Tennessee (Tennessee State University, University of Tennessee Knoxville Combined) Annual Report - FY2021

Report Status: Approved as of 07/08/2022

Contributing Organizations

Tennessee State University
University of Tennessee Knoxville

Executive Summary

Overview

Tennessee's two land-grant institutions comprise the Tennessee Agricultural Research and Extension System. They work independently and collaboratively to conduct Research and Extension programs in all 95 counties and to serve the state's 6.9 million people. The University of Tennessee is based in Knoxville and serves as the state's 1862 institution. It includes the University of Tennessee Extension (UT Extension) and the Tennessee Agricultural Experiment Station (UT AgResearch). Based in Nashville, Tennessee State University is the state's 1890 institution; it includes the Tennessee State University (TSU) Cooperative Extension Program and the TSU Institute for Agriculture and Environmental Research. The TSU Cooperative Extension Program has county agents in 50 counties, co-located with UT Extension in local county extension offices. This 2021-2022 Annual Report represents the combined efforts of UT Extension, UT AgResearch, TSU Cooperative Extension Program, and the TSU Institute for Agriculture and Environmental Research.

Agriculture is integral to Tennessee's economy and culture. Almost one of every eight to nine dollars generated in the state is associated with agriculture or an industry that generates products from a natural resource - more than $79.3 billion annually. In addition, nearly 339,000 Tennesseans are directly employed by agricultural or natural resource industries, making effective research and Extension programs critical. Tennessee's land-grant institutions conduct research and provide Extension outreach in five key areas to address critical issues affecting the state: supporting food, fiber, and energy systems; enhancing biodiversity and environmental quality; enriching our economy; developing our workforce; and strengthening our health. Research projects provide new knowledge to help stakeholders address issues that affect them. Extension and education activities share that knowledge with stakeholders ultimately to result in a change in action or condition.

Tennessee's land-grant system continued to be impacted by the COVID-19 pandemic. Both UT and TSU have experienced significant disruptions in the execution of our planned programs in research and Extension. Even though our Extension professionals have started to initiate communication through traditional means, and our research scientists have been able to plan and complete some field research, full capacity will not be achieved until the country has the virus contained.

During this reporting year, Extension continued to provide programs to address the needs of the state. Extension's combined overall economic impact for 2021 was $595.3 million. For every $1 in public fund invested in to UT Extension programs, an estimated $8.29 is returned to the people of Tennessee. 32 additional agriculture extension agents in rural and distressed counties were added in 2021. To strengthen our Extension and research for the state's livestock producers, researchers and Extension personnel will jointly implement research and outreach in hay schools, late gestation nutrition, marketing, forage testing, and stockpiled forages. Tennessee Extension has developed programs to strengthen the livestock industry and provide value- added opportunities for producers. Workforce development programs for youth and adults will continue to be of top priority for Tennessee Extension. Workforce development programs such as Skill Up Tennessee and Tennessee 4-H Workforce Preparation programs help youth and adults to acquire new skills and increase aspirations regarding the life skills of achieving goals and communicate effectively.

TSU Extension also conducted internal needs assessment and SWOT analysis in 2019-2020 by collecting the input from its county Extension agents and campus-based Extension faculty. As a result, action plan was prepared to make TSU Extension more relevant and impactful to the people we serve. To strengthen support for TSU Extension agents and Extension programs in the counties, TSU implemented monthly Zoom meetings between county Extension agents and TSU campus Extension faculty to share teaching curriculum and research-based programs.

TSU Extension has appointed Program Leaders in family and consumer sciences, 4-H youth development, and agriculture and natural resources to provide linkage with program areas between UT and TSU Extension. These appointees also serve on the TSU Extension Programming Council to coordinate integrated and interdisciplinary programming efforts. TSU Extension faculty was provided with goals and expectations to prepare and distribute research-based teaching material to our TSU agents. They were also given the expectation to strengthen educational ties with our Extension stakeholders. With additional funding from State, TSU Extension plans to expand it's outreach from 50 to 60 county Extension offices.

UT AgResearch conducts research within its eight academic departments and seven physical centers, and at ten AgResearch and Education Centers located throughout the state. These units drive planned research programs and facilitate the faculty's research projects. In addition to "A Decade of Excellence: Ten- Year Strategic Plan for UTIA, 2018-2028," AgResearch operates under its "2021-2024 AgResearch Strategic Action Plan" (ASAP) with the objectives to balance a portfolio of integrated, inter-disciplinary programs, cultivate teams to approach complex problems, advance concepts with structured support, and to ensure research and development capacity with targeted investment.

Under the ASAP, AgResearch is focusing on four main identified programmatic themes to establish integrated programs to accelerate new solutions to complex problems. The UT One Health Initiative, a UT System-wide approach housed within AgResearch, is working to preserve and promote human, animal, plant, and environmental health to advance economic growth, and conserve biodiversity at local, national, and global scales. Scholars from across AgResearch are actively supporting studies that seek to define the factors threatening human and animal health, and the health of our environment. Significant investment continues to build capacity in precision livestock farming (PLF). More than two dozen faculty and staff from multiple departments form the foundation of this expanding team that is working to meet the anticipated growth in demand for animal proteins. The transformational Agricultural Genomics and Synthetic Biology program addresses animal and plant-based productivity and resilience. This initiative engages faculty in multiple departments to create state-of-the-art science needed to respond to the pressures associated with climate change. The BioEconomy Advancement initiative is an established interdisciplinary, multi-departmental program focused on sustainable fuels, chemicals, and materials from stranded resources. It has highlighted the potential for team research to accelerate progress and have greater impact.

Opportunities to move in new directions to meet shifting priorities are available, including the need for R&D in sustainable aviation fuels. In addition to these programmatic themes, AgResearch will look ahead to identify the next critical areas that may emerge in the foreseeable future.

Through the Institute of Agricultural and Environmental Research, the of goal of agriculture research at Tennessee State University is to create and communicate new knowledge in the agricultural and environmental sciences, especially as it relates to the challenges faced by socially and economically disadvantaged groups. Utilizing faculty in the in the Department of Agricultural and Environmental Sciences and the Department of Human Sciences, our research is coordinated through focus groups in the plant, animal, food, and human sciences. These faculty-led groups facilitate the identification of research priorities of importance to stakeholder groups and the pursuit of collaborative approaches to address those priorities. To ensure we remain relevant to the needs of our stakeholders, a college-wide advisory committee is being formed to ensure that new and existing programs address the needs of agriculture in America. This committee includes leaders from national and regional commercial entities, state and local government representatives, plus state and regional stakeholder organizations. Additional efforts to shape the future of agricultural research and Extension at TSU include a new Futuristic Agricultural College Committee to provide a vision for a college that will respond to the grand challenges of the agricultural sector by utilizing the technological advances of today's world. We believe that technological advances, profitable business opportunities, and policy changes will help solve climate change, declining rural population, increasing labor costs, and lack of nutritional security to many disadvantaged and minority populations.

Despite the challenges imposed by COVID, TSU IAgER continues to expand research capabilities through the addition of new faculty in biotechnology, food science, precision agriculture, and agricultural economics. We are moving forward to the construction phase of a new Food Science and Technology Building that will support our expanding expertise in food technology and food safety. The Agricultural Research and Extension Center associated with the TSU main campus was heavily damaged by a tornado in the spring of 2020. Although field operations have partially resumed, all greenhouse, shadehouse, and indoor activities at the facility have ceased. The timeline for rebuilding dictates that research in these facilities will be significantly delayed for at least another year.

Critical Issue: Agronomic Crop Systems

This critical issue exists in the Tennessee report as an artifact from the REEPort to NRS transition. There should be no active projects or programs associated with it. We are in communication with NIFA to have this critical issue removed.

Critical Issue: Developing Our Workforce

A key component for thriving communities is a strong workforce in rural and urban areas. Extension plays a major role in educating students moving into that workforce to solve present and upcoming challenges. Through outreach and engagement Extension also is educating youth and adults to better understand the vital role that agriculture and animal industries play in people's lives and the career opportunities these industries provide.

Skill Up Tennessee is UT Extension's SNAP Employment and Training program. Supplemental Nutrition Assistance Program Employment & Training (SNAP E&T) is a partnership between the United States Department of Agriculture (USDA) and states to provide training and employment services to eligible SNAP participants. The purpose of the program is to assist eligible SNAP participants in gaining skills, training, work or experience that will increase their ability to obtain regular employment. The ultimate goal is self-sufficiency. In Tennessee, the program is administered by the Tennessee Department of Labor and Workforce Development through a partnership with the Tennessee Department of Human Services. UT Extension provides Skill Up Tennessee as a SNAP E&T partner.

TSU Extension's "Buy, Cook and Eat" nutrition education program is a signature program for TSU SNAP Ed program. TSU SNAP Ed program has staff in seven nutrition deficiency counties with support from campus-based trainings and teaching materials. TSU Extension 4-H Youth Development also plays a critical role in Workforce Development by education youth on life skills, citizenship skills, technology education and STEM science education.

By planting the seeds of strong workforce development, adults and youth are better equipped to enter the workforce. Workforce development leads to prosperous employees, businesses, and local communities. By training and upskilling our workforce, companies can enjoy more skilled staff, lower turnover, and exciting growth opportunities for economy as a whole.

Women are a traditionally underrepresented demographic in the turfgrass industry. As the industry faces labor shortages, increased recruitment and retention of women to the field may reduce labor issues. Researchers at UT AgResearch are promoting change within the turfgrass industry and subsequently increasing female recruitment efforts by identifying unique barriers faced by women that influence female leadership success. Women participating in this research program proved to be vibrant leaders in the industry and faced similar challenges in their journeys to leadership positions, including inappropriate peer conduct, difficulty building a family, and overcoming stereotypes. Women sustained career success by engaging in self-efficacy through educational development, mentorship, and personal growth. These findings can be used by both women and men in the turfgrass industry to improve the current culture for women and eliminate the problems plaguing it.

Critical Issue: Enhancing Biodiversity and Environmental Quality

Safeguarding and enhancing the natural resource environment has become increasingly complex within environmental, social, resource and personal contexts. Through collaboration among researchers, industry, producers, environmental groups, and government, we are helping preserve a diverse and resilient environment for future generations.

Excessive use of nitrogen is detrimental to the environment and unsustainable in global agricultural production. TSU researchers are working to identify novel peptide hormones in legumes that play a role in facilitating nitrogen uptake and root nodule symbiosis. They have identified one novel peptide that affects root architecture under low nitrogen conditions. This research may identify non-GMO routes to enhance N-acquisition.

Tennessee is home to a billion-dollar nursery industry. Red maple trees become stunted when potato leafhoppers feed on the tips of branches, but concern for killing beneficial insects limits treatment choices for growers. TSU entomologists investigated lower risk products for insect control and identified three treatments they know will reduce damage of potato leafhopper on red maples and safer for beneficial insects. Additionally, research revealed that one of the active ingredients they normally apply for potato leafhopper management is less effective than these new treatments.

Sustainable agriculture requires better management of production systems while protecting the environment. TSU scientists are examining extracellular nucleic acid (eDNA) binding on soil minerals that controls organic phosphorus cycling. The knowledge gained from their research can be used to better manage the phosphorus nutrient cycling in the agricultural land as well as undesirable soluble phosphorus loss in the environment. The public is ultimately benefited by the improvements of sustainable agricultural systems by advancing understanding on the nutrient cycling.

Ornamental plant production in nurseries is a particularly important component of the agricultural economy of Tennessee and the mid-South region of the U.S. The whorled sunflower (Helianthus verticillatus) is a federally endangered plant only found in five locations in southeast. Very reliable and vigorous propagation systems for the whorled sunflower, which were unknown for this species before this

project, have been developed by UT AgResearch scientists and will ensure its survival. Identical copies of selected individuals can be produced in the laboratory (by tissue culture) and in the greenhouse (by rooted cuttings) for additional experiments in physiology, genetics, and reproduction. The rooted cutting propagation system is essentially the same for all the selections and is easily adapted for plant production by nursery growers. Recently, individual plants with desirable horticultural characteristics (e.g., red/purple, and green stems, and resistance to some diseases) were selected, and it is estimated that over 500,000 plants can be produced in seven years. A strategy to protect the plant from extinction is to make it available to producers for commercialization.

Anaerobic soil disinfestation (ASD) is an effective alternative to soil fumigation for control of soilborne plant pathogens of high value crops (e.g., strawberry, tomato, and pepper) in several environments. Studies in the southeastern U.S., including at UT AgResearch, have established that ASD is a viable soil fumigant replacement for broad-spectrum soilborne disease management, and that yield and/or economic returns compare favorably to fumigated or non-fumigated production. This work is an important first step in better describing and understanding the role of volatile fatty acids produced in soil during anaerobic soil disinfestation on fungal plant pathogen suppression to ultimately improve treatment recommendations for growers of high value fruit, vegetable, and other specialty crops.

Commercial and private applicators, structural pest control operators, farmers, landscapers, and others need to be aware of Federal and state regulations and ensure they are followed for public safety. The University of Tennessee, Pesticide Safety Education Program (PSEP) provides training and training materials for individuals who want to become certified and/or licensed through the Tennessee Department of Agriculture.

The PSEP provides safety training information concerning many of pests which occur within the state. With proper pest identification and pest control knowledge, a potential reduction of pesticide usage is possible because individuals would be applying products only when needed. This commonly reduces labor, and product costs, impact on the environment and may reduce potential risks to applicators and/or handlers. Reduced cost for the applicator can reduce the cost to the public utilizing the applicators services. Information provided to private and commercial applicators during certification sessions provides information concerning relatively new topics/issues which often have great impact on the community if proper controls and/or safety measures are not taken. Providing pesticide safety education helps reduce the incidence of pesticide misuse, spills, and undesirable damage to non-target organisms.

UT Extension has established an integrated, multi-disciplinary research, education, and outreach program to develop and disseminate information pertaining to crop fertility practices and associated economic and environmental impacts. We promoted the adoption of profitable and environmentally conscious resource management practices through presentations at field days, county, and/or on-farm demonstrations, newly-developed publications and/or mass media articles, and on-site visits. With low crop prices, increasing prices of nitrogen and phosphorus fertilizers, and the contribution of production agriculture to diminished water quality in the Mississippi River Basin, fertility practices need to be reevaluated to better benefit our producers and the environment. Increasing the use of sustainable resource management practices will enable the world to meet present needs while continuously improving future generation's ability to meet their own needs. This can be done not only by lessening our environmental impacts, improving human health, and improving the economic and social well-being of Tennessee's communities, but also by increasing productivity to meet current as well as future food, fuel, and fiber demands.

Critical Issue: Enriching Our Economy

Helping farms and agriculture businesses become more profitable and individuals become financially secure boosts the local, state, and national economies. Our programs strive to strengthen the economic viability of all facets of agribusiness, and improve the financial literacy of Tennesseans and beyond so they may build and protect wealth for themselves and future generations.

The COVID-19 pandemic has caused adverse effects on the supply chain for agricultural commodities by disrupting the production, processing, food manufacturing and by delaying transportation of agricultural products. Economists at TSU calculated the direct, indirect, and induced impact on revenue and employment using industry contribution analysis for the both the state and selected counties in Tennessee considering different scenarios developed based on the information from literature and assumptions. Results are useful for policy makers to design and prepare remedy measures for similar types of external shocks to the economy. The results also bridge the research gap by providing evidence-backed data to decision making authorities in their efforts to recover and strengthen our economy.

The Federal Imported Fire Ant Quarantine restricts movement of nursery stock from Tennessee to many northern markets. The main approved insecticide that is approved for growers to use (chlorpyrifos) has been deemed unsafe by the EPA and growers are losing access to it. Without the insecticide, Tennessee growers cannot ship their product to their primary, northern markets. Loss of northern markets would have a devastating impact on the Tennessee nursery industry. TSU entomologists are examining alternative treatments that will

meet the quarantine requirements. Long-term experiments are being conducted to generate the data required to revise the accepted treatments under the Federal quarantine. This research is essential for the continued viability of the Tennessee and southern U.S. nursery industry.

Scientists at UT AgResearch are investigating the potential financial impact of transitions (e.g., required cage-free production) on egg producers. Capital needs, financial performance, and risk of two production systems have been evaluated. Given the required investment, cost structure, and production parameters, a cage-free egg is about 40% more expensive to produce than a conventional egg. Furthermore, the price premia paid for cage-free eggs in recent years at the farm gate do not offset its higher production cost, making cage-free production less profitable than conventional production. The research team is providing a framework for egg managers, capital providers, and the government to analyze strategies to cope with as farmers transition to a more uncertain cage-free eggs market.

UT Extension's Measuring, Analyzing, Navigating, and Achieving Goals Effectively (MANAGE) was designed specifically to help Tennessee farm families carefully evaluate their individual situation and assist them in improving their quality of life. The MANAGE program is conducted by University of Tennessee Extension. More than 15,000 Tennessee farm families have participated in the intensive farm and financial planning phase of MANAGE.

The MANAGE program provides individualized and unbiased information The MANAGE program helps families analyze their total farming business so they can make informed decisions regarding their future. Staff trained in farm and financial management help families: review their current financial situation, capitalize on strengths and reduce weaknesses in the farm business, develop individualized farm and financial plans, explore alternatives both on and off the farm, evaluate capital investment opportunities including land and/or machinery purchases, analyze likely consequences of changing the scope of enterprises, and determine appropriate production practices

In addition to individualized farm and financial planning assistance, Extension is offering dozens of workshops and other educational programs to help farmers improve their financial situation. For example, workshops are available on a variety of topics including improved marketing, goal-setting, and strategic planning.

Although the MANAGE program will not remove uncertainty of the future, it can provide farm families with a clear understanding of their current financial situation and help them evaluate their alternatives for the future. Making informed decisions today may be the best way to prepare for tomorrow's opportunities. The educational program is offered at no cost to participating farm families in all 95 Tennessee counties. Families are not formally enrolled into the program.

Extension created a state-level education and outreach program to develop and disseminate information about market outlook, risk management, and marketing alternatives to assist row crop producers in improving profitability and mitigating production, financial, and marketing risk. Field days, grain conferences, county and multi-county meetings, popular press articles, Extension publications, personal contacts, and online meetings have been used to disseminate applied research, decision aids, and educational materials to Tennessee row crop producers.

Value-added agriculture, direct marketing and agritourism enterprises contribute to the sustainability of Tennessee farms and rural economies. UT Extension programming for participants helps improve their potential for success by increasing knowledge and skills needed to analyze, develop, improve and/or expand value-added agriculture, direct marketing and agritourism operations.

Tennessee Extension help families increase savings, decrease debt, spend wisely, and plan for the future. Through research-based education, coaching, and community engagement, UT Extension Department of Family and Consumer Sciences (FCS) delivers consumer solutions that help Tennessee families spend, save, borrow, and protect their assets. FCS offers research-based programming to our Extension county agents for use in communities across Tennessee.

Consumer Economics programming continued its focus on (1) training citizens, both youth and adults, in sound basic financial practices, (2) encouraging Tennesseans to save to build assets over their working lives, and (3) encouraging individuals and households to reduce dependence on credit and discharge debt. Consumer Economics education activities are conducted through bankruptcy education, homebuyer education, personal finance training for teachers, saving education for adults and youth, workforce development education and financial education simulations for youth.

Critical Issue: Strengthening Our Health

Making healthy choices is important for humans, animals, and even our planet. As a leader in nutrition, animal welfare, and environmental education, we are working to understand how food, physical activity, and social connections affect overall health (i.e. One Health). From food safety to disease prevention and maintenance to the state of our environment, these efforts will help Americans and the rest of the world lead healthier lives for generations to come.

Food safety is an important component of public health world-wide. Each year, thousands of US citizens are sickened or killed by consuming contaminated foods. A TSU project is developing new systems in using UV light to sterilize opaque liquids, like milk. Results show that the UV systems can be used to inactivate milk-borne pathogens ensuring milk safety. TSU and an industrial collaborator are filling to get FDA approval for skim milk treatment. The advantage of UV sterilization is that unlike heat pasteurization, the milk retains bioactive proteins and peptides.

Antibiotic resistance is concern in human health. The high use of antibiotics in livestock production is thought to lead to antimicrobial resistant bacteria in agricultural ecosystems. To help reverse this trend, TSU scientists analyzed antibiotic-resistant *Escherichia coli* and Enterococcus spp. in ponds, creeks, and streams that are used for irrigation in small-scale farms in Tennessee. Their results provide a roadmap and the necessary insights to mitigate antibiotic resistant bacteria in fresh produce, and to deliver educational materials for growers to decrease unwanted bacteria.

Salmonella is one of the most important foodborne pathogens. To reduce the incidence of Salmonella, new detection technology is needed for reliable and efficient identification of pathogens in foods. TSU scientists have developed new ways to detect Salmonella. The method is highly sensitive and can be performed within 2.5 hours. It can be further developed into small portable measuring devices to facilitate preliminary screening tests. The technology can be used by regulatory agencies and meat and poultry processors to facilitate the identification of food safety fallouts in processing facilities and final products. With this new technology, the testing time will be reduced from days to hours and the cost will be reduced by 50% compared to current methods.

An important component of predicting pandemics (or any illness) is early detection, and detection is best made on-site. This year, UT AgResearch scientists made major advances in development of a new on-site (in-field, bedside) detection and diagnostic methods. This method will revolutionize disease management strategies in human and animal health. On-site detection will reduce the negative impacts of infectious diseases on human/animal wellbeing and on the economy.

Ice recrystallization is a significant problem for the frozen food industry as it affects the taste, texture, and quality of frozen food, decreasing consumers' acceptance. For example, it is vital to control ice recrystallization in ice creams because crystals with a size larger than 50 μm (roughly the diameter of a hair) will lead to a grainy and icy texture that reduces consumer appeal. Researchers at UT AgResearch have discovered a group of novel and inexpensive nanocellulose additives for inhibiting ice recrystallization. These nanocellulose-based ice recrystallization inhibitors offer a low-cost and sustainable solution to the frozen food industry in resolving this challenge.

Tennessee Extension helps people make healthy choices, manage health conditions, and create healthier environments. Through research-based education and community partnerships, the UT Extension Department of Family and Consumer Sciences engages individuals, families, and communities to ensure Tennesseans have the opportunity to achieve the best health possible. Extension provides research-based programming to our Extension county agents for use in communities across Tennessee.

Through the Expanded Food and Nutrition Education Program (EFNEP) and the Supplemental Nutrition Assistance Program Education Tennessee Nutrition and Consumer Education Program (SNAP-Ed: TNCEP), UT and TSU Extension Family and Consumer Sciences continues to offer nutrition education programming and interventions for limited-resource audiences.

The primary objectives of these multi-level, community health programs and interventions were to increase the likelihood that limited-resource persons would make healthy food choices within a limited budget and choose physical activity guidelines consistent with the current Dietary Guidelines for Americans. Youth from preschool to high school and adults from young adulthood to seniors benefited from this work.

Consuming a healthy diet is essential for people of all ages. Despite the importance of a healthy diet, most people in the United States do not follow dietary recommendations. In Tennessee, average intake of fruits and vegetables, a key component of a healthy diet, is below recommendations. Only 11.1% adults in Tennessee consume the recommended amounts of fruit and only 9.6% of Tennessee adults meeting consume the recommended amounts of vegetables (CDC). A person's food choices are dependent on multiple factors, including personal preferences, cultural traditions, and a person's ability to access and afford nutritious foods.

Participants report making dietary improvements that aligned with recommendations in the Dietary Guidelines for Americans, such as eating more fruits, vegetables, and whole grains and drinking fewer sugar-sweetened beverages. Participants report preparing healthy meals. University of Tennessee Extension FCS helped Tennesseans manage their food resources for healthy diets. Through surveys designed for nutrition education programs, participants reported they were better able to manage their food budgets and food resources. Participants report planning meals to manage their food resources.

Critical Issue: Supporting Food, Fiber, and Energy Systems

Safe, sustainable agricultural systems that are socially, economically, and environmentally responsible are key to enhancing the lives of Tennesseans and supporting a growing global population. We are exploring ways to deliver discoveries using a systems approach to agriculture productivity that will provide customizable solutions for producers.

Bacterial wilt disease is one of the most destructive diseases of some major vegetable crops and contributes to significant losses in affected areas. TSU scientists have been able to identify vegable accessions that have resistance to bacterial wilt. These accessions will be the subject of further studies to identify the genetic basis for the resistance.

Breeding cattle in the summer is advantageous from a feed and productivity standpoint, but heat stress can suppress fertility. To improve cattle herd performance TSU research has identified a procedure to score early shedding of the winter hair coat that can help lessen the impact of summer temperatures on fertility. Using a simple, low-cost management practice such as hair scoring to identify and select cows will benefit most southern cattle managers. Approaches that reduce production animal stress are also viewed favorably by consumers.

Synthetic packaging materials cause severe environmental problems on land and in our oceans. The use of natural polymers for packaging has many advantages due to their environmentally friendly virtues. Scientists at TSU generated nanoparticles using sweet potato starch, yellow mustard, and essential oils. The particles had improved release profiles when applied as active food packaging materials. Results of this research generate more environmentally friendly packaging materials, and more byproducts and wastes will be removed from the waste stream.

Sustainable disease management strategies are needed to reduce soilborne diseases in nursery crop production. TSU scientists are assessing a variety of environmentally friendly ways to treat these diseases. Results have established procedures for using natural biofumigants and solarization for disease control, the novel use of substances derived from fire ant venom to treat fungal and oomycete pathogens, and the use of cover crops in disease suppression. This research provides the nursery industry with efficacious, cost-effective and sustainable recommendations for soilborne disease management.

Biofuels are expensive relative to petroleum and are the only alternative fuel for aviation. UT AgResearch scientists maximized the value of biomass by creating high-value products from lignin (e.g., supercapacitors) isolated from the components used for sustainable aviation fuel production. Analysis showed that biobased jet fuels could be produced at less than $3/gasoline gallon equivalent, making them an increasingly competitive option.

The biopesticides market is growing at almost three times the rate of conventional agrochemicals. In the Southeast, cultivation of hemp, a crop grown for food, fiber, and biofuel has increased significantly in the past 5 years due to its profit potential. Identification of organisms that grow in and on the plant can lead to identification of species that can act as pathogens as well as those that can act as biopesticides. Recent work at UT AgResearch co-isolated a fungus (*Epicoccum nigrum*) with three pathogens, (*Fusarium sp., Biopolaris maydis, and Alternaria alternata*) that are good candidates for development of a biopesticide targeting disease in hemp, as well as other crops. Plants inoculated with *E. nigrum* alone had no disease symptoms, and reduced disease severity in plants inoculated with the three pathogens, as well.

While controlled environment agriculture (CEA) has given us the ability to precisely control the growing environment, the "optimal" environmental conditions for maximum plant yield, quality, and energy efficiency are largely unknown for most crops. Thus, there is a critical need to improve environmental growing models for leafy greens such as lettuce. Research at UT AgResearch has determined that increasing the light intensity during green- and purple-leafed butterhead lettuce seedling production, increases in yield of up to 175% to can be realized at harvest. Due to high plant density during propagation (seedling production) and short production duration, the increase in lighting costs (fixtures and energy) can be spread across more plants. This strategy has the potential to improve production efficiencies, increase lettuce yield, and decrease production duration.

The grand challenge of producing sufficient food for the growing population without compromising our environment is compounded by the potential adverse impact of extreme changes in climatic patterns on agricultural soils. Researchers at UT AgResearch are looking into the agronomic and ecological benefits of other aspirational cropland management practices beyond no-tillage. Early results indicate a 32% increase in organic carbon stock in the top 10 cm of soil under no-tillage compared to chisel tillage. Additionally, the inclusion of winter wheat as cover crop increased carbon stocks by 30% in subsoil (30-60 cm) compared to growing no cover crops.

Waxes are crucial for waterproofing, sealing, and preservation. Despite their ubiquity, there have been only a handful of reports over the last 40 years that attempted to relate the interplay among chemical composition, crystallinity, nanostructure, and physical properties. UT AgResearch is leading the way on engineering and designing bio-based waxes that will replace petroleum based and imported waxes for applications in the agricultural postharvest, pharmaceutical and paperboard coating industries.

The impacts of climate change and the rapidly expanding global population is placing significant stress on food and agricultural systems in the U.S. and abroad. To meet emerging challenges, it is essential that novel strategies and approaches for crop improvement be developed. Researchers at UT AgResearch have developed an innovative approach for plant genetic engineering to accelerate the path towards commercialization of chloroplast-engineered crops. Since chloroplasts have a high capacity to produce heterologous proteins, this new method will have a significant impact on the development of plant-based vaccines, value-added products, nutrient dense foods, and bioenergy.

Livestock and forage systems includes multiple livestock industries and the forage resources required for their existence in the state of Tennessee. This focus area combines educational programs and application-based research for improving livestock production and management. UT and TSU Extension delivers this information to adult and youth livestock and equine owners to ensure sustainable information transfer that will improve the livelihoods of Tennesseans who produce meat, milk, and fiber.

