Hawaii (University of Hawaii System) Annual Report - FY2021

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Contributing Organizations

University of Hawaii System

Executive Summary

Overview

The College of Tropical Agriculture and Human Resources (CTAHR) at the University of Hawai'i at Manoa (UHM) is composed of six academic departments that cover a wide array of topics including natural resource management, tropical plant production and management, soil science, animal science, human nutrition and dietetics, molecular biology, bioengineering, plant pathology, entomology, family and consumer sciences, and fashion design. CTAHR is also home to the Center on the Family, the Center for Tropical and Subtropical Aquaculture, the Western Insular Pacific Sun Grant Subcenter, and a statewide network of 22 Research Stations and Extension Offices on five Hawaiian Islands. Since Hawai'i is the only tropical island state in the USA, and because it is the most remote population center on the planet, CTAHR operates within unique social and biophysical environments. CTAHR's programs are therefore not only addressing national and international issues, but also focus on Hawai'i's unique natural resources, diversity of crops, invasive pest pressures, and development needs of youth, adults, families, and communities.

Hawai'i has virtually every recognized soil type. It has elevations over short distances that range from sea level to as much as 13,000 feet; and it has annual rainfall variation from less than ten to over 400 inches per annum. Ecosystems range from desert, to tropical rainforest, to snow covered mountains. Hawai'i also faces unique environmental challenges unknown in other parts of the USA. When there is volcanic activity, Vog (volcanic fog) is produced which stresses agriculture, native forests and human communities alike. Periodic volcanic eruptions deposit ash. Lava can destroy native forests, human habitats and agricultural land and operations. For example, eruptions and lava flows on the island of Hawai'i in 2018 destroyed as much as 50% of the papaya industry and about 60% of the dendrobium orchid industry, while also obliterating the CTAHR research station at Malama Ki.

Presently, Hawai'i imports between 80% and 90% of its food. CTAHR, in partnership with stakeholders across the state, is actively searching for opportunities to increase local food production in a sustainable way while also making it more profitable. While there are opportunities, there are also substantial constraints. The costs of land, labor, and energy exceed those found in most other states. Agrochemicals and animal feed are mostly imported and exporting products to distant markets reduces the farmers' competitive ability. The high costs of energy, lack of skilled labor and reduced interest in farming are major challenges. The farm size is not always at the scale which determines economic viability. Hawai'i has 7,328 farms, 66% of which are less than 10 acres in size, with another 23% between 10-49 acres. And only 12% of all farms have annual sales with a value greater than $50,000.

Hawai'i's agricultural sector includes specialty crops grown nowhere else in the USA, such as coffee, macadamia nuts, and cacao. Although livestock producers in Hawai'i are making progress toward the goal of grass-finished healthy beef, the majority of calves are still shipped to mainland feedlots due to lack of economical local feed supplements. Lack of slaughterhouses for livestock is another challenge for small livestock producers. Invasive species and the attendant costs of insect, disease, and weed management, and export limitations imposed by plant quarantine regulations also place additional burden on Hawai'i's farmers.

CTAHR faculty understand these challenges and engage in a broad spectrum of research and extension activities, including management of invasive species that constantly threaten the "gateway" state of Hawai'i. The Governor's Hawai'i Interagency Biosecurity Plan for 2017-2027 addresses the problem comprehensively with actionable items for several state agencies, including CTAHR. With new pests frequently entering Hawai'i, biosecurity research and extension are crucial. Currently, Coffee Leaf Rust is threatening coffee production across the state, and Rapid Ohi'a Death is devastating the native forest of the Big Island and just recently Kauai. The coffee berry borer, the two-line spittle bug, little fire ant, and a viral disease on ornamental ginger are a few additional examples of what the state is fighting. The use of technology in the form of genetically modified organisms and pesticides are not universally accepted as practices; and in some cases, they are considered to be counter to native Hawaiian ways. Other areas in which CTAHR continues to work, and needs to enhance

its capability, is in improved cultivation and processing of specialty crops, agricultural advanced technology, development of value-added products, increasing forest productivity, protection of forests, watersheds and coastal resources, plant and animal breeding and genetic improvement, biofuel development to address soaring energy costs and fossil fuel depletion, plant stresses related to drought and climate change, food safety and security, the health (mental, physical, and financial) of Hawai'i's citizens and communities, and human nutrition programs. CTAHR needs to address the lack of current technology used in Hawaiian agriculture and be at the forefront of new technology specific to the needs of the state.

CTAHR administration and faculty have continued working within the framework of five Critical Issues, which are: Bioengineering for Agriculture/Natural Resources/Health; Biosecurity of Agriculture and Natural Resources; Diversified Tropical Agricultural Systems; Protect and Manage Natural Resources and the Environment; and Youth/Family/Community Development and Health. During FY2021, the continuation of the coronavirus (COVID-19) pandemic and its associated impacts on human health and the economy resulted in selective modifications to the 2021 plan of work. While some research and extension activities were necessarily either delayed or canceled, others were reoriented towards meeting specific needs of the Hawaii population due to the pandemic.

Critical Issue: Bioengineering for Agriculture/Natural Resources/Health

Molecular biology and bioengineering provide critical knowledge and tools for improving agriculture, natural resource management, and human and ecosystem health. CTAHR faculty are leading efforts to use the science of molecular biology and bioengineering to mitigate the negative impacts of climate change, to expand the use of renewable energy, to develop field-based diagnostic tools for identifying and monitoring pathogens and environmental contamination, to improve food technology and food safety, and to better understand the role of different microbiomes on human and ecosystem health. Specific techniques and approaches used include molecular biotechnology, genomics/bioinformatics/proteomics, plant/microbe interactions, waste management using bioconversion/bioenergy, development of biosensors, and the application of environmental biochemistry to ecosystem and human health.

For example, current work is researching the role that enzymes extracted from agricultural plants can have on dementia and obesity. Other current approaches deal with the bioconversion of waste to energy and the development of nutraceuticals and pharmaceuticals from agricultural crops and endemic plants. In diagnostics, robust field-deployable and lab-based detection assays for identifying plant pathogenic bacteria are being developed and tested successfully in the field. For anaerobic digestion systems, machine learning assisted micro-aeration is being studied to optimize and predict system performance for organic reduction and biogas production. Additional research on innovative bioprocessing and metabolic engineering is resulting in new technologies that enable zero-waste or near-zero-waste conversion of regional agro-waste to multiple streams of value-added products such as single-cell protein (SCP) fish feed and soil biofumigants.

In food technology, a new technique based on subzero nonfreezing preservation (supercooling) has been developed to eliminate the formation of ice crystals while maintaining below freezing conditions for food. The process of supercooling foods is far more advantageous than freezing because it decelerates the rate of spoilage without compromising the sensory quality and nutrient composition of food. The supercooling process, by avoiding the formation of ice crystals, allows the cellular structure of food tissues to remain intact. Furthermore, the lack of ice crystal formation eliminates the need for thawing, thereby preserving the nutrient quality of the food.

Critical Issue: Biosecurity of Agriculture and Natural Resources

In Hawai'i, the introduction and establishment of invasive species represents a constant threat to agricultural production, farm profitability, and Hawai'i's surrounding natural and urban ecosystems. CTAHR conducts research and extension on the biology and control of invasive insects, plant diseases, and weedy plant species, including studying their impacts on farms, native biota, and local ecosystems, and developing integrated pest management strategies. Integrated research and extension are leading to the development, testing, and implementation of comprehensive approaches to the control of invasive species that are based on scientific understanding and participatory methods in both monitoring and control actions.

Early detection and rapid response efforts are key to reducing the negative impacts of non-native plant pests and pathogens. In one project, CTAHR has developed and employed a wide range of detection technologies for pest and pathogen detection. For pests we have utilized detector canines, improved trap design, and attraction lures. For pathogens we have developed new and improved isothermal and PCR-based diagnostic assays. We are also continuing to develop serological assays and adopting the use of nanopore sequencing for Hawaii.

CTAHR is also developing innovative technologies to rapidly identify invasive organisms and microbial pathogens in the environment, and to implement control measures for these in otherwise inaccessible terrains. For example, researchers are developing a prototype of a low-cost surveillance system for deployment in remote/distributed traps to automatically detect catches of Coconut Rhinoceros Beetle (CRB). They are also combining this capability to identify CRB with an aerial spraying platform (drone based) for precision spot treatment of pesticide sprays into palm crowns to kill boring CRB.

Critical Issue: Diversified Tropical Agricultural Systems

Hawai'i imports 80% to 90% of its food. Hawai'i's Governor has set a goal to double local food production. To that end, CTAHR conducts basic and applied research to increase production, efficiency, and profitability of diversified agricultural industries for not only food but also other products of the bioeconomy, while also protecting the environment. Research and extension efforts include: breeding and crop improvement; variety selection for pest and disease resistance; identification and evaluation of new specialty crops; nutrient and water management; import replacement with locally grown produce; livestock production; protected agriculture, and aquaponics and hydroponics.

Notable progress during FY2021 includes advances made in addressing animal health and management issues affecting livestock, poultry, and aqua-cultured animals in Hawaii as well as addressing public health/zoonotic threats and diseases of economic importance. Hawaii livestock producers adopting Extension recommended grazing and pest management practices increased their economic returns by as much as 70%.

Progress was also made in improving management and production of alternative specialty crops. Multiple field trials and workshops were completed to identify and distribute well adapted turmeric and heirloom tomato germplasm to growers. For managing insect pests, screenhouse technologies were shown to provide a 50% reduction in insecticide use for controlling pests such as fruit flies, caterpillar aphids, whiteflies, and thrips. With the use of screenhouse systems, Extension and research trials have documented up to a five-fold increase in marketable yields in the production of (non-pollinated) cucumber, kale, and zucchini.

A comprehensive set of interventions designed to improve soil health (rotating cover crops) and pest management (IPM and screenhouses) were tested several years on a large number of farms in Hawaii. Survey data showed there was a 1.2-fold increase in planned cover crop conservation acreages, and a 3.11-fold increase in planned and applied cover crop conservation acreages in Hawaii. This has resulted in 1,957 acres (268 contracts/plans) of cover crop installed by producers in Hawaii for FY 2020.

Work has also begun on characterizing the soil microbiome in Hawaii, in particular those that associate with the roots of crop plants, plants of economic, conservation, and cultural significance, and those associated with different cropping systems. The outcome thus far is a biological atlas of the diversity and functional characteristics of soil microbes that with further exploration could help us understand how microbes contribute to sustainable agriculture and nutrient cycling in tropical soils.

Critical Issue: Protect and Manage Natural Resources and the Environment

CTAHR research and extension efforts place a high priority on protecting and managing the unique and diverse fragile ecosystems in Hawai'i. Active projects focus on an array of topics, including forest resource management, agroforestry, range management, wildland fire science, nutrient management, soil erosion, soil quality and bioremediation, biological diversity, rehabilitation of degraded and idle lands, wildlife management, and water quality. To preserve, protect, and renew Hawai'i's natural resources, we have developed programs on environmental education that target schools, youth groups, land managers, tourists, local government, and private partners. We are also involved in international partnerships and collaborations on management of natural resources around the world.

On-going grazing trials for grass-finish beef production reveal important information on the interaction between harvest intensity, pasture sustainability, and animal productivity and meat quality. This research is providing the beef cattle industry in Hawaii with guidelines (Best Management Practices) for efficiently finishing beef cattle on pasture in Hawaii, while maintaining pasture and rangeland sustainability and providing a quality meat product for Hawaii consumers.

Hawai'i's most important native tree, Ohi'a lehua (*Metrosideros polymorpha*), has been dying across large areas of Hawai'i Island mainly due to two fungal pathogens (*Ceratocystis lukuohia* and *Ceratocystis huliohia*) that cause a disease collectively known as Rapid Ohi'a Death (ROD). Working closely with state and federal entities, as well as private landowners, CTAHR researchers and extension specialists have focused on attaining a better understanding of the disease, how it is spread, and how it may be controlled.

New tools and approaches for making informed decisions regarding the management of natural resources are being developed and tested with stakeholders. A method referred to as Structured Decision Making (SDM) was recently applied to groups in three different cases: (1) To Division of Forestry and Wildlife staff and a natural reserve manager to prioritize landscape management; (2) To the Hawaii Department of Health, County of Maui and stakeholders in Upcountry Maui to prioritize cesspools for upgrading; and (3) To a community group interested in local fire management and formation of a state fire alliance. In all cases, applying the SDM process clarified decisions, revealed objectives, generated creative alternatives, and improved the transparency and rigor of decisions.

Critical Issue: Youth/Family/Community Development and Health

The family has a profound influence on the health and well-being of its members, particularly its youth and elderly. CTAHR strengthens families by providing research and extension in family health, intergenerational programs, youth development, and parenting. Well-integrated research and extension initiatives have been developed to improve diet and nutrition in Hawai'i's multi-ethnic population addressing diabetes, obesity and weight management. CTAHR plays a key role in collecting, compiling, and reporting to legislators, government agencies and non-profit organizations on current social indicators for Hawaiian families and communities. The 4- H Youth Leadership program focuses on healthy living, science, citizenship, volunteer development, marketing and public relations.

During FY2021, we continued to engage in a number of large-scale program evaluation activities to enhance the capacity of local agencies and programs. Selected issues relating to individual and family well-being in Hawaii included childhood lead poisoning, child welfare, health outcomes, substance abuse, homelessness/housing, and aging. The evaluation is intended to: (a) document trends in individual and family well-being through social indicators; (b) understand resiliency factors that allow families to adapt to personal, economic, and social challenges; and (c) enhance the capacity of local agencies and programs that serve individuals and families.

During the height of the COVID 19 pandemic, the 4-H large vegetable project provided families with an opportunity for quality family time and activity, as well as providing the family with high quality food. This project was also an example of how the Hawaii 4-H Program made a major pivot to help families cope well during the course of a worldwide pandemic.

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

College priorities and research and extension programs are in line with expressed stakeholder needs, although stakeholders from all industry groups would like to have increased support from CTAHR for their particular sector. Given the large number of upcoming retirements, past budget and staffing cuts, and the effect of the pandemic and restrictions on hiring, stakeholder requests will be a challenge to meet. Nevertheless, as CTAHR recovers from the pandemic, the University of Hawai'i System President has highlighted the college as representing an essential area that merits greater investment. Prior to the pandemic, priority positions were determined for a five-year hiring plan based on faculty, state, and industry input. Anticipating changes in a post pandemic world, CTAHR has begun a Strategic Positioning process (early Fall 2021) that will inform a new staffing plan to address the future challenges and opportunities for serving the people of Hawaii.

Highlighted Results by Project or Program

Critical Issue

Bioengineering for Agriculture/Natural Resources/Health

Engineering for food safety and quality

Project Director

Soojin Jun

Organization

University of Hawaii System

Accession Number

1023498

Results

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

The use of frozen storage is the most popular way to preserve highly perishable foods; however, ice crystal formation causes an irreversible decline in texture quality because of inevitable drip loss after thawing. Thus, a new technique based on subzero nonfreezing preservation has been of interest to researchers. One technique that addresses the problems associated with freezing is known as supercooling. Supercooling is able to eliminate the formation of ice crystals while maintaining below freezing conditions for food. The process of supercooling foods is far more advantageous than freezing because it decelerates the rate of spoilage without compromising the sensory quality and nutrient composition of food. Without the formation of ice crystals, the cellular structure of food tissues remains intact. Furthermore, the lack of ice crystal formation eliminates the need for thawing which consequently reduces the amount of drip loss significantly, thereby preserving the nutrient quality of the food.

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.

Freezing extends the shelf-life of food by slowing down the physical and biochemical reactions; however, ice crystal formation can occur irreversible damage to cell structure and texture. Supercooling technology has the potential to preserve the original freshness of food without freezing damage. In this study, fresh asparagus was preserved in a supercooled state and its quality changes such as color, weight loss, texture, chlorophyll and anthocyanin content, and enzymatic activities (superoxide dismutase and catalase) were evaluated. The asparagus samples were successfully supercooled ate3°C with the combination treatment of pulsed electric field (PEF) and oscillating magnetic field (OMF), and the supercooled state was maintained for up to 14 days. Asparagus spears preserved in the supercooled state exhibited lower weight loss and higher levels of quality factors when compared with frozen and refrigerated control samples.

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

Cold storage is one of the most popular methods to preserve perishable produce; however, freeze damage when stored at the subzero temperature would result in undesired changes in color, odor, texture, enzymatic activity, and sensory values. It would be beneficial to fresh produce industries to develop the supercooling technology for the extended shelf life of fresh produce without quality degrading and spoilage.

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

The use of cold storage is the most popular method to preserve highly perishable foods. However, at refrigeration temperatures, the shelf life of these foods is limited, and spoilage leads to massive food waste. Moreover, freezing significantly affects the food's properties. Ice crystallization and the growth will cause irreversible textural damage to the food through volumetric expansion, moisture migration by induced osmotic pressure gradients, and freeze concentration of solutes leading to protein denaturation. Although freezing will preserve perishable foods for months, these disruptive changes decrease the consumer's perception of the food's quality. Therefore, the development and testing of new and improved cold storage technologies is a critical research pursuit to improve the safety and quality of our food supply. Supercooled foods can be preserved and stored over an extended period of time, limiting food spoilage; therefore, minimizing food wastes. The use of

supercooling inventions could expand to include the entire food preservation industry, commercial appliances, as well as the food supply chain system by ensuring food safety through a farm-to-table approach to reduce and prevent foodborne illness since we can replace key elements associated with temperature abuses within the entire food cold chain.

Closing Out (end date 09/07/2023)

Micro-aeration to Reduce Volatile Fatty Acids Accumulation During High Loadiing Rate Anaerobic Digestion Processes: Evaluation of Pathway and Mechanism

Project Director
Samir Khanal
Organization
University of Hawaii System
Accession Number
1016755

Results

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

Anaerobic digestion systems of sewage sludge in wastewater treatment plants are usually operated with low biogas production. Food waste anaerobic mono-digestion is also encountered with volatile fatty acids (VFA) accumulation causing low pH and eventual system failure. Machine learning-assisted microaertation and co-digestion could enhance system performance and stability.

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.

Continuous studies suggested that co-digestion of sewage sludge and food waste resulted in higher yield and performance and better stability than sewage sludge and FW mono-digestions. Without co-digestion with sewage sludge, anaerobic digestion of food waste alone led to failure at the same organic loading rate. Furthermore, the biogas production of sewage sludge digestion increased by 50% after co-digestion with food waste. The application of machine learning could optimize, and predict the system performance, including biogas/methane production and organic matter reduction.

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

Artificial neuron networks is an emerging technology based that can be applied to predict performance of co-digestion and microaeration. Based on the results, recurring deep reinforcement learning for system control to optimize system performance can be developed. This proof of the concept project is beneficial in both hydrolysis and alleviating volatile fatty acid accumulation in anaerobic co-digestion. These collaborative projects aim at providing baseline data for techno-economic feasibility. The research activities are regularly updated in the website – www.samirkkhanal.com which provides opportunity for recruiting local graduate and undergraduate students in this emerging field of “AI”, Several local graduate and undergraduate students are being recruited and receiving training in the Lab. These students are fulfilling the local workforce needs in the STEM disciplines. The research works also is inspiring local students in joining undergraduate and graduate program focusing on AI, agriculture, sustainability and resource recovery within University of Hawaii system.

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

The organic waste treatment by AD and application of machine learning results in better remediation and higher bioenergy production. The system performance can be maximized using the integration of microaeration and co-digestion. The nutrient-rich digestate from the system can be used for direct land application and co-composting. Instead of landfilling, high moisture organic waste streams can be converted into energy. Machine learning-assisted anaerobic digestion is a promising resource recovery approach contributing to the circular economy. Bioenergy and Environment Research Group is highly active in research and development in AD field. The group's research activities are regularly updated in the group’s website – www.samirkkhanal.com which provides research update to global audiences. The group has published near 15 research and review papers on this very theme and 1 paper on ML thereby disseminating the research outcomes to broader audiences globally. Project PI also delivered nearly 6 invited/plenary/guest lectures and sharing research works to much broader global audiences. Thus, group’s research work is inspiring researchers around the global on how AI can be applied in AD field.

