# 2021
## Impact Report

## Western Pacific Tropical Research Center
College of Natural & Applied Sciences
University of Guam

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# Impact Report

This report is dedicated to the legacy of Bernard Watson.

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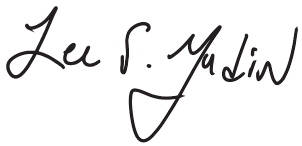
Hafa adai,

The Western Pacific Tropical Research Center continues to demonstrate both the diversity and importance of research in trying to solve local issues in agriculture production/sustainability, invasive species, and new scientific discoveries on Guam and in the region. I want to thank the faculty, staff, graduate students, and our community partners who have worked extremely hard during the continuation of these COVID times and have contributed to this report. I can continue to hope that in 2022, we will be blessed by putting this pandemic behind us.

In 2021, Guam's farming community lost one of its most productive farmers, Mr. Bernard Watson. Bernard was always willing to try new technologies that our research and extension faculty provided and gave his honest opinion as to whether he found these new technologies useful or not. Therefore, the CNAS administration would like to dedicate this 2021 Impact Report to the man, to the legacy Mr. Watson left to Guam, and to his lifetime devotion as a proud farmer and primary producer of agriculture products on Guam. We hope his legacy is passed to the next generation of agriculture students who might consider farming as their natural choice.

In this issue, we explain what a Land-Grant institution is all about, when was it established in the United States and why. We also note when the University of Guam became a Land-Grant institution and what the future might hold for the next 50 years. The eleven articles highlight the diversity of our faculty in both research and extension projects. Enjoy the articles and please know you are welcome to share with us your ideas of how we can improve what we do as a Land-Grant institution.



Lee Yudin
Dean/Director
CNAS/WPTRC

Buenas and Hafa Adai,

This is written after another difficult year at WPTRC. Nonetheless, I am happy to report that again CNAS faculty continued valuable research work despite the uncertainties brought by the now two-year-long pandemic. Some of the studies and ancillary activities are depicted in this impact report. As usual, a broad variety of subjects are represented: aquaponics, bee ecology, consumer preference for local produce, farmer livelihoods, plant diseases, and soil conservation. There is more good news … The UOG President's Council has approved the search for 12-month research faculty positions at WPTRC. This will reverse the pervasive faculty attrition that has hindered WPTRC functioning in recent years. The additional faculty will bring new ideas, increased capacity to pursue extramural funds, augmented collaborative initiatives, and enhanced support for CNAS academic mission. Coupled with the continuous improvement of laboratories and experimental stations, the enhanced human capacity will boost WPTRC contributions to Guam and the Pacific Region.

"There is no more beautiful excess than gratitude" penned an American writer. Earnest thankfulness to the numerous stakeholders and for the generous funding from federal and local sources is indeed an ever present feeling at WPTRC. Our responsibility is to continue retributing all the support with outstanding research to improve environments and livelihoods in Guam and beyond.

Adrian Ares
Associate Director
WPTRC

**What is Land-Grant? When and why was it established?**
The Morrill Act of 1862 served as the start point for establishing the Land-Grant System for US universities. This and subsequent legislative amendments allowed each state to develop its respective programs in institutions of higher learning. Among other Act objectives, the most noteworthy dealt with federal support of education and expanding access to all educational opportunities. The University of Guam (UOG) is among the 1862 cohort of institutions. In 1890 and 1994, other institutions followed, making up the current group of Land-Grant institutions. Over time, other legislation on public education access provided agricultural research support to farmers and practical education to individuals, families, and communities. The Hatch Act of 1887 supported farmer research and established the initial Agricultural Experiment Station arm of the land grant system.
The Smith-Lever Act of 1914 created the Cooperative Extension system as it exists today, supporting vocational, agricultural, and home economics education. Today, these programs exist at UOG within the Western Pacific Tropical Research Center (WPTRC) and the Cooperative Extension and Outreach (CE&O).

The age-old reference of land-grant universities carries the tripartite mission of fostering an integrated structure that supports education, research, and outreach to the broadest audience possible. In 2014, the Cooperative Extension system celebrated 100 years since the passage of the founding legislation, The Smith-Lever Act, carrying forward the elements distinguishing the role of public institutions of higher learning with a specific engagement focus, tied to sharing research findings.

**When did the land grant system come to Guam?**
The University of Guam became a land-grant institution in June of 1972.

**What is the importance of the land grant system in Guam?**
The 1999 Kellogg Commission report captured what a land grant should have at its most basic tenet and how it embraces research, education, and informational engagement that addresses local and national needs. The Kellogg Commission report identified seven guiding characteristics of relevancy in public institution of higher learning.

1. Responsiveness
2. Respect for partners
3. Academic neutrality
4. Accessibility
5. Integration
6. Coordination
7. Resource partnerships

**How does land grant play a role in shaping Guam's future?**
Extension and research components continue to provide varying degrees of complex supportive organizational roles that include, but are not limited to, planning, program development, non-formal teaching, and research-based knowledge (content and process expertise) that are designed to solve many issues affecting individuals, families, organizations, and communities on Guam and the region.

The support work roles are carried out through the existing delivery structures of WPTRC and the CE&O program units of Agriculture and Natural Resources, 4-H Youth Development, Family and Consumer Sciences, and Community Development. Each of these programs responds to several needs and continues to leverage the roles and assets of the human capital capacity and research capacity of WPTRC and CE&O, as well as the University of Guam as a whole.

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# Bernard Watson: a farming legacy

Bernard Watson monitors his tomato crop for signs of nutritional deficiencies.

The recent passing of Bernard Watson has left a large void in the local community of farmers and consumers who relied on his goodwill and his quality produce. Students, researchers, and extension professionals from the College of Natural and Applied Sciences (CNAS) have enjoyed working with Bernard over the last forty years and are deeply moved by this loss.

Extension Agent Jesse Bamba recalls meeting Bernard in 1995 as an undergraduate student in the agriculture program when CNAS was the College of Agriculture and Life Sciences. "Over the years Bernard was a teacher, a mentor, a collaborator, and a good friend," recalled Bamba, "Many lively discussions and new ideas to try came about over a bottle of beer…or two."

One of Bamba's first memories of Bernard took place in 1995 when now retired CNAS Cooperative Extension Agent Frank Cruz took him to his farm. Cruz had helped Bernard bring in a hybrid banana variety called "Williams" from Hawaii. He planted the trees and watched in awe as they produced the biggest bananas he had ever grown. They were more than twice the size of Chiquita bananas sold in many stores. He was delighted, until he realized consumers were not interested in big bananas. Perhaps it was this incident that inspired Bernard to always analyze the market for a return on investment.