UT and TSU Extension Agents and Specialists will conduct educational programs to reach livestock producers across the state. Best management practices in livestock production were taught at group meetings, and on-site visits (i.e. home, farm, workplace). The methods were reinforced by digital communications and mass outreach communications. The objective is to provide Tennessee livestock producers with information and experience that can improve profitability while simultaneously making more efficient and sustainable use of natural resources. TSU Extension's New Farmer Academy provides research-based information, education and training to new and beginning farmers, ranchers, returning veterans and women farmers to strengthen their business operations.

Commercial horticulture encompasses the production and management of ornamental plants and turfgrass, as well as fruits and vegetables for profit. Extension programs in this area focus on challenges facing these segments of the industry in marketing, integrated pest management, sustainable cultural practices, environmental and human health risks, invasive species, regulations, and profitability.

Through educational programming, UT Extension provides the latest information to our producers on meeting the regulatory requirements of the Food Safety Modernization Act (FSMA), developing integrated pest management programs, reducing off-farm inputs, and extending their cropping season with the use of high tunnels and greenhouses- with the overall profitability of their farming operation in mind.

Crop production includes the production and management of row crops such as soybean, corn, cotton, wheat, and tobacco for profit. Extension programs in this area focus on challenges facing crop producers and supporting industries in marketing, integrated pest management, sustainable cultural practices, environmental and human health risks, invasive species, regulations, and profitability.

Extension agents and area Extension specialists conducted educational programs on best production practices are taught at group meetings and on-farm visits. Extension agents also provide vital information for the National Agriculture Statistics Service (NASS) Crop Weather Reporting for their respective regions. The data provided by agents are incorporated in the weekly weather and crop bulletins provided by the U.S. Department of Commerce and USDA.

Merit and Scientific Peer Review Processes

Updates

Tennessee Extension programs funded by Smith-Lever or NARETPA Section 1444 and 1445 require a merit review process. A panel of Extension administrators, program leaders and scholars from four states reviewed and approved the Tennessee Extension merit review criteria. Criteria includes assessing needs, delivery methods, implementation steps, evaluation, ensuring diversity and defined outcomes. UT and TSU coordinate merit review processes. State Extension specialists propose planned programs. All proposed programs are reviewed and approved by a review team of UT and TSU Extension administrators and specialists.

UT AgResearch continues to utilize the process that has been in place since it has proven to be both effective and efficient. Hatch regular and Hatch/Multi-state research projects also undergo a review process for merit and scientific soundness, and to ensure alignment with established research priorities. The review process for Hatch regular research projects begins informally with discussions between the project director, colleagues, the department head, and, if applicable, AgResearch and Education Center administrators if field work is

required for the project. A review panel of three scientists then evaluates the proposal for clarity, technical relevance, and scientific merit (that should lead to publishable data). The project director makes any necessary changes and submits the proposal to the department head for review. If approved, the Dean/Director of AgResearch then conducts a final evaluation and endorses the proposal for submission to NIFA.

Hatch/Multi-state projects go through a comparatively more extensive review at the regional level, so the internal review process is abbreviated. The faculty member officially joins a multi-state project after consulting with colleagues and, if applicable, the AgResearch and Education Center administrators. The project director then submits a proposal reflecting the UT component directly to the Associate Dean/Associate Director of AgResearch for review and comment. Once the review is complete and any necessary changes are made, the researcher submits the project to NIFA.

As per NIFA recommendations, each proposed TSU research program is peer-reviewed for relevancy and practicality. The review is performed by subject-specific faculty focus groups and the college administration. The Associate Dean for Research facilitates additional reviews by external subject matter experts in the 1890 and 1862 Land-grant system. Faculty proposals within the Critical Issues are evaluated for relevance, scientific soundness, and appropriateness of planned outcomes. Following evaluation and recommended modification, only those proposed programs that successfully meet all criteria are developed into executable outcome objectives.

The TSU College of Agriculture continues to provide dedicated time and monetary support for focus group members to hold off-campus retreats to discuss, evaluate, and plan program objectives without the distractions of campus life. Also, the Associate Deans of the college continue to hold regularly scheduled group and individual meetings with faculty members to review research priorities, Extension work plans, and progress in these areas. These meetings facilitate an almost continual avenue for monitoring of progress and problem resolution. The above -described procedures contribute significantly to ensuring that projects under the Critical Issues are executed efficiently and with maximum benefit to stakeholders.

Stakeholder Input

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

UT and TSU Extension pursued multiple data collections for this Annual Report. All 95 counties have local Extension advisory groups that provide ongoing stakeholder input. The UT-TSU Extension State Advisory Council reviews and updates plans bi-annually. Extensive strategic plan activities also informed this plan. Employees, community members and state agency leaders participated in surveys, listening sessions and focus groups to identify critical issues affecting their communities and how Extension could address these concerns. Based on this input, the State Extension Advisory Council identified plan priorities. New state action agendas were created to address priorities. Plans are reviewed annually to determine progress and make changes.

UT AgResearch continues to seek stakeholder feedback through several means. The UT Commission on Agriculture holds public meetings twice per year to provide valuable feedback to UT leadership. Three UTIA Regional Advisory Councils meet twice per year to discuss agricultural and natural resources issues, UTIA program priorities, and how UTIA, including UT AgResearch and UT Extension, may respond to these issues. Successful partnerships with commodity and industry groups, the Tennessee Farm Bureau, and several departments within the Tennessee state government are beneficial to the advancement of common research interests. Advocacy/advisory groups serve the UT AgResearch academic departments and the ten AgResearch and Education Centers at the invitation of the department head and Center director, respectively, to provide stakeholder feedback and to guide future research priorities. Faculty help drive the UT AgResearch agenda by remaining abreast of emerging research and actively engaging with the scientific community, program leaders with state and federal funding agencies, the public, and agricultural and natural resources commodity and industry groups.

Through the development of relationships with the leadership and members of stakeholder-related organizations, TSU research obtains valuable stakeholder input concerning research priorities. To ensure our faculty and programs remain relevant to the needs of our stakeholders, a college-wide advisory committee is being formed to propose and guide new initiatives, and make certain current initiatives address the needs of agriculture in America. This committee includes leaders representing national and regional commercial entities, state and local government representatives, plus state and regional stakeholder organizations. Additional efforts to shape the future of agricultural research and Extension at TSU include the establishment of a Futuristic Agricultural College Committee.

TSU research and Extension places a very strong emphasis on our faculty to partner with the industry, trade, commodity, or professional organizations associated with their respective program areas. In addition to interacting with industry, trade, commodity and professional organizations, faculty are encouraged to assume leadership roles in the organizations. Examples of associations in which our faculty have

enhanced roles of engagement are the: Entomological Society of America, American Phytopathology Society, American Society of Agronomy, Southern Nursery Association, Tennessee Soybean Board, Tennessee Cattlemen's Association, Amaranth Institute, Tennessee Organic Growers Association, Tennessee Nursery and Landscape Association, SE Branch-Entomological Society of America, International Plant Propagator's Society, Tennessee Goat Producers Association, and the Tennessee Urban Forestry Council.

In addition to private groups, TSU faculty regularly engage public agencies to provide guidance and feedback about our programs. Agencies include USDA/NIFA, USDA/APHIS, USDA/ARS, USDA/FSA, USDA/FS, USDA/NRCS, USDA/ERS, USDA RMA, Tennessee Department of Agriculture, Tennessee Department of Forestry, Tennessee Plant Material Advisory Committee, Tennessee Wildlife Resources Agency, and the Tennessee Department of Environment and Conservation. A number of different programs maintain an active presence on social media and utilize feedback gained from those sources in their programs.

Methods to identify individuals and groups and brief explanation

UT and TSU Extension employ their extensive, statewide network of advisory groups for stakeholder input. The State Extension Advisory Council provides input and direction for statewide initiatives. Tennessee Extension Agents will continue to place special emphasis on involving youth and other underrepresented groups in needs assessment activities. All of Tennessee's 95 counties have a County Agricultural Committee of seven local stakeholders, nominated by the County Mayor and approved by majority vote of the County Commission. Every County Agriculture Committee meets four times annually, and their duties include input into hiring decisions, local funding, and local programming. Counties also have individual program advisory committees that help determine program needs in each county.

UT AgResearch implements several methods to identify stakeholders for input. The UT Commission on Agriculture includes representatives from commodity and industry groups, the state government, and the community. It holds public meetings twice per year to provide feedback to UT leadership on research, extension, and education issues. Three UTIA Regional Advisory Councils are comprised of the UT Senior Vice President for Agriculture and Deans, representatives from Tennessee agricultural and natural resources commodity groups, and clientele served by UTIA programs. UTIA personnel nominate the commodity group and clientele members. Each of the three Regional Advisory Groups elects a chair to guide meetings. In addition, UT AgResearch administrators and faculty are actively engaged with agricultural and natural resources commodity and industry groups. As new priorities arise, these groups seek out one another to discuss common research priorities and opportunities for partnership. Advocacy/advisory groups for the UT AgResearch academic departments and the AgResearch and Education Centers identify additional stakeholders based on the individuals' and groups' relevant background, expertise, and community connections, etc. UT AgResearch faculty regularly interact with their peers at professional meetings and through joint project ventures. UT AgResearch administrators encourage faculty to meet with program leaders at state and national funding agencies to discuss research priorities.

Additionally, faculty have opportunities to meet with the public during AgResearch and Education Center field day events.

To date, TSU research has employed a strategy to identify stakeholders in a manner that will provide the most useful and accurate feedback possible about stakeholder concerns. Groups that serve the stakeholders (community-based groups) or groups that represent stakeholders (industry and trade associations) are a primary source of input. Examples of groups are listed in the previous section, "Actions to Seek Stakeholder Input". Individual stakeholders are utilized where there are no associated groups representing the program area, or when an opportunity for face-to-face interaction (i.e., at an association meeting, field site visit, or community event) is presented. In these cases, individuals involved the program outputs are identified and queried for input.

In addition to this strategy, as previously discussed, TSU College of Agriculture is creating an Advisory Board of individuals representing decision-makers from industry, government, and commodity groups. This board will provide invaluable coordinated, stakeholder-based input and programmatic direction to our research and Extension programs.

Methods for collecting stakeholder input and brief explanation

Tennessee Extension (UT/TSU) Agents and Specialists are trained in needs assessment strategies and how to select individuals for Advisory Committees. Community leaders selected for Advisory Committees are chosen to represent the diversities (i.e., gender, age, racial/ethnic, socio-economic, political, educational, etc.) of the county or area served. The UT Commission on Agriculture conducts public meetings twice per year (specific to UT Extension). Extension Agents recruit individuals who have participated in past and current Extension programs; and they recruit individuals who have not used Extension to serve on local advisory committees and participate in open listening sessions. Extension Agents also conduct surveys on planned program areas.

UT AgResearch collects input through regular contact with stakeholders. The UT Commission on Agriculture and the UTIA Regional Advisory Councils meet twice per year. The UT Senior Vice President for Agriculture responds to any issues raised, and, as appropriate, may delegate action to the Deans/Directors of UT AgResearch and UT Extension. UT AgResearch administrators meet with external stakeholders throughout the year. They have face-to-face meetings with the academic department heads and virtual meetings with the AgResearch and Education Center directors monthly; collectively they meet once per year. The academic departments and AgResearch and Education Centers meet with their advocacy/advisory groups annually and share stakeholder feedback with AgResearch administrators and faculty as appropriate. Faculty attend professional meetings and read scientific journals and popular press articles throughout the year. Departments hold monthly faculty meetings where individuals have the opportunity to share their insights with peers and their department head.

TSU research collects input from stakeholders by interactions with commodity groups via survey instruments or face-to- face discussions. Survey instruments are a useful tool to assess information from broader groups of stakeholders. The face-to-face discussions are often held with individual stakeholders, community group representatives or trade association representatives, or with individual stakeholders in a group setting. These interactions allow for questions and answers to direct and stimulate discussion of areas important to stakeholders. Many research programs regularly employ surveys of stakeholders to solicit feedback on important issues; surveys for feedback on individual topics are also used following informational talks at educational programs, field days, etc. While some stakeholders prefer the anonymity and brevity of a survey instrument (often resulting in increased level of input gained), it does not always allow for discussion of previously unrecognized areas of concern. The increased acceptance of social media presents opportunities for stakeholder input.

Many programs maintain an active presence on social media; these platforms serve as a source of information on stakeholder needs and concerns. Research presentations to non-academic stakeholders solicit feedback via evaluations; information gained is incorporated into program focus areas.

Also, as previously discussed, TSU College of Agriculture is creating an Advisory Board of individuals representing decision-makers from industry, government, and commodity groups. This board will provide invaluable coordinated, stakeholder-based input and programmatic direction to our research and Extension programs.

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

Created from stakeholder input, the State Extension Strategic Plan for 2010-2020 identified emerging issues, redirected Extension programs, built state action agendas and set program priorities. Based on stakeholder input, the performance measures at local, regional, and statewide level are monitored and adjustments to the deployment of the strategic plan are considered. UT Extension will develop and expand program areas based on the needs of the state and address the five critical issues outlined in this Plan of Work.

Stakeholder input is an active part of setting UT AgResearch budget priorities and redirecting allocations as critical needs emerge, are addressed, and wane. Stakeholder input directly impacts hiring patterns, faculty equipment budgets, scientific communication efforts, forward-looking action plans, and grant-writing directions.

TSU Extension will continue to use extensive stakeholder input to determine what extension faculty positions and extension agent positions are needed for the state of Tennessee. TSU Extension will also continue to partner with UT Extension, county extension offices and extension advisory councils to determine staffing needs, emerging issues and determine priority areas for Tennessee.

Based on a needs assessment, TSU Extension implemented a program called, "Tennessee New Farmer Academy" for farmers, ranchers and returning veterans, to address the need of shortage of production farmers due to aging farm population. We have also expanded the locations to each region of the state. TSU Extension small and minority farms outreach program has been supporting minority and small farmers in Tennessee. It offers several two-day outreach conferences across the state to serve small, minority and women farmers.

As previously stated, TSU research utilizes stakeholder input during the planning and execution of research programs. Information gained through this process did not result in any major changes in research direction or research scope this past year. Rather, it provided information on additional facets for research exploration. For example, discussions with nursery growers and regulatory agencies have led to a major emphasis being placed on education and research in an emerging disease affecting our nursery industry, a yet-to-be named syndrome impacting growers of some of our leading woody ornamentals. Continued concerns over consumer health and food safety issues drives our emphasis in these areas of research. These new, or additional information changes, are examples of stakeholder-inspired modifications we encounter most frequently.

Highlighted Results by Project or Program

Critical Issue

Developing Our Workforce

Skill Up Tennessee

Project Director

Hannah Wright

Organization

University of Tennessee Knoxville

Accession Number

7000101

Skill Up Tennessee

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

On average, approximately almost 870,000 Tennesseans participated in the Supplemental Nutrition Assistance Program (SNAP) each month in 2021. Based on 2018 data, average median income of households on SNAP was $19,917 which is one-third the average median household income of non-SNAP households. Seventy-five percent (75%) of SNAP households had 1 or more workers, yet 53% were below the poverty level. A low level of education is a barrier for many of these individuals. Knowledge of jobs available, the skills needed for those jobs, and how to gain those skills is a limiting factor. Cost is an important factor as well, both for direct training costs such as tuition and books and vital supports such as transportation and childcare which often present significant barriers. Low levels of training and education affect individuals and their families as employment opportunities are limited. Middle-skill jobs, or those requiring more than a high school diploma but less than a 4-year degree, are in demand and available with a moderate amount of training. Employers are affected when there is a shortage of workers with the required knowledge, skills, and soft skills necessary to be successful in these jobs.

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.

Skill Up Tennessee, UT Extension's SNAP Employment and Training Program conducted in partnership with the Tennessee Department of Labor and Workforce Development, was implemented to help qualifying adult SNAP participants set and reach training and employment goals that lead to self-sufficiency. The program is marketed through partners at the county level, in collaboration with Family and Consumer Sciences Extension agents and Career Navigators (Extension Assistants), to recruit interested individuals for the program. Case management is provided by Career Navigators to help participants address barriers, make a plan, and pursue training leading to employment. Agents in the majority of counties have been trained to participate in the program. Based on 2021 reporting, 149 group meetings, 156 on site visits, 3760 personal correspondence, 199 digital contacts, and 24 mass outreach activities were reported from counties and the Department of Family and Consumer Sciences. Partnerships have been developed with statewide, regional, and local organizations to promote the program.

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

Skill Up Tennessee has connected participants with support and resources to help them gain the training and skills needed for employment. Supportive services such as tuition assistance, help with the cost of textbooks, and assistance with transportation were provided as barriers were identified. In program year 2021, four hundred fifty-eight (458) individuals preregistered with 329 of those verified as eligible to participate in the program. Together with those already engaged, 414 individuals from 74 counties participated in the program. Two hundred sixty-six (266) participated in vocational/technical training at a Tennessee College of Applied Technology, community college, or other training provider; 54 earned a recognized credential in vocational/technical training, at least 19 have obtained employment, and 22 participated in job retention. Because of the nature of the program, this fits the typical pattern of initial recruitment, enrollment in training that can last up to two years, then earning a credential that leads to employment. The program is voluntary and participants must maintain eligibility so there are credentials earned and employment gained that are not reported if individuals stop participating.

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

Based on 2020 data, for every dollar that is spent, the Skill Up Tennessee program adds a total of $1.92 back to the economy. The most recent data (FY 2021) indicate a total of $876,664 was invested in the Skill Up Tennessee program resulting in significant economic impact across the state.

Tennessee 4-H Workforce Preparation

Project Director
Hannah Wright
Organization
University of Tennessee Knoxville
Accession Number
7001313

Tennessee 4-H Workforce Development

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

Due to the changing nature of the 21st century workplace, Tennessee youth need the skills, experience, and confidence necessary to meet its demands and thrive in a high-performance economy characterized by high-skill, high-wage employment. Attention must be paid to introduce students to and encourage an interest in science and other STEM fields at an early age. Students oftentimes lose interest in STEM subjects by middle school (Grades 6-8) (Barker & Aspray, 2006). Early interventions help to create a STEM pipeline for students to major in STEM-related fields and enter STEM careers.

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.

UT and TSU Extension Volunteers made 251,513 direct educational contacts, as well as 163,135 digital contacts to help youth gain new knowledge, acquire new skills and increase aspirations with regards to positive youth development. Programs by volunteers were delivered as indicated: Group Meetings and On-site Visits: 8,515; Digital Methods: 2,042; Personal Correspondence: 22,143; Mass Outreach Methods: 347.

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

Youth were surveyed to determine the impact of 4-H positive youth development programs. Of the youth who participated:

- 3,456 youth can analyze the results of a scientific investigation.
- 3,072 youth can record data accurately.
- 3,063 youth can use specific scientific knowledge to form a question.
- 3,025 youth can ask a question that can be answered by collecting data.
- 2,460 youth can design a scientific procedure to answer a question.
- 527 youth can create a display to communicate scientific data and observations.
- 423 youth can use models to explain scientific results.

- 291 youth can use the results of their investigation to answer the question they had asked.
- 273 youth can use science terms to share scientific results.
- 272 youth can communicate a scientific procedure to others.
- 157 youth can use data to create a graph for presentation to others.
- 6,845 youth get excited about new discoveries.
- 6,841 youth like experimenting and testing ideas.
- 6,216 youth report they now like science.
- 5,778 youth report wanting to learn more about science.
- 5,073 youth like to see how things are made or invented.
- 4,721 youth now do science activities that are not for school.
- 4,684 youth report they are good at science.
- 3,874 youth would now like to have a job related to science.
- 3,183 youth who are now making plans to achieve their goals.
- 2,582 youth now set high goals that require work to achieve them.
- 2,388 youth report that they now achieve goals they set for themselves.
- 1,847 youth who have put their goal(s) in writing.
- 1,536 youth have set a goal for their job or career.
- 555 youth try to get as much assistance as they can when working toward their goal.
- 549 youth have a goal set for their job or career.

- 364 youth who work out the details when others set goals for them.
- 1,200 youth who keep trying if they do not achieve their goal the first time.
- 1,026 youth set deadlines to achieve their goals.
- 5,090 youth now work to achieve their goals.
- 3,543 youth put their goals in writing.
- 3,320 youth set high goals.
- 3,056 youth break goals down into steps so they can check their progress.
- 776 youth report they have improved photography skills.
- 639 youth have explored careers in communications.
- 2,888 youth report they have learned skills in visual communications.
- 2,399 youth are now better listeners.
- 1,542 youth report they can now keep records.
- 783 youth use parliamentary procedure to run a meeting.
- 286 youth have knowledge of careers in the communications field.
- 248 now can create on-screen (multi-media) presentations.
- 201 youth now communicate through a website.
- 138 youth report that it is now easier to express their opinions to someone with a different opinion than their own.
- 7,143 youth can express ideas with a poster, exhibit or other display.
- 4,864 youth can now share their ideas through writing.

- 4,334 youth are better able to understand and follow directions.
- 3,935 youth can use technology to help themselves express ideas.
- 3,467 youth have learned at least five jobs in which communication skills are important.

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

By planting the seeds of strong workforce development at a young age, youth are better equipped to enter the workforce as an adult. Workforce development leads to prosperous employees, businesses, and local communities. By training and upskilling our workforce, companies can enjoy more skilled staff, lower turnover, and exciting growth opportunities for economy as a whole.

Closing Out (end date 09/07/2023)

Cognitive Influence on Teaching, Learning, and Decision Making Around Critical Agricultural and Natural Resource Issues

Project Director
Carrie Stephens
Organization
University of Tennessee Knoxville
Accession Number
1020538

Women in Turf

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

Women are a traditionally underrepresented demographic in the turfgrass industry. As the industry faces labor shortages, increased recruitment and retention of women to the field may reduce labor issues. The purpose of this descriptive study was to explore the lived experiences of 13 female leaders in the turfgrass industry representing diverse job titles, years of experience, and geographic locations.

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 objective of this research was to promote change within the turfgrass industry and subsequently increase female recruitment efforts by identifying barriers faced uniquely by women and influences on female leadership success. To discover this information, participants engaged in 30-to-90-minute semi-structured interviews with the central research question, “What lived experiences have shaped your career in the turfgrass industry?” Transcriptions of interviews were open-coded and used to develop six main themes: (a) career paths, (b) mentorship involvement, (c) leadership styles, (d) challenges, (e) opportunities for personal growth, and (f) opportunities for industry growth.

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

Interviewed women proved to be vibrant leaders in the industry and faced similar challenges in their journeys to leadership including inappropriate peer conduct, difficulty building a family, and overcoming stereotypes. Women sustained career success by engaging in self-efficacy through educational development, mentorship, and personal growth. These findings can be used by both women and men in the turfgrass industry to improve current culture for women.

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

The women in turf research has been extraordinary in empowering women in the turf industry. Articles related to this work were published in three highly visible areas and are listed below.

- Carroll, D. & Stephens, C. A. (2021). Women in the green industry: An emerging labor force. *The Turf Zone: Tennessee Turf Grass, August/September*, 14-21.

- Carroll, D. & Stephens, C. A. (2021). Women in the turfgrass industry: University of Tennessee study examines barriers, opportunities, and more. *SportsField Management Magazine, 37*(5), 8-12.

- Carroll, D. & Stephens, C. A. (2020). Growing new grass: Women in turf influencing change. *Golf Course Management Magazine*.

Critical Issue

Enhancing Biodiversity and Environmental Quality

Identification and characterization of small signaling peptides in nodulation and nitrogen acquisition in legumes

Project Director

Sonali Roy

Organization

Tennessee State University

Accession Number

7000302

Identification and characterization of small signaling peptides in nodulation and nitrogen acquisition in legumes

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

Using the model legume *Medicago truncatula*, we are trying to identify novel peptide hormones that play a role in mediating Nitrogen uptake and root nodule symbiosis. Excessive use of Nitrogen is detrimental to the environment and unsustainable in the long run. Our research contributes to identification of putative agrochemicals that may identify non-GMO routes to enhance N-acquisition.

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 the last 6 months, I have successfully hired two graduate students; one doctoral student and one working towards a Masters in Agricultural Sciences on this project. We have identified one novel peptide that affects root architecture under low Nitrogen conditions. Work has begun on identifying stable transgenic lines over expressing this gene and a novel nodulation specific peptide. Finally, I also published a review of the subject area in the journal Trends in Plant Sciences.

Roy, Sonali, and Lena Maria Müller. "A rulebook for peptide control of legume–microbe endosymbioses." *Trends in Plant Science* (2022).

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

During this period, students hired on this project have recieved training in data analysis, CRISPR guide RNA design, cloning and legume nodulation assays. The review published on peptide in nodulation is an open access publication that was read by several members of the target symbiosis community and beyond. It provides a summary of the present state of literature and derives biological principles from existing published work. I also presented work from my laboratory at the North American Plant Phenotyping Network Meeting in Athens, GA and disseminated results, part of which included results from a data analysis completed by my graduate student at TSU.

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

The peptide hormone identified during this period is a potent growth modulating chemical. Further investigation of their function might provide a potentially commercializable agrochemical that can be used to modify root architecture at low doses.

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 transgenic line screening was delayed due to a delay in the greenhouse re-construction but has now been started and is on track for completion in 2022.

Closing Out (end date 09/07/2023)

On Greater Understanding of Extracellular Nucleic Acid Binding Mechanisms on Soil Minerals

Project Director
Sudipta Rakshit
Organization
Tennessee State University
Accession Number
1025021

On Greater Understanding of Extracellular Nucleic Acid Binding Mechanisms on Soil Minerals

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

Extracellular nucleic acid (eDNA) binding on soil minerals controls many biogeochemical processes such as organic P cycling, spread of undesirable genetic materials (such as antibiotic resistant genes). Current literature lacks thorough understanding of the mechanisms of eDNA adsorption on soil minerals under environmental relevant conditions.

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.

Adsorption of small nucleotide (adenosine-5'-monophosphate, AMP), which is a building block of deoxyribonucleic acid (DNA), was studied on a common iron oxide mineral, hematite under a range of environmentally relevant solution properties. Strong retention of AMP was noticed at acidic to neutral conditions, which drastically decreased under alkaline conditions. Addition of inorganic phosphate, mimicking the conditions of inorganic phosphate fertilizer application in the field, to the reaction mixture, greatly solubilized (~50%) the retained AMP from the surface of hematite. A similar desorption behavior of AMP was noticed in the presence of citrate, which is a common organic acid in root exudate. These results were corroborated by the Fourier transformed infrared (FTIR) spectroscopic results. Overall, these results add significantly to the current knowledge of biogeochemical cycling of nucleic acid based organic phosphorus cycling. The knowledge gained from these results can be used to better manage the phosphorus nutrient cycling in the agricultural land as well as the undesirable soluble phosphorus loss in the environment.

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

At this point of the project, the target audience is scientific community who can use these findings to further develop organic phosphorus based nutrient management practices while preventing the loss of inorganic phosphorus from the agricultural land.

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

Sustainable agriculture requires better management of production system while protecting the environment. The public is ultimately benefited by the improvements of sustainable agricultural systems by advancing understanding on the nutrient cycling.

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

One MS student is trained in the project. The results will be published in peer reviewed scientific journals and be presented in conferences.

Horticultural Landscape Plant Breeding, Biotechnology and Pathology Program

Project Director
Robert Trigiano
Organization
University of Tennessee Knoxville
Accession Number
1021516

Assessment of Helianthus verticillatus (Whorled sunflower) for propagation and diseases

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

Helianthus verticillatus is a federally endangered sunflower species only found in small populations in the southern United States. Very little is known concerning the asexual and sexual propagation of the species as well as some of the diseases that may interfere with production and survival of the plant. Research developed asexual (clonal) propagation methods for the sunflower as well as investigated and cataloged some common diseases of the sunflower and explored sexual reproduction and breeding techniques.

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 few individual *Helianthus verticillatus* plants were selected based on stem color and developed a vegetative method of propagation using stem cuttings taken in May. These cuttings were rooted in the greenhouse under controlled conditions that included mist (to maintain soil moisture and humidity). Without rooting growth regulators, nearly all of the cuttings from the green plants rooted easily and transitioned to a growing greenhouse. Only 70% of the cuttings from the purple plants produced roots and were not as successfully transitioned to a growing greenhouse. This project found many minor pathogens of leaves that did not interfere with either growth/flowering or aesthetics of the plants. However, two pathogens, a rust and a powdery mildew, were widespread and severe in the late growing season (August/September). These pathogens did not interfere with abundant flowering, but did significantly impact the appearance of the foliage. The diseases did not kill plants and no chemical control measures were necessary. Individuals of one of the selected clonally produced plants were planted in isolated areas to assess sexual reproduction. We confirmed that these plants exhibited almost total self-incompatibility (could not mate with themselves) and did not produce seeds. Also, the green and purple variants were not compatible and did not produce seeds. Copious amounts of seeds were produced in the fall by multiple, non-clonally produced plants. Self incompatibilty of clonal plants is very important because the sunflower cannot become invasive via distribution of seeds by birds and wind.