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 original proposed project focused on mono-digestion of lignocellulosic biomass with micro-aeration. During the course of the research, the project concept was modified to focus on emerging issue of organic wastes remediation and process control/optimization using machine learning. The new direction provided opportunity in providing training opportunity in AI field. The research works have been disseminated via publication of research and review papers and thorough several oral presentations to broader audience. This new research direction will keep us in forefront of AD research globally. We plan to develop ML-based tool for effective co-digestion of food waste and sewage sludge with micro-aeration.

Closing Out (end date 09/07/2023)

Value-added Products from Renewable Feedstock via Innovative Bioprocessing and Metabolic Engineering

Project Director
Wei-Wen Su
Organization
University of Hawaii System
Accession Number
1016852

Results

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

Hawaii is facing unique challenges in food and energy security, and in sustaining its natural resources and environment. This project addresses these challenges by developing technological advances that enable cost-effective and sustainable conversion of regional agricultural wastes and byproducts into value-added products, to achieve a circular economy. It aims to provide new opportunities for growing the economy in Hawaii while keeping our environment clean.

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

During the last report period, we developed a new low-cost bioreactor called “suspended shaken bioreactor” (SSB) for scalable microbial culture to convert culled papaya waste to single-cell proteins (SCP) derived from the Yarrowia lipolytica yeast cell mass. In this current report period, we demonstrated the feasibility of the Yarrowia SCP to replace up to 25% of the fishmeal in a tilapia feed trial. We also conducted detailed engineering characterization of SSB in terms of power consumption, oxygen transfer and mixing, and further improved the design by refining the shaking mechanism. We successfully used the new SSB system in culturing engineered astaxanthin-producing Yarrowia yeast cells using culled papaya based nutrient media at a scale of 5 L, under dissolved oxygen control. Such astaxanthin-containing SCP is a novel and high-value product for aquatic feed. Yeast growth and astaxanthin production in the SSB are similar to that achieved in shake-flask cultures. We also conducted a basic techno-economic analysis (TEA) of the microbial bioprocess that converts culled papaya into single cell proteins for fish feeds, using SSB vs. conventional stirred fermenters. Based on the TEA, the SSB is economically favorable over stirred-tank fermenters at small-to-moderate production scales due to their extremely low investment cost. An important advantage of the SSB system over standard stirred fermenters stems from its simplicity, and hence it is amenable to operation even by low-skilled workers, and requires very low cost to set up and operate.

In addition to utilizing sugar in culled papaya waste for microbial culture, we also investigated the novel use of papaya ground seeds (PGS) as a natural soil fumigant. Papaya seeds contain a high level of benzyl glucosinolate that is enzymatically hydrolyzed via myrosinase to form benzyl isothiocyanate, which has potent pesticide activities against a range of soil-borne phytopathogenic nematodes, insect pests, and fungi. During this report period, in collaboration with collaborator Dr. Koon-Hui Wang, we designed and conducted greenhouse studies to determine the efficacy of the papaya seed biofumigant against Fusarium oxysporum f. sp. Letucae and root-knot nematode, Meloidogyne incognita, under different biofumigant formulations and application regimes, using lettuce and kai choi as test crops. Laboratory studies have also been conducted to optimize the preparation of the PGS as biofumigants, and to investigate the impact of PGS application on soil bacterial/archaeal communities. We showed that the PGS biofumigant can be produced easily by simply drying the papaya

seeds at 50°C for 2 days, followed by milling into fine powders. Dry seeds stored for over a month under room temperature can produce similar amounts of BITC upon milling into PGS, as those from fresh seeds. Seeds from Sunrise and Rainbow papaya generate similar amounts of BITC. The greenhouse pot experiments revealed that PGS at 0.5 or 1% amendment rate level could pose a phytotoxicity effect on young lettuce seedlings if transplanted immediately after soil amendment, but planting at 1 week after amendment avoided this problem. PGS at 1% rate was more consistent in suppressing F. oxysporum than PGS at 0.5%. Adding papaya seed crude extract (PGS+CE) did not improve either F. oxysporum or root-knot nematode suppression than using PGS alone. Further optimization of crude extract preparation is necessary. Overall, the results indicated that PGS would be safer to use as post-plant treatment or to wait for few days to a week before seedling transplanting. Besides effects on the crop and the target pathogens, itis useful to probe the environmental impacts of PGS by examining its effect on soil microbial diversity. To this end, the 16S rRNA gene amplicon sequencing is shown to be a useful approach. Different PGS treatments (PGS+CE, PGS 0.5%, PGS 1%, and NA) resulted in significantly different microbial composition in soil, as indicated by the statistically different Beta diversity indices, but did not significantly affect the microbial richness, as indicated by the non-statistically different Alpha diversity indices. Eight plant growth promoting bacteria were identified in the soil samples. Different treatments resulted in significant difference in the abundances of these plant growth promoting bacteria. The abundance of plant growth promoting bacteria under the PGS+CE treatment was significantly lower than under other treatments. Interestingly, treatment with PGS at 1% amendment rate showed the highest abundance of plant growth promoting bacteria.

This project contributes to development of innovative solutions that enable zero-waste or near-zero-waste conversion of regional agro-waste to multiple streams of value-added products such as SCP fish feed and soil biofumigants, and to establishment of innovative applications of these waste-derived products, which are the main objectives of our hatch research.

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

The target audience of this project include aquaculture, aquatic and animal feed industries, papaya industry, producers of value-added agricultural by-products, and farming communities with soil pathogen issues. Our project findings will benefit our target audience by providing practical and simple-to-adopt technologies, as well as scientific knowledge and know-how related to practicing these technologies for making nutritional aquatic feed ingredients using locally sourced waste feedstock and natural soil fumigants for managing soil-borne phytopathogens.

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

Our study contributes to development of innovative solutions for valorization of regional agro-wastes, with focus on the culled papaya fruit wastes. We developed new technologies that enable zero-waste or near-zero-waste conversion of regional agro-waste to multiple streams of value-added products such as SCP fish feed and soil biofumigants, which should have a positive impact on the general public and our society as a whole, by moving towards a more sustainable circular economy.

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

One postdoctoral fellow and a graduate student were trained to conduct this hatch research. During the next reporting period, we will conduct additional laboratory tests to further characterize and optimize emission of the active biofumigant compound from PGS, and carry out greenhouse/field trials to further optimize and validate PGS as an effective alternative soil biofumigant. We will also evaluate the SSB for additional applications.

Detection, Phylogeny and Comparative Genomics of Important Bacterial Species of Tropics

Project Director

Mohammad Arif

Organization

University of Hawaii System

Accession Number

1014144

Results

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

Plant pathogenic bacteria cause numerous diseases of plants throughout the world and have a direct impact on food security. Hawaii relies on imported food supplies and imported seeds and propagative stock of plants which have introduced new bacterial species and strains. Introduction of these new strains can have a huge impact on local crops and ornamentals. Therefore, the aim of this Hatch proposal is to develop advanced diagnostic tools and understand population and genome biology of important bacterial pathogens to support effective disease management and mitigation procedures.

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

During this year (2020-21), we have made considerable progress in achieving the goals of this project. In diagnostics, robust field-deployable and lab-based detection assays were developed and published in peer-reviewed journals. A qPCR-based detection method for *Clavibacter michiganensis*, a divastating bacterial pathogen of tomato, was developed (Ramachandran et al, 2021). A field-deployable loop-mediated isothermal amplification assay for specific detection of serious pathogen of potato, *Pectobacterium parmentieri* was developed (Domingo et al, 2021). A LAMP assay for *Dickeya fangzhongdai*, a taro pathogen, was also developed. We also developed qPCR and recombinase polymerase amplification protocols for *Xanthomonsa oryzae* pv *oryzae* and *X. oryzae* pv *oryzicola;* both protocols are now being validated in APHIS laboratory so that they can be used for CAPS surveys and screening of the suspected samples. Our activities in diagnostic also include developing and validating methods based on NGS (Nanopore Oxford and Illumina). We have a standardized method for detecting plant bacterial pathogens from infected samples. This method would help stakeholders and farmer communities to quickly identify pathogens. In collaborations with researchers from Oklahoma State University, we have analyzed e-probes for multiple pathogens, including *Ralstonia solanacearum, Xanthomonas oryzae* pv. *oryzae*, *Xanthomonas oryzae* pv. *oryzicola* and *Dickeya solani* and we are continuously developing probes for the other high consequence pathogens. These e-probes can detect the target pathogens in metagenome dataset. In population biology and comparative genomics, a comprehensive MLST analysis was conducted with anthurium pathogen, *Xanthomonas phaseoli* pv. *dieffenbachiae* (Xpd). This pathogen causes bacterial leaf blight on aroids and has been listed as an EPPO A2 quarantine organism since 2009. In this study, multi-locus sequence typing (MLST) with housekeeping genes *atpD, dnaA, dnaK, gltA*, and *gyrB* was used to analyze 59 representative aroid strains selected from different hosts, temporal and geographical origins. Sequences of related *Xanthomonas* species/pathovars and Stenotrophomonas, a member of the *Xanthomonadaceae*, were retrieved from the NCBI GenBank database to elucidate the phylogenetic and genealogical relationships with aroid strains. The analysis results of 161 concatenated sequences revealed the aroid strains clustered in clades with six *Xanthomonas* species/pathovars and two Stenotrophomonas species. Overall, this study revealed high heterogeneity among strains from diverse hosts and origins and suggested the existence of new taxonomic species.

We have described multiple new species of *Dickeya* (*Dickeya colocasiae* sp. nov.) and *pectobacterium* (*Pectobacterium colocasiae* sp. nov.), and elevated *Clavibacter michiganensis* subsp. *californiensis* to species level as *Clavibacter californiensis* sp. nov., and merged/re-classified of *Clavibacter michiganensis* subsp. *chilensis* and *Clavibacter michiganensis* subsp. *phaseoli* as *Clavibacter phaseoli* sp. nov. based on complete genome sequence. A comprehensive evolutionary and comparative genomic analysis of *Clavibacter* is underway. We reported multiple first reports in Hawaii (*Pectobacterium* species causing soft rot on multiple new hosts, including mizuna and pak choi). In comparative genomics and interactions studies, we analyzed novel strains of *Dickeya zeae* isolated from pineapple and taro in Hawaii. In this study, we used Pacific Biosciences single-molecule real-time (SMRT) sequencing technology to sequence high-quality complete genomes of novel strains of *D. zeae*: PL65 (size: 4.74997 MB; GC: 53.6%) and A5410 (size: 4.7792 MB; GC: 53.5%) isolated from economically important Hawaiian crops, taro, and pineapple, respectively. Additional complete genomes of *D. zeae* representing three additional hosts (philodendron, rice, and banana) were retrieved from the NCBI GenBank genome database and used them for comparative and taxonomic analyses. The outcomes of this study highlighted the genetic constituents of pathogenicity determinants and genomic heterogeneity that will help to understand the virulence mechanisms and aggressiveness of this plant pathogen. In another study on *Xanthomonas* strains causing bacterial leaf blight of Panax (*Polyscias guilfoylei*) in Hawaii, we have identified *X. euvesicatoria* as a causal agent (previously it was reported as *Xanthomonas hortorum* pv. *hederae*). We have performed pathogenicity, phenotypic and comparative genomics analyses on multiple strains from panax. Multiple comparative genomics analyses and interactions studies are underway to understand the genomic biology and interactions of bacterial strains from *Dickeya, Clavibacter* and *Xanthomonas*.

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

This project has audiences from different areas, which include scientists and researchers from both basic and applied sciences, extension workers requiring quick tests to detect on field, industries, diagnosticians and farmers. PI has provided diagnostic assays for benefiting local farmers and stakeholders. The tools are being used by seed certification agencies, diagnostic laboratories, and regulatory agencies. The other research activities in this project providing knowledge about population and genome biology and interactions with hosts of important bacterial pathogens, vital for plant disease management. Graduate students were trained in bacteriological and molecular techniques, and bioinformatics analyses.

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

The research outcomes of the project activities were presented by PI, postdoc and students at national meetings, and through invited seminars in different institutions. Over ten presentations/seminars were delivered from different activities of this Hatch project. During these presentations, we interacted with scientists and researchers from many institutions. PI always interacts with farmers. In diagnostics, we presented on the following topics: The future of plant diagnostics and disease surveillance (Special Session: APS Annual Meeting 2021, virtual); Development of loop-mediated isothermal amplification assay for rapid detection of *Pectobacterium parmentieri* in infected potato and soil samples (APS Annual Meeting 2021, virtual); Minimum standards for publication of diagnostic assays: required or optional for next-generation diagnostics? (APS Pacific Division Meeting 2021); Recombinase Polymerase Amplification: An emerging isothermal technology (Beltsville Laboratory, USDA APHIS PPQ, Science and Technology, Beltsville, MD).

In population biology, we presented on the following topics: *Xanthomonas* strains isolated from Araceae reveal diverse phylogenetic relationships and origins (APS Annual Meeting 2021, virtual); Pathological and molecular biology of *Xanthomonas* strains causing bacterial leaf blight of Panax (Polyscias guilfoylei) in Hawaii (APS Annual Meeting 2021, virtual).

In comparative genomics and interactions, we presented on the following topics: Comparative genomics and phylogenetic analyses suggest a taxonomic re-organization and inclusion of a new species in the genus *Clavibacter* (APS Annual Meeting 2021, virtual); Investigating microbial communities associated with source irrigation and wet taro field water using amplicon Oxford Nanopore MinIon sequencing (APS Annual Meeting 2021, virtual); The influence of genomic content on biology and evolution of plant pathogenic bacteria, *Clavibacter* (School of Life Sciences, University of Hawaii Manoa, Honolulu, HI); Biology and evolution of *Clavibacter michiganensis* (Department of Plant Pathology and Crop Physiology, Louisiana State University, Baton Rouge, LA).

The outcomes were also disseminated through peer-reviewed publications. PI also provides advice to extension agents regarding bacterial diseases and their biology and diagnostics.

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.

During this reporting period, five graduate students (4 PhDs and 1 MS) and a postdoc received training on different aspects of bacterial diseases (population biology, genomics, interactions, microbiome and diagnostics). They presented their research work at national meetings. Two PhD students graduated during this period. Students within the college received training in molecular diagnostics and phytobacterial techniques. The students of my course PEPS 627 Molecular Diagnostics: Principle and Practices get hands-on training, worked on a class project and published a peer-reviewed manuscript on molecular detection of *Pectobacterium parmentieri* (Domingo R, Perez C, Klair D, Vu H, Candelaria-Tochiki A, WangX, Camson A, Uy JN, Salameh M, Arizala D, Dobhal S, Boluk G, Bingham JP, Ochoa-Corona F, Ali ME, Stack JP, Fletcher J, Odani J, Jenkins D, Alvarez AM, Arif M. Genome-informed loop-mediated isothermal amplification assay for specific detection of *Pectobacterium parmentieri* in infected potato tissues and soil. Scientific Reports, 11, 21948. doi.org/10.1038/s41598-021-01196-4), 2021.

In the next one year (last year of this project), we will focus on developing high throughput sequencing-based detection methods and develop a pipeline that can help to identify pathogens from infected samples (metagenome). We will continue working on phylogenomic analyses of *Clavibacter, Xanthomonas, Pectobacterium* and *Dickeya*. We will also focus on water/endophytic microbiome, and interactions of plant pathogens (pectinolytic bacteria) with food-borne human pathogens.

During this reporting period, we have published 9 peer-reviewed manuscripts and we have more than 10 manuscripts in preparations for peer-reviewed journals.

1. Boluk G, Arizala D, Dobhal S, Zhang J, Hu J, Alvarez AM, Arif M (2021). Genomic and phenotypic biology of novel strains of *Dickeya zeae* isolated from pineapple and taro in Hawaii: insights into genome plasticity, pathogenicity, and virulence determinants. Frontiers in Plant Science. doi:10.3389/fpls.2021.663851

2. Domingo R, Perez C, Klair D, Vu H, Candelaria-Tochiki A, Wang X, Camson A, Uy JN, Salameh M, Arizala D, Dobhal S, Boluk G, Bingham JP, Ochoa-Corona F, Ali ME, Stack JP, Fletcher J, Odani J, Jenkins D, Alvarez AM, Arif M (2021). Genome-informed loop-mediated isothermal amplification assay for specific detection of *Pectobacterium parmentieri* in infected potato tissues and soil. Scientific Reports, 11, 21948. doi.org/10.1038/s41598-021-01196-4

3. Arif M, Busot GY, Mann R, Rodoni B, Stack JP (2021). Field-deployable recombinase polymerase amplification assay for specific, sensitive and rapid detection of the US Select Agent and toxigenic bacterium, *Rathayibacter toxicus*. Biology, 10, 620. doi.org/10.3390/biology10070620

4. Larrea-Sarmiento A, Stack JP, Alvarez AM, Arif M (2021). Multiplex recombinase polymerase amplification assay developed using unique genomic regions for rapid on-site detection of genus *Clavibacter* and *C. nebraskensis*. Scientific Reports, 11, 12017. doi.org/10.1038/s41598-021-91336-7

5. Klair D, Silva J, Arizala D, Boluk G, Dobhal S, Ahmad AA, Uyeda J, Alvarez AM, Arif M (2021). First Report of *Pectobacterium brasiliense* causing soft rot on mizuna (*Brassica rapa* var. *japonica*) in the United States. Plant Dis. doi.org/10.1094/PDIS-03-21-0644-PDN

6. Arif M, Busot GY, Mann R, Rodoni B, Stack JP (2021). Multiple internal controls enhance reliability for PCR and real time PCR detection of *Rathayibacter toxicus*. Scientific Reports, 11, 8365; doi.org/10.1038/s41598-021-87815-6

7. Klair D, Boluk G, Silva J, Arizala D, Dobhal S, Arif M (2021). First report of bacterial soft rot disease on pak choi (*Brassica rapa* subsp. *chinensis*) caused by *Pectobacterium brasiliense* in the United States. Plant Dis. doi.org/10.1094/PDIS-08-20-1854-PDN

8. Ramachandran S, Dobhal S, Alvarez AM, Arif M (2021). Improved multiplex TaqMan qPCR assay with universal internal control offers reliable and accurate detection of *Clavibacter michiganensis*. J Appl Microbiol, doi.org/10.1111/jam.15017

Integrated Studies of Nutraceuticals, Food Safety and Environmental Management

Project Director
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1013574

Results

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

Research activities address issues related to nutraceuticals, food safety and environmental management. We hypothesize that integration of laboratory research and extension activities will facilitate research progress and increase accomplishments. Scientific questions learned through extension activities will be addressed through laboratory research.

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.

Alzheimer's disease (AD) is the most common type of dementia. Mouse studies were performed to investigate the relevance of inflammation and β-amyloid deposition with AD. Our studies showed that the flavone C-glycoside isoorientin inhibits inflammation in macrophages and endotoxemia mice by regulating glycogen synthase kinase 3β (GSK-3β). Isoorientin rescues synaptic dysfunction, spatial memory deficits and attenuates pathological progression in APP/PS1 model mice. Nutrient balance is critical for human health. A proteomics study suggested that dietary vitamin B3 deficiency suppresses the formation of ocular depression and up-regulation of optomotor-related blind gene-1 in Mediterranean fruit fly larvae.

Microbial communities attribute largely to cleanup of environmental pollutants. Our studies characterized bacterial populations in an industrial scale petrochemical wastewater treatment plant for the composition, function and their association with environmental factors. Microbes have also been used to generate methane via the co-digestion of potato pulp waste and dairy manure amended with biochar. Dibutyl phthalate is a plasticizer widely present in the environment. Research activities investigated effects of dibutyl phthalate on physiology, phytohormone homeostasis, rhizospheric and endophytic bacterial communities of turnip.

