specifics (104%). Participant confidence to perform ratings started a bit higher than their knowledge ratings, but ended up with similar ratings (Beef 5.6-8.0, Pork 5.0-7.4, Lamb/Goat 4.1-8.2, Poultry 3.4-8.5).

Participants reported that they intend to use knowledge and skills gained to seek out opportunities to expand livestock / meat operations (44.7%), adopt meat quality and food safety skills to livestock / meat operations (38.3%), maintain a career in meat industry (19.2%), and seek a career (14.9%).

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

Purdue Extension contributed to increased knowledge and confidence for those interested in processing meat for themselves, their farm, or their processing facility, to increase meat processing during pandemic challenges of supply chain availability and costs.

Indiana Families Prepare the Next Generation for the Future of their Farm Operations

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

As Indiana farm families face the issue of transferring the farm to the next generation of operators, the need for information and resources has become crucially important for the smooth transition of the business. Ultimately, nothing can be scarier to the incumbent generation than to inherit farmland without any plans for the future.

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 help those currently facing inheriting farmland, Purdue Extension adapted a program from the University of Nebraska Extension, “So You Inherited a Farm, Now What?” via two online, evening sessions. Presentations addressed land values and trends, types of leases, communication strategies, succession planning, and legal issues (provided by an attorney). Some 84 participants attended live sessions, 25 viewed the first session recording, and 45 viewed the second. By offering this online program, absentee landlords owning property within the state, but who were not located in Indiana, could participate.

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

Within nine months after the program, five participants reported they had developed a succession plan, two had completed risk assessments of their business, and one had adopted formal written land leases.

Participants (43.8%) revealed that they had made additions or changes to their farming operation or land rental, including these: am in process of gifting land to family members, transferring ownership to grandson who works on the farm and cash renting from him as an income source, lease changes, more frequent communication, in process of changing the trustee, and changed some land titles.

Most (83.3%) stated changes they made led to improved financial outcomes for their farming operation or land rental. A quarter (21.4%) estimated financial impact of the program to their farming operation was greater than $10 per acre.

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

Purdue Extension’s So You Inherited a Farm, Now What? helped Indiana families prepare for the next generation to take on the farm operation. As one participant stated “We had inherited the farm several years before I attended the seminar. The result was that many of the topics discussed were ones we had already addressed or had already researched. The seminar did give

me some resources for future reference and did hammer home the importance of communication and family cohesiveness."

Indiana Small Farm Conference Impacts Knowledge, Networking, and Adoption of Practices

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

Small farms, based on area (acres) are significant in Indiana. Over the last 30 years, according to the U.S. Census of Agriculture, the number of Indiana farms has decreased from 70,506 in 1987 to 56,649 in 2017. During that time, the only farms to increase in number, other than farms of 2,000 acres or more, are farms with 49 acres or less, which increased from 20,544 to 26,287. Furthermore, farms with fewer than 180 acres represent 71% of Indiana farms. Unlike many Indiana commodities, the only types of farms that increased in number have been vegetable, fruit, some livestock farms, and organic farms. Additionally, according to the 2017 census, Indiana has 23,262 producers who identify as new or beginning, defined by USDA as having farmed for 10 years or less. These numbers indicate there is a market for small-scale agriculture production in Indiana and there are farmers filling this demand. The Indiana Small Farm Conference provides education and an opportunity for peer networking for these small and beginning farms in a state that has traditionally lacked 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.

Now in its ninth year, the Indiana Small Farm Conference is the annual education and farmer-to-farmer networking event for the small-scale and diversified farming community. The event features nationally-recognized keynote speakers, all-day workshops and tours, concurrent sessions on research and practices, trade show, and poster session. Conference goals are: 1) educating and increasing awareness among attendees on a variety of topics in agriculture, 2) increasing the adoption of best practices, and 3) bringing a variety of people together, creating a space for networking, and increasing collaboration.

Due to pandemic restrictions, the conference was modified to virtual delivery via Microsoft Teams. Pre-conference activities included six pre-recorded farm tours. Conference sessions were from 9 to 5 on two days, with the first and last hours reserved for the virtual trade show. There were two-hour topic sessions and hour-and-a-half sessions for keynotes. Topics presented were regenerative agriculture, crop and livestock production, business & marketing, and urban agriculture. Based on feedback from previous participants, separate sessions offered beginning or advanced information. Youth engagement options were available. Sessions were recorded and made available allowing participants to see all content. A mental health channel provided resources to all, even those who had not registered.

A total of 285 adult and 7 youth attendees took part. A post-survey was sent to 313 email addresses for adult attendees, exhibitors/vendors/sponsors, poster presenters, and Purdue Extension personnel. There were 98 post-surveys received. Half of survey respondents were attendees. Participants reported they were non-Hispanic (89.2%), white (81.9%), female (57.8%), age 30-39 (22.9%), and had Bachelor's degrees (34.9%). Over half indicated they currently farm (62.7%), and farm less than 10 acres (57.7%). Over a third (35.8%) reported being affiliated with a minority- or women-led organization, farm, operation or group. They reported their farming skill level as intermediate (33.8%), advanced beginner (25.4%) and experienced (21.1%). Over half (58.5%) had attended the conference in the past.

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

As a result of the conference, adult participants reported they learned about: sustainable practices and technologies (72.3%), diversified farming (57.8%) and crop production (54.2%). Most (67.4%) reported learning about available assistance and/or technical support, Purdue Extension (86.2%), and USDA/NRCS (69.0%). Even though this was an online conference, over half (52.3%) developed relationships, interacted, or connected with other farmers, producers, participants, or people interested in specialty crop farming.

Three-quarters (72.1%) agreed/strongly agreed they had learned about opportunities for small-scale farmers, producers, and operations/organizations, and 79.1% planned to apply one or more ideas learned. Participants (53.9%) reported plans to include information learned into their developing business plan. There were 14.0% who indicated plans to start a new business within the next year. Despite the virtual setting, many (43.7%) reported they developed relationships, interacted or connected with other farmers, producers, participants, and/or people interested in specialty crop farming during the conference. Participants rated their satisfaction with a +11 Net Promoter Score, which is considered a good rating. Most (75.0%) indicated the conference was inspiring.

In a 9-month follow-up evaluation from 2020 (71 surveys received), a majority (69.2%) reported adopting recommended practices related to farming, producing crops, raising livestock, and sustainable practices and technologies. Results experienced from those adopted practices were conservation of resources, increased yields, and increased efficiencies. Some (35.4%) reported adopting recommended practices related to business planning, finances, or marketing, and most (53.4%) reported those practices were very or extremely helpful. Over half (56.7%) reported they shared relevant information learned at the conference with others.

There were 22 previous participants with paired data for the 2020 post- and 9-month follow-up surveys related to adoption of practices. Most (86.4%) who ***intended to adopt*** recommended farming practices, reported they ***did adopt*** these practices for farming, producing crops, raising livestock, and sustainable practices and technologies. Previous participants (41.7%) who ***planned to adopt*** recommended business practices, reported they ***did indeed adopt*** those practices.

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

Results show the Indiana Small Farm Conference is reaching its goals and contributing to knowledge, networking, and adoption of practices for small-scale farming operators and enthusiasts across the state.

Purdue Extension and Agricultural Centers Events are Valued Resources for Indiana Farmers

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

There are 56,800 farming operations in Indiana. Some 97% of Indiana's farms are family-owned. Of Indiana's roughly 23.3 million acres of land, 84% of it is farms, forests and woodland. Corn ($3.16 billion) and soybeans ($2.84 billion) account for the largest value of sales for Indiana's commodities. Successful and sustainable production requires attention to a vast array of variables, including, but not limited to, soil health, water availability and access, prevalence of weeds, insects, invasive species, and diseases, and seasonal and weather variability. The need for access to, and understanding of, new technologies and management is great for Indiana's producers and the future of crop production. It is prudent for Indiana to protect its resources and support productivity of the land, farms, and operations.