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

The results were published in scientific journals (Plants and Plant Disease) for other researchers investigating *Helianthus verticillatus* and other sunflowers. Additionally, the information and goals of the research program were shared with stakeholders at field days at the University of Tennessee. The project is also exploring allowing local nurseries to propagate and distribute the plants with the aims of protecting the species and introducing a very interesting, fall-flowering plant to the landscape.

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

Two clones, 'Autumn Sunshine', a green stem selection and 'Purple Majesty', a purple-red stem selection, have been reviewed and released by the University of Tennessee Institute of Agriculture for additional development and distribution to local producers for trials. The development and trials of these two assessions of *Helianthus verticillatus* will benefit local growers and homeowners as well as help sustain this endangered species.

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.

Citations:

- Boggess, S.L.E. C. Bernard, A.S. Windham, and R. N. Trigiano. 2022. First report of *Stagnonsporopsis heliiopsidis* causing a leaf spot on the whorled sunflower, *Helianthus verticillatus*, in the United States. Plant Dis. DOI: 10.1094/PDIS-11-21-2568-PDN

- Trigiano, R.N., S. L. Boggess, M. Odio, D. Hadziabdic E. C. Bernard and M. C. Aime. 2022. First report of *Coleosporium helianthis* infecting *Helianthus verticillatus*, whorled sunflower, in the United States. Plant Dis. DOI: 10.1094/PDIS-11-21-2496-PDN

- Trigiano, R.N., S. L. Boggess, C.R. Wyman, D. Hadziabdic and S. B. Wilson. 2021. Propagation methods for the conservation and preservation of the endangered whorled sunflower (*Helianthus verticillatus*). Plants 10, 1565. https://doi.org/10.3390/plants10081565

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

The Horticultural Landscape Plant Breeding, Biotechnology and Pathology Program is designed to develop (through breeding and selection) and evaluate new plant materials grown in Tennessee and the mid-south region. These plants are expected to be marketed nationwide as well as globally, and are projected to enhance the economic well-being of the ornamental plant industry. The program also investigates the underlying anatomical characteristics and molecular genetics of resistance to plant diseases, host-pathogen relationships, genetic diversity, and other horticultural and biological characteristics of plants.

Ornamental plant production in nurseries is an important component of the agricultural economy of Tennessee and the mid-South region of the United States (US). *Cornus* species (dogwoods), specifically, *C. florida* (flowering dogwood) and *C. kousa* (Korean dogwood), are essential plants in the nursery industry and make-up a large portion of the wholesale woody plant market. Most flowering dogwood cultivars are susceptible to two diseases: powdery mildew and dogwood anthracnose, which have adversely affected local and national sales in the last twenty years. During this project, plants resistant to the major diseases of dogwood species, powdery mildew and dogwood anthracnose, have been provided to commercial production nurseries. Recently, 'Melissa Mountain Snowfall', a multiple stem Korean dogwood that is a robust grower, bears many brilliantly white flowers in the spring, and abundant large red fruits in the fall was made available to commercial growers. This selection is strongly disease- and insect-free. There are very few red-bract flowering dogwoods with good resistance to powdery mildew. A new tree was identified from self of a commercially available variety with disease resistance. 'Erica's Appalachian Sunrise' is a prolific bloomer and appears to be highly resistant to powdery mildew. This dogwood is grown at six Tennessee nurseries at present and should be available for sale to the public in the next several years. The whorled sunflower (*Helianthus verticillatus*) is a federally endangered plant only found in five locations in southeastern US. This species grows to about 12 feet tall and produces spectacular displays of yellow, daisy-like flowers in late September and October, when few other plants are blooming. Over 45 species of native and introduced insects that may act as pollinators for this plant have been identified.

Very reliable and vigorous propagation systems for the whorled sunflower, which were unknown for this species before this project, have been developed, and will ensure its survival. Identical copies of selected individuals can be produced in the laboratory (by tissue culture) and in the greenhouse (by rooted cuttings) for additional experiments in physiology, genetics and reproduction. The rooted cutting propagation system is essentially the same for all the selections is easily adapted for plant production by nursery growers. Recently, individual plants with desirable horticultural characteristics (e.g., red/purple and green stems and resistance to some diseases) were selected, and it is estimated that over 500,000 plants can be produced

in seven years. A strategy to protect the plant from extinction is to make it available to producers for commercialization. The means to produce clones has been developed and trials have determined that sexual reproduction (via seeds) is only possible when two distinctly genetically different plants are present. The advantage of clonal production is that no seeds will form, and therefore the whorled sunflower, unlike many other sunflowers, will not become a weedy species in the landscape. The breeding schemes are very amenable for incorporating disease resistance and changes in stem color to new varieties of the plant. Many native plant producers are interested in propagating this species, which has great commercial potential.

Closing Out (end date 09/07/2023)

Biological Control of Arthropod Pests and Weeds

Project Director
Jerome Grant
Organization
University of Tennessee Knoxville
Accession Number
1017855

Biology, Behavior and Biological Control of Crape myrtle Bark Scale

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

Crape myrtle bark scale, an invasive species from Asia, is a new pest of crape myrtles and has been found in several locations across the state. This insect affects the aesthetics and saleability of crape myrtles, and the appearance of infested trees in landscapes can lead homeowners to have the trees removed, imposing an economic hardship on families. The impact of this invasive insect will impact nursery producers who grow and sale this plant, as well as homeowners and landscapers.

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.

Because little is known about its state-wide distribution, lifecycle, biology, natural enemies, and impact on crape myrtles, a study was initiated to gain additional knowledge to mitigate crape myrtle bark scale before it becomes an economic barrier for production and growth. This pest, first found in Shelby County in late 2013, has been documented in 16 counties (10 counties are in West TN, 4 in Middle TN, and 2 in East TN). It has now been found in four major metropolitan areas (Chattanooga, Knoxville, Memphis and Nashville), and extensive damage is apparent in many of these areas. We have identified the lifecycle of this invasive pest, which encompasses eggs, four nymphal instars, adult females (sessile), and winged males, with two or three overlapping generations per year. Overwintering populations of last-stage instar females, adult females, and pre-pupal/pupal males are found in mid-February. Populations of several species of lady beetles were found to reduce scale densities at some locations; at least one species, Hyperaspis bigeminata, which was abundant at several locations, may be an important population regulator of CMBS.

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

The target audience of this project include nursery producers who grow and sell crape myrtle, wholesalers and garden stores that sell crape myrtle, and homeowners who plant and grow crape myrtle in their landscapes. Results of this study will enhance management of this invasive pest, improving/maintaining profitability for growers and enhancing plant survival and aesthetics for homeowners.

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

The broader public benefits from this project by the maintenance of beautiful landscapes where crape myrtles grow, enhancing landscape aesthetics. They also benefit by fewer pesticides in the environment to control this invasive pest, and reducing the potential of pesticide pollution in the environment due to reduced pesticide use. The project's activities provide healthier, more aesthetically pleasing landscapes, while minimizing threats to the environment.

Increasing sustainability of Tennessee fruit and vegetable production systems

Project Director
David Butler
Organization
University of Tennessee Knoxville
Accession Number
1014161

Soil volatile fatty acids impact on fungal plant pathogens

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

Anaerobic soil disinfestation (ASD) is an effective alternative to soil fumigation for control of plant pathogens in several environments, but the precise mechanisms of control are not well understood across environments, plant pathogens and cropping systems. It is likely that numerous changes in soil chemical, physical, and biological properties contribute to treatment effects of ASD, including the production of volatile fatty acids (VFAs) during anaerobic decomposition of organic soil amendments. A more complete understanding of the function of VFAs during ASD treatment will help crop managers better design management tactics to control soilborne plant pathogens for high value fruit, vegetable and specialty crop production.

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.

Anaerobic growth chamber trials were conducted to evaluate effects of volatile fatty acid (VFA) and VFA concentration, and interactions with soil pH and soil texture, on the viability of the fungal plant pathogen *Athelia rolfsii* (the cause of southern stem blight of tomato). Fungal survival structures were exposed to acetic or *n*-butyric VFAs at 4, 8, or 16 mmol VFA/kg soil in sandy soil; soil pH was buffered to 5, 6, or 7. Pathogen viability was generally reduced by both VFAs, notably at pH 5 (29% germination at 4 mmol/kg soil, 1% at 8 mmol/kg soil, and 0% at 16 mmol/kg soil). Pathogen viability in water or HCl controls was consistently above 90%. Pathogen survival structures were also placed in sandy or sandy loam soil and exposed to 4 or 16 mmol VFA/kg soil at soil pH 5 or 6. Pathogen viability was generally less in sandy soil compared to sandy loam soil (4 mmol VFA/kg soil at pH 5, 62% germination in sandy loam versus 0% in sandy soil), but not at pH 5 and 16 mmol/kg soil (< 1% germination in both soil textures). Soil clay and organic matter concentration likely plays a role in reduction of VFA activity. VFAs are probable important factors in fungal plant pathogen suppression due to ASD treatment in many soil environments, but activity is dependent on VFA concentration, soil solution pH, and soil texture.

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

The target audience of scientists, agricultural researchers, and agricultural professionals benefitted from project activities through scientific presentations/abstracts and publication of scientific manuscripts. We expect that these results will be translated to extension outputs in the coming years.

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

While there was limited direct public impact during the reporting period, increased knowledge of biological soil disinfestation systems will accelerate the adoption of non-fumigant systems in place of chemical soil fumigation, ultimately improving agricultural sustainability, environmental health and human health.

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

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Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Anaerobic soil disinfestation (ASD; also termed biological soil disinfestation) is an effective alternative to soil fumigation for control of soilborne plant pathogens of high value crops (for example, strawberry, tomato, pepper, and other vegetable, fruit and ornamental crops) in several environments. Studies in the southeastern U.S., including at the University of Tennessee, have established that ASD is a viable soil fumigant replacement for broad-spectrum soilborne disease management, and other studies have shown that yield and/or economic returns compare favorably to fumigated or non-fumigated production. The technique involves soil incorporation of organic amendments (typically cover crop residues or agricultural by-products and wastes), irrigating planting beds to field capacity, and tarping soil with plastic mulch for at least 2 weeks prior to crop planting. The procedure generates anaerobic conditions during microbial amendment decomposition. Anaerobic decomposition increases soil concentrations of volatile fatty acids (VFAs), reduced forms of soil iron and manganese, and a range of other volatile compounds that are potentially detrimental to inoculum of plant pathogens. Work in Tennessee and in other locations has also indicated that ASD can increase interactions of crop roots with beneficial soil microorganisms, including organisms like the fungus Trichoderma which are known to function as fungal biocontrols and plant biostimulants.

At the same time, the precise mechanisms of control of plant pathogens by anaerobic soil disinfestation are not well understood across differing environments, soil properties, plant pathogens or cropping systems, which limits transferability and development of recommendations for use by growers. It is likely that numerous changes in soil chemical, physical, and biological properties contribute to treatment effects of ASD both directly and through additive and interactive mechanisms. This is especially true of VFAs (such as acetic and butyric acids) produced during anaerobic decomposition of organic soil amendments. A more complete understanding of the function of VFAs and interactions with soil properties during ASD treatment will help crop managers better design management tactics to control soilborne plant pathogens for high value fruit, vegetable, and other specialty crop production.

In this project, a series of anaerobic growth chamber trials were conducted to evaluate effects of VFA and VFA concentration anaerobic soil disinfestation, and interactions with soil pH and soil texture, on the viability of the fungal plant pathogen *Athelia rolfsii* (the cause of southern stem blight of tomato and diseases of numerous broadleaf crop plants). In the first trials, fungal survival structures were exposed to acetic or *n*-butyric VFAs at a range of concentrations (4, 8, or 16 mmol VFA/kg soil) in sandy soil with the soil pH buffered during treatment at a range of acidic to neutral soil pH (pH 5, 6, or 7). Pathogen viability was generally reduced by both VFAs in a concentration and soil pH dependent manner, with the greatest suppression at higher concentrations of VFAs and more acidic soil pH. For example, at soil pH 5 there was 29% pathogen viability at 4 mmol VFA/kg soil concentration, 1% at 8 mmol VFA/kg soil concentration, and 0% at 16 VFA mmol/kg soil. In contrast, pathogen viability in water or inorganic acid controls was consistently above 90%. **It is likely that soil pH effects on the chemical form of VFA (protonated or deprotonated) influences fungitoxicity.**

To evaluate soil texture effects, in the second series of trials, pathogen survival structures were placed in sandy or sandy loam soil and exposed to two VFA concentrations (4 or 16 mmol VFA/kg soil) and two soil pH values (soil pH 5 or 6). Pathogen viability was generally less in sandy soil compared to sandy loam soil (4 mmol VFA/kg soil concentration at pH 5, 62% viability in sandy loam versus 0% in sandy soil), but not at soil pH 5 and 16 mmol VFA/kg soil concentration due to low viability in both soil textures (< 1% viability). **The higher concentration of clay and organic matter in the sandy loam soil texture (as compared to the sandy soil) likely plays a role in this observed reduction of VFA activity through adsorptive interactions of the soil particles and the VFAs.**

To evaluate effects of soil microbial metabolism and organic soil amendments on the function of VFAs, in a third series of trials the effects of VFA (acetic or *n*-butyric acid), VFA concentration (4, 8, or 16 mmol VFA/kg soil), soil sterilization by autoclaving (to reduce soil microbial activity), and organic soil amendment on the viability of *Athelia rolfsii* survival structures and soil populations of the beneficial fungus *Trichoderma* were evaluated. Greenhouse experiments were similarly conducted to evaluate indigenous soil populations of *Trichoderma* following soil exposure to VFAs. Our results showed that fungal pathogen viability was again generally reduced by soil exposure under these conditions to acetic (35% viability) or *n*-butyric (22% viability) acids compared to water (74% viability) and inorganic acid (63% viability). Viability was reduced as VFA concentration increased from 4 to 8 and 16 mmol VFA/kg soil (40%, 29% and 17%). **In organic amended soils, there was no difference in fungal pathogen viability compared to non-amended soils, but in the greenhouse experiment there was a *Trichoderma* population increase of over 300% in amended soil compared to the non-amended soil.** Soil autoclaving to reduce microbial activity had no effect on fungal pathogen viability at low VFA concentrations, but fungal pathogen viability was reduced at higher VFA concentrations compared to non-autoclaved soil. These results again show that VFAs contribute to

fungal pathogen mortality in strongly acidic soil environments, and mortality is influenced by VFA components and environment. Antifungal activity of VFAs is however less in non-sterile soil environments more typical of field conditions than in sterile laboratory conditions, suggesting the need to redesign laboratory experiments to better evaluate and model these relationships.

This work is an important first step in better describing and understanding the role of volatile fatty acids produced in soil during anaerobic soil disinfestation on fungal plant pathogen suppression to ultimately improve treatment recommendations for growers of high value fruit, vegetable, and other specialty crops. To build on this work, we are currently evaluating how amendment and environmental properties (for example, amendment carbohydrate to protein ratio and soil temperature) affect formation of VFAs during anaerobic soil disinfestation, how VFAs affect other import soilborne plant pathogens, and how the effect of VFAs interacts with presence of reduced iron and manganese minerals in soils during anaerobic soil disinfestation.

Sustainable Turfgrass Management Practices for the 21st Century

Project Director
John Sorochan
Organization
University of Tennessee Knoxville
Accession Number
1013923

Sustainable Turfgrass Management Practices

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

In 2019, the USDA-SCRI Annual Bluegrass Resistance Project started. This is a $5.2 million endeavor involving 14 different universities across the United States that drew Congressional attention in DC. Multiple herbicide resistant weeds have been identified across the state of TN and entire southeast. Biotypes of annual bluegrass and goosegrass exhibiting resistance to herbicide inhibitors of acetolactate synthase, photosystem II, and EPSP synthase have been identified in several counties. Biotypes resistant to mitotic inhibitors have been identified as well. Several populations of annual bluegrass have shown resistance to multiple modes of action. In each case, research has been conducted not only to confirm resistance but also to provide alternative control options to stakeholders.

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.

New cultivar evaluation studies were initiated to determine relative fitness for both warm and cool-season turfgrass species for Tennessee. In particular, a comprehensive zoysiagrass variety evaluation research programs was established for golf and sports turf. Significant progress was also made determining the impacts of athlete to surface interactions for safer sports turf playing surfaces, including collaborating with biomechanics and kinesiology faculty on main campus. Major renovations were done to advance both natural and synthetic sports turf research plots to focus on future human test subject research. Finally, a new five year grant and contract was extended with Astroturf, after the previous ten year grant and contract expired.

Research into bermudagrass decline, *Gaeumannomyces graminis* var. *graminis* is examining how the fungus spreads on a putting green and develops over time. At the same time, different measures such as fungicides and cultural measures are being examined for long-term control. Research is continuing on fungicide programs to help golf course superintendents maintain quality turfgrass while utilizing as few fungicide applications as possible.

Research on optimal control methods for *Rhizoctonia* pathogens on both warm- and cool-season grasses used in home lawns and golf courses has been conducted. As a result, a few new fungicide programs have been identified, and primary cultural practices needed to reduce disease development have been determined. Research continues to further improve the efficiencies of fungicides providing control, and cultural practices to minimize disease damage.

In 2021, project activities helped make significant progress to address the objectives of our turfgrass research, outreach, teaching programs. Specifically, significant strides were made in the areas of understanding and investigating herbicide resistance in turfgrass stands, identifying sustainable turfgrass fungal disease management practices, and investigating improved species and cultivars for a changing climate; particularly, in the the transition zone.

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

The target audience benefited from project activities by gaining evidence based knowledge that was disseminated through monthly (TN Turf Tuesdays) outreach webinars, in-person visits, trade magazine, and peer review publications.

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

Developing the monthly online TN Turf Tuesdays, a broader audience has been reached statewide, regionally, nationally, and internationally. In fact, the program average is approximately 200 live participants from five continents, and have recorded viewership of more than 1,500 people per event.

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

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Extension Environmental Stewardship Programs

Project Director

Hannah Wright

Organization

University of Tennessee Knoxville

Accession Number

7001307

Crop Nutrient Stewardship

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

With low crop prices, increasing prices of nitrogen and phosphorus fertilizers, and the contribution of production agriculture to diminished water quality in the Mississippi River Basin, fertility practices need to be reevaluated to better benefit our producers and the environment. Increasing the use of sustainable resource management practices will enable the world to meet present needs while continuously improving future generation’s ability to meet their own needs. This can be

done not only by lessening our environmental impacts, improving human health, and improving the economic and social well-being of Tennessee’s communities, but also by increasing productivity to meet current as well as future food, fuel, and fiber demands.

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.

An integrated, multi-disciplinary research, education, and outreach program has been established to develop and disseminate information pertaining to crop fertility practices and associated economic and environmental impacts. We promoted the adoption of profitable and environmentally-conscious resource management practices through presentations at field days, county, and/or on-farm demonstrations, newly-developed publications and/or mass media articles, and on-site visits.

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

The Crop Nutrient Stewardship Workgroup's educational efforts in 2021 to promote nutrient use efficiency in Tennessee have resulted in the following impacts (with 38% of counties reporting): (1) 1145 producers assessed nutrient needs by conducting soil sampling on approximately 450,000 acres and (2) 834 producers utilized UT fertility recommendations on approximately 232,000 acres.

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

By assessing nutrient needs through soil sampling and analysis, 1145 producers potentially reduced fertilizer costs by $16.50/ac and 7,500 tons of excess P2O5 from potentially moving offsite and causing environmental degradation on over 450,000 row crop acres. By utilizing UT fertility recommendations on approximately 232,000 acres, 834 producers had a potential reduction in P2O5 fertilizer costs of $17.76/ac as well as more than 17,700 tons of P2O5 that could move offsite and have negative environmental consequences.

Pesticide Safety Education Program (PSEP)

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

Commercial and private applicators, structural pest control operators, farmers, landscapers and others need to be aware of Federal and state regulations and ensure they are followed for public safety. The University of Tennessee, Pesticide Safety Education Program (PSEP) provides training and training materials for individuals who want to become certified and/or licensed through the Tennessee Department 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.

Recently hired county Extension agents and personnel received pesticide safety related training in the areas of research and demonstrations as well as were provided information concerning Worker Protection Standards (WPS). A new web design was completed in WordPress for the Pesticide Safety Education Program (PSEP). Also, to combat potential herbicide related issues with the use of products containing formulations of dicamba, new training materials were developed to be distributed to county personnel for their production meetings. CropLife and the National Pesticide Safety Education Center with the assistance of industry and university pesticide safety education programs developed a updated paraquat safety training presentation. This presentation was made available to county extension personnel in Tennessee so it could be used as a commercial applicator recertification topic in counties which rely on the product for production purposes. Information concerning pesticide safety was also provided on the web as well as duplicated onto media in presentation formats which were distributed to county personnel. Online materials were developed to provide pesticide users and producers information concerning the PSEP program as well as current pest related issues. Pesticide Safety and Education Training sessions were taught at 52 separate meetings. Over, 138,000 individuals were aware of university efforts due availability of online related materials concerning pesticide safety and pest related issues. Publications and websites were maintained, updated and placed online for Extension personnel and the general public's usage.

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

The Pesticide Safety Education Program provided several scheduled state training sessions, where industry was able to obtain training for newly hired personnel in a timely manner as required by the Tennessee Department of Agriculture. Additional trainings were also provided. Listed below provides a breakdown of training events and individuals impacted.

- Four Extension personnel and 3 research assistants received pesticide certification training for category 10 and Core.
- 1,590 commercial applicators received training in various pesticide categories provided monthly.
- 41 individuals received commercial licensing training through quarterly training sessions.
- 933 individuals received initial certification training from January 1, 2021 to December 20, 2021, and most were obtained through training held at county offices, however of these, 221 private applicators received initial certification made available through online training. County personnel used training materials developed by the state PSEP program.
- 361 individuals received online dicamba specific training.
- 2,179 individuals received face to face dicamba specific training provided by materials made available through joint efforts of PSEP, Plant Sciences and Marketing and Communications.
- 530 workers and/or handlers received Worker Protection Standard training through efforts made available through Tennessee's PSEP Program.

All training was provided by county extension personnel. Also, employers may have provided training and used materials posted on the PSEP and WPS website.

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

Well-trained pesticide applicators are better equipped to control pest problems safer, more effectively with less impact on human health and/or on the environment. Pesticide safety education helps reduce the incidence of pesticide misuse, spills and undesirable damage to non-target organisms.

The program provides safety training information concerning many of pests which occur within the state. With proper pest identification and pest control knowledge, a potential reduction of pesticide usage is possible because individuals would be applying products only when needed. This commonly reduces labor, and product costs, impact on the environment and may reduce potential risks to applicators and/or handlers. Reduced cost for the applicator can reduce the cost to the public utilizing the applicators services. Information provided to private and commercial applicators during certification sessions provides information concerning relatively new topics/issues which often have great impact on the community if proper controls and/or safety measures are not taken. Providing pesticide safety education helps reduce the incidence of pesticide misuse, spills and undesirable damage to non-target organisms. The PSEP program distributed approximately 4,044 copies of various pesticide safety related publications which were distributed to commercial businesses to help increase their employee's knowledge of pesticide safety and aid with proper pest identification. Certification training received by private applicators allows producers to apply restricted-use pesticides which may be needed to obtain satisfactory pest control while reducing economic losses and commonly increasing returns to the producer therefore increasing value of the product to the consumer. Using data from 2021 and methods developed by the Bureau of Labor Statistics it was estimated that Tennessee's impacts combined for both commercial and private applicators is just over $519 million dollars.

Extension Natural Resource Programs

Project Director

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7001300

Developing Sustainable Grasslands – Center for Native Grasslands Management

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

Native grasslands were once abundant in the region and today can play a vital role in agricultural systems for livestock production and by providing ecosystems services including soil health, water conservation, and enhancement of biodiversity, notably at-risk wildlife, and pollinators. The 14-state portion of the eastern United States, centered around Tennessee, provides the forage base for a beef cattle industry that has a 50-million-acre footprint. Within Tennessee, 47% (32,960 operations) of all farms have beef cattle with farm receipts in 2017 of $719,701,000 and more than 2.63 million acres devoted to pasture with an additional 1.66 million acres in hay production, all supporting 1.82 million cattle.

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 Center for Native Grasslands Management has provided research-based knowledge for producers and agencies interested in restoring and enhancing grasslands (forages, biofuels production, and natural areas restoration) for Tennessee and much of the eastern United States. This included training technical and science experts in Tennessee and nationally as well as producers (13 presentations/sessions, 1,641 direct contacts). Steps are being taken to develop CECs through various professional societies for the on-line video curriculum ('Native Grass College') as an additional learning tool supplementing a new technical bulletin and 4 popular and trade magazine articles. Furthermore, in 2021, a 22-chapter book, "Native Grass Forages for the eastern U.S." was completed. This is the most up-to-date and comprehensive publication regarding use of native grass forages and associated uses such as soil health, biodiversity conservation, and biofuels production. An additional 2 sessions (435 direct contacts) were implemented to train land managers, wildlife biologists, landscape architects, foresters, and other scientists on oak woodland and savannah restoration.

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

In-service trainings and multiple presentations at professional meetings allowed experts to be more competent in educating their producers and land managers. Printed, web-based materials, and videos augmented face-to-face and indirect contacts providing producers in Tennessee and surrounding states with the latest research results for managing native grasses in a forage setting and for multiple objectives. Web-based tools (technical bulletins, on-line database, decision support, videos) provided producers and professionals in agriculture and natural resources with user-friendly, science-based resources for making informed business decisions involving summer forage options. Regional initiatives and demonstration projects allowed the Center for Native Grasslands Management to enhance Extension programming, more effectively meet producer needs, and reach larger audiences.

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

Grasslands in the region provide critical agricultural production capacity that can be enhanced through use of native grasses leading to reduced risk from drought loss, summer forage slump common to the Tall Fescue belt, and impacts from fescue toxicosis (estimated to be $2 billion annually across the US). Furthermore, soil health can be improved, water conservation improved, and at-risk wildlife populations benefitted.

Tennessee Healthy Hardwoods Extension Program

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

US Forest Service data consistently shows that although Tennessee has a stable standing timber supply, the quality of the timber is declining. Landowners often cannot reach professional foresters to assist them in making responsible long-term forest management 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.

Now in the 16th year, the Tennessee Healthy Hardwoods Program (THH) is a program that seeks to educate owners of family forests on the importance of sustainable forestry practices. Through hands-on, on-site field days, landowners are able to learn directly from professional foresters about the many acceptable forest management practices. During 2021, four THH field days were held at Tennessee State Forests.

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

Over 200 landowners attended the four field days (attendance restricted by Covid Protocol). The 2021 theme was Special Forest Products. A full 100% of the participants indicated they gained a better understanding of special forest products; 90 percent are more likely to grow special forest products; 98 percent are likely to share the information learned; 81 percent were likely to engage a professional forester as a result of attending the event; pleasingly, 35 percent of the attendees had never attended an Extension Forestry event before. On a scale of 1-10 (10 = high), participants reported the value of the program at 9.4.

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

Sustainable forest management assures that society has a steady supply of wood products, clean water, abundant wildlife, and opportunities for outdoor recreation.

Welcome to Your Woods Extension Program

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

The average tenure of ownership of forested properties in Tennessee is estimated at only 11 years, and hundreds of tracts of forestland transfer ownership each year. New owners often make hasty, harmful, and long-lasting forest management decisions, including improper timber harvesting that leads to soil erosion and degraded forest stands. However, if reached promptly, new owners are receptive to educational advice.

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.

An educational program was needed to reach and teach new forestland owners about sustainable forestry practices. In partnership with the Tennessee Department of Agriculture Forestry Division and the Tennessee Forestry Association, Welcome to Your Woods (WYW) was created. Utilizing a $48,445 grant, a five-year program was initiated. Each year, a list of the new Tennessee Forest Landowners is obtained from the State Tax Assessor's Office. The list is pared down to the largest 700 owners and these owners are mailed a packet of forestry educational material. The purpose is to invite them into the forestry network, provide educational material to guide them as they get started, and direct them to professional foresters for assistance.

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

The 700 landowners contacted via WYW during 2021 collectively own 102,314 acres (mean 146 acres). The program netted an increase in private forest value of $512,000. After the mailing, five percent of the recipients were surveyed to assess the effectiveness of the program. Survey results indicate: 93% feel that the educational material was valuable and useful; 80% either have or plan to contact a professional forester; 87% suggest that because of the material received they are more likely to practice responsible forestry; 92% felt that the program should be continued. The program provides the impetus; recipients take the action; professionals deliver the advice - and forests are better managed to provide the greatest good, for the greatest number, in the long run.

