

# Kentucky (Kentucky State University, University of Kentucky Combined) Annual Report - FY2021

**Report Status: Approved as of 07/08/2022**

## Contributing Organizations

---

Kentucky State University  
University of Kentucky

## Executive Summary

---

### Overview

**Critical Issue: Agricultural, Environment and Natural Resources**

**Critical Issue: Economic and Financial Well-Being**

**Critical Issue: Food Safety and Security**

Food is an essential part of our lives, particularly during the holiday season, when families get together and enjoy different varieties of food prepared at home. During this time it is also very important to keep food safety in mind, specifically while serving immunocompromised individuals. While private food safety certification system is becoming an integral component of the global food system, little is known about how the food safety certification market functions and how it interacts with other players in the system (e.g., producers, certifiers, policymakers). Many big questions important to the policymakers (such as the U.S. Department of Agriculture [USDA] and the FDA) remain unaddressed, such as “can the government trust the private food safety certification system to optimize the use of budgeted resources?” Kentucky researchers have aimed to examine whether long-term relationships between certification bodies and producers induces learning-by-doing and therefore reduces the time needed to conduct and finish the certification process, resulting in efficiency gain. Other efforts included the development and testing of new treatment methods to reduce E.coli contamination in fresh produce and a cost-effective, fast method for assessing oil quality in foods. A price analysis study also aimed to determine the dynamics of price adjustments on the food supply chain. From a more consumer-based emphasis, Extension's Cook Wild Kentucky program aimed to provide food insecure families with hearty meals, using wild game meat.

**Critical Issue: Leadership and Community Engagement**

Community leadership development is the cultivation of individual knowledge, skills, and dispositions as well as collaborative processes that

help initiate and sustain change in communities. Effective community leadership development:

- Occurs at the individual, small group, and coalition/community levels
- Results in strong leadership across all areas of civic life and attends to developing the next wave of leaders
- Values public participation, shared leadership, capacity building, and inclusivity

Community Engagement is the process of intentionally involving community members in collective efforts. Typically through groups or involvement to improve the community, engagement may include co-creating a vision, building on assets, defining issues, finding solutions, and taking action. Efforts have occurred to promote leadership among 4-H youth and other community volunteers. Another major effort included the local business flood relief initiative that empowered communities to rebound after major disasters. In addition, Extension efforts have engaged over 6000 people in programs that afforded them with new-found skills, which led to obtaining new leadership roles.

The University of Kentucky College of Agriculture, Food and Environment and Kentucky State University College of Agriculture, Communities, and the Environment were founded as land-grant institutions (1862 and 1890, respectively), offering access to knowledge and learning to enhance the lives of Kentuckians. The two programs are fundamentally interdisciplinary, applying the biological, physical, and social sciences to challenges in agricultural, food, and environmental systems. Our work encompasses farms and forests, food and fiber, families, and communities.

The University of Kentucky College of Agriculture, Food and Environment holds a unique position as the home of the Kentucky Agricultural Experiment Station and the Kentucky Cooperative Extension Service. The teaching, research, and Extension programs are part of a national system that maintains a statewide presence and links local, state, national and global issues. Kentucky State University Land Grant Program and College of Agriculture, Communities and the Environment (ACE) focuses on teaching, research, and Extension to address the needs of the small-scale and limited-resource farmers; minority and underserved/disparity communities, as well as diverse and at-risk youths. These programs include research to identify new and niche products and markets for small-scale, limited-resource, and minority farmers, to enhance availability and safety of locally produced, nutritious foods, and reduce fertilizer and pesticide runoff to improve soil and water quality while reducing farmer and forester expenses.

Our vision is to be recognized for excellence in fostering learning that changes lives, discoveries that change the world and opportunities that shape the future. Research and Extension, as full partners with expanding linkages throughout the University of Kentucky and Kentucky State University and with support from every Kentucky county, seek to 1) facilitate lifelong learning informed by scholarship and research, 2) expand knowledge through creative research and discovery, and 3) serve Kentuckians by sharing and applying knowledge.

Research and Extension seek to sustain the land-grant heritage of achievement in these challenging times, but the Commonwealth and the universities are undergoing many significant changes. As Kentucky continues to move from a tobacco-based agricultural economy and explores new options and commodities, land-grant programs face increased demands and expectations. Technology is redefining the way people acquire and distribute information and how they solve problems. While urbanization is claiming farmland, it is also creating new markets for traditional and non-traditional agricultural products. Changing lifestyles and demographics are challenging us with opportunities for greater involvement in youth, family, and community programs.

More than half of the state's cash receipts from farm markets result from animals and animal products. Signature industries include beef and equine, which rely on cutting-edge research to mitigate fescue toxicosis, control infectious diseases and improve reproductive efficiencies. Nearly all animal production systems, including poultry, swine, small ruminants and aquaculture, are faced with increasing public pressure to ensure high levels of animal welfare and operate in environmentally sustainable ways. There is increasing interest among producers for precision animal management tools that can help increase margins and a continued need for assistance developing and marketing value-added products, particularly for the state's declining dairy industry and for small and limited-resource farmers.

Soybeans and grain crops have become increasingly important to Kentucky as the tobacco industry continues to decline. Producers rely on the land-grants for research-based guidance on managing intensive production with minimal environmental impact. Research and extension programs address management of nutrients, pests and diseases, variety selection in a changing climate and water management. They help producers effectively use proven precision farming and land management tools. Additionally, forage systems underpin the state's signature equine and beef industries; their management continues to be a focus for research and extension programs in the state.

Value opportunities in agriculture creates jobs, many of which are within rural communities. Value opportunities also create expanded demand for local agricultural products. Initiatives are required to encourage local entrepreneurial creativity and risk-taking and to build a network of support resources. Kentucky is making substantial resource commitments to support value-added innovations that utilize local agricultural products, particularly in the areas of livestock, horticulture, secondary wood products, and agritourism. The current public interest in community- and region-based local food systems provides Kentucky's research and Extension programs an ideal opportunity to showcase relevance to all citizens across the state and address issues of food security, nutrition, prosperity, and sustainability in both rural and urban communities.

Educational training on the safe production, preparation, handling, and storage of food for producers, processors, consumers, and at-risk groups is the traditional approach to decreasing the risks of food-borne illness. Additional work is needed on research, discovery, and education in the areas of production and processing practices. These programs focus on established businesses as well as the growing home and microprocessing food industry.

Kentucky's natural biological wealth and beauty has drawn the attention of people for centuries. The agricultural, forest, and coal industries have historically been the economic base for Kentucky's economy, but Kentucky's biological wealth is threatened. Protecting soil, air and water resources through better land management and production technologies is a prime goal of programs that serve the spectrum of Kentucky's agricultural enterprises, rural landscapes and communities. Our programs have been instrumental in the implementation of no-till production and that legacy will continue through new innovations in soil and water management.

Concern over ecosystem issues by the general public as well as national and state government has generated recognition of the need for research and education programs. Kentucky's biological wealth may continue to be threatened unless comprehensive and sustainable approaches are researched and utilized for enjoying, studying, and, at the same time, harvesting the fruits of the land through logging, mining, and agricultural production. Ecosystem services must be preserved, anti-microbial resistance must be mitigated and pollinator populations must be protected. Approaches must also consider how these systems adapt to and mitigate climate change. Programs must strive to elucidate how climate change will impact agricultural and natural resource systems while developing programs and technologies that will help farmers, foresters, and others adapt.

The land-grant system's mission of enhancing economic opportunity and improving the quality of life for Americans goes well beyond agricultural production. It includes the empowerment of people and communities through research-based information and education to address economic and social challenges facing our youth, families, and communities. Our goal is to improve the capacity of communities to identify and address these critical issues, and others that affect the lives of citizens. We can best do this by fostering the development of personal and interpersonal skills, stimulating volunteer leadership, and promoting active participation in community problem-solving. Without the acquisition of life skills needed by young people and adults, it is doubtful the citizens of Kentucky will reach their full potential as both individuals and as members of families.

We approach Kentucky's challenges through an integrated model that includes a needs assessment conducted at the grassroots level through the Cooperative Extension Service, advisory groups, councils, and committees. Once identified as priorities, specific problems and needs are addressed by our researchers and Extension specialists. The research, developments, findings, and technologies are transferred through traditional and innovative mechanisms, including educational and training programs, technology transfer, research reports, and partnerships with other colleges, universities, and state and local governments.

Whether it is preserving our rich agricultural tradition by helping farmers, food processors, and agribusiness cope with technical issues, reaching goals, or enhancing the life skills of families, our research, education, and Extension programs are helping shape the future of Kentucky's agriculture, food systems, and communities as well as the quality of life of its citizens.

#### **Critical Issue: Life Skill Development**

Life Skill Development helps individuals become leaders. Leadership is a needed and important programming emphasis for the Cooperative Extension Service. The Cooperative Extension Service provides opportunities to adults and families to help improve their leadership ability and create more positive futures. Life Skill Development opportunities for youth and adults create a setting that reduces the access of risk factors that can negatively impact their success. Basic Life Skill development are essential for success in all areas of life; professionally and personally. By assisting in the development of Life Skills in youth and families, we improve their ability to face the challenges of tomorrow. Several projects were implemented to promote life skill development among clientele. The Extension Fine Arts Education program aimed to increase access to quality arts programming in limited resource communities. Youth in 4-H were taught traditional skills through virtual learning. University partnerships were formed to strengthen programming and outcomes. Residents were also educated on the importance of developing and learning more about the diverse society in which we live. In one endeavor, teachers were equipped with the tools to provide insight and awareness regarding safety as well as community and economic impact.

#### **Critical Issue: Nutrition and Healthy Lifestyles**

#### **Critical Issue: Small Farm Development**

This program helps farmers who want to improve their farming operations, improve the marketability of their products with value-added enterprise, and who want to further their farming and agricultural knowledge through educational trainings. Kentucky State University's Sustainability of Farms and Families supports new economic opportunities for limited-resource farmers through demonstration projects

With nearly 80,000 farms in the state and an average 171 acres per operation, Kentucky is dominated by small and mid-sized family farms. However, many of these farms are major producers of traditional agricultural commodities, such as livestock, tobacco, and grain. Some seek new opportunities in specialty crops and industrial hemp. Others are operated on a part-time basis or involve limited resources. The research and extension programs at both land-grant institutions provide the breadth needed to address the state's diversity of agricultural operations and agroecosystems.

More than half of the state's cash receipts from farm markets result from animals and animal products. Signature industries include beef and equine, which rely on cutting-edge research to mitigate fescue toxicosis, control infectious diseases and improve reproductive efficiencies. Nearly all animal production systems, including poultry, swine, small ruminants and aquaculture, are faced with increasing public pressure to ensure high levels of animal welfare and operate in environmentally sustainable ways. There is increasing interest among producers for precision animal management tools that can help increase margins and a continued need for assistance developing and marketing value-added products, particularly for the state's declining dairy industry and for small and limited-resource farmers.

Kentucky conducted successful programming related to agricultural, environment and natural resources which included efforts in forest education, water and soil quality/conservation, agricultural improvement programs, nanotechnology, performance of small grain varieties and industrial hemp to name a few.

Highlighted accomplishments resulting from research this year include:

- Providing horticultural crop producers with proven ways to reduce losses from root-knot nematodes in high tunnel systems
- An improved understanding of nitrogen immobilization in no-till systems that helps devise better fertilizer recommendations that minimize potential negative environmental effects
- New information on how the beef growth promoter ractopamine influences meat quality at the molecular level
- The creation of a new, simplified tool for detecting livestock parasites in the field
- The discovery of a new pest in alfalfa not previously reported in the U.S. and the subsequent registration of an insecticide for use in its control

Final reports submitted in 2021 worth highlighting include:

Using behavioral data to manage antibiotic use in calves- Technologies that track calf behavior can help manage antibiotic use and more effectively treat respiratory disease. UK dairy researchers found that failure to respond to antibiotic treatment can be correlated to changes in calf behaviors before clinical signs to disease recurrence can appear. Retreatment can be more effective if provided earlier rather than later so tracking these behaviors through technologies like activity trackers and robotic automated feeders that measure milk intake, drinking speed and grain intake.

Understanding the interactive effect of landscape position and winter cover crop selection on N dynamics - Despite decades of research on nitrogen utilization in intensive row crops, worldwide fertilizer N use efficiency remains less than 50%. A more thorough understanding of the influence of macro- and micro-scale ecosystems and landscape properties on soil N dynamics is needed to continue improving N use efficiencies in US corn crops. UK researchers investigated the interactive effect of landscape position and winter cover crop (rye-clover mixture, rye monoculture, no cover) on N dynamics during corn growth. This included a litter bag study investigating how cover crop mass loss and N release vary across hillslopes throughout the corn growing season. They found that cover crop decomposition and N release was similar among landscape positions and between cover crop treatments despite differences in temperature and moisture conditions. However, when they multiplied the proportion of N released by the biomass produced at each landscape position, they found that more N was released from rye-clover mixtures than rye monocultures on backslopes. This finding suggests that planting a mixture on sloping land could increase N supply to the corn crop relative to a rye monoculture, helping producers know where to invest the extra cost of legume cover crop seed. They also found that, although cover crops can increase soil C storage, this beneficial effect on the greenhouse gas balance may be partially offset by higher N<sub>2</sub>O fluxes when they are placed in landscape positions, such as toeslopes, where their presence increased N<sub>2</sub>O emissions.

and grants funded through support from the Kentucky Agricultural Development Board and the state's tobacco settlement funds. This granting program impacts the production and sales of Kentucky-grown farm products and offers funding for educational ventures. Over 1,100 grant proposals have been reviewed with 520 projects funded totaling \$1.9 million to Kentucky producers. Additionally, a farmer education grant is offered to producers in Kentucky who want to learn more about a specific subject through workshops, conferences and/or printed materials. Applicants for education may receive up to \$500 to pay for registration, lodging and, in some cases, travel.

Families continued with facing increasing financial difficulties. Many Kentucky families are in debt and are not saving enough to secure their financial future; many are on the edge of financial disaster. Families need assistance in learning to live within their income and earning capacity and in planning for the future.