He loved growing plants and he farmed with his hands and his head. Before he planted anything, he knew exactly what price point he needed to break even. He liked growing crops that had potential and was not afraid to experiment. "It was always rewarding to work with Bernard. He was a passionate farmer who wanted to take advantage of current research and modern diagnostic tools to make informed decisions about his crops and he allowed us complete access

Bernard Watson speaks with a visitor in the post harvest production area of his farm where vegetables were sorted and packaged for deliveries.

to his fields to monitor and assist," said Bamba. Roland Quitugua, CNAS Extension professional, worked with Bernard for over 30 years. At the time he met Bernard, he was working in the Western Pacific Tropical Research Center (WPTRC) Plant Pathology Lab with now retired Plant Pathologist George Wall. Papaya ringspot virus caused the death of many of Bernard's papaya trees and he needed help. "The work we did with those infected plants became part of the standard recommendations we give farmers today about growing papayas," said Quitugua. Bernard's papayas became the most popular on Guam. He created a red label with the word "dagua", which means "red flesh of the papaya", that he put on papayas for sale. That label came to signify excellence and consumers looked for it.

It was Bernard who first notified WPTRC scientists of the mysterious deaths of



Continue reading →

# Bernard Watson: a farming legacy

A Macau banana flower on Bernard's farm. Bananas were one of his main cash crops.

hundreds of ironwood trees, known in CHamoru as *gågu,* in 2003. He observed many of his young ironwood trees, planted as windbreaks for his crops, dying. Since that time, the condition, labeled by Plant Pathologist Robert Schlub as ironwood tree decline, has been responsible for the death of hundreds of ironwood trees throughout parks, golf courses, farms, and residential areas on Guam.

Bernard was also the first farmer to agree to work with soil scientist Mohammad Golabi on the Smart Irrigation Scheduling project, which would potentially save farmers money on water bills. “He was very cooperative and allowed to use his farm to evaluate this technology,” said Golabi.

Bernard’s top crops that he depended on to make a profit over the last 20 years were bitter melon, Macau banana, cherry tomato, and eggplant. He really liked to grow sweet peppers, but could not make a profit, so he switched to hot peppers, which are difficult to harvest. He made a canopy on wheels for the workers so they could pick in the shade, but he was not able to make those peppers profitable so he grew them for fun.

Through all the years of storms, typhoons, pests, and problems, Bernard continued supplying Guam with top quality produce. He was talking to the Guam Legislature about food security for the island long before sustainability became a buzzword and he was one of the founding members of the current Farmers Co-operative Association of Guam. Bernard’s legacy to Guam goes beyond farming. “His legacy is who he was as a person: smart, kind, and caring,” said Bamba. For Quituqua, “The example he set for all is his legacy. Bernard was a pioneer and the ultimate collaborator. All of us at CNAS learned so much from solving problems with him. When we work with farmers today, we speak from the experience of working with Bernard on his farm.”


In another example of his generosity, Bernard sells his produce with all proceeds to benefit the Guam Hotel & Restaurant Association (GHRA) scholarship fund.

Bernard will also leave yet another banana legacy. Since he had a fondness for experimentation, he tried growing new-to-Guam tissue-cultured banana varieties. He found a variety that his local clientele greatly appreciate, the “Tanduki”. The tree is shorter and stouter, which gives it a better chance of not getting blown over, and it produces more and larger hands than the “original Tanduki”. This time, consumers have embraced the big bananas. He will be greatly missed.

# Agroforestry management system for protecting corals

Novel agroforestry experiment plots located at the Ija Research & Education Center in southern Guam.

Soil sedimentation causes serious damage to corals on southern Guam's fringing reefs. In watersheds in the red clay hills of the southern villages, large amounts of sediment move downstream into the ocean with plumes of sediment extending out quite a distance from shore during heavy rain events.

Soil scientist Mohammad Golabi and graduate student Daniel Encio have been experimenting using novel agroforestry techniques to slow down the runoff and mitigate erosion and sedimentation from agricultural practices and other sources.

Using several types of plantings in sloping conditions at the Ija Research & Education Center, experiment plots were designed so that runoff would be funneled through weirs at the end of the plots and collected in storage tanks. Sediment levels could then be measured for each plot treatment, which included three vetiver grass treatments with different numbers of hedgerows and agroforestry plots with plantings of two tree species, noni and eggfruit. Additional plots were striped of vegetation to resemble the badlands in the area or not manipulated at all allowing vegetation that grows naturally in the surrounding savanna.

Graduate student Daniel Encio plants vetiver hedgerows as one type of six different plot treatments to study erosion and sedimentation. Below left is a close up of the weir that directs water into collection barrels located underground at the end of each plot.

The results showed that vetiver grass is highly effective in controlling soil runoff, which suggests that farmers in southern Guam may wish to plant borders of vetiver grass along the slope-side of their plots. Farmers can also utilize sloping lands to grow crops in between rows of vetiver and the rows of trees.

Farmers who wish to grow on lands with sloping contours can safely plant their crops using vetiver and agroforestry techniques and know that a heavy rain will not fill the rivers, streams, and bays with sediment.

*Funded by the USDA Hatch Program*

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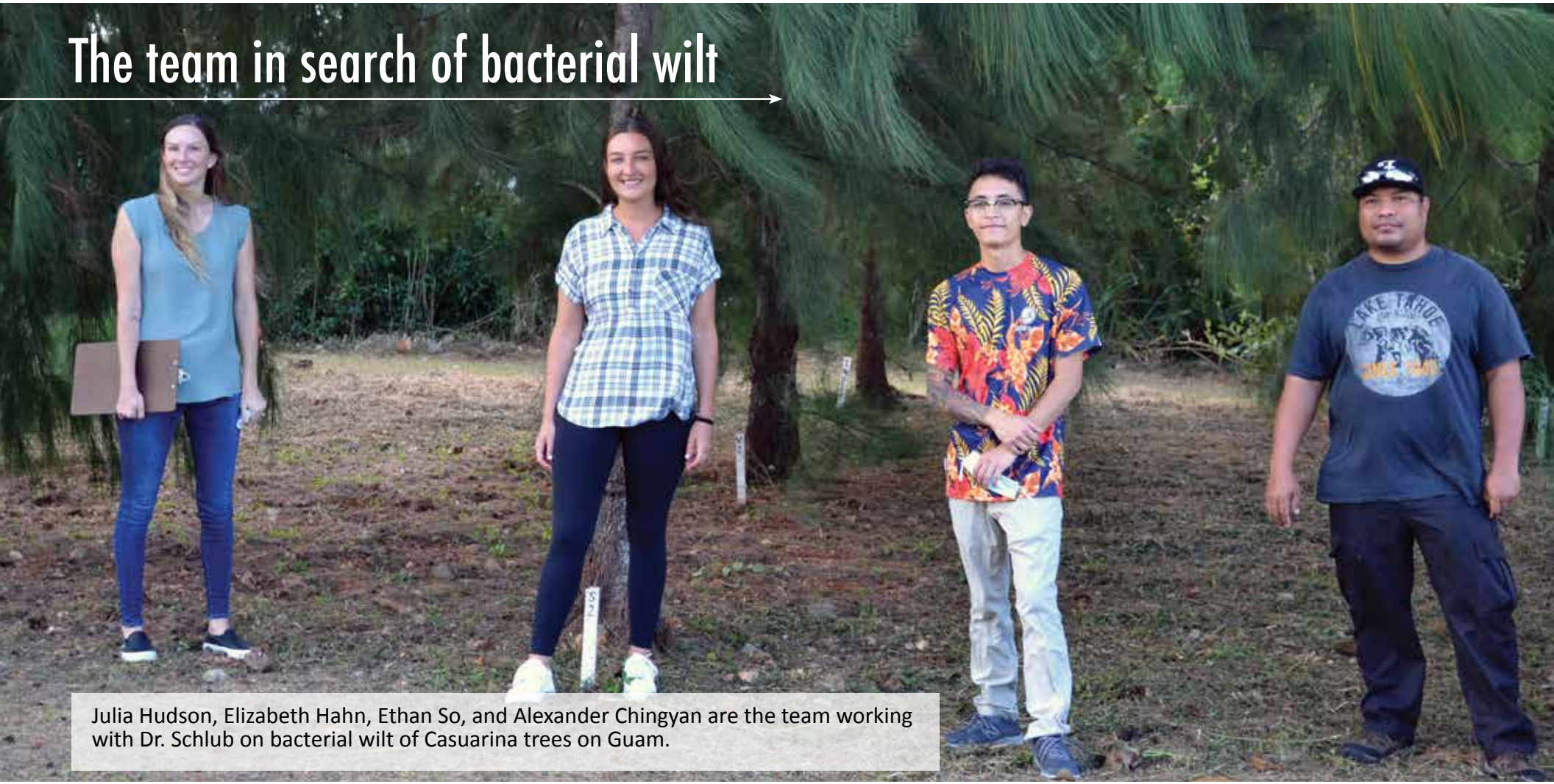
# The team in search of bacterial wilt