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

Although landowners own the trees on their property, the larger bundle of far-reaching beneficent uses of the forest belongs to the greater society. One well-managed forest gradually leads to another. Knowledge builds on knowledge. In turn, the result is cleaner air and water, diverse/abundant/healthy wildlife, and a renewable, natural, biodegradable, and growing

supply of timber.

Critical Issue

Enriching Our Economy

Closing Out (end date 09/07/2023)

Development of Alternative Imported Fire Ant Quarantine Treatment Options for Nurseries

Project Director

Jason Oliver

Organization

Tennessee State University

Accession Number

1025219

Development of Alternative Imported Fire Ant Quarantine Treatment Options for Nurseries

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

Imported fire ants now infest 148.5 million hectares in the southern U.S. (i.e., regulated area) and the Federal Imported Fire Ant Quarantine (FIFAQ) restricts movement of regulated articles like nursery stock from the regulated area. Field-grown nurseries (i.e., trees and shrubs grown directly in soil and harvested bare root without soil or with a soil root ball) are severely impacted by the FIFAQ because they only have 3 options available to treat plants, including: 1) post-harvest immersion of soil root balls in chlorpyrifos or bifenthrin, 2) two post-harvest drenches in chlorpyrifos with a soil root ball rotation between drenches, or 3) pre-harvest broadcast application of granular chlorpyrifos and a fire ant bait. The primary FIFAQ insecticide (i.e., chlorpyrifos) is under review for possible removal by the judicial system, which would leave nursery producers with one logistically impractical FIFAQ option (post-harvest root ball immersion in bifenthrin). Thus, this project is addressing the need for new and more practical treatment options to meet FIFAQ certification requirements.

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

This project has 3 objectives with the following activities under each objective:

Objective 1: To develop pre-harvest pyrethroid band spray options for field-grown nurseries to meet Federal Imported Fire Ant Quarantine (FIFAQ) certification. A new pre-harvest soil band spray test using OnyxPro (12.8 fl oz/acre), Scimitar GC (14.5 fl oz/acre), or rotations of these pyrethroids was established at a commercial nursery. Soil spray bands were applied at 3-month intervals with the initial spray including a tank mix of preemergent herbicides (Surflan and Princep). Fire ant colonies in tree rows were quantified before the initial March 2021 treatments. Nursery rows were rated for colony activity at about 2-week intervals through Feb. 2022. Results indicate a possible issue with the herbicide tank mix negatively impacting the fire ant pyrethroid treatments. A second pyrethroid band test evaluating 5, 10, and 15 fl oz/acre rates of Scimitar applied at 3-month intervals was sprayed a final time in February 2021 and was monitored biweekly through October 2021. The 15 fl oz Scimitar rate was effective at preventing fire ant infestations in nursery rows, and data will be combined with earlier band test studies to support a 15 fl oz / acre rate recommendation for the FIFAQ.

Objective 2: To develop pre-harvest pyrethroid and biopesticide individual tree treatments to meet FIFAQ certification. Pre-harvest individual tree treatment tests evaluate drenches applied to the soil at the base of single in-field nursery trees to provide potential FIFAQ certification for shipping plants. A pre-harvest individual tree treatment test was initiated in fall 2020 using Scimitar GC (lambda-cyhalothrin pyrethroid) at rates of 0, 1.6, 10, 20, 30, 40, and 50 fl oz/7,128 sqft. The 7,128 sqft was based on the maximum number of trees typically harvest per year (i.e., 675) and harvested at the maximum size (i.e., 32-inch root balls plus buffer zone of 6 inches [10.56 square feet of soil surface per plant]). Colony survival was monitored daily post-treatment for 7 days, then every other day for 21 days, and then monthly out to 6 months. Soil samples were harvested at 1.5, 3, and 6 months post-treatment and laboratory bioassayed against hybrid imported fire ant workers to confirm continued soil toxicity to the ants. The test indicated complete colony control at 7 days after treatment (DAT) for rates ≥ 20 fl oz, 11 DAT for 10 fl oz, and 20 DAT for 1.6 fl oz. The test was repeated October 2021 and the repeat test will be reported in the 2022 fiscal year reporting period. A second pre-harvest individual tree test was performed spring 2021 evaluating Scimitar (20 fl oz/7,128 sqft) alone or with labeled rates of Damoil dormant oil or a surfactant (LescoWet Plus). The dormant oil and surfactant were tested

to determine the potential to rapidly kill sick (i.e., moribund) ants that often survive the initial Scimitar drench treatments (sometimes up to 2 weeks). A fourth treatment compared an emulsifiable concentrate formulation of lambda-cyhalothrin (Lambda-Cy EC RUP [17.6 fl oz/7,128 sqft]) against the Scimitar treatment to determine which might kill fire ants more rapidly. Treatments were evaluated daily for 7 days and then every other day to 22 days. The Scimitar only, Scimitar + surfactant and the Lambda-Cy EC RUP treatments both eliminated all live ants by 4 DAT. However, the Scimitar + dormant oil treatment was not 100% effective until 10 DAT, so apparently the oil lessened insecticidal efficacy.

Objective 3: To develop post-harvest drench plus injection treatments to meet FIFAQ certification. During spring 2021, 24-inch diameter balled and burlapped (B&B) soil root balls were harvested from a commercial nursery in Warren Co., TN. Trees were selected with mature fire ant colonies within the harvest zone and then machine dug and wrapped in burlap and metal baskets. Burlap was pre-sprayed with 0.25 ml OnyxPro per liter to facilitate containment of the fire ants in the soil root ball. Trees were moved to the TSU Nursery Research Center and left for 24 hours before treatment. Trees were then drenched with pyrethroids OnyxPro or Lambda-Cy EC RUP, or the organophosphate chlorpyrifos (i.e., FIFAQ standard). The chlorpyrifos standard was performed according to FIFAQ requirements, which is a 10% drench volume of solution on one side of the root ball, then waiting 20 minutes, and then flipping the root ball and drenching the opposite site with another 10% volume. The pyrethroid treatments each received a 5% drench volume with root ball flipping after 20 minutes and then another 5% volume. Then, another 10% volume of the individual pyrethroids was injected equally among 6 lateral root ball locations using an inverse pyramid pattern from the top of the ball (3 injections), middle of the ball (2 injections), and bottom of the ball (1 injection). The inverse pyramid pattern mimics the truncated cone shape of the root ball, plus puts three injections near the top where the fire ant colonies are generally located after root ball harvest. A non-treated control treatment received just tap water applied as a 10% volume drench, root ball rotation, and 10% volume drench. Root balls were broken apart at 14 days post-treatment and no surviving ants were found in the Lambda-Cy EC RUP treatment, but 2 sick reproductive ants (i.e., alates) were still present in one root ball of the OnyxPro treatment. The non-treated control had three root balls with 1,000+ live ants, one with 300+ live, one with 30+ live, and one with no ants. The chlorpyrifos standard had one root ball with 200+ live ants, one with 150+ live, and three with no ants. Soil samples were collected from inner and outer locations of the root balls during ant survival evaluations and were subsequently laboratory bioassayed against red imported fire ant alates by Dr. David Oi at the USDA-ARS Center for Medical, Agricultural, and Veterinary Entomology Gainesville, FL facility. Pyrethroid treatments were nearly 100% effective at killing alates in laboratory biosassays, but the chlorpyrifos treatment had alate survival at some soil sampling sites and the untreated control had high survival rates. Chemical analysis of lambda-cyhalothrin residues from soil samples by Dr. Karla Addesso are still pending. The pyrethroid treatments were more effective than the chlorpyrifos standard or non-treated control treatments. The spring 2021 B&B drench and injection test was repeated in October 2021 and results will be provided in the 2022 fiscal year reporting period.

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

During the project period, there were 2,369 contacts in total, including 404 direct contacts (17%) and 1,965 indirect contacts (83%). Among the contacts were 1,729 nursery grower contacts (73%) and 640 stakeholder contacts (e.g., extension, homeowners, etc.) (27%). The primary contact methods were email (n=626; 26.5%), in-person (n=49; 2.1%), phone (n=16; 0.7%), and other (n=1,678; 70.9%). Examples of contact activities benefitting stakeholders included insect sample identifications, insect management recommendations, advice on fire ant quarantines, insect specimens shared with university and government agencies, information shared to stakeholders via an intermediate person like extension, and grower alerts via extension listservers. Online training modules with the Tennessee Master Nursery Program continued to provide nursery growers with educational training and to allow participating nurseries to qualify for a 50% cost share through a Tennessee Dept. Agric. Agricultural Enhancement Program funding.

In addition to participant benefits detailed above, the project had direct contact and information exchange with a representative from U.S. Senator Bill Hagerty's office and a local Warren Co. TN government official. A TSU professor and 3 graduate students participated in an insect curation workshop. International outreach included the Netherlands Food and Consumer Product Safety Authority, European and Mediterranean Plant Protection Organization, and scientists at the University of Pissa Italy. Two media outlet contacts included interviews with an Atlanta freelance reporter and a WATE Channel 6 Knoxville news story (viewership stats of 379,517). Other specific target groups benefitting from the project included graduate students at Tennessee State University (TSU) and Tennessee Tech University, the Middle Tennessee Nursery Association, the Tennessee Nursery and Landscape Association, Horticultural Research Institute and AmericanHort, Tennessee Department of Agriculture, Tennessee AgTech Mentor Network, USDA-APHIS, USDA-ARS National Arboretum (McMinnville, TN), USDA-ARS Horticultural Insects Laboratory (Wooster, OH), USDA-ARS Emerging Pests and Pathogens Research Unit (Ithaca, NY), USDA-ARS Center for Medical, Agricultural and Veterinary Entomology (Gainesville, FL), USDA-ARS Thad Cochran Southern Horticultural Research Laboratory (Poplarville, MS), scientists at the University of Georgia and Clemson Univ., Syngenta Crop Protection Inc., OHP Inc., Bayer Environmental Science, TSU and University of Tennessee extension agents, and multiple miscellaneous stakeholders and homeowners.

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

During this fiscal performance period, the major impact of this project was data collected to support 1) new pyrethroid pre-harvest soil band spray treatments for the Federal Imported Fire Ant Quarantine (FIFAQ) to replace the current granular chlorpyrifos broadcast treatment, 2) new rates of lambda-cyhalothrin evaluated as preharvest individual tree treatments (a new treatment method allowing nursery growers to treat specific in-field trees tagged for harvest and then to rapidly ship), and 3) post-harvest drench and injection pyrethroid treatments to replace the current post-harvest chlorpyrifos immersion or drench treatments. The data collected are essential for the continued viability of the Tennessee and southern U.S. nursery industry, since the main FIFAQ insecticide option (i.e., chlorpyrifos) is under judiciary review for possible elimination. Although USDA-APHIS has an exemption in place with the U.S. EPA for continued use of chlorpyrifos as a regulatory treatment, even in the event of a product ban, nursery producers are already having trouble finding chlorpyrifos product due to production shortages and reduced manufacturing incentives by suppliers. Thus, even if the chlorpyrifos is not commercially banned, nursery producers may still not have access to chlorpyrifos; and therefore, there is a strong need for alternative options to certify plants against fire ants and keep shipping markets open. Data we have collected will support several new pre- and post-harvest options for nursery producers to continue to certify and sell plants in markets outside of the FIFAQ regulated area, while also preventing the undesirable spread of imported fire ants into new U.S. locations via ornamental plants.

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 or problems occurred during the fiscal progress reporting period. The project is currently on schedule with the proposed research.

Opportunities for training and professional development included one Tennessee State University (TSU) Masters student who assisted with the pre-harvest pyrethroid band spray and post-harvest root ball fire ant tests and received training in experimental research techniques. Two additional TSU Masters students and one TSU PhD student also received training from the project director via graduate committee service, as well as one PhD student from Tennessee Tech University (external committee member). The project director also provided training to nursery growers during one-on-one interactions at field test sites and other extension contacts. The Tennessee Master Nursery Producer (TMNP) grower online training modules developed by the project director also are providing continuous educational training opportunities to nursery producers on fire ant and other pest management related issues.

Project results were directly disseminated to nursery producers via routine extension interactions at test sites and by email or phone (details in targeted audience section). Information also was shared with the Middle Tennessee Nursery Association for dissemination with the nursery grower community, as well as regular communications with Tennessee Department of Agriculture Plant Inspectors that work directly with producers. A virtual meeting to share and review project data and determine needed research directions was held on 24 August 2021 with Dr. Herbert Bolton (USDA-APHIS National Policy Manager – Emerald Ash Borer, Imported Fire ant and Roseau Cane Scale), Dr. Ronald Weeks (USDA-APHIS-PPQ Biological Control, Imported Fire Ant, and PPA 7721 Coordinator), Dr. David Oi (Research Entomologist, USDA-ARS Center for Medical, Agricultural, & Veterinary Entomology), Dr. Karla Addesso (TSU Chemical Ecology), and the project director. The USDA-APHIS personnel are directly involved in regulation and rule changes in the Federal Imported Fire Ant Quarantine, which could impact all U.S. southern nursery growers.

In the next reporting period, we will continue to evaluate on-going pre-harvest pyrethroid band spray and pre-harvest individual tree fire ant tests and to collect field soil samples to laboratory bioassay against fire ants to confirm continued insecticidal toxicity. A new Scimitar plus herbicide interaction test was started in March 2022 and will be evaluated throughout the next fiscal reporting period. Soil samples from post-harvest root ball studies will be evaluated in the laboratory for the ability to control reproductive (alate) fire ants. Additional pre-harvest individual tree tests and post-harvest root ball tests may be established to address other data needs for certification approvals.

Assessment of Economic Impact of Novel Coronavirus (SARS-CoV-2) on Agriculture and Food System in Tennessee

Project Director

Prabodh Illukpitiya

Organization

Tennessee State University

Accession Number
1025178

Assessment of Economic Impact of Novel Coronavirus (SARS-CoV-2) on Agriculture and Food System in Tennessee

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

The COVID-19 pandemic has caused adverse effects on the supply chain for agricultural commodities by disrupting the production, processing, food manufacturing and by delaying transportation of agricultural products. In addition, employees in various categories involved in provision of food services have temporary become unemployed, many processing facilities and food outlets were closed and consumers were reluctant to go to stores and restaurants. While the human costs of the COVID 19 outbreak that devastated were obvious, the economic impacts of the crisis were unclear hence the economic impact study will help us to get a better and more accurate picture about economic impact across agri-food sector.

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 collected and reviewed case studies on economic impact due to pandemic; reviewed NAICS industry classification system to better understand agriculture and food related sectors for the impact assessment. We purchased IMPLAN data package needed for the analysis. Using IMPLAN data package, out of 546 industries exclusive to IMPLAN, we categorized affected food system into two aggregate sectors namely food production and food processing industries. Accordingly, we considered restaurant and retail food sector category for the analysis. The direct, indirect, and induced impact on revenue and employment were estimated using industry contribution analysis for the both the state and selected counties in Tennessee considering different scenarios developed based on the information from literature and assumptions.

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

The target audiences include students, researchers, general public, and policy makers. We are in the preliminary stage of the project updating our analyses. The participated students for the project activities were able to learn the IMPLAN software and its uses in impact analyses. The study findings showed the magnitude of the loss of revenue and employment in the selected agri-food sectors in the state economy. Research results is useful for the researchers in understanding and comparing the economic impact of the pandemic and design/prepare remedy measures for similar types of external shocks to the economy. The study findings will also bridge the research gap by providing evidence-backed data to decision making authorities in their efforts to recover and strengthen our economy.

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

General public understand the human costs of the COVID 19 outbreak but may not have better understanding of the magnitude of economic impacts of the crisis. The broader public will gain more knowledge on of direct effect, indirect effect and induced effects of revenue and employment losses in the economic. The county wise analysis will provide them a better picture about the magnitude of the impact in the communities that they are living. Community leaders can make better assessment on negative impact caused due to pandemic in economic development.

Agricultural and Rural Finance Markets in Transition

Project Director
Carlos Trejo Pech
Organization
University of Tennessee Knoxville
Accession Number
1020537

Management Strategies, Capital Needs, and Policy Impacting the Financial Performance and Long-Term Sustainability in the US Egg Industry

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

The goal of this Multi-Hatch project is to examine the financial and risk components of firm management, including capital needs, financial performance, firm value, governance structure, and managerial strategies associated with food, fiber, and/or bioenergy enterprises. The result reported this year focuses on chicken eggs production.

Chicken eggs are produced in the US under two production systems: (1) a “conventional” system under which laying hens are caged and (2) a “cage-free” system under which hens are kept in larger spaces in a hen house. It is estimated that in the US around 80% of eggs are conventionally produced and 20% are produced following a cage-free system. This industry is amid a structural change due to a combination of (1) recent legislation across several states in favor of cage-free production and (2) pledges by large egg buyers such as McDonald’s, Walmart, and more than 200 restaurants and supermarkets, to buy cage-free only products by 2025. The two production systems have different financial and risk characteristics but not much is known about these differences because cage-free is a relatively new production system. Our research evaluated managerial strategies, capital needs, and financial performance and risk of the two production systems, and attempted to understand how the new cage-free policy may affect producers across the egg industry supply chain.

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 year we published four peer-reviewed journal articles that disseminated results of our diverse analyses comparing conventional and cage-free egg production systems. These publications allowed us to achieve the goal of understanding the financial performance and risk of the two egg production systems amid ongoing legislation related to cage-free production. The analyses published increased the knowledge base on this topic in the academic community.

Specifically, our analyses were conducted to understand the expected investment capital, cost structures, and revenues of the two production systems at the farmer level. The research suggests instances on which it would be worthwhile for a producer to switch production systems. Our research also attempted to understand the perspective and position of large/vertically integrated firms producing eggs under these two production systems.

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

The target audience includes researchers and graduate students interested in agricultural economics and agricultural or agribusiness finance problems. The four peer-reviewed publications on chicken egg production that resulted from our research during this year increased the knowledge base for the scholarly community. In addition, findings of our research were presented before the Agricultural & Applied Economics Association Annual Meetings.

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

This does not apply to the result reported this year.

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 following peer-reviewed journal publications are directly related to the result reported this year.

- Trejo-Pech, C.O. and Thompson, J. (2021). Discounted cash flow valuation of conventional and cage-free production investments. *International Food and Agribusiness Management Review*, 24(2): 197-214. https://doi.org/10.22434/IFAMR2020.0046

- Trejo-Pech, C.O., and White, S. (2021). Cal-Maine Foods Inc.: stock price estimation in the midst of pandemic. *International Food and Agribusiness Management Review. 24(5):887-900* https://doi.org/10.22434/IFAMR2020.0182

- Trejo-Pech, C.O., and White, S. (2021). Egg production: Conventional or cage-free? *The Case Journal*. 17(4): 462-493. DOI 10.1108/TCJ-10-2020-0132

- Trejo-Pech, C. and White, S. (2020). Capital budgeting analysis of a vertically integrated egg firm: Conventional and cage-free egg production. *Applied Economics Teaching Resources,* 2(4): 34-46. DOI: 10.22004/ag.econ.307148

In addition to contributing to an increase in the knowledge base, results from this research have been adapted and used in the classroom. During this year and the previous year, research findings from the chicken eggs project were used as teaching materials for Agricultural Finance Risk Management (AREC 412) and Advanced Agribusiness Finance (AREC 512), a graduate and undergraduate class respectively taught at the Herbert College of Agriculture at the University of Tennessee at Knoxville.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Chicken eggs are produced in the US under two production systems mainly: (1) a “conventional” system under which laying hens are kept in tiny cages with little ability to move and (2) a “cage-free” system under which hens are kept in larger spaces in a hen house, where they have more freedom of movement. After many years of gradual regulations aimed at protecting laying hens (and other animals), the Prevention of Cruelty to Farm Animals Act was approved in 2018 in California. This legislation required all eggs sold in California to come from cage-free production by 2022. Other states, including Michigan, Washington, Ohio, Massachusetts, and Oregon, have passed cage-free production laws. In addition, large egg buyers such as McDonald’s, Walmart, and more than 200 restaurants and supermarkets have pledged in recent years their intention to buy cage-free only products by 2025. These legislation and consumer demand changes imply structural changes in the chicken egg industry. Some egg producers are already cutting conventional production in favor of cage-free volume. Our research aimed to mainly understand the potential financial impact of this transition on egg producers.

More specifically, our research evaluated capital needs, financial performance, and risk of the two production systems and attempted to understand how the new cage-free policy may affect producers across the egg industry supply chain. This year, we published a few peer-reviewed articles that disseminated the results of our diverse analyses comparing conventional and cage-free egg production systems. The publications increased the knowledge base on this topic in the academic community since not much is currently known about the financial differences between production systems, particularly about long-term profitability and risk. We documented that the two production systems have significantly different financial and risk profiles. Given the required investment, cost structure, and production parameters, a cage-free egg is about 40% more expensive to produce than a conventional egg. Furthermore, the price premia paid for cage-free eggs in recent years at the farm gate do not offset its higher production cost, making cage-free production less profitable than conventional production. Further, cage-free production is riskier than traditional production based on variability in historical price and production parameters.

Our research also suggests that egg producers, particularly small to medium-size farmers, are likely to find this transition significantly challenging, given the high investment needed to accommodate a new production system and the speed at which the egg industry is expected to adjust production systems to meet demand. Currently, it is estimated that around 80% of eggs are conventionally produced in the US, and 20% are produced following a cage-free system. Further, it is expected that to meet future cage-free egg demand, roughly 70% of total laying hens would need to be cage-free by 2027. This implies an accelerated transition from conventional to cage-free production in the following years. Many farmers might not be able to afford this transition and remain competitive given projected profitability based on our models. The role of capital providers in facilitating investment will be relevant to accomplishing this transition. Whether cage-price prices will increase in the future and by how much—negatively affecting consumers and supply chain participants—to adjust farmer profitability is difficult to predict. As cage-free laws are implemented in the mid-term and major food buyers meet their cage-free purchase goals, an ex-post analysis should provide predictions. Overall, our research provides a framework for egg managers, capital providers, and the government to analyze strategies to cope with as farmers transition to an uncertain cage-free eggs market. In addition to contributing to an increase in the knowledge base, results from our research have been adapted and used in the classroom. Research findings from the chicken eggs project were used as teaching materials for a graduate and undergraduate class at the Herbert College of Agriculture, University of Tennessee at Knoxville.

Extension Consumer Economics Programs
Project Director
Hannah Wright
Organization
University of Tennessee Knoxville
Accession Number
7001315

Tennessee Extension Consumer Economics Programs

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

Our current economic landscape tells the story of two realities. The Tennessee economy is strong with consumer spending up and unemployment down from 5.3% at the end of 2020 compared to 4.0% at the end of 2021 (Boyd Center for Business and Economic Research, 2021). Increased wages and job availability have benefitted many Tennessee families affording them the ability to reevaluate their jobs and work-life balance. Additionally, in 2021, families received multiple waves of federal support including stimulus checks and child tax credits. For families of stable financial situations, these streams of additional income provided the ability to increase consumer spending, increase savings and reduce debt. Yet, this reality does not tell the entire story of Tennesseans; lived experiences. Instead, the K-shaped nature of the pandemic recovery has translated into increased financial vulnerability for families that were already struggling pre-pandemic (Office of Employment and Unemployment Statistics, 2021). The COVID-19 pandemic has created a money crunch for these families. Reduced work hours, furloughs, and unemployment threaten financial livelihoods forcing families to reevaluate normal habits of earning, spending, and saving. For financially fragile families, the waves of federal support were often used to meet the costs of daily living leaving little remaining for savings and debt reduction. When COVID-19 hit, over 800,000 Tennessee households were already one emergency away from a financial crisis (United Way of Tennessee, 2020). As the pandemic continues, some Tennessee families face challenges meeting basic household needs. Navigating child care, obtaining adequate food resources, and paying for housing costs are top barriers currently facing both rural and urban Tennessee families (United Way of Tennessee, 2020). The Consumer Economics Programs are designed to provided needed.

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.

Consumer Economics programming continued its focus on (1) training citizens, both youth and adults, in sound basic financial practices, (2) encouraging Tennesseans to save to build assets over their working lives, and (3) encouraging individuals and households to reduce dependence on credit and discharge debt. Agents from 49 counties reported conducting Consumer Economics programming.

Consumer Economics education activities are conducted through bankruptcy education, homebuyer education, personal finance training for teachers, saving education for adults and youth, workforce development education and financial education simulations for youth. Agents reported 33,893 direct educational adult contacts through group meetings, programs, and other direct methods. Agents reported 4,102 contacts via on site visits, 12,913 in personal visits, 189,941 digital contacts, and 1,595,914 through mass outreach. Agents logged a total of 13,690 hours in financial education programming with 2,192 additional hours logged by volunteers.

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

Among the most successful learning and behavioral outcomes for adults participating in Consumer Economics programs were:

- 86.5% (n=2,593) identified resources for meeting the needs of their household.
- 97.4% (n=2,956) evaluated their housing options based on what they needed and could afford.
- 95.9% (n=2,810) better understood basic insurance needs.
- 97.1% (n=2,747) better understood credit reporting and scoring.
- 93.2% (n=3,551) identified ways to reduce spending.
- 99.9% (n=2,238) successfully completed homebuyer education requirements.
- 93.4% (n= 2,364) understood the dangers of using too much credit.

- 96.9% (n=2,247) learned who to pay first if they can't pay everything.

- 88.1% (n=1,729) learned how to better manage stress caused by financial issues.

- 99.7% (n=1,263) set savings or investment goals.

Three months after participating in a Consumer Economics Extension program,

- 85.6% (n=1,411) followed a spending plan.

- 2,247 prospective homeowners successfully completed homebuyer education requirements of which 564 purchased a home resulting in $98,566,947 in loan activity and $837,716 in transfer and mortgage filing fees.

- 414 individuals from 74 counties participated in the Skill Up Tennessee program.

- 266 Skill Up Tennessee clients participated in vocational/technical training at a Tennessee College of Applied Technology, community college, or other training provider; 54 earned a recognized credential in vocational/technical training, at least 19 have obtained employment, and 22 participated in job retention.

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

The percentage of Extension clientele reporting saving decreased from 80% in 2020 to 47% in 2021. However, the amount clientele reported saving for six months increased from $2,897,183 to $12,720,576 and a total of $8,141,958 in debt reduction. The total savings and debt reduction of Consumer Economics clientele for six months was $20,862,534.

Based on 2020 data, for every dollar that is spent, the Skill Up Tennessee program adds a total of $1.92 back to the economy. The most recent data (FY 2021) indicate a total of $876,664 was invested in the Skill Up Tennessee program resulting in economic impact of $1,683,195.

2,247 prospective homeowners successfully completed homebuyer education requirements of which 564 purchased a home resulting in $98,566,947 in loan activity and $837,716 in transfer and mortgage filing fees.

The economic value of volunteer’s time given to financial education programming totals $53,748.

Overall, the total economic impact of Consumer Economics programming is estimated to be $120,320,945.

Tennessee Homebuyer Education Program

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

The national housing market as well as the housing market in Tennessee have had historic impacts. Often, housing is the greatest single expense for families. Consumers must look at renting versus buying a home and determine what is best for their current situation as well as the future. Home ownership continues to be the main source for building wealth among low and moderate incomes. However, knowing how much home you can afford and when you are ready to purchase a home are critical to a homeowner's success. The Tennessee Homebyer Education Program's affordable housing education is desgined and delievered to prepare homeowners with education and resources in order to stay in their homes

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.

UT Extension agents reached over 2,000 consumers through group meetings and other direct methods with affordable housing information A majority of affordable housing work was accomplished through online Home Buyer Education. Twenty-two agents are certified by NeighborWorks America to teach this program in partnership with the Tennessee Housing

Development Agency (THDA). Some agents also worked with their local Habitat for Humanity partners and USDA Rural Development to reach consumers with housing education.

Three agents are HUD certified who reached 180 households and provided homebuyer education to 174 households across their three counties. Seventy-eight total one-on-one counseling sessions were conducted. In these sessions, participants learned how to avoid eviction and improve living conditions through rental counseling; developed sustainable household budgets; and improved their financial capability.

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

As a result of the programs activities, Affordable Housing program participants demonstrated the following outcomes:

- 98.7 percent (n=2,347) analyzed their readiness for home ownership.
- 97.4 percent (n=2,956) evaluated their housing options based on what they needed and could afford.
- 99.9 percent (n=2,238) successfully completed homebuyer education.
- 97.0 percent (n=2,291) gained better understanding of the mortgage process.

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

As a result of both face-to-face and online home buyer education, 564 consumers purchased homes with THDA loans, which is down from 2020's 938. This is an indicator of the low inventory of affordable housing. The properties for these mortgages were located in 67 counties, both rural and urban. In rural counties, 397 homes were purchased and 167 homes were located in urban areas. The dollar value for all loans totaled $98,566,947, with an average home loan of $174,764. This economic impact breaks down to $69,117,734 in rural counties; $29,449,213 in urban areas. Impacts to county government through transfer and mortgage filing fees total $837,716. Notice not all of the reported contacts purchased a home. Homebuyer education also serves to help consumers determine if they are financially ready to purchase a home. In spite of the housing market, total economic impact of affordable housing programs for 2021 was $99,404,663.