Peroxidases can be useful industrial enzymes. Three palm tree peroxidases were expressed by the bacteria *Escherichia coli*. African oil palm tree peroxidase expressed by E. coli showed similar stability and 30-100-fold greater activity than that of recombinant royal palm tree peroxidases, but both of their comprehensive indexes were superior to the commercial, native horseradish peroxidase.

Novel bacterial species have been isolated from soil and environmental samples. Immobilization of *Cupriavidus nantongensis* X1T enhanced biodegradation of insecticides in industrial wastewater. *Paraburkholderia* sp. C3 can effectively co-metabolize the petroleum contaminant dibenzothiophene and the biodiesel byproduct glycerol, which C3 genome, metabolic pathways and characteristics were studied. Halophilic bacterial strain *Staphylococcus haemoliticus* strain 10SBZ1A can degrade benzo[a]pyrene, one of the most persistent polycyclic aromatic hydrocarbons (PAHs) derived from petroleum oils and combustion processes. *Cupriavidus nantongensis* X1T can preferentially degraded the more toxic but less insecticidal isomer (R isomer) of the organophosphorus insecticide isocarbophos.

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

A total of 20 peer-reviewed paper have been published. Alzheimer's disease (AD) is the most common type of dementia. Studies have defined some functional food components are beneficial for health and elucidated how they are beneficial to heath.

Bacterial communities and isolated bacterial strains have been studied for the bioremediation of environmental pollution and utilization of biodiesel byproducts for environmental cleanup.

Genes encoding peroxidases were cloned from palm species. The recombinant palm peroxidases have been successfully expressed with the bacteria E. coli for potential scale-up production. The peroxidases can be further explored to produce valuable products and to clean up water pollutions.

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

The findings have been published in peer-reviewed journals and presented at professional conferences. Effort has also been made to disseminate research findings of functional food in relevance to Alzheimer's disease to local communities. The published papers have been cited for approximately 1800 times.

Critical Issue

Biosecurity of Agriculture and Natural Resources

Detection and Management of Invasive Plant Pests and Diseases Impacting Agricultural and Natural Ecosystems in Hawaii

Project Director

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Results

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

Non-native plant pests and pathogens have negative impacts on Hawaii's agricultural and natural ecosystems. Early detection and rapid response efforts are key for reducing these impacts. This project employs a multi-pronged approach to detect incursions of pests and pathogens, as well as respond to incipient populations of the most damaging pests and 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.

During the project period, we have conducted extensive surveys for plant pests and pathogens of regulatory importance. The purpose of these surveys are to detect incipient populations of species not known to occur in Hawaii or identify the geographic distribution of incipient populations. Statewide detection surveys were conducted for pests and/or pathogens of numerous crops or crop groups of economic importance to Hawaii and the US Mainland including avocado, citrus, corn, hibiscus, macadamia, taro, and vegetables. In addition, a large delimiting survey for coconut rhinoceros beetle was performed on the island of Oahu.

The ability to detect plant pests and pathogens in an accurate and robust manner is critical for their management. During the project period we have worked to develop and employ a wide range of detection technologies for pest and pathogen detection. For pests we have utilized detector canines, improved trap design, and attraction lures. For pathogens we have developed new and improved isothermal and PCR-based diagnostic assays. We are also continuing to develop serological assays and adopting the use of nanopore sequencing for Hawaii.

During the project period we have been developing and implementing management strategies for plant pests and pathogens that occur as incipient populations in Hawaii. For coconut rhinoceros beetle, we have developed protocols for heat and fumigation treatment of infested breeding materials using a mobile vacuum steam unit and sulfuryl fluoride, respectively. With collaborators, we have identified the dosage required to sterilize adult beetles using radiation, allowing for the possibility of sterile insect technique or to release and track sterile individuals for research purposes. We have also implemented landscape-scale treatment approaches using insecticide injection of host trees. Our program also maintains and distributes plant germplasm that is indexed for targeted systemic pathogens. This germplasm is distributed to nurseries, growers, and residents to ensure that they are using the highest quality material possible, lessening the spread of these pathogens in Hawaii. Using a controlled import permit, we brought coffee germplasm into our lab. This germplasm is putatively resistant to coffee leaf rust, a devastating disease that recently arrived in Hawaii. Following a mandatory quarantine period, this germplasm will be evaluated for its horticultural characteristics in Hawaii, as well as its disease-resistance.

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

Our target audience includes state and federal regulatory agencies, land managers, agricultural producers, and fellow scientists and researchers. Regulatory agencies have benefited from our work in several ways. First, survey data generated by our program strengthens our agricultural trade platform by providing empirical evidence of pest/pathogen absence. This similarly applies to incipient pest/pathogen populations that are under formal eradication or control programs administered by our program. Our diagnostic services support crop production in both Hawaii and the US Mainland. For the latter, we partnered with seed potato certification programs for several mainland states during their winter grow-out activities in Hawaii. This helps to ensure the nation's potato industry can continue to flourish. Land managers have benefited from our activities, most notably those part of our response to coconut rhinoceros beetle. Our landscape-scale management approaches have helped to ensure the health of their iconic palm trees. Agricultural producers have benefited by using our clean germplasm and improved diagnostic services as disease management approaches. Finally, fellow researchers benefit from the peer-reviewed articles that we have published detailing our program's activities.

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

Our project has two very active public outreach programs for coconut rhinoceros beetle and rapid ohia death. These outreach programs engage the public through both in-person (limited during the reporting period due to covid-19 restrictions), television, and online activities (websites, online newsletters, social media accounts). Through this public engagement, we are able to educate the broader public on the threats invasive species pose to Hawaii's agricultural and natural ecosystems, as well as their own backyards. By increasing the public support for our activities, other aspects of our project become much more effective. Aside from this direct engagement and education of the public, the people of Hawaii also benefit from our project's activities limiting the impact of invasive species.

Leveraging Fitness Costs Associated with Insecticide-Resistance and Host Plant Heterogeneity for Pest Management

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Results

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

Agricultural insect pests are becoming increasingly resistant to chemical insecticides. The project investigates alternative methods to control the insecticide-resistant pests.

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 goals and objectives of the project are to find alternative control methods for insecticide-resistant agricultural pests. Research for the project has focused on two major pests in Hawaii: melon flies and diamondback moths. From this project we have been successful in identifying high levels of resistance of melon flies to spinosad, which is one of two insecticides registered for their control. To make alternative insecticides available to cucurbit growers, we field-tested three alternative insecticides and are currently working with Hawaii Department of Agriculture to obtain local registration for those products. For insecticide-resistant diamondback moths, we have identified effective trap crops and insectary plants to enhance biological control by their natural enemies.

1. Identify local insect populations that exhibit resistance to different classes of insecticides and assess differences in lifehistory parameters that might be associated with their levels of resistance.

- We have identified spinosad resistant melon fly populations in Hawaii.
- Currently assessing insecticide resistance in multiple populations of diamondback moths.

2. Measure fitness costs of resistance in each resistant line.

- We have assessed the susceptibility of spinosad resistant melon flies to several chemical insecticides in the field.
- We have determined the most suitable trap crops for insecticide-resistant diamondback moth populations in Hawaii.

3. Identify environmental and crop management practices that magnify the costs associated with resistance.

- We determined that a rotation of different insecticide chemical classes can prevent resistance and provide long-term control of melon flies.

- Discovered a new parasitoid species of diamondback moths in Hawaii.

- Currently assessing the effects of trap crops, insectary plants, and living mulch on fitness costs in insecticide-resistant diamondback moths.

4. Conduct field trials to determine if factors that magnify fitness costs can accelerate the reversion of highly resistant populations back to susceptibility.

- Ongoing.

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

The cucurbit growers will have three alternative insecticides to use against melon flies, though we are still working on obtaining local registration. The cruciferous vegetable growers have been informed of suitable trap crops and insectary plants to combat insecticide-resistant diamondback moths.

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

The broader public has benefited from the project's activities as cruciferous vegetable growers may be able to reduce the numbers of insecticide treatments if the trap crops and insectary plants can reduce or at least delay the growth of diamondback moth populations. Once local registration is obtained for the alternative insecticides for melon fly control, the broader public may benefit from lower cucurbit prices as farmers should be able to obtain greater yields. For example, on the commercial farm where we conducted the field trial, our insecticide rotation increased the yield of marketable (uninfested) zucchini fruits from 51% to 97%.

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.

Dissemination:

- Research findings have been disseminated to extension agents at University of Hawaii at Manoa College of Tropical Agriculture and Human Resources, a group of producers through an IPM miniconference, and individual farmers through personal communications.

- Concepts and knowledge from the research have been transferred to undergraduate students at the University of Hawaii at Manoa (UHM) through the PI's courses, which include PEPS 363 General Entomology, PEPS 250 World of Insects and PEPS 421 Foundations in Pest Management.

- Concepts and knowledge from the research have been disseminated to graduate students at UHM through independent research projects and a graduate seminar course.

- An undergraduate student has learned the research concepts and methodologies through a summer research assistantship.

Training:

- One MS student graduated from the lab in 2021.

- Four MS students are currently being advised by PI Shikano.

- One undergraduate student from Colby College conducted research in the lab in summer of 2021.

Plan for next reporting period:

- Conduct field studies on the effectiveness of trap crops, insectary plants, and living mulch to control insecticide resistant diamondback moths.

- Develop a novel method to use a fungal pathogen to control melon flies.

- Assess spinosad resistance in five species of fruit flies in Hawaii.

Products:

Conference Presentations 2021

Shikano, I. (2021) Behavioral ecology in integrated pest management. Hawaiian Entomological Society Meeting. May 28. Virtual meeting (oral).

Shikano, I. (2021) Impact of the naturalized weed Virginia pepperweed (*Lepidium virginicum*) on the behavior of the diamondback moth (*Plutella xylostella*) and its parasitoid (*Cotesia plutellae*) in Hawaii. Entomology 2021; Annual Meeting of the Entomological Society of America. Oct. 31-Nov.3; Virtual Presentation. (oral)

Shikano, I. (2021) Parasitoids and weeds for diamondback moth management. Integrated Pest Management Mini Conference. University of Hawaii, College of Tropical Agriculture and Human Resources, Cooperative Extension. Sept. 28; Virtual Meeting. (oral)

Journal Articles Published 2021

Honsberger, D., Matsunaga, J.N., Wang, K.H. & **Shikano, I.** (2022) *Oomyzus sokolowskii* (Hymenoptera: Eulophidae) joins the small complex of parasitoids known to attack the diamondback moth on Kauai. *Proceedings of the Hawaiian Entomological Society* 54:21-25.

Hsu, J-C., Chou, M-Y., Mau, R.F.L., Maeda, C., **Shikano, I.**, Manoukis, N.C. & Vargas, R.I. (2021) Spinosad resistance in field populations of melon fly, *Zeugodacus cucurbitae* (Coquillett), in Hawaii. *Pest Management Science* 77:5439-5444.

Mogren, C.L. & **Shikano, I.** (2021) Microbiota, pathogens, and parasites as mediators of tritrophic interactions between insect herbivores, plants, and pollinators. *Journal of Invertebrate Pathology* 107589

Distributed Technologies for Improved Environmental Biosecurity

Project Director
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Results

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

The overall objective of this project is to develop innovative technologies to rapidly identify invasive organisms and microbial pathogens in the environment, and to implement control measures for these in otherwise inaccessible terrains.

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 made several iterative steps towards a low-cost embedded surveillance system for deployment in remote/distributed traps for automatically detecting catches of Coconut Rhinoceros Beetle (CRB). These prototypes included use of miniature/low cost imaging sensors and digital microphones interfaced to a wireless/WiFi / Bluetooth enabled microcontroller, and development of power regulation systems to enable remote power management with small rechargeable battery and photovoltaic panel. We developed simple wireless networks for communicating between a mesh array of these systems. We have continued to build up our libraries of imagery of CRB and other insects and materials commonly found in traps, in order to train Artificial Intelligence models to accurately and autonomously identify CRB catches to relay alerts to project personnel. We proposed, developed standard operating procedures and experiments, and evaluated numerous alternatives to enable precision spot treatment of pesticide sprays into palm crowns to kill boring CRB. For safety and to ensure accurate dosing it was strongly preferred that these approaches could be implemented using fully autonomous flight plans. Spray accuracies of automated plans were never sufficient for our application, so at the end of the project year we sent our aerial spraying platform back to the vendor for upgrade with "real time kinematic" corrections from a base station for improved (~ a few centimeters) positional accuracy, and to include integral downward facing camera (to supplement the existing forward facing camera), as well as addition of forward facing LIDAR to enable collision avoidance, and downward facing radar to enable contour following. For molecular diagnostics we focused on developing designs and fabrication processes for integrated disposable electrodes on a flexible polyimide substrate ("Flex" electrodes) including metallic conductor tracks to facilitate simple and stable "plug-in" connection to readout instrumentation, and variety of electroactive surfaces to support biosensors (laser inscribed graphene as well as integral silver/ silver chloride reference electrodes for analytical control or applied potential). We used these devices in preliminary testing to determine redesign requirements of our "ABE-Stat" instrument to support analysis of disposable electrode arrays for SARS-CoV-2 (COVID-19), and also for determination of hemoglobin A1C (used for estimating long-term average blood glucose levels to tune therapeutic approaches for controlling diabetes).

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

The target audience has benefited from some incremental advances towards implementation of remote surveillance methods for invasive plants and insects, to enable more affordable and effective control operations, and has also benefited from advancement of open source instrumentation and molecular methods to enable molecular diagnostics that can be used to improve food safety and the biosecurity of agricultural production.

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

The broader public has benefited from this project as the technologies can support more effective and affordable conservation efforts, as well as the sustainability of food production.

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

Journal Articles Published 2021

McLamore, E. S., E. Alocilja, C. Gomes, S. Gunasekaran, D. M. Jenkins, Y. Li, Y. Mao, S. R. Nugen, J. Reyes-de-Corcuera, P. Takhistov, O. Tsyusko, J.P. Cochran, T-R. Tzeng, J-Y. Yoon, C. Yu, and A. Zhou. 2021. FEAST of biosensors: Food, environmental and agricultural sensing technologies (FEAST) in North America. Biosensors and Bioelectronics. V178, 4/15/21, 113011. https://doi.org/10.1016/j.bios.2021.113011

Diaz, L. M., Y. Li, and D. M. Jenkins. 2021. Chemical stabilization of dispersed *Escherichia coli* for enhanced recovery with a handheld electroflotation system and detection by Loop-mediated Isothermal AMPlification. PLoS One 16(1) e0244956.https://doi.org/10.1371/journal.pone.0244956

Diaz, L. M., B. E. Lee, and D. M. Jenkins. 2021. Real-time optical analysis of a colorimetric LAMP assay for SARS-CoV-2 in saliva with a handheld instrument improves accuracy compared to endpoint assessment.Invited manuscript for special September issue on LAMP for SARS-CoV-2. J Biomol Tech. 2021 Sep; 32(3): 158–171. DOI: 10.7171/jbt.21-3203-011

Pathogenicity Mechanisms and Control of Economically Important Plant Pathogenic Oomycetes

Project Director

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Results

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

Oomycete plant pathogens, such as basil downy mildew pathogen *Peronospora belbahrii*, and *Phytophthora palmivora* that infects a wide range of plant species, including papaya and cacao to cause *Phytophthora* blight of papaya and black pod rot of cacao, severely threaten agricultural production and food security. The current disease control measures are insufficient, in part due to the lack of understanding on the molecular mechanisms of pathogen infection and plant resistance/susceptibility. This project is to identify the targets of effective genetic and chemical control by identifying and characterizing pathogen and plant genes that play key roles in plant disease or resistance, and meanwhile to develop effective disease control strategies.

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.

Growing disease-resistant varieties is one of the most effective ways to control basil downy mildew. To generate downy mildew-resistant sweet basil and understand the molecular basis of basil-*Peronospora belbahrii* interactions, we previously generated transgenic plants expressing a putative resistance-related gene Oblectin1in a suscptible cultivar, and genome-edited plants with basil candidate susceptibility (*S*) genes *ObDMR1* or *ObDMR6* mutated using CRISPR/Cas9 technology.

For transgenic plants expressing Oblectin 1, we selected four T0 lines with relatively high expression of transgene and obtained homozygous T2 seeds during the last project period. During this project period, we performed pathogen infection assays to evaluate the level of resistance. We inoculated four T2 lines, and evaluated disease development by quantifying pathogen biomass at 4 days post inoculation (dpi) and observing disease symptoms. Comparing to the wild-type (WT), significant reduction in pathogen biomass was detected for all four T2 transgenic lines. Disease symptoms, such as chlorosis and tissue collapse, were clearly visible in all inoculated plants after 15 dpi, but developed later in T2 transgenic lines compared to WT. Altogether, these results demonstrated that ectopically expressing Oblectin 1 in a susceptible cultivar enhanced resistance to *P. belbahrii*, but the resistance was not able to provide complete protection from this pathogen under the infection conditions we applied.

For generation of downy mildew resistance using CRISPR/Cas9 technology, previously we obtained T2 seeds from transgene-free complete knockout T1 plants and evaluated disease resistance in lab conditions. Although we did not obtain conclusive results on *ObDMR1* mutants, for *ObDMR6* mutants, we consistently observed significantly reduced pathogen biomass and sporangial production in repeated experiments, suggesting that mutation of *ObDMR6* enhances downy mildew resistance. During this project period, we have written and published the results on the generation and disease resistance of *ObDMR6* mutants in a peer-reviewed journal. We explored the permit conditions and regulatory requirements for a potential field trial to evaluate the resistance under field conditions with natural inocula.

To identify *P. palmivora* genes that play key roles in pathogenesis and understand the underlying mechanisms, we mainly focused on determining the role of an RxLR effector, PpalRxLR1, in pathogenicity of *P. palmivora* on cacao during this project period. PpalRxLR1 and two close homologs PpalRxLR1-h1 and PpalRxLR1-h2 were found in the genomes of multiple cacao isolates examined, but not in the two papaya isolates investigated. We used CRISPR/Cas9 gene editing to generate PalRxLR1 mutations in a *P. palmivora* cacao isolate collected in Hawaii. We identified three single-zoospore derived mutants, each with PpalRxLR1 completely mutated. When inoculating the wild type (WT) and mutant *P. palmivora* strains side-by-side on cacao pods, all three mutants either entirely failed to infect or only developed tiny lesions at the inoculation sites, while the WT strain infected successfully at the majority of inoculation sites and rapidly developed large lesions. These data suggest that PpalRxLR1 plays a crucial role in contributing to pathogenicity of *P. palmivora* on cacao.

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

Our research on basil downy mildew has been published in an open-access peer-reviewed journal, and presented in ASPB annual meeting. It has led to collaborations with multiple research groups, including a vegetable plant pathology group in North Carolina State University, a USDA scientist based in Illinois, three scientists in Israel. The knowledge and protocols

generated from our research have been shared with them to advance their research. The collaborations have produced three conference presentations and one peer-reviewed publication, and a collaborative grant application to US-Israel Binational Research and Development Fund (BARD).

The research on gene-editing of *ObDMR6* also attracted interest from a seed company, who discussed with us for a potential collaboration to further characterize the mutant lines for potential commercialization.

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

The impact on the broader public is hard to measure. However, we do know that our research has reached a broader public. For example, a college student from Santa Fe College in Florida contacted me for the materials and protocols regarding the sweet basil gene editing system we established, with which they will perform a group science project for their plant biotech class.

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 list of conference presentations:

Hasley J. A. R. and Tian M. (2021) CRISPR/Cas9-mediated mutagenesis of multi-copy sweet basil candidate susceptibility gene *ObDMR6* enhances downy mildew resistance. ASPB Annual meeting 2021 abstract.