Julia Hudson, Elizabeth Hahn, Ethan So, and Alexander Chingyan are the team working with Dr. Schlub on bacterial wilt of Casuarina trees on Guam.

An extensive search on Guam for one of the most severe soil-borne plant bacteria complex is underway. *Ralstonia solanacearum* species complex (RSSC) comprise a group of plant pathogenic bacteria that are found in the soil and infect plants through root wounds such as those caused by cultivation or pests. Once inside the plant host, RSSC has an affinity for the vascular system where it multiplies rapidly, filling the xylem with bacterial cells and slime. This leads to the wilting of the host and ultimately to its death.

Though known to be present on Guam since the 1970s and occasionally impacting tomato and eggplant production, its presence was never considered a serious threat to any of Guam's plants until 2011 at which time it was discovered in *Casuarina equisetifolia*, locally known as gågu in CHamoru and in English as ironwood.

In 2014, then University of Hawaii graduate student Caleb Ayin, identified Guam's ironwood RSSC as *R. solanacearum* phylotype 1 biovar 3. In 2019 it was determined that the presence of RSSC was related to ironwood tree decline, which was first reported in 2002.

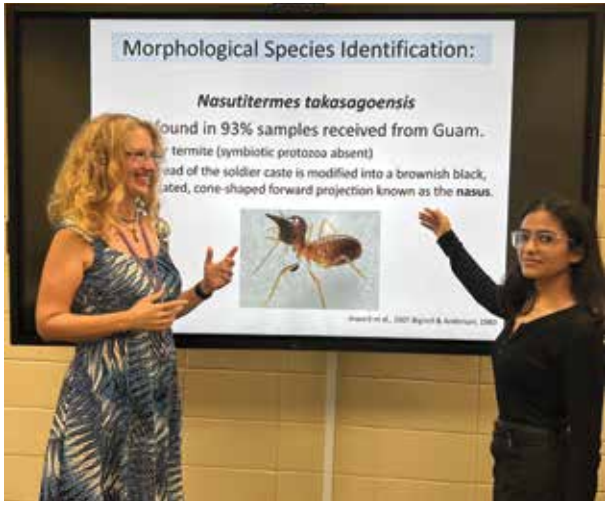
Characterization of samples from Guam in 2020 by University of Hawaii graduate student Sujan Paudel, confirmed the presence of *R. pseudosolanacearum,* phylotype I (Asian and African continent strain) (Rps) and also of *R. solanacearum,* phylotype II (American continent strain) (Rs).

With the need to understand the full impact of bacterial wilt on Guam, the USDA Hatch program funded a two years project searching for bacterial wilt among Guam's agricultural, landscape and forest plant species. The search consists of three main objectives: a literature review for plants reported to have been infected with bacterial wilt, a search of those plants on Guam, and identification of the RSSC found in these plants.

Starting with a list of RSSC hosts of over 450 plant species in 54 botanical families, Alex Pong Chingyan cut the list down to 100 plants from which to survey on Guam. With the help of Benjamin Deloso, they began testing plants for RSSC using a rapid *Ralstonia solanacearum* specific immunostrip tests. By September of 2021, they had performed 382 tests of 78 different plant species on Guam, including native and ornamental species. Of these 78 species, two have been tentatively identified as new RSSC host reports for Guam: *Dracaena marginata* L. (dragontree) and *Colocasia esculenta* L. (taro).

Symptoms of southern bacterial wilt in a tomato plant caused by *Ralstonia solanacearum*.

Occurring concurrently is research conducted in Dr. Claudia Husseneder's lab at Louisiana State University (LSU) by graduate student Garima Setia. With assistance from Alex, Ben, and Julia Hudson, LSU is evaluating the bacterial flora of Guam's ironwood tree termites and thus determining if termites may be responsible for movement of RSSC and other bacteria linked to ironwood tree decline. This research is being funded by Dr. Robert Schlub's WSARE Research and Education project (SW19-906), which will end in August 2022.




Garima Setia (right) discusses her master's thesis proposal on the role of termites in ironwood tree decline on Guam with Dr. Claudia Husseneder.