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 were 67 hours of instruction provided by Purdue Extension at nine events held at the Purdue Agricultural Centers (PACs) for commodity producers, crop/livestock advisers, and others seeking knowledge in crop and produce production, farm management, land use, and small-scale farming/gardening. Most events returned to in-person events as pandemic safety guidance opened up more opportunities for gathering, although there was one event that provided virtual programming. These PAC events were: Indiana Grazing Schools at SIPAC and Cutler, Pinney PAC Crop Diagnostic Training, NEPAC Crop Diagnostic Workshop, SWPAC Virtual Field Day, NEPAC Organic Field Day, Pinney PAC Vegetable Field Day, Pinney PAC Field Day Morning Session and Twilight Program, NEPAC Field Day, and Pinney PAC Crop Diagnostic Training.

Topics addressed in these events included:
Livestock: Animal nutritional needs and forage quality, Extending the grazing season, Fencing and watering, Forage types, growing forage, grazing systems, Integrating Livestock into cropping systems, Paddock design, Pasture evaluation and recordkeeping, and Plant-induced forage disorders
Crops: Agriculture economy outlook, farm budget update, Corn and soybean updates, early season growth and development, late season development and harvest, Manure, manure application field research, and manure and fertilizer regulations for Indiana, Marketing for organic grain, and preparing for organic inspections, Soil care, fertility, testing, and nutrient management, strategies for reduction of nutrient losses, Sulfur and boron fertilizer considerations in corn, and Stored grain management.
Diseases, Pests, and Weeds: Cover crops for weed management in organic sweet potato and in the home garden, and management after winter rye cover in no-till systems for corn and pumpkin, Cover crops and soil health, Crop diseases update, disease management in organic field crops, and in corn and soybeans, Efficient crop scouting using drone assistance, Managing resistance of fungicides, Minibulk regulations and pesticides, Pros & cons of insurance pest management, the new IPM, Weed management, and Wildlife damage of crops.
Produce: Making and using compost in the garden, Managing two spotted spider mites on cucumbers in high tunnels, Soil health practices and compost amendments for pepper production, Vegetable storage and cooking winter squash, and Winter

squash culture and varieties.
Safety: Basic first aid/CPR, Farm truck regulations, Grain entrapment/bin simulator, Pulling out stuck trucks and equipment safely.

A total of 792 participants attended the nine PAC events. There were 329 participants who completed post-surveys, a 41.5% response rate. Participants reported they were White (92.5%), non-Hispanic (88.8%), male (85.9%), and age 50 or older (62.7%). At these PAC events 556 participants were informed about field crops, 590 participants were informed about crop production issues, 619 participants were informed about agronomic management practices, and 677 participants were informed about agronomic issues.

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

Participants answered the Net Promoter Score® items: On a scale of 0 to 10, how likely are you to recommend this program to a friend, colleague, or family member, and What is the primary reason for your score? The NPS® is a measure of customer loyalty that helps inform decision-makers of the experiences they are providing. Loyal, passionate customers engage more, are willing to pay more, contribute suggestions, and share praise of the organization to friends and colleagues.

For all events combined, the NPS® calculated score was +37 (on a scale from -100 to +100) and is considered a good rating. Promoters (those selecting 9 or 10) shared these reasons for their scores: Events were very informative and provided excellent information (always good/excellent, good/great), They learned new things, learned a lot, or gained a lot of knowledge, They liked the content that was provided, and listed specific topics of interest, The presenters were knowledgeable and amazing, enthusiastic, excellent, good, great, The events provided practical, useful, helpful, and valuable, advice, tools, resources and information, They enjoyed it and indicated it was an interesting experience, and, They liked networking and connecting with their neighbors and other farmers.

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

These Extension and Purdue Agricultural Centers events contribute valuable and practical information for farmers across Indiana as these activities are very informative opportunities, provide practical, useful, helpful and valuable tools and resources for learning, feature knowledgeable, amazing, enthusiastic, and excellent experts, are enjoyable events, and support and enhance networking and connections among farmers.

Critical Issue

Human, family, and community health and well-being

Examining Substance Use among Young Indiana Adolescents Within Families Experiencing Homelessness/Housing Instability

Project Director
Yumary Ruiz
Organization
Purdue University Main Campus
Accession Number
1022950

Examining Substance Use Among Indiana Adolescents

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

Substance use in adolescents is associated with adverse outcomes throughout the life-course including risks for psychopathology and mental health problems as well as the continuation of substance use into adulthood. Early substance use has also been linked to poor academic outcomes such as missing school, long-term learning impairments, poor school functioning, and lower academic achievement. Several factors can contribute to early substance use including having favorable expectancies towards substance use, low self-esteem, poor cognitive functioning, poor decision-making skills, and exposure to parent and peer use. More recently, there is good reason to believe that substance use may be increasing among adolescents due to COVID-19 related stressors such as the strain of social isolation, overexposure to family conflict, loss of supportive relationships, loss of routine and healthy outlets, and gaps in health care access.

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.

Important to highlight that during the grant period the project needed to **pivot and adjust due to the COVID-19 pandemic**. Originally, the project was going to recruit from the PALS program, a physical activity- PYD life skills program offered to Tippecanoe County youth from low-income families between the ages of 9-14. Like most programs in 2020, the PALS program was canceled due to the COVID-19 pandemic, unfortunately, unlike other programs, the PALS program has remained canceled.

The following has been accomplished:

1. Identified new project partner/community collaborator: The COVID-19 pandemic has exacerbated disparities and hardships faced by low-income families which have led to rising rates of mental health problems among youth including depression and anxiety, two risk factors that have been linked to increasing young people's risk of engaging in maladaptive coping behaviors such as substance use, A new partnership /collaboration has been developed with Family Promise of Greater Lafayette, an organization that provides housing and case management to families experiencing homelessness/housing instability. This partnership provides the project an opportunity to explore substance use among youth from the perspective of the most vulnerable families in Tippecanoe County.

2. **Collected data with the new community partner, Family Promise of Greater Lafayette:** To understand factors that may affect substance use among youth who are living through the COVID-19 pandemic and whose families are in housing crises we are collecting data from organizational staff that provide services to these families as well as caregivers from families in crises. Specifically, these efforts seek to learn the needs, stressors, and coping mechanisms of families experiencing homelessness/housing insecurity and how COVID-19 has impacted these factors.

3. **Collected data:** Both quantitative and qualitative data are being collected from organizational staff and caregivers of families in housing crises. To date, 15 organizational staff members have participated in semi-structured in-depth interviews and 13 caregivers have completed surveys and participated in semi-structured in-depth interviews.

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

Nothing significant to report

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

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.

The COVID-19 pandemic has resulted in significant disruptions and challenges to the project that has required changes in the approach taken.

1. **Due to COVID-19, the project could not take place at and with our original community partner, PALS**. As mentioned above, originally, the plan was to recruit from the PALS program, a program offered to Tippecanoe County youth from low-income families between the ages of 9-14. Like most programs in 2020, the PALS program was canceled due to the COVID-19 pandemic, unfortunately, unlike other programs, the PALS program *has remained canceled*. ***Plan to resolve challenges:*** We identified a new community partner, Family Promise of Greater Lafayette. Because the pandemic has exacerbated disparities and hardships faced by low-income families our new partnership with Family Promise of Greater Lafayette will allow us to understand how COVID-19 has impacted the needs, stressors, and coping mechanisms of the most vulnerable low-income families in Tippecanoe county, those struggling with homelessness or housing instability.