Both urban and rural areas of the state continue to be plagued by high unemployment and underemployment. Nearly 30% of Kentucky's youth fail to graduate from high school. With many industries relocating to other countries, job closings have affected many areas of the state. Many Kentuckians lack the educational preparation and skills needed to secure and maintain employment or qualify for new-era jobs. Throughout their lives, both youth and adult Kentuckians need to develop skills essential to become productive members of the community and workforce. Being a productive member of society as an adult requires young people to gain experience as active citizens at an early age. 4-H community service activities provide learning experiences that help youth develop life skills needed to be effective in various adult roles in society.

The COVID pandemic helped emphasize the importance of US agricultural production and how local food systems contribute to food access and resiliency, but is also brought significant economic hardship. Producers continue to struggle with supply chain issues and increased input costs, making margins smaller and the costs of agricultural goods higher for consumers. A significant increase in solar energy production interests across the state add to the economic pressures placed on farmland owners and managers.

In order to address these issues, several projects, programs and evaluative studies were implemented. The Job Club enhanced opportunities for employment seekers by helping individuals hone skills. Financial management programs offered tips on saving and maximizing resources. A study of macro and micro scale land issues in production was conducted. Another study investigated the environmental, social and economic sustainable practices in crops and landscape systems. In addition, another study assessed the impact of investing in critical infrastructure on rural economic development. Researchers continue to evaluate the potential on-farm economic benefits of adopting emerging technologies. Research also addressed the role that race and gender of producers plays in consumer decision making related to agricultural products.

Three leading causes of morbidity and mortality in Kentucky are cardiovascular disease, cancer, and diabetes. The recommendations for their prevention and treatment of these chronic diseases include strong nutritional and physical activity components. Obesity is a contributing factor in the development of these diseases. In Kentucky, the prevalence of overweight adults has escalated over the last decades. Early diagnosis of cancer, diabetes, and cardiovascular disease is associated with improved outcomes, including improved quality of life and longevity. Prevention, detection, and treatment of chronic disease in Kentucky is particularly important in today's changing healthcare environment. People with chronic diseases require skills for self-care. Without such skills, people with diabetes or heart disease often require costly acute care. The prevention of chronic diseases through better self-care also requires skills. Diet, nutrition, and exercise are some of the most effective tools for self-care and prevention of chronic diseases.

Diets rich in fat and low in fiber contribute to obesity, diabetes, heart disease, stroke, and cancer. Nutrition programs like the National Cancer Institute's 5-A Day and USDA's MyPlate can have a profound effect on Kentucky citizens and communities. Recent studies show that fewer than one in five Kentucky adults eats an adequate number of servings of fruits and vegetables. In rural areas of Kentucky, including Appalachian and western regions as well as in urban areas, consumers may not have ready access to a variety of fresh fruits and vegetables at reasonable prices. Younger generations are less familiar with managing and preparing food at home. Over 50% of Kentuckians with incomes just below poverty level are overweight, and children and youth are especially at risk. The need to improve health and quality of life for citizens of the Commonwealth is evident.

A significant portion of Extension programming has been geared toward mental health among farmers and farm families. Eliminating health disparities is another priority, resulting in several Extension and research projects. The goal is to promote health and nutrition in diverse communities. Kentucky has also aimed to address environmental factors (pollutants, etc.) that can also affect cardiovascular health.

Kentucky State University's Small-Scale Farm Grant gives priority to four specific areas (up to \$5,000): food insecurity, organic agriculture, aquaculture, and value-added processing. With nearly 80,000 farms in the state and an average 171 acres per operation, Kentucky is dominated by small family farms. However, many of these farms are major producers of traditional agricultural commodities, such as livestock, tobacco, and grain. Several have received assistance from both Kentucky State University as well as the University of Kentucky to explore new opportunities in specialty crops and industrial hemp, for instance.

## Merit and Scientific Peer Review Processes

---

### Updates

None

### Stakeholder Input

---

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

None

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

None

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

None

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

The Kentucky Cooperative Extension program development process is based on a grassroots, six-stage model that begins with the engagement of local advisory councils for agriculture, 4-H, Family and Consumer Sciences and Extension Homemakers. All program committees used a variety of methods for developing linkages with the public to capture input, including council dialogue and discussion, focus groups, surveys, program evaluations, and working with other local agencies and organizations. Stakeholder input aided the development of programs that addressed the following: Extension programs continue to evolve and be flexible in regard to delivery modalities; Extension responded quickly, and many offices served as emergency response centers for multiple agencies and uses; A new position has been added within Extension Administration to be the facilitator and liaison for Extension evaluation; A new position has been developed to provide administrative leadership to review current Extension workforce development efforts and resources, assess opportunities for Extension involvement and support of workforce initiatives including partner and funding development, as well as, build Kentucky Cooperative Extension's capacity for cultural relevance and diversity; Urban Extension is partnering with students and faculty in the Department of Hispanic Studies to increase outreach to Spanish-speaking clientele through translation of popular Extension gardening publications; Through a partnership with the UK Institute of Rural Journalism and Community Issues in the College of Communications, Extension specialists worked to develop a package of stories, art, and links for vaccine education through local community newspapers.

Research programs at the Kentucky Agricultural Experiment Station regularly interact with stakeholders through meetings with commodity groups including the Ky. Soybean Promotion Board, Ky. Corn Growers and Small Grains Association. Research priority discussions guide how individual faculty plan for leveraging their capacity funds through commodity group and other competitive grant applications. Engagement with extension colleagues and individual companies also provide insight on priority research needs. New capacity research project proposals must describe how they are addressing the needs of Kentucky, regional or national stakeholders when they are submitted for approval.

### Highlighted Results by Project or Program

---

Critical Issue

#### Agricultural, Environment and Natural Resources

---

##### [Developing and Evaluating Perennial Ornamentals for Durability and Resilience in Kentucky](#)

Project Director

Hideka Kobayashi

Organization

**Breeding project**

---

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

Kentucky is a state which has a relatively small industry for the production of nursery, greenhouse and floriculture crops. Production of a niche crop with a high-value such as orchids and *Begonia* is one strategy to optimize 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.**

The strategy proposed in this proposal is to develop cold hardy or cold temperature tolerant ornamentals such as *Begonia*, succulents (i.e., *Mangave*), and to a lesser extent, orchids hybrids that can be commercially produced with minimum heat input. Upon identification of selections, commercial growers as well as nurserymen and limited resource farmers, who have not previously considered ornamental plant production, will have a valuable option to produce these crops in cold frame or high tunnels. During this reporting period (April 1, 2021 - Sept. 30, 2021), 169 *Cattleya* types, 46 *Cymbidium*, and 66 *Dendrobium* as well as 412 *Begonia* and 34 *Mangave* (*Manfreda* x *Agave*) crosses were made. Of these crosses made, ovary development was observed for 48 *Cattleya* types, 1 *Cymbidium*, 24 *Dendrobium*, 25 *Begonia* and 0 *Mangave* crosses. While most of orchid seed capsules have not matured enough for the harvest, *Begonia* seeds have been collected and stored. Orchid seeds harvested from this portion of the project will be germinated *in vitro* once the tissue culture lab is set up.

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

The target audience for this project includes, limited-resource farmers, small farmers, orchid hobbyists as well as stakeholders, and consumers who are interested in growing ornamentals. Creation of resilient ornamentals and subsequent production of such hybrids that can be grown with reduced energy inputs will not only bring an additional income to those who are seeking to diversify their income source but also gives them a competitive advantage to commercial orchid and ornamental growers who are growing traditional, high heat requiring species and hybrids.

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

This is an ongoing pre-breeding project to develop temperature tolerant ornamentals. Acquisition of breeding materials and germplasm have been actively acquired, and some of the materials have been distributed to project collaborators (i.e., Santa Barbara Orchid Estate, and Steve's Leaves). Additionally, one selection of *Begonia* hybrid (*B. formosana* x *grandis* 'Heron's Pirouette') was sent to a collaborator's site (Plant Delights Nursery) to test for winter hardiness. As the project progress, there will be more hybrids that would be available to collaborators to test their performances.

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

Approximately 15 *Agave* plants have been acquired, but none bloomed during this period. Through collaboration with the Plant Delight Nursery, pollen of *Agave ovatifolia* 'Fifty Shades of Grey' was acquired, but none of seed capsules developed. While attempts to cross *Mangave virginica* and *Agave* species will continue this year, this portion of the project may be terminated, depending on the outcome. Similarly, the *Cymbidium* breeding is also hampered by the low success rate. While seed capsules may develop, no or very little seed is harvested. *Cymbidium* breeding may also be suspended or terminated to reserve spaces for other plants and seedlings from the project. In addition, the temperature control in a room which is reserved for orchid seedlings *in vitro* has not been well maintained, further delaying the overall timeline of this project.

**Training opportunities:**

The PI attended a workshop on genetic sequence analyzer (SeqStudio). The use of this equipment could be highly useful in determination of orchid virus diagnosis. A workshop was planned for the use of Sysmex Cyflow Ploidy Analyzer, but was canceled due to a scheduling conflict.

**Project or program plans:**

Pollinations will continue for all kinds of ornamentals mentioned in the proposal for this year. Once seeds are harvested, they will be subjected to germination and/or viability tests. Once the condition of the tissue culture room is corrected, orchid seeds will be germinated *in vitro* and will be grown. Once experimental condition is optimized for medium, light intensity, etc., polyploidization with oryzalin will take place. As for *Begonia*, selection of hybrids developed from the previous period have started, and they will be propagated and tested for winter-hardiness. Back crossing of these hybrids to *B. grandis* has already taken place, and more crosses will be made with *B. grandis* F1 hybrids with *B. grandis*. Some of selected hybrids will also be introduced *in vitro* to induce polyploidy.

**Presentation:**

Kobayashi, H. 2021. *Begonia*, the Underexploited Genus with Numerous Novel Species. Presented at the American Society for Horticultural Science (Oral).

**Extension Supports Agricultural Entrepreneurship**

Project Director

Kenneth Jones

Organization

University of Kentucky

Accession Number

7002122



**Nothing Significant to Report**

---

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

No additional information at this time.

**Sustainable Solutions to Problems Affecting Bee Health**

Project Director

D Potter

Organization

University of Kentucky

Accession Number

1024685



**Determining Urban Clover Lawn Composition to Supply Resources for Bee Populations**

---

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

Bees provide important services in urban settings by pollinating food crops in backyard and community gardens, and wild and cultivated plants that provide fruits, seeds, and insect prey for birds and other desirable wildlife. As native bee populations decline due to agricultural intensification, habitat loss, and other causes, research shows that flower-rich urban



landscapes can be refuges for pollinator conservation. However, traditional turfgrass lawns, which occupy 39-54% of the total area devoted to urban development in the United States, provide few resources for pollinators, so research on alternative lawns is 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.**

Maintenance of turfgrass lawns requires substantial inputs of fossil fuels, water, and pesticides, and runoff or leaching of nitrogen lawn fertilizers is a significant source of water pollution. Thus, there is growing interest in alternative lawns requiring fewer inputs and providing greater ecosystem services. One approach to creating more sustainable lawns is to incorporate white clover, a nitrogen-fixing legume, into grass seed mixtures or existing turfgrass swards. Common or ‘Dutch White’ clover [DWC] forms non-uniform clumps when intermixed with turfgrasses, thus it is often considered to be a lawn weed. Recently, several dwarf white clover varieties were bred for small leaf size and low growth habit, allowing them to tolerate low mowing heights and blend better with grasses. We did a multi-year field study to determine if dwarf clovers are as attractive to bees as standard clover, and if clover lawns are more resistant to insect pests than are all-turfgrass lawns. We established field plots with combinations of DWC, two cultivars of dwarf clover, and tall fescue in monoculture or mixed swards, and compared the invertebrate communities therein. Dwarf clovers were attractive to bees and supported similar bee assemblages as DWC. Clover lawns, tall fescue lawns, and clover-tall fescue mixtures had similar populations of beneficial insects and earthworms. All three clover types significantly suppressed root-feeding Japanese beetle grubs in monoculture, but not when intermixed with tall fescue. All clover types supplied nitrogen to tall fescue, comparable to applying 150-200 kg N/ha/year. Using dwarf clovers that blend well with turfgrasses may encourage greater public adoption of clover lawns, which may in turn help to support health and biodiversity of urban bees.

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

This research benefits homeowners, landscape and park managers, extension educators, and others concerned with promoting, creating, and maintaining urban landscapes. By documenting and publicizing clover lawns for supporting pollinators and reducing need for lawn pesticides and fertilizers, it supports greater public acceptance of an alternative, more sustainable lawn model.

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

Even in communities where there is normative social pressure to maintain uniform turfgrass front lawns, other sites including back yards, institutional grounds, road median and verges, parks, cemeteries, and other low-maintenance sites provide opportunities to incorporate clover or other low-growing flowering forbs to support pollinators without compromising aesthetics or use for informal recreational activities. For example, if most homeowners devoted just a small portion, say 10%, of their back yard to clover, benefits to urban pollinators would be substantial. More widespread adoption of clover lawns would increase sustainability of cities and suburbs. By documenting that dwarf lawn-type clovers provide the same benefits as standard clover, and publishing those findings in a prominent open-access journal, our research will encourage greater interest in alternative lawns.

**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 disseminated by publication in *Sustainability*, an open-access, multidisciplinary refereed scientific journal, and an article in *Encyclopedia*, a free, open platform for researchers to share their results. The results also were disseminated via several invited presentations at major conferences, and as a poster at the national meeting of the Entomological Society of America. Results were presented at conferences providing Continuing Education Credits to professional stakeholders. Dr. Potter will be retiring in August 2022.

Potter, D.A.; Redmond, C.T.; McNamara, T.D.; Munshaw, G.C. Dwarf White Clover Supports Pollinators, Augments Nitrogen in Clover-Turfgrass Lawns, and Suppresses Root-Feeding Grubs in Monoculture but Not in Mixed Swards. *Sustainability* **2021**, *13*, 11801. <https://doi.org/10.3390/su132111801>



## 1. Evaluate devices to generate flow in floating raceways

---

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

Flow rate is a defining parameter in flowing water systems and different devices may induce flow in floating raceways. In this study three devices were evaluated in three Superior Floating Raceways Model 11000, in a 0.8 ha pond. Devices included a 1 hp grid airlift (GAL) with some adjustment for depth, 3/4 hp aerator motor with propeller (AMP), and a 1/15 hp slow rotational paddlewheel (SRP). A 1hp variable speed AMP was also evaluated. Flow was measured in a rigid flume as it was discharged from the raceway.