Johnson E. T., Doehring M., Kim H. S., Tian M., Gonda I., and Dudai N. (2021) Dual transcriptome analysis of the susceptible interaction between basil and *Peronospora belbahrii*. (Abstr.) Phytopathology 111: S2.36. https://doi.org/10.1094/PHYTO-111-10-S2.36

Standish J. R., Bowman M. J., Childs K. L., Tian M., Quesada L. M. (2021) Development and validation of *Peronospora belbahrii*-specific diagnostic markers. (Abstr.) Phytopathology 111: S1.5. https://doi.org/10.1094/PHYTO-111-9-S1.5

Standish J. R., Bowman M. J., Childs K. L., Tian M., Quesada L. M. (2021) Developing a probe-based real-time quantitative PCR assay to detect *Peronospora belbahrii* using species-specific diagnostic markers. Phytopathology 111: S2.113. https://doi.org/10.1094/PHYTO-111-10-S2.113

A list of publications:

Hasley J. A. R., Navet N., Tian M. (2021) CRISPR/Cas9-mediated mutagenesis of sweet basil candidate susceptibility gene *ObDMR6* enhances downy mildew resistance. PLoS One,16(6): e0253245. doi: 10.1371/journal.pone.0253245.

Johnson E. T., Kim H. S., Tian M., Dudai N., Tal O., Gonda I. (2022) Dual transcriptional analysis of *Ocimum basilicum* and *Peronospora belbahrii* in susceptible interactions. Plant Gene, 29:100350. https://doi.org/10.1016/j.plgene.2021.100350

Closing Out (end date 09/07/2023)

Characterization and Management of Emerging Plant Virus Diseases in Hawaii

Project Director
John Hu
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University of Hawaii System
Accession Number
1016982

Results

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

Pineapple (*Ananas comosus*) is a monocotyledonous tropical crop with an edible fruit native to South and Central America. Mealybug wilt disease of pineapple (MWP) was first described in Hawaii in 1910 and has contributed to yield reductions in pineapple-growing countries around the world. To date, ampeloviruses infecting pineapple and found to be associated with MWP include three recognized members designated as pineapple mealybug wilt-associated virus-1 (PMWaV-1), -2 (PMWaV-2), and -3 (PMWaV-3), and one proposed putative member PMWaV-5.

The etiology of MWP is not fully understood but appears to be associated with the presence of certain viruses, mealybugs as vectors, ants that protect mealybugs and favor spread, and environmental factors. PMWaV-2 together with active mealybug feeding have been shown to play a role in the etiology of MWP in Hawaii, whereas pineapple plants infected with PMWaV-1 or PMWaV-2, or both, without observed mealybug feeding appear not to develop symptoms. PMWaV-2 has been strongly associated with MWP symptoms in Hawaii, Cuba, and recently in Brazil. By contrast, in Australia, induction of MWP is correlated with mixed infections by either PMWaV-1 and PMWaV-3 or single infections with PMWaV-3, but less frequently with PMWaV-2. Additionally, other viruses belonging to the *Badnavirus*and *Sadwavirus* genera that infect pineapple may also be involved with MWP.

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.

High-throughput sequencing was conducted to characterize a new virus identified in symptomatic pineapple plants and tentatively named pineapple mealybug wilt-associated virus 6 (PMWaV-6). Data analyses revealed a genome of 17,854 nucleotides with an organization resembling members of the genus *Ampelovirus*, family *Closteroviridae.* Encoded proteins shared sequence identity with the corresponding proteins of grapevine leafroll-associated virus 3, blackberry vein banding-associated virus, and PMWaV-2. The present study includes the discovery of PMWaV-6, a putative and distinct new member of the genus *Ampelovirus*, subgroup I, its potential involvement in MWP, and the development of PMWaV-6-specific RT-PCR assays to detect and monitor this virus in field samples.

The complete genome sequence of a member of a novel species of *Sadwavirus* (family *Secoviridae*) infecting pineapple on the island of Oahu, Hawaii was determined by high throughput sequencing. The genome comprised two RNA molecules of 5,958 nt and 3,922 nt in length, excluding the poly-A tails at the 3' end and each encoding a single large polyprotein. The RNA-1 polyprotein contained five conserved domains, all associated with replication, while the RNA-2 polyprotein is cleaved into the movement protein and coat protein. Analysis of the Pro-Pol region revealed less than 75% amino acid identity with pineapple sect virus A, chocolate lily virus A, and Dioscorea mosaic-associated virus, all members and candidate members of the proposed subgenus *Cholivirus.* Two specific primer sets derived from HTS data were used in RT-PCR assays, confirming the presence of this new virus infecting pineapple. The name "pineapple secovirus B" is proposed for this putative new virus.

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

Using the extremely specific and ultrasensitive assays developed in this study, we were able to help Hawaii's pineapple industry and the USDA ARS germplasm repository to detect the new viruses from their pineapple plants.

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

Mealybug wilt of pineapple (MWP) is the most important and complex viral disease affecting pineapple worldwide. The identification and characterization of new viruses from diseased pineapple plants will provide new opportunities to develop effective strategies to control this pineapple disease worldwide.

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.

Alejandro Olmedo Velarde, Philip Waisen, Alexandra T. Kong, Koon Hui Wang, John S. Hu, and Michael J Melzer 2021. Characterization of taro reovirus and its status in taro (Colocasia esculenta) germplasm from the Pacific. Archives of Virology DOI: 10.1007/s00705-021-05108-9

Alejandro Olmedo-Velarde, John Hu, Michael J. Melzer 2021 A Virus Infecting Hibiscus rosa-sinensis Represents an Evolutionary Link Between Cileviruses and Higreviruses. Frontiers in Microbiology https://doi.org/10.3389/fmicb.2021.660237

Adriana Larrea-Sarmiento, Alejandro Olmedo-Velarde, Xupeng Wang, Wayne Borth, Tracie K Matsumoto, Jon Y Suzuki, Marisa M Wall, Michael Melzer, John Hu 2021, Nnovel ampelovirus associated with mealybug wilt of pineapple (Ananas comosus var. comosus). Virus Genes https://doi.org/10.1007/s11262-021-01852-x

Xupeng Wang, Alejandro Olmedo-Velarde, Adriana Larrea-Sarmiento, Anne E. Simon, Alexandra Kong, Wayne Borth, Jon Y Suzuki, Marisa M Wall, John Hu, Michael Melzer 2021. Genome characterization of fig umbra-like virus. Virus Genes https://doi.org/10.1007/s11262-021-01867-4

Current Invasive Pest Concerns and Research in Hawaii

Project Director
Jeffery Goodwin
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Accession Number
7000810

Coffee Berry Borer Area-Wide Management

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

The Situation

The coffee berry borer (CBB) is an insect pest that was first detected in Hawai'i in 2010, resulting in dramatically reduced production of high-quality coffee for which Hawai'i is known. Basic questions about the timing of control methods and monitoring pest populations were unknown at that time without basic research on the CBB beetles in Hawai'i. The Coffee Berry Borer Area-Wide (CBB AW) Project received funding to study CBB and develop options for integrated pest management (IPM). Many farmers and researchers cooperated to gather data and develop effective control measures to prevent loss of quality and yield.

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

Extension's Response

UH CTAHR researchers and Extension personnel, researchers from the USDA ARS DKI Pacific Basin Agricultural Research Center (PBARC), and local farmers evaluated control methods that were effective in other coffee growing regions in which CBB was found. They learned how to monitor farms for CBB activity and use IPM methods to minimize CBB populations. One example of recommended IPM methods is to spray plants with a commercially available biocontrol agent, a fungus that can kill CBB. Another technique is to remove all remaining coffee berries at the end of harvest season because CBB populations reproduce in these berries and later emerge to infect new coffee crops. The teamwork among CTAHR, PBARC, and growers resulted in significant control of CBB in Hawai'i through research and outreach

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

Impacts

Prior to implementation of the CBB AW Project in 2017, research and Extension efforts to control CBB using IPM methods were restricted due to limited funding. The estimated revenue increased due to implementation of IPM, from $0 in 2010 to $2,984 per acre in 2016. After 2017, the estimated revenue due to IPM implementation increased, from $3,359 in 2017 to $5,350 per acre in 2020e- an indication of the effectiveness of the CBB AW project. During the 2021-2022 season in Hawai'i, coffee was grown on 7,100 acres, with a value of more than $60,000,000 (NASS, 2022, ISSN: 2471-6812). **An estimate of the economic benefit from CBB management during 2017-2020 in Hawai'i is $132,000,000.**

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

The coffee industry still has challenges from CBB and now, coffee leaf rust is also a problem. Timely information through the integration of research and Extension will provide growers with IPM tools to sustain coffee production in Hawai'i.

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

There are many agencies in Hawaii with overlapping agenda related to invasive species. CTAHR with its solid research backbone and robust extension network should play a lead role in coordinating and integrating this group, for communication on current invasive pest concerns in Hawaii. This can take place in the form of regular working group meetings, mini- conference, and long-term annual events.

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 total of six virtual Invasive Pest Mini-Conference were organized. This is a half-day mini-conference comprising 4-6 talks per session, focusing on current invasive pest concerns delivered by experts speakers.

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

Short-term Impact (Learning):

There was a significant impact of the mini-conferences with:

- 77% of participants reporting that the resources presented in the mini-conferences were helpful for educators/extension personnel to develop extension programs in invasive pest management,

- 81% reporting that the resources were helpful for researchers to develop and prioritize research programs on invasive pest management.

Mid-term Impact (Action):

Out of 98 participants in one mini-conference:

- 45% reported that they would definitely use the information to minimize the spread,

- 21% reported that they would use it for implementing rapid responses and 14% reported that they would use it for implementing IPM of invasive pests.

Long-term Impact (Planned Change in Social, Economic, Civic, or Environmental Conditions):

This bimonthly Invasive Pest Mini-Conference has been established as a regular CTAHR extension program. The mean attendance in the last 6 mini-conference was 59 and was attended by 292 different participants from Hawaii, including the USA mainland and a few internationally. This mini-conference will become the most popular forum for communicating the most current research on invasive pest management statewide. 90% of participants improved knowledge and implement techniques delivered in the mini-conference to manage invasive pests in their capacity and role.

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

This project helps educators/outreach/extension personnel to develop extension programs in invasive pest management; researchers to develop and prioritize research programs on invasive pest management and response planners to implement response activity to manage invasive pests in Hawaii.

Diversified Tropical Agricultural Systems

Extension Programs Supporting Ag and Ornamental Crop Production

Project Director
Jeffery Goodwin
Organization
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Accession Number
7000119

Evolution of Screenhouses in Hawai'i Agriculture

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

Using EcoSystem enhancement to manage a broad spectrum of crop pests for sustainable farming operations.Hawai'i agriculture must enlist technology to increase production levels of various crops and commodities and in turn, increase the profitability for producers.

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

CTAHR's Cooperative Extension Service (CES) has been designing and testing screenhouses best adapted for managing insect pests, especially those that develop resistance to common crop protection insecticides. Screenhouses serve as a non-chemical, physical barrier which puts the pest at a disadvantage.

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

Growers can see a 50% reduction in insecticide use for management of small insect pests, such as fruit flies, caterpillar aphids, whiteflies, and thrips. With the use of screenhouse systems, CES research trials have documented up to a five-fold increase in marketable yields in the production of (non-pollinated) cucumber, kale, and zucchini. The addition of the "Ecosystem Enhanced Screenhouse" method, which integrates insectary plants that attract beneficial insects inside the screenhouse, can generate even higher crop yields. Note: In some trials, cucumber marketable yields increased seven-fold compared to cucumbers grown outside of the screenhouse.

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

Long-Term Impacts

Since 2014, CES has been evaluating different prototypes of screenhouses (DIY vs commercial systems), and has placed roughly 24 screenhouses on a wide range of farming systems in Hawai'i. Applied research findings have been shared statewide and in partnership with external agencies. CES has also collaborated closely with the USDA and NRCS to showcase the advantages of integrating screen with high-tunnel systems for environmental conservation. To date, NRCS has contracted for the installation of 187 commercial high tunnels in Hawai'i through federal cost share programs. The adoption of this technology has resulted in a magnified footprint of food production across the state.

Sustainable Pest and Soil Health Management Approaches Using Cover Crops and Other Non-chemical Based Pest Management Strategies

Project Director
Koon-Hui Wang
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University of Hawaii System
Accession Number
1020597

Results

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

Based on Hawaii Census of Agriculture 2017 (HDOA, 2019), although the total number of farms in Hawaii increased by 5% since 2012, the market value dropped by 14.7%, in part due to the end of the sugar operations and the decline in the seed corn value in Hawaii. As market value dropped and farm operation shifted to small-scale farming, new farms in Hawaii shifted to farming with less input with a decrease in total farming expense of 12.7%. More and more farmers expressed great interest to improve soil and ecosystem health (pesticide and fertilizer inputs were reduced 46.3% and 31.8%, respectively; irrigated land decreased by 44.4%). Among the 7,328 farms in Hawaii, only 201 farms reported using cover crops (NASS 2017). The overall goal of this project is to reduce pesticides and synthetic fertilizer inputs and promote water and soil conservation practices in Hawaii.

In terms of specific pest problem, diamondback moth (DBM) is a recurring pest on cruciferous crops, with a well-documented propensity to develop insecticide resistance, especially threatening cole crop (head cabbage, kale) production in Hawaii.

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

During FY 2021, my activities to achieve each of the goals and objectives listed in my non-technical summary are described below:

Objective 1: Promoting the use of a cover crop calculator for nitrogen and soil health management.

Throughout FY2021, I presented talks that included how the use of a cover crop calculator to estimate plant available nitrogen from growing cover crops to 4 cohorts of GoFarm Hawaii new farmers (this is reaching out to 48 new farmers). In addition, I worked with Oahu Resource Conservation & Development Council (Oahu RC&D) on their annual Together We Farm: Hawaii Women Farmer's Network in collaboration with CTAHR Extension Agent, Joshua Silva. We generated a workshop to go through with the 12 participants at the workshop with demonstration trials of how the use of Cover Crop Calculator reduced fertilizer inputs to half of what the farmers normally used and did not reduce the yield of their crops. In collaboration with Kahumana Farm in Waianae, the workshop was filmed and posted at Oahu RC&D YouTube Channel. These are resources for all Oahu RC&D field staff to promote soil conservation practices. In addition, I also narrated a Cover Crop Lecture for Together We Farm Online Learning Platform. Oahu ACA.tovuti.io. At least two commercial farms adopted fertilizer cut back using the Cover Crop Calculator for plant-available Nitrogen.

Objective 2: Encouraging the use of cover crops and reducing tillage for plant and soil health management.

A total of 5 outreach presentations were delivered to farmers, 3 oral presentations were presented at Scientific Conference (Society of Nematologists) or regional meetings for MultiState (NE1640) project, and 5 education talks invited by NRCS, UC Davis Plant Pathology Department, and Environmental Legislative Caucus (Lisa Marten) were presented to promote conservation tillage and cover cropping. We completed 2 field trials in 2021 to demonstrate the use of sorghum/sorghum-sudangrass hybrids in no-ill vs low till system could improve soil health and water conservation compared to conventional farming practice of till and bare fallow. A peer reviewed publication was generated to depict the close relationship between soil health indicators with soil water conservation properties (soil organic matter, soil moisture over an entire cropping season, microbial biomass). In 2021, the PI had consulted > 20 farmers referred by Koolau Seed Supplies (local cover crop seeds distributor) on what cover crops to use for weeds and soil health management. At the end of FY 2021, two new soil conservation related grants were funded to PI Wang from NRCS and NIFA OREI to continue this line of work. One was granted by NRCS CIG grant to develop "*Cover crop mix for orchard or trellis fruit and vegetable crops: Better soil health and weed management in Hawaii*" and another by NIFA OREI (Organic Research and Education Initiative Grant) for "*Organic sweetpotato IPM and soil health management for small- and mid-size farms*".

Objective 3: Show case non-chemical based integrated pest management plans against arthropod pests in particular on the use of insectary plants.

Two graduate students completed a CTAHR Team Science Concept Note Project entitled "*Insecticide resistance management for diamondback moths in organic farms: from manipulating insect behavior and biological control to push and pull strategies*". Two extension articles were published through Haina'Ai Newsletter. From these studies, we found that foliar spray of a locally isolated entomopathogenic nematode (EPN), *Steinernema feltiae* MG14, twice during a 5-week examination period on kale, suppressed 87% of DBM before it reached the economic threshold. However, EPN treatment was not effective

when DBM exceeded the economic threshold of 0.5/plant. Most effectively, when we planted 'Hirayama' kai choi as a trap crop bordering the cash crop, it consistently reduced the numbers of DBM on kale and head cabbage by 46% in two field trials regardless of DBM population densities. However, these trials were conducted in commercial organic farmers that integrate trap cropping with their standard biopesticide, Bt, application (Budhathoki et al., 2020). In addition, intermittent sprinkler irrigation (ISI) to deter the DBM away from the cash crop was also evaluated. Results showed that ISI at dusk disrupted the feeding damage of DBM only by 19%, but daytime ISI would reduce feeding damage of another insect pest of cole crops, the imported cabbage worms (ICW). Thus, we provided multiple non-chemical approaches for organic cruciferous crop producers to overcome DBM and ICW damage. Multiple manuscripts are under development from this project with some submitted and pending on review.

Objective 4: Develop an ecological friendly DIY screenhouse by integrating turn-the-page weed exclusion, biofumigation against nematode pests, organic mulching or companion (with insectary purposes) planting against arthropod pests.

Tremendous activities were accomplished on this objective in previous years' report and lead to a recognition from Agweb Farm Journal's "Farm Journal Monthly Story" in 2020. We continued to help the community in 2021. In particular, CTAHR Student Organic Farm Training (SOFT) garden consulted us to build another screenhouse using the DIY protocol we published. SOFT Garden coordinator, Eric Collier commented "very easy to follow protocol for DIY screenhouse, students constructed the screenhouse without the PI's team coming out to install it".

Objective 5: Reinoculating agriculturally disturbed soil with beneficial soil microorganisms through soil amendment or inundative inoculation to improve soil suppressiveness to soil-borne pathogens.

We completed an NRCS CIG funded project in 2021, and published two extension articles, hosted a Virtual Soil Health and Sustainable IPM Mini Conference, presented one conference paper at the 2021 Society of Nematologists annual meeting. We worked with three commercial farms with a long history of soil-borne disease problems on lettuce (Fusarium wilt), banana (Panama wilt) and asparagus (crown and root rot). We learned from all three cropping systems that managing soil health with organic amendments whether it has biofumigation properties or whether it is chitin based could lead to reduction of soil-borne Fusarium incidence. Biofumigation with brown mustard is more effective if the plant tissues were macerated followed by soil incorporation and covered with black or solarization plastic for only 1 week. However, disease suppression of biofumigation was never as effective as soil fumigation with synthetic fumigants like Vapam. None-the-less, farmers recognize the urgent need to prepare for alternatives to soil fumigants.

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

These project's activities are well received by our target audience. A survey was conducted following a Soil Health and IPM Mini-conference where most of the participants were small-scale and beginning farmers. Majority of the participants are looking for on-farm resources to manage soilborne disease problems. They are particularly interested in using cover crops that have biofumigation properties and have desire to look for effective on-farm resources to manage soil-borne fungal diseases. They find study on post-plant soil health management technique using biofumigation or chitin-base organic amendment on asparagus very informative as an example to manage other soil-borne disease problem on a long-term crop. Since we published our findings soon after we completed each field trial in CTAHR publications or Haina'Ai newsletter, many farmers have immediate access to these findings as they are subscribers to Haina'Ai or CTAHR Extension Agents' announcement list. PI Wang also created a YouTube Channel to post any videos related to this hatch project and they are searchable whenever someone is looking for specific information. All these studies also generated firsthand experience we can share with farmers during our GoFarm Hawaii guest lecture series, presentations to legislators, NRCS workers, scientists at conferences or agriculture students. We continue to maintain the Sustainable Pest Management website with updated publications or video lists. During one of the Soil Health and IPM Mini-conference presentations, we summarized and compared the cost of different soil amendment, cover cropping or biofumigation practices to yield loss if farmers do not manage soil health or soil-borne disease problem. Oahu Conservation District and local cover crop seed distributors are also frequently referring to my project website or sending e-mail to me when their clients ask information about benefits of different cover crops suitable for the tropic.