*Funded by the WSARE Research and Education Program*

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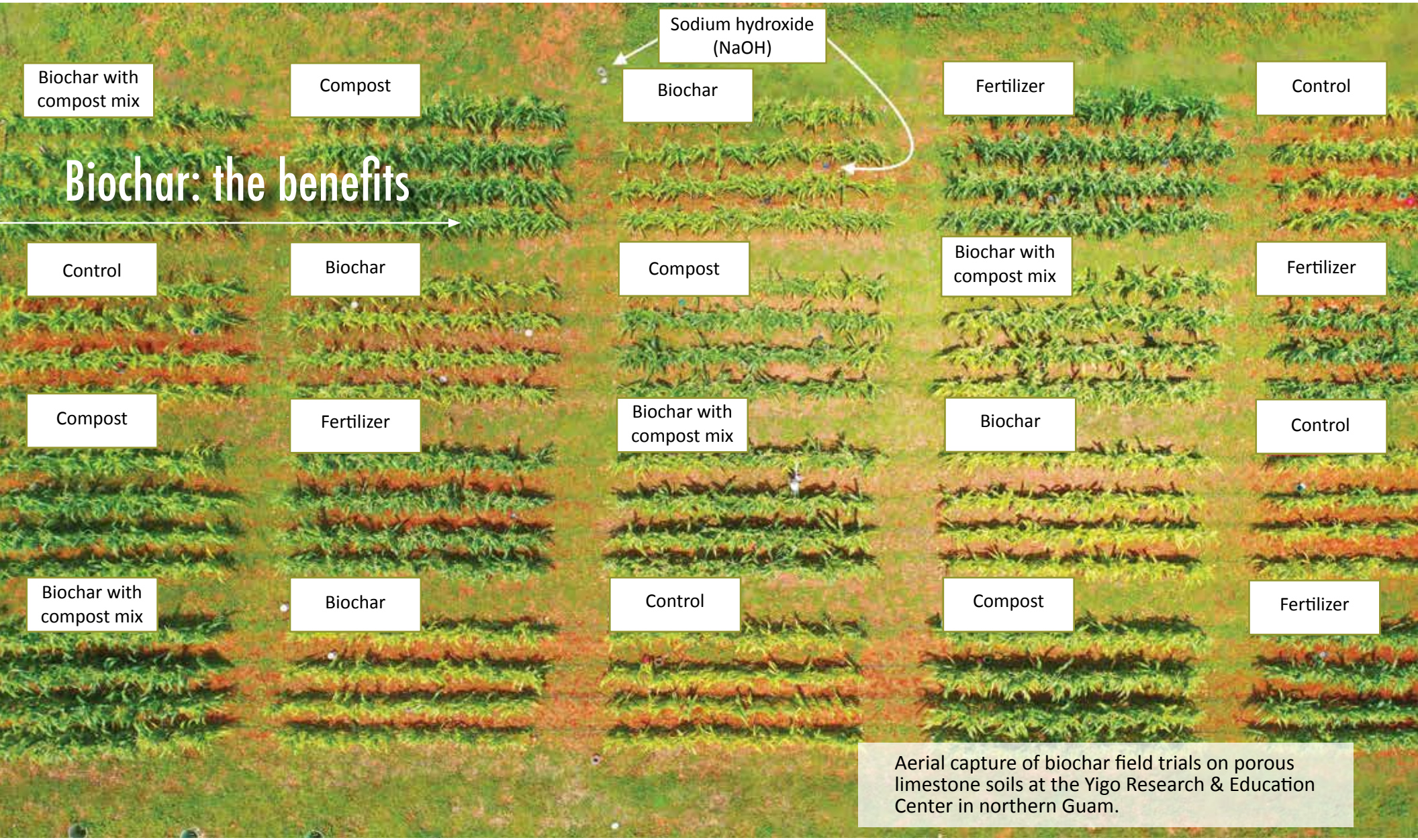


Aerial capture of biochar field trials on porous limestone soils at the Yigo Research & Education Center in northern Guam.

The pre-contact indigenous people of the Amazon are credited with being one of the first to use charred organic substances to enrich the nutrient-lacking soil common in the tropics. Today, researchers are investigating the use of biochar as a soil amendment and as a strategy for sequestering carbon.

Carbon-rich biochar is derived from plants or other organic materials that have been burned under the complete absence (pyrolysis) or partial absence (gasification) of oxygen. Soil scientist Mohammad Golabi, with the assistance of Research Associate Ferdinand Galsim, has been conducting field experiments with biochar as a soil amendment to study the efficacy of the use of biochar to sequester carbon and as an alternative to inorganic fertilizer for crops.

Previous experiments were undertaken on the acidic red-clay soils of southern Guam looking only at the carbon sequestering abilities of biochar. The most recent field trails were conducted on the porous limestone soils of northern Guam at the Yigo Research and Education Center. The study plots included several treatments including compost, biochar, biochar/compost mix, and synthetic fertilizers, which then had rows of corn planted to serve as the monitoring crop.

Crop yield, soil microbial activities, and soil nutrient analyses were performed and the presence of crop diseases was monitored throughout the planting season. Collaboration with Alan Franzleubbers, a soil microbiologist with USDA, allowed for samples from the Yigo plots to be sent to North Carolina. Dr. Franzluebbers analyzed the samples for the presence of microorganisms. Soil microorganisms such as bacteria and fungi are important in facilitating nutrient availability to plants.

Carbon dioxide emissions were measured for each of the plot treatments using a $CO_2$ capturing device.

A $CO_2$ capturing device is placed between rows of corn to collect carbon dioxide emissions during the active growing period.

The results of these trials have shown that the application of biochar not only improved soil quality, it increased the carbon content of the soil due to its ability to sequester carbon. This indicates biochar can be successfully used to keep carbon in the soil, thereby reducing the amount of carbon emissions caused by soil disturbances from industrial farming and deforestation. Additionally, crop yields from the open-pollinated sweet corn variety grown in biochar plots increased by 40% compared to control plots.

The findings of these on-going experiments contribute to the overall scientific efforts of understanding the role of biochar in carbon dynamics of soils and the ways in which biochar applications may reduce atmospheric carbon dioxide emissions, a major cause of global warming. Healthy soils mean healthy plants and a healthy environment.

*Funded by the USDA Hatch Program*

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# Interdisciplinary team: Summer Math Research Experience

Mathematics faculty, Drs. Oh, Choi, and Aquino, facilitated the first Summer Math Research Experience, an intensive summer program that brought undergraduate students together with subject matter faculty to apply math modeling and game theory to research focused on issues pertaining to local ecosystems.

"Applying mathematics principles to real-world problems opened an array of possibilities, which helped students discover that the theories they were learning had practical applications that could contribute to the conservation of native plants and animals," said Dr. Leslie Aquino, Division Chair of Mathematics and Computer Science.

The Summer Math Research Experience (SMRE) was held in conjunction with two other math research experience programs: the Young Scholars Research Experience in Mathematics (YSREM) for high school students, and the National Research Experience for Undergraduates Program (NREUP). While this was the first summer for the SMRE program, YSREM and NREUP are in their second and third summers, respectively.

Students in the three programs worked with data collected by UOG researchers, investigated the effects of pathogens on the population dynamics of the coconut rhinoceros beetle, developed models to study the population dynamics of the Mariana eight-spot butterfly and parasitoid wasps, and examined overfishing and the health of coral reefs.

"All of the projects this year were focused on local issues, so I was excited to help out this summer," said Regina Mae Dominguez, one of two research assistants who served as mentors for the students. Dr. Aquino believes the success of this inaugural summer program was due to the hard work of the students and the close mentorship by the research assistants and faculty.