2. **Data collection Delays**. Prior to COVID-19 our data collection timeline involved collecting data with PALS youth and program mentors to greater understand the factors that influence substance use prevention and use in PALS youth. ***Plan to resolve challenges:*** We have pivoted and are now collecting data from organizational staff that provide services to families in housing crises and caregivers from families in housing crises. To understand how COVID-19 has impacted these vulnerable families needs, stressors, and coping strategies. For instance, it will allow us to learn if youth are engaged in maladaptive coping behaviors such as substance use.

3. **COVID-19 challenges.** We expect to continue to face challenges due to the COVID-19 pandemic including recruitment and data collection challenges. We also anticipate that the pandemic will result in the growth of positive cases among families, closures of the partner site (Family Promise), restrictions put forth by our partner site and by Purdue University. ***Plan to resolve challenges:*** We are continuing to meet and work with Family Promise. We have also taken steps to expand our partner network.

4. **Establishment of Partner Network:** In addition to working with Family Promise of greater Lafayette, we have developed new partner relationships with other community agencies that serve adolescent populations and their families including (1) The Lafayette Salvation Army which offers numerous services including adult drug rehabilitation centers to support families combating drug addition (2) Bauer Family Services offers family and youth centered programs focused on reducing child abuse and neglect through programming that strengthens families, (3) Food Finders Food Bank provides food assistance to families struggling with food insecurity, and (4) YMCA which offers youth programming at many of its sites.

5. Provided Research Mentorship, Training, and Professional Experience to Undergraduates: Through our study with our new community partner, Family Promise, we have provided mentorship, training, and professional experience opportunities to a number of students (2 graduate and 10 undergraduate students) who have been involved in the project through a combination of credits, paid work, and internships. Project PI (Dr. Ruiz) has provided significant ongoing training to the research team including training on IRB procedures, research ethics, informed consent, and engaging in data collection. In total, the project has provided research experience to 2 graduate and 10 undergraduates, of which 42% are from underrepresented minority groups and 92% are women. Undergraduate students are matched with graduate students to provide mentorship in the tasks they participate in. Undergraduate students have been largely engaged in recruitment efforts, lab administration tasks, conducting literature reviews, transcription of qualitative data, all of which have contributed to their professional development in research. We have supported students through external programs (Office of Undergraduate Research (OUR) Scholar and the Louis Stokes Alliance for Minority Participation Program (LSAMP) that offer students additional professional and research development.

Vitamin D, Obesity and Chronic Disease Prevention

Project Director
Dorothy Teegarden
Organization
Purdue University Main Campus
Accession Number
1019822

2021 Hatch Progress Results

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

Although mortality rates for breast cancer have dropped significantly (estimated 91% five-year survival rate), the majority of cancer deaths are a result of metastasis. Further, metastasis has been considered a late stage of cancer progression, however emerging results suggest the potential of metastasis occurring very early, even before tumor formation. Therefore, our project is focused on identifying the mechanistic bases of targets in order to develop safe and effective recommendations to prevent metastasis even before diagnosis as well as following therapy may be a key method of reducing mortality in breast cancer, and potentially extended to include other cancers.

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 of the project The overarching objective of Dr. Teegarden's research is in preventing chronic disease, including cancer. Vitamin D is a promising agent that studies suggest inhibits breast cancer from early progression to metastasis.

The **objective** of the proposed studies are to determine the mechanistic basis by which vitamin D inhibits breast cancer progression, including overall and specific steps (surviving extracellular matrix (ECM) detachment and migration) of metastasis. Our overall **hypothesis** is that vitamin D specifically inhibits energy metabolism necessary for breast cancer cells to progress and metastasize (metabolic plasticity).

We have made significant progress towards these goals in relationship to vitamin D, as well as general cellular energy adaptations in breast cancer cells. We have demonstrated that the active form of vitamin D inhibits the ability of cancer cells to survive in conditions where they are not able to attach to the extracellular environment (ECM detached conditions) due to the down-regulation of the protein pyruvate carboxylase (PC). PC regulates the flux of the glucose produce pyruvate into the energy-producing tricarboxylic acid (TCA) cycle. The downregulation of the PC by the active vitamin D form prevents the cancer cells from adapting their use of energy substrates in the stressful ECM detached conditions. We have also demonstrated that metastatic cancer cells are less viable when exposed to higher glutamine concentrations. Further, we have shown that the synthesis (which is inhibited by the active form of vitamin D), storage, then release of fatty acids from cellular lipid droplets is essential to support the migration of metastatic breast cancer cells, an essential step in the metastatic process. Finally, we have also shown that the active form of vitamin D reduces lipid accumulation in metastatic breast cancer cells, and that the enrichment of the proteome of lipid droplets in breast cancer cells is significantly different than other cell types, with proteins involved in metastasis in the top categories of proteins identified, and lipid metabolism far down the list of categories represented on the lipid droplets.

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

We have published two review articles in the last year. We also published one original research article, and have three others submitted and under review. The results of our studies have also been presented at academic institutions, and several presentations (oral and poster) at local, national and international conferences in abstract form.

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

The information generated from our research will potentially contribute to developing targeted strategies, including vitamin D recommendations, to prevent the development and progression of breast cancer.

Supporting Healthy Children, Youth, Families and Communities

Project Director
Julie Huetteman
Organization
Purdue University Main Campus
Accession Number
7001778

American Citizen Planner – Indiana: Community Leaders Earn Certification for Public Planning

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

Indiana plan commissions, city and town councils, boards of zoning appeals, and county commissions make land-use planning decisions that impact their communities. These decision-makers need to have a grasp of federal, state, and local regulations, community values, land use decision-making, and economic, social, and environmental considerations. Indiana provides authority to city and county governments to pursue self-determined goals through comprehensive planning and locally developed land use regulations, therefore it is up to local jurisdictions to develop plans, implement public engagement processes, and make decisions that achieve community goals. Indiana has a unique state statute that requires Purdue Extension Agriculture and Natural Resource Educators to serve on most county plan commissions. Those serving their communities as decision-makers on planning related board or commission come from a wide variety of backgrounds, as do those who are interested in becoming more involved in local planning issues. Both need education to grasp the foundational aspects of local planning and the nature of serving as a public official to better understand the important role they play in planning and land-use decisions.

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 partnership with the Extension Foundation, Michigan State University, and the Purdue Land Use Team, Purdue Extension adapted the American Citizen Planner curriculum for Indiana audiences. The program goal is to prepare citizens to serve their communities by building understanding of planning processes, land-use regulations, zoning, decision-making with the public, and incorporating public input. There are two online courses covering fundamentals of comprehensive planning, public engagement, and land use regulation. Content addresses ethics for public planning officials, moving from issue to future land use policy, and enhancing equity in planning. Participants build knowledge of theories, tools and legal aspects related to planning and working with the public and, thus equipped, help shape plans that guide the future of their communities. Participants learn the role and duties of the plan commissioner and current and emerging issues in planning. Participants complete the first online course, then they attend a workshop (in-person or via webinar) led by ANR Educators. Next, they complete the second online course, and attend a second workshop. These workshops explore expand on course content and cover an additional, locally relevant topic selected by the host ANR Educator with input from their local plan commission. A guest speaker is invited to present on the topic. Past presentations have included including renewable energy, invasive species management/ natural resource planning, public health and planning, and public participation strategies for planning. To advance equity in planning practice as a response to the historic racial justice events of 2020 and the lack of training available to public planning officials in Indiana, Educators delivered the enhancing equity in planning content during workshops. A total of 35 workshops were delivered from 14 Indiana host counties for 67 hours of instruction. Upon completion, participants may take the comprehensive, online exam, and those obtaining at least a 70%, earn a Master Citizen Planner Certificate.