### **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 graduate student was selected for the project. He developed a thesis proposal consistent with project objectives and a committee was formed to direct his work. Raceways became operational in September of 2020 and trials were conducted with no fish through spring of 2021. Channel catfish were stocked for the growing season and additional flow data were recorded.

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

This project generated useful information regarding performance of various devices to induce flow in floating raceways. The GAL device remains the device of choice due to its capacity to aerate and induce a high rate of flow. There is an optimum setting for manifold pressure and related grid depth with regard to flow. The 3/4 hp AMP device yielded flow comparable to the GAL device, is simple to install, and may have application both pulling and pushing water through the raceway where aeration is not required or supplemental aeration is provided as needed. Of the three devices SRP had the highest flow efficiency, but will require further development. As expected, there is significant reduction in flow with decreasing mesh size. Average flow rate ranged from 9.45 m<sup>3</sup>/min (68% open) to 15.96 m<sup>3</sup>/min (100% open).

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

Investigators work closely with a fish producer near London, KY to demonstrate a floating raceway for production of catfish and trout. The farmer has successfully double cropped with catfish during the summer months and trout during the winter months. As information regarding floating raceway technology is developed and adopted to produce fish for food and recreation, products and services will become available to the broader public. We are in the early phase of this process.

### **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.**

Plans for next reporting period. It is expected that the graduate student will complete his thesis and graduate in spring of 2022. Publications, presentations, dissemination of results for this objective are described in objective 3.

Training and professional development: Student and staff participation in Aquaculture America 2021, August 11-14, San Antonio, TX.



## **Amino acid nutrition of largemouth bass (*Micropterus salmoides*): studies on dietary lysine and threonine requirements**

---

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

- Largemouth bass (LMB; *Micropterus salmoides*) is a freshwater carnivorous teleost native to North America where its production as food fish has increased in recent years mainly due to increased output from U.S. farms.
- Most of the nutritional requirements of LMB are unknown. Protein represents about half of the nutrients in LMB feeds, and it is the most expensive component of feeds.
- The essential amino acids lysine and threonine are among the first limiting amino acids in modern aquafeeds, and must be supplemented to meet nutritional requirements of the target species.
- As only limited information on the quantitative amino acid requirements of LMB exist, this project aimed at determining the dietary requirements for lysine and threonine in LMB.

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

We have finalized the experiment to determine the threonine requirement of LMB in the fall of 2021. Major activities included: design and formulation of experimental diets; sourcing of ingredients for use in experimental diets; sourcing of dispensable items for use in the research, manufacturing of seven diets with incremental levels of threonine; acquisition of LMB fingerlings; conduction of the feeding trial; data collection and statistical analyses; presentation of results in the Aquaculture conference. We are currently putting together a peer-review manuscript for this study.

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

- Feed companies will have access to the research results and will be able to use them as guidelines for adequately meeting the nutritional requirements of LMB in commercial feeds.
- Graduate students in the Fish Nutrition Laboratory of KSU acquired hands on experience in fish nutrition research.

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

Meeting the nutritional requirements of foodfish leads to increased production efficiency including faster growth rates, high feed efficiency and survival. Nutritionally-balanced feeds also support a more environmentally friendly aquaculture industry by reducing nutrient outputs to receiving waters. This project not only provided the means by which feeds for LMB can be better formulated, but it also supported the training of students who soon will join the workforce needed by the industry.

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

Covid-19 and a shelter-in-place established by the Kentucky State University prevented us from conducting the two experiments needed in this project. Therefore, a request for a one-year extension of this project was made, which will allow the completion of the second study (lysine requirement) in 2022.

## **Environmental and Genetic Determinants of Seed Quality and Performance**

Project Director

R Geneve

Organization

University of Kentucky

Accession Number

1021610



### **Finding Biotic and Abiotic Stress Influence on Seed Germination and Dormancy**

---

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

Investigations from this project will help understand how biotic and abiotic stress influences seed germination and stand establishment. These results are expected to increase efficiency and cost effectiveness of crop establishment and habitat restoration. Results will further our understanding of biological processes involved in stress management during germination

#### **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.**

Studies were conducted to reduce or bypass the stratification requirement for dormancy release and germination in grape seed. By utilizing fresh seed from mature fruit that had not completed the final maturation drying stage of development was found to be induced to germinate after a 2000 ppm gibberellic acid treatment or after clipping the distal end of the seed. This effect was further enhanced by combining the gibberellin and clipping treatments yielding germination and seedling development comparable to traditional stratification treatments.

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

The audience includes private and public seed technologists, seed producers and seed scientists. Efforts included preparation and submission of scientific publications, presentations at professional meetings and manuscript reviews.

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

Grape is commercially important both as a table fruit, a processed fruit for raisins, juice, and jams, as well as for wine production. Weather patterns around the world are changing and there is a need to breed and propagate new adapted selections of a variety of traditional crops including grape. For grape, there are predictions for dramatic reductions (up to 81% by the late 21st century) of suitable wine grape acreage in the United States. Grape seed has physiological dormancy and requires three to four months of chilling stratification. The current system bypasses this stratification time to expedite seedling production that would reduce breeding cycle times and facilitate novel “accelerated breeding” programs that utilize advanced genetic approaches.

#### **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.**

Bridget Bolt was an undergraduate student involved in the grape research project. During the reporting period a paper was presented International Plant Propagator’s Society – Eastern region annual meeting. 2021.

Raihan, T., Geneve, R., Perry, S., and Rodríguez López, C. M. (2021) The regulation of plant vegetative phase transition and rejuvenation: miRNAs, a key regulator. *Epigenomes* 5:24; <https://doi.org/10.3390/epigenomes5040024>

## [Alternative management methods to enhance sustainability of Kentucky vegetable production systems](#)

Project Director

Rachel Rudolph

Organization

University of Kentucky

Accession Number

1021069



### **Determining Location and Level of Influence Plant-Parasitic Nematodes Present on Kentucky Crops**

---

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

This project seeks to determine the location and level of pressure of plant-parasitic nematodes in Kentucky. It is currently unknown how many growers are currently dealing with root-knot nematodes (RKN). Root-knot nematode is becoming an increasing issue in high tunnels because of the wide host range and lack of rotation. We seek to evaluate several non-chemical methods for their efficacy in managing RKN, specifically in high tunnels.

#### **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.**

Distribution of different RKN species in the region is largely unknown except for the ongoing survey being conducted in Kentucky. To date, 46 samples have been collected from 16 counties. Of those 46 samples, 22 were confirmed to have either *M. incognita* or *M. hapla*. Only five growers out of the 22 positive samples were already aware they had RKN on their farm. This sampling has not only revealed the presence of RKN where it was previously unknown, but also that there is more than one species of RKN present in Kentucky soils. It is important to know the species as that will affect the recommended management approach. For example, there are many commercially available RKN-resistant rootstocks, which have shown to be effective in reducing yield loss in tomato. However, that resistance is for *M. incognita*, not *M. hapla*. A grower who is dealing with *M. hapla* will need to utilize a different approach. Two on-farm high tunnel trials were carried out in 2021. For both trials, we were evaluating different RKN resistant rootstock in high tunnels naturally infested with RKN. The tomato rootstock was grafted onto the tomato scion of each growers' choice. We evaluated yield, plant biomass, soil root-knot nematode populations (sampled monthly), and final RKN egg densities in plant roots (once at the end of the season). This was the second and final year of the Knox Co. trial. This was the first year in Boyle Co. and we plan to repeat this in 2022. Yield of grafted tomato plants was significantly higher in both trials compared to the non-grafted control. Soil RKN population densities in Knox Co. were significantly higher in the soil surrounding non-grafted plants compared to grafted plants. Root RKN population densities were significantly greater in non-grafted plants compared to grafted plants. In Boyle Co., RKN soil population densities were significantly higher surrounding non-grafted plants compared to soil surrounding 'Arnold', 'Estamino', and 'Shin Cheong Gang' grafted plants, but were not significantly different than soil surrounding 'Maxifort' grafted plants. RKN root populations in non-grafted plants were significantly higher compared to 'Arnold' and 'Shin Cheong Gang', but not significantly different from 'Estamino' or 'Maxifort'. I conducted a cultivar trial of six different biofumigant cover crops in fall of 2021. This trial will help provide information regarding which biofumigant cover crops could potential be used by growers to manage RKN and other soilborne diseases. We evaluated three different planting dates and collected data on biomass production. As for Objective 3, we repeated a greenhouse tomato study evaluating different levels of phosphorus (P) in soil. This trial is nearly complete, but the data has not yet been analyzed. We have also just begun a greenhouse study with lettuce and different levels of P.

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

My target audience is commercial vegetable growers. The survey information allows us to know what issues growers are dealing with and the distribution of those issues. The aboveground symptoms of RKN parasitism often go undiagnosed or misdiagnosed for a nutrient deficiency.

This grafting project results provides growers with guidance on selecting the best rootstock for their operation and provides them with an applicable strategy to continue to grow tomatoes even under RKN pressure. However, it also demonstrates that this method alone will not manage RKN populations. It should be combine with another method, such as nematicides or solarization.

There has been increasing interest in cover crops from vegetable growers. Prior to the Brassicaceae cover crop trial, there was no information about how these types of crops perform in Kentucky. Along with an undergraduate student, we have written a factsheet as well as a small research report. This report will appear in next year's Fruit and Vegetable Research Report.

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

One of the challenges of RKN is that it is often undiagnosed. It is in the soil, affecting plants, but growers do not know. Over time yield begins to decline. Growers often don't know that yield has declined because many of them do not collect yield data or track their yields from year to year. They can provide profit information, but usually not yield data. The results of the grafting project reinforces the need to track yield in order to address issues as they arise. Local food demand is high and being able to meet that demand is not only important for growers and their profit margins, but also to the community at large.

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

I spoke at the 2021 Kentucky Fruit and Vegetable Conference about grafting and managing RKN. There were approximately 150 participants/attendees for my talk. I gave a guest lecture to a vegetable production class (PLS 520) at the University of Kentucky (~15 students). I have also provided guidance to several growers who are interested in grafting (~10 growers). I have also trained my graduate student on this project. In-person trainings on grafting have not taken place this year due to concerns related to COVID. I recently conducted an agent training where one of the main topics was cover cropping. I used the mustards as part of the demonstration for the agents. The mustard cover crop trial was part of an undergraduate research project. The student received credit for maintaining the plots, collecting data, and writing both a factsheet and a research report. This project is part of a M.S. thesis. The student is on track to graduate in May 2022. Before then, we plan to publish the results in a peer-reviewed journal. We expect to submit this for publication before May 2022. To date, the only dissemination that has occurred has been presentations to colleagues in which I gave an academic seminar and to growers and county agents.

Our original plan has not changed significantly. We plan to repeat the Boyle Co. grafting trial and finish soil sampling across the state (at least 50 more samples). I will also be leading a solarization trial evaluating efficacy on RKN, optima time of year, and the temperatures reached at various depths. My lab will be conducting various RKN host assays to be able to provide better recommendations for growers who are interested in non-host rotations. We will conduct the biofumigant cover crop cultivar trial in the spring to compare results to the fall season. The greenhouse lettuce cultivar trial will be repeated and data will be analyzed. The results of the biofumigant cover crop trials will be in next year's Fruit and Vegetable Research Report. The factsheet will be published with the UK Center for Crop Diversification. Yield collection from Boyle Co. was not complete (the grower stopped recording yield a couple weeks early) as the farm family we were working with contracted COVID and then they had a serious medical emergency. In-person trainings were planned for this, but did not occur because of COVID concerns.

**Biology, Ecology & Management of Emerging Disease Vectors**

Project Director

Subba Palli

Organization

University of Kentucky

Accession Number

1021146



**Understanding the Distribution of Ticks to Improve Lyme Disease Prevention**

---

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

Tick-borne diseases are on the rise in Kentucky. The distribution of ticks and the pathogens they transmit is not well known in Kentucky. The main goal of this project is to conduct surveillance and speciation and diagnostics of pathogens.

**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.**

Lyme disease is the most common tick-borne illness in the United States. In Kentucky, where Lyme disease is non-endemic, the number of reported human cases in 2010 totaled five. In 2019, that number had increased by over 300%. Identifying the distribution of *I. scapularis* populations infected with *B. burgdorferi* is important data for effective prevention strategies and an important first step in monitoring disease spread. In collaboration with the Kentucky Department for Public Health, we performed surveillance for *I. scapularis* throughout the state of Kentucky using both active and passive surveillance methods. Diagnostic testing for the identification of *Borrelia burgdorferi* (sensu stricto) was also conducted. We identified 457 *I. scapularis* ticks from March 2019 to December 2020 from 32 counties in Kentucky. *B. burgdorferi* was detected in *I. scapularis* populations collected from 14 different counties. These results add to the little data that exists in Kentucky on *I. scapularis* and *B. burgdorferi* distribution.

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

This information will help public health departments to protect public from tick-borne diseases.

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

The knowledge will help public to protect themselves from tick-borne diseases

**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 results were published in international journal, Ticks and tick-borne diseases. We will develop RNAi-based method to control major pest, the fall armyworm.

Pasternak, A.R. and Palli, S.R. (2021) Mapping distributions of the Lyme disease vector, *Ixodes scapularis*, and spirochete, *Borrelia burgdorferi*, in Kentucky using passive and active surveillance. Ticks and Tick-borne Diseases, 13:101885  
<https://doi.org/10.1016/j.ttbdis.2021.101885>

Closing Out (end date 09/07/2023)

**[Dynamics of Nitrogen Fertilizer Transformations in a No-Tillage Agroecosystem](#)**

Project Director

Christopher Matocha

Organization

University of Kentucky

Accession Number

1018389



**Improved Understanding of Ammonium Fate in No-Tillage Soil**

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

One barrier to further adoption of no-tillage management is lower crop yields which has been attributed to nitrogen immobilization and gaseous losses. Nitrogen immobilization has both an abiotic and biological component yet the contribution of these components is unclear. Accordingly, the overall goal of this proposed study is to investigate N fertilizer transformation processes which affect N availability in a no-tillage agroecosystem.