Students were divided into six groups, with YSREM high schoolers working together with NREUP undergraduates on ecology-related projects, and SMRE students working together on coral reef projects. Students confidently presented their work after a rigorous seven-weeks of intensive study. Two groups analyzed different control measures to combat the invasive coconut rhinoceros beetle. One group concluded the best way to control the beetles on Guam is to remove all dead or dying coconut trees. The other group determined that an increase in the use of *tekken* nets as traps was the better solution. Dr. Aubrey Moore assisted the students providing data, lectures on how biologists use modeling for population dynamics, and some instruction on coding. Moore stated, "All scientists are modelers starting with a conceptual model, the hypothesis, moving into a mathematical model and then to computer models." He greatly enjoyed the interdisciplinary aspect of the experience and learned something new that he can use in his research.

Two groups focused their research project on the endangered Mariana eight-spot butterfly. One group looked at population dynamics between the Mariana eight-spot butterfly and parasitoid wasps with the other group investigating the population dynamics between the eight-spot butterfly and two other related butterfly species in Guam. Both groups concluded that an increase in the native host plants for the eight-spot butterfly was the best way of ensuring its survival.

The SMRE groups looked at two issues affecting Guam reefs: the effects of overfishing on coral reef ecosystems and the resilience of coral to environmental stressors. One group found the sustainable harvest of parrotfish in Guam should not exceed 13% of the current population. The other group determined that the death of bleached corals and the resiliency of diseased corals are important to maintaining healthy coral reefs.

The Summer Math Research Experience was funded primarily by GECCO (EPSCoR-Guam Ecosystems Collaboratorium for Corals and Oceans). The work done by students will be used to assist modeling efforts for the Common Garden Project, an EPSCoR-funded study that will examine three important reef-building coral species and their responses to environmental change.

"This experience showed students what they were capable of, especially when they looked back after their final presentations at where they started on day one and how much they accomplished," said a gratified Aquino.

*Funded in part by GECCO*

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# Decupled aquaponics systems and polyculture possibilities of sea grapes and shrimp

Native sea grapes (*Caulpera racemose*) to be considered as a potential candidate for polyculture with shrimp or other marine species.

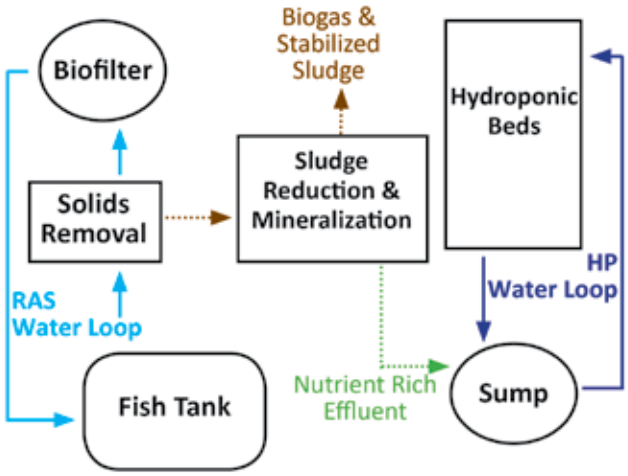
Aquaculture is one of the fastest growing food sectors in the world, but the US aquaculture sector has experienced slower growth at 1% annually. The US seafood market is dominated by imports, which is comparable to Guam where most food is imported, with only 10% of food consumed on the island produced locally. The complexity of the regulatory environment, foreign competition, social licensing issues, lack of investment, market uncertainty, diseases, and low-profit margins were some of the identified factors behind limited growth in US aquaculture.

Guam's aquaculture remains small-scale with many risks from production to market. As a consequence, it is necessary for the island to develop and promote local aquaculture by addressing the challenges in order to limit the effects of food insecurity and limited food options on families and communities. Recent research efforts in evaluating/mitigating the risks related to production, disease, health management, and markets are summarized below.

Infectious disease outbreaks are the most catastrophic threats to the aquaculture industry. Health management via the establishment of high health stock, and implementation of systematic prevention and control of diseases are fundamental to sustainable aquaculture development. For fourteen years, Dr. Hui Gong Jiang and her team have complied with effective biosecurity measures and maintained health management standards to produce high health status stock at the Guam Aquaculture Development and Training Center (GADTC). Strict health surveillance and monitoring regimes have been actively in place for the facility and its operations. Both shrimp and prawn stocks remained specific pathogen-free (SPF) from the many viruses that plague the industry including WSSV, IHHNV, TSV, YHV, IMNV, LSNV, CMNV, MrNV, BP, HPV, SMV, AHPND/EMS, EHP, NHP-B, and SHIV/DIV1. By far, this is a much more comprehensive SPF list than the World Organization for Animal Health (OIE) list, which includes all significant pathogens, both known and emerging.

As for shrimp and prawn selective breeding efforts, Jiang and her team continuously select for fast growth strains in Guam's environment, work to maintain genetic diversity and minimize inbreeding of the existing stock population of *Macrobrachium rosenbergii* (giant freshwater prawn) and *Penaeus vannamei* (whiteleg shrimp), both of which are commercially important species worldwide. Experiments are currently underway to evaluate the co-culturing of these species for the best combination in terms of production performance. Native sea grapes (*Caulpera racemose*) are also on the list to be considered as a potential candidate for polyculture with shrimp or other marine species.

Dr. Hui Gong Jiang and Dr. Kuan-Ju Chen have initiated a multistate project to investigate ways to expand and diversify U.S. aquaculture production by combining the analyses on consumers' preferences and production challenges and opportunities. Dr. Hui Gong Jiang, David Crisostomo, and Dr. Kuan-Ju Chen are collaborating in evaluating production and costs for a commercial decoupled aquaponics system. Traditional aquaponics systems were arranged in a single-process loop that directs nutrient-rich water from fish to plants and back. Given the differing specific plant and fish nutrients and environmental requirements, such systems presented a compromise to the ideal conditions for rearing of both, thus reducing the efficiency and productivity of the systems. More recent designs that allow for decoupling of units




Schematic implementation for a decoupled aquaponic system.

provide a more finely tuned regulation of the processed water in each of the respective units while also allowing for better recycling of nutrients from sludge. A decoupled aquaponic system has the potential to be a nearly zero-discharge system.

Keeping the needs of farmers and the environment in the forefront, WPTRC aquaculture researchers and economists are moving forward with strengthening the aquaculture industry and food security for Guam.

*Funded by USDA NIFA*

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# Finding the flowers bees visit

A honey bee forages for pollen, which she stores in the "pollen basket" on her hind legs. Pollen is a rich and important protein source for the colony.

The WPTRC Entomology Laboratory continues to keep studies of honey bees on Guam in the forefront of their diverse projects. *Apis mellifera* arrived in Guam via the Hawaiian Islands in 1907. Since that time there have been very few studies on Guam honey bees, the plants they visit, or the pollen they collect.