Since 2020, there were a total of 124 program participants who indicated they were citizen planners serving, or planning to serve, on area or advisory plan commissions, interested residents, elected officials, and municipal, county, or nonprofit staff. There were 32 who responded on the post-survey (25.8% response rate). They were white (100%), non-Hispanic (100%), female (55.2%), ranging in age from 27 to 72. They had Master's degrees (50.0%), and annual incomes between $100,00 and $149,999.

About one-third were plan commission members (34.4%), local planning staff (28.1%) and Purdue Extension staff (28.1%). Over half (56.3%) were associated with County government units.

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

Three-quarters (73.1%) completed all course requirements and passed the exam and earned the Master Citizen Planner Certificate. For knowledge levels before and after the program, participant average scores increased the most for: Access to continuing education resources for land use planning, and Legal, regulatory, and constitutional powers related to land use planning and zoning.

With average scores 3.9 (5-point scale), participants indicated as a result of the program, their confidence increased the most for their ability to: 1) apply concepts of public land use and development in your community, and 2) communicate about plan commission activities with residents. Participants indicated with an average 4.2 (5-point scale) they are likely to "use information from this program for future community planning efforts."

Participants indicated how and when they will apply what they learned. Most common themes on how they will apply what they learned were: improving work with and understanding of the comprehensive plan, improved abilities in my role as a commission / committee member, and better engagement with others/ community. Three-quarters (76.7%) indicated they would apply what they learned immediately.

Participants indicated their most significant takeaways from the program was the importance of the comprehensive plan, openness and communication, and greater understanding how all the parts relate and interact. Most (86.2%) participants would recommend the program to others and indicated that it was very informative, valuable and provided good and comprehensive content.

In a one-year follow-up with participants, 10 respondents (15.9% response rate) indicated that in the year since completing the program they had used the: data or resources provided in their decision-making, knowledge gained to develop or modify a plan, policy, or ordinance, and knowledge gained to improve resident and partnership engagement in the planning process.

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

The American Citizen Planner – Indiana prepares individuals with knowledge and resources to make decisions, work with policies, and improve engagement in local planning for Indiana communities.

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

4-H began over 100 years ago, and has since grown into the largest youth development program in the nation. 4-H prepares young people to be leaders in their community and around the world through hands-on experiences alongside their peers and caring adults. Backed by a network of more than 6 million youth, 540,000 adult volunteers, 3,500 professionals, and more than 60 million alumni; 4-H delivers research-based programming around positive youth development. 4-H is delivered through America's 109 land-grant universities and the Cooperative Extension Service reaching every corner of our nation.

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 Indiana, 4-H can be found in all 92 counties delivered through Purdue Extension. Community clubs, afterschool programs, school enrichment, camps/workshops, and special interest programs are all ways youth across Indiana can be involved with the 4-H program.

In 105 4-H programs held across 46 Indiana Counties, Areas, multi-county collaborations, statewide, and virtually, there were 1,784 youth (grades 4 – 12) who completed Common Measures 2.0 post-surveys. Over half (59.1%) reported they were female. For grade levels, 12th grade had the largest percentage (14.4%), followed by 5th grade (14.0%), and 4th grade (13.5%). The largest number were 11 years old (15.4%), age 10 (13.6%), and age 13 (11.2%). Two-thirds (67.9%) reported their race as White or Caucasian.

Program evaluation efforts focused on core concepts: 4-H experience, universal skills including personal mindset, social and leadership, animal science, civic engagement, healthy living, science and engineering, and college and career readiness.

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

Focusing on the 4-H experience, 485 youth in 14 programs reported that 4-H is a place where: they feel safe (3.80), they learn about ways to help their community (3.77), it's okay for them to make mistakes (3.76), and adults care about them (3.76).

For universal skills, 249 youth in 16 programs who reported (4-point scale): I am willing to work hard on something difficult (3.68), I try to learn from my mistakes (3.56), I treat others the way I want to be treated (3.55), and I like to learn new things (3.50).

In animal science, 82 youth in three programs reported (3-point scale), they learned the right way to store and handle feed (2.49), they practice safe animal handling (2.48), and they learned about housing/shelter for their animal (2.45). Youth reported aspirations toward animal science, showing they would like a career: caring for animals (2.35), raising animals (2.33), and training animals (2.14).

Looking at civic engagement, 138 youth in ten programs reported: they (99.3%) like helping people in their community, they (92.0%) had met community leaders because of 4-H, they (87.7%) had encouraged others to volunteer in the community, they (97.8%) like to help people, they (92.6%) feel a responsibility to help their community, and they (97.1%) were inspired by 4-H to volunteer in their community.

In healthy living, 169 youth in 16 programs reported they (98.4%) learned about healthy food choices at 4-H, they (71.0%) have given their family ideas for healthy meals or snacks, they (83.3%) encourage friends to be active with them, and they (70.0%) talked about ways to be active at 4-H.

With science and engineering, 341 youth in 30 programs reported learning about robotics (3.22), engineering (3.19), and animal science (3.17). Youth expressed positive attitudes about science with nearly all (96.8%) reporting that they like science. Most (86.0%) responded that they would like a job that uses science.

Focusing on college and career readiness, 388 youth (grades 8-12) in 16 programs reported (4-point scale), it is important to: be trusted by an employer (3.99), arrive to work on time (3.97), do their job well (3.96), and show respect for others (3.93). Youth reported that 4-H helped them to: think about the amount of education they might need in the future (98.7%), identify things they are good at (95.7%), and explore future career options (92.4%).

In current 4-H activity, youth reported spending less than one hour to five or more hours each week on 4-H activities. For past 4-H involvement, youth reported they are in, or have been in, a 4-H Club (67.6%), participated in County-level competitive events (54.7%), and attended 4-H camp or other overnight 4-H experience (42.1%). Just 21.4% of youth reported that this was their first 4-H event. Looking ahead to future 4-H participation, youth were interested in activities with animals, will not participate/am not active in 4-H, becoming a teacher, leader, counselor, or volunteer, advancing grade levels for participation, attending meetings/having in-person meetings, and projects/fair activities.

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

Indiana 4-H contributed to positive youth development, to growth in personal and social skills, to gains in knowledge and skills, and to positive attitudes through civic engagement, healthy living, animal science, science and engineering, and college and career readiness programs.

Purdue Extension Connecting Indiana Communities through Local Coalitions and Partners to Positively Impact Health

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

In 2020, America's Health Rankings had Indiana listed 36th in overall health outcomes. Of particular concern were drug use, mental health, tobacco use, infant mortality, obesity, diabetes, and physical inactivity.

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 health concerns in Indiana communities, Purdue Extension and partnering organizations have come together to form local community coalitions to address health needs. Purdue Extension found coalition success with staff working across program areas to bring the variety of strengths to the community. Purdue Extension reported coalition involvement in 76 of 92 counties, an increase of 43.4% from the previous year, and activities were reported for 170 coalitions, an increase of 59.3%. Top areas of focus for coalitions were: substance use, wellness, tobacco, local foods, wellness and chronic disease prevention, systems of care, and mental health.