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

Based on NRCS Pacific Island Area (PIA) contracted and conservation plan record (e.g. EQIP, AMA, CTA, CSP), between 2014 and 2020, there was a 1.2-fold increase in planned cover crop conservation acreages, and 3.11-fold increase in planned and applied cover crop conservation acreages in Hawaii. This has resulted in 1,957 acres (268 contracts/plans) of cover crop installed by producers in Hawaii for FY 2020. Replenishing soil in the tropics with soil building cover crops is especially important in Hawaii as the warm climate all year round tends to deplete soil organic matter much quicker than the MidWest. Conserving soil health could lead to better water conservation as shown in our multivariate analysis. Farmlands ae the biggest

consumption of water usage. Better management of soil water conservation will prepare Hawaii farmers better for the climate change. If farmers in Hawaii can be more successful in reducing farm inputs to generate local produce, we can make local food more competitive with imported food. If we can increase the revenue from agriculture, Hawaii can be more self-sustainable. Thus, more food and job security for Hawaii residents.

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 described how we disseminated findings for each Objective earlier. Here is an overall list of output generated in 2021.

Peer reviewed publication

1. Silvasy, T., A.A. Ahmad, K.-H. Wang, T.J.K. Radovich. 2021. Rate and timing of meat and bone meal applications influence growth, yield and soil water nitrate concentrations in sweet corn production. MDPI-Agronomy 11: 2945 (https://www.mdpi.com/2073-4395/11/10/1945/pdf).

2. Paudel, R., P. Waisen, and K.-H. Wang. 2021. Exploiting the innate potential of sorghum/sorghum–sudangrass cover crops to improve soil microbial profile that can lead to suppression of plant-parasitic nematodes. MDPI-Microorganisms 9:1831 https://doi.org/10.3390/microorganisms9091831

3. Waisen, P., Z. Cheng, B. S. Sipes, and K.-H. Wang. 2021. Biofumigation effects of brassicaceus cover crops on soil health in cucurbit agroecosystems. Pedosphere (accepted 6/5/2021; Manuscript ID pedos202010638).

Graduate Student Thesis

Budhathoki, S. 2021. Strategies to enhance efficacy of entomopathogenic nematodes against diamondback moth (Plutella xylostella) and imported cabbageworm (Pieris rapae). M.S. Thesis. Tropical Plant Pathology Graduate Program, University of Hawaii at Manoa, Honolulu, HI. June 24, 2021

Extension Publications

Paudel, R., S. Budhathoki, and K.-H. Wang. 2021. Revitalized degraded soil in the tropic with energy sorghum. https://myemail.constantcontact.com/The-Latest-H-nai-Ai-News---April---May---June-2021-Volume-42.html?soid=1102675671876&aid=F9Y1OK_qJKk.

Catherman, H., K.-H. Wang, R. Paudel, S. Budhathoki, and C. Mogren. 2021. Pigeon pea: A multipurpose N-fixing border crop. https://myemail.constantcontact.com/The-Latest-H-nai-Ai-News---April---May---June-2021-Volume-42.html?soid=1102675671876&aid=F9Y1OK_qJKk

Wang, K.-H., S. Budhathoki, M. Pugh, I. Shikano, J. Silva, J. Uyeda and R. Manandhar. 2021. Insecticide resistance management for diamondback moth in organic farms: Integration of trap cropping, intermittent sprinkler irrigation and biological control. H?nai?Ai Newsletter Jan-Mar, 2021. https://gms.ctahr.hawaii.edu/gs/handler/getmedia.ashx?moid=67939&dt=3&g=12

YouTube Videos

Paudel, R., S. Budhathoki and K.-H. Wang. 2021. Revitalized degraded soil in the tropic with energy sorghum (https://www.youtube.com/watch?v=hbCSWttx8_A&t=16s).

Catherman, H., K.-H. Wang, R. Paudel, S. Budhathoki, and C. Mogren. 2021. Pigeon pea: a multipurpose N-fixing border crop.

Invited SPEAKERS

1. Wang, K.-H. 2021. Cover Cropping and Conservation Tillage. Working Effectively with Organic Producers – Pacific Island Area. September 27-30, 2021, from 11:30-2:30 HST each day [virtual learning] (Organized by Amy Koch, 30 participants, a combination of NRCS and partner (SWCD, ORCD) employees.

2. Wang, K.-H. 2021. Regenerative Agriculture and Carbon Capture: Cover Cropping and Conservation Tillage. Environmental Legislative Caucus Meeting. Aug 30, 2021 (organized by Representative Lisa Marten; 30 participants).

3. Wang, K.-H. 2021. Pest management resources in Hawaii. PIA Pest Management Considerations in Conservation Planning JAA Training (through Webex), July 27, 2021 (35 participants) organized by Jason Hanson and Giulio Ferruzzi.

4. Wang, K.-H. 2021. Pest management for orchid gardeners. The Central Ohio Orchid Society (COOS) monthly meeting (through zoom), June 17, 2021 (28 participants), organized by Tracy Strombotne.

5. Wang, K.-H. 2021. Ecological & Sustainable Nematode Management. NRCS Conversations on Soil Health: Nematode Management and Cover Crops (Adobe Acrobat on-line event), June 17, 2021 (75 participants-NRCS Staff), Organized by Rachel Seman-Varner, Ph.D.

6. Wang, K.-H. 2021. Managing plant-parasitic nematodes in agroecosystems through cover cropping or biological derived products. University of California at Davis, Department of Plant Pathology Seminar. Zoom. Jan 25, 2021 (Coordinator: Dr. Ioannis Stergiopoulos, Attendance: ~60).

7. *Wang, K.-H.* 2021. Cover crop on-line training for 'Together We Farm'. Tovuti online platform. Oahu Agriculture and Conservation Association (Organizer: Michelle Gorham).

Conference Presentations

1. *Wang, K.-H., Waisen, P., R. Paudel, S. Budhathoki and J. Uyeda. 2021. Relationships between nematode community and incidence of asparagus crown and root rot. Society of Nematologists Annual Conference, Sep 12-15, 2021.*

2. *Budhathoki, S., and K.-H. Wang. 2021. Strategies to enhance the efficacy of entomopathogenic nematodes for the management of diamondback moth and imported cabbageworm. Society of Nematologists Annual Conference, Sep 12-15, 2021.*

3. *Paudel, R. and K.-H. Wang, Screening sorghum/sorghum-sudangrass hybrids for allelopathic effects against root-knot nematodes and their potential for soil health management in a no-till agroecosystem. Society of Nematologists Annual Conference, Sep 12-15, 2021.*

Public Media

Teruya, L. How the hunt for the perfect sweet potato may help Hawaii farmers. Civil Beat, Hawaii Grown (October 18, 2021). https://www.civilbeat.org/2021/10/how-the-hunt-for-the-perfect-sweet-potato-may-help-hawaii-farmers/

Outreach

1. Paudel, R. and K.-H. Wang. Benefits of cover crops for water conservation. Sustainable and Organic Agriculture Program (SOAP) Mini-Conference. Oct 28, 2021 (37 participants).

2. Uyeda, J. and K.-H. Wang. Co-organized for "Virtual Soil Health and Sustainable IPM Mini Conference". Sep 28, 2021 (60 participants).

- Wang, K.-H., and Uyeda, J. Avocado lace bug management.

- Budhathoki, S. R. Paudel, J. Mew, K.-H. Wang. Vegetative Propagation of Papaya Video

- Wang, K.-H., J. Silva, L. Braley, S. Nakamoto. Papaya seed for biofumigation.

1. Wang, K.-H., J. Silva, and C. Zuckerman. 2021. Integrating cover crops and organic fertilizers into your nutrient management regime to meet your farm's soil health goals. Hawaii Women Farmer's Network: Soil Health Workshop Four-Part Series. Kahumana Organic Farm, June 15, 2021 (12 participants), organized by India Clark, Oahu Resource Conservation and Development Council.

2. Wang, K.-H., C. Mogren, J. Silva, J. Uyeda. 2021. The science behind cover cropping. Oahu County Cooperative Extension's Research in the Garden Series. Urban Garden Center, May 27, 2021. Organized by J. Sugano (30 participants).

3. Wang, K.-H. 2021. Together We Farm Online Learning Platform. Oahu ACA.tovuti.io

4. Wang, K.-H. 2021. Natural Farming in Hawaii. AP Environmental Science class, Mililani High School. Jan 19, 2021 (for two sessions, total of 21+28 participants; Instructor: Jennifer Kuwahara).

Future plans

As mentioned, we are funded by NRCS and OREI in 2021. We will continue soil health and non-chemical approaches needed for 1) tree crops using permanent ground cover crop; 2) sweet potato.

Evaluation of Alternate Crops and Non-conventional Production Techniques

Project Director
Stuart Nakamoto
Organization
University of Hawaii System
Accession Number
1021037

Results

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

The goal of this umbrella project is to develop combinations of new crops, crop products and crop management techniques for Hawaii, to be tested and demonstrated in small-scale, exploratory plantings. This will help to diversify producer's operations, and allow producers to better manage their risks and increase farm profitability. This umbrella product will enhance the financial sustainability of farmers and their operations, farm families, and their communities.

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.

Objectives:
1. Screen potential crops and crop products for production in Hawaii. The crop might be one currently being grown, or a new crop for commercial production in Hawaii, to be paired with selected crop management techniques.
2. Test and demonstrate non-conventional crop management techniques. The combination of crop and technique will be new for Hawaii.
3. Train the trainer. The notion that operating in an isolated environment creates a knowledge and information vacuum will be addressed at two levels.
a. Research plots and associated activities will provide opportunities for interaction among agents, specialists, and

researchers on a regular basis. The opportunities include the ability of recently hired faculty to learn by observation and participation with more experienced colleagues.
b. Common interests fostered by project activities will be used as the basis for broader professional development activities including invited speakers/presenters or travel to conferences and educational tours. Other funding is used for this group of activities.

New crops including crop products and methods to deal with new challenges, can help producers to better manage existing crops, diversify their operations and increase profitability. This umbrella project encompasses activities that enhance the financial stability of farmers, their families, and their communities. We tested new ideas and shared the results with growers for several crops.

A. Blueberries. Our previous research concluded that containerized production under cover is necessary to produce this fruit in Hawaii because of extreme, year round disease pressure from blueberry rust, Pucciniastrum vaccinii. As previously reported, on-station research was terminated due to resource constraints. Outreach and applied research on pest control and pruning to manage timing of fruit production had continued with an industry cooperator, but formal collaboration ended with the retirement of project personnel.

B. Coffee (separately funded projects).
CLR. In October 2020, Coffee Leaf Rust (CLR), Hemileia vastatrix, was discovered in Hawaii. This is the most devastating disease of coffee worldwide that if untreated, will cause yield losses of 30%+ and eventual tree death. Management of CLR in Hawaii will be extremely challenging; available labelled pesticides will suppress, but not kill CLR, and only if applied when less than 5% of leaves are infected. The accepted long-term strategy for CLR management centers on replacing orchards with coffee varieties that are resistant to the specific race(s) of CLR in Hawaii. The process includes identifying the CLR race, finding the appropriate CLR-resistant varieties and testing for suitability to Hawaii conditions and consumer acceptability, importing plant material into the U.S. and Hawaii, obtaining sufficient quantities of plants, replacing and re-establishing orchards.

This process will take many years. In the interim, the challenge is to adapt appropriate strategies from other coffee-producing regions and educate industry in their use, further complicated by the many non-English speaking growers and industry workers. Six publications were produced with several others in process, and most of more than 50 extension events involved CLR and/or coffee.

Coffee Berry Borer (CBB) Hypothenemus hampei. Previous research by the economics component of the Area Wide Coffee Berry Borer project developed two economic decision models for CBB management which in turn were used to identify an ideal spraying strategy to maximize a farm's net returns. Simulations with those models highlight the importance of using IPM recommended sanitation practices to start the new crop season with as low an infestation as feasible, then to follow a spraying strategy.

Although CBB is still a serious pest, management strategies have proven to be successful. Industry still needs to actively manage this pest so it is included in extension events. Previously completed research was published. Work with CBB has otherwise been sidelined due to the severity of CLR.
Coffee nematode trial. Coffee root knot nematode (CRKN), Meloidogyne konaensis, was identified in Kona, Hawaii in the early 1990s. CRKN is an insidious pest, often not recognized by growers, that will severely weaken and eventually kill almost all coffee trees. Recent statistics point to coffee yields being a third, if not less, of historical standards. Evidence implicates CRKN as the likely culprit, causing more damage to the industry than CBB.

Prior research identified grafting onto CRKN tolerant/resistant rootstocks as the only viable strategy to manage the pest. However, a newly grafted tree will take several years to reach full production, and growers are hesitant to destroy infected trees that are still producing, especially if the extent of the production decline is not obvious. The trial/demonstration plot to compare two strategies – destroying the existing, infected tree and planting a new tree in its place, and planting the new tree next to the weakened original so some production continues while the new trees mature -- is producing its first (small) harvest in the 2021-2022 season, with full production expected in the next two years.

As with CBB, resources and attention shifted to CLR. However, this work is likely to have a central role as it is expected that the new CLR-resistant coffee varieties will be susceptible to CRKN.

Coffee pruning trial. The trial that provided observations and data on yields, on coffee berry borer management, and on the economics of orchard management and harvesting for four styles of pruning methods was discontinued due to the combined effects of CLR on the plantings, and COVID on plot management. Three of the four pruning styles make it extremely difficult to manage CLR. Data to date will be analyzed, perhaps for applicability when orchards have transitioned to CLR-resistant varieties.

D. Ohelo. The native vaccinium species in Hawaii have demonstrated strong potential as nutraceuticals and in other applications. Two plantings had been established as alternative sources to wild harvesting and to test the feasibility of fruit production (separately funded). The second plot on a cooperator's farm was lost due to the sale then resale of the operation, complicated by restrictions imposed by Covid that did not allow for plot maintenance. Lab analyses have continued and several outputs are in process (see HAW02024-H).

E. Tea. Results from the 2019 followup survey were published. Activities at the Mealani Research Station beyond plot maintenance were suspended during the reporting period, and the on-island project investigator retired at the end of 2020. Subsequent to the reporting period, the multi-state team was invited to prepare a SCRI proposal (PI: Y Chan, Louisiana State University). Given its 10-20 year head start, Hawaii's experiences with tea are likely to play an important role.

F. Other.
• Conducted train-the-trainer events on risk management and business applications for agriculture, including crop insurance tools available for Hawaii producers (funded by WERME). As for many other projects, in-person workshops that had been planned were changed to a webinar series due to COVID.
• Research on a biofumigant derived from papaya seeds has progressed from greenhouse trials to limited field work (funded by SARE). Data is being collected to estimate the cost of producing and using the product, and its economic feasibility. One intriguing aspect of this project is that a waste product from papaya is being used to develop a product that could be useful for many other crops.
• Investigator in new project "Addressing Economic and Market Needs of the U.S. Aquaculture Industry" at Center for Tropical and Subtropical Aquaculture, focusing on locally produced feed. Assist with preparation of a survey of potential uses.

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

New crops including crop products and methods to deal with new challenges, can help producers to better manage existing crops, diversify their operations and increase profitability. This umbrella project encompasses activities that enhance the financial stability of farmers, their families, and their communities. We tested new ideas and shared the results with growers for several crops. Trained agents are better able to serve their clients.

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

The improvements at the farm have direct and induced multiplier effects on related industries as well as the general communities.

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

Opportunities for training and professional development.
A train-the-trainer grant supported several events directly targeting this objective.

How results have been disseminated.
Primarily extension-outreach workshops/field days and one-on-one consultation subsequently moved to online/virtual and similar venues due to COVID; publications; collaboration with industry members. Contingent on requirements of individual projects.

List of Products. In addition to products listed below, over 50 webinars, workshops, and field days were offered to coffee growers.

Nakamoto, Stuart T. 2021. "Recordkeeping and An Introduction to a Cost Estimator for Cut Ornamentals." Webinar for 2021 University of Hawaii Floriculture and Nursery Webinar Series
a. June 15, 2021
b. June 8, 2021

Kawabata, Andrea M and S.T. Nakamoto. August 2021. Pambobomba Upang Sugpuin ang Kalawang ng Kape (Hemileia vastatrix) Dito sa Hawaii (Spraying to Suppress Coffee Leaf Rust (Hemileia vastatrix) in Hawaii). College of Tropical Agr. and Human Resources, University of Hawaii at Manoa. Plant Disease PD-122_Tagalog. 5 pp. url: https://www.ctahr.hawaii.edu/oc/freepubs/pdf/pd-122.pdf

Kawabata, Andrea M and S.T. Nakamoto. August 2021. Panagpasuyot Tapnon Malappedan ti Lati ti Bulong ti Kape (Hemileia vastatrix) ditoy Hawaii (Spraying to Suppress Coffee Leaf Rust (Hemileia vastatrix) in Hawaii). College of Tropical Agr. and Human Resources, University of Hawaii at Manoa. Plant Disease PD-121_Ilocano. 5 pp. url: https://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-121.pdf

Kawabata, Andrea M, Rosemary Gutierrez-Coarite, and S.T. Nakamoto. July 2021. Pulverizacion para suprimir la roya del café (Hemileia vastatrix) en Hawai (Spraying to Suppress Coffee Leaf Rust (Hemileia vastatrix) in Hawaii). College of Tropical Agr. and Human Resources, University of Hawaii at Manoa. Plant Disease PD-120_Spanish. 5 pp. url: https://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-120.pdf

Nakamoto, S.T., S. Motomura-Wages and R. Hamasaki. June 2021. Hawaii Tea Growers' Survey. College of Tropical Agr. and Human Resources, University of Hawaii at Manoa. Fruit & Nut FN-62. 28 pp. url: https://www.ctahr.hawaii.edu/oc/freepubs/pdf/FN-62.pdf

Kawabata, Andrea M and S.T. Nakamoto. June 2021. Spraying to Suppress Coffee Leaf Rust (Hemileia vastatrix) in Hawaii. College of Tropical Agr. and Human Resources, University of Hawaii at Manoa. Plant Disease PD-118. 5 pp. url: http://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-118.pdf

Bittenbender, HC and S.T. Nakamoto. June 2021. CTAHR and Coffee in Hawaii 1986 to 2017. College of Tropical Agr. and Human Resources, University of Hawaii at Manoa. Fruit & Nut FN-61. 14 pp. url: https://www.ctahr.hawaii.edu/oc/freepubs/pdf/FN-61.pdf

Woodill, A. John, S.T. Nakamoto, A.M. Kawabata and P.S. Leung. June 2021. Optimal Spraying and Harvesting Strategy to Combat CBB: A Dynamic Approach. Journal of Agriculture and Food Research, Vol 4, June 2021, 100125. url: https://doi.org/10.1016/j.jafr.2021.100125

Nakamoto, Stuart T. April 1, 2021. "Overview of Recordkeeping and Cost Estimators for Ornamental Crops." Webinar for CTAHR Ornamental Agents.

Sand, Shannon, A.M. Kawabata and S.T. Nakamoto (organizers). February-March 2021. Train-the-Trainer Risk Management Webinar Series

a. (2/4) Intro to Risk Management (Nakamoto)
b. (2/11) Whole Farm (Antonini)
c. (2/18) Crop Insurance (Lind)
d. (2/25) USDA Disaster Assistance Programs
e. (3/4) Production record keeping (Nakamoto)
f. (3/11) Financial record keeping (Sand)

Myers, Roxana, Andrea Kawabata, Alyssa Cho, and Stuart T. Nakamoto. 2020. Grafted Coffee Increases Yield and Survivability. HortTechnology, 30(3), 428-432. https://doi.org/10.21273/HORTTECH04550-20.

Kawabata, A.M., S. Wages, and S.T. Nakamoto. 2020. Pruning methods for the management of coffee leaf rust and coffee berry borer in Hawaii. Honolulu (HI): University of Hawaii. 9pp. https://www.hawaiicoffeeed.com/pruningcbbclr.html

Kawabata, A.M., S.T. Nakamoto, L. Keith, and D. Oishi. 2020. Surveying, sampling, and monitoring of coffee leaf rust (Hemileia vastatrix) for early disease control in Hawaii. Honolulu (HI): University of Hawaii. 15pp. https://www.hawaiicoffeeed.com/clrmonitorenglish.html

Nakamoto, Stuart T. December 2020. "Some thoughts on dealing with covid and the economic crisis." Presentation for Ka'u Coffee Virtual School, December 23, 2020.