**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 major activities during the past year involved laboratory experiments designed to investigate the fate of added ammonium in soil, whether it is abiotic or biologically immobilized, which has been under long-term no-tillage management. We have found that washing the soil with sodium chloride is necessary to enhance ammonium removal. In addition, wet chemical experiments have also been performed using a selective inhibitor of biological immobilization and compared with experiments without the inhibitor. It was hypothesized that the inhibitor would lower the rate of ammonium removal by an amount equivalent to biological assimilation. However, the inhibitor actually increased the ammonium removal rate, suggesting the possibility that blocking the biological pathway frees up the abiotic removal of ammonium. We have also been studying ammonium sorption by soil clays to elucidate the mechanism of removal using Fourier Transform Infrared Spectroscopy.

These results will aid in timing and efficiency of N fertilizer applications.

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

Changes to the curricula delivered to undergraduate and graduate students in my three plant and soil science courses have been made to include the role of mineralogy in the fate of ammonium in no-tillage management systems. The number of students reached in the undergraduate course is approximately 80 and there are usually 5-10 in my graduate courses.

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

Nitrogen fertilizer recommendations are adjusted upward in no-till systems due to decreased N availability, presumably due to N immobilization or gaseous losses of N. A better understanding of N cycling in this no-till system will move us one step closer to designing management strategies to enhance N availability while concurrently minimizing adverse environmental impacts of reactive N.

**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 technician and one undergraduate student have helped perform wet chemical and spectroscopic experiments to address the objectives. The exposure to quantitative analyses has been a good experience for the undergraduate student, allowing him to acquire lab skills and organize a lab notebook. Results from this project were presented at the 2021 ASA-SSSA International Meeting.

### [Integrative Management Actions Against Current and Potential Invasive Arthropod Pests of Field Crops in Kentucky](#)

Project Director

Raul Villanueva

Organization

University of Kentucky

Accession Number

1014521



### **Management Actions for Current and Potential Invasive Arthropod Pests**

---

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

1. Several sink bug species are key pests in soybeans and the invasive brown marmorated stink bug (BMSB) *Halyomorpha halys* was detected in field crops in western Kentucky in 2020 expanding its geographic range. This expansion may cause more damages in field crops.



2. Soybean stem borer, *Dectes texanus* infested great numbers of soybean fields and may cause lodging of plants, project evaluated cultivars that may be resistant to lodging.
3. Slugs are becoming a more frequent pest in soybeans and causing damages in soybeans seedlings that replanting of fields are conducted to avoid reduction of plant densities. Replanting in some case are conducted up to three times.
4. Evaluated the presence of kudzu bug *Megacopta cribraria* (an invasive pest) in Kentucky fields.
5. In conventional corn, evaluation of caterpillars were completed in Princeton and Lexington in a study where corn was planted under two different dates early and late.
6. The sugarcane aphid *Melanaphis sacchari*, caused severe damages and reduced yields in grain sorghum and sweet sorghum in Kentucky, its management to reduced populations was evaluated
7. Detected a new pest in alfalfa not previously reported in the USA

**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. A thesis was published on stink bugs based on the work conducted by a student where it showed that pesticide preventive applications for stink do not affect yields when pest population of stink bugs are low. Thesis also showed that sampling for stink bugs can be conducted using 5-gallon buckets instead of sweep nets. Between 2020 to 2021 we noticed an increase on BMSB in soybean fields of Western that is causing changes on species composition between these years. For the stink bugs in soybeans, the species composition changed abruptly between 2020 and 2021. For green stink bugs, the complex of *Euschistus* brown stink bug, and BMSB changes were from 68% to 49%, 18% to 11%, and 14% to 40%, respectively. These changes may cause modifications on the management of stink bugs in 2022.
2. Evaluations for *Dectes* infestations in soybeans showed that this pest is well distributed in KY. Also, the project detected soybean varieties that can be tolerant or resistant to lodging. Project found that the application of pesticides may not cause a reduction of soybean infestations. For first time in KY, this project detected that there is a new pest of soybeans. This is a native insect that affects alfalfa and clover but also can cause death of soybean foliage, this insect can complete its life cycle in a single petiole of soybeans, but it may not cause economic damages, this new pest is the clover stem borer *Languria mozardi*. This borer was previously described in some other states of the south.
3. Slug outbreaks are more frequent now and they are becoming key pests in soybeans. Slug feeding of seedlings causes replanting of fields, in 2020 and 2021 some farmer reported replanting up to three times in some fields. This project has conducted several studies in different areas for the management of mollusks. They included detection of natural enemies (ground beetles), evaluation of molluscicides, and potash for slug control and transference of information in field days, where farmers learned about these topics. Currently two products are registered for control of slugs and snails in corn and soybeans in Kentucky, Dealline™ M-PS Mini-Pellets (metaldehyde) and Sluggo™ (iron phosphate). Preliminary evaluations were conducted on the efficacy of these molluscicides, and farmers learned about the use of them. In addition, the project tested potash and found that predatory capacity of some carabid beetle species that are being identified. These beetle species had the capacity to prey on all stages of slugs from egg to adults.
4. The kudzu bug is still present in very low numbers in KY, they are mostly found in areas where kudzu plants are growing. During the last 5 years, kudzu bugs were not found in soybean plants however, in 2020 and 2021 some fields have low numbers of this pest in at least five different counties (Lyon, Caldwell, Trigg, Todd, and Logan). In 2021 we searched with parasitoids of eggs. From egg clusters collected during early May 2021, the study found that the average egg cluster had 18 eggs, the hatch rate was near 68%, ranging from 14% to 100%. Parasitoids were not found in any of the eggs. Percentages of eggs unhatched were 32%.
5. Several caterpillar species are of economic importance for conventional field corn grown in Kentucky. These species include European corn borer (ECB) *Ostrinia nubilalis*, and corn ear worm (CEW), *Helicoverpa zea*. The major occurrence of these species affected corn fields that did not carry GMO traits. These corn fields are grown for the distillery industry or

specialized food niche markets. This study aimed to study the differences of caterpillar attack on corn planted early and late using in conventional corn and GMO in two locations (Lexington-central KY and Princeton-western KY), and to evaluate management effects based on insecticides applications using IPM threshold, and scheduled sprays on yields of non-Bt and Bt-corn. Tallies conducted in Princeton in ears showed significantly ( $p < 0.001$ ) fewer CEW caterpillars were found on the early planted compared with the late planting. During the 2-years, significantly fewer CEW caterpillars were found in the Bt corn compared with the other treatments. In Lexington damages from CEW were not observed.

6. Working with sweet sorghum growers in a community of Trigg Co. KY we conducted several outreach programs (field days and trainings), and visits to their fields to support them in their fight against the sugarcane aphid from 2016 to 2021. This community learned successfully to identify this pest, and their natural enemies, and how to manage this pest. Up until 2019 they conducted insecticide applications of flupyradifurone to the majority of their fields to control the yellow sugarcane aphids. In 2020 and 2021 the application of this pesticide was reduced as they conducted scouting and applied only when the insects were above thresholds.

7. This project started due to the discovery of a new pest in alfalfa, a larva of a crane fly (Diptera: Tipulidae) (Villanueva, unpublished) in 2019. The larva of this insect called leatherjacket caused severe damage to alfalfa in Kentucky in 2019, 2020 and 2021. Using DNA-based identification and available sequences on public databases, this insect was identified as a native species, *Tipula paterifera*. This new pest represents a common challenge in pest management in which new pests are found, but effective management reaction is limited. Prior to this observations, no tipulids have been reported to cause significant damage to alfalfa. Because this new insect pest affects alfalfa growth in the spring, feeding on crown buds and axillary buds, this pest may impact first alfalfa cut on early spring. The observed damage affected all parts of the plants; lateral roots were completely consumed, as well as the foliage, crowns, and stems, and causing 25 to 100 losses in the spring cut. The insect presence is notorious especially on the spring and affects the first alfalfa cutting. To help the farmers, we supported the registration of Warrior II with Zeon Technology® a group 3 pyrethroid insecticide with the active ingredient lambda-cyhalothrin (22.8%), that was approved under FIFRA section 2(ee) (Warrior for crane flies) to be used for the control of crane fly larvae in alfalfa.

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

Growers of Kentucky learned and benefited on the findings in my research programs on each of the different topics as it is described below:

- On stink bug abundances and control, farmers and scout agents learned on the geographical expansion of the BMSB, their overwintering behavior, and learned to identify this species from another “brown” stink bug species in western Kentucky.
- Now they are aware of the presence of the soybean stem borer (Dectes), and the “new pest” in soybeans the clover stem borer. Growers are learning that these species feed on soybeans and do not cause economic losses but know they can inspect plants and evaluate their presence
- Farmers are learning how to detect the damages caused by slugs, scout for slugs, and how to manage them using molluscicides. Additionally, they are now aware of the presence of beneficial natural ground beetle species (Carabids) that can have a positive impact on reducing populations of slugs. Although, potash is reported as an alternative tool to reduce slugs our data shown that this needs further evaluation, farmers now known that compared to molluscicides, potash does not reduce egg oviposition.
- On the control and management of the yellow sugarcane aphid farmers learned to scout them, conduct decision making applications based on the thresholds, and farmers use an effective insecticide, and Amish farmers conduct applications using modified equipment that they designed specifically to target this pest.
- We are still in initial studies on the new pest in alfalfa, however, this information was published in the Kentucky Pest News newsletter of the University of Kentucky, and to the National Alfalfa and Forage Association members in Kentucky that are supporting a research that will be conducted in 2022.

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

The programs I conducted with partial support of this hatch grant benefits primarily to the farmers, scout agents, county extension agents and student ins Kentucky. Results of the programs described above are transmitted to the clientele first to learn, next to adopt, and finally to change their practices that will benefit them. In the stink bug case farmers learned to identify the different species and also if they conduct preventative sprays and stink bug populations are low, the spray will not provide any benefits. Slugs in soybeans is a reoccurring more frequently. In the past two years, molluscicides are being used already by some farmers and in this case the cost this product per acre (\$20) benefits the farmer as he/she may not need to replant or delay harvest. In addition, with the identification of natural enemies a sustainable practice can be developed to avoid targeting beneficials.

In the case of the yellow sugarcane aphid since my intervention the farmers of Trigg Co. were able to progressively produce sweet sorghum and increase their acreage to produce sorghum applying the knowledge I delivered and transforming the sorghum in molasses.

The new leatherjacket pest caused severe damages to roots, foliage and crowns of alfalfa plants and entire fields in KY, and historical records on this pest are not found anywhere else. As a new pest this can cause outbreaks in the future, however the program I am conducting will leads to a more in deep work in this new pest and preventive measures can be planned in an eventual large occurrence of this pest in alfalfa, a high value forage, with more than 2. 2 million of acres in KY and surrounding states and may impact other regions of the USA

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

I have participated in the Kentucky Agriculture Training School ([KATS](#)) conducting scouting programs to identify pests and natural enemies in wheat and soybeans in 2020. In 2021 a 11th grade student was trained to work with kudzu bugs and an undergraduate from Murray State University was trained to work evaluating the management of soybeans. The results of these studies were disseminated using diverse media including digital and printed forms. Also, some of these results were presented to colleagues and students through annual conferences, and professional meetings (Entomological Society of America) and field days and county extension meetings. Some of them were in the Kentucky Pest News Blog. Also, one webinars was presented in each 2020 (Management of Bean Leaf Beetles, Three-cornered Alfalfa Hoppers) and in 2021 (the Fall Armyworm Geographic Expansion of Brown Marmorated Stink Bug and Concerns for SB Management in Kentucky Outbreak in 20210). Hiring of personnel to complete some task due to the COVID-19 pandemic was a challenge. Funding from agencies to specifically complete applied field research is scarce and to compete with salaries of companies is problematic.

#### Reviewed Publications:

- Gonzalez, Y. (2020). Management of Stink Bugs (Hemiptera: Pentatomidae) on Soybean in Kentucky. Master Thesis in Entomology, University of Kentucky.
- Musser, Fred; A. Catchot, S. Conley, J. Davis, C. Difonzo, J. Greene, G. Lorenz, D. Owens, D. Reisig, P. Roberts, T. Royer, N. Seiter, R. Smith, S. Stewart, S. Taylor, K. Tilmon, **R. Villanueva\***, and M. Way. 2020. 2019 Soybean Insect Losses in the United States. *Midsouth Entomologist*. *Midsouth Entomologist* 13:1-23. (\*Contributed with data and edits for this publication). [PDF last accessed Oct 13, 2020]. Available at: [https://www.researchgate.net/publication/340950846\\_2019\\_Soybean\\_Insect\\_Losses\\_in\\_the\\_United\\_States](https://www.researchgate.net/publication/340950846_2019_Soybean_Insect_Losses_in_the_United_States)

#### Virtual North Central Branch Meeting of Entomological Society of America. June 21-23, 2021

- Expansion of the brown marmorated stink bug to western Kentucky soybean fields. Raul T. Villanueva and Zenaida Viloria

#### Extension publication

- ID-268 and ID-268P: 2020. Kentucky Grain Crop Production at a Glance. C. Knott, C. Bradley, C. Lee, T. Legleiter, S. McNeill, E. Ritchey, R. Villanueva, and K. Wise <http://www2.ca.uky.edu/agcomm/pubs/ID/ID268/ID268.pdf>

## **Enhancing the Competitiveness and Value of U.S. Beef**

Project Director

Surendranath Suman

Organization

University of Kentucky

Accession Number

1014747



### **Protein Analysis of Cattle Beef to Determine Market Value and Competitiveness**

---

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

Our long-term goal is to identify ongoing market risk associated with domestic livestock protocols to the U.S. beef industry. This strategy could improve quality, safety, and domestic and international marketability of U.S. beef products by examining palatability attributes, increasing shelf life, developing novel products from variety meat items, and developing innovative carcass fabrication 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.**