Of 76 participating counties, the status of coalition activities included: actively conducting interventions (40%), involved in health interventions to improve health knowledge and outcomes with evaluations in place (26.5%), and active in the county with key partners with health goals in place but not yet conducting interventions (17.6%). Coalition activities are captured on this map of Indiana counties.

Pandemic conditions impacted local coalitions in different ways: 97 coalitions changed their approach, pausing activities or going virtual (some virtual meetings allowed more people and groups to be involved), 30 coalitions changed their focus to urgent community needs like hunger by taking on activities to elevate food distribution, or to trauma and mental health issues.

Coalition activities included trainings/workshops, health fairs, town halls, and events for food distribution and school backpacks. Some communities supported syringe exchanges or provided naloxone training, and others conducted health equity discussions. Some coalitions formed partnerships to provide educational programs to inmates, and others to increase awareness of substance use and mental health.

Purdue Extension successfully leveraged national and state programs fostering interdisciplinary work and partnerships. One example was Well Connected Communities, a 10-year nationwide effort to cultivate wellness led by the National Cooperative Extension System in partnership with the National 4-H Council and supported by the Robert Wood Johnson Foundation. Indiana was one of 13 pilot states for Wave One (2017-19). Wave Two (2019-2021) now focuses on three Indiana counties: Fayette, Greene, and Scott. Key initiatives included development of, or strengthening, community-led coalitions or health councils, engaging youth as equal partners in coalitions, addressing issues of health equity, and, establishing youth and adult health/wellness volunteers.

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

Purdue Extension involvement enhanced the work of local coalitions by: building new or improved networks or relationships, increasing awareness of the community for an issue, increasing member knowledge and skills, bringing new and diverse faces to the coalition, and facilitating the group to work together toward a common goal. With County Extension office involvement in local coalitions, the effectiveness of Purdue Extension was improved in these ways: enhancing the role of Extension in the community, helping broaden networks of community partners, and increasing new partners for programs, awareness of health issues in the community, and access to new audience groups. Due to Purdue Extension involvement in coalitions, 413 new networks, partnerships or collaborations were created, averaging 2.7 per coalition.

Purdue Extension reported 2,959 active groups or agencies (community, health systems, education, social services, government, and business) across the coalitions. Some 559 groups were new to the coalitions, and 286 were introduced to the coalitions by Purdue Extension. Focusing on grants, funding, and donations, over $5,021,000 was obtained for 47 coalitions, ranging from $50 to $1,000,000.

There were 58 coalitions involved with policy, systems and environmental work. For 30 health policies enacted, examples were changes in smoke free policies, implementing Mobile Integrated Response Teams, allowing distribution of food to community sectors not being served, updating school wellness policies to include comprehensive tobacco policies, and improving worksite wellness. Some 88 health-related systems were developed, including: distributing mental health provider lists and the suicide prevention hotline to all schools, developing food pantries systems to protect volunteers and clients to remain open during the pandemic, mapping Recovery Oriented System of Care (for substance abuse and mental health services), creating scholarships and sponsorships for health and positive image programs for girls. There were 67 environmental strategies achieved, including: installing bike racks, increasing tobacco free sites, a walking challenge measuring minutes not steps, installing security cameras at two local parks for safety, creating a new Story Trail (combining walking, literacy, and time in nature), developing a Seed to Store Initiative linking local growers directly with grocery stores, and promoting local trails.

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

Purdue Extension played a major role in connecting communities through local coalitions and partnerships which positively impact and support the health of all throughout Indiana.

Critical Issue

Natural resources and the environment

Beneficial Use of Residuals to Improve Soil Health and Protect Public, and Ecosystem Health

Project Director
Linda Lee
Organization
Purdue University Main Campus
Accession Number
1021346

PFAS Occurrence, Leaching and Mitigation Potential

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

Over 260 million tons of residual by-products such as biosolids, recycled water, food scraps, other municipal solid waste, manure, industrial sludges and waste byproducts are currently produced in the U.S. Among these, biosolids are particularly known to be nutrient and carbon-rich materials that improve soil quality and plant growth. However, there are obstacles that can limit the beneficial use of residual products such as Per and polyfluorinated alkyl substances (PFAS) occurrence in biosolids. PFAS are a large group of highly fluorinated manmade chemicals used in a myriad of ways resulting in their ubiquitous detection in multiple media types. PFAS are difficult to remove by conventional wastewater treatment processes and partition to biosolids leading to concerns when they are land applied. This project is addressing PFAS occurrence and fate in biosolids and land-applied biosolids and mitigation of PFAS mobility from biosolids. These investigations will generate knowledge needed to sustainably manage our biosolids with good environmental stewardship practices protective of human and ecosystem health.

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.

We continue to enhance our extraction and analytical methods for PFAS in a range of biosolids type with 54 PFAS now targeted for quantitation in addition to screening for other PFAS. We assessed what happens to PFAS in typical anaerobic and aerobic treatment processed in municipal water and wastewater resource recovery facilities (WWRF) by comparing PFAS in the material entering the WWRFs to those in the final biosolids that can be land-applied. The process leads to volume reduction so even with no changes in the PFAS present, PFAS concentrations can increase by approximately two-fold. However, larger PFAS that can be biodegraded to smaller PFAS included intermediates (partially degraded) or terminal (final products) products that are PFAS. PFAS that can degrade to one or more other PFAS are referred to as precursor PFAS or simply precursors. Many precursors are not quantified by commercial laboratories or cannot be quantified due to lack of standards, inability to detect them, or difficulty in extracting them from the biosolids. In both aerobic and anaerobic processes, but more so in the aerobic processes, concentrations of some quantifiable PFAS increased by more than an order of magnitude due to the conversion of precursor PFAS. These products tend to be more mobile thus with a higher leaching tendency and potential for plant uptake.

Finished biosolids were collected and characterized from multiple municipal water resource recovery facilities. PFAS (54 quantified) ranged from below 50 to 1300 µg/kg (dry weight basis). For all biosolids, greater than 75% of the fluorine associated with PFAS was associated with precursors with more than 50% being di-substituted polyfluorinated phosphate esters (diPAPs) which were the most abundant PFAS identified in the biosolids. Using 7 of these biosolids, we observed sustained leaching of PFAS during the 6-month study duration with outdoor columns containing soil plus 1% biosolids in the upper portion. Leachate concentrations of perfluoroalkyl acids (PFAAs); no diPAPs were detected in the leachate. The PFAAs leaching from the biosolids exceeded the PFAA mass initially present in the biosolids (typically by greater than an order of magnitude), which was attributed to aerobic precursor transformation. These results highlight the importance of PFAA precursors initially present in biosolids and their contribution to long-term leaching of PFAAs from land-applied biosolids.

We also evaluated PFAS leaching from biosolids and a biosolid-mulch blend applied to plots constructed with soil from a site where land reclamation was needed. Leachate was collected over a 2-y period using zero-tension drainage lysimeters installed 15 cm below the soil surface. Leachate only contained PFAAs and 6:2 fluorotelomer sulfonate. Blending biosolids with mulch at a 0.75:1 ratio reduced PFAS loads in leachates by approximately 30%. Conversely, temporal trends and distribution of PFAS species were similar between both treatments with short-chain perfluoroalkyl acids (<C7) dominating in both treatments. This study indicates that strategies such as blending biosolids with other organic material that is low in PFAS serve to dilute PFAS concentrations in the amendments such that PFAS concentrations in leachate are also reduced. This approach warrants further exploration towards the sustainable beneficial reuse of biosolids.