Germplasm Selection and Management to Optimize Vegetable Quality and Yield in Tropical, Organic Production Systems

Project Director
Theodore Radovich
Organization
University of Hawaii System
Accession Number
1021201

Results

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

This project seeks to evaluate the performance of diverse vegetable germplasm under certified organic conditions in order to:
1) Support Hawaii's growers by developing cultivar recommendations for high value crops, and
2) Answer basic and applied questions regarding genotype x environmental interactions to understand how to develop resilient food systems in a changing environment.

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

During FY 2021, our primary research and outreach focus was on three species: Turmeric (Curcuma longa), Tomato (Solanum lycopersicum) and Sweet Potato (Ipomea batatas). In addition to the research outlined below, In the period 10/1/20 thru 9/30/21 multiple field trials and workshops have been completed to identify and distribute well adapted turmeric and heirloom tomato germplasm to growers. GoFish, a new program designed to support beginning commercial aquaponic producers was initiated with 5 workshops and a practicum developed and delivered during this reporting period.

Our quarterly newsletter and social media accounted for the bulk of our over 120,000 indirect contacts this reporting period and represents the one of largest and most impactful online agriculture extension efforts in the state. We have continued to publish a quarterly column titled “Understanding Organic’s” in the Hawaii Farm Bureau Federation’s magazine, Farm and Food.
We host a weekly radio show on KTUH that includes interviews with agricultural scientists, extension workers and growers to highlight advances in the science and technology of organic production.

Identify High Yield Heirloom Tomatoes for Hawai’i Growers.
Ongoing field studies have focused on identifying productive, high-valued germplasm suitable for the local market. The growing demand for heirloom and artisanal fresh-market tomatoes suggests further research into the local-niche market is required. Although traditional heirloom varieties present considerable challenges concerning pest and disease susceptibility, emerging germplasm may present an alternative for the local market. New hybrid cultivars offering the phenotypic and organoleptic qualities of traditional heirlooms (TH), but with the desired virus tolerance of commercial hybrids (CH), demonstrate flexibility to the heirloom labeling scheme. It is unclear whether these emerging cultivars, advertised as “modern classics” or “hybrid heirlooms (HH),” can meet the yield and quality expectations of producers and consumers.

Fourteen Cultivars representing each market class (TH, HH, and CH) were evaluated for yield (kg/plant) and quality traits. Fruit characteristics were quantified using the phenomics software Tomato Analyzer (v. 4.0) and used to characterize motifs for each market type and validate class-cultivar representation. Significant differences in marketable yield (0.56 ±0.13 to 2.5 ± 1.3 kg/plant) were observed among cultivars. Several HH exhibited comparable TH phenotypes with regard to fruit shape and initial quality screening. Data evaluation continues on several promising cultivars. One variety (‘Pink Smart’) identified by the project has been adopted by commercial growers, who are receiving $6 per pound farm-gate. ‘Quasimoto’ and ‘Old German’ are also among promising varieties identified by the project; final recommendations are pending upon completion of data analysis. A presentation to growers and industry on project updates is publicly available here: http://go.hawaii.edu/bwV

Increase Yield and Quality of Hawai’i Grown Turmeric.
The primary focus of this project has been to identify and distribute to growers, turmeric varieties with both high yield and curcuminoid content. A major objective this year is to determine the relationship between natural senescence (die back) in turmeric and size of the plant rhizome (yield). This is important because growers often harvest their turmeric early (before complete dieback) in order to get better prices early in the season. However, it is thought that this results in some yield loss since rhizomes are assumed to continue to develop as the plant declines.

Field trials in Waimanalo and Poamoho were harvested in 2021 and results show that yields at the start of plant decline were on average 15% lower than in plants harvested at complete senescence. For maximum yield it is recommended that growers wait until plants show significant signs of dieback before harvesting.

Analysis of curcuminoid content during this reporting period has confirmed that the newly introduced cultivar ‘Roma’ is higher in curcuminoid content than the industry standard ‘Hawaiian Red’. Roma and other improved varieties were distributed to growers statewide. An additional field day and distribution event is scheduled in March 2022 prior to the project end date.

A presentation to growers and industry on turmeric project updates is publicly available here: http://go.hawaii.edu/Vwa

Evaluation of Hawaiian Heritage Sweet Potato (Ipomoea batatas (L.) Lam.) Breeding Lines.
During FY2021, sweet potato germplasm was maintained in the greenhouse in preparation for FY2022 activities. Additionally, in FY2021 previous sweet potato germplasm work was published:
Anderson T, Radovich T, Bingham J-P, Sinclair N, Bryant G, Kantar MB. Evaluation of Hawaiian Heritage Sweet Potato (Ipomoea batatas (L.) Lam.) Breeding Lines. Agronomy. 2021; 11(8):1545. https://doi.org/10.3390/agronomy11081545

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

100% of program participants surveyed described programs as good or excellent. 91% of program participants reported some increase in knowledge as a result of attending the program/workshop.

Based on stakeholder surveys, it is estimated that over 300 growers have adopted sustainable and organic practices subsequent to participation in our workshops in this reporting period. regarding turmeric alone, 50 growers received and planted improved germplasm on approximately 100 acres.

Based on yield data generated in field trials and the number of growers adopting new turmeric varieties, it's estimated that our activities directly resulted in an estimated increase of $810,000 in turmeric sales.

We have also contributed significantly to the 5% overall growth in the local organic sector during the reporting period.

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

In addition to our substantial online and radio outreach mentioned above, our community outreach conducted by our Learning Center program at the Waimanalo Research Center has generated 10,146 direct community contacts in 2021. These community contacts are essential to build support for CTAHR's effort in the community and to transform the Waimanalo Research Station into a Center of Learning that empowers self-provisioning and self-sufficiency in the community it is a part of, while preserving and enhancing service to commercial growers and other traditional stakeholders.

Livestock Extension Program Coordination

Project Director
Jeffery Goodwin
Organization
University of Hawaii System
Accession Number
7000809

Livestock Extension Program

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

The Hawaii livestock industry is affected by many unique constraints that continually limit the state's production potential. These constraints included limited local slaughter capacity, transportation costs and regulations, environmental regulations, high marketing and production costs, diseases and pests, and the cost, availability and quality of land, resources, and facilities to start and/or maintain productivity. Thus, there is a need to simultaneously continue CTAHR's focus on helping the livestock industry remain sustainable by addressing these constraints and provide assistance to new livestock owners outreach in animal husbandry and welfare. The Livestock Extension Group, comprised of extension specialists and agents in livestock production, and animal science research faculty, are uniquely aligned to meet this challenge.

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. Industry Needs Assessment - The initial phase of the Hawaii Livestock Industry Needs Assessment, conducted through survey circulated via email and social media was completed at the end of September 2020. However, the faculty member coordinating the surveys resigned and left the University in October 2020. Recovery and analysis of the data and other files has been slowed as a result. Additionally, COVID-19 restrictions that remained in place through 2021, and the lack of funding from July – September prevented initiation of the next level of needs assessment activities.

2. Annual Mealani Livestock Field Day – Covid-19 travel and meeting restrictions prevented the organization of a live Mealani Livestock Field Day program in 2021. However, in an effort to remain connected or our stakeholders and provide educational and outreach opportunities to our them we continued to hold monthly Livestock Producer's Pau Hana sessions via zoom from October 2020 through March 2021 (6 events; 180 contacts). Eleven (11) communications went out in the Range and Livestock Extension Newsletter viewed by 1,206 contacts. Fifteen (15) new educational videos were added to the UH Livestock Extension You Tube Channel which had 2,347 distinct viewers between October 2020 and September 2021.

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

Short-term Impact (Learning):

On average 64% of the registrants (47) for the Livestock Producer's Pau Hana join each session. When polled:

- 91% those participating in the Pau Hana sessions have indicated that they learned something new of value to them,
- 100% want the program to continue.

Participants in the Livestock Producer's Pau Hana have included state and federal legislators, and county, state, and federal employees with connections to agriculture. All have expressed interest in the continuation of the Pau Hana noting that it is valuable in raising their awareness of key issues affecting the livestock industry. The Range and Livestock Extension Newsletter sent out 11 communications that were read by 1,206 contacts.

Videos on the UH Livestock Extension You Tube Channel were watched by 2,347 individuals for over 185 hours. The channel also gained 40 new subscribers and had a reach of over 31,800 impressions.

Mid-term Impact (Action):

State and Federal legislators, and county, state and federal employees that have attended the Livestock Producer's Pau Hana have indicated that the program has helped them shape agricultural policy positions. Livestock producers, on the other hand, have indicated that the program helped them decide on applying for federal and state assistance for covid and disaster related relief after hearing reports by HDOA and FSA personnel at the Pau Hana. Feedback and comments from viewers of videos on the UH Livestock Extension You tube channel indicate that the material has encouraged adoption of livestock management practices, or shaped management decisions for livestock production, range and pasture management, and beef cattle genetics.

Long-term Impact (Planned Change in Social, Economic, Civic, or Environmental Conditions):

Hawaii livestock producers adopting Extension recommended grazing and pest management practices increased their economic returns by as much as 70%.

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

A stable and secure livestock industry in the State leads to better food security and economic stability for Hawaii's communities. In addition, better managed rangelands improve the ecological services provided to the citizens of Hawaii.

Development and Promotion of Best Management Practices for Livestock Production in Hawaii
Project Director
Jenee Odani
Organization

University of Hawaii System
Accession Number
1013579

Result

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

This project addresses health and management issues affecting livestock, poultry, and aquacultured animals in Hawaii as well as addressing public health/zoonotic threats and diseases of economic importance.

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.

Testing for small ruminant gastrointestinal parasite load continues to provide producers with information regarding the health/parasite infectivity status of the individual animal, on the herd level; they can use this information to make decisions whether to treat or not to treat, and when combined with measuring the fecal egg count reduction after deworming, the efficacy can be used to make decisions to use different dewormers, with the goal if minimizing their use and preventing anthelmintic resistance. Work was done with student groups to improve their ability to manage the health of their animal projects (4-H) and comply with rules and regulations designed for their and their animal's safety. The Hawaii poultry improvement program continues to be developed and outreach to improve biosecurity of poultry farms is conducted. Outreach, education, and assistance is provided to veterinarians and producers seeking assistance with diagnosing and controlling diseases affecting their animals. Information and updates are regularly shared with state veterinarians, extension personnel, and producers of various commodities.

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

Producers have learned what background lesions can exist in normal appearing shrimp; how to use the FAMACHA test to assess their animals for anemia, especially that caused by gastrointestinal parasites; which dewormers might be useful in their herds and which are no longer effective; how to understand product labels and what extralabel drug use is; how to find out approved withdrawal times when products are used extralabel; what disease status based on specific testing of their herds; how to mix disinfectants properly.

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

Information regarding rat lungworm disease (neural angiostrongyliasis) in animals was helpful for animal owners and veterinarians. The extension publication covering this issue is used as a reference for the broader public. This project helps provide animal health management information to producers and veterinarians.

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.

Fieldwork was limited due to Covid restrictions and unwillingness of stakeholders to meet in person. Outreach had to be conducted virtually using electronic means and expansion of video recording/editing to generate material. A critical collaborator in aquaculture activities suddenly passed away, disrupting project work in that area.

The Hawaiian Soil Microbiome: Towards an Atlas of Diversity and Function of Hawaii's Soil Microbial Resources

Project Director
Nhu Nguyen
Organization
University of Hawaii System
Accession Number
1013753

Results

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

This project aims to characterize the soil microbiome in Hawaii, in particular those that associate with the roots of crop plants, plants of economic, conservation, and cultural significance, and those associated with different cropping systems. The outcome of the project is a biological atlas of the diversity and functional characteristics of soil microbes that with further exploration could help us understand how microbes contribute to sustainable agriculture and nutrient cycling in tropical soils.

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

• Completed analyzing data and submitted a manuscript on how the complexity of fertilizers (urea vs. compost) can change the robustness of soil microbial communities.

• Completed analyzing a data and submitted a manuscript on the soil microbes associated with different crop plant species, and how continuous agriculture significantly changes soil microbial communities.

• Developed and tested molecular tools for identification of soil nematodes and protists by using high throughput sequencing.

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

The outcomes of this project directly contributed to scientific knowledge of tropical soil microbiomes associated with crop species and cropping systems through a manuscript and a presentation.

Manuscript:
Heisey S, Ryals R, Maaz TM, Nguyen NH. Continuous monoculture of annual crops, not plant species, is a strong determinant of microbial community structure in a tropical Oxisol soil. Accepted.
https://www.frontiersin.org/articles/10.3389/fsoil.2022.749212/abstract

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

In the recent years, we are seeing a surge in public appreciation for the microbiomes, in particular those that are associated with soil health and sustainable agriculture. Locally, there is growing interest in soil and root microbiomes, and general body of work in a broader sense supports and reinforces local interests.

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:
This project provided support for one graduate student and one undergraduate student.

Paper in review:
Ishwora D, Nguyen NH. Continuous monoculture of annual crops, not plant species, is a strong determinant of microbial community structure in a tropical Oxisol soil. Submitted to Environmental Microbiology.

Plans for the next period:
Complete and publish three manuscripts and wrap up project:

1) Continuous monoculture of annual crops, not plant species, is a strong determinant of microbial community structure in a tropical Oxisol soil.

2) Molecular characterization of rhizobia associated with soil and legumes in Hawaii.

3) Multiplex primer sets to rapidly detect soil biota associated with management practices.

Critical Issue

Protect and Manage Natural Resources and the Environment

Soil Organic Matter: The Key to Soil Health, Climate Smart Agriculture, and Resilient Landscapes

Project Director

Susan Crow

Organization

University of Hawaii System

Accession Number

1021472

Results

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

Climate change, induced predominantly by fossil fuel consumption and deforestation for intensive agricultural production, is an immediate threat to Hawaii and our communities and requires action from every sector. Although small in size, Hawaii must do our part to reduce carbon and other greenhouse gas (GHG) emissions while also building resilience into our landscapes and communities in order to adapt to the changing environment. As sectors with major sources of emissions, such as energy and transportation, are tackled in the coming decade, land-based climate actions must also begin immediately to improve their own GHG balance, and ultimately sequester enough carbon to offset residual non-renewable emissions within the new carbon economy. Multiple policy goals must be met in the coming decades, including increased local food production, 100% renewable energy, carbon neutrality, and improved soil health and carbon sequestration in natural and working lands, all of which require physical space in our landscape to achieve. For lands remaining productive, whether in protected forests, agroforests, rangeland, and cropping systems, soil health is a unifying principle. We will define soil health and develop a soil health index for Hawaii, measure and monitor soil health with partners changing management and land use on the landscape, initialize and improve available agroecosystem models, build a web-based tool, and effectively communicate the potential value of actuating land-based soil health and climate smart practices, with particular emphasis on the vast array of co-benefits that healthy, resilient soils bring to communities. With an increased knowledge base, recommendations and training for land use and practices to increase carbon drawdown, i.e., transfer from the atmosphere to long-term storage reservoirs, can be developed. The outputs will be quantitative, science-based decision support and policy tools that will help implement legislation and incentivize good practices for all land managers and producers. To actuate means to make something work, synonyms include activate, switch on, trigger, set in motion, initialize, energize, motivate, stimulate, drive, fire up. The ultimate goal, or outcome, of the proposed work is actuating land-based soil health and climate smart practices, with particular emphasis on the vast array of co-benefits that healthy, resilient soils bring to society.

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

During the pandemic, we undertook an overhaul of our research lab to improve capacity for collaborative soil health research and higher throughput of sample analysis for the 11 soil health parameters we propose as key indicators. As a result of our efforts, we can now enter into a more service-oriented option for soil health analysis with Hawaii producers. This expansion allows us to reach not just our network, but also the next layer of clients who have heard about our work through their own network or online search. Each client understands we are a research group, with a commitment to developing a soil health index and database to further our understanding of what soil health is in Hawaii and other island or sub/tropical regions. Now, every sample that arrives and is measured via our growing network provides additional data, not just for soil parameters, but also about land use history and management practices that will allow us greater understanding of soil health benchmarks, change over time, and connection to practitioners. Our research group also continued and initiated more focused understanding of short-term (i.e., 1-3 yr) changes in soil health parameters because of implementing soil health management practices in on-farm demonstration trials. We successfully sought funding from multiple agencies and now monitor soil health over time in over 14 farms across Hawaii, with new studies planned for Puerto Rico and American Samoa. Over time, our database will continue to grow and cover key elements of past land use history, mineralogy, and current practices that are important to Hawaii and our regional neighbors that are critical to developing a soil health index.

During this period, our research team worked with collaborators at Colorado State University to conduct a second phase initialization of soil carbon and ecosystem models. We focused on the MEMS models, and conducted refinement with measurements of carbon pools other supporting data within original v1.0 structure. We originally used the MEMS model to simulate current states of 3 soils (Ultisols, Inceptisols, and Andisols) and 3 land common uses (conventional crop, pasture, and forest) for each soil. As a result of the first phase results, we revised our approach to dominant mineralogies (LAC - low activity clays, HAC - high activity clays, and PNCM - poorly and non-crystalline minerals) and triplets of land uses in close proximity to serve as proxies for land use change. The latter is consistent with tropical sites and dominant land uses in Hawaii and beyond and we still achieved a range of values in the parameters known to be sensitive in MEMS v1.0. The next stage is to complete additional refinement with alterations to the rate modifiers using additional measured parameters.

Our Hawaii Soil Health Webtool went live, with key messaging and outreach blog about soil health. In our efforts to help land managers select management practices that restore, maintain, and improve landscape health and resilience in Hawai'i, we launched the first outreach events focused on extension agents and specialists from the College of Tropical Agriculture and Human Resources (CTAHR). The goal of these events were to (1) educate about soil health and the HSH indicators, (2) train and navigate the Hawaii Soil Health Tool (HSHT), and (3) receive feedback on the use of the HSHT for extension agents and land managers use. A series of three formal webinars targeted extension agents who are a critical link between our research efforts and on-the-ground producers. Follow up efforts ensured that we reached key sectors that did not participate or were underrepresented in the formal event, these included our forestry and ranching colleagues. Inclusivity is an important, purposeful component to our work reaching and communicating potential value of actuating land-based soil health and climate smart practices, with particular emphasis on the vast array of co-benefits that healthy, resilient soils bring to communities.

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

The target audiences during this reporting period included farmers, producers, land managers, students, researchers, extension agents, local business and sustainability leaders, institutions, and policy makers. We relied heavily on our diverse network of Hawaii's farmers, producers, and land managers across the entire range of natural and working lands on three islands for progress on our research and, in turn, provided knowledge, discourse, and data services. CTAHR extension agents also were invaluable resources. Government agencies such as NRCS and the University extension service providers use our results to advise agribusiness and sustainable management practices to land owners, managers, and farmers. PI Crow and Co-PI Deenik serve as CTAHR representatives in the State Greenhouse Gas Sequestration Task Force. Hawaii State Planning Office's Greenhouse Gas Sequestration Task Force (formerly Carbon Farming Task Force), International Soil Carbon Network, and the North American Carbon Program's Carbon Cycle Science Interagency Working Group; Science Leadership Group.

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

International Soil Carbon Network (Action Team co-Leader) Large Scale Assessment of soil carbon storage, stability, and susceptibility to disturbance. Hawaii State Planning Office Greenhouse Gas Sequestration Task Force (Member) – Established by Act 15, SHL 2018, the Task Force is comprised of 15 members from State agencies, nonprofit sector, private associations, and a researcher and an extension agent from CTAHR. The broad purpose is to expand and make permanent the task force, align the energy and sequestration efforts with climate initiatives, and make recommendations to achieve carbon neutrality by 2045. August 2018-present. PI Crow contributed to a working paper crafted by the Hawaii Climate Change Mitigation and Adaptation Commission, entitled Nature-based Resilience and Adaptation to Climate Change in Hawaii: A Climate Ready Hawaii Working Paper.