The global demand for meat as a source of high quality animal protein is increasing, and the applications of growth technologies in animal agriculture play an important role in achieving food security. Beta-adrenergic agonists are oral growth promotants approved in livestock production. Ractopamine is a beta-adrenergic agonist approved for use in beef cattle and pigs in more than 25 countries, including the United States. Dietary ractopamine is a repartitioning agent that enhances protein synthesis, increase leanness, and decrease lipid deposition. Dietary ractopamine causes a muscle fiber shift in cattle, and the biochemistry of mitochondria in postmortem muscles is influenced by fiber type. Nonetheless, the influence of ractopamine on beef skeletal muscle mitochondrial proteome has not been evaluated. Therefore, the objective of this study was to examine the effects of dietary ractopamine on mitochondrial proteome of postmortem longissimus lumborum (LL) from feedlot crossbred steers. Pen-housed crossbred steers were fed either a corn-based basal diet (CON) or a diet top-dressed with Optaflexx 45 (Elanco Animal Health) to provide 400 mg of ractopamine hydrochloride/steer per day (RAC). Ractopamine was fed the last 28 days prior to the harvest. The LL muscle samples were obtained from nine (n = 9) RAC and nine (n = 9) CON carcasses. The mitochondrial proteome was analyzed using two-dimensional gel electrophoresis and mass spectrometry. Seven differentially abundant proteins ( $P < 0.05$ ) were identified. Three proteins over-abundant in RAC were complement component 1 Q subcomponent-binding protein (C1QBP), very long-chain specific acyl-CoA dehydrogenase (ACADVL), and aconitate hydratase (ACO2). On the other hand, four proteins, ATP synthase subunit beta (ATP5B), prohibitin (PHB), cytochrome b-c1 complex subunit (UQCRC1), and thioredoxin-dependent peroxide reductase (PRDX3), were over-abundant in CON. The differentially abundant proteins belong to four functional groups – energy metabolism (ATP5B, UQCRC1, and ACO2); chaperone activity (C1QBP and PHB); antioxidant (PRDX3); and fatty acid degradation (ACADVL). The increased protein synthesis and leanness reported in ractopamine-fed cattle may be attributed to the increased expression of enzymes involved in fatty acid degradation and the decreased expression of enzymes involved in oxidative phosphorylation. Additionally, the decreased tenderness previously reported in beef from ractopamine-fed cattle may be attributed to the increased expression of antiapoptotic protein (C1QBP) and decreased expression of proapoptotic protein (PHB) resulted from ractopamine supplement. These results explain the increased feed efficiency, growth rate, leanness, and toughness previously reported in ractopamine-fed cattle.

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

The target audience for this project is meat/food scientists and meat/food industry. The innovative data from this work indicated that dietary ractopamine modulates beef muscle proteome and thus can impact meat quality. This information could be exploited to develop novel pre-harvest strategies to improve beef quality.

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

The activities in our project have provided information to educate the public that the applications of growth promotants in cattle modulate beef quality.

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

Research training was provided to Shuting Li and Yifei Wang on muscle proteome isolation, spectrophotometry, two-dimensional electrophoresis, gel image analyses, analyses of mass spectra, and evaluation of meat color stability. Yifei Wang (MS Student with Dr. Suman) received 1st place in the Graduate Student Research Poster Competition (M.S. Division, 2021) of American Meat Science Association. Yifei Wang (graduate student with Dr. Suman) graduated with MS (2020) at the University of Kentucky.

Dr. Surendranath Suman was recognized as University Research Professor (2021) at the University of Kentucky.

Results were published in the fully open access journal *Fleischwirtschaft International*. Dr. Surendranath Suman delivered virtual presentations on meat quality at Sichuan Academy of Grassland Science (China) and Annual Conference of Association of Meat Scientists and Technologists (India).

Kim, H.M.; Suman, S.P.; Wang, Y.; Li, S.; Beach, C.M.; Nair, M.N.; Zhai, C.; Harsh, B.N.; Boler, D.D.; Dilger, A.C.; Shike, D.W. 2021. Vitamin E influences proteome profile of beef longissimus lumborum muscle. *Fleischwirtschaft International*, 4: 65–69.  
Antonelo, D.S.; Gomez, J.F.; Silva, S.L.; Beline, M.; Zhang, X.; Wang, Y.; Pavan, B.; Koulicoff, L.A.; Rosa, A.F.; Goulart, R.S.; Li, S.; Gerrard, D.E.; Suman, S.P.; Schilling, M.W.; Balieiro, J.C.C. Growth rate within the feeding regime seems to drive early postmortem metabolism and beef tenderization: a proteomic approach. 67th International Congress of Meat Science and Technology, August 2021, Krakow, Poland. Abstract # 17.

Antonelo, D.S.; Beline, M.; Silva, S.L.; Gomez, J.F.; Ferreira, C.; Zhang, X.; Pavan, B.; Koulicoff, L.A.; Rosa, A.F.; Goulart, R.S.; Gerrard, D.E.; Suman, S.P.; Schilling, M.W.; Balieiro, J.C.C. Variations in intramuscular fat content and profile in Angus x Nellore steers under different feeding strategies contribute to color and tenderness development in longissimus thoracis. 67th International Congress of Meat Science and Technology, August 2021, Krakow, Poland. Abstract # 18.

Kiyimba, F.; Suman, S.P.; Joseph, P.; Abraham, A.; Mafi, G.G.; Ramanathan, R. Bioinformatics analyses to characterize how proteome regulates metabolome and its impact on muscle-specific fresh beef color stability. 67th International Congress of Meat Science and Technology, August 2021, Krakow, Poland. Abstract # 28.

### [Genetic Studies of Alternative Aquaculture Species](#)

Project Director

Boris Gomelsky

Organization

Kentucky State University

Accession Number

1014338



### **Investigation of genetic variability of tilapia strains using microsatellite DNA markers**

---

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

Tilapia is a new promising alternative species for US aquaculture. The origin of many tilapia strains is frequently unknown or poorly documented. Nearly all aquaculture stocks supporting the expanding tilapia culture have been derived from very small founder populations and probably have low genetic variability. Investigation of tilapia genetic variability should be performed to identify distinctness of cultured strains. The main purpose of this study was to investigate the genetic variability of tilapia strains by using microsatellite DNA markers.

**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.**

Genetic variability of tilapia strains has been investigated using microsatellite DNA markers. A total, five mixed-sex and four YY-male strains were analyzed. Nine analyzed microsatellite loci showed different level of variability. Tilapia strains with low and high level of within-strain variability have been identified. The different levels of genetic differentiation between strains have been detected. A dendrogram constructed according to microsatellite data analysis revealed the existence of two distinct clusters among strains. These data showed which tilapia strains are genetically close with each other and which are genetically distant.

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

The obtained data on genetic variability of tilapia strains will help Kentucky and US farmers to choose optimal schemes of fish breeding and identify best strains for production of fast-growing interstrain hybrids.

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

The results of this study were published in a peer-reviewed journal. The obtained data will be useful for farmers, scientists and educators.

**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 results of the study on genetic variability of tilapia strains have been published in peer-reviewed journal:

Thomas, B. L., B. Gomelsky, T. A. Delomas, and N. D. Novelo. 2021. Genetic variability of Nile tilapia strains as determined by microsatellite DNA markers. *North American Journal of Aquaculture* 83:177–183. DOI: 10.1002/naaq.10181

**High-Value Horticultural Crops for Small Farms in Kentucky**

Project Director

Kirk Pomper

Organization

Kentucky State University

Accession Number

1014378



**To breed and select new superior pawpaw cultivars and advanced selections for potential cultivar release**

---

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

Improved pawpaw cultivars are needed for commercial growers. Many growers currently sell fruit collected from wild trees, or seedling trees of poor quality. Pawpaw varieties with late flowering, earlier fruiting, vigorous, high yields, and improved shipping and storage characteristics are desirable to improve profits for farmers.

**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 trial of 400 controlled crosses (Sunflower x 7-90, Sunflower x Susquehanna, 4-1 x Sunflower, and Susquehanna x Sunflower) and seedlings of superior cultivars (seedlings of Susquehanna and Shenandoah) was planted at the KSU Harold R. Benson Research and Demonstration Farm in May 2017. Controlled crosses were performed utilizing parents with high vigor, early ripening, disease resistance, high yields, and other desirable characteristics. Trees that did not survive were replaced as needed. Data were collected on growth, survival, precocious flowering, and fruiting. Pawpaw seedlings generally take 7-8

years to produce fruit. The first of these trees (3 out of 500+ planted) fruited in September 2021, only 4 years after planting. These trees were noted as exhibiting precocious fruit production, which is an excellent characteristic to have in a cultivar, or for use as future breeding material.

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

Cultivars developed from this breeding program will be made available for farmers, orchards, and nurseries in Kentucky to plant and grow in their orchard and nursery enterprises. Higher quality cultivars will lead to higher yields and premium prices, increasing profitability. Disease resistant cultivars will reduce pesticide inputs, saving growers money and protecting the environment. Precocious fruiting trees will shorten the length of time for trees to begin producing and enable producers to harvest and sell fruit ~2 years sooner, reducing the time to recoup establishment costs and begin profiting from the orchard.

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

Consumers will have access to higher quality fruit at farmers markets. Processors will have higher yielding and better quality fruits to make value added products such as pawpaw wine, beer, brandy, jam, and ice cream. Cultivars developed from this breeding program will be made available for individuals around the US to plant and grow at home, promoting greater food security by enabling people to grow their own high quality, nutritious food.

**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.**

Publications

Pomper, K.W., S.B. Crabtree, and J.D. Lowe. 2020. Pawpaw. Register of New Fruit and Nut Cultivars List 50. Editors Ksenija Gasic, John E. Preece, and David Karp. HortScience 50:30-31.

Presentations

Growing Pawpaws in Kentucky. Crabtree, Sheri B. April 8, 2021. Horticulture Webinar Series sponsored by Franklin, Woodford, Harrison, and Bourbon County Cooperative Extension offices via zoom (23 live attendees, zoom recording sent to 50 registrants)

Crabtree, Sheri B. 2020. Growing Pawpaws in Kentucky. Mountain Zoom virtual seminar series. November 2020.

Crabtree, Sheri. 2021. Starting pawpaws from seed. Presented as demonstration at Kentucky State Fair.

Crabtree, Sheri. 2021. All About Pawpaws. Zoom presentation hosted by Boone County Arboretum .

Crabtree, Sheri. 2021. Pawpaw 101. September Third Thursday Thing, September 16 at the KSU Harold R. Benson Research and Demonstration Farm.

**[Agroecological impacts of integrating small, pastured livestock into organic grain and organic vegetable cropping systems](#)**

Project Director

Shawn Lucas

Organization

Kentucky State University

Accession Number



## Agroecological impacts of integrating small, pastured livestock into organic grain and organic vegetable cropping systems

---

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

Our project examines changes in soil quality and water quality in a small ruminant based integrated crop-livestock system.

**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 replicated research plots we established an integrated crop-livestock rotation where all phases of the rotation were/are present every year of the study. The rotation is a five year rotation with the following annual phases: Year 1 - organic corn, Year 2 - organic soybean, Year 3 - Pasture with goats, Year 4 - Pasture with goats, and Year 5 - Pasture with goats. We also have control plots consisting of continuous corn>soybean and continuous pasture with no animals. The project covers one full cycle of the rotation. We were able to assess soil quality by measuring soil carbon parameters and water quality by measuring nitrogen and phosphorous content at 1m depth in ceramic tipped soil water samplers.

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

The project provides information on soil quality impacts and water quality impacts of a small ruminant based integrated crop-livestock rotation in a certified organic production system. At the time of this writing we have conducted 4 years (4 phases) of the rotation. As described above, our experimental design allowed us to nominally have each phase of the rotation present every year. Initial analysis of 2 years of water quality data (2018-2019) indicated that more nitrogen is leached from plots while under crops (maximum 19ppm) compared to plots under pasture (maximum 4ppm) while more phosphorous is leached in plots under pasture (0.8 ppm) compared to plots under crops (0.45 ppm). Neither nutrient was leached at a rate that would be considered detrimental and animals did not contribute significantly greater amounts of either nutrient. We also saw increases in labile organic carbon in the pasture treatments after four seasons of study indicating that pasture with goats may have potential to mitigate soil quality losses associated with cropping. Labile C levels after three years of pasture were similar to those in perennial pasture control plots. This information will help producers interested in integrating small ruminants into cropping system rotations.

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

The broader public benefits from these activities in that we are producing data that demonstrates that diversified systems using integrated crop-livestock rotation (incorporating small ruminants) are potentially sustainable production systems that, when managed carefully, do not pose a significant risk of nutrient pollution to groundwater from nitrogen or phosphorous. Our data also indicates that these systems maintain or build soil organic matter, which is a requirement of National Organic Program standards and is critical in maintaining soil quality and by extension delivery of ecosystem services in agricultural production systems. Healthy organic agroecosystems provide profits for producers, food, fiber and fuel for consumers.

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

In general the labor and time required to complete objective 1 have been extensive. Staff turnover over the first 4 years of the project as well as the need to renovate facilities (high tunnels) have made addressing objectives 2-5 difficult. Renovation of lab facilities from 2016-2019 and the COVID19 pandemic has also provided challenges. Access to labs at a partner institution (University of Kentucky) was limited in 2020 and 2021 due to COVID. We have addressed objective 4 (crop productivity) and objective 5 (hemp in organic rotations). Data analysis for those objectives is ongoing. 2022 is the final field season of the project and we will continue address in objectives 1, 4 and 5. Results have been disseminated through 3 presentations in 2021 as well as through submission of a peer-reviewed manuscript to *Agonomy Journal* (under review at this writing). The project has trained four graduate (M.S.) students over its duration to date. Three undergraduate students were also trained in cropping practices, data collection and laboratory analysis in 2021.



Project Director

Martin Nielsen

Organization

University of Kentucky

Accession Number

1012983



## Improved methodologies for parasite fecal egg counting and cyathostomin species identification

---

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

Increasing levels of anthelmintic resistance in equine parasites raises demands for reliable and well-validated diagnostic tools. Traditional technologies suffer from lack of precision, are highly operator-dependent, and do not allow parasite species identification.

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

In the past year, we have focused on further demonstrating the benefits of an automated egg counting system developed in our laboratory. The system is counting parasite eggs by use of image analysis and is largely independent of the operators. In one study, we demonstrated that training status of operators had a large impact on the precision of manually determined fecal egg counts, whereas counts determined by the automated system was not affected by training status. Furthermore, we evaluated the impact of sample homogenization on the performance of the automated system, and found that precision was not affected, but a positive effect on accuracy was observed. In a separate study, we provided proof-of-concept for the ability of this system to determine parasite fecal egg counts in ruminants. Finally, we published our first paper describing a DNA metabarcoding assay capable of identifying and describing cyathostomin species composition in samples from horses with natural, mixed species infections.