Another PFAS leaching mitigation strategy we are exploring is to mix other types of WWRF residuals with biosolids. Aluminum chlorohydrate (ACH) is used to improve finished water quality. The Al-based residuals after water treatment (WTRs) have been found to be a good sorptive medium for anionic phosphates, thus may sorb PFAAs which are typically anionic. We evaluated the affinity of ACH-based WTRs (< 2 mm and freeze-dried) to attenuate seven PFAAs (PFBS, PFHxS, PFOS, PFHxA, PFHpA, PFOA and PFNA) from porewater generated from two biosolids. PFAA sorption (24-h) and desorption (48-h) were conducted using 0.005 to 0.5 g ACH-WTRs equilibrated with 9-mL of biosolid-derived porewater amended with PFAAs to increase initial PFAA concentrations. Adsorption increased with increasing ACH-WTR mass and increasing PFAA chain length. Desorption decreased with increasing ACH-WTR mass and generally increasing PFAA chain length. Sorption/desorption results indicate that applying ACH-WTR to biosolid-amended fields may serve well to reduce PFAS leaching. Along a similar theme, we evaluated PFAA sorption to and desorption from biosolids-derived porewater using biochar derived from pyrolyzing biosolids at 350 C with minimal oxygen present. Previously, we found that PFAS release from this biochar was negligible. PFAA sorption/desorption trends were similar to the ACH-WTRs. For both sorbents, 80 to 100% sorption was achieved for longer chain PFAS. Therefore, we co-application of ACH-WTRs or biochar with biosolids may offer another strategy for sustainable land application of biosolids.

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

The target audiences for this work includes municipal entities responsible for drinking water provision, wastewater treatment and handling of treatment, and other waste management operators as well as regulatory bodies, farmers, the general public and other researchers. The information provided by our activities have improved our understanding of PFS occurrence in our waste-derived soil amendments, what happens to PFAS in waste solids during municipal treatment or once applied to soils, and potential biosolids management strategies for minimizing PFAS leaching while still being able to take advantage of the multiple carbon and nutrient benefits provided by land-application of biosolids.

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

Home owners and farmers within Indiana and undergraduate students from multiple colleges at Purdue University learned more about PFAS challenges in multiple sectors, how they can manage PFAS exposures, and what they can do to facilitate a reduction in the use of PFAS in consumer and commercial products. In like manner, Dr, Lee impacted a broader audience than just Indiana and Purdue through various news, radio and television outlets.

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.

No major changes or problems were incurred except that due to COVID restrictions, only one student was able to present work at a conference in person. This project has involved the training of 5 PhD students (one was from University of Florida) and one post-doctoral assistant in conducting PFAS fate experiments, soil and biosolid extractions and target and nontarget analyses. In addition, 5 undergraduate students were trained in various steps including freeze-drying, solid-phase extraction, solvent extraction of solids, and injection vial preparation for liquid chromatography- mass spectrometry.

Conservation of Natural Resources

Project Director
Julie Huetteman
Organization
Purdue University Main Campus
Accession Number
7001779

Improving Conservation Tree Planting with Increased Knowledge and Connection to Professional Foresters

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

Conservation tree planting is important for restoring habitats, reducing erosion, regenerating forests, and sequestering carbon. Indiana landowners have access to tree seedlings from state and private nurseries, but may not have experience or knowledge of best practices to improve tree planting success. A Purdue study found that 75% of surveyed conservation tree planters were first-timers and working with a professional forester more than doubled tree planting success. Directing landowners considering tree planting to professional assistance and sources of science-based information can lead to improved success of conservation tree plantings.

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.

Purdue Extension has provided in-person conservation tree planting clinics for over 40 years. Due to pandemic restrictions, the program was held via webinar, as well as one small in-person program. A two-hour presentation was provided on conservation tree planting science and practical experience, and included access to reference materials and contact information for resource professionals available to assist landowners.

Purdue Extension publications, and research from Purdue's Forestry and Natural Resources, and Hardwood Tree Improvement and Regeneration Center, informed recommendations. Professional foresters from Indiana Department of Natural Resources and the private sector also attended to assist with questions and to discuss services for landowners. The in-person program was held in cooperation with LaGrange County Extension and Soil and Water Conservation District offices.

The online program was advertised to individuals who had purchased seedlings from the Indiana DNR state tree nurseries and to the general public. The in-person program was advertised to general audiences through Purdue Extension and LaGrange County contacts. There were 114 participants for the webinar, and 15 for the County program. Most were landowners planning to do conservation tree plantings.

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

Participants responded on post-surveys (webinar 20.6%, in-person 60.0%) rating their before/after knowledge (5-point scale) related to conservation tree planting. Average scores were calculated for site evaluation and preparation, planting techniques, weed control, and post-planting management. Webinar participant averages increased from 2.87-3.26 to 4.33-4.52, and LaGrange County participant averages from 2.78-3.33 to 4.22-4.78. Also, participants (91%) indicated they plan to take at least one action for conservation tree planting in the next year.

Some participants stated the program value: “This webinar especially helped me think about planning (soil testing), planting (rows or not), watering (not necessary), weed control (not mowing but find other ways), and deer (I think I will now build a fence of some sort).” “Very, very good presentation, I will try to steer others toward this resource.”

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

Purdue Extension’s programming increased knowledge of landowners planning conservation tree plantings and connected them to professional foresters available to help them.

Indiana Conservation Partnership Employees Learn Tree and Shrub Identification for Sharing with their Clients

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

Purdue Extension is a member of the Indiana Conservation Partnership (ICP), http://icp.iaswcd.org/, and one responsibility is to provide science-based information and training for partnership members (including USDA, Indiana State Department of Agriculture, Soil and Water Conservation District, and Indiana Department of Natural Resources), who work with Indiana landowners and managers. Providing natural resources training to these ICP members leverages the capacity of Purdue Extension to reach more citizens. Survey results of ICP members revealed the need for tree and shrub ID training.

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.

Early in the year, Purdue Extension presented two live webinars, “How to Identify Trees in Indiana”, and “How to Identify Shrubs in Indiana”. Recordings were posted on the Purdue Forestry and Natural Resources Extension YouTube channel and accessible by ICP members and the general public. In the fall, four Regional Tree ID Field Programs were held. There were about 140 webinar and 70 field program attendees who were employees of the ICP organizations. There have been over 1,000 views of the posted videos.

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

Webinar (38.6%) and Regional Tree ID Field Program (65.7%) participants, in post-survey responses, rated their training knowledge (5-point scale) before and after the programs about parts of the trees and shrubs used for ID, resources for tree and shrub ID, and tree and shrub ID principles. Webinar average scores improved 1.5 points and Regional Tree ID Field Program average scores improved 1.2 points.

Webinar (88%) and Regional Tree ID Field Program (93%) participants indicated they plan to take action steps in their job in the next year using information learned. Webinar participants commented: “This was great... not sure I've even been actually 'taught' this. Now I just need to somehow retain all this.” “I found both the tree and shrub webinars very fascinating! Would love to see more like this in the future.” Regional Field Program participants commented: “Totally awesome, learned a ton, great training, thank you!!” “Great program-loved the hands-on approach.” “I already know a lot about tree ID, but learned a lot about more advanced ID using bud and twig characteristics.” “I learned a lot of things that I was out of practice on, and new things that I never knew before.” “Highly recommend this and would do it again in another area to learn even more!”

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

Purdue Extension’s Tree and Shrub ID Webinars and Tree ID Field Programs helped increased the knowledge of ICP employees who will use that for instruction and engagement with their clients across Indiana.