Our Hawaii Soil Health Webtool went live, with key messaging and outreach blog about soil health. In our efforts to help land managers select management practices that restore, maintain, and improve landscape health and resilience in Hawai'i, we launched the first outreach events focused on extension agents and specialists from the College of Tropical Agriculture and Human Resources (CTAHR).

On-farm visits and in-person delivery of soil health reports were continued as safety measures allowed.

One graduate student received training: students was in the Ph.D. program (female). Christine Tallamy Glazer, Research Technician and P.I. of the Soils and Ecosystems Lab continued to develop analytical skills in the area of soil health assessment. One recent graduate was given the chance to remain in our group as a research technician (international student, Mizuki Ebihara, Japan). Three current UH Manoa students were employed as research assistants (2 female, 1 male), and 2 completed their internship requirements for degrees with us. One UH system community college student completed her internship requirement with our group (female) and a visiting scholar, Martin Sampson joined our team for an intensive field campaign.

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

The COVID-19 pandemic continued to present challenges, but we're optimistic about the higher throughput of our research lab now and expanded capacity.

Best Management Practices for the Sustainable Productivity of Hawaii's Range and Pasture Lands

Project Director
Mark Thorne
Organization
University of Hawaii System
Accession Number
1020612

Results

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

Improper grazing management practices will eventually lead to significant losses in the social, ecologic, and economic value of the Hawaii's pasture and rangelands. If livestock production is to be sustained in Hawaii, extension and research efforts are needed to develop a suite of recommendations for the efficient and effective management of these lands that fit Hawaii's unique production requirements. These Best Management Practices (BMPs) should provide livestock producers, extension agents, and federal land management personnel with efficient, economical, and ecologically sound alternatives for range and pasture improvements, converting former sugarcane and pineapple lands into sustainable forage production systems, controlling noxious weeds, invasive grasses and pests (Twoline spittlebug, grass webworm, army worm, etc.), increasing the nutritional quality of forages for animal production, and developing grazing management practices that improve animal distribution, grazing efficiency, and protect native ecosystems and the services they provide.

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

On-going grazing trials for grass-finish beef production reveal important information on the interaction between harvest intensity, pasture sustainability, and animal productivity and meat quality (Objectives 1 and 2). This research will provide the beef cattle industry in Hawaii with guidelines (Best Management Practices) for efficiently finishing beef cattle on pasture in Hawaii, while maintain pasture and rangeland sustainability and providing a quality meat product for Hawaii consumers (Objective 2). Research into the ecology and biology has revealed valuable information on their impact on Hawaii rangeland forages, habitat selection, and distribution and rate of spread in the environment. Host-plant resistance trials have yielded a list of grasses that are resistant, tolerant, or susceptible to Twolined spittlebug feeding. Importantly the information on resistant grasses provides livestock producers with a list of grasses that can be used to reseed severely damaged rangelands and increase their resilience to future spittlebug attack (Objectives 2 and 3). Results of these projects have been shared through online meetings (due to Covid-19 restrictions), webinar, recorded videos, and on the Hawaii Rangelands website (WERA 1008 Rangelands Partnership multi-state project).

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

Adoption of BMP and IPM strategies derived from the research under this project help livestock producers increase animal productivity while maintaining or improving pasture and rangeland productivity through enhanced nutrient and water use efficiency, and carbon sequestration. Improved pasture and rangeland condition will lead to improved economic and economic sustainability of the livestock industry in Hawaii.

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

Improved management of Hawaii's rangelands results in many economic, ecological, and social benefits to local communities and the state. Rangelands provide valuable ecosystem services, such as clean air and water, that are of better quality in well managed rangelands, that directly benefit Hawaii residents. Additionally, profitable ranching operations provide jobs and create valuable revenue streams for local communities, while also providing for food security through the sale of quality meat products.

Closing Out (end date 09/07/2023)

Building Capacity for Structured Resource Management Decision Making

Project Director
Kirsten Oleson
Organization
University of Hawaii System
Accession Number
1017056

Results

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

Natural resource decision-making can be complex, and is often done ad hoc. The goal of the project is to increase the technical capacity of state resource decision-makers to use a process called structured decision making, and to apply decision analysis to diverse natural resource management problems in the state. Specifically, the project will use a structured approach to decision making to improve the scientific basis of decisions.

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

The project implemented a number of activities to build capacity at UH and in resource management agencies/partners to adopt a structured decision making (SDM) approach. Activities have includes training(s), materials, outreach, and applied cases, where PIs ushered an SDM process for real-world problems brought by stakeholders. Each case followed the Problem-Objective- Alternatives-Consequences-Trade-off Analysis (PRoACT) cycle. This involved carefully and collaboratively defining the decision problem, setting quantifiable objectives, building predictive models, and evaluating outcomes.

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

Three cases reached three main research audiences. First, we ran a rapid prototyping SDM process with Division of Forestry and Wildlife staff and a natural reserve manager to prioritize landscape management. Second, we worked with the state Department of Health, County of Maui and stakeholders in Upcountry Maui to prioritize cesspools for upgrading. Third, we worked with a community group interested in local fire management and a state fire alliance. In all cases, applying the DM process clarified decisions, revealed objectives, generated creative alternatives, and improved the transparency and rigor of decisions.

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

Introducing SDM as a method for improving decision-making has given our state, county, and community a new way to grapple with complex decisions. The lessons seem to be percolating through to other decisions. For instance, the state cesspool working group used insights from the Upcountry Maui study to inform the statewide prioritization process. Assuming the practice proliferates, there could be enormous efficiency gains (more benefit for less cost).

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 affected our ability to conduct in-person SDM, though we adapted to using Zoom. A graduate student was employed, and was trained in SDM and modeling. The next phase of the project will be focused on producing articles for publication.

Closing Out (end date 09/07/2023)

Integrating Research and Extension to Manage Wildland Fire and Climate-related Hazards on Pacific Islands in the 21st Century

Project Director
Creighton Litton
Organization
University of Hawaii System
Accession Number
1017116

FY21 Annual Results

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

Wildland fire is a prevalent, yet largely overlooked, disturbance in Hawaii. The state has experienced multiple years in which the proportion of island land area burned exceeded that of states in the Western US. Drivers of fire occurrence include the establishment and expansion of flammable savannas and nonnative grassland vegetation, seasonal and episodic rainfall variability, and predominantly human-caused ignitions. The impacts of fire can be more acute on Pacific islands than continental regions due to the connectedness of watersheds, communities, and nearshore resources, and the vulnerability of native ecosystems that evolved in the absence of frequent fires. Moreover, the capacity and resources available for fire risk assessment, fire suppression and, more importantly, fire hazard mitigation are limited relative to the continental US due to highly variable climates, novel fuel types, and limited funding and infrastructure, especially from the large federal fire suppression agencies (e.g., US Forest Service, BLM) who have very little direct management responsibility in the Pacific region.

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 Hawaii wildfire extension program continued to focus on outreach among land managers, conservation programs, and the wider public through the Pacific Fire Exchange, part of the Joint Fire Science Program's national network of Fire Science Exchanges. Due to the COVID pandemic, we focused primarily on improving program communications. In December 2020, the four-member PFX project staff and eight-member Steering Committee (twelve total) invited hundreds of colleagues and members of the public with diverse expertise from across Hawai`i and the Pacific to sign up for a unified wildfire contact database.

In response to fire responders' desire for a wildfire "curriculum," the PFX developed wildfire modules across 12 different topical areas, including the following subjects: wildfire basics (fuels and behavior); hazardous vegetation; overview of wildfire (both in Hawai`i and the Pacific); preventing and containing the spread of wildfires; an identification guide to wildfire hazards; what to do after wildfire (a post-fire management guide); "myth busters" (how to identify common misperceptions of wildfire); and wildfire education basics ("it's up to all of us"). Land managers and wildfire practitioners also expressed a desire for a greater understanding of how a warming climate and resulting increases in fuels affects wildfire risk and community response. As a result, we published two fact sheets: (1) Changing Climate and Fire: a Crisis Brewing in the Pacific and (2) Wildfire Review Series: Abandoned Agriculture in 2019 is Hawai'i's Fire Problem.

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

A positive achievement from FY2021 has been the active and sustained engagement of the 11-member Steering Committee for the Pacific Fire Exchange program through facilitated, task-oriented quarterly meetings. The new Wildfire Communications list- serve, designed by the program to target communications, received 320 members, indicating sustained interest in program outputs. The project also experienced significant increase in website traffic and access to wildfire-related information. In total, the PFX website (pacificfireexchange.org) received 12,697 page views (averaging about 1 minute in length) in FY21 compared to the 7,603 page views in FY20, which represents a 67% increase.

The most significant long-term impact of the program has been a shift in engagement and scope of wildfire mitigation activities in Waianae on the Island of Oahu. As a result of CTAHR extension workshops and site visits in FY20, a working group of farmers, residents, educators, and representatives from agencies, utilities and the state legislature has organized and been meeting monthly throughout FY2021. Group members have solicited funding through the Hawaii Wildfire Management Organization and implemented 5 fuels reduction projects across the valley including mown fuel breaks, water infrastructure improvement, grazing strips and irrigated green strips. In addition, these activities were integrated into a place-based learning program led by Kay Fukuda at UH Manoa and the Hawaiian Studies program at Waianae High School in which students participated in fire risk reduction activities as part of a summer hands-on learning program. This program will continue in FY22.

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

The wildfire program served as a hub for growing media interest in FY21 regarding wildfire risk in Hawaii and the broader Pacific. This included coverage from the NY Times who interviewed PI Trauernicht, and others, and cited PFX publications in the article (Even Hawaii is Battling a Wildfire Surge, NY Times). Local news organizations including Hawaii Public Radio, Honolulu Civil Beat, and KHON News also covered the fire issue in FY21, interviewing PFX PI and Steering Committee members and using statistics published in PFX fact sheets. The 40,000 acre Mana Road Fire in August 2021 received global coverage with articles including interviews with PFX Steering Committee members and use of PFX published statistics (e.g., Record wildfire burns at least 40,000 acres on Hawaii's Big Island, sets up mudslide danger, Washington Post; Here's why wildfire is a growing threat to Hawaii, one of the wettest places on earth, NY Times; 'A perfect storm': Hawaii firefighters confront Big Island's largest wildfire in history, The Guardian). The Associated Press also reached out to PI Trauernicht and integrated PFX fact sheets and information into an article and video segment on wildfire across the Pacific region, which was reprinted by more than two dozen news outlets including the LA Times, Fox News, US News, ABC news, and MSN News (Climate-fueled Wildfires Take Toll on Tropical Pacific Isles; Pacific islands not immune from wildfires). Finally, the interest in fires at the regional scale prompted The Hill to ask PI Trauernicht to write an Op-Ed piece, in which he highlighted PFX contributions and framed the regional context of wildfire for a general audience (Pacific Island Wildfires highlight vulnerability to climate change and what to do about it).

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.

FY2021 Outputs

Peer-Reviewed Publications

Zhu, T.R., Litton, C.M., Giardina, C.P., Trauernicht, C., 2021. Moisture availability and ecological restoration limit fine fuels and modelled wildfire intensity following non-native ungulate removal in Hawaii. J. Appl. Ecology 58:.2207-2219.

Bremer, L.L., Nathan, N., Trauernicht, C., Pascua, P.A., Krueger, N., Jokiel, J., Barton, J. and Daily, G.C., 2021. Maintaining the Many Societal Benefits of Rangelands: The Case of Hawai 'i. *Land*, *10*:764.

Selmants, P.C., Sleeter, B.M., Liu, J., Wilson, T.S., Trauernicht, C., Frazier, A.G. and Asner, G.P., 2021. Ecosystem carbon balance in the Hawaiian Islands under different scenarios of future climate and land use change. Environmental Research Letters 16:104020.

Malone, A., Bremer, L.L., Crow, S.E., Hastings, Z., Winter, K.B., Ticktin, T., Rii, Y.M., Wong, M., Kukea-Shultz, K., Watson, S.J. and Trauernicht, C., 2021. Assessing Baseline Carbon Stocks for Forest Transitions: A Case Study of Agroforestry Restoration from Hawaii. *Agriculture*, *11*(3), p.189.

Lucas, M.P., Trauernicht, C., Frazier, A.G. and Miura, T., 2020. Long-Term, Gridded Standardized Precipitation Index for Hawaii. Data 5:109.

Nugent, A., R. Longman, C. Trauernicht, M.P. Lucas, H.F. Diaz, T.W. Giambelluca. 2020. Fire and rain: the legacy of Hurricane Lane in Hawaii. Bulletin of the American Meteorological Society. Published online: https://doi.org/10.1175/BAMS-D-19-0104.1

Other Publications

Trauernicht, C. 2021. Pacific Island wildfires highlight vulnerability to climate change and how to address it. Op-Ed, The Hill.

Faccenda, K., M. Chimera, C. Trauernicht. 2022. Weed fire risk assessment for Hawaii. Pacific Fire Exchange Fact Sheet. http://www.pacificfireexchange.org/research-publications-1/

Trauernicht, C., M. Chimera, E. Pickett, N. Baretto. 2021.Changing Climate and fire: A crisis brewing in the Pacific. Pacific Fire Exchange Fact Sheet. http://www.pacificfireexchange.org/

Trauernicht, C. and M. Chimera. 2021. Wildfire Review: Abandoned Agriculture is Hawaii's fire problem in 2019. Pacific Fire Exchange Fact Sheet. http://www.pacificfireexchange.org/

Trauernicht, C. and M. Chimera. 2021. Wildfire Review: Abandoned Agriculture is Hawaii's fire problem in 2019. Pacific Fire Exchange Fact Sheet. http://www.pacificfireexchange.org/

Trauernicht, C. and M. Chimera. 2020. 2019 Wildfire Summary for the Western Pacific. Pacific Fire Exchange Fact Sheet. http://www.pacificfireexchange.org/

Services

Site consultation, Waianae Agricultural Park, Waianae Ag Park Fuel Break

Site consultation, Hawaii Division of Forestry and Wildlife, Kumaipo Ridge Burn area

Site consultation, Hawaii Division of Forestry and Wildlife, Post-fire restoration at Makua Keeau

Project Consultation, online, Fire Control for USDA NRCS Standards

Project Consultation, HFD; NRCS, Post-Fire Assessment

Project Consultation, Parker Ranch, Post-Fire Assessment

Activities

Facilitation, online, Pacific Fire Exchange Steering Committee Quarterly Meetings

Facilitation, Waianae Community Wildfire Coordinating Group, Updates

Presentation, Online, Fire science basics - Waianae High School

Presentation, West Maui Taxpayers Association, Maui fuels management/mitigation

Presentation, Kauai Fire Dept. Brushfire meeting, Fire history and mitigation

Events

Workshop, Online, Palau National Fire Planning (w US Forest Service)

Workshop, Army Natural Resources Management Program, Needs and expectations

Workshop, online, FIREWISE community update

Workshop, Online, Ready, Set, Go Workshop

Products

Waianae Community Wildfire Hui, working group/network, monthly meetings since Oct 2021

Wildfire Communications, wildfire-specific listserve, 308 subscribers

Closing Out (end date 09/07/2023)

Kaiaulu - Enhancing Resilience through Community Level Resource Management

Project Director

Mehana Vaughan

Organization

University of Hawaii System

Accession Number
1017591

Results

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

With many ʻaina-based organizations have emerged over the years, this project captures the trend, pattern, and unique cases, in order to understand the different factors that contribute to the successes or failures in this process. Focusing on the local management practices of over fifty ʻaina-based organizations in Hawaiʻi, I document the stories, knowledge, and growth of these organizations, and map out their networks in relation to each other. This mapping puts organizations of different kind, size, focus, into communication and cultivates collective knowledge in communal management of socio-eco systems that could birth new generations of community leaders and organizations.

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.

My college-level classes in the past year have provided opportunities for around 50 students to engage with thirteen ʻaina-based local organizations across Hawaiʻi. Kupuna and community members were able to share their stories about the organizations and their knowledge in local environmental management. Products such as GIS story-maps, presentations, and videos help record the growth of different organizations and publicize their effort in ʻaina-based work. To visualize the connections among organizations and contribute to the larger community, I also connected with AinaVis, an existing dataset that represents organizations working for ʻaina. Past and present students' organization-focused projects will be incorporated into this larger network. Two local-level teacher training workshops were implemented to enhance ʻaina-based education programs. Two fieldtrips for K-12 participants were implemented to cultivate connections to place, knowledge, and capacity for local-level resource management.

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

The target audience of this project includes community members, government agencies and officials, students, fellow academics, non-profit organizations, and practitioners in Hawaii, the U.S., and globally. For students and future leaders, the project provided multiple opportunities for training and professional development including two college-level courses, and a semester-long community outreach college class serving over fifty individuals. In collaboration with local communities, students and participants created two GIS story maps, five websites, and three community presentations, reaching over 500 individuals. In addition, students also create a Facebook group sharing ʻike kupuna, making available indigenous frameworks for policymakers. Future leadership capacity was developed, mentored and now are working in the communities we have studied and engaged with. The significance and findings of this project are also shared in guest lectures and invited talks, influencing more than 250 college students across the U.S., and fostering cross-cultural, cross-regional conversations on communal resource management. In addition to college students and community members, over fifty K-12 participants engaged in place-based summer program and fieldtrips, and seventy-five teachers participated in ʻaina-based education workshop, building the foundation for knowledge transmission across generations.

Product examples:

https://storymaps.arcgis.com/stories/4fa43540677241b686073fab1718c364 (story-map)

https://www.koihonua.org/ (website)

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

This project lead to multiple public presentations and talks that reached more than 300 audiences. The connections built and products created have in general raised the public's awareness of ʻaina-based education and existing community efforts. More publicized products such as websites and story maps are used as resources for the general public to learn more about these organizations and get involved.

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.

- Luat-Hueu, K., Winter, K., Vaughan, M., Barca, N., Price, M. (2021). Understanding the co-evolutionary relationships between Indigenous cultures and non-native species can inform more effective approaches to conservation: the example of pigs (pua'a; Sus scrofa) in Hawai'i. *Pacific Conservation Biology*, *27*(4) 442–450. DOI: https://doi.org/10.1071/PC20086.

- Iwane, M., Leong, K., Vaughan, M., & Oleson, K. (2021). When a Shark Is More Than a Shark: A Sociopolitical Problem-Solving Approach to Fisher-Shark Interactions. *Frontiers in Conservation Science, 2* (10). DOI: https://doi.org/10.3389/fcosc.2021.669105.

- Fernández-Llamazares, Á., Lepofsky, D., Lertzman, K., Armstrong, C., Brondizio, E S., Gavin, M.C., Lyver, P. Nicholas, G.P., Pascua, P., Reo, N. J., Reyes-García, V., Turner, N.J., Yletyinen, J., Anderson, E.N., Balée, W., Cariño, J., David-Chavez, D. M., Dunn, C.P., Garnett, S.C., Greening (La'goot), S., Shain Jackson, S., (Selapem, N.), Kuhnlein, H., Molnár, Z., Odonne, G., Retter, G., Ripple,W. J., Sáfián, L., Bahraman, A.S., Torrents-Ticó, M., Vaughan., M.B. (2021). Scientists' Warning to Humanity on Threats to Indigenous and Local Knowledge Systems. J. of Ethnobiology, 41(2):144-169 (2021). https://doi.org/10.2993/0278-0771-41.2.144

- Vaughan, M., Montgomery, M., Luebbe, K. (2020). Waialeale. In Goodyear-Kaopua, N., Howes, C., Osorio, J.K.K., and Yamashiro, A. (Ed.), *The Value of Hawai'i III: Hulihia, the Turning*. Honolulu, HI: University of Hawai'i Press, 185-198. https://doi.org/10.2307/j.ctv1pncr2m

Extension Forestry in Hawaii

Project Director

Jeffery Goodwin

Organization

University of Hawaii System

Accession Number

7000808

Rapid Ohia Death

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

Rapid Ohia Death. Rapid Ohia Death is a newly discovered disease that is devastating to ohia (Metrosideros polymorpha), Hawaii's most important native tree. Ohia forests protect Hawaii's watersheds, provide habitat for hundreds of native species, and are important to Hawaiian culture.