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

Our target audience is equine veterinarians and owners and managers of horses. The aforementioned automated egg counting system has been made commercially available for veterinarians, and the data generated in the past year has helped demonstrate the robustness of the system. This, in turn, will benefit the horse owners and managers as well. The DNA barcoding assay is a research tool at this stage, but will allow much more detailed information to be generated about equine cyathostomin parasites on a species level. This information, again, is of great benefit to our target audience.

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

Increased animal welfare is in the general public's interest. By offering these novel diagnostic technologies, we enable better parasite management and less reliance on chemotherapy, which, in turn, reduces further development of drug-resistant organisms.

### **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 results were published in well-respected peer reviewed scientific journals (see references below). Furthermore

Cain, J.L., Peters, K.T., Suri, P., Roher, A., Rutledge, M.H., Nielsen, M.K. The effect of analyst training on fecal egg counting variability. *Parasitology Research* 2021, 120, 1363-1370. DOI: 10.1007/s00436-021-07074-2.

Nielsen, M.K., Doran, D., Slusarewicz, P. Effects of sample homogenizing on the performance of an automated strongylid egg counting system. *Veterinary Parasitology* 2021, 300, 109623. DOI: 10.1016/j.vetpar.2021.109623.

Poissant, J., Gavriluc, S., Bellaw, J., Redman, E.M., Avramenko, R.W., Robinson, D., Workentine, M.L., Shury, T.K, Jenkins, E.J., McLoughlin, P.D., Nielsen, M.K., Gilleard, J.S. A repeatable and quantitative DNA metabarcoding assay to characterize mixed strongyle infections in horses. *International Journal for Parasitology* 2021, 51, 183–192. DOI: 10.1016/j.ijpara.2020.09.003.

Slusarewicz, P., Slusarewicz, J.H., Nielsen, M.K. Development and performance of an automated fecal egg count system for small ruminant strongylids. *Veterinary Parasitology* 2021, 295, 109442. DOI: 10.1016/j.vetpar.2021.109442.

**Conference abstracts:**

Cain, J., Peters, K., Suri, P., Roher, A., Rutledge, M., Nielsen, M.K. Too cool for school: How analyst training affects fecal egg count variability. American Association of Veterinary Parasitologists, 66th Annual Meeting, June 19-22, 2021, p. 71.

Slusarewicz, P., Slusarewicz, J., Nielsen, M.K. Assessment of an automated fecal egg count system for small ruminants. American Association of Veterinary Parasitologists, 66th Annual Meeting, June 19-22, 2021, pp. 71-72.

Critical Issue

## Economic and Financial Well-Being

---

### [Sustainable Practices, Economic Contributions, Consumer Behavior, and Labor Management in the U.S. Environmental Horticulture Industry](#)

Project Director

Shuoli Zhao

Organization

University of Kentucky

Accession Number

1025365



### **Understanding the influence of beginning farmer race and gender on direct consumer behavior**

---

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

Agricultural participation in the U.S. is facing the problem of aging and lack of diversity, we examine if farmers' gender and racial background affects consumers' willingness to support beginning farmers and their preferences for agricultural products produced by socially disadvantaged farmers.

**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 evaluate whether a beginning farmers' gender and racial background affect the market value of agricultural products and consumer's monetary and time/effort support in a donation setting. We conducted an incentivized online experiment with 1,539 participants where we exogenously manipulated the race (i.e. White, Hispanic, and Black) and gender (i.e. male and female) of the beginning farmers' food label in separate between-subject treatments. We then estimated the treatment effects on willingness-to-pay, monetary allocation, and effort/time allocation to support beginning farmers. Our results provide evidence of discrimination primarily against Hispanic, Black, and female beginning farmers given market discrimination for their products, fewer monetary donations, or less effort exerted to support them. We further conduct a sub-sample analysis by gender and race to explore the potential source of discrimination and find evidence of treatment effects on discrimination by specific gender and racial groups.

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

The target audience of this study includes policymakers, consumers, marketers of private sectors, and extension specialists. The results of this study highlight the importance of creating educational programs and policy interventions that support minority and disadvantaged farmers, in particular Hispanic female beginning farmers.

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

With the insights from consumer perception, this study could provide information that helps shape the direction of optimal design on the policy support and marketing efforts that support socially disadvantaged farmers and beginning farmers.

**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 results were presented at 1) the 2021 American Agricultural Economics Association Annual Meeting, 2) the 2021 National Agricultural Marketing Summit, and will be presented at the 2022 Southern Agricultural Economics Association Meeting. Generate two manuscripts for publication in peer-reviewed journals, one focuses on the consumer support for beginning farmers, and another aims at the consumer perception toward farmers of different gender and racial backgrounds.

## **The Impact of Investing in Critical Infrastructure on Rural Economic Development**

Project Director

Alison Davis

Organization

University of Kentucky

Accession Number

1024125



## **The Impact of Investing in Critical Infrastructure on Rural Economic Development**

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

This project addresses a significant concern rural communities are facing: an underinvestment in critical infrastructure necessary to sustain a local economy. As rural communities experience population decline and industry loss, the decline in the economic base makes it increasingly more challenging to invest in new and updated infrastructure. For the purposes of this project we measure “infrastructure” as the necessary foundation for a healthy workforce and robust local economy. Specifically, we explore the relationship between water/wastewater, broadband, and healthcare as infrastructure components of a functioning rural community.

**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.**

Water and Wastewater project – We collected and mapped small water systems in the south. We then overlaid these maps with communities of persistent poverty and communities of color to determine if there was a correlation between underfunded water systems and poverty. In addition, we completed qualitative research to better understand how significant issues, like the deep freeze in Texas, affected small rural communities. This initial exploration is the first step to better understanding if and how communities of color are facing more significant infrastructure issues.

Healthcare project – We reviewed all recent publications related to the nexus of rural healthcare and local economies with a particular emphasis on COVID-19. We summarized these results and these are currently under peer review. We also explored how the use of telehealth impacted a hospital’s cost structure in rural places. This publication is also under peer review.

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

Water project - Persistent poverty communities and communities of color are our targeted audience. By bringing this lack of investment to light and sharing research with policy makers, particularly while there is a significant infrastructure bill in place, we hope that additional infrastructure investment will be targeted for these communities.

Healthcare project – We have defined hospitals, health care providers, and rural communities as our target audience. We have equipped our audience with research about the economic importance of their industry and provided training about how to communicate their value to the local, state, and federal stakeholders.

We also provided county data profiles for all counties in Kentucky related to the local economy, healthcare, workforce, agriculture, housing, etc.

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

As each year passes it becomes exponentially more expensive to repair water systems. The longer a community waits, the more challenging it will be to make necessary repairs. By addressing this issue now, we hope that the increases in water rates can be minimized as well as a decreasing number of water quality violations.

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

We did not participate in any training opportunities, but we did provide them for rural healthcare providers across the country. We disseminated results through a series of webinars and policy briefs (currently under review). In addition, we have one manuscript under review.

Brian Whitacre and Alison Davis, Higher Electronic Health Record (EHR) Functionality Lowers Urban – But Not Rural – Hospital Operating Costs submitted to Health Economics, under review

**Understanding rural economic dynamics in Appalachian Kentucky: rural livelihood strategies and access to productive resources**

Project Director

Karen Rignall

Organization

University of Kentucky

Accession Number

1012499



**Improving Community and Policymaker Understanding of Rural Socio-Economic Dynamics through Community Engaged Research**

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

The project entitled Understanding rural economic dynamics in eastern Kentucky: rural livelihood strategies and access to productive resources examines access to productive resources and rural economic dynamics in Eastern Kentucky at the household and community levels. Using close partnerships with cooperative extension, the public school system, and community partners in Eastern Kentucky, especially Martin County, the project has used qualitative, engaged-research strategies to involve residents from diverse groups in reflecting on and addressing the challenges of economic and energy transition in Kentucky, with a focus on land ownership patterns and land use change. A parallel track, conducted in partnership with Dr. Julie Zimmerman, analyzed rural prices throughout the commonwealth to determine how the cost of living in rural areas compares to urban settings.

**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.**

As an engaged research project that uses anthropological, field-based methods to work intensively with communities, this project evolves according to the needs, priorities, and circumstances of project partners and also produces more qualitative insights than broad-based quantitative results. Activities were as follows:

**Appalachian land ownership and energy/economic transition:**

1. Data analysis and writing of co-authored assessment of project's progress (listed below in publications in press)
2. Developed community engagement proposal for renewable energy company installing utility scale solar panels on reclaimed surface mine (as part of land study's engagement with community-based economic and energy transition efforts)

3. Conducted a survey with 152 respondents on Martin County resident priorities for development, questions, and concerns about the proposed solar project
4. Held virtual town hall for Martin County residents to present the results of the community survey and further disseminated results via the Mountain Citizen newspaper (the Martin County newspaper), a dedicated facebook group for the solar project community engagement efforts, and press coverage, such as an NPR print/audio story
5. Continuing discussions with the solar energy company on institutionalizing a community engagement strategy
6. Instituted a partnership with the Nunn Center for Oral History at the University of Kentucky and, working with an AppalachiaCorps intern, developed a website to house the oral histories collected as part of the Stories of Place project (an effort to document people's connection to and understanding of the land as part of the land ownership study)
7. Worked with two field-research interns (young people from Martin County) to collect 10 oral histories over the summer of 2021, to be housed on the website noted above.
8. Developed a partnership with Higher Ground Theater to offer an in-class module at the Martin County High School with the objective of engaging young people in the process of researching and storytelling about their relationship to the land (module to be delivered in March 2022)
1. Article summarizing and analyzing results of our survey of rural prices in eight Kentucky counties submitted to the flagship journal, Rural Sociology (under review)

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

Martin County residents (and land study participants) benefited by receiving greater access to information about a large scale renewable energy project and by offering their perspectives and questions through a broad-based community engagement strategy that I and regional partners spearheaded. Residents, students, and other young people also benefited from greater social connection, new technology and research skills, and an introduction to public humanities methodologies for community development. Benefits from the Rural Price Project are outlined below.

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

Appalachian land ownership and energy/economic transition: Eastern Kentuckians and Kentuckians in general have benefited from the conduct and publication of a survey of county residents' attitudes about and priorities for a proposed utility scale solar plant in the county and for the economic development possibilities associated with the installation. This creates a model for community feedback and engagement in energy transition efforts, highlighting the importance of broad public input in new initiatives. Central Appalachians also benefit from the development of a curriculum and web platform that uses public humanities (oral history, storytelling methodologies) to foster community-based dialogue about communities' pasts and visions for the future. Efforts to disseminate these approaches regionally are in development with extension faculty at the University of Kentucky.

Rural price project: Policymakers, researchers, and extension agents benefit from understanding the specific burdens and challenges residents of rural Kentucky face in meeting their basic needs. The insight that it is not necessarily cheaper, and in many cases is substantially more expensive, to live in rural areas can support the development of policy and strategies for program implementation at the county level. Family and Consumer Sciences extension agents and county-based groups (homemakers, in particular) have used these data to inform their approaches.

**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.

Training and professional development opportunities include:

1. I offered intensive, two-month long, experiential training to two field-based research interns in Martin County, one a graduating senior from the University of Kentucky and the other a graduating senior from Martin County High School.
2. I and the AppalachiaCorps web development intern received training on the University of Kentucky Nunn Center for Oral History's digital indexing and archiving system to be embedded in our Stories of Place Martin County website.

Results have been disseminated in the following ways:

1. Two journal articles and two book chapters, all in press or under review
2. In-class module in the Martin County High School junior English classroom
3. Two articles in the Mountain Citizen newspaper, the local newspaper for Martin County
4. Virtual town hall attended by nearly 40 people (September 2021)

The COVID-19 pandemic delayed project activities in each area of activity but a turn to virtual forums and flexibility in scheduling allowed me to fulfill most project objectives. The exception is the Rural Price Project's efforts to report back the results of our empirical research and conduct focus groups on study participants' experience of rural economic changes, especially price variations in the consumer products and services they require. We anticipate conducting this research in 2022.

Peer-Reviewed Publications:

[In press] K. Rignall, L. Shade, C. Starr, and L. Tarus. "The Role of Land in a Just Transition." In *The Quest for a Just Transition: Reports from the Field*. S. L. Scott and K. Engle, eds. Lexington: University Press of Kentucky.

[Under review] Zimmerman, J., K. Rignall, and C. McAlister. "The Enduring Price of Place: Revisiting the Rural Cost of Living." *Rural Sociology*.

[Under review] Rignall, K. "Nurturing Civic Space through Stories of Place: Place-based Learning in Central Appalachia as Public Humanities." In *Public-Facing Humanities: Diverse Methodologies, Issues of Enduring Concern*. J. Cohen and M. Todd (eds). Iowa City: University of Iowa Press (edited volume under review, delayed because of the pandemic).

Critical Issue

## Food Safety and Security

### Optimization of Analysis of Hemp Cannabinoids Using High-Performance Thin Layer Chromatography (HPTLC)

Project Director

Avinash Tope

Organization

Kentucky State University

Accession Number

1022048



Preliminary activities

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

The 2018 Farm Bill removed hemp from Schedule I status with respect to the Controlled Substance Act, and set requirements for levels of chemical components. Hemp growers need a rapid, high-throughput analytical system for quantification of the most abundant cannabinoids, especially, Delta-9 tetrahydrocannabinol, occurring in their hemp to comply with these requirements. This collaborative research project is designed to optimize and validate a high-performance thin-layer chromatography (HPTLC) technique to meet this need.

**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.**

Using reference standards, we optimized the solvent system for separation of various cannabinoids and established their respective Rf values. (Compounds can be identified based on their Rf value). Resolution and Rf for various sample volumes and concentrations of cannabinoid references were obtained to determine limits of detection (LOD).

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

This HPTLC technique, when established, will be a much less expensive, faster, and equally precise alternative to those methods of analysis currently in use by hemp growers and processors.