Landowners Learn about Prescribed Fire for Grassland Conservation

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

Many of Indiana's natural areas, prairies, savannas, and oak-hickory forests are dependent on natural disturbances like fire to flourish. With more than 97% of Indiana's land in private ownership, private landowners are the stewards of a majority of the landscape. More than 200,000 acres of Indiana cropland are enrolled in the USDA's Conservation Reserve Program. These acres require management including prescribed fire to fulfill contractual obligations and enhance plantings for wildlife. However, most landowners lack awareness of prescribed fire benefits to wildlife and natural areas, and may have preconceived notions about risks. Providing landowners with information about prescribed fire benefits and safety, and demonstrating safe application, can help them make informed decisions for their property.

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.

Purdue Extension leads annual "Learn-N-Burn Prescribed Fire" workshops. The most recent workshop focused on prescribed fire in grassland ecosystems. The workshop had a classroom portion about prescribed fire laws and regulations, managing grasslands for wildlife, how to use fire to enhance wildlife habitat, how to safely conduct a prescribed fire, and prescribed fire ignition techniques. This was followed by an outdoor, hands-on, field portion addressing equipment, and providing a demonstration of a live prescribed fire.

There were 22 participants. Participants were landowners, college biology students, and public natural area managers. Eleven completed the program evaluation. Most reported they were non-Hispanic (80%), White (72.7%), male (64%), and 40 years or older (60%). Participants reported they owned or managed a total of 12,750 acres.

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

Participant knowledge ratings (5-point scale) improved from before to after the workshop. Average knowledge scores increased for: how seasons of fire (fall vs. spring) impact vegetation (96.6%), benefits of conducting a prescribed fire for wildlife (80%), how to improve grasslands for wildlife (59.7%), equipment used in conducting prescribed fire (47.2%), and safety considerations when conducting fire (43.1%).

Participants indicated the workshop was useful in providing new knowledge to help them take action (100%) or make future decisions (91%) on their property. The Net Promoter Score®, a measure of customer loyalty, was 45, and is considered a good rating, indicating most participants would recommend the workshop to family, friends or colleagues.

Based on information presented, participants plan to take the following actions in the next 12 months: conduct a prescribed fire (64%), seek more information about managing grasslands for wildlife (45%), and seek assistance in conducting a prescribed fire (45%).

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

Purdue Extension's "Learn-N-Burn Prescribed Fire Workshop" helped landowners learn how to conduct prescribed fires for conserving grasslands.

Purdue Extension Helps Indiana State Parks to Teach Families to Improve Water Quality to Protect Wildlife

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

The Eastern Hellbender is a rapidly declining species throughout the eastern U.S. Government agencies and universities have spent considerable funding to recover the species. Moreover, the primary cause of decline is poor water quality which affects all members of the public.

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.

Purdue Extension trained 60 Indiana Department of Natural Resources' State Park naturalists in presenting the program, Hellbender Conservation: Saving the Slimy Salamander. These naturalists then presented this program 18 times at their state parks throughout the year. State Park visitors of all ages attended the programs. State Park naturalists administered pre- and post-knowledge surveys to all families attending. These state park programs reached about 125 families with a minimum estimated attendance of 298 individuals.

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

On pre/post scores, there was an average knowledge gain of 157.2% across. Topics were "hellbender habitat and biology", "hellbender adaptations", how water quality and human actions affect amphibians and other aquatic life ("amphibians and water pollution", "threats to aquatic ecosystems", and "reasons for hellbender decline"), and "what you can do to help hellbenders" focusing on simple actions the public can take to protect water quality and improve habitat for hellbenders and other aquatic organisms.

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

By partnering with the State Parks, Purdue Extension leverages the ability to share information and actions for improving water quality, and habitat for hellbenders, other amphibians and aquatic life across Indiana.

Purdue Extension Shared 17-Year Cicada Outbreak Information and Resources with Thousands Across Indiana

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

Once every 17 years, millions of cicadas per acre crawl out of the ground and climb into trees where they spend an entire month screaming louder than a lawnmower, mate, and lay their eggs on the tips of branches. Cicadas are not harmful to humans, provide a feast for wildlife, and mostly only cause cosmetic injury to trees. However, there are some trees that will need protection to survive. Female cicadas cause damage when they puncture or slit 3/16" to 7/16" diameter twigs of trees and shrubs to lay their eggs. Infested branches appear as if the eggs have been stitched in by a sewing machine. These branches will turn brown, die, and sometimes break off. Although cicadas do not cause long-term harm to trees, many people unfamiliar with them refer to these insects as a plague of locusts and attempt unnecessary or unsafe approaches to killing them. The goal of Purdue University's multidisciplinary Cicada Outreach Team was to promote public safety and prevent panic with an education campaign that framed the cicada emergence as a wonder to be enjoyed and not a plague to be endured.

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.

Purdue Extension developed a coordinated system to create and share education resources to support existing county and campus-led programs across multiple departments. Specific messages were crafted and shared for tree producers, nurseries, landscapes, and specialty crops. Information delivery occurred via county Master Gardener groups, commodity newsletters (Facts for Fancy Fruit, Purdue Landscape Report and Indiana Woodland Steward) and activities (Entomology's Virtual Bug Bowl, Forestry and Natural Resources' Ask the Expert). Cicada slides were developed and shared in over 35 hours of live and recorded programs by Extension Educators reaching over 1,500 youth and adults.

"Emergence of the 17-Year Cicada," the Team's website https://extension.entm.purdue.edu/cicadas/, introduced this insect to prevent panic spraying of insecticides, or the hiring of contractors selling false promises of protection. Website visitors were encouraged to sign up for a newsletter to stay informed of the cicada emergence, and to participate in Indiana Cicada Emergence Trackers a community science effort to report and map cicada activity on smartphones via i-Naturalist. Community science programs were divided for two audiences: general public and Master Gardeners. In addition, a variety of activities, videos, and resources were featured including a specially-designed poster for use in State Parks, youth education activities, origami, and cookie recipes.

The Cicada Team generated a buzz strong enough to experience an extraordinary amount of media coverage reaching nearly 30 local and national news outlets including the Indy Star, South Bend Tribune, NBC, CBS, ABC, NPR, Disney Plus, and National Geographic. The team lead conducted 47 media interviews and local Extension Educators and Specialists added many more.

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

“Emergence of the 17-Year Cicada” had nearly 23,000 unique views, with over 950 downloads of posters and 120 downloads of youth education activities. Videos deployed by the team on Facebook and YouTube were viewed more than 12,000 times. Zombie Cicadas, the most popular video, was downloaded 6,095 times. The social media campaign reached nearly 85,000 individuals.

Community science efforts resulted in 75 observers across the state reporting over 360 observations of cicadas and other Indiana species. These observations are currently being analyzed to refine understanding of the seasonal biology of the cicada in Indiana. In consultation with leaders in the tree care industry, the Cicada Team worked with AES (formerly Indianapolis Power and Light), Indy Parks, and the Indiana Arborist Association to distribute information about how to protect newly planted trees during the annual tree giveaway. One thousand information sheets were distributed with trees during the one-day event.

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

Purdue Extension’s coordinated and multidisciplinary efforts for the 17-Year cicada provided helpful insect, tree, and shrub information, resources, and education reaching thousands across Indiana.

Train-the-Trainer Activities for Conservation Professionals Help Indiana Farmers Improve Agricultural Sustainability

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

Healthy and functional soils support productive agroecosystems while providing essential ecosystem services. Unfortunately, mismanagement of soil resources has led to multiple soil resource concerns in Indiana including soil erosion, loss of soil organic matter, poor water infiltration and impaired nutrient cycling. These resource concerns result in on-farm (e.g., decreased/variable crop yields, increased need of fertilizer inputs) and off farm (e.g., impaired water quality, decreased soil carbon stocks) impacts.