For her thesis, graduate student Jonae Sayama is conducting pollination studies on Guam bees. She has been collecting monthly pollen samples from hives on Guam and sending the samples to Jonah Ventures Laboratory in Boulder, Colorado for metabarcoding in order to determine the plant species used as foraging by the bees. DNA metabarcoding is the preferred technique for pollen identification because it analyzes larger complex samples, detects more species, and reduces cost and labor.

Sayama is sampling pollen from three hives at each of ten honey bee apiaries maintained on Guam within a one-year sampling period. The results from this study can be used to promote honey bee colony health and serve as a foundation for future honey bee studies on Guam.

“One thing that I am hoping to find is whether honey bees are foraging from native species. I believe that this research will provide us with a better understanding of the role of bees as pollinators on Guam,” said Sayama.

Honey bees store the many-hued colors of pollen in the brood chamber next to capped and uncapped brood. This file is licensed under the Creative Commons Attribution-Share Alike 3.0.

The consumption of pollen and honey by humans has increased because of their potential nutritional values. This increase in demand has sparked interest in pollen collection and identification. Pollen can be collected from returning honey bees at the entrance of the hive using a pollen trap or by extracting the pollen directly from the pollen cells in a frame.

The type of pollen collected may be influenced by seasonal weather and the position of the hive in relation to the nearby floral resources. The pollen can then be used to identify the plants from which it was collected. Pollen identification may assist in assessing the habitat diversity of food resources available to foraging honey bees. Floral diversity in a bee’s diet may result in increased lifespan and reduced colony loss. Pollen identification will also allow beekeepers to be confident that their bees are not experiencing nutritional deficiencies. The composition of the pollen directly influences the nutritional value, quality and safety of honey bee products, such as honey and pollen pills.

Guam bees and beekeepers continue to benefit from the ongoing research conducted by Dr. Ross Miller and his students.

*Funded by the USDA Hatch Program*

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# A study to examine increasing the consumption of local fruits and vegetables is off to a great start

Despite being surrounded by tropical fruits and vegetables in Guam, children and adults are not meeting the dietary recommendations for these foods. Some of the known challenges to eating fruits and vegetables in the mainland U.S. are cost, preparation time, and availability, yet these challenges have not been well documented in Guam. Community nutrition education programs, like SNAP-Ed and EFNEP, are long-standing community efforts that help to improve household food security through food resource management, food safety, nutrition, and physical activity lessons. These programs, however, lack focus on providing fresh fruits and vegetables, which are included in Community Supported Agriculture (CSA) programs. Separately, SNAP-Ed and CSA programs have helped to improve fruit and vegetable consumption. Being offered together may result in a greater improvement in fruit and vegetable intake.

To address this issue, a new study was launched in February 2021 to determine the most feasible approach to improve the consumption of locally grown fruits and vegetables among adults in Guam. Embedded in this study are surveys to document perceived barriers and facilitators to participating in CSA-like programs that exist in Guam. The study had a slow start related to the challenges of the public health emergency around COVID-19. The research team transitioned to online surveys, online delivery of SNAP-Ed lessons, and contactless pick up of variety produce bags. Utilizing these strategies, they were able to screen 56 interested adults and enroll 33 participants. Participants were assigned to one of three groups: nutrition education only, local produce bags only, or the combination of both. Preliminary data among the 15 participants that completed all study activities is promising.

All participants improved or maintained their fruit and vegetable intake, no matter the study group. Those participants that received a combination of local produce bags and nutrition education had a greater vegetable intake than participants that only received one – either nutrition education or local produce bags only.

For the first time, facilitators and barriers to shopping at Farmers' Markets or using a variety-pack of local produce programs (or CSA-like programs) in Guam were captured. Early analysis of the data revealed that facilitating factors included assisting local farmers, more budget-friendly produce (only for Farmers' Markets), fresher vegetables, and supporting locally produced food. Barriers were unfamiliarity with local produce and food preparation, inexperience with the program, expense, lifestyle (e.g., prefer to eat out, infrequent grocery shopping, short shelf-life of local produce), and accessibility (e.g., limited schedule). Interestingly this is no different from what has been reported in other studies conducted in the U.S.

Overall, the initial study activities show that a variety-pack of local produce is feasible within existing community programs, like SNAP-Ed, and this will improve the access to local fruits and vegetables. Making this shift may ultimately result in increasing fruit and vegetable intake that leads to improved health. The study will continue for two more years with a plan to assess fruit and vegetable intake using new technology, the Veggie Meter®, to objectively measure fruit and vegetable intake along with self-reported intake with surveys. We will employ non-invasive methods to measure skin carotenoids, which is an indicator of fruit and vegetable intake and a biomarker associated with better health.

*Funded by the USDA Hatch Program*

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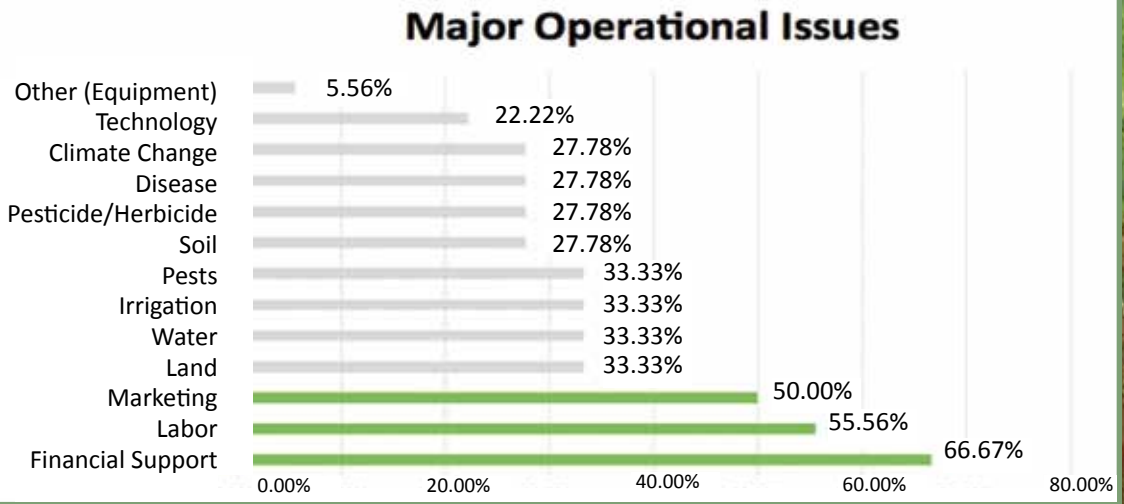
# Farmer livelihood during the COVID-19 pandemic

**Figure 1. Production Issues**



Preconditioned to the vulnerabilities of a small Pacific Island, Guam's traditional sectors recognize many challenges to natural, social, and economic factors. In addition to limitations and smallness, another level of sensitivity exists where the island relies heavily on an open economy of tourism and imports. The impact of the COVID-19 pandemic has created disruptions that have shocked markets, which brought attention to self-sustainability and resiliency.