Extension Agri-Business Economics and Entrepreneurship Programs

Project Director
Hannah Wright
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University of Tennessee Knoxville
Accession Number
7001310

Tennessee Extension MANAGE Programs

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

Measuring, Analyzing, Navigating, and Achieving Goals Effectively (MANAGE) was designed specifically to help Tennessee farm families carefully evaluate their individual situation and assist them in improving their quality of life. The MANAGE program is conducted by University of Tennessee Extension. More than 15,000 Tennessee farm families have participated in the intensive farm and financial planning phase of MANAGE.

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 MANAGE program helps families analyze their total farming business so they can make informed decisions regarding their future. Staff trained in farm and financial management help families:

- Review their current financial situation
- Capitalize on strengths and reduce weaknesses in the farm business
- Develop individualized farm and financial plans
- Explore alternatives both on and off the farm
- Evaluate capital investment opportunities including land and/or machinery purchases
- Analyze likely consequences of changing the scope of enterprises
- Determine appropriate production practices

The MANAGE program provides individualized and unbiased information. All financial and personal information will remain confidential.

In addition to individualized farm and financial planning assistance, Extension is offering dozens of workshops and other educational programs to help farmers improve their financial situation. For example, workshops are available on a variety of topics including improved marketing, goal-setting, and strategic planning.

Although the MANAGE program will not remove uncertainty of the future, it can provide farm families with a clear understanding of their current financial situation and help them evaluate their alternatives for the future. Making informed decisions today may be the best way to prepare for tomorrow's opportunities. The educational program is offered at no cost to participating farm families in all 95 Tennessee counties. Families are not formally enrolled into the program.

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

In addition to other activities, MANAGE hosted two programs with notable outcomes.

Farmland Legacy Webinar Series included five sessions with 7 difference topics. Topics included:

- Why Succession Planning?
- Estate Planning Tools
- The Hardest Part of Transition Planning: Talking to Each Other
- Practical Tips for Succession and Estate Planning
- Taking Stock of Your Estate
- Finding and Working with Professionals

- Agricultural and Business Transition Planning

125 producers participated in the webinar series. Participants indicated the information knowledge gained from the Farmland Legacy Webinar and potential changes it will have on their farming operations averaged of $25,714 per participants ($720,000 program total).

The Tennessee Master Farm Manager focuses on solid business principals to help you better manage your operation. We will focus on helping you utilize resources on your farm efficiently. In 2021, 695 producers participated in the program and 674 received the course certification. Tennessee Master Farm Manager offered 8 sessions that covered 10 different topics. Topics included: understanding and creating financial statements, taxes and record keeping, veiling, banking, leasing, trade, equipment purchases,and farm transitioning planning.

Participants indicated the information knowledge gained from the Tennessee Master Farm Manager and potential changes it will have on their farming operations averaged of over $14,000 per participants ($7.8 million program total).

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

The MANAGE Program's educational efforts focus on improving the profitably, quality of life, and sustainability of Tennessee's farm families. In turn, those families strengthen the agriculture industry, and have a more positive impact on the standard of living and economic development in their local and state economies.

Tennessee Row Crop Risk Management and Marketing

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

Row crop prices and yield are influenced by multiple factors. Price and yield volatility necessitate producer education in order to implement risk management and marketing tools and strategies. Tennessee crop producers have many tools available to mitigate the production, financial, and marketing risks they face (crop insurance, storage, futures and options, marketing contracts etc.). Use of risk management and marketing tools improve the financial stability and long-term viability of the farming operation. Increased cost of production (fertilizers, chemicals, seed, fuel, and labor) and low/negative profit margins requires row crop producers to actively seek out alternatives that can mitigate risk and enhance profitability. Additionally, the Farm Safety net (Farm Bill) and ad hoc federal government payments provided risk management tools and direct payments that helped producers manage risk and improve profitability. Producer education on USDA programs was essential to increase awareness and use.

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 state-level education and outreach program has been established to develop and disseminate information about market outlook, risk management, and marketing alternatives to assist row crop producers in improving profitability and mitigating production, financial, and marketing risk. Field days, grain conferences, county and multi-county meetings, popular press articles, Extension publications, personal contacts, and online meetings have been used to disseminate applied research, decision aids, and educational materials to Tennessee row crop producers.

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

In 2021, Extension educational efforts promoting the adoption of risk management and marketing tools to mitigate production, financial, and marketing risk and improve net returns resulted 3,017 producers and agri-industry personnel being educated through in-person or virtual meetings Additionally, over 50 popular press articles, 7 extension publications, and 2 online decision aids reached over 109,000 people.

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

This Extension program contributed to the effective use and adoption of this essential risk management tool.A sample of producers attending meetings indicated an average direct economic benefit of $4,700 per operation by participating in the program with an economic impact of over $14.1 million dollars to the State of Tennessee.

Value-Added Agriculture, Direct Marketing and Agritourism

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

The 2017 Census of Agriculture for Tennessee reported: The value of farm products, including value-added products, produced, and sold for human consumption of more than $38.8 million from 3,773 farms. They also reported the value of food sold by farms direct to retail markets was more than $30 million by 458 farms. Additionally, the value of value-added agricultural products was more than $16 million by 757 farms and the value of agritourism, and recreational sales was more than $15.5 million from 644 farms.

These producer entrepreneurs face many challenges in analyzing and developing enterprises including business planning and management, market planning and implementation, risk assessment and management, and understanding and abiding by regulations. The economic impact of farms in these enterprise types can be increased through educational programs.

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 2021, educational efforts in value-added agriculture, direct farm marketing and agritourism included a multitude of in-person and online delivery methods considering the continuation of the COVID-19 pandemic. Efforts by county agents and state specialists reached 3,248 contacts through 131 group meetings, 1,342 contacts through 250 on-site visits, 15,093 contacts through 1,644 personal correspondences, 76,381 contacts through 164 digital contact methods, and 323,605 contacts through 50 mass outreach efforts.

Major educational programs offered by Extension and industry partners in 2021 included Starting a Food Manufacturing Business in Tennessee: MarketReady: Marketing Directly to Restaurants, Grocery Stores, and Institutions: Exploring Agritourism for Your Farm, Grow Your Farm Sales with Pick Tennessee Products Workshops, Evaluating Market Outlets for Dairy Products Workshops, and Reaching Local Farms Workshops.

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

As a result of Extension programming in value-added agriculture, 469 participants gained knowledge/skills to increase sales revenue, increase savings, reduce costs, or make one-time capital purchases. Additional impacts reported include:

- 173 participants increased their understanding of new enterprise or market opportunities and challenges.
- 153 participants developed goals for implementing new or improved marketing strategies.
- 70 participants to evaluate whether to pursue the development of a new agritourism enterprise.
- 48 participants to evaluate whether to pursue the development of a new agritourism attraction/product/activity or service to an existing enterprise.
- 44 participants used the information learned in workshops to implement new or improved marketing strategies.

As a result of Extension programming in value-added agriculture, participants reported total economic activity of $416,086 from increased sales revenue, increased savings, reduced costs and one-time capital purchases.

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

Value-added agriculture, direct marketing and agritourism enterprises contribute to the sustainability of Tennessee farms and rural economies. UT Extension programming for participants helps improve their potential for success by increasing knowledge and skills needed to analyze, develop, improve and/or expand value-added agriculture, direct marketing and agritourism operations.

Critical Issue

Strengthening Our Health

Closing Out (end date 09/07/2023)

SMART ULTRAVIOLET (UV) LIGHT-EMITTING DIODE SYSTEM FOR CONTROLLING CHEMICAL AND BIOLOGICAL CONTAMINANTS IN FOODS AND FOOD CONTACT SURFACES

Project Director

Ankit Patras

Organization

Tennessee State University

Accession Number

1025362

SMART ULTRAVIOLET (UV) LIGHT-EMITTING DIODE SYSTEM FOR CONTROLLING CHEMICAL AND BIOLOGICAL CONTAMINANTS IN FOODS AND FOOD CONTACT SURFACES

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

Food safety is an important component of public health world-wide. Each year, more than 16% of the U.S. population acquire a foodborne illness, and 3,000 people are killed by consuming contaminated foodse Also, the United States is burdened by more than $50 billion in economic costs related to foodborne illnesses each year. Green and sustainable technologies are needed to inactivate pathogenic micro-organisms including toxins.

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

This project primarily focused on developing bench and pilot scale systems in understanding bacterial, spore and viral inactivation in highly opaque fluids including mycotoxins. The project objective was sub-divided into four main tasks. [1]. Virus inactivation: [2]. Bacterial inactivation: [3]. Endospores inactivation. This was a collaborative project between Tennessee State University, University of Tennessee, Agriculture & Agri-Food Canada.

Task [1]. Hepatitis A virus (HAV) outbreaks cause serious disease symptoms in humans worldwide. Improved technologies are sought for viral inactivation to ensure safe foods and simultaneously retain nutrient value and consumer appeal. Ultraviolet light emitting diode (LED) technologies that are sustainable and environmentally safe are being researched for viral inactivation. The objective of this research was to determine and compare the UV-C dose-response of HAV on Formica coupons and in phosphate buffered saline (PBS) using a traditional 254 nm UV-C system and a novel 279 nm UV-C LED system. Methods: HAV (~5 log PFU/mL) in 5 mL PBS within 10 mL beakers was stirred constantly during treatments using 254 nm UV-C with 0 to 34 mJ/cm2 or 279 nm UV-C LED with 0 to 4.14 mJ/cm2. HAV (100 µL) was also surface-spread on Formica coupons (3×3 cm2), air-dried, and treated with UV-C ranging from 0 to 28 mJ/cm2 (N=3). Virus-PBS optical properties were determined using a UV-Vis spectrophotometer. Surviving viruses were enumerated by plaque assays in 6-well plates containing confluent host cells in duplicate from 3 replications. Results: HAV inactivation showed a linear response to UV-C dosage with D10-values of 12.39±0.70 mJ/cm2 on Formica coupons, and with 1 log reduction after 0.57 min treatment and showed D10-values of 4.37±0.61 mJ/cm2 in PBS with 1 log reduction after 0.42 min treatment using UV-C LED. However, HAV showed linear D10-values of 12.40±1.15 mJ/cm2 on Formica coupons with 1 log reduction after 0.71 min and 15.27±2.01 mJ/cm2 in PBS with 1 log reduction after 4.51 min using UV-C (254 nm). Thus, both the UV-C LED system and the UV-C traditional system showed inactivation of HAV on a surface and in a clear fluid. Significance: This study showed the suitability of using novel UV-C LED systems to inactivate HAV on a model food contact surface as well as in a model liquid system. Results from this study will help to calculate the optimal UV-C doses to enable practical delivery for targeted HAV log reductions on food contact surfaces and in clear fluids.

Task [2] Although use of UV irradiation to pasteurize milk has shown promise, the effect of physicochemical and optical properties of opaque liquids such as milk on the efficacy of UV irradiation to inactivate L. monocytogenes has not yet been characterized and studied. This information is critical to designing appropriate UV irradiation systems for milk pasteurization. Identify the effect of suspended milk solids on UV-C (254nm) absorption (µa) and scattering (µ's) in milk, and develop an improved method to calculate UV fluence required to inactivate L. monocytogenes in milk, taking µa and µ's into account. Five milk samples' composition and particle size was analyzed using MIR Spectroscopy and Mastersizer 2000, respectively. Milk optical properties were measured using UV-VIS spectrophotometer and used in the µa and µ's calculation by Inverse Adding-Doubling program. Correlations between physicochemical and optical parameters were analyzed using ordinary least squares. The µa and µ's were taken into account on the UV-C fluence rate (E'avg) and exposure time calculation for UV-C dose 0, 2, 4, 6, 8, and 10 mJ/cm2 using multiphysics engineering. Suspended particles size in milk correlated with µa, while an increase in its concentration reduced µa. All particles except protein increased µ's. Suspended solids in milk cause the incidence of UV-C light absorption and scattering, resulting in lower E'avg in milk. E'avg in cow milk skimmed, 2%, 3.8%, goat milk 2%, 3.8% were 0.0319, 0.0227, 0.0206, 0.0193, and 0.0155 mW/cm2, respectively. The developed E'avg calculation method could estimate similar UV fluence between milks with various optical properties, but requires further improvement to provide an accurate E'avg value in milk. It was also observed that L. monocytogenes cocktails was inactivated by 1 log cycle at doses between 2 -3.8 mJ/cm2/log for cow and goat milk. Data revealed that L. monocytogenes was very sensitive to UV- C irradiation. Results demonstrate that UV irradiation can be used to inactivate milk-borne pathogens ensuring milk safety.

Task 3. The UV action spectrum of a microorganism is a measure of inactivation effectiveness as a function of wavelength. UV inactivation of microorganisms was studied extensively at 254 nm using a low-pressure mercury lamp (LPM). Recently, UV light-emitting diodes (UV-LEDs) at various germicidal wavelengths have emerged as a new source for UV-C radiation generation. Knowledge about microbial inactivation kinetics at various germicidal wavelengths is crucial to design an efficient UV-C treatment process. In addition, understanding optical properties of fluid at target wavelength is important to select UV-C wavelength for better light transmission. This study investigated the comparative effect of UV-C light at various wavelengths (254, 265, 279 nm) on vegetative bacteria and endospores. Overall, the data showed UV-C light at 265 nm efficient (10 and 13 % higher) against E. coli and B. cereus endospores in comparison to 254 and 279 nm. Light transmission through microbial suspensions are higher (31 % for E.coli and 16 % for B. cereus endospores) at 279 nm than 265 nm and makes it suitable for highly opaque liquid foods. This data will be useful for custom selection of the germicidal wavelength where the target beverages absorb less UV-C light which minimize the nutrient loss through photodegradation. Overall the results discussed above demonstrates that light based technologies are very effective in inactivating bacteria, viruses and spores in foods and food contact surfaces. Results demonstrate that UV irradiation is a relatively cheaper technology as compared to conventional thermal processing techniques.

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

Currently TSU and an industrial collaborator is filling a 403(h) federal petition to get FDA approval for skim milk treatment (MPC85).

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

If the petition is approved, UV exposed skim (defatted, MPC85) will be available to public with retained biactive proteins and peptides. These proteins has several health benefits. Heat pasterurization denatures these proteins. This research activity has a huge impact on human health and wellness.

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.

nothing to report.

Closing Out (end date 09/07/2023)

Freeze-thaw Induced Biopolymer Interactions: Implications in the Quality of Frozen Foods

Project Director

Tao Wu

Organization

University of Tennessee Knoxville

Accession Number
1016040

Ice Recrystallization Inhibition Effect of Cellulose Nanocrystals - Influence of Sucrose Concentration

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

Stabilizers are commonly used to inhibit the ice recrystallization process that leads to the formation of large ice crystals, decreasing consumer acceptance of ice cream. However, the ice recrystallization inhibition (IRI) effect of stabilizers is very dependent on measurement conditions. The cause of this dependence is not clear, which imposes problems in comparing the IRI activity and understanding the IRI mechanism of stabilizers.

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 investigated the influence of sucrose concentration on the IRI effect of cellulose nanocrystals (CNCs), which are newly identified IRI active materials, and found out that the IRI effect of CNCs is correlated with the ratio between CNCs concentration in the unfrozen phase and total surface area of ice crystals. It is strong evidence of an ice-binding mechanism for the IRI effect of stabilizers.

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

Our findings will benefit us and other researcher in this field on selecting suitable measurement conditions to screen IRI active materials in future studies. To screen IRI active material, stabilizers' IRI activity should be measured at a high ratio of stabilizer concentration/total surface area of ice crystals where surface coverage is not an issue.

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

Our findings could benefit the ice cream industry in developing new materials and recipes to control ice recrystallization.

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.

This research work can improve our understanding on opposing results in the literature from a fundamental perspective. This project offered training for a Ph.D. student. A paper has been published in a top journal in the field:

- Li, M.; Dia, V.; Wu, T*. Ice recrystallization inhibition effects of cellulose nanocrystals: influence of sucrose concentration. Food Hydrocolloids. 2021. 121. 107111

In next reporting period, we will continue our work to understand the effect of measurement conditions on the ice recrystallization inhibition activity of nanocelluloses.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

The ice recrystallization is the growth in the size of ice crystals during the manufacturing, storage, and transportation of frozen foods. Ice recrystallization is a significant problem for the frozen food industry as it affects the taste, texture, and quality of frozen food, decreasing consumers' acceptance. For example, it is vital to control ice recrystallization in ice creams because crystals with a size larger than 50 µm – or roughly the diameter of a hair - will lead to a grainy and icy texture that reduces consumer appeal. Partially supported by the hatch project, a group of novel and inexpensive materials – nanocelluloses for inhibiting ice recrystallization has been discovered. These nanocelluloses-based ice recrystallization inhibitors will offer a low-cost and sustainable solution to the frozen food industry in combating ice recrystallization.

The work has also advanced our understanding of how food polysaccharides interact with ice and inhibit ice recrystallization. Several food polysaccharides are used as stabilizers in ice creams for controlling ice recrystallization. Our current understanding of the ice recrystallization inhibition mechanism of these polysaccharides is based on their high viscosity or gel-forming ability. Our work significantly advanced our understanding here. We showed that these stabilizers inhibit ice recrystallization by adsorption on the ice surface instead of through the viscosity or gel-forming ability. Additionally, the ice recrystallization inhibition activity of polysaccharide stabilizers is dependent on measurement conditions, and past studies obtained conflicting results. The same polysaccharides can be ice recrystallization inhibition (IRI) active or inactive in different studies, usually explained by the difference in measurement conditions, without knowing the underlying mechanism. Our work has made significant strides in revealing the underlying mechanism causing these contradicted results. These advancements fill the knowledge gaps in understanding how food ingredients influence ice recrystallization and enable other scientists to discover and design new materials with potent IRI activity.

With further research, these antifreeze nanocelluloses may be used to prevent ice-induced damage in the cryopreservation of cells, which is an essential tool in modern medicine and biotechnology. Currently, chemicals such as dimethyl sulfoxide or glycerol are used as cryoprotectants in cryopreservation. These chemicals are either toxic or used in high concentrations, which must be removed through a time-consuming centrifuge process before use. The use of ice recrystallization inhibitors as cryoprotectants can avoid this centrifugation step and significantly increase the survival rate of cells in cryopreservation.

Investigations in One Health: Surveillance, Risk and Management of Pathogen Transmission Among Free-ranging Wildlife, Domestic Species and Humans

Project Director
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Accession Number
1012932

Investigations in One Health: Surveillance, Risk and Management of Pathogen Transmission Among Freeranging Wildlife, Domestic Species and Humans

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

The goal of this project is to apply a One Health approach to investigations of emerging diseases relevant to free-ranging and captive wildlife (including fishes) and the human populations with which they interact. This integrated approach is vital to improving global 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.

Chytrid fungi and ranaviruses have been responsible for the greatest known loss to global vertebrate biodiversity in modern history. There were four major research findings in 2021 produced by the UTIA Amphibian Disease Laboratory. We discovered that the disease, *Batrachochytrium salamandrivorans* (*Bsal*) chytridiomycosis, could develop in frogs, which was previously unknown and substantially increases the biodiversity threat of this emerging pathogen. We found that transmission of *Bsal* was density independent and estimated invasion potential (R0) above 3, indicating *Bsal* outbreaks can occur rapidly and have the potential to cause host (salamander) population extinction. We found that susceptibility to *Bsal* infection was temperature dependent, with greatest host mortality rates occurring at 15C or below. Thus, *Bsal* outbreaks are mostly likely to occur during winter, spring or fall in temperate regions, and invasion risk could shift geographically with climate change. Lastly, we found that eastern hellbender (*Cryptobranchus alleganiensis*) larvae were very susceptible to ranavirus infection and that exposure to glyphosate herbicide increased mortality due to ranavirus. These findings will guide natural resource organizations in the United States and elsewhere in preparing for and managing outbreaks of emerging amphibian pathogens. They also will help conserve biodiversitye- a key component of the wildlife public trust doctrine in the United States.

A collaborative study focused on the impact of climate change on leatherback sea turtles, made significant advances this past year and the UT collaborator was a member of an international working group developed because this species is expected to disappear within the next 60 years. This past year we have discovered pathogens in hatchlings that were previously only

thought to occur in adults, initiated investigation into leatherback microbiome, and made significant advances into development of an appropriate diet for use in rehab, research, and headstart programs. Initial findings will be presented at conferences in 2022.

The study focused on health and assisted reproduction of ocelots made significant advances in semen collection and storage (including in deceased animals) and in artificial insemination. Ocelot numbers are in severe decline in the US and we are identifying health parameters that may be playing a role.

The ongoing explosion of fine-resolution movement data in animal systems provides a unique opportunity to empirically quantify spatial, temporal, and individual variation in transmission risk and improve our ability to forecast disease outbreaks. However, we lack a generalizable framework that can leverage movement data to quantify transmission risk and how it affects pathogen invasion and persistence on heterogeneous landscapes. We developed a flexible framework "Movement-driven modeling of spatio-temporal infection risk" (MoveSTIR) that leverages diverse data on animal movement to derive metrics of direct and indirect contact by decomposing transmission into constituent processes of contact formation and duration and pathogen deposition and acquisition. We applied MoveSTIR to two disease systems: chronic wasting disease (CWD) and mule deer and African swine fever virus (ASFv) and feral swine with the goal of identifying how real-world animal movements captured by GPS collars drive spatio-temporal transmission potential. In brief, our results demonstrate that ignoring fine-scale animal movements on actual landscapes (as is typically done in wildlife disease ecology) can severely mischaracterize transmission risk and epidemiological dynamics. Moreover, our approach provides fine-scale predictions of who, when, and where are potential "hotspots" for transmission, yielding useful information for applied applications. Ultimately, MoveSTIR represents a key step toward integrating real-world animal movements to improve the transportability of epidemiological predictions across spatial, temporal, and ecological contexts.

The new on-site (in-field, bed-side) detection and diagnostic methods being developed by our group will make changes in the disease management strategies in human and animal health, which eventually reduces negative impacts of infectious diseases not only on human/animal wellbeing but also on economy. Also, the methods will help attaining new knowledge in disease epidemiology.

Many pathogens of public health and conservation concern persist in host communities with multiple species. Identifying candidate maintenance and reservoir species is therefore a central component of disease management. However, we lack a systematic understanding of i) how often conclusions are made about maintenance and reservoir species without reference to mechanistic models ii) what types of biases may be associated with these conclusions and iii) how explicitly invoking causal or mechanistic modeling can help ameliorate these biases. Filling these knowledge gaps is critical for robust inference on pathogen persistence and spillover in multihost parasite systems, with clear implications for human and wildlife health. To address these gaps, we developed general epidemiological models as well as models focused on a system of conservation concern – amphibians infected with the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) – with the aim of improving our ability to identify potential reservoir species that disproportionately contribute to pathogen persistence. Our general models highlighted the severe limitations of inferring potential maintenance potential from pathogen surveillance data alone (e.g., just using observed sero-prevalence data). A follow-up comprehensive literature review showed that this type of inference is repeatedly made in wildlife disease studies that identify putative reservoir species, meaning that significant biases likely exist with regards to how we currently identify maintenance species. This work demonstrated that mechanistic disease models are an essential, yet underused, tool in applied studies that seek to target maintenance and reservoir species for disease management. Applying these concepts to a specific system, we combined mechanistic models, laboratory experiments, and extensive field data to test a candidate amphibian reservoir (northern and southern leopard frogs) for the amphibian fungal pathogen *Bd*. In brief, we found that seasonal fluctuations in infection prevalence made it unlikely that leopard frogs could act as reservoir species for *Bd*, highlighting the need for alternative host species for long-term *Bd* persistence in many seasonal amphibian communities in the southern and eastern USA.

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

This project generally targets the scientific community at large, agricultural producers, outdoor recreationalists, and residents of Tennessee and the Southeast. These organizations have a vested interest in wildlife conservation and preserving biodiversity, and our research provides insight into the risk of emerging pathogens to wildlife.

Work on reservoir species for Bd was partially geared toward identifying the potential effects of Bd on amphibian communities existing in Department of Defense (DoD) installations across the USA. For four unique locations spanning from Louisiana to Tennessee to Pennsylvania to Vermont, we were able to use our models to make empirically informed predictions regarding how temperature fluctuations and changing amphibian community dynamics could affect Bd persistence and amphibian health at these DoD locations.

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

Humans, animals, plants and the environment are interconnected and the health of any one of these impacts (and is impacted by) the health of the others. Our work strives to identify the factors that contribute to these and other wicked health issues we face. Furthermore, the species we study often serve as sentinels for human health, which directly benefits the broader public. Our amphibian studies address the importance of preserving biodiversity within our region (which is a global amphibian hotspot, especially for salamander species) and beyond, a key component of the wildlife public trust doctrine in the United States. Amphibians are one of the most imperiled vertebrate taxa in the world, with emerging infectious diseases being a major cause of global amphibian declines and extinctions. Amphibian declines have received significant public attention and funding and our research associated with this significant result contributes to public understanding of these disease-induced declines, a necessary step for ongoing conservation efforts. Similarly, the broader public will benefit from our studies in chronic wasting disease and African swine fever through the development of fine-scaled, targeted maps of potential transmission risk for pathogens of public concern such as CWD and ASFv. Finally, development of an on-site diagnostic tool will greatly increase our efficiency and success in disease investigations.

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.

Undergraduate, graduate, and veterinary students were trained on this project, and in most cases were provided individualized research studies.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Our team of One Health researchers contributed several significant impacts from studies in surveillance, risk and management of pathogen transmission among free-ranging wildlife, domestic species and humans. These impacts include the following:

Batrachochytrium salamandrivorans (*Bsal*) is deadly to salamanders and is especially concerning within our Appalachia region, which is known as a global hot spot for salamander species diversity. We discovered that the disease, *Bsal* chytridiomycosis, could develop in frogs, which was previously unknown and substantially increases the biodiversity threat of this emerging pathogen. We also found that transmission of *Bsal* was density independent and estimated invasion potential (R0) above 3, indicating *Bsal* outbreaks can occur rapidly and have the potential to cause host (salamander) population extinction. We found that susceptibility to *Bsal* infection was temperature dependent, with greatest host mortality rates occurring at 15 C or below. Thus, *Bsal* outbreaks are most likely to occur during winter, spring or fall in temperate regions, and invasion risk could shift geographically with climate change. These findings will guide natural resource organizations in the United States and elsewhere in preparing for and managing outbreaks of emerging amphibian pathogens.

The OneHealth team also made significant progress in disease modeling. First, general and specific epidemiological models were developed with the aim of improving our ability to identify potential reservoir species for disease, with implications for human and wildlife health. The models highlighted the severe limitations of inferring a species' reservoir potential from pathogen surveillance data alone (e.g., just using observed (sero)prevalence data). Applying these concepts to a specific system, mechanistic models, laboratory experiments, and extensive field data were used to test a candidate amphibian reservoir (northern and southern leopard frogs) for the amphibian fungal pathogen *Batrachochytrium dendrobatidis (Bd).* Results showed that seasonal fluctuations in infection prevalence made it unlikely that leopard frogs could act as reservoir species for this pathogen, highlighting the need for alternative host species for long-term *Bd* persistence in many seasonal amphibian communities in the southern and eastern USA.

Another important advance in disease modeling was use of a flexible framework "Movement-driven modeling of spatio-temporal infection risk" (MoveSTIR) that leverages diverse data on animal movement to derive metrics of direct and indirect contact by decomposing transmission into constituent processes of contact formation and duration, and pathogen deposition and acquisition. We applied MoveSTIR to two disease systems: chronic wasting disease (CWD) in mule deer and African swine fever virus (ASFv) in feral swine with the goal of identifying how real-world animal movements captured by GPS collars drive spatio-temporal transmission potential. The results demonstrated that ignoring fine-scale animal movements on actual landscapes (as is typically done in wildlife disease ecology) can severely mis-characterize transmission risk and epidemiological dynamics. Moreover, our approach provides fine-scale predictions of who, when, and where are potential "hotspots" for transmission, yielding useful information for applied applications.

An important component of predicting pandemics (or any illness) is early detection, which is best made on-site. This year, major advances were made in development of a new on-site (in-field, bedside) detection and diagnostic method. This advancement will revolutionize disease management strategies in human and animal health, reducing the negative impacts of infectious diseases on human/animal wellbeing and on the economy.

Aquatic ecosystems are being negatively impacted by climate change, and sea turtle hatchlings are especially impacted due to rising beach (incubation) temperatures. Currently, southern Pacific leatherback sea turtle populations are expected to disappear within the next 100 years, and thus our efforts are primarily focused on discovering ways to help mitigate these declines. This year, research discovered pathogens in sea turtle hatchlings that were previously only thought to occur in adults. To better understand the factors that contribute to hatchling survival and ability to resist pathogen invasion, an investigation was initiated into skin and shell microbiome. Additionally, significant advances were made into development of an appropriate diet for use in rehab, research, and headstart programs. The findings support conservation and management programs dealing with sea turtle health and survival and may be critical components in recovering southern Pacific leatherback populations.