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

Adoption of this technique by various labs will help the consumer of cannabinoids to have safer, less expensive, and fully compliant products available for their use.

**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 fact sheet was disseminated to the lay public: Patel, S.V, Tope, A.M., Cannabidiol (CBD) supplements: Are we there yet? KSU Cooperative Extension Publications, Dec 2020.

During the next reporting period, we plan to select solvents and determine Rf values, LOD and calibration curves for other cannabinoid references such as THCA, CBG, CBGA and CBDA. Different hemp samples from KSU's Organic Hemp farm will be analyzed for quality and quantitative purposes.

Changes/Problems: The research work paused in January 2021 due to relocation of labs to the new Atwood facility and resumed in March 2021.

## **Development of New Luminescence Methods to Measure Hydroperoxides in Foods**

Project Director

William Boatright

Organization

University of Kentucky

Accession Number

1020731



## **Development of New Luminescence Method to Measure Peroxide Value for Use in the Food Industry**

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

Edible fats and oils exhibit inherent susceptibility to oxidation leading to rancidity. Throughout the food industry, from the edible oil refinery to foodservice and retail food processors, fats and oils must be continually tested to meet product and quality specifications. The industry standard for measuring levels of oxidation in edible fats and oils is the peroxide value (PV). The current American Oil Chemists' Society (AOCS Cd 8b-90) method for PV is an iodometric titration that requires

laboratory glassware, the use of flammable and toxic solvents that are expensive to purchase and dispose after use, takes about 15 minutes to conduct, suffers from lack of sensitivity and poor endpoint determination and requires trained personnel. The food industry would benefit from a faster and more convenient method to measure PV.

**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.**

These research activities have contributed to the invention and improvement of a materials that emit luminescence in the visible region of the electromagnetic spectrum, and the level of light emission is proportional to the hydroperoxide content of edible oils. The use of the luminophore sensor method to measure PV can be conducted in about 3 minutes at about half the cost, ; the sample vial is disposable. The research and development of this new type of sensor material has required several research cycles that involved a broad range of analytical instrumentation (described in the project details), interpretation of results, development of new novel hypotheses, and the repeated implementation of findings into the design of improved PV sensor materials.

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

The increasingly stringent food processing and safety norms have led to tighter control over testing the quality and content of processed and packaged food, where oxidative stress detection is widely used. The continued demand from the food industry will likely be strongest from North America and Western Europe, where food and safety norms are much more stringent. The global oxidative stress detection market is expected to grow at a compound annual growth rate (CAGR) of 9.28%. The stagnation of technological advances in recent decades, the high cost of instruments, labor, reagents and a dearth of trained manpower for new and emerging technologies are the major factors restraining the growth of this market. The use of novel metal-phosphate luminophore sensors for PV assays provides improved accuracy, cost and time savings and the elimination of toxic and flammable waste. Also, there is a relatively low cost for the hand-held luminometer and this technique can be performed by minimally-trained personnel.

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

Implementation of the metal-phosphate luminophore sensor technology will enhance the sustainability of natural resources and reduce the flow of toxic and hazardous waste into landfills and waste disposal systems. Improved monitoring of oxidative conditions of important agricultural commodities with a more convenient and less expensive technique will also help improve the efficient use of important natural resources.

**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.**

Product performance and methodology was shared directly with food manufactures, leading agricultural commodity companies, trade organizations and the manufactures of analytical instrumentation. Intellectual property that was (in part) developed during this project was published with the US Patent Office.

Closing Out (end date 09/07/2023)

**Enhancing Microbial Food Safety by Risk Analysis**

Project Director

M Newman

Organization

University of Kentucky

Accession Number

1017985



**Science based intervention to mitigate pathogen contamination of produce**

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



Fresh produce is one of the most common sources of food-borne outbreaks, involving various pathogenic microorganisms such as *Escherichia coli*. Recent outbreaks have clearly shown that post-harvest washing has limited effectiveness on decontaminating produce and may contribute to cross-contamination of produce. Bacteriophages have the ability to selectively eliminate pathogenic bacteria. Bacteriophages of bovine origin can be utilized against the pathogens as a treatment during produce processing.

**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 research focused on utilizing bacteriophages, which are viruses that specifically infect and kill bacterial pathogens such as *E. coli* O157:H7 to control pathogens on produce during washing.

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

Dunk/dip/immersion tank washing for produce is one of the most high-risk practices requiring investigation in the produce industry. Several foodborne outbreaks related to fresh produce have been traced back to improper post-harvest handling. Thus, poor wash water quality and improper sanitation may serve as a vector for contaminating produce when washed in dunk tanks. For this reason, bacteriophages are a promising antimicrobial for use in the food system as an effective bio-preservative, especially in ready-to-eat produce such as spinach, lettuce, and other leafy greens. Due to their ability to act as a natural antimicrobial, they can be integrated as a part of a multi-level sanitation process with commercially used sanitizers to eliminate pathogens of concern

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

Utilizing specific bacteriophage cocktails in concert with traditional chemical sanitizers should improve the microbiological safety of leafy greens for the consumer.

**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 disseminated via publications and participation in Multistate meeting. Plans for the next period is just to continue investigating the use of bacteriophage in produce.

1. Badrinath Vengarai Jagannathan, Steven Kitchens, Paul Priyesh Vijayakumar, Stuart Price and Melissa Morgan. Efficacy of Bacteriophage Cocktail to Control *E. coli* O157:H7 Contamination on Baby Spinach Leaves in the Presence or Absence of Organic Load. *Microorganisms* 2021, 9(3), 544; <https://doi.org/10.3390/microorganisms9030544>
2. Badrinath Vengarai Jagannathan, Steven Kitchens, Paul Priyesh Vijayakumar, Stuart Price and Melissa Morgan. Potential for Bacteriophage Cocktail to Complement Commercial Sanitizer Use on Produce against *Escherichia coli* O157:H7. *Microorganisms* 2020, 8(9), 1316; <https://doi.org/10.3390/microorganisms8091316> Patents and Plant Variety Protections filed

Critical Issue

## Life Skill Development

### Life Skills Development

Project Director

Allison Young

Organization

Kentucky State University

Accession Number

7002530



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

Recent research puts coding at the forefront of future careers. By the end of 2019, 2.4 million STEM jobs were projected to go unfilled. Between 2017 and 2027, the number of STEM jobs will grow 13%, compared to 9 percent for non-STEM jobs- with positions in computing, engineering, and advanced manufacturing leading the way

**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.**

Currently Only 35% of all high school grads are ready to take college-level science courses, 74% of middle school girls express interest rest in STEM but only 0.3% choose computer science as a major, and African-American and Latino workers also now represent 29% of the general workforce population but just 16% of the advanced manufacturing workforce, 15 percent of the computing workforce and 12 percent of the engineering workforce. As a result of these factors as well as others there is a need for coding programs for students.

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

Kentucky State University 4-H Jefferson Co. partnered with Guttermuth Elementary school to offer Coding with Ozobots to their Kindergarten team of 3 classes serving 75 students from 6 different nationalities for 6 weeks. Coding with Ozobots helps kids learn brand new, in-depth experiences by using an Ozobot (small robot) to encourage students to be creative with visual coding with lines and colors they can touch. Using The Coding with Ozobots program, kids were able to collaboratively build skills they can apply in the real world, get comfortable with introduction to coding, innovative problem solving and interactive exploration using a tiny robot. Through the 6 weeks students were able to learn through research based hands on activities that allowed them to learn coding in a fun way.

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

As a result of the Coding program at Guttermuth students were able to learn: computational skills, problem-solving skills, career opportunities in coding, creativity, and improved math skills. Students through pictures evaluated the program and made several comments on how they loved working with the Ozobots, learning how to code and writing codes using markers. Teachers assisting with the program stated that they noticed serious growth in the kids especially the students who had been struggling in reading, math, or struggling with behavior problems but excelled in the Coding with Ozobots program and would like for it continues for the rest of the year. Kentucky State University 4-h will continue its partnership with Guttermuth Elementary.

Critical Issue

## Nutrition and Healthy Lifestyles

### Nutrition and Healthy Lifestyles

Project Director

Allison Young

Organization

Kentucky State University

Accession Number

7002531



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

According to the Center for Disease Control (CDC) more than 1 in 4 Americans ages 50 and older get no exercise beyond their normal daily routine and Kentuckians get the second-least amount of exercise in the nation. Regular exercise is vital for healthy aging. It can reduce or delay many chronic diseases faced by adults age 50 and older. These include stroke, heart disease, arthritis and some types of cancer. Thirty minutes of physical activity is recommended, however, getting any amount offers some health benefits

**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 an effort to increase the amount of exercise along with the benefits of healthy food choices the SNAP (Supplemental Nutrition Assistance Program) Education Assistant in Anderson County KY provided a Nutrition and Exercise Program at the Public Library. The participants learned healthy eating choices using My Plate as a guideline and also learned the importance of being physically active. A chair based exercise class including strengthening exercise was offered.

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

In a follow up visit with one of the class participants the SNAP Education Assistant learned that before the class, exercise was not a part of this fifty three year old ladies life. After the class she stated that she started out walking around her house, as she grew stronger she walked around the block and today she is working out most days with a group of ladies at a local gym and has lost over forty pounds. She credits the Library class with getting her on the right path.

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

Teaching people that an exercise program can be started at any age and fitness level will lead to a happier healthy life.



**SNAP-Ed assist with Shepherd's Shelter Victory Garden**

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

When the pandemic hit in 2020 the Governor challenged Kentucky Extension and Nutrition Education Program to help promote Victory Gardens in Kentucky. Victory Gardens were started during the World Wars to help decrease the effect of food rations and increase fresh food supply. During the pandemic uncertainty of how long the shutdown was going to be, many started hoarding food and supplies leading to a shortage (4).

**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.**

Shepherd Shelter Treatment Center in Mount Sterling was way ahead of the game, since the SNAP-Ed Nutrition Program at Kentucky State University had helped them implement a garden in 2018, and it continues to expand each year with the assistance of the SNAP-Ed program. Shepherd's Shelter is an all-male Rehabilitation Center that started out as a homeless shelter, but soon realized the increase in the homeless population was due to the increase of drug and alcohol addiction (3). Kentucky is one of 4 states in the Appalachia region with the highest rate of opioid misuse and overdose deaths than other parts of the country (5). Proper nutrition and hydration are key to the substance abuse healing process because they help restore physical and mental health and improve the chance of recovery (1). Life skills is one important training a person in recovery needs to be successful in their recovery efforts and return to society, Shepherd Shelter has partnered with Montgomery County KSU SNAP-Ed Program since it began offering the "Healthy Choice for Everybody" classes in 2017 to offer lessons on life skills and nutrition. The Classes are research-tested direct education intervention that teaches planning nutritious meals on limited budgets, safe food-handling practices, food preparation skills needed for a healthy lifestyle and adopting a physically active lifestyle (6). Gardening is another skill that helps those recovering success, gardening and recovery go hand

in hand, gardening helps improve the diet which has been neglected during the addiction, and gardening is way the recovering addict can get more exercise, relief stress, decrease blood pressure, depression and anxiety and boost the immune system (2). Shepherd's Shelter wanted to continue this partnership during the pandemic, so classes continued virtually.

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

The SNAP-Ed Program Assistant would drop off supplies needed for the garden at the door to the facility and offer advice over the phone. The garden started off in 2018 at 30' X 40' and has expanded to 40' X 70' in 2021. During the pandemic the facility had approximately 20 males in recovery. It was the guys' responsibility to care for the garden which included planting, maintaining the plants to yield produce and harvesting the fruits and vegetables. They also learned from the SNAP-Ed weekly program, the importance of consuming fruits and vegetables into their daily meals and to follow MyPlate recommendations for their calorie intake.

The picture below shows the guys cutting fresh strawberries to use in the smoothie recipe shared with them in class. The produce from the garden is used in the meals at the facility prepared by guys in recovery. In addition to the strawberries, onions, green beans, corn, peppers, tomatoes, pumpkin, watermelon, cantaloupe and cucumbers are some of the produce grown at the facility along with some fruit trees that have been planted. Graduates of the "Healthy Choice for Everybody" classes showed improvement in one or more diet quality of eating fruits, vegetables, red and orange vegetables, dark green vegetable, drinking less regular soda, drinking less fruit punch and teas, as well as improvement with physical activity.

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

Growing a garden can help with budgeting, reducing salt and sugar in the daily diets, eating lower calories, increases outdoor exercise, increase vitamin D, and be a natural stress reliever. During the summer of 2020, twelve guys at Shepherd's Shelter graduated from the classes and gained knowledge on gardening. These twelve men will be able to continue to make changes to improve their overall health. They will be able to take their knowledge gained from the SNAP-Ed program back into their individual homes once leaving the recovery center and have knowledge on how to plant their own Victory Garden. SNAP-Ed plans to continue to offer classes and gardening advice to the next group of men at the Shelter.

Critical Issue

## Small Farm Development

Closing Out (end date 09/07/2023)

### Virtual Safety Week

Project Director

Kenneth Jones

Organization

University of Kentucky

Accession Number

7002125



### Nothing Significant to Report

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

No additional information

## Developing Decision Support Systems (DSS) for Agroecosystems Management and Sustainability

Project Director

Buddhi Gyawali



## **Developing Decision Support Systems (DSS) for Agroecosystems Management and Sustainability**

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

This project aims at increasing access to existing geospatial data and applied technology for efficient, optimum, and sustainable management of agroecosystems. Primarily the project evaluates the relative vulnerability of agroecosystem health and production capacity and tracks changes in soil, land cover, and biomass. A major part of the project seeks to provide an improved understanding of the conditions faced by our farmers and other land managers and to provide a means for everyone to quickly access the data and associated knowledge using the tools available to them.

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

Major activities of this grant include a wide range of research and outreach activities, each designed to help achieve the stated objectives. Development of an integrated geospatial database and mapping system is being continued. This effort leads to the compilation of various sets of spatial and non-spatial information for assisting farmers and land managers to improve farm operation strategies for greater farm returns and environmental stewardship from the managed activities. Independent measures of total agricultural production amounts, produce qualities, and yields are then modelled using accessible, and interpretable, statistical methods and repurposed for planning strategy and forecasting outcomes in the current context.