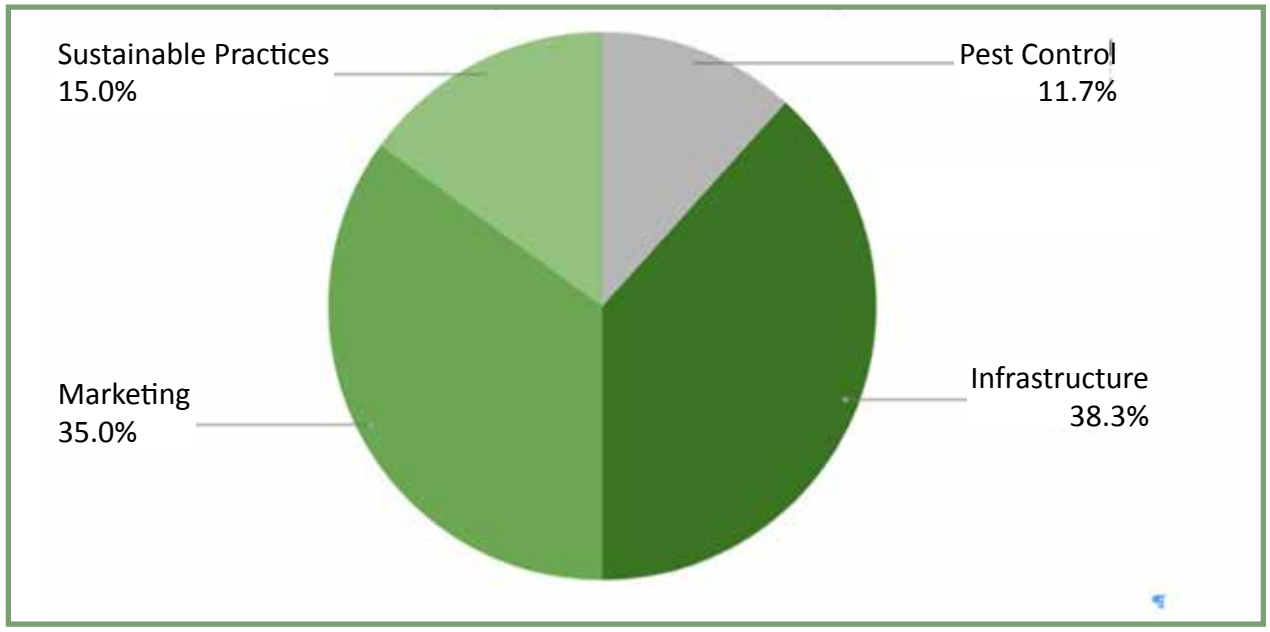
To enable strong and sufficient communities, building resilient food systems and promoting food security are critical. This study uses a mixed methodology that combines individual and collective perspectives. The survey approach considers major issues (Figure 1), followed by focus group discussions to identify potential opportunities (Figure 2).

In June 2021, a diverse group of producers gathered to share insights, including members of agricultural organizations, as well as commercial and subsistence farmers. Participants discussed top concerns for operations and shared potential development programs to develop the agricultural industry in Guam.

Results determined that significant barriers to production include securing infrastructural resources, marketing techniques, and implementing sustainable practices taking into consideration climate change. These top three challenges emphasize reducing pressures and enhancing production.

Despite the fact that there are many direct and indirect marketing paths for local producers to promote their products, there seems to be a disconnect from the local producer and the consumer. Establishing a series of programs is essential to address marketing locally grown produce as it is continuously competing with the retail prices of imported goods. Preliminary steps to developing any type of program will require more research on the market itself. An achievable stride toward this involves research that will analyze the consumer market by determining consumers' willingness to pay for local sustainable products, resulting in developing practical marketing strategies for local agriculture on Guam and the neighboring islands.

**Figure 2. Focus group discussion of challenges**

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# Consumer preference for genticially modified foods in the Pacific

In response to shifting technologies and rising populations, there is a critical need to match global food demands. Combining these pressures and Guam's susceptibility to limited resources, new techniques and innovations are needed to develop the agriculture sector. Genetic modifications benefit agricultural communities by proving higher crop resiliency, yield, and nutritional values. Essentially, this pilot study was to capture the market knowledge and interest for genetically modified foods.

A survey was conducted using the double-bound contingency model with a follow-up. The consumer was asked if they are willing to pay for a genetically modified product (GMO) at the same price as non-GMO foods. The study observed willingness to pay for popular staples including ground beef, coconut milk, and rice (Figure 1).

To provide a measurable estimate, a discount and premium follows after the initial answer of "no" or "yes", respectively. The follow-up for a premium and discount gives an estimate of willingness to pay and possible ranges. From September through December 2020, a consumer preference survey was carried out at three major supermarkets in the North, Central, and South of Guam. In addition, the survey was available through QR codes and Qualtrics™ online surveys. The inclusion criteria required participants to be at least 18 years or older and residents of Guam.

The willingness to pay provides a baseline amount from the original price at 100%. Findings show that all groups are at least willing to pay a 10% discount for genetically modified ground beef, coconut milk, and rice (Figure 2). The survey randomized information treatment groups that shared positive insight to genetically modified organisms (GMO). However, those presented without the information were more willing to pay a premium to as much as 7%. The intent of this research is to pilot consumer purchasing behaviors and markets for genetically modified foods. The efforts and data collected will be used to bridge policy making and developing the agriculture sector.

**Figure 1. Customer willingness to pay for GMO foods**

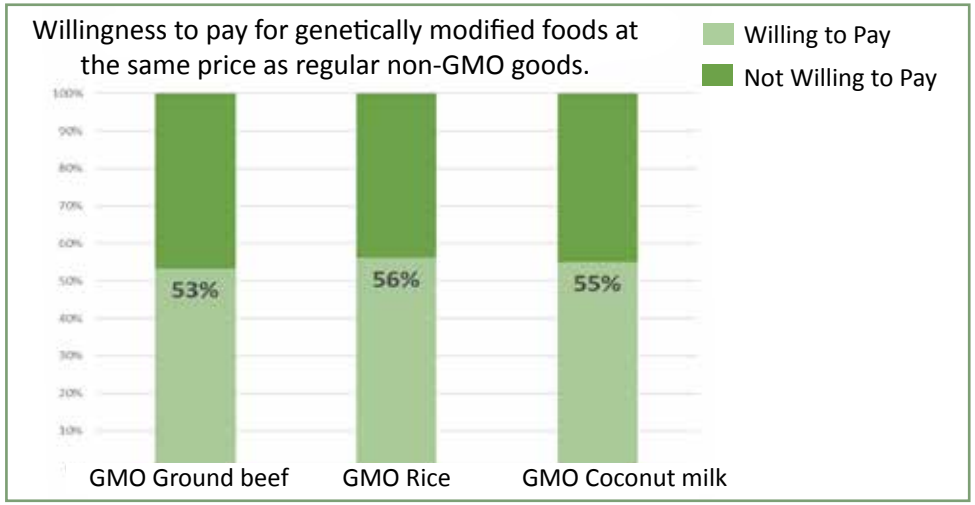


**Figure 2. Estimates of consumer willingness to pay**

| GM Coconut Milk | Willingness to Pay | Confidence Interval | |
|---|---|---|---|
| All group (N=177) | 91 | 83 | 98 |
| Control (N=98) | 97 | 87 | 107 |
| Treatment (N=79) | 82 | 71 | 94 |
| **GM Ground Beef** | **Willingness to Pay** | **Confidence Interval** | |
| All group (N=179) | 90 | 82 | 98 |
| Control (N=100) | 95 | 85 | 106 |
| Treatment (N=79) | 83 | 70 | 97 |
| **GM Rice** | **Willingness to Pay** | **Confidence Interval** | |
| All group (N=179) | 92 | 85 | 99 |
| Control (N=101) | 97 | 88 | 105 |
| Treatment (N=78) | 84 | 72 | 97 |