Extension Health and Nutrition Programs

Project Director
Hannah Wright
Organization
University of Tennessee Knoxville
Accession Number
7001311

Healthful Diets for Tennesseans Across the Lifespan

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

Consuming adequate amounts of nutritious foods is essential for all people of all ages. Despite the importance of a healthful diet, children and adults in the United States fall short of meeting dietary recommendations, often consuming inadequate amounts of fruits, vegetables, whole grains, seafood, and dairy products, while exceeding recommendations for nutrients that should be limited, like saturated fats, added sugar, and sodium. In Tennessee, average intake of fruits and vegetables, a key component of a healthful diet, is below recommendations with only 11% of Tennessee adults consuming the recommended amounts of fruit and only 9.5% of Tennessee adults consuming recommended amounts of vegetables (Lee et al. 2022). A healthful diet is important for physical and mental health, playing an important role in growth and development and preventing and managing chronic conditions like heart disease, type 2 diabetes, and dementia. Consuming inadequate amounts of nutritious foods not only negatively impacts growth, development, and health but can also result in increased healthcare costs from diet-related chronic conditions like heart disease and type 2 diabetes. Thus, nutrition interventions that help Tennesseans prepare and consume nourishing, healthful foods are important for the health and wellbeing of Tennesseans at all stages of the lifespan.

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 2021, University of Tennessee Extension Family and Consumer Sciences (FCS) reached 48,899 youth and adult contacts with Extension nutrition programming. Through virtual and in-person Extension nutrition classes, University of Tennessee? Extension?FCS helped Tennesseans across the lifespan develop knowledge, skills, and self-efficacy to plan for nutritious meals and snacks and to choose and prepare nutritious foods. Through social media, email, printed publications, television, radio, YouTube, and other communication efforts University of Tennessee Extension FCS reached Tennesseans with information about healthful food choices.

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

Through surveys designed for FCS Extension nutrition education programs, participants reported positive dietary change and knowledge gains.

- 9,132 of 11,588 (79%) surveyed participants reported making dietary improvements that helped them align their eating patterns with recommendations in the Dietary Guidelines for Americans. These dietary improvements include actions

such as eating more fruits, vegetables, and whole grains and drinking fewer sugar-sweetened beverages.

- 3,400 of 5,141 (66%) surveyed participants reported using meal planning techniques to serve healthful meals and snacks for themselves and/or their families.
- 8,648 of 11,265 (77%) of surveyed participants reported preparing healthful meals and snacks.
- 1,278 of 1,476 (87%) of surveyed participants reported using skills learned in Extension classes, such as following the diabetes plate method, to help them self-manage their chronic conditions through their food choices.
- 3,183 youth now recognize how food choices affect their health.

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

Through University of Tennessee Extension nutrition education, Tennesseans made dietary improvements that align their eating habits with recommendations in the Dietary Guidelines for Americans, resulting in an estimated economic benefit of $41,459 through healthcare cost savings (Calculations estimated from?Scrafford?et al 2019). This program and the results achieved helps to decreases the overall healthcare cost burden to the state.

Healthy Families Healthy Communities (EFNEP and TNCEP): Improving dietary and physical activity behaviors for limited-resource Tennesseans

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

Poor dietary quality and lack of physical activity continue to affect SNAP-eligible Tennessee adults and youth. Increased incidence of diet-related chronic diseases such as diabetes, hypertension and certain cancers are prevalent among this population. Access to healthy food options and physical activity opportunities, along with nutrition education programming and community interventions, are important for helping limited-income individuals and families reduce health risks while managing food resources effectively. In 2021, COVID-19 exacerbated these issues as it exposed large systemic gaps in food resources. In other words, food insecurity rates rose as people became unemployed and food distribution was interrupted by the global pandemic.

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.

Through the Expanded Food and Nutrition Education Program (EFNEP) and the Supplemental Nutrition Assistance Program Education Tennessee Nutrition and Consumer Education Program (SNAP-Ed: TNCEP), UT Extension Family and Consumer Sciences continues to offer nutrition education programming and interventions for limited-resource audiences. The primary objectives of these multi-level, community health programs and interventions were to increase the likelihood that limited-resource persons would make healthy food choices within a limited budget and choose physical activity guidelines consistent with the current Dietary Guidelines for Americans. Youth from preschool to high school and adults from young adulthood to seniors benefited from this work.

Social marketing and the use of social media were particularly high this year with limited face-to-face programming options available. Programs were converted to indirect education or online/remote learning through zoom and Facebook live. Trainings for program assistants and agents from the state level included guidance on remaining compliant with grant funding and reaching audiences creatively with the objective to increase soft skills while teaching online.

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

The Tennessee Nutrition and Consumer Education Program directly provided education to 8,267 youth and adult participants. As a result of this education programing the following outcomes were noted.

- 31% of youth and adults (1014 out of 3247) increased consumption of vegetables.
- 32% of youth and adults (1031 out of 3247) increased consumption of fruit.
- 29% of youth and adults (953 out of 3247) decreased consumption of sugar-sweetened beverages.
- 33% of youth and adults (1070 out of 3247) increased time spent in physical activity.
- 95% of adults (586 out of 619) improved in at least one food resource management behavior.

The Expanded Food and Nutrition Education Program (EFNEP) directly provided education to 5.330 participants. As a result of this education programing the following outcomes were noted.

- 42% of youth and adults (894 out of 2111) increased consumption of vegetables.
- 45% of youth and adults (957 out of 2115) increased consumption of fruit.
- 48% of youth and adults (1013 out of 2110) decreased consumption of sugar-sweetened beverages.
- 51% of youth and adults (991 out of 1960) increased time spent in physical activity.
- 90% of adults (1226 out of 1358) improved in at least one food resource management behavior.

In addition, policy, systems, and environmental (pse) change strategies were implemented designed to promote healthy behaviors and encourage the opportunities to have healthy choices readily available and easily accessible in the community. Over 17,000 pse changes were documented during the 2021 program year.

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

The economic benefit of UT SNAP-Ed: TNCEP and EFNEP programming is $64,904,701 in reduced long-term health care costs. This brokedn down to $39,216,752 for UT SNAP-Ed: TNCEP and $25,687,949 for EFNEP.

Critical Issue

Supporting Food, Fiber, and Energy Systems

Closing Out (end date 09/07/2023)

Evaluation of Biological Control Agents for Phytophthora Capsici Disease Management in Bell/Sweet Pepper

Project Director

Margaret Mmbaga

Organization
Tennessee State University
Accession Number
1025835

Evaluation of Biological Control Agents for Phytophthora Capsici Disease Management in Bell/Sweet Pepper

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

Plant pathogens impose major constraints on agricultural production systems and cause huge losses in crop yields. Persistent challenges in using conventional fungicides to control plant diseases include toxicity hazards to humans, non-target beneficial organisms, environmental contaminations and development of fungicide resistance that render some fungicides ineffective. There is clearly a need to increase the diversity of eco-friendly products that are effective in disease management and are safer to human health, non-target organisms and environmental quality. Microorganisms that colonize the internal tissues of plants without causing any external symptoms [endophytes]; colonize the same tissue as disease-causing organisms. Such organisms have potential to provide valuable natural resource for plant disease management. The overall goal of this project is to identify and develop microorganisms that can protect plants against diseases as biological control agents (BCAs) for disease management and for plant growth promotion.

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.

Assessment of selected microorganisms on diverse fungal pathogens showed their potential for controlling/managing different pathogens. (2) Colonization of plants by the selected beneficial microorganisms was evaluated on different plant species and the mechanisms that underlie the beneficial interactions between selected organisms and their host plants was analyzed. Compounds that are produced when the beneficial organisms interact with the host plant, and with pathogens were analyzed and our results showed that volatile and non-volatile compounds are involved. Information generated from this project can be used to reduce the use of conventional fungicides; reducing health and environmental hazards from chemical fungicides. Results also showed that there is natural protection of plants by microorganisms colonizing plants naturally. It is thus important to preserve diverse microbial communities colonizing plants.

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

The project activities showed the importance of reducing the usage of chemical fungicides that kill microorganisms indiscriminately and erode natural microbes that play a role in protecting plants against diseases. The project also showed that the bio fungicides that are commercially available can be used as safer products for disease control.

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

The project activities also benefited the broader public by showing the existence of natural plant protection in form of existing microorganisms that colonize plants naturally but get eroded by chemical fungicides. Such beneficial organisms can be developed into natural products for disease management and plant growth promotion.

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.

This project provided an avenue for student training and research results have been published in journal articles and presented in meetings.

Assessing the Relationship between Hair Shedding and Cow-Calf Performance in Spring-Calving Dexter Cattle

Project Director
Richard Browning
Organization

Tennessee State University
Accession Number
1025587

Assessing the Relationship between Hair Shedding and Cow-Calf Performance in Spring-Calving Dexter Cattle

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

Managing for spring-born calves in a beef cow herd matches high cow nutrient demand with greatest forage nutrient value in the spring, but requires summer breeding. Breeding cattle in the summer poses the challenge of achieving satisfactory pregnancy rates because heat stress is a noted suppressor of fertility. Early shedding of the winter hair coat can help lessen the impact of spring and summer climatic conditions on thermal status in cattle; whereas, delayed shedding of winter hair can increase the risk of heat stress in cows.

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.

Project activities involve performance recording of preweaning calf growth and cow reproductive performance in Dexter cows scored for hair coat status. The expectation is that information generated will indicate the extent to which hair shedding is a trait to be recorded in spring-calving beef cattle as an influencer of cow-calf performance. Early results suggest positive relationships between early hair shedding and both preweaning calf weights and cow herd fertility.

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

Small-scale cattle managers, limited-resource farm operators, and livestock managers considering alternative production systems could benefit from the results of this project. Small-framed and alternative heritage cattle breeds represent an overlooked, potentially sustainable option for beef production. Increased producer interests in grass-finished beef, local beef marketing, perserving unique breeds, and regenerative agricultural practices that seek to follow natural biological patterns are served by this project. Demonstrating methods of improving cattle hrd performance such as using a simple, low-cost management practice such as hair scoring to identify and select cows with potentially higher summer fertility would benefit most southern cattle managers.

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

Animal welfare is a broader public interest when cattle production is discussed. Approaches that reduce production animal stress would be viewed favorably by consumers. Some segments of the general public are also appreciative of efforts that are seen as being in line with natural processes. Reduced artificial herd inputs and the natural image that comes with calving on spring pasture would also generate favorable impressions of cattle management in the general public.

Closing Out (end date 09/07/2023)

Resource Optimization in Controlled Environment Agriculture

Project Director
Kellie Walters
Organization
University of Tennessee Knoxville
Accession Number
1025614

Dynamic lighting for lettuce

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

In 2019, 35% of controlled environment agriculture (CEA) producers in the United States grew lettuce. Through growing environment optimization, lettuce fresh mass yield and phytonutrient concentrations can be improved, potentially increasing crop value and profitability. Environmental optimization during the seedling phase is crucial to improving profitability because plant density is greater and fixed growing costs such as lighting can be spread across more plants.

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 project quantified how light intensity during indoor seedling production influenced green and purple butterhead lettuce yield and nutritional quality after transplanting into a common greenhouse environment. The project determined that growing green butterhead lettuce 'Rex' seedlings under 200 µmol m–2 s–1 and purple butterhead lettuce 'Teodore' seedlings under 400 µmol m–2 s–1 or greater for 24-hours per day is necessary to maximize yields after transplanting and finishing the crop in a common greenhouse environment for three weeks. The light intensity and photoperiod recommended is greater than traditionally used in young plant production.

Differences were determined in anthocyanin (antioxidant compounds contributing to purple coloration) due to propagation environment did not persist through harvest, but carotenoid (benefical phytonutreints for human health) concentrations tended to decrease as propagation light intensity increased.

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

Greenhouse and indoor lettuce growers now know the light intensity suitable for lettuce seedling production, thus improving subsequent yield and production efficiencies.

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

Improved optimization of controlled environment food production will reduce energy inputs and costs, improving the economic feasiblity of controlled environment production and increasing widespread access to tasty nutritious food.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

While controlled environment agriculture (CEA) has given us the ability to precisely control the growing environment, the “optimal” environmental conditions for maximum plant yield, quality, and energy efficiency are largely unknown for most crops. Thus, there is a critical need to improve environmental growing models for leafy greens such as lettuce. Lettuce is the most grown leafy green in CEA, but lettuce production is impacted by tip burn, a calcium deficiency resulting in necrotic tips on young lettuce leaves that can occur when plants are grown under high light intensities. Since tip burn usually occurs later in the production cycle, light intensity could be increased in early production stages to drive growth without damaging the plant. Traditional lighting recommendations for lettuce seedling growth are lower than recommendations for finishing stages. This research, however, has determined that increasing the light intensity during green- and purple-leafed butterhead lettuce seedling production, increases in yield of up to 175% to can be realized at harvest. Due to high plant density during propagation (seedling production) and short production duration, the increase in lighting costs (fixtures and energy) can be spread across more plants. In our experiment, 54 seedlings were grown in the space of 1 finished plant. This strategy has the potential to improve production efficiencies, increase lettuce yield, and decrease production duration.

UT Extension Beef Cattle Programs

Project Director

Hannah Wright

Organization

University of Tennessee Knoxville

Accession Number

7000459

UT Extension Beef Cattle Programs

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

Challenges facing the beef cattle industry in Tennessee range from the adoption of very basic management practices to complicated global market drivers that affect input costs. Nutritional, reproductive, genetic, and health management are the general areas that impact profitability most.

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.

UT Extension Agents and Specialists spent 26,442 hours conducting educational programs that reached 44,7923 direct contacts. Best management practices in beef cattle production were taught at 1771 group meetings and 4945 on-site visits. These direct methods were reinforced by 1,849 digital communications and 6,796 mass outreach communications reaching an estimated 4.9 million indirect contacts. Volunteers invested 2,216 hours of their personal time (at a value of $54,336) to establish a total of 37,755 direct and indirect contacts.

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

As a result of the beef cattle programs, the following outcomes and results were achieved in 2021.

- 4,653 beef producers sold 147,854 calves that were managed for improved marketing methods, according to practices promoted by UT Extension, to increase returns by $10,793,342.
- 5,608 beef producers utilized bulls (through natural service or artificial insemination) with greater genetic potential producing 435,612 head of calves to increase returns by $1,011,048.
- 3,807 beef producers implemented reproductive management by conducting breeding soundness exams on bulls producing 80,315 head of calf increasing returns by $165,168.
- 3790 beef producers implemented reproductive management by conducting pregnancy diagnoses on cows/heifers producing 82,319 head of calf increasing returns by $4,968,850.

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

The improved resource use efficiency resulting from UT Extension beef cattle programming continued to enhance the lives and livelihood of Tennesseans producing the most important agricultural commodity of our state in 2021. As a direct result, these programs improved the social, environmental, and economic conditions of rural economies across the state which, in turn, improved the entire state's social, environmental, and economic conditions - both rural and urban.

Closing Out (end date 09/07/2023)

Screening and Identification of Host Resistance to Bacterial Wilt (BW) in Accessions of Cucumis Melon (muskmelon) and Cucurbita Pepo (squash and pumpkin).

Project Director
Charles Dumenyo
Organization
Tennessee State University
Accession Number
1025419

Screening and Identification of Host Resistance to Bacterial Wilt (BW) in Accessions of Cucumis Melon (muskmelon) and Cucurbita Pepo (squash and pumpkin).

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

Cucurbits are major vegetable and fruit crops that contribute significantly to global food security and to grower income. However, many factors including pests and disease are responsible for significant reductions in cucurbit yields. Bacterial wilt disease is one of the most destructive diseases of some cucurbit crops and it contributes to significant losses in affected areas. The most susceptible cucurbits are muskmelon, cucumber and squash. Although widespread resistance is not known in the susceptible cucurbit species, varying levels of resistance exist in some cultivars. We propose to identify possible sources of tolerance or resistance to bacterial wilt of cucurbits disease by screening select accessions of melon and squash from USDA collection of over 3000 accessions in greenhouse experiments. Generating lists of melon and squash genotypes with resistance will increase our understanding BW while providing the necessarily resources for the development of resistant cultivars.

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.

Through the screening of muskmelon accessions, we have been able to identify a few accessions that have some levels of resistance to bacterial wilt. These accessions will be the subject of further studies to identify the genetic bases for the resistance.

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

The agricultural research community benefited through the findings which have already been published and are in the public domain. Members of the community can build on these findings in their effort to improve the productivity of cucurbits in the nation and across the world. The education community will be able to incorporate our findings into their teachings in the classroom, laboratory, greenhouse and field.

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

1. The results were presented in a local conference on campus.

2. The results have been published in a peer-reviewed journal.

3. The PI incorporates the results in his classroom teaching.

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 tornado of March 2020 that swept through Tennessee State University's research station destroyed our greenhouse facilities. The damage led to the suspension of our APHIS Permit to work with *Erwinia tracheiphila* and other pathogens in the greenhouse. The screening work has therefore been suspended and will resume after the greenhouse has been repaired and the permit reinstated. The university was closed for a considerable period of time because of the outbreak of Covid19 pandemic. During the closure, the administrators work out the conditions for the return of researchers to work. That closure also affected the progress of the work on this project. Without the APHIS permit, the screening work has been halted and is in a standstill. While we wait for the reinstatement of the permit, we plan to conduct a field trial of some the identified resistance accession for their performance under field conditions.

Closing Out (end date 09/07/2023)

Field Deployable Biosensor for Detection of Salmonella in Foods

Project Director

Fur Chi Chen

Organization

Tennessee State University

Accession Number

1025042

Field Deployable Biosensor for Detection of Salmonella in Foods

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

Salmonella is the leading cause of deaths and hospitalizations related to foodborne illness. This project is focus on developing a rapid, low-cost, sensitive and accurate detection method that will address the priorities for improving food safety surveillance.

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

This project is developing a nonculture method for rapid screening of *Salmonella* Typhimurium flagellar antigens in raw chicken products. Chicken drumsticks were artificially contaminated with *S*. Typhimurium at various levels and washed with deionized water. Flagellar antigens were extracted from the sediments of the chicken rinse after centrifugation. Immunomagnetic nanoparticles functionalized with monoclonal antibody (MAb 1C8) specific to flagellar antigens were prepared and incubated with the sample extract. The antigen-antibody nanoparticle complexes formed after incubation were concentrated and purified using a magnetic column. The purified nanoparticle complexes were then reacted with another biotin-labeled MAb 1E10 specific to flagellar antigens and subsequently detected by an avidin-enzyme conjugate in the format of a sandwich immunoassay. The developed assay was highly sensitive and can be successfully performed within 2.5 hours. The assay showed a log-linear correlation for the concentration of *S*. Typhimurium in the range of 101-106 CFU/g, with an R2 value of 0.9933. The detection limit of the assay was determined as low as 10 CFU/g. The results suggested that it can be further developed into small portable measuring devices in order to facilitate preliminary screening tests. The flagellar antigens of *S.* Typhimurium can be detected directly from the contaminated foods without conventional culture methods. This assay allows the specific contamination sources to be traced along the processing and distribution lines in a timely and economic manner.

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

The method developed is intended to be used by regulatory agencies and food industry to facilitate identification of dangerous foodborne pathogens in the production and processing environment. Scientific knowledge gained from this project include new methods for isolation and detection of Salmonella. Students and faculty at TSU have learned knowledge and skills of applying biosensors in agricultural research. Interested industrial partners were informed the opportunity to avail of the new technology developments.

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

The results have been presented to industrial professionals in two online meetings. A technical presentation entitled “A Nonculture Technique for Rapid Screening of Salmonella Typhimurium Flagellar Antigens in Raw Chicken Meat” is planned for the Annual Meeting of International Association for Food Protection in Pittsburgh, Pennsylvania, July 31, 2022. This project is expected to produce a technology that includes a process of on-site isolation and concentration of *Salmonella* from food samples and a potable electrochemical biosensor for field testing. The improved time-saving concentration process coupled to the low-cost electrochemical biosensor would provide a rapid and attractive alternative to the current culture methods for efficient isolation and identification of *Salmonella*.

Closing Out (end date 09/07/2023)

Development of Functional Materials Using Natural Polymer Based Electrospray

Project Director
Ying Wu
Organization
Tennessee State University
Accession Number
1025030

Development of Functional Materials Using Natural Polymers

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

Synthetic materials are causing severe environmental problems. Use of natural polymers are obtaining increasing interests due to their biodegradability and environmental friendly virtues. However, natural polymers have some weaknesses including less homogeneous ous structure, weaker tensile strength. Novel materials are sought continuously to incorporate with mixed ingrdients for better performances. The current project is to explore natural polymers from agricultural byproducts or wastes, and apply them in fabrication of advanced materials for specific functions such as controlled release or antimicrobial activities using electrospray.

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.

Electrospray is an emerging technology with low cost, non-thermal and simple process. It can produce smaller particles with narrow size distribution. Fabrication of micro- or nanoscale particles using synthetic or fossil- based materials will create harmful problems to environment or human health due to their toxic residue or pollution. Meanwhile, they cannot meet the demands of new applications such as oral delivery or tissue engineering. Therefore, natural polymers are attracting great attention in recent years due to their biodegradability, biocompatibility, easy design and preparation, and structure variations. In this proposal, a natural polysaccharide will be used as a model material for fabrication of micro and nanoparticles by electrospraying technology for food applications. Four goals will be achieved: 1. Fabricate micro and nanoparticles using the electrospraying of natural polymers; 2. Evaluate physicochemical and functional properties of the particles; 3. Improve research and teaching capability in food material science and engineering; 4. Ameliorate student competency by involving undergraduate students in the research activities.

Goal 1 was accomplished: Fabricate micro and nanoparticles using the electrospraying of natural polymers. Nanoparticles were generated using sweet potato starch and water soluble yellow mustard mucilage as wall materials, and essential oils as core materials. Goal 2 was partially accomplished: Evaluate physicochemical and functional properties of the particles. The morphology study by SEM showed that the particles are sphere shaped. The generated particles were proven with better release profile while applied as active food packaging materials.Goal 2 will be completed during the next reporting period, including publishing of a research paper on the physicochemical and functional evaluation of the generated particles; Goal 3. (Improve research and teaching capability in food material science and engineering) will be completed by collaboratively working with professors in engineering school and Vanderbilt University, and train more students who are participating in undergraduate and graduate programs.

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

A variety of audiences were reached out during this reporting period by presenting in conferences, publishing in peer reviewed journals and in classroom teaching. The audiences included researchers, scientists, professors, students, farmers, industries and consumers. By being exposed to the knowlege, the farmers will be aware of the potential additional value of their products, the industries will be aware of some novel materials in market, and the general public may have better choices against synthetic polymers. Researchers and students will be exposed to the knowlege and research findings via publications and presentations.

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

More environmentally friendly materials will be generated and more choices of materials will be available to industries and the general public. More byproducts and wastes will be used thus adding value to the production chain.

Ecology and Management of Arthropods in Corn

Project Director
Juan Jurat-Fuentes
Organization
University of Tennessee Knoxville
Accession Number
1023240

Population genomics of fall armyworm

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

The fall armyworm is a relevant pest of corn and other crops, and host strains that prefer feeding on corn (C-strain) or rice/turf (R-strain) have been described. Populations of fall armyworm from the Caribbean are notorious for carrying resistance to diverse insecticides, including transgenic corn producing insecticidal proteins from the bacterium *Bacillus thuringiensis* (Bt). Current evidence suggests limited interaction between fall armyworm from the Caribbean and the US Corn Belt, but studies at the whole genome level to test this hypothesis have not been performed. In addition, while laboratory strains of fall armyworm are commonly used as a proxy to field populations, differences in genetic diversity between field and laboratory strains have not been examined.

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 purified and sequenced the genomic DNA from 55 individual fall armyworms captured in the continental USA, Puerto Rico, Brazil and Kenya. These genomic sequences were compared for genetic diversity based on geography, host strain (corn or rice) and laboratory versus field origin. Comparisons were also made at the mitochondrial genome level. Bioinformatic comparisons at the whole genome level suggest genetic flow and mixing of *fall armyworm* from all tested locations, with only a minor reduction in gene flow due to distinct host strains (corn versus rice). All samples that were resistant to the insecticidal Cry1F protein (produced in transgenic corn) were identified as belonging to the corn-strain, as expected from lack of selection with Cry1F in the rice host strain. We found members from the Eastern Hemisphere interspersed with fall armyworm samples from the continental USA overwintering subpopulations, suggesting multiple introductions to Africa. Genetic diversity between laboratory and field collected fall armyworms was not drastically different, supporting the continued use of laboratory strains for field-relevant research.

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

Genomic sequences were made publicly available, thus allowing their use by the scientific audience and facilitating research on fall armyworm. Target audience working on fall armyworm acquired new knowledge on the lack of population structure among fall armyworm populations in the Western hemisphere and the validation of laboratory strains for field-relevant studies.

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

Benefits of transgenic Bt corn in production of food and feed are considered a public good by regulatory agencies. The fall armyworm is one of the pests threatening the long-term utility of Bt corn. Our activities identify potential risks to Bt corn production and advance studies to improve resistance management tools extending utility of Bt corn and its public benefits.

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.

Results were shared with communities of interest (academic, government and industry) during presentations at scientific meetings and disseminated in a peer-reviewed publication:

- Schlum, KA, Lamour, K, de Bortoli, CP, Banerjee, R, Meagher, R, Pereira, E, Murua, MG, Sword, GA, Tessnow, AE, Viteri Dillon, D, Linares Ramirez, AM, Akutse, KS, Schmidt-Jeffris, R, Huang, F, Reisig, D, Emrich, SJ, and Jurat-Fuentes, JL, 2021. Whole genome comparisons reveal panmixia among fall armyworm (*Spodoptera frugiperda*) from diverse locations. BMC Genomics 22:179.

Genomic sequences were made publicly available through a public repository.

Future efforts are aimed at improving current genomic resources for fall armyworm using resequencing and longer DNA reads, including the genome of fall armyworms resistant to Bt corn.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

The overarching goal of our project is increasing sustainability and improving control of key caterpillar pests of corn and other crops using biotechnology. Current research is focused on the use of transgenic corn varieties producing insecticidal proteins from the bacterium *Bacillus thuringiensis* (Bt), which represent more than 84% of the corn acreage in the US. Additionally, we aim to develop novel insecticidal technologies that increase returns to farmers and provide public and environmental benefits while delivering effective pest control in corn production. Lines of active research include identifying genes and mechanisms that insects evolve to overcome transgenic Bt corn, the development of DNA-based tools to detect insects carrying mutations that make them resistant to Bt crops, and the development of insecticidal gene silencing technology applicable to corn. The project utilizes larvae of the fall armyworm (*Spodoptera frugiperda*) and the corn earworm (*Helicoverpa zea*) as targets, due to their economic relevance to US agriculture. The fall armyworm is also considered by FAO as a serious threat to food and fiber security globally. Information from our project leads a change in knowledge on the use of biotechnology for pest control, which leads to a change in action by informing optimization of biotechnology. These outcomes are expected to lead a change in conditions by increasing sustainability of current technologies and providing new biotechnologies for environmentally sensitive food and fiber production in the US.

Objective 1: *Identification of genes and mechanisms responsible for resistance to transgenic Bt corn* –

Out of the seven insecticidal proteins produced by transgenic Bt corn and currently commercialized in the US, Vip3Aa is the only remaining protein for which field resistance has yet to be reported. Thus, it is critical that we investigate mechanisms of resistance against this protein and that we screen for resistant insects in the field. During 2021 we compared Vip3Aa binding to intestines of susceptible and Vip3Aa-resistant fall armyworm and corn earworm lines, which were generated from field-isolated individuals. Results obtained demonstrate a dramatic reduction in Vip3Aa binding in resistant lines from both insects, representing a change in knowledge by identifying alteration of Vip3Aa receptors as mechanism of resistance in fall armyworm and corn earworm lines. Knowledge of the mechanism of resistance and genes involved will be conducive to a change in action by allowing development of more inexpensive and sensitive DNA-based resistance detection tools as alternative to current bioassay-based monitoring methods. In addition, we produced, purified, and shared Vip3Aa protein with collaborators at multiple U.S. states to support current resistance monitoring efforts in corn pests. Information from this objective is expected to favor a change in condition by maximizing sustainable use of Vip3Aa for insect control and thus safeguarding its public and environmental benefits for US agriculture.

