ANNUAL REPORT FOR ACCOMPLISHMENTS AND RESULTS

Agricultural Experiment Station

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Location

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Executive Summary

Guam, an unincorporated Territory of the United States, is located in the Western Pacific. It is the largest of 16 islands in the Mariana archipelago. It is approximately 3,600 miles west-southwest of the Hawaiian Islands and about 1,500 miles due east of Manila, Philippines. According to the 2000 census, Guam's population is 154,805. On June 22, 1972, the U.S. Congress passed Public Law 92-318, which designated the University of Guam as a member of the 1862 Land Grant institutions. In recognition of the University of Guam's land grant status, the Guam Legislature, through Public Law 13-47, assented to the federal provisions dealing with the research and extension functions of a land grant institution. In March 1974, the University of Guam Board of Regents created the College of Agriculture and Life Sciences (CALS) to facilitate the tripartite functions of the college: research, extension and teaching. On August 1, 2003, the University executed a major reorganization, which included consolidating five colleges into three major colleges. Agriculture Experiment Station became a component of College of Natural and Applied Sciences (CNAS). The Dean of CNAS is simultaneously the Director of the Agriculture Experiment Station (AES). The primary mission of AES is to conduct applied and basic research in agriculture and to protect the natural environment. The Hatch funds and their respective Government of Guam matching funds are used to maintain operations of the University of Guam Agriculture Experiment Station. These funds principally support the salaries of permanent personnel of AES.

National Goal 1.

An agricultural system that is highly competitive in the global economy.

Key theme: Plant germplasm

Experiment Station conducted research on plant genetic resources conservation and utilization. Activities for this project included 1)collection of local and international plant germplasm and to propagate selected cultivars by seed production and in-vitro propagation for conservation of germlines and distribution, 2) evaluation of field performance of collected germplasm for tropical climate adaptation, pest resistance, and other desirable characters for consumers in Guam, and (3) improvement of a plant acquisition and management system for germplasm collection and plant propagation program by advancing technology of the Guam Agricultural Experiment Station Horticulture Laboratory.

During 2005, activities of the project in Guam included (1) field evaluation of hot peppers (*Capsicum annum*) and large tomato (*Lycopersicum esculentum*) for tropical climate adaptation, pest resistance, and other desirable characters for consumers in Guam, (2) phenetic analysis of sweet potato accessions and (3) continuation of germplasm collection, conservation and distribution.

Seven hot pepper accessions were evaluated in a calcareous soil for the total yield, marketable yield, and consumer preference. Three commercial cultivars originated from Taiwan yielded greater than four local lines, however Taiwan cultivars were less pungent. Thus they were not preferred by Chamorro, natives of Guam.

Cultivars and breeding lines of hot peppers *Capsicum* spp. were obtained from the Asian International Vegetable Research Development Center (AVRDC) in Taiwan and the U.S. National Plant Germplasm System (NPGS) and commercial seed companies. Two landraces were also collected in Guam.

Impact:

The research results will help to improve the production performance of hot peppers. The qualitative and quantitative information of biochemical properties, in particular quantitative measurements of capsaicinoids will assist us in the selection of hot peppers for production of ‘dinanche’ sauces with a local recipe. The result of sensory evaluation will help us to further expand production of value-added products to satisfy ethnic demands in the Western Pacific region and potentially in other part of the U.S. and international market.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional

Key theme: Plant germplasm

A new large tomato cultivar, 'Solar Fire' developed at the University of Florida was evaluated for adaptability to Guam's climate in on-farm trial. For 6-week harvest period from March to mid-April, 'Solar Fire' (8.2 kg/plant) yielded comparably with a heat tolerant cultivar 'Solar Set' (9.0 kg/plant) and was superior to 'Sun Chaser' (7.0 kg/plant). 'Solar Fire' has a slightly smaller fruit (194±8 g) than 'Solar Set' (223±8 g), but larger than 'Sun Chaser' (161±5 g) (mean±SE, n=10). 'Solar Fire' was susceptible to bacterial spots (*Xanthomonas campestris*).

Twelve sweet potato (*Ipomoea batatas*) accessions were studied for morphological, growth and genetic characteristics. Accessions included germlines from AVRDC (Asian Vegetable Research and Development Center) in Taiwan, Saipan, Rota and Guam. Characters included marketable yield, growth habit and characteristics of tuberous roots (color, shape, sugar content and moisture content). For genetic analysis DNAs were extracted and PCR products were analyzed by random amplified polymorphic DNA (RAPD) fingerprinting. The phenetic analysis revealed four major clusters according to tuberous root characteristics. Accessions from Rota and Guam were closely related each other while they were remote from accessions originated from Taiwan.

The seeds of two local vegetables, okra (*Abelmoschus esculentus*) cv. Charlie, and corn (*Zea mays*) 'Guam white corn' were distributed locally and were sent to Saipan.

Impact:

Conservation and evaluation of important tropical plant germlines will support development of sustainability agriculture in the region. The project generated information on field performance of collected germplasm for tropical climate adaptation, pest resistance, and other desirable characters for consumers.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional

Key theme: Plant production efficiency

Scientists at Guam Agricultural Experiment Station investigated response of vegetable crops to mycorrhizal inoculation in tropical limestone soils. The influences of Glomus aggregatum on growth of tropical vegetable crops grown in Guam cobbly clay soil were examined. The pot culture revealed the positive effect of the VAM fungus on seedling growth of papaya (Carica papaya) and green onion (Allium fistulosum). A field experiment was conducted to find out the influences of G. aggregatum and application of inorganic fertilizers on plant development of corn (Zea mays) in Guam cobbly clay soil. The experiment was conducted in a split-plot design with the level of fertilizers as a main plot and the inoculation with G. aggregatum as a subplot. At 40 DAP (days after planting) and at final harvest the shoot biomass was greater with mycorrhizal inoculation for all level of fertilization treatment. When the fertilization level was higher, the shoot biomass was greater. Currently the results of leaf tissue analysis are being summarized.

Impact:

Glomus aggregatum inoculation improved plant growth and development of tropical vegetables. The study demonstrated the benefit of this VAM fungus on papaya and green onion seedlings grown in Guam cobbly clay soil in pot culture. The field experiment also demonstrated the possibility of improved performance of corn by inoculating G. aggregatum. Utilization of mycorrhiza in island agriculture may contribute in advancing the sustainable agricultural system.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional

Key theme: Plant production efficiency

New project was conducted in 2005 by scientists from Agriculture Experiment Station along with University of Florida investigated *Corynespora cassiicola* and its impact on quarantine regulations.

Permits were secured, contracts finalized, and agreements signed, thereby allowing for the purchase of equipment and supplies, payment of services, and the collection, storage, and shipment of cultures.

Isolates from all 20 hosts have been obtained from Guam. Isolates from 10 of the hosts have been obtained from Florida.

Contacts have been established for the various islands and arrangements are being finalize for surveys to be conducted between April and August of 2006. Isolates from Coleus have been obtained from Guam, Hawaii, and Florida. They will be analyzed for differences that can be directly related to geographic location (biotypes).

Progress on molecular characterization of Corynespora: ITS1, 5.8 rSSU, ITS2 sequence (597 base pairs from ribosomal DNA):

cttggtcatt tagaggaagt aaaagtcgta acaaggtttc cgtaggtgaa cctgcggaag

gatcattatc gtaggggcct cgcccccttc gagatagcac cctttgttta tgagcacctc

tcgtttcctc ggcaggctcg cctgccaacg gggacccacc acaaacccat tgtagtacaa

gaagtacacg tctgaacaaa acaaaacaaa ctatttacaa ctttcaacaa cggatctctt

ggttctggca tcgatgaaga acgcagcgaa atgcgataag tagtgtgaat tgcagaattc

agtgaatcat cgaatctttg aacgcacatt gcgcccttg gtattcctta gggcatgcct

gttcgagcgt catttcaacc ctcaagccta gcttggtgtt gggcgtctgt cccgcctccg

cgcgcctgga ctcgcctcaa aagcattggc ggccggttcc cagcaggcca cgagcgcagc

agagcaagcg ctgaagtggc tgcgggtcgg cgcaccatga gccccccccac accagaattt

tgacctcgga tcaggtaggg atacccgctg aacttaagca tatcaataag cggagga

This sequence only has two parsimoniously informative bases when compared with the sequence of *Corynespora olivacea* from gene bank. Therefore, it does not vary enough to distinguish between isolates of *C. cassiicola*. The next step will be to develop primers for a more rapidly evolving region of DNA such as the actin or beta-tubulin genes.

Impact:

Data from this project will be used to construct a Corynespora isolate diversity map for the Caribbean and Pacific Basins. Field agents at the various survey locations will be provided with a summary of results specific for their region. Each agent will receive a complete list of hosts susceptible to *C. cassiicola*. The list will indicate the hosts that occur in their location as well as the hosts found to harbor the pathogen during the survey. A chart summarizing the location of each isolate as well as the pathogenic, morphologic and molecular characteristics will be included. Susceptible crops that are currently free of the disease will be identified in each location. Based on pathogenicity studies, plant material containing isolates virulent to those crops will be identified. This will provide the basis for APHIS quarantine decisions. Additionally, an authoritative review of *C. cassiicola* based on our research results will be produced and disseminated to field agents at survey locations as well as state Departments of Agriculture, APHIS offices, and growers associations. This grant will provide quarantine regulatory agencies with the necessary information to restrict virulent subspecies from being established in new locations in the US.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: National, Regional

Key theme: Aquiculture

Scientist at Guam Agricultural Experiment Station conducted a disease survey and marketing prospects for SPF shrimp production on Guam. Post-larval shrimp have been produced at the Guam Aquaculture Development and Training Center (GADTC) for many years. Post larvae (PLs) have been provided to Guam, Palau, the Commonwealth of the Northern Marianas in Micronesia, and numerous other parts of the world. However, much of the shrimp stock had to be destroyed during 1994-5 because of an outbreak of infectious hypodermal and hematopoietic necrosis virus (IHHNV), one of several viral diseases that have seriously impacted shrimp production worldwide (Lightner 1983; 1996a).

While the current GADTC *L. vannamei* stock has not shown signs of disease, it has not been closely examined; and currently there is no ongoing disease monitoring program. The lack of an on-going disease monitoring program on Guam also means that the general health status of the local industry is not known and the risks to the industry from seedstock imported from Taiwan or from other sources can not be determined.

Also, the GADTC uses a well with a pump submersed to provide seawater to their flow-through shrimp production system. As there have been shrimp in the facility continuously since 1986, there is a possibility that there are remaining external sources of the viral pathogens that could contaminate existing or new stocks. Under these conditions it cannot be certain that the GADTC is producing disease-free seedstock and SPF certification is not possible.

There is a need for additional SPF stocks on Guam. There are indications from the GADTC hatchery and the local industry that larval production has declined and that the growth rates of the seedstock produced are lower than they were with earlier stocks. These differences are thought to result from of a lack of genetic diversity or in-breeding depression in the current stocks. To help alleviate this problem, additional stocks of SPF *L. vannamei* could be brought in if the facilities are certain to be pathogen free. In addition, a second species such as *P. monodon* could be brought in to further strengthen the economic viability of the facility. The black tiger prawn (*P. monodon*) is a highly desired species throughout the Asia-Pacific region, but successful hatchery production of this species may require research to achieve maturation in captivity and to insure the quality of post-larvae. If production of SPF *P. monodon* post-larvae from Guam can be realized, it is anticipated that the export markets for these will be lucrative.

The health of the GADTC shrimp stocks have been monitored since the start of the projects none of the viruses of concern have been found. There were White Spot Syndrome virus outbreaks on Guam and on Kauai in 2005. Since the shipment of shrimp P.L.s that was stocked immediately prior to the stocking found to be WSSV positive on Guam was from Hawaii, we suspected that the WSSV might have come from Hawaii. However, we compared the number of tandem repeats in the two virus samples and they proved to be different strains of the virus. The results of the monitoring project were reported at the 2005 World Aquaculture Society meetings in Bali).

Both commodity shrimp and mangrove crabs have been sampled from local markets on Guam. We have found both WSSV and IHHNV viruses in both commodities. Seventeen of the 18 commodity shrimp samples tested positive for IHHNV while 1 of the 18 samples tested positive for WSSV. The IHHNV in mangrove crabs has not been reported previously. We also initiated a monitoring program for wild crabs and shrimp in the estuary where the WSSV had been found on Guam. We wanted to see if the WSSV had established in the wild. We obtained 69 samples from eight different species of crabs and fresh water shrimp. None of the samples were positive for any of the shrimp viruses. While this does not prove the absence of WSSV in the wild, it is somewhat reassuring. The results of this monitoring were presented at the 2006 meeting of the Aquaculture America Meetings in Las Vegas last month (a copy of the poster is attached.)

We have literally searched the world for a stock of IHHNV free *P. monodon* stock that we could purchase for the hatchery. We have generally found that all of the available stocks test positive for IHHNV or they are not available for sale to us. On the advice of our collaborators at the University of Arizona, we have decided to obtain wild-caught broodstock from Tanzania. We have constructed a shrimp quarantine facility at the UOG Yigo Experimental farm, cut a purchase order for the breeders and obtained import permits from Guam Department of Agriculture. we are presently waiting for the first shipment to arrive.

Impact:

Data indicated that it is unlikely that truly clean P. monodon stock of shrimp exists on Guam. Most stocks turned out to be contaminated with IHHNV. Results suggest there may multiple viruses present in their Monodon stocks at very low levels.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional

Key theme: Small Farm Viability

Scientists from Guam and Virgin Islands Agricultural Experiment Station constructed and tested a model sustainable farm for the U.S. Caribbean and Pacific Islands. The project was conducted to illustrate successful sustainable agriculture under Guam's limited resource constraints. Specific objectives were set to produce profitable local fruit and vegetable crops, to produce ornamental plants used in local art and lei making, and to raise goats to illustrate rotational grazing techniques. The demonstration farm became a site of education in tropical island agriculture. There were no additional federal funds in 2005 but project continued. Numerous fruit trees were planted in the orchard. In the rotational operation for vegetable and goat production, star grass and pangola grass were planted in mother beds, more goats were purchased. Windbreaks and hedges were planted end established.

Impact:

The model farm became an educational tool to the community on how to recycle resources, improve crop production and protect the environment.

Source of funding — USDA CSREES Special Project TSTAR and local funds.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional, national.

Key theme: Plant health/ plant production efficiency

Plant Scientist at Guam Agricultural Experiment Station investigated photosynthetic recovery rates of Ifit. This project was designed to determine the limitations on photosynthetic rates at the canopy level, and how the rate of foliar development and specific physiological characteristics help optimize yields during times of environmental limitations.

Impact:

We studied post-defoliation leaf expansion and photosynthetic functioning in Intsia bijuga plants. The species is Guam's official territorial tree, and it is highly susceptible to defoliation during typhoons. Defoliation is the essential reason the species recovered rapidly from typhoon damage: It allows wind forces to pass through the canopy without them being transferred to the stems and trunk. The rebuilding of leaves is rapid following defoliation, and photosynthetic capacity reaches mature levels in about three weeks after leaf expansion begins. Rapid development of photosynthetic capacity explains the general ability of this species to tolerate typhoon damage. This project increases understanding of how native ecosystem responds to periodic tropical storm systems.

Source of funding — Multi-state Hatch

Scope of impact — State specific

Key theme: Plant Health

AES Scientist has been addressing issues related to phenology and toxicology of the Guam cycad. Objectives addressed during past year were: to determine the influence of resource availability on the production of secondary metabolites in the Guam cycad, 2) to determine the concentrations of secondary metabolites in seeds from the Guam cycad as a function of phenology. 3) to determine concentrations of secondary metabolites in pollen from the Guam cycad.

During the past year we have completed all field work on this project. We have also completed the biochemical analyses for every objective. Three refereed articles were published in the past year, adding to the refereed article this grant generated in 2004. Three more articles have been accepted and are currently in press, and two more have been submitted and are currently in review. We are currently working on the 10^{th} manuscript from this grant. Additionally, the IUCN has just Red Listed *Cycas micronesica* for provisional conservation status of "Endangered". Much of the hard data needed by the IUCN in order to change this conservation status was directly generated by the work supported by this grant.

All field work and biochemistry analyses have been completed on this objective. Our first two secondary chemistry articles (Marler et al., 2005a,b) touched on some of the issues relevant to this objective and set the foundation for the remainder of publications. The first major manuscript generated from this work is currently in review with *Biotropica*. Appendix 1 is the abstract and some data from this manuscript. The next manuscript will be looking at the direct influence of covariates from the plant and habitat descriptors on seed chemistry. Additionally, the time spent in Guam's urban and natural forests to satisfy this objective allowed us to make other interesting observations that led to unplanned publications. One was published earlier this year (Niklas et al., 2006) and compared the allometric properties of cycads with that of other plant categories. The other is currently in press and covers the arthropods that consume cycads in Guam's environment (Marler and Muniappan, 2006).

All field work and biochemistry analyses have been completed on this objective. The first article from this objective is currently in review with the journal *Functional Plant Biology*. Appendix 2 is the abstract and some data from this manuscript. The major manuscript from this objective will be written in the coming year using source-sink relations as the foundation. All data have been analyzed.

We have determined sterile glycoside and sterol levels in pollen samples from four habitats. The results validate for the first time that pollen from the Guam cycad is loaded with these neurotoxic glycolipids. More importantly, these data are the first conclusive data revealing a distinct difference between the plants from southern Guam (Inarajan) and the plants from the other three habitats in northern Guam.

The metabolites are stigmasterol β-D-glucoside (SG), stigmasterol (SS), and β–sitosterol (BSS). What remains to be done is to quantify some of the plant and habitat variables that influence the

loading of these metabolites into pollen to see if we can identify the reasons behind the higher concentrations in the pollen from southern Guam.

Our only work remaining for all three objectives is to continue publishing. The 10th manuscript we are currently working on will define the plant and community factors that control *Cycas micronesica* seed chemistry. The 11th manuscript will be a source-sink physiology article looking at resources and total glycolipid bioaccumulation in various organs. The 12th manuscript will be another source-sink article following glycolipid levels in germinating seedlings. This will allow us to determine if biosynthesis occurs in seed tissue, or if seeds are loaded by transport with these chemicals during development. All of the biochemistry analyses have been conducted. What remains is analyzing the data and continued writing.

Source of funding — Multi-Regional Hatch

Scope of impact — Scope of Impact: Regional, national.

Key theme: Adding Value to Old Agricultural Products

Scientists at Guam Agricultural Experiment Station investigated possibilities of increasing market of traditional root crops of Guam. The study was designed to conduct field evaluation of sweet potato (Ipomoea batatas), and a market study of sweet potato, taro (Colocasia esculenta and Xanthosoma sp.), cassava (Manihot esculenta). This study also included sweet potato preference test and taste test of selected sweet potato accessions. The concept test showed that people of Guam consumed sweet potato, taro, cassava and yam in both traditional dishes and as new processed foods. Taro and cassava tamales were still popular forms among Chamorro, and a variety of processed root crops were available at local market. Chips and breads of sweet potato and taro have a great potential to be processed foods made in Guam for local consumption as well as for export.

Anthocyanins are natural pigments alternative to synthetic colorants. Purple sweet potato (PSP) possesses high content of acylated anthocyanins, which are more stable than non-aclylated anthocyanins to pH, heat and light. The stability of anthocyanin of PSP was determined during steaming and dehydration. The PSP cultivar 'Terlaje' were steamed for 0, 0.5, 1, 2 and 4 hours. The PSP steamed for 0.5 hour were dehydrated at 55°C for 0, 4, 8, 20, 24 hours. Anthocaynins were extracted with 1% HCl acidic water from steamed or dehydrated PSP. The total anthocyanin content was measured with the UV spectrophotometer based on monomeric anthocyanin pn 3-caf.sop-5-glc (mg/100 g fresh weight). Polymeric anthocyanins were assayed with bisulfite-treated extract. The hue angle (h°) and chroma (C*) of PSP were calculated from color values L*, a* and b* measured by a Chroma meter.

Steaming PSP for 0.5 hour resulted in an increase of anthocyanin content from 42 to 60 mg/100 g and a decrease of h° from -8.5° to -26.5° and C* from 28.7 to 21.6, indicating an enhancement of purple color of PSP. Steaming PSP for 1 to 4 hours caused a decrease of anthocyanin content from 47 to 42 mg/100 g and of h° from -25.04° to -1.94° and of C* from 21.6 to 19.7. Although dehydration for 24 hours resulted in an increase of about 50% of polymeric color, the

dehydration did not decrease anthocayanin content of steamed PSP. After 24 hour dehydration, the PSP powder exhibited a color value at h° -18.1 and C* 27.9.

The effect of light on PSP anthocyanin extracts was also investigated during storage. Semi-purified anthocyanin extracts were prepared with C-18 Sep-Pak catridges. The anthocyanin extracts at pH 1 were treated with fluorescence light for 2 months. The stability of anthocyanin were determined with total anthocyanin content or the UV/Vis spectrum and color value (L*, a*, b*). The stability of anthocyanin of PSP was also compared with that of red cabbage, grape skin, and synthetic colorant Red #40. the Tinctorial strength of the colorants in pH 1 buffer was also measured.

Light-treated PSP anthocyanin extracts exhibited a 5% increase in absorbance at 520 nm on the first day and then a decrease of 55% in absorbance after 2 months storage. The lightness (L*) value is increased from 85 to 88. The red (a*) and blue (b*) color values decreased from 9 to 3 and 4 to 2, respectively. Non-light-treated PSP extracts exhibited a 10% increase in absorbance and no significant changes in L*, a* and b* values during 2 month storage. The light stability of anthocyanin extracts and synthetic colorant was: Red #40 > red cabbage > purple sweet potato > grape skin.

Impact:

Anthocyanins in purple sweet potato are stable in neutral pH during steaming and dehydration. Steaming and dehydration can be used to process purple sweet potato powder as food ingredient with good pleasant purple color. Although purple sweet potato possessed high content acylated anthocyanins, the anthocaynin of purple sweet potato was not stable to light. Application of anthocyanin extracts of purple sweet potato in acidic foods requires no exposure to light during storage. This research information will be useful for food industries to consider applying purple sweet potato powder or anthocyanin extract from purple sweet potato in food products.

Source of funding — Multi-Regional Hatch

Scope of impact — Integrated research and extension

Key theme: Plant Production Efficiency

Plant scientist at Guam Agricultural Experiment Station investigated regulation of photosynthetic processes. Understanding its regulation is fundamental in designing strategies to develop improved crop systems that are environmentally sound. This project is designed to determine the limitations on photosynthesis of tropical species, and how development and physiological characteristics may be deployed to optimize yields during times of environmental limitations. Fluctuations in non-structural carbohydrates were studied in papaya plants following manipulation of source-sink balance by leaf removal. Starch pools were minimal and unchanged following defoliation. Lateral roots had higher concentration than taproots or stems, but maximum levels were only 5 mg/g. Glucose and fructose concentration was similar for taproot and stem tissue, but was lower in lateral root tissue. Alternatively, sucrose concentration was

similar for lateral root, taproot, and stem tissue. Other saccharides were minimal or undetectable in papaya tissues. The increased need for carbohydrates for reconstructing source leaves following foliage injury was not apparently met by mobilization of soluble carbohydrates from stem or root tissue.

Impact:

Source-sink relationships play a key role in plant recovery from any environmental stress, especially one that severely impairs source size or function. Source-sink dynamics of herbaceous plants may not apply to the arborescent papaya species, since organ and non-structural carbohydrate pool size are much greater than other herbaceous species. Alternatively, source-sink dynamics of tree