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# Teamwork to upgrade WPTRC laboratories

Laboratory equipment is vital for research. Different types of equipment are used to determine the chemical composition of soils, plants, and food; presence/absence of pests; and water quality among other purposes. Equipment should provide accurate and precise results in operationally efficient and safe ways. Instruments and other laboratory components are also valuable for instruction, service, and training engaging undergraduate, graduate, and high school students, government personnel, and other community members.

Equipment previously available to researchers working on WPTRC projects was often old, lacked accessories, and suffered unexpected breakdowns resulting in work delays, unreliable data, operator frustration, and customer dissatisfaction. Given the age of some models, supplier service and parts were sometimes no longer available forcing technicians to find creative solutions to continue operations. To compound the problem, there was no access to faster, user-friendly, and higher resolution devices generated by new technologies to gradually replace older systems.

The purchase, installation, and training for new equipment are seldom quick and easy processes from Guam. There are several bottlenecks including vast government procurement regulations, delayed shipments, international permitting rules, necessity of infrastructure upgrades to accommodate the acquired items, or, simply, lack of space. Persistence and patience are therefore needed to move from checking a company catalog to beginning to operate the equipment in the laboratory.

A considerable equipment upgrade at CNAS laboratories has continuously taken place. Drs. Gong, Marutani, and Wu have obtained USDA Agriculture and Food Sciences Facilities and Equipment grants to fund this effort. Dedicated staff like Chasy Cayton and Clancy Iyekar were instrumental in coordinating procurement, installation, and training for the equipment.

Iyekar, who has been working at the CNAS Soil Laboratory for 15 years said, “One of most anticipated upgrades was the Atomic Absorption Spectrometer, that was recently installed to replace the Spectrometer purchased in 1996. This instrument will not only be used for research but also by students to have hands-on use of highly scientific instruments. This is a great way to have students get more involved in their programs and advance their knowledge on research in agriculture, natural resources, and related disciplines.”

Listed below are several examples of equipment purchased for research projects at CNAS, which range in price from $10,000 to $100,000.

- Optima XE-90 IVD ultracentrifuge and rotors
- Dual flame-graphite furnace atomic absorption spectrometer with autosampler
- Flash Smart EA combustion carbon/ nitrogen analyzer
- Nanodrop One spectrophotometer
- Refrigerated 17.8 cu. ft. growth chamber
- Benchmark autoclave
- 96-well gradient thermal cyclers
- Centrifuge, rotors, and adapters
- Compound and stereo microscopes
- UV – Vis detector automated chromatography system

These recent upgrades to equipment will keep WPTRC scientists competitive in grant applications and students will benefit through the use of the latest technology.

*Funded by USDA NIFA*

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**Aflague, T.F.,** G. Badowski, H. Sanchez, D. Sablan, C.M. Schroeder, E. Sanchez, R.T. Leon Guerrero. 2021. Improving willingness to try fruits and vegetables and gross motor skills in preschool children in Guam. Nutrients 14: 93. https://doi.org/10.3390/nu14010093.

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**Golabi, M.H.**, **F.P. Galsim**, D. Endale, S.A. Tareyama, **C. Iyekar**. 2021. Agronomic value of composted organic waste application on porous soils of northern Guam. Malaysian Journal of Soil Science 25: 143-160. ISSN: 1394-7990.

**Jiang, H.G.**, J. Channarong, L. Ngernsiri, A. Swatdipong. 2021. Microsatellite techniques in Guam's specific-pathogen-free *Penaeus vannamei* stock: Genetic variance and parentage Identification. Fisheries and Aquaculture Journal 12: S2 No 1000003.

Katoh, S., K. Takayama, H. Katoh, **M. Marutani**, N. Murakami, **M. Martinez, J. Manglona, J. Tuquero, J. McConnell**. 2021. Genetic diversity of *Serianthes nelsonii* on Guam and Rota. Micronesica 3: 1-10. http://micronesica.org/volumes/2021.

**Marler, T.E.** 2021. Reciprocal garden study reveals acute spatial-edaphic adaptation for *Cycas micronesica*. Diversity 13: 237. doi:10.3390/d13060237.

**Marler, T.E.** 2021. Direct *Aulacaspis yasumatsui* infestation of pre-harvest *Cycas* seeds reduces germination and performance of seedlings. Horticulturae 7: 562. doi:10.3390/horticulturae7120562.

**Marler, T.E.** 2021. Leaf elemental concentrations, stoichiometry, and resorption in Guam's coastal karst forests. Diversity 13:545. doi:10.3390/d13110545.

**Marler, T.E.** and R.M. Callaway. 2021 Talking with strangers: Improving *Serianthes* transplant quality with interspecific companions. Forests 12: 1192. doi:10.3390/f12091192.

**Marler, T.E.**, C. Musser, A.N.J. Cascasan, **G.N. Cruz, B.E. Deloso**. 2021. Adaptive management lessons for *Serianthes nelsonii* conservation. Horticulturae 7: 43. doi:10.3390/horticulturae7030043.

**Marler, T.E.**, A.J. Lindström, G.W. Watson. 2021. *Aulacaspis yasumatsui* delivers a blow to international cycad horticulture. Horticulturae 7: 147. doi:10.3390/horticulturae7060147.

**Marler, T.E.** and A.J. Lindström. 2021. Leaf nutrient relations of cycads in a common garden. Tropical Conservation Science 14:1-10. doi:10.1177/19400829211036570.

**Marler, T.E.** and L.I. Terry. 2021. *Aulacaspis yasumatsui* invasion reduced *Cycas micronesica* microstrobilus size and pollinator brood site competence. Insects 12: 1023. doi:10.3390/insects12111023.

Liu, J., A.J. Lindstrom, **T.E. Marler**, X. Gong. 2021. Not that young: combining plastid phylogenomic, plate tectonic and fossil evidence indicates a Paleogene diversification of Cycadaceae. Annals of Botany 128: mcab118. doi:10.1093/aob/mcab118.

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