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.

Conducted a virtual 3-day event on ohia, replacing a live event we had held in previous years. The event included presentations on identification of ohia varieties, ohia seed collection, and growing lei plants, along with cultural features such as Hawaiian chants. A total of 533 people attended.

We conducted five on-line workshops on how to make ohia-free lei and wreaths in order to move people away from cutting ohia. About 115 people attended.

We conducted a series of five train-the-trainers outreach workshops for other agency staff who are doing outreach on ohia, Rapid Ohia Death, and native forests in general. Each workshop included both scientific information and how-to knowledge and skills on conducting outreach programs. About 80 people attended.

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

Short-term Impact (Learning):

In a post-workshop survey, 97% of the people who participated in the Rapid Ohia Death outreach workshop reported that they "likely, very likely, or absolutely" would use the information they learned in the workshops in their own outreach programs. Almost all of the approximately 115 people who attended the ohia-free wreath and lei making workshops make their own wreaths and lei.

Mid-term Impact (Action):

In a survey given six months after the Rapid Ohia Death outreach workshop, the average respondent reported contacting 33 new people with the information and using the skills taught at the workshop.

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

Ohia forests cover approximately 12% of the state. Because of the forestry extension program, native forest landowners and mangers are learning how to protect their forests from Rapid Ohia Death and restore forests that are affected by the disease.

Critical Issue

Youth/Family/Community Development and Health

Individual and Family Wellbeing

Project Director

Barbara DeBaryshe

Organization

University of Hawaii System

Accession Number

1020694

Results

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

This umbrella project includes complementary sub-projects based on the collective work of a multidisciplinary team of six faculty. Each sub-project addresses selected issues relating to individual and family well-being (e.g., childhood lead poisoning, child welfare, health outcomes, substance abuse, homelessness/housing, aging), with a focus on the state of Hawaii. The work aims to: (a) document trends in individual and family well-being through social indicators; (b) understand resiliency factors that allow families to adapt to personal, economic, and social challenges; and (c) enhance the capacity of local agencies and programs that serve individuals and families.

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

Key activities to **document trends in individual and family well-being** focused on publishing social indicator data through existing and newly-created web tools. Efforts included updating nearly 70 indicators of child and family well-being, i.e., gathering the most current data available from national and state sources, cleaning, processing, and publishing data to the Hawaii pages of the KIDS COUNT Data Center. Additionally, in collaboration with our community partner on the Hawaii KIDS COUNT Project, we developed and published the new online web tool, the Household Pulse Survey Data Dashboard. The dashboard provides nearly real-time data gathered from the US Census Household Pulse Survey measuring the pandemic impacts on children and families. After the release of the Community Profiles in 2020, we continue to promote the use of these profiles through the Center on the Family website and our stakeholder networks. These data products provide our target audiences current and trend data to inform decision-making and advance sound policies and large-scale initiatives that support the well-being of Hawaii's children and families.

We continue to engage in a number of large scale program evaluation activities to **enhance the capacity of local agencies and program**s. During the reporting period, we completed an evaluation of Hawaii's Childhood Lead Poisoning Prevention Program's risk assessment system. The evaluation assessed the current method for determining areas of high-risk for childhood lead exposure and provided the state's Department of Health alternative methods to current procedures.

We completed a 3-year evaluation of the Housing First project funded by the City and County of Honolulu. The evaluation results showed a high level of implementation fidelity achieved, a successful housing retention rate (at 94%), and a clear improvement in the behavioral health and healthcare utilization among program participants. The report also addressed areas where improvements are needed.

In leading the program evaluation of five federally-funded substance abuse treatment grants and one underage drinking prevention grant that the state received, our focus is to build the capacity of service providers to collect, report, and use program- and client-level data for their work. During the reporting period, we developed two databases to facilitate the data collection and reporting process, and one data dashboard to disseminate program results. We also provided data collection training and technical assistance to service providers, and submitted data and evaluation reports to the federal funder.

Our evaluation of active aging programs continues. We conducted a survey of program participants to examine the impacts of the pandemic when in-person exercise classes were suspended due to COVID-19 restrictions. Nearly all (96%) of respondents indicated that the pandemic impacted their lives, with the number of physical activities they participated in declining by 12%. The findings were presented to legislators and community stakeholders to initiate discussions on innovative ways to support seniors to live an active lifestyle and stay healthy longer in community settings as we move on to a "new normal" with COVID-19.

We continue to serve on a team of evaluators conducting a five-year assessment of a federal Medicaid Demonstration project, which aims to improve health outcomes for Medicaid beneficiaries and support strategies and interventions targeting social determinants of health. During the reporting period, we guided the development of reporting templates for data collection from various health plans on long-term and special health care services. The data to be collected in the future will allow the team to (1) track the process and progress of each health plan providing services to Medicaid beneficiaries, and (2) identify the impact of these services on the health outcomes of beneficiaries.

We also provided evaluative consultation and data analysis to the Hawaii Department of Human Services' Family First Hawaii (FFH) program, a diversion family services program aimed at reducing the number of children entering foster care in Hawaii. While the provision of FFH services begins in 2022, significant progress was made during the reporting period in preparing child welfare caseworkers and private providers to collect the necessary information on children and families for the ongoing evaluation.

Finally, we continue to serve as the data analyst for the Hawaii Youth Opportunity Initiative (HYOI), whose mission is to implement policies and programs that support young people transitioning out of foster care. During the reporting period, we provided analysis of outcome data from a semi-annual survey administered to nearly 400 young adults previously in the child welfare system. Our work is instrumental in assisting the initiative to utilize research and data for decision-making in the development of programs and policies that impact this population, and to generate public will and increase awareness of the challenges they face.

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

By making our social indicator data available in online, user-friendly formats, our target audiences are able to track the well-being of Hawaii's children and their families for effective decision and policy making. Google analytics suggests that traffic to these online tools is especially high during the state legislative session and during months that align with federal and state grant preparation periods. Our data products have been used and cited in legislative testimony, community needs assessment reports, and grant proposals.

We have and continue to make significant contributions to our state partners through our evaluation activities. Findings from the lead poisoning screening system evaluation are expected to inform improvements to the methods used to identify children at-risk of lead poisoning. The Housing First evaluation helped the program improve its adherence to the Housing First model and obtain funding to continue the services. The evaluation efforts for the federal substance abuse treatment grants and the underage drinking prevention grant have contributed to better data reporting and increased use of data to inform programs. The survey of physical activity among seniors helped relevant stakeholders to identify service gaps and gain support for the program.

The reporting tools developed and evaluative consultation provided as part of the Medicaid and FFH assessments have provided the respective state agencies a solid foundation for these ongoing, large-scale evaluation efforts. For example, the state's Child Welfare Branch administration and caseworkers, as well as private providers of family support services, now have a clearer understanding of the goals and objectives of the FFH program, as well as the importance of timely and accurate information on the children and families they serve.

Finally, our work during the reporting period on HYOI focused on tracking various outcomes (i.e., education, employment, permanency, housing, health, financial capacity, and social capital) of Native Hawaiian young people formerly in foster care. The initiative's lead agency, EPIC Ohana, reports that data analysis conducted during this period was used to inform educational program efforts for this population.

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

Our evaluation activities have important implications for the broader public. For example, improvements to lead poisoning screening methodologies will result in a more targeted identification of children at highest risk of lead exposure and perhaps improve the identification of sources for mitigation. The evaluations of the Housing First program, substance abuse treatment programs, and underage drinking prevention programs have made it possible for the public to monitor whether public funds are invested in effective programs and activities in communities where they are most needed. Two of our larger evaluation projects are still in their early stages. The data that will be collected and analyzed for the Medicaid evaluation will inform the impact of this demonstration program on the health outcomes of beneficiaries and identify needed services to improve outcomes. Finally, the public will soon benefit from our efforts on the child welfare evaluation by having clear and timely information on the success of the FFH program in reducing the size of the foster care population in Hawaii.

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.

Dissemination of results to communities of interest:

Social indicator data available through the Hawaii KIDS COUNT online data center/webtools received nearly 9,400 hits during the reporting period.

We also produced evaluation reports of the state's Childhood Lead Poisoning Prevention Program and the City and County of Honolulu's Housing First Program. Citations are as follows:

Zan, H., DeBaryshe, B., Kim, J., Azuma, J., Stern, I., & Gauci, K. (2021). *Hawai'i Childhood Lead Poisoning Prevention Program risk system evaluation*. Honolulu, HI: University of Hawai'i, Center on the Family.

Zan, H., Azuma, J., Kim, J., DeBaryshe, B. (2021). *Hawai'i Childhood Lead Poisoning Prevention Program risk system evaluation: Technical report*. Honolulu, HI: University of Hawai'i, Center on the Family.

Yuan, S., Liu, L,, & Azuma, J. (2021). *City and County of Honolulu: Housing First Increment II, program evaluation report, 2016–2019*. Honolulu, HI: University of Hawai'i, Center on the Family.

What the project or program plans to do during the next reporting period to accomplish the goals:

Hawaii KIDS COUNT and its related social indicator efforts are ongoing. We will continue to update and maintain social indicator datasets, and will continue to promote the use of Community Profiles.

A number of our evaluations are also multi-year efforts, such as the Housing First, substance abuse prevention and treatment programs, and active aging programming. We will continue the Medicaid demonstration program evaluation by analyzing quarterly data and identifying data quality issues in the reporting process, and will provide training for better data reporting. To lay the foundation for the future analysis of program impacts on the health outcomes of Medicaid beneficiaries, we will also access different data sources (e.g., administrative data and screening data) in the next reporting period. The evaluation of efforts to safely reduce the size of the foster care population will combine information from a myriad of data systems to provide a full picture of the correlates of success for children, families, and family serving organizations. Finally, in order to inform statewide programming and policy development for young adults previously in the child welfare system, we will continue our analysis of outcome data from the semi-annual survey administered to that population.

Closing Out (end date 09/07/2023)

Artificial Intelligence-powered Digital Solutions in the Fashion Industry

Project Director

Ju Young Kang

Organization

University of Hawaii System

Accession Number

1017033

Results

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

In spite of the escalating pace at which AI-based customer services are employed in many industries, academic research on how AI-based customer services influence the customers' experience and behavioral outcomes is relatively sparse. Therefore, this research project examined the uses and gratifications of AI-based customer services and the influence of customers' perceptions of service quality regarding AI-based customer service on customers' behavioral outcomes through a sequential mixed-method design. Also, there is no problematic issue related to conducting this research activity (i.e., data collection, analysis of data, etc.)

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 data and findings of Study 1 were analyzed. By employing a uses and gratifications theory, this qualitative study found that (1) seeking instant response and real-time information, (2) seeking convenient and fast navigation and transaction, (3) seeking useful advice and suggestions, and (4) seeking a customized and personalized shopping experience with innovative technology were found to be the "how and why" of AI chatbots as well as the motivations (i.e., uses and gratifications). When it comes to the cons of using AI chatbot, participants mentioned (1) lack of detailed answers and options due to the repetitive pre-programmed responses, (2) lack of its sense of intimacy, (3) having difficulties understanding how to use the AI chatbot, (4) taking some time to search and show the results, and (5) useless product recommendations from AI chatbots.

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

My target audience would be apparel retailers and academic communities. I plan to develop a manuscript during the next time period. At this point, there is no report for this question. For the next plan, a manuscript for Study 2 and Study 3 will be created and submitted to an academic journal. Therefore, after publishing a journal article, I will disseminate this article/manuscript to apparel retailers in Hawaii and academic communities via email and social media. Therefore, apparel retailers and academic communities will see how customers' perception of empathy in AI-based customer services positively influenced favorable customer experiences (Study 2). They will understand how consumers' hedonic shopping motivations and omnichannel shopping tendencies influenced their responses to and behavior with AI-based applications such as chatbot platforms (Study 3).

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

Based on the findings of this project (Study 2 and Study 3), a lecture regarding AI applications in the fashion industry has been provided in the FDM 301 Fashion Forecasting and Marketing class. A manuscript for Study 2 and Study 3 will be created and submitted to an academic journal during the next time period. Therefore, the broader public will see how customers' perception of empathy in AI-based customer services positively influenced favorable customer experiences (Study 2). They will understand how consumers' hedonic shopping motivations and omnichannel shopping tendencies influenced their responses to and behavior with AI-based applications such as chatbot platforms (Study 3).

Mindfulness and Skillful Living to Promote Well-being in Hawaii

Project Director
Thao Le
Organization
University of Hawaii System
Accession Number
1013576

Results

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

This project proposes to address problems associated with self and emotional regulation that result in maladaptive outcomes such as anxiety, depression, aggression, interpersonal conflict, including delinquency among youth and young adult in Hawaii by culturally adapting and developing a mindfulness-based curriculum for ecological validity. Mindfulness-based curricula from the mainland may not be effective for Hawaii population due to lack of attention to cultural nuances and relatability, and lacks a place-based component and framework. Given the rise in anxiety, depression, and mental health concerns among youth and family, this project proposes to assist youth and community with development of skills and strategies to mitigate and prevent stress, and to provide more effective coping skills.

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

The major activities for this reporting period include development and dissemination of two children's book, Mindfulness with Aloha Breath (4,000 copies) and Akahai (1,000 copies) that were provided to K-12 teachers, school counselors, social workers, health providers, and other allied social service providers. In addition, 10 lesson plans were developed for Mindfulness with Aloha Breath and workshop trainings were provided to teachers and staff at various social service agencies throughout Hawaii in the use of the lesson plans. These books and lesson plans provided social-emotional skills in a place-based, culturally-based format that were well received by the participants, and which became a significant resource during the covid pandemic.

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

Target audience included youth, teachers, and social service providers throughout Hawaii. Youth benefitted by having a resource that provided them with concrete skills to help them regulate distress, stress, and anxiety. Teachers and social service providers benefited by also having an educational tool that provided information on stress and stress management in a culturally-based, place-based format, and could effectively share it to youth and family members.

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

The broader public benefited from project activities as youth and family who are social-emotionally healthier, and know how to regulate their emotions, are more likely to be productive and contributing member of their community and society.

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 major challenge during this reporting period was the covid pandemic which limited in-person workshops and trainings. All trainings were done online, on zoom, which limits demonstration of experiential activities and engagement.

An opportunity for training and development is a recent collaboration with the Living Life Source Foundation which is a Native Hawaiian organization dedicated to providing health and wellbeing for Hawaii youth and community through restoration of ecological and indigenous agricultural and natural resources practices. The project is working with the Living Life Source Foundation to further refine the lesson plans, and to develop a research project at the fishpond and with farmers and their families.

Hawaii 4-H

Project Director

Jeffery Goodwin

Organization

University of Hawaii System

Accession Number

7000118

4-H Junior Master Gardener Program

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

The Situation

With the COVID-19 pandemic stay-at-home orders, families needed ways to keep their children engaged during the day. Also, schools were looking to supplement their students with a “stay at home” project that was (1) educational, (2) connected to their class studies, and (3) could be completed from the safety of their home.

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

Extension’s Response

Hawai‘i County 4-H started a program in 2012 to grow giant pumpkins. Due to the popularity of this program, it has continued to be held annually. Over the years, we were able to diversify to include many other giant fruits and vegetables.

Typically, this program would start in June and conclude in September. However, when the COVID-19 pandemic hit and “stay at home” orders began, an effort was made to start the program earlier to give youth “something” to do, supplement school studies, and get our youths outdoors and away from their computers.

Prior to plant distribution, we held a seminar to provide growing information and answer questions about growing giant produce. We established a Facebook Group page so participants could post their successes and receive assistance when challenges would arise. Monthly “Talk Story” sessions and an annual tour (all held virtually) added to even more educational opportunities throughout the 2020 program.

In an effort to have more accountability and give plants a good start, families/ schools were expected to provide photos showing their garden area was ready to receive plants. This step not only helped ensure project success, but also provided an indication of families needing

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

Impacts and Outcomes

Because many youths were at home a greater portion of the day due to the pandemic, they were well-positioned to manage and take better care of their plants, which resulted in more contest entries at the conclusion of the program:

- In 2019, there were 22 entries for our contest. In 2020, we ended up with 76 entries — an increase of 245%!
- Seven state records were produced.

Survey results indicated:

- 50% of the participants were first-time gardeners.
- Highly significant positive changes in participant knowledge/ability to grow “Giant” vegetables and plants.

- 100% of the responses indicated that families/ schools want to see:
  - the annual seminar continue
  - monthly 'Talk Story' sessions continue - continued on back February 2021
  - the annual tour continue
  - they ALL had fun participating
  - 100% of the 2020 participants stated they would participate again in 2021.

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

During the height of the COVID 19 pandemic, the 4-H large vegetable project provided families with an opportunity for quality family time and activity, as well as providing the family with high quility food. This project was also an example of how the Hawaii 4-H Program made a major pivot to help families cope well during the course of a world wide pamdemic.

Hawaii 4-H Youth Development Program Management

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

One of the most significant challenges facing the Hawai'i 4-H program is the fierce competition for the out-of-school-time of today's youth. In order for the Hawai'i 4-H program to survive and thrive, involvement of Hawai'i 4H families in the program requires adaptation of traditional 4-H delivery methods to align with the needs of today's families. In times of finite resources, the future Extension educational programs will depend on capitalizing on the strengths and solid foundation of the both the Land-grant system and the 4-H program itself.

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.

- Shifted the focus in delivery to increase in school-based programming
- Delivered programs compatible with the CTAHR Food Systems Imitative including GET Local, AGduino, Junior Master Gardeners, and the creation of the 4-H project garden at the Urban Garden Center
- Integrated programming into community organizations through partnerships including a cooking series, positive youth development programs, a Wounded Warrior Camp, STEM Kits, disaster preparedness, plants and gardening knowledge and skills, and public speaking skills
- Opened the statewide cooking contest to youth outside of the 4-H program
- Recruited and trained new volunteers and added new county-based 4-H clubs
- Provided volunteer training and updates on COVID-19 guidelines and record books

- 4-H club members statewide participated in community service projects including elder care housing donation package and handwritten notes projects, service learning projects, elder care paper flowers, homeless services package donations, and ocean clean up

- Submitted county, regional, and national grant applications

- Maintained county and state social media campaigns

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

Short-term Impact (Learning):

- Increased school-based 4-H programming participation by 53%

- Delivered 5 multi-county programs supporting the CTAHR Food Systems Imitative

- Doubled participation in the statewide cooking contest

- Increased public visibility of 4-H through a 1450% increase in Instagram views

- Established 3 new collaborative efforts with other youth serving organizations

- Increased dollar amount of extramural funds to support programs by 52%

- Expanded outreach through content program delivery to 746 community youth

- 707 4-H members participated in community service projects

- Conducted multi-state collaborations with 3 other states

- 2662 youth gained life skills through participation in positive youth development programs

- Youth gained content knowledge and skills through participation in 8 project areas

- 444 youth received high quality 4-H programming at installations via the Military Partnership

Mid-term Impact (Action):

- Provided multi-year program outreach beyond individual counties and state through pandemic-responsive,

- distance education programs

- Youth program participants responded they encouraged others to be active and to make responsible
- choices
- Youth program participants responded they help educate family members about healthy meals and snacks
- Staff gained PYD knowledge and applied it to their organization's programs creating and delivering high

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

Increased public awareness of Hawai'i State 4-H will allow for greater program support and allow for the recruitment of new leaders and youth members, which will strengthen the delivery of positive youth development programming into the community.

Youth participants increase skills and knowledge and gain confidence in life skills such as leadership, communication, and collaboration necessary to become successful and productive community members.

Volunteers benefit from making a difference in the community and in the lives of the youth they work with. Through continued connections with 4-H affiliate groups, community needs are shared and addressed through a network of 4-H alumni who are far more likely to donate, volunteer regularly, be involved with faith or politics, and support funding for public universities.

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

Not Provided