Conservation practices are needed to preserve soil and water. Indiana is a national leader in conservation, in part due to long-standing cooperation and work by the Indiana Conservation Partnership (ICP). Purdue Extension is one of eight partners sharing a common goal of promoting conservation. Annual input from staff and field offices shows that soil health and cover crops have consistently ranked in the top five annual needs for professional development training.

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 professional development and continuing education, ICP representatives, a panel of experts, and the Conservation Cropping Systems Initiative (CCSI) provide training, outreach and soil health education support for partners across Indiana. These professional partnerships bring together similar goals, staff with a variety of roles, and complimentary, but not duplicative or competitive efforts, for Indiana. Purdue Agricultural Centers conduct research on cover crops, nutrient management and cropping systems. Purdue Extension contributes on-farm research and soil health education. Annual conservation trainings are supported with SARE professional development funds. These efforts build consistency for Indiana professionals working in agencies, counties, and regions of the state to provide information, tools, and resources, to support farmer implementation of cover crop practices. Train-the-trainer activities also provide opportunities for Indiana professionals seeking Natural Resources Conservation Service (NRCS) Certified Conservation Planner status.

Due to the pandemic, programs had to be adapted to a hybrid environment, while maintaining effectiveness of in-person experiences when safe to do so. “Core Cover Crops and Soil Health Systems Training” was held as a series of three virtual events (aka Virtual Core Series) of two hours weekly for three weeks, with resources and supplemental content made available in between. Nine modules were presented: Sustainable and Regenerative Soil Health Systems, Cover Crop ID, Deep Dive into Cover Crops, Benefits and Selection, Indiana Seed Laws, Cover Crop Strategies and Equipment, Soil Health Cropping Systems and Equipment, Insect Pests and Beneficials Management Considerations in Soil Health Systems and Cover Crops, Seeding Tools and Calculators, and Weed Management Considerations for a Soil Health System and Basic Cover Crop Termination. Participants learned about identification and management of cover crops, nutrient management of soil health systems, when and where to use cover crops, pest management, and beneficial insect management.

“Soil Health and Sustainability for Midwestern Field Staff” became a three-day hybrid series with two days in the field and a day of interactive webinars and virtual activities. Nine modules were presented: Soil Health Basics, Linking Soil Biology to Soil Health, Soil Health Planning Principles, Strategizing and Implementing a Soil Health System, Resource Concerns and Soil Health Indicators, Ecological Management, Cover Crop Management, Grazing Management to Improve Soil Health, and Social and Economic Considerations. Participants learned about in-field troubleshooting, diagnostics, example problems shared by farmers, zones of soil habitat, and crop system approaches where practices could be used and stacked to implement a soil health system. Nationally and internationally known farmers help with training, participants visit their farms for an in-person immersion experience of a fully functioning soil health system, and Purdue researchers, Extension and NRCS partner to enhance this unique training agenda.

“Advanced Trainings” and “In-field Diagnostics Trainings” were canceled, so a panel of training, education, and content experts convened to evaluate the program series and update content and delivery methods. The panel identified one training that no longer fits current stakeholder needs and will be redesigned, one training series had too much overlap with other trainings, so new learning objectives are being identified and modules redirected. The rest of the series remains valid and needed, and will continue as planned. The Curriculum Advisory Committee, an action team delivering training, drawing from the panel of experts’ recommendations, reviewed the training, and identified key concept areas with delivery methods. A remodeled plan for the future included new learning objectives for more impactful training programs.

There were 77 participants in the Virtual Core Series. For the Midwestern Field Staff training, because of pandemic restrictions to maintain social distancing, participant numbers were limited to 25.

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

Of 19 survey respondents (24.7% response rate) for the Virtual Core Series, 94.7% were somewhat or very satisfied with the training, and 89.5% were likely or very likely to recommend the training to a friend or colleague. Participants rated the nine topic presentations as good to excellent. Participants liked: the volume of resources, links and tools to use, that recordings were available for later review, and the wealth of knowledge from speakers. With virtual delivery, some participants indicated parts could have been better as in-person or hands-on experiences, but understood pandemic limitations. One respondent stated, “I love these workshops because they are helping me talk to the producers in our District.”

For 10 survey respondents (40.0% response rate) of the Midwestern Field Staff training, 90.0% indicated they will likely use the information learned in their day-to-day work activities “all the time, every day” or “maybe once a week or a few times every two weeks”. All respondents were somewhat or very satisfied with the training. Participants rated the nine modules as good or very good.

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

Purdue Extension, ICP, and CCSI, working together, provided effective training for conservation professionals to help Indiana farmers implement conservation practices for improved on-farm sustainability by increasing soil health, reducing total nutrient, herbicide, and insecticide applications, increasing resilience to extreme weather events, and producing more steady and predictable yields.

Critical Issue

Sustainable energy

Development of microbial platform capable of fermenting non-conventional substrates for high yield production of value-added chemicals from agricultural and forestry residues

Project Director

Eun Joong Oh

Organization

Purdue University Main Campus

Accession Number

1026066

Design heterologous metabolic pathways to assimilate carbon sources derived from agricultural byproducts

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

Metabolic engineering has been advanced as a useful tool to enhance industrial fermentation processes. However, not all fermentation processes are currently applicable to industrial-scale production. This limitation is due to several challenges, such as high feedstock costs and low productivity. The proposed research addresses essential issues in developing optimal microbial strains producing value-added chemicals from agricultural and forestry residues

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 efficient utilization of the mixtures of sugar monomers present in hydrolysates derived from pectin-rich residues and lignocellulosic biomass is essential for their biotechnological application. Yeast cells utilize glucose preferentially from mixtures of glucose and other sugars. This glucose repression problem is a major barrier to efficient fermentation using sugar mixtures from renewable biomass. We use cellobiose, xylose, arabinose, and galacturonic acid as the carbon sources to avoid glucose repression and cross interferences between different sugars. Cellobiose is a dimer of glucose, which is readily released from cellulose by cellulases, and it does not inhibit other carbon sources' uptake, unlike glucose. Xylose is the second most abundant sugar in lignocellulosic hydrolysates. The cellulose and hemicellulose fractions of pectin-rich biomass yield xylose, arabinose, and galacturonic acid. To construct a cell factory platform, we engineered a set of *Saccharomyces cerevisiae* strains capable of utilizing multiple substrates derived from lignocellulosic and pectin-rich biomass. We successfully introduced heterologous pathways for the assimilation of non-glucose carbon sources to diversify cellular metabolism. The resulting strain will be used to produce food ingredients and value-added chemicals as a platform cell factory for a future study.

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

Since widely used cell factories such as *Saccharomyces cerevisiae* cannot ferment carbon sources in agricultural residues, research efforts have been focused on developing engineered yeast strains capable of co-utilizing carbon sources in the hydrolysates of biomass. However, the fundamental understanding of substrate co-utilization in central metabolism is still lacking. This lack of mechanistic knowledge hampers our ability to strategically use lignocellulosic and pectin-rich biomass as carbon sources to alter microbial native metabolic capacities toward improved biosynthesis. My project's activities enhance the understanding of desired phenotypes for bioconversion in fermentation sciences and synthetic biology. Also, our target audience could redesign biological systems for useful purposes based on our results.

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

My project's activities can be rational bases for design of heterologous metabolic pathways aimed at improved fermentation performances for exploiting industrial yeast strains. Also, my projects contribute to a new microbial platform for fermenting agricultural byproducts and residues to value-added products in industry.

Type

Projects / Programs without a Critical Issue

Not Provided

Projects / Programs

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