Newly integrated during this reporting period is the crop classification and extent mapping using USDA NASS Crop Layer system data. Knowing where the crops are is the first step to understanding the conditions and practices implemented for the land dedicated to farm production. Also new is the gSURRGO soil data and associated bio-physical definition tables with known attribute values. The crop layer data is used to pin and label our observations and make it possible to then evaluate the gSURRGO soil attribute information to describe the existing conditions for the site. Soil attribute information is extensive and covers, among others, the amount of organic carbon in the soil, moisture availability and storage capacity, thickness of specific soil layers, and constituent component materials. We also couple official survey data on reported productivities and values with the knowledge of the spatial correlation of soil resources and the distribution of crop-specific management strategies.

Under the Objective One and Two, during the reporting period, we continued to incorporate additional Lidar (light detection and ranging) data, including aerial based data distributed by the state, as well as, drone based data collected in ultra-high resolution and detail. This data continue to be utilized for comparisons in elevations of topographic and vegetation canopies, in a spatially and temporally explicit manner. This approach has enabled us to monitor and quantify the short term volumetric erosion of the landscape and the changes in vertical canopy structure over time. Capturing these quantities has enabled the systematic assessment of various individual management or mitigation techniques used to control the landscape. Particular strategies aimed at combating erosion, for example, that use controlled deposition of soil behind individual drainage dikes has been assessed on reclaimed mine sites throughout the state. Similar activities are quantifying the changing structure of the tree canopy, particularly protected areas facing increased density of invasive species dominating the understory growth and limiting diversity.

Under objective 3, development of practical web-based decision support system, we have continued a high level of outreach in effort to promote familiarity of the technology and to demonstrate the capacity of data based approaches for enhancing the parts of the management strategies that make sense. The project implemented several trainings with a particular focus on the fundamentals of integrating current drone-based sensor and Lidar driven approaches to problems on-farm and in-forest. The major programming from efforts under objective 3, has yielded several collaborative projects including base mapping of farmland and forestry resources. The demonstrations and outreach activities have provided opportunities for farmland managers to gain more understanding of how management decisions can ultimately manifest given the conditions of environmental degradation, soil erosion and vegetation distribution, change in market value. The project team is now better able to understand how the each constituencies are likely and able to make use of the data for operational decision making.

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

Activities under Objective 1 and 2, the development of an integrated geospatial database and other systems, aim to provide the information useful for land managers and farmers. The construction of a geographic database informs all managers on climatological parameters dictating temperature and precipitation patterns as well as the bio-physical constraints imposed by prevailing topographic and hydrological conditions. During the reporting period, we continued to take on a wide range of comprehensive mapping projects, each with a focus on providing useful products to a smaller subset than the whole of the land management community. Implemented outreach activities have put the technology directly in the hands of the farmers and forest managers through demonstrations and hands-on training opportunities that have led to new collaborations. Promising examples that directly impact targeted land managers include drone-based characterization of specific areas of the KSU Research and Demonstration Farm to map the distribution of browsing stock, as well as, changes to the distribution as a function of the various rotational browsing strategies employed by the managers. Related, a project on the farm involves the use of photogrammetry versus lidar derived terrain models to measure the direct impact of livestock traffic management strategies in terms of changes in erosional patterns over short term. Two graduate thesis projects were completed during the reporting period and were submitted for publication to share with the community of science: (1) Soil Loss Analysis of an Eastern Kentucky Watershed Utilizing the Universal Soil Loss Equation and (2) Estimation of runoff and sediment yield in response to temporal land cover change using the soil and water assessment tool (SWAT) in Kentucky.

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

The project accomplishments during the reporting period speak to the ability to scale broad level generalizations about land management decision support systems down to the individual field or plot level to have a significant impact on livelihoods. Much of that work involves the integration of publicly available or obtainable satellite and aerial imagery and other spatial data into process-based modeling to assist land managers in the assessments and forecasting of productivity outcomes given various management strategies and activities. Multiscale analysis fills in the gaps between datasets collected for specific scientific purposes and those that are accessible and available to small farmers and other land managers. Many of the activities implemented under grant Objectives 1 and 2 have contributed to an ability to quickly ascertain, for any land area in Kentucky, the precise mix of environmental properties and the associated bio-physical qualities that drive the conditions dictating the management strategies available to our farmers and other land managers. This information is continuously discussed publically via presentations and documentation and is expected to benefit farmers and land managers.

In addition, Earth observation systems are recognized as an important element in the scaling of next-generation land management decision support systems and serve as a bridge between the use of disruptive technology, conservation of land resources, and the sustainable practice of agriculture and forestry in the region. In addition to the land managers, our programming has delivered to the up and coming workforce, the future scientists, researchers, and field agents currently in high school. We have collaborated on many STEM-based learning for virtual and in-person programs coordinated by colleagues across KSU including presentations and skill development workshops in environmental monitoring for Earth Day 2021 and several youth summer programs including 4-H Ignite, Summer Transportation Institute, Ag Discovery, and Summer Apprenticeship Program, Kentucky Academy of Science, Southern Rural Sociological Society meetings and other events. Other integrated activities centered on technology demonstrations and skill development for youth learners included the 4-H Open House, KSU Farm Field Day, Small Farmers Conference, and multiple Third Thursday events at Kentucky State University.

**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.**

Additional opportunities generated for project team members consisted of a range of activities design to provide participants with the knowledge, hard, and soft skills needed to successfully complete planned activities. Given the condition of COVID-19 impacts, this reporting period has provided opportunities for the public, including, land managers, staff, and students to gain familiarity with the geospatial technology and to advance skill sets in pursuit of mastery of the technology. As part of trainings detailed in the section above, the approximate reach of each program to number of participants: Earth Day (30), Summer Apprenticeship Program (25), STI (20), AgDiscovery (25), Extension Drone Workshops (20), Third Thursday (50), KSU Farm Field Day (20), 4H-Ignite (24). The Drone Workshops also provided assistance for multiple research staff to pursue licensure under the Part 107 Certification in order to take on the drone-based data collection at farm and forest areas under investigation by the project.

Public dissemination of results was not as extensive as years past due to the restrictions on travel imposed by the pandemic mitigation measures during much of this reporting period. Presentations detailing student works were presented at the Kentucky Academy of Sciences and received an award as best student project in category. Project outcomes and other details

are also expressed at all of the above referenced events featuring public audiences, all in an effort to continue the dialog between stakeholders, the staff dedicated to serving them, and project team members.

During the next reporting period, we intend to accomplish all activities related to the project objectives. We expect to have at least two manuscripts for submission and four presentations for societal presentations. Additional outreach and Extension publications will be made in the KSU's Third Thursday events and Small Farms conferences.

## Small Farm Development

Project Director

Allison Young

Organization

Kentucky State University

Accession Number

7002597



### Teaching farmers how to do Fecal Floatation Tests and Fecal Egg Counts

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

The largest challenge for small ruminant producers in the southeastern United States are parasites. Parasites by far cause the most production losses for farmers. Farmers need to be able to identify which animals are infected and the parasite they may have. This becomes essential in their treatment plans. Most veterinary clinics will perform fecal floatation testing. This will cost farmers approximately 18-25\$ per sample. In livestock production the profit margin is low and this expense may quickly add up.

**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.**

Kentucky State University host many educational programs that help farmers understand the latest information on internal parasites. FAMACHA trainings are held which is a system that uses mucous membrane color to estimate an animal's burden of Haemonchus species. This method is easy for farmers and can be done without any equipment, however, it cannot detect other parasites. Fecal floatations are diagnostic tests that examine fecal material for worm eggs or protozoal oocytes. This method of testing is much more sensitive and can detect many different types of parasites. Kentucky State Animal Health program teaches hands-on wet labs in which farmers are able to learn how to do fecals themselves. Multiple training has been hosted in multiple locations, including Franklin, Lincoln, Boyle, Mercer, Grant, and Pulaski. These trainings were hosted by local extension offices, producer associations, and other groups of farmers.

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

Many small ruminant producers in Kentucky have been able to buy microscopes and begin doing fecals on their own farm. The cost of the microscopes will vary depending on technology, capabilities and new vs used. A binocular compound microscope can be purchased for 100-200\$ in most cases and is a one-time fixed cost. Supplies used during samples will cost about 40\$ for every 100 samples (40 cents per sample).

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

This allows farmers that implement fecals on their farms to save money on the fecal exams, as well as monitor their animals more closely and treat them correctly. This increases animal health and welfare as well as decreases losses to improve the sustainability of small farms in Kentucky.



### Teaching small ruminant production to new farmers

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

Kentucky State offers a variety of programs to help small and beginning livestock farmers. These programs range from educational presentations, hands-on workshops, small ruminant herd appraisals, funding opportunities/grants, and email or phone consultations or on farm consultations.

**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.**

Sometimes situation arises when farmers may not be prepared for new technologies. Often time produces require one on one technical assistance to help with the transfer of knowledge. One producer reach out to the Kentucky State University's Animal Health Specialist to address a variety of problems from predators, to breeding management, death and illnesses and parasites, In 2017, out of a total of 112 goats (adults and kids), he had a death loss of 22%, reproductive losses and poor growth rates and 14 of 23 kids produced died.

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

Kentucky State University's Animal Health Specialist, made an onsite farm visits to assess what areas of management needed improvement for new and beginning small ruminant farmers. Education and guidance was provided on areas that could help the producers production. Topics on facility management (fencing, feeders, shelter, and predator protection), nutrition of the herd, and health were addressed. Once these areas were under control, the farmer was able to set up a breeding program. The producer also attended workshops on how to identify and treat parasites, Third Thursday, Fort Harrod goat association educational meetings and followed up with several consultations throughout 2017-2019.

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

The producer has increased his herd size of breeding does, his animals are in overall better health and higher producing. In 2018 he only lost 10 of 58 kids born and in 2019 his losses were down even more to only 6 deaths of 79 kids, (compared to 2017, death loss 14 of 23). His farm has become more profitable and his farm more sustainable. The producer has also recently been awarded a small-scale farm grant for 5,000 dollars in agroforestry to expand his goat production and maintain forest on his farm. We will continue to stay in touch with Mr. Long as well as other small farms throughout the state to be an educational resource to improve animal health and sustainability of small farms.

Type	Projects / Programs
<b>Projects / Programs without a Critical Issue</b>	<b>1</b>

**Dissecting defense signaling pathways in Soybean (*Glycine max*) and *Arabidopsis thaliana***

Project Director

Aardra Kachroo

Organization

University of Kentucky

Accession Number

1014539



**Generating broad-spectrum crop resistance without significantly impacting growth, development, and agricultural yields**

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

Plant diseases have major negative impacts on crop plants produced for food, feed, and fiber. Current disease management strategies involving the use of genetic resistance, chemical treatments, and farming practices, generally offer partial protection often only against specific pathogen strains. Our project focuses on developing in-depth understanding of plant defense signaling mechanisms that will enable sustainable disease management strategies with potential long lasting and broad spectrum efficacy.

**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 identified multiple plant chemicals that induce a unique plant immune mechanism called systemic acquired resistance (SAR). SAR protects the plant against a broad spectrum of pathogens and is long lasting in nature. We also studied how these chemical inducers affect plant responses to beneficial microbes such as nitrogen fixing rhizobacteria. In addition, we studied the effects of environmental factors such as light and abiotic stresses on the plant's ability to fight infection

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

*Plant science research community:* Increased knowledge of the plant immune response and identification of novel signaling pathways.

*Program leaders (National Science Foundation, USDA, etc.):* Increased knowledge of on-going research activities.

*Soybean & corn growers:* Understanding of university research and potential availability of products for use in crop production.

*Agri-tech companies:* Partnerships to develop commercially viable products for use in crop production.

*Graduate & Undergraduate students:* Training in molecular biology techniques and plant physiology

*High school & middle school students:* Lab research experiences and improved understanding of plant physiology

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

The long-term goal of this project is to develop sustainable strategies for generating broad-spectrum disease resistance without significantly affecting growth, development, and ultimately yields in agriculturally important crops. A current pending patent application derived from this work is being leveraged to generate commercially viable products for the agricultural industry. This will ultimately benefit the United States agricultural economy because it is directly relevant to the two of the largest crops (corn and soybean) produced in the United States. In addition to corn and soybean, the products also exhibit efficacy in disease protection of other crops such as tomato, tobacco and hemp, all of which are extremely relevant to KY and USA economy. This research benefited undergraduate students via two experiential learning research-based courses ABT 395, BIO199, and area high school students by providing lab research experiences.

**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.**

Training activities

- One postdoctoral scholar, one visiting scientist, two graduate students, three undergraduate students and two high school students received training in plant biology based research via daily laboratory research, participation in group discussions and one-on-one meetings with the PI.
- Community workshops provided training in basic plant biology techniques to area middle and high school students and their families.

Professional development

*Mentoring:* Postdoctoral scholar and graduate students were involved in mentoring undergraduate and high school student interns, and serving as judges at undergraduate poster presentations

*Oral/poster presentations:* Postdoctoral scholar and graduate students received training in preparing and making oral and poster presentations at national conferences (virtual).

*Networking opportunities:* Postdoctoral scholar and graduate students had the opportunities to network with national and international scientists via attendance of national conferences, meetings with project collaborators and interactions with scientists invited to speak at the Department of Plant Pathology weekly seminar series.

National and international oral presentations: The PDs and four graduate students made multiple research presentations in various forums (national and international meetings, conferences, invited talks, etc). These were primarily done virtually due to COVID related restrictions on travel and in-person gatherings. Meeting with KY Soybean & corn growers (12/17/2021).

Kachroo P, Burch-Smith TM, Grant M. 2021. [An Emerging Role for Chloroplasts in Disease and Defense](#). *Annu Rev Phytopathol.* 59:423-445. doi: 10.1146/annurev-phyto-020620-115813.

Yu K, Liu H, Kachroo P. 2021. [Pipelicolic Acid Quantification Using Gas Chromatography-coupled Mass Spectrometry](#). *Bio Protoc.* 10(23):e3841. doi: 10.21769/BioProtoc.3841.

Kachroo A, Kachroo P. 2020 [Mobile signals in systemic acquired resistance](#).

*Curr Opin Plant Biol.* 58:41-47. doi: 10.1016/j.pbi.2020.10.004