Mutations in the ABCC2 gene has been linked to field practical resistance in the fall armyworm against insecticidal proteins produced in Bt corn. In contrast, nothing is known on the role of this gene in resistance to Bt corn proteins in the corn earworm. In solving this knowledge gap, we collaborated with Dr. O.P. Perera at the USDA Southern Insect Management Research Unit in generating and testing corn earworms genetically edited to contain mutations in the ABCC2 gene resembling those found in fall armyworm resistant to Bt corn. Results from binding assays using the Cry1Ac protein produced in Bt corn demonstrate that mutations in the ABCC2 gene induce a drastic reduction in Cry1Ac binding in corn earworms. However, this reduction in binding does not translate in a dramatic alteration of susceptibility to Cry1Ac. This information changes our knowledge on how Bt proteins work in different target pests and provides guidance in optimizing insecticidal proteins.

Objective 2*: Development of DNA-based tools to detect insects resistant to Bt corn* – During 2021, we developed a platform to analyze DNA sequencing data and detect mutations that can allow fall armyworm to thrive on Bt corn. We obtained proof of concept for this tool by screening armyworm samples collected in Puerto Rico and the continental USA and detecting that 43% of the tested insects in Puerto Rico carry one of these resistant mutations. This high frequency contributes to a change in knowledge by explaining how resistance to Bt corn evolved dramatically fast (in less than 6 years) in the island. In contrast, this high frequency of resistant mutations is not observed in samples from the continental US, where mutations seem rare. More importantly, while multiple mutations were detected, only one individual in the US carried a mutation detected in Puerto Rico. This observation leads a change in knowledge by supporting that resistance to Bt corn in continental US mostly evolves locally and does not result from Caribbean migration. This information will contribute to a change in action by informing resistance management tools to delay evolution of resistance to Bt corn.

Objective 3*: Development of insecticidal gene silencing technology applicable to corn* – Gene silencing by RNA interference (RNAi) is a new technology for pest control that is based on delivering a double stranded RNA (dsRNA) molecule to the target insect by feeding. This molecule activates a cellular pathway resulting in lack of production of a vital protein, causing the death of the insect. This RNAi is dependent on dsRNA sequence complementarity to a target gene in the insect, and thus presents probably the highest specificity among pesticides. Development of this technology for pest control in corn is expected to generate a change in action by farmers preferring application of these dsRNA-based biopesticides over conventional products, which will lead to a change in conditions by decreasing use of pesticides with wide toxicity, thus promoting public and environmental health. During 2021 we have selected and tested several target genes from the fall armyworm to determine if their silencing results in detrimental effects in the insect. Testing was done by injecting purified dsRNA targeting the different genes and observing the health of the injected insects. Based on the results, we selected a shortlist of target genes whose silencing results in fall armyworm mortality in further optimization for delivery by feeding. The

intestine of caterpillars is a very abrasive environment and thus dsRNA is usually degraded, hindering the silencing and subsequent insect mortality. Our research is testing distinct modifications of dsRNA that may increase its stability and delivery to target insect cells, increasing mortality.

Engineering for food safety and quality

Project Director

Jiajia Chen

Organization

University of Tennessee Knoxville

Accession Number

1023982

Engineering wax matrix to deliver proper barrier, thermal, and textural properties

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

Waxes are crucial for waterproofing, sealing, and preservation. Despite their ubiquity, there have been only a handful of reports over the last 40 years that attempted to relate the interplay among chemical composition, crystallinity, nanostructure, and physical properties. All waxes are inherently complex mixtures composed of alkanes, alcohols, aldehydes, fatty acids, and wax esters. Knowing how their synergistic interactions at the nanoscale impact functional properties can lead to identification of bio-based and environmentally safe alternatives.

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.

Researchers at the University of Tennessee finalized and published this work in 2021. This project aimed to probe the structure-function role of select wax constituents, n-alkanes, alcohols, aldehydes, and fatty acids in the C18-19, C22-23, and C26-27 carbon chain-length families. The behaviors of pure compounds and the engineered binary mixtures were characterized using calorimetry and X-ray powder diffraction, particularly to study their nano-crystallization behaviors (in forming monoclinic (M), triclinic (T) and orthorhombic (O) lattices) and compatibility. The orthorhombic (O) lattice is more desirable than the other forms in forming crystals of larger volumes and providing barrier properties. The water vapor permeability (WVP) of model systems cast as films was also determined. WVP decreased (the lower the better) in the order: fatty acid≈ even n-alkane > odd n-alkane >≈alcohol≈ aldehyde.

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

Engineering the wax composition as well as nano-crystallinity of waxes can allow for precise tuning of physical properties such as melting point, hardness, and gas permeability. This work and our future effort will fill the knowledge gap of fundamental crystallization mechanisms and nano-macro relationships in solid lipid systems.

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

The ultimate goal is to engineer and design bio-based waxes that will replace petroleum based and imported waxes for applications in the agricultural postharvest, pharmaceutical and paperboard coating industries. This work will ultimately lead to fulfilling the demands of sustainable and green economy.

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

A PhD student has been trained exclusively on wax chemistry and crystallization. Two manuscripts have been published (as below) and another two will be submitted in 2022.

- Leyva-Gutierrez F., Fei T., Wang T. 2020. Synthesis of functionalized high-oleic soybean oil wax coatings and emulsions for postharvest treatment of fresh citrus fruit. Eur. J. Lipid Sci. Technol. 122, 2000005.

- Leyva-Gutierrez, FMA, Wang, T. 2021. Crystallinity and water vapor permeability of n-alkane, alcohol, aldehyde, and fatty acid constituents of natural waxes. Industrial & Engineering Chemistry Research. https://doi.org/10.1021/acs.iecr.1c02924.

- The rotator phases of aliphatic aldehydes and role in plant crystal growth, under preparation.

- The role of hydroxy fatty acid esters in carnauba wax, under preparation

Biopesticide Potential and Efficacy in Controlling Pathogens and Pests of Hemp

Project Director
Kimberly Gwinn
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University of Tennessee Knoxville
Accession Number
1024067

Pathogens of hemp

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

In the southeastern U.S., cultivation of hemp (Cannabis sativa), a crop grown for food, fiber, biofuel, and natural medicine, has increased significantly in the past 5 years due to the potential for agricultural profits. Hemp is a new crop in most locations, and both identification of diseases that cause losses in hemp and development of cost effective and safe biopesticides is needed to minimize disease and economic losses of hemp producers.

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.

Epicoccum nigrum species isolated from symptomatic hemp did not cause disease. Disease symptoms did not develop when plants were inoculated with spore suspensions (108 spores/mL) spread on leaves (wounded or not wounded) or applied as a root drench. However, in detached leaf assay, tissue degraded in areas of fungal growth. When 'Katani' seedlings (3-4 weeks after planting) were inoculated with E. nigrum spore suspension, then challenged with spores of Bipolaris, disease severity caused by Bipolaris was reduced. In dual culture, E. nigrum inhibited growth of all tested phytopathogens (Fusarium sp., Bipolaris sp., and Alternaria alternata). Bipolaris and Fusarium were more sensitive to the presence of E. nigrum than Alternaria. This competition between E. nigrum and other pathogens of hemp, supporting our hypothesis that E. nigrum has potential to reduce diseases in hemp.

Several species in the genus Fusarium have been reported in pre-or post-harvest flower buds of C. sativa. Combined with the fact that Fusarium-associated mycotoxins have been isolated from hemp seed cake and that these pathogens are seed transmitted in other crops, it is reasonable to assume that C. sativa seed have propagules of one or more Fusarium species either in the seed (true seed transmission) or on the seed surface. Seed colonized by the Fusarium sp. isolated from symptomatic hemp tissues, and colonized seed did not germinate.

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

Two reviews were prepared for publication in refeered journals. The first is a multidisciplinary open-access journal whose target audiences are academics, industry leaders and the public. The second is aimed specifically at those interested in nematology. Four project reports were given at the UT Summer Research Scholars Symposium 2021 as a final product for the REACH REEU. These reports were communicated to the university community. Two of these reports and a summary of the review paper were presented at the Science of Hemp Conference which targets professionals in hemp research and Extension.

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

Projects for Tennessee community college students participating in REACH (TEN2017-0640 -Agro-Industrial Research Experience for Community College Students) were focused on hemp production, pathogens, and products.

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

Pathogen identification and protection. Studies for protection of hemp and use of biostimulant for hemp plant health are ongoing in the greenhouse. Bioassays for the identifcation of natural products that reduce disease in hemp are ongoing. Students are continuing research on hmep pathogens and fulfilling Koch's postulates for Fusarium and Alternaria previously isolated from hemp. Assay for competition among fungi isolated from hemp are also ongoing.

Outreach and education. Three students from the REACH program are continuing their research on hemp at the University of Tennessee. Two of these students are taking a research course for credit. Biopesticides approved by the EPA for use on hemp are used in experiential learning exercises in a graduate course on Biopesticides.

1. ***Gwinn, K.D***., Z. Hansen, H. Kelly, and B. H. Ownley. 2022. Diseases of *Cannabis sativa* caused by diverse *Fusarium* species. Frontiers in Agronomy 3:796062. doi: 10.3389/fagro.2021.796062.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

The biopesticides market is growing at almost three times the rate of conventional agrochemicals. This is attributed to their ability to provide superior crop yields and quality while reducing the environmental impact of agriculture that consumers are demanding. In the southeastern U.S., cultivation of hemp (*Cannabis sativa*), a crop grown for food, fiber, biofuel, and natural medicine, has increased significantly in the past 5 years due its profit potential. Hemp is a new crop in most locations, and research on diseases that cause significant crop losses and EPA-approved control measures have developed at a slower pace than the adoption of the crop. Because of the long-standing prohibition of its cultivation, information on the microbiome (pathogens and beneficial organisms) of hemp is limited. Identification of organisms that grow in and on the plant can lead to identification of species that can act as pathogens as well as those that can act as biopesticides. Recent work co-isolated a fungus (*Epicoccum nigrum)* with three pathogens, (*Fusarium* sp., *Biopolaris maydis*, and *Alternaria alternata)* that are good candidates for development of a biopesticide targeting disease in hemp, as well as other crops. Our evidence is two-fold: 1) *E. nigrum* negatively affected *in vitro* growth of pathogens, and 2) hemp plants inoculated with both *E. nigrum* and pathogen had reduced disease severity when compared with those inoculated with the pathogen alone. Because it can be a pathogen of other plants, our original hypothesis was that *E. nigrum* was a pathogen of hemp itself; however, plants inoculated with *E. nigrum* alone had no disease symptoms. The *E. nigrum* isolates inhibited growth of the three pathogens and reduced disease severity, as well. Pigments, which have previously been reported to inhibit growth of other fungi, were produced by all *E. nigrum* isolates in culture. These encouraging results suggest that further study is warranted.

Only 20 studies have been published on the effects of hemp and hemp products on *Meloidogyne incognita* (root-knot nematode, RKN), one of the world's four most prevalent root parasites. To generate the baseline data needed to develop effective biopesticides, a series of greenhouse experiments were conducted to determine the resistance of fiber and medicinal hemp (CBD-dominant) to this root-knot nematode (RKN). The "Reproductive Factor" is an indicator of host suitability, where susceptible plants have an RF greater than 1 and non-hosts have an RF values of less than 1. It was observed that the vascular tissue of susceptible cultivars was remarkably thickened but convoluted and presumably non-functional. The fiber crop 'Delores' proved to be a very compatible host, with numerous galls, egg masses, and high reproduction (up to 1 million eggs/root system). The RF was 36?81. In contrast, a high-CBD cultivar, 'Wife', had only a few galls, and reproduction was much lower (RF= 0.2). The majority of cultivars investigated in the study exhibited RF's between 1 and 20; however, two other CBD cultivars (Cherry Bubble and Merlot) exhibited resistance with RF's less than 1. Clearly there is wide variation in susceptibility of hemp to this nematode, providing a useful tool for management of this destructive parasite. Plant roots contain numerous chemicals that have been shown to be nematocidal. As such, these data will provide valuable foundation knowledge for the development of high throughput screening methods of hemp for nematode resistance.

Land use and management practice impacts on soil carbon and associated agroecosystems services

Project Director

Sindhu Jagadamma

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University of Tennessee Knoxville
Accession Number
1022836

Profile-scale SOC stock in response to conservation management practices

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

The hot and humid climatic conditions in tandem with loess-derived cropland soils in Tennessee favor soil organic carbon (SOC) mineralization over accumulation. It is unclear which conservation management practices favor profile-scale SOC accumulation in such environments. No-tillage combined with cover cropping, crop rotation, and regenerative farming practices have been tested for achieving net SOC storage in these soils.

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 study leveraging a long-term (40-year) continuous cotton experiment that includes different management treatments showed that the SOC stocks for the 0-60 cm soil profile was similar for chisel tillage and no-tillage treatments. No-tilled surface soil layer (0-10 cm) showed a 32% increase in SOC compared to the chisel tilled surface layer. These results indicated that chisel tillage re-distributed a significant amount of SOC from surface to subsoil. Irrespective of tillage practices, the inclusion of winter wheat as a cover crop increased the SOC stocks by 30% compared to growing no cover crops.

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

The finding that both conventional and no-tillage accumulated a similar amount of SOC when 0-60 cm soil profile was considered revealed that no-tillage alone is not enough to accumulate SOC in the loess-derived agricultural soils of Tennessee. From this understanding, producers were given information on testing other aspirational practices such as cover crops, crop rotation, biochar application, and grazing integrated farming in tandem with no-tillage.

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

Apart from giving technical knowledge and training to producers on adopting multiple conservation practices simultaneously, two PhD students, one postdoctoral researcher, and two undergraduate students received training on field and laboratory activities related to the project ojectives.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Food security is one of the most serious global challenges humanity has been facing. The grand challenge of producing sufficient food for the growing population without compromising our environment is compounded by the potential adverse impact of extremes changes in climatic patterns on agricultural soils. On this front, a team of researchers at different land-grant universities across the U.S. is focused on improving soil health and agricultural productivity by implementing conservation management practices. Since Tennessee ranks #1 in the nation for the no-tillage adoption rate, the researchers at the University of Tennessee are looking into the agronomic and ecological benefits of other aspirational cropland management practices beyond no-tillage. The researchers are testing different novel practices including simultaneous diversification of cover crops and cash crops, integration of warm-season and cool-season pasture grasses, reduction of synthetic nitrogen application with growing legume cover crops, etc. For example, a study that leveraged a 40-year continuous cotton experiment that includes different management treatments showed 32% increase in organic carbon stock in the top 10 cm soil under no-tillage compared to chisel tillage. However, inclusion of winter wheat as cover crop increased carbon stocks by 30% in subsoil (30-60 cm) compared to growing no cover crops. Another study found that cool-season pasture grasses store more soil carbon than warm-season grasses. During this reporting period, two Ph.D. students, one postdoctoral researcher, and two undergraduate students received training in this area. In addition, 8 peer-reviewed

publications, 5 conference presentations, and 4 outreach presentations were produced. Through these outcomes, producers were informed about regional-specific management options available, beyond no-tillage, to foster soil health and sustainable crop production.

Closing Out (end date 09/07/2023)

Ecological and Genetic Diversity of Soil-borne Pathogens and the Soil Microbiome

Project Director
Fulya Baysal Gurel
Organization
Tennessee State University
Accession Number
7000501

Ecological and Genetic Diversity of Soil-borne Pathogens and the Soil Microbiome

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

Improved sustainable disease management strategies will significantly reduce the risk of soilborne disease epidemic development in the field. It is our goal to identify effective soilborne disease management strategies for field nursery production of woody ornamentals to manage soilborne pathogens that can be easily and readily adopted by Tennessee field nursery producers.

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. Assess environmentally friendly biofumigants in combination with solarizationfor soilborne diseases and improved plant growth.
Impact: Provide the woody ornamental nursery industry with an environmentally friendly disease management strategy that suppresses soilborne disease population densities comparable to chemical products.

2. Assess the efficacy of chemical and biorational products for controlling soilborne diseases with different application methods, intervals and reduced-rate applications in woody ornamentals.
Impact: Provide the woody ornamental nursery industry with efficacious, cost-effective and sustainable recommendations for soilborne disease management.

3. Engage in outreach and technology transfer with field nursery producers.
Impact: We were able to provide significant outputs to the woody ornamental nursery industry, researchers, extension specialists and agents on the effectiveness of different application methods, intervals and reduced fungicides rates, efficacy of soilborne disease management strategies such as biofumigants for reducing soilborne pathogen populations. This will lead to outcomes of nursery producers changing their behavior to include more sustainable production practices and reduction in the amount of fungicides applied in field-grown nurseries of woody ornamental.

Evaluate the efficacy of chemical and biorational products for controlling soil-borne diseases with different application methods, intervals and reduced-rate applications in ornamentals.
The purpose of this study was to evaluate fire ant venom alkaloids and an alarm pheromone analog against several plant pathogens, including Botrytis cinerea, Fusarium oxysporum, Phytophthora nicotianae, P. cryptogea, Pseudomonas syringae, Phytopythium citrinum, Rhizoctonia solani, Sclerotonia rolfsii, Xanthomonas axonopodis, and X. campestris. All pathogens were tested against red imported fire ant venom alkaloid extract and alarm pheromone compound for growth inhibition in in vitro assay. The venom alkaloid extract inhibited fungal and oomycete pathogens. Neither of the treatments were effective against bacterial pathogens. Three soilborne pathogens, P. nicotianae, R. solani, F. oxysporum, and one foliar pathogen, B. cinerea were selected for further in-vivo assays on impatiens (Impatiens walleriana 'Super Elfin XP violet'). Total plant and root weight were higher in venom alkaloid treated plants compared to an inoculated control. The venom alkaloid treatment reduced damping-off, root rot severity, and pathogen recovery in soilborne pathogen inoculated plants. Similarly, venom alkaloid reduced Botrytis blight. However, higher venom rates caused foliar phytotoxicity on plants. Therefore, additional work is needed to evaluate rates of venom alkaloids or formulations to eliminate negative impacts on plants. Overall, these results suggest that red imported fire ant venom alkaloids may provide a basis for new products to control soilborne and foliar plant pathogens.

Develop improved soil-borne disease management strategies based on cultural approaches for suppression of Rhizoctonia and (or) Phytophthora spp. and other soil-borne pathogens.

We studied the response of the major cover crops being used by woody ornamental growers in the Southeastern United States to Phytopythium vexans, Phytophthora nicotianae, and Rhizoctonia solani in greenhouse conditions to identify the effective cover crops that can be used in a nursery field production system. Data related to post-emergence damping-off and plant growth parameters (plant height increase and fresh weight) were recorded. Similarly, cover crop roots were assessed for root rot disease severity using a scale of 0-100% roots affected. Among the tested cover crops, the grass cover crops triticale (×Triticosecale Wittm. ex A. Camus.), annual ryegrass (Lolium multiflorum L.), Japanese millet (Echinochloa esculenta (A. Braun) H. Scholz), and the legumes Austrian winter pea (Pisum sativum var. arvense (L.) Poir) and cowpea 'Iron and Clay' (Vigna unguiculata (L.) Walp.), showed lower root rot disease severity and post-emergence damping-off in the soil inoculated with P. nicotianae, R. solani, or P. vexans compared to the other crops. Since these cover crops can act as non-host crops and benefit the main crop in one way or another, they can be used in the production system.

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

Graduate assistantship: Two M.S. level and 3 PhD level (Advisor) and one M.S. level (co-Advisor) students participated into this project. The students involved in protocol development, experimental design, conducting experiments, data collections for the projects.

Extension/Outreach: As woody ornamental plant pathologist, interacted directly with nursery producer, TSU extension agents and TDA regulatory officials to provide diagnoses of biotic and abiotic problems and management recommendations to support sustainable nursery production in Tennessee.

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

Woody ornamental plant pathology lab interacted directly with nursery producer, TSU extension agents and TDA regulatory officials to provide diagnoses of biotic and abiotic diseases and management recommendations to support sustainable nursery production in Tennessee. Our lab diagnosed over 250 woody ornamental samples in spring 2021. Woody ornamental plant pathology lab also participated in the training of nursery growers on soilborne diseases and their management.

Closing Out (end date 09/07/2023)

Metabolic Relationships in Supply of Nutrients for Lactating Cows

Project Director
Agustin Rius
Organization
University of Tennessee Knoxville
Accession Number
1017614

A postbiotic from Aspergillus oryzae attenuates the impact of heat stress in lactating cattle

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

Global climate change is predicted to alter temperature patterns across the world, with severe implications for human and animal health as well as the economic viability of food-producing enterprises worldwide. This is likely to worsen because the frequency and intensity of extreme heatwave events have increased in the past decades and are expected to aggravate this burden in the future. Increased ambient temperature causes heat stress, which affects the physiological and molecular functions of dairy cattle.

Typical physiological changes associated with excessive heat exposure includes a shift of splanchnic blood flow to peripheral tissues to increase heat flow and reduction of feed ingestion to lower heat production through cellular respiration and the impairment of thermoregulation. In addition, studies conducted in heat-stressed animal models consistently confirmed systemic and intestinal inflammation, immunosuppression, and alterations of cellular homeostasis. The molecular mechanisms underpinning heat stress-associated phenotypes in food-producing animals are not clearly understood, however, in part due to the limitation of these models to explain cause-effect relationships

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.

Global warming and the increase of frequency and intensity of heatwaves are likely to continue and, thus, exacerbate the problem of
heat stress. Heat stress leads to the impairment of physiological and cellular functions on animals. Therefore, it is critical to conceive ways of protecting animals against the pathological effects of heat stress. In experiments with endothermic animals highly sensitive to heat (Bos taurus), we have previously reported that heat-induced systemic inflammation can be ameliorated in part by nutritional interventions. Results showed that the supplementation with the Aspergillus oryzae (AO) postbiotic to lactating dairy cows experiencing heat stress decreased plasma concentrations of serum amyloid A and lipopolysaccharide-binding protein, and the expression of interleukin-6 in white blood cells. These alterations were paralleled by increased synthesis of energy-corrected milk and milk components, suggesting enhanced nutrient partitioning to lactogenesis and increased metabolic efficiency. In summary, clear evidence showed that a postbiotic from AO enhances thermal tolerance, likely through a mechanism that entails reduced inflammation.

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

Producers may be able to use the information generated to combat heat stress on farm.

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

The general public can benefit from this project as we develop nutritional alternatives to improve animal health and well being

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

The US dairy industry is a major contributor to the diets of Americans and the economic viability of rural communities as well as many states. My long-term goal is to improve the efficiency of milk production, animal health, and thus promote environmental and economic sustainability in the US dairy industry. My approach to achieve this goal is to systematically identify those biological and nutritional management processes that will provide the greatest improvement and to concentrate my research efforts there. The term precision feeding systems reflect the goal of being able to feed dairy cattle that widely differ in genetics, environment and diets, not to reflect any particular methodology or feed delivery system. Although dairy producers, large and small, feed in a large variety of ways, a major goal is to be precise in meeting the needs of their cattle.

My laboratory has tackled several knowledge gaps particularly around the improvement and understanding of feed and nutrient use-efficiency of dairy production. Some of our outcomes have improved feeding management; ruminal microbial metabolism; intestinal digestion; physiology and metabolism of major organ systems; molecular and cellular biology; and the role of nutrition in cattle health. The overarching goal is to do sound research directed toward finding out the most specific biological concepts and processes, and to apply that knowledge to the improvement of dairy cattle feeding in the practical work. My work has contributed to 1) improved accuracy of feeding standards for dairy cattle and future National Research Council publications on the nutrient requirements of dairy cattle, 2) reduced losses of nutrients to the environment from dairy cattle, 3) profitable and environmentally sustainable use of available feedstuffs, and 4) continued supply of affordable, nutritious products for human consumption.

Identification and Characterization of Nanomaterials from Plants, and Translation into Relevant applications

Project Director

Scott Lenaghan

Organization

University of Tennessee Knoxville

Accession Number

1012962

Development of abiotic stress-inducible promoters

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

Plants are commonly exposed to a variety of abiotic stresses including heat, drought, and salinity. These stresses negatively impact plant performance leading to reduction in yield. Researchers have identified osmotic and salt stress-inducible promoters in poplar that could be used to control the effects of these stresses on poplar growth.

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 basic molecular tool development aspects and infrastructure supported by this project helped to generate this result. More simply, the pipeline established throughout this project for regulatory element discovery enabled us to design-build-test multiple iterations of promoters to identify ones that were abiotic stress inducible.

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

Previous work has demonstrated how stress-inducible promoters can be harnessed to reduce the harmful effects of the stress conditions by turning on antagonistic genes in respose to the stress. For this particular example, it may be possible to use these stress-inducible promoters to increase the robustness of poplar to osmotic and salt stress.

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

Better poplar feedstock will have increased yield and robustness that will enable more biomass available for bioenergy and other applications.

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

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Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

The impacts of climate change and the rapidly expanding global population is placing significant stress on the food and agricultural systems in the U.S. and abroad. To meet emerging challenges, it is essential that we develop novel strategies and approaches for crop improvement. Increasing the resilience of food crops to abiotic stress and bolstering their nutrient density are key thrusts associated with ensuring global food security. This Hatch project have generated several successes related to these long-term goals. First, a novel approach for plant genetic engineering was developed to simplify the path towards commercialization of chloroplast engineered crops. Since chloroplasts have a high capacity to produce heterologous proteins, this new method will have a significant impact on the development of plant-based vaccines, value-added products, nutrient dense foods, and bioenergy. Second, utilizing synthetic biology approaches, this project developed osmotic stress-inducible promoters for use in poplar. Poplar is a highly relevant bioenergy crop, and the ability to trigger “rescue” genes in response to stress events can significantly increase the robustness of this key crop. Finally, a novel plant phenotyping platform was developed to remotely detect the expression of fluorescent proteins in plants. This platform has been used to engineer plants as biosensors for a wide array of compounds, with the ultimate readout a fluorescent protein. These biosensors have broad use in agriculture, from early pest/pathogen detection, to abiotic stresses, and even to the detection of environmental pollutants. These plant sentinels could not have been developed without the breakthrough technology supported by this project.

Adding value to lignocellulosic biomass through integrated biorefining

Project Director

TIMOTHY RIALS

Organization

University of Tennessee Knoxville

Accession Number
1012359

Development of bio-derived polymers and products

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

Industry generates a vast amount of low-value lignin. The valorization of industrial lignin is restricted by the properties of lignin that limit its compatibility and dispersion into the commonly used hydrophobic polymer matrix.

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.

Development of lignin-based composites is an important strategy to valorize lignin in bulky volume. Industrial kraft lignin and organosolv lignins to varying in botanical sources were modified to produce lignin grafted poly(ε-caprolactone) copolymers. The lignin copolymer showed remarkably improved compatibility and dispersion in acetone, chloroform, and toluene, suggesting its readiness for mixing and blending with polymers for composite manufacturing. The state-of-the-art spectroscopic analysis revealed the copolymerization reaction is correlated with certain hydroxyl groups in lignin regardless of the origin. Adding plasticizer to lignin/poly(lactic acid) composites enhanced both the tensile strength and ductility of the products.

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

Our studies and findings are beneficial to multiple stakeholders including both industry and academia. The US has abundant agroforestry residues that can be tapped for value-added chemicals and bioproducts. The lignin modification and composite fabrication will provide lignin valorization methods and strategies for biorefinery and pulping industries to deploy lignocellulosic biomass. The correlation of lignin functional groups and polymerization provides fundamental knowledge to engineering, biology, and material scientists to design polymers with tailored structure and properties. The biodegradability of the lignin and polycaprolactone components should offer attractive attributes for the design of products with a reduced carbon footprint.

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

The projects have trained 3 graduate students and 3 undergraduate students in the STEM for future high-skill workforce and preparation of high-quality scientists in new technology. We especially emphasize the training of people from the under-represented groups by including female students and minorities. Five out of the six students are female students registered in the STEM-related major at the University of Tennessee. The development and application of bioderived lignin-based polymers, chemicals, and fuels will advance the local economy, and the mitigation of climate change by reducing the carbon footprint.

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

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Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

The industry generates a vast amount of low-value lignin ~130 million tons per year from pulping, paper, and biorefining. The majority of this lignin stream is combusted for energy recovery in the industry. However, lignin is an attractive feedstock for a broad array of bio-derived chemicals and materials that could bring extra value to the existing industry. Lignin-based polymers and composites appear to be one of the important avenues to tap this waste stream to advance the bioeconomy and mitigate climate change. The current challenge of lignin-based materials development technology lies in the agglomerating properties of lignin that limit its compatibility and dispersion into the commonly used hydrophobic polymer matrix. We have manipulated the chemistry of lignin to modify lignin macromolecules to their reactive sites, change the properties of lignin, and ultimately advance its application and processibility to lignin-contained products. We have modified industrial kraft lignin and organosolv lignins varying in botanical sources to synthesize lignin-poly(ε-caprolactone) copolymers. The lignin copolymer showed remarkably improved compatibility and dispersion in commonly used solvents, such as acetone, chloroform, and toluene, suggesting its readiness for mixing and blending with polymers for composite manufacturing. The art-of-the-state instrumental analysis reveals the copolymerization reaction is correlated with certain hydroxyl groups in lignin regardless of the lignin origin. More importantly, the synthesized copolymer is expected to have rapid environmental degradability due to the biodegradable attributes of the lignin and polycaprolactone components. This work is significant because the bio-derived copolymers have the potential to replace the current one-time-use plastics, such as grocery bags and packaging films, which are persistent in the environment for almost a century. Collaborative work between the University of Tennessee and Auburn University has demonstrated that lignin can be blended with polylactic acid, a biodegradable polymer, as high as 20% by weight. Another collaborative work between the University of Tennessee and Kansas State University has shown that lignin can be decomposed and transformed into value-added compounds such as fatty acids and carotenoids by marine protist microbe, namely, *Thraustochytrium striatum*. Our group will continue working on the lignin-derived polymers to underpin the environmental biodegradability and to improve the mechanical properties.

Value-added Lignin Co-products

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

Biofuels are expensive relative to petroleum but needed for transportation**.** Dedicated bioenergy feedstocks could be fractionated into components that can be upgraded into high-value products. Using a patented biomass fractionation technology, a team of researchers demonstrated that lignin can be upgraded into valuable carbon products for energy storage and filtration. This approach distributes the cost of conversion across different streams to reduce expense of the commodity fuel.

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.

Leveraging funding from USDA and DOE along with access to high-performance computing and high energy neutron and x-ray beamlines, new binding mechanisms were discovered for lithium and sodium-ion batteries, leading to higher energy densities. Subsequent control over processing led to producing the highest surface area ever recorded (4,500 m2/g) for activated carbon. This result has vast implications for affordable battery and filtration materials from plant biomass. Additionally, lignin-based nanoparticles have been produced for regenerative medicine. As a result of these advances, our conservative economic analysis demonstrated that biobased jet fuels are achievable at a price less than $3/gge.

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

Research and outreach efforts focus on improving the environment and creating jobs in TN. I have since worked with startup companies and large industry to develop these materials for commercial products.

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

The research and development efforts extended to Volkswagen and other companies doing business or looking to do business in Tennessee. Within the past three years, I participated with a team of researchers from the CRC and College of Engineering to attract VW to put an innovation hub on the Cherokee Campus. Since then, we have collaborated on five projects incorporating renewable material into their cars and are looking at efforts to improve recycling. Of great importance, we are sourcing most of these materials locally to incorporate into cars built in Tennessee. I work with two spinoff startup companies out of the UT Research Foundation, Genera and Prisma Composites (Formerly Tennera), to grow their businesses in East TN. I have worked with 4 other local startups to help support innovation into green technologies and grow jobs in the area.

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

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Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Biofuels are expensive relative to petroleum and are the only alternative fuel for aviation. The Harper group maximized the value of biofuels by creating high-value products from lignin separated from other components used to make aviation fuels. Our result demonstrated that biobased jet fuels could be achievable at less than $3 / gasoline gallon equivalent. We converted the lignin into porous carbon materials that possess the surface area of two football fields in one gram. We then created energy storage devices (supercapacitors) using these low-cost materials and easily obtained and recycled stainless steel and sulfuric acid. These new supercapacitors possess energy densities equal to commercial Li-ion batteries (~120 Wh/kg) cheaply without the environmental costs.

Extension Horticulture Programs
Project Director
Hannah Wright
Organization
University of Tennessee Knoxville
Accession Number
7001309

Commercial Fruit and Vegetable Production in Tennessee

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

Fruit, nut, and vegetable sales in Tennessee were valued at nearly $112 million across 3,315 farms in the 2017 USDA Ag Census. Commercial fruit and vegetable growers face a number of challenges, including implementing food safety practices, integrated pest management, organic and sustainable cultural practices, season extension and profitability.

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

Through educational programming, UT Extension provides the latest information to our producers on meeting the regulatory requirements of the Food Safety modernization Act (FSMA), developing integrated pest management programs, reducing off-farm inputs, and extending their cropping season with the use of high tunnels and greenhouses- with the overall profitability of their farming operation in mind.

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

UT Extension programming in fruit and vegetable production resulted in over 57,000 direct contacts during 2021. Best production and management practices were taught at 191 group meetings and 508 on-site visits. Over 1,042 social media outlets, radio programs, TV stories, newspaper articles and other publications reaching 3,109,982 stakeholders supported the direct contacts. Moreover, 100 fruit and vegetable producers implemented best practices including site selection and development, variety/rootstock selection, pest/disease/weed identification, effective pesticide use, soil/plant tissue testing, research-based fertilization, and proper postharvest handling. Additionally, 65 fruit and vegetable producers adopted good agricultural practices (GAPs) on over 4,000 acres to improve food safety and enhance marketing opportunities.

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

The total economic impact of Extension's commercial fruit and vegetable horticulture programming was estimated at $257,946 in increased savings, increased income, and one-time capital purchases by adopting GAPs, season extension or organic production practices.

Consumer Horticulture and Extension Master Gardener

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

Estimates nationally are that 74% of all households participate in indoor and outdoor lawn and garden-related activities and spend a reported 36.9 billion dollars within the do-it-yourself horticulture industry (National Garden Survey, 2016). In the state of Tennessee, 74% of households represents 1,921,996 households and 4,843,430 residents (US census). Average spending was approximately $500.00 per household in these lawn and garden areas (National Garden Survey, 2017). These numbers provide a perspective on the size and economic impact of stakeholders within residential and consumer horticulture with estimated yearly home and garden spending of over $95 million in Tennessee. Specific needs include proper site and plant selection, fertilizer and pesticide use in residential landscapes, vegetable, and fruit production, and demonstrating practices that conserve valuable soil and water resources. Continued steady growth in food gardening and involvement by millennials illustrate the critical need for investment in technology and up-to-date educational resources. In the pandemic year of 2020, there were an estimated 18.3 million new gardeners (National Garden Survey, 2021) specifically highlighting the rapidly rising demand for horticulture and gardening information. The role of and need for nimble and effective horticulture technology tools and resources to reach new and diverse stakeholders as well as the strain placed on our current Extension programs and personnel has been made extremely clear. This presents both exciting opportunities as well as challenges for Extension horticulture educators.

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.

Our Extension program in the areas of both consumer horticulture and TEMG developed collaborative, statewide digital horticulture education in addition to our continued focus on publications and training materials that deliver practical and research-based information to consumers in Tennessee. 2021 saw us deploy the first ever live, collaborative statewide Extension Master Gardener training with more than 20 counties participating in 13 live, zoom teaching sessions. Additionally,

a range of consumer horticulture outreach efforts engaged consumers across the state. These educational programs and products are delivered by Extension agents, specialists and Extension Master Gardener volunteers throughout the state and results are presented below.

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

In the Home and Garden knowledge area, there were 2,661 group meetings reaching 114,786 contacts along with 6,082 onsite visits (12,568 contacts), and 44,683 occurrences of personal communication (274,523 contacts). There were also 78,707 digital outreach events reaching 12,470,142 contacts and 521,374 mass outreach occurrences reaching 17,829,037. These efforts give a snapshot of the cumulative impact of Tennessee Extension agents, state and area specialists and TEMG volunteers in the area of residential and consumer horticulture in 2021. In addition to diverse county programming efforts designed to meet the high horticulture demand in 2021, the consumer horticulture and TEMG team developed and conducted four distinct statewide digital educational series (31 webinars in total) as well as 50 new videos and 14 Extension publications. These products support both consumer horticulture outreach as well as Extension Master Gardener volunteer training and engagement.

TEMG volunteers contribute substantially to the overall horticulture education and outreach capacity within Tennessee Extension. Each year intern Extension Master Gardeners complete an initial training course that prepares them for ongoing service and education in horticulture across the state. In 2021, 572 Extension Master Gardener interns received 40 hours of training (both in-person and distance) in plant and soil science principles; landscape design, selection, and maintenance; pest and disease control (Integrated Pest Management); fruit and vegetable production; and environmental stewardship of water and soil resources. Extension Master Gardener volunteers serve through education and outreach in county programs for many years after training. In 2021, there were approximately 2,685 current certified TEMG volunteers reporting 158,926 hours of service in consumer horticulture education in Tennessee that is valued at $3,896,866 (Independent Sector, 2020 data). Specifically, in the Tennessee Extension Master Gardener program, volunteers provided these impacts for the state in 2021.

- TEMGs managed 95 landscape and ornamental gardens to demonstrate sustainable practices.
- TEMGs managed 39 food gardens that contributed 66,606 pounds of produce to local citizens and communities.
- TEMGs taught or engaged in 39 youth events reaching 5,978 TN students.
- Across the state, 674,250 contacts using traditional media and 736,417 contacts using social media were reported for and by Extension Master Gardener volunteers.

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

Extension Master Gardener volunteers serve through education and outreach in county programs for many years after training. In 2021, there were approximately 2,685 TEMG volunteers reporting 158,926 hours of service in consumer horticulture education in their local Tennessee community that is together valued at $4,535,748.04 (Independent Sector, 2021).

Tennessee Nursery Production Extension Program

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

Tennessee's nursery production industry contributes considerably to the state's agricultural economy. It directly contributes nearly $965 million in economic activity to the state's economy and with multiplier effects, nearly $1.8 billion. The Tennessee nursery industry employs 13,126 Tennesseans directly and with multiplier effects, employs a total of 19,409. Recent changes in the industry have created new challenges for the nursery trade. These challenges include marketing strategies shifting toward social media and other digital platforms, widespread adoption of patented plants and associated royalty fees, pervasive labor scarcity and uncertainty regarding immigration reform, pollinator health, understanding environmentally conscious consumers and their buying habits, invasive species, and changing regulations.

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.

Extension agents and area and statewide Extension specialists conducted nursery production educational programs, virtual and in-person events, and utilized social media to share nursery production and pest management information. Extension agents and area and statewide During 2021, Extension specialists reached nearly 700 growers through on-site visits and 1,197 at 37 group meetings. More than 16,000 contacts were made through mass outreach, 19,010 digital contacts were made, and 6,953 contacts were made through personal communication to further advance commercial nursery and landscape horticulture programming objectives.

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

As a result of Extension programming, the following outcomes are noted.

- 55 nursery producers implemented recommended, research-based practices for fertilizer and pesticide usage and frequency, and/or implemented automation or other labor saving-strategies on 24,840 acres resulting in a total estimated annual savings of $49,680 and increasing profitability by $26,000 per year.

- 72 nursery producers implemented recommended, research-based practices that reduced solid pesticide use from 180,144 total pounds per year to 166,800 total pounds per year, while another 22 nursery producers implemented recommended, research-based practices that reduced liquid pesticide use from 26,400 total gallons per year to 24,000 total gallons per year. 58 nursery producers implemented recommended, research-based practices that reduced pesticide application frequency from 3258 applications per year to 2532 applications per year.

- 42 nursery producers implemented recommended, research-based practices that reduced solid fertilizer use from 9,601,200 total pounds of fertilizer per year to 9,200,800 total pounds of fertilizer per year.

- 12 nursery producers implemented recommended, research-based practices that reduced irrigation water use by 40,000,000 gallons per year.

- Graduates of the Tennessee Master Nursery Producer (TMNP) Program report saving on average $6,309 per person due to knowledge gained and practices changed and estimate increasing plant inventory value by an average of $7,333 for a total of $286,500 in benefits from participating in these online programs. Graduates indicate that the economic impact of the online programs is 3.0 times that of the original in-person class (held once while the online program was built) and that they will have a reoccurring annual savings of over 13% in the years following graduation due to a reduction in inputs such as fertilizer.

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

Tennessee nursery producers refined and reduced pesticide and fertilizer use, which helps preserve environmental quality and improve worker safety. Additionally, by reducing input costs these practices helped improve profitability, which strengthens individual nurseries and ultimately their surrounding rural communities and the region.

Extension Crop Production Systems

Project Director

Hannah Wright

Organization

University of Tennessee Knoxville

Accession Number

7001308

Tennessee Extension Tobacco Producer Education

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

Tobacco production in Tennessee has averaged 35,000,000 pounds annually over the last five years (2016-2021) which equates to $80,000,000 in cash receipts for Tennessee's agricultural economy. Burley, dark fire-cured, and dark air-cured are the predominate types produced, however, cigar wrapper types have recently received interest from leaf buyers and growers. The intensive labor requirement for tobacco production combined with fluctuating market prices and increasing input cost results in tightened profit margins. Key production issues include the selection of high yielding varieties, disease management, labor saving practices, and harm reduction. These issues are the primary focus of the tobacco educational programs in Tennessee.

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.

UT Extension conducted tobacco educational programs reaching over 15,000 direct contacts during 2021. Good Agricultural Practices (GAP), diseases including black shank and angular leaf spot, harvesting, and curing practices, labor, and harm reduction, as well as pesticide residues were primary educational topics covered. These were taught through approximately 57 group meetings and almost 600 on-site visits. These direct contacts were supported by almost 30,000 digital and mass media correspondence.

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

Tobacco educational programs had over 15,000 contacts during 2021. These programs resulted in tobacco producers implementing Good Agricultural Practices that increased yields by 36% through following recommendations for crop rotations, variety selection, and pest and disease control. This is equivalent to 1,116 lbs/acre (6,000 acres) for dark fire-cured, 810 lbs/acre for dark air-cured (4,000 acres), and 540 lbs/acre for burley tobacco (2,900 acres). In addition, 100% of certified GAP growers selected varieties based on disease resistance and field history, 98% used crop rotation, and 100% incorporated insect and disease scouting programs. There were 421 growers that completed GAP training.

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

The increase in tobacco yield and subsequent profitability from incorporating good agricultural practices and university recommendations was significant. Based on acreage data and current market price, this 36% increase in yields results in approximately $17.7 million, $7.6 million, and $3.1 million for dark fire-cured, dark air-cured, and burley tobacco, respectively. The total impact of the tobacco educational program is valued at $28.5 million dollars.

Tennessee Row Crop Production- Corn and Soybeans

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

Challenges facing the row crops industry include understanding and adopting changes in technology, integrated pest management, sustainable agronomic practices, and profitability. Corn and soybean were harvested on more than 970,000 and 1.6 million acres, respectively in Tennessee in 2021. The 2021 growing season had challenges, weather wise, beginning with cold weather into May followed by a growing season that included moderate to hot temperatures and more plentiful rainfall across the state that delayed harvest.

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.

Extension agents and area Extension specialists conducted corn educational programs reaching over 170,000 direct and indirect contacts during 2021. Best corn production practices were taught at more than 170 group meetings and over 846 on-farm visits. Indirect contacts as mass outreach (31) and digital contacts (121) as well as correspondence related to corn production (2,753) was reported. Volunteer contact data of 360 hours valued at over $8,500 to more than 10,000 contacts related to corn production was reported.

Extension agents and area Extension specialists conducted soybean educational programs reaching over 540,000 direct and indirect contacts during 2021. Best soybean production practices were taught at more than 143 group meetings and over 905 on-farm visits. Indirect contacts as mass outreach (92) and digital contacts (112) as well as correspondence related to soybean production (3,467) was reported. Volunteer contact data of 260 hours valued at over $6,375 to more than 10,000 contacts related to soybean production was reported.

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

As a result of the extension programming effort, the following outcomes were reported.

- 628 of 808 (78%) of corn producers gained knowledge of UT recommended agronomic and pest management practices and 419 of 561 (75%) adopted two or more of those practices.
- Corn producers increased yield 123,259 total bushels by adopting two or more recommended production practices on 856,177 acres, increasing total income by $8,877,373 dollars.
- 712 of 941 (76%) of soybean producers gained knowledge of UT recommended agronomic and pest management practices and 465 of 639 (73%) adopted two or more of those practices. Soybean producers increased yield
- 60,666 total bushels by adopting two or more recommended production practices on 1,525,662 acres, increasing total income by $7,862,978 dollars.

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

As a result of extension's programming efforts in corn and soybeans, over $16.7 million in economic impact through increased revenues, increased savings, and one-time capital purchases.

Tennessee Row Crops- Cotton and Wheat Production

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

Cotton production within Tennessee has been challenged with marginal prices fueled by stagnant demand. Current market conditions have narrowed margins and left little room for error concerning variety selection, integrated pest management, and sustainable agronomic practices. Frequent, excessive rains fell throughout the end of the season and negatively impacted fiber quality, but overall yields were very good. Key production issues include the selection of high yielding varieties, best management practices for soil and water, and the control of herbicide resistant weeds and troublesome insect pests.Tennessee wheat production was greatly impacted by the extension effort of UT extension agents and specialists. Updated wheat variety and agronomy information provided producers information on how to efficiently increase wheat production on their farms. Moreover, pest-management information assisted growers in controlling pests with and an integrated pest approach to pest management.

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 cotton programs, Extension agents and area Extension specialists conducted educational programs reaching over 1,082,810 indirect and direct contacts during 2021. Popular press and blog articles (63), publications (13), and social media posts supported the direct contacts.

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

As a result of extension's cotton and wheat programming, the following outcomes were noted:

- 75% of cotton producers gained knowledge of UT recommended agronomic and pest management practices and 75% of producers adopted those production practices.

- 177 cotton producers increased yields by 453 pounds of lint per acre by adopting production practices on 295,564 acres of cotton, increasing total income by $23,126,459.00.

- 166 cotton producers gained knowledge of UT recommended agronomic and pest management practices.

- 101 cotton producers adopted recommended agronomic and pest management production practices.

- 332 of 361 wheat producers gained knowledge of UT recommended agronomic and pest management practices.
  - 271 of 361 producers adopted two or more of those practices.

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

Surveyed producers stimated an average value of $30/acre for information provided by UT Extension cotton programming. In 2021, there was over $23.1 million economic impact as a result of the cotton programs offered by UT Extension. Wheat producers increased yield by 440,757 total bushels by adopting two or more recommended production practices on 512,130 acres increasing total income by $2,093,595.75.

Tennessee Variety Test Program for Corn Grain, Silage, and Soybeans

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

Tennessee producers need information concerning corn and soybean variety test performance specific to their region so that they can select varieties/hybrids that will optimize the profitability of their production systems.

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 variety test program provides important information on which varieties perform best in Tennessee. In 2021, replicated variety tests were conducted on corn grain (71 hybrids; 10 brands), corn silage (8 hybrids, 3 brands), and soybeans (110 varieties; 13 brands) at six of UT's Research & Education Centers and AgriCenter International which represent the different physiographic regions of Tennessee. Data were collected on yield, quality, and agronomic traits.

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

Results from these crop trials were compiled, along with results from the County Standard Tests (CST) and soybean disease variety trials and published in three peer-reviewed Extension publications. These were distributed electronically as both pdf and mobile-friendly, searchable tables on search.utcrops.com as well as through hard copies (corn silage - 210, corn grain – 2200, soybean – 2200) distributed to farmers, extension agents, seed industry reps, consultants and other interested clientele. In 2021, the variety test program provided an estimated $121.9 million in additional revenue to Tennessee producers. This number includes $59.3 million from corn and $62.6 million from soybean. These numbers were calculated by determining the monetary value of growing top performing varieties compared with varieties that exhibit average yield performance. Yield advantage was calculated by subtracting the test average from the average yield of top performing varieties, defined as varieties that did not differ statistically from the highest yielding variety within each test. In 2021, top performing varieties exhibited a yield advantage of +12 bu/a for corn and + 4 bu/a for soybeans. This number was multiplied by USDA reported

price per bushel (corn - $5.79 and soy - $12.10) and Tennessee acreage harvested (corn – 970,000 and soy – 1.47 million) in 2021. This number was then multiplied by 0.88 based on results from a 2017 survey which indicated 88% of respondents use the variety test results to select top performing varieties.

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

By helping producers distinguish between top-performing and average or poorly adapted varieties, the Tennessee variety test program provided an estimated $121.9 million ($59.3 million from corn, $62.6 million from soybean) in additional revenue to Tennessee producers in 2021. The variety test program has a significant economic impact to Tennessee and continues to be a program that is highly valued and supported by producers.

Extension Livestock and Forage Programs

Project Director
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Equine Extension Programs

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

The equine industry has an impressive economic and agricultural impact to the State of Tennessee. Currently, home to over 104,000 horses, ponies, mules, donkeys, and burros valued at more than 4.5 million dollars (USDA, 2017). Despite the significance of the industry from an economic perspective, the industry is often overlooked as an agricultural entity because equine species are not used for meat or fiber in the United States. With over 41,000 equine operations accounting for nearly 30% of Tennessee's agricultural acreage, UT Equine Extension programs are essential to sustainable agriculture in the State (Kenerson and Moore, 2004). Equine farm operators and owners often lack a background in agriculture and are unfamiliar with best management practices. Further, as the youth hold the key to future agricultural success, attention to the education and development of hands-on equine-related skills is critical to the future of the equine industry.

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

An integrated, multi-disciplinary extension and applied research program was active in 2021 through new and existing programs to unify equine owners, business operators, industry members, and stakeholders alike. In 2021, county meetings, field days, on-farm/on-site visits, news articles, publications, college-level courses, personal contacts, and educational websites were used to promote adoption of recommended equine management practices. Despite the ongoing effects of the COVID-19 pandemic on traditional programming opportunities, the Equine extension program was successful in delivering meaningful programs. The Tennessee Master Horse Program piloted an online format, reaching over 250 individuals from 12 states. An applied research program was conducted on alternative diet strategies for rehabilitating starved horses, which generated over $80,00 in grants and contracts to the Equine Extension Program. Programs and events targeting youth and adult audiences to enable adoption of practices across a wide variety of stakeholders were also implemented on a county, state, and national level, including state-wide agent trainings, along with youth- and adult-centered learning sessions. Efforts to determine Tennessee equine industry demographics and economic impact through partnership with the Tennessee Department of Agriculture were developed this year.

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

Through the actions of Extension personnel across Tennessee, over 400,000 people have been reached through group meetings, farm visits, social media interaction, and large-scale outreach efforts. The UTHorse website reached an additional 8,947 individuals, with users from all 50 United States and 130 countries. The 4-H Horse Program enrolled 5489 youth in 2021, with 2840 youth participating in horse judging. Alterations in nutrition programs, pasture and waste management strategies, and preventative care schedules based on scientific recommendations have elevated the level of awareness and education, saved equine owners money, and ultimately improved the health and well-being of the animal.

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

Overall, the combined aforementioned efforts saved Tennessee equine owners $1,612,855 in 2021. Individual savings based on management practices are listed below.

- Equine owners feed 686 equids according to recommended nutritional requirements and management practices, such as adjusting rations based on body condition score and using forage testing to make feeding adjustments, saving $200,655 in 2021.

- Equine owners follow recommended health practices (including deworming, vaccination, hoof, and dental preventative care) on 614 equids, saving $1,412,200 last year

Extension Small Ruminant Programs

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

The small ruminant industry contributes to Tennessee agriculture in a variety of ways including milk, meat, animal sales, employment opportunities and purchases from local businesses. There is a need for research-based education addressing sectors of the small ruminant industry.

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

To address these producer needs, the following contacts/activities were conducted:

- 4 visits to Extension Offices (6 contacts);

- 4741 contacts from group meetings and presentations;

- 108 contacts from on-site visits; and

- 3 state livestock shows (~200 contacts per show).

Education materials were posted on Social Media sources for indirect contacts 118,166 and lectures/programs posted on YouTube had almost 800 views.

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

As a result of the programing and education opportunities offered to the small ruminant industry, the following outcomes were reported.

- 786 small ruminant producers implemented management strategies on 29,849 head of sheep/goats to reduce production/death loss caused by internal parasites.

- 620 goat producers have implemented practices related to genetic improvement, nutrition, health, reproduction and other information as a result of the Master Small Ruminant Program.

- 534 small ruminant producers sold 14,214 lambs/kids that were managed for improved marketing methods, according to practices promoted by UT Extension.

- 340 goat producers report improved production efficiency due to practices implemented from their Master Small Ruminant Program participation.
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Briefly describe how the broader public benefited from your project's activities.

UT Extension programming for small ruminant production and management continues to enhance the lives and livelihood of Tennessee sheep and goat producers by providing them with information to better their herds and provide opportunities for increased profitability and savings.

Forage Educational Program for Livestock and Hay Producers

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

Livestock production in Tennessee depends primarily on forage crops for the feed supply. Grazing, hay, and haylage make up the overwhelming majority of livestock diets and are the major cost in livestock production. Improving efficiency and decreasing costs are the primary focus of the forage educational program in Tennessee.

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.

UT Extension conducted forage educational programs reaching over 40,000 direct contacts during 2021. Stockpiling tall fescue and weed control, as well as adding clovers to grass pastures and utilizing warm-season forages were primary educational topics covered. These were taught through approximately 180 group meetings and almost 2000 on-site visits. These direct contacts were supported by over 500,000 digital and mass media correspondence.

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

Forage educational programs had over 40,000 contacts during 2021. These programs resulted in 56,000 acres being planted with clovers, 20,000 acres planted to warm-season grasses for summer forage production, and 37,000 acres of tall fescue stockpiled to decrease winter feed costs. Over 100,000 acres of forage crops were treated to decrease weed pressure. Approximately 54,000 head of cattle were fed using improved feeding methods.

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

The increase in forage profitability from these practices was significant. Based on data from research studies, the fertilizer savings from planting clovers was $1.68 million. The improved forage production from warm-season grasses is valued at $400,000, while stockpiling tall fescue saved $1.5 million in feed costs. Weed control improved forage production by approximately $4 million. Improved hay feeding methods saved $2 million dollars in hay costs. The total impact of the forage educational program is valued at $9.5 million dollars.

Tennessee Extension Dairy Production and 4-H Programs

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

The dairy industry contributes to the Tennessee economy in a variety of ways including milk sales, dairy product sales, animal sales, employment opportunities, and purchases from local businesses. Milk sales alone account for 3.1%, or $105,924,000 of Tennessee's economy annually (USDA ERS, 2020). The dairy cattle housed in Tennessee also contribute to the 14.0% ($487,665,000) of Tennessee's annual economy attributed to cattle and calf revenues (USDA ERS, 2020). Dairy production in Tennessee faces one of the primary issues of dairy production across the nation, which is loss of dairy farms. Some of the main challenges to our farms and their survivability are milk quality, efficiency of production, and cost of production. Understanding issues faced by our dairy producers, providing updated management recommendations, and encouraging small business principles may help producers be successful. An additional effort to increase dairy survivability is value-added dairy opportunities including farmstead creameries

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.

Collaborative, multi-disciplinary extension education and applied research was conducted to address issues faced by our dairy producers, provide updated management recommendations, and encourage small business principles. During 2021, Extension personnel spent a total of 13,793 hours on activities related to dairy production, milk quality, and 4-H activities. Volunteers contributed 102 hours with a value of $2,501.04. These included:

- 385 group meetings and demonstrations (8,780 contacts);
- 134 on site visits (536 contacts);
- 6,971 direct mail, calls, & emails (14,944 contacts);
- 1,179 digital outreaches (Facebook and Instagram; 21,213 contacts); and
- 6 mass outreaches (354,970 contacts).

In total, Extension personnel engaged in 8,675 contact methods and reached 353,133 contacts including 5,347. A total of 4,420 female and 5,660 male contacts (343,053 unidentified contacts) were reached (915 identified minority contacts, total). The Tennessee Master Dairy Program offered 11 1-hour webinars focused on timely topics including: producer assistance programs, COVID-19 safety, forage quality, farm management, and value-added dairy opportunities. Additionally, a two-day Value-Added Dairy Conference was conducted (474 contacts). Tennessee's 4-H Dairy program had to adapt to COVID-19 concerns but was still able to offer state and regional dairy judging and shows. N

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

The direct engagement of Extension personnel, achieved the following:

- 1,112 attendees learned about dairy economics, facility sanitation, proper housing, new health care techniques, calving, reproduction, and financial management because of participating in 20 educational sessions delivered during the past calendar year because of participating in the Tennessee Master Dairy Producer Program and Webinar Wednesday.
- 474 attendees learned about value-added dairy processing equipment, feasibility studies, and business management by participating in the 2021 Value-Added Dairy Conference.
- 31 attendees were eligible for certification through the Tennessee Master Dairy Program; 73 producers attended at least one Tennessee Master Dairy Program.
- 29 dairy producers used improved calf rearing techniques, including, but not limited to, group housing and increased milk allotment.
- 36 dairy producers increased milk production and quality following UT Extension recommended practices dealing with parlor procedures and cow comfort/housing.
- 10 extension publications were created focusing on dairy management, economic efficiency, value-added dairy production, and precision technology.

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

UT Extension efforts have adapted quickly to the challenges presented by COVID-19, increasing frequency and convenience of programming where possible. Through the Tennessee Master Dairy Program, 47**%** of dairy producer received continuing education on farmer assistance during COVID-19, farm business management, parlor and labor management, nutrition, and animal health. Across 1,586 attendees, the average knowledge value attributed to each presentation was $7,500.

Type	Projects / Programs
Projects / Programs without a Critical Issue	0

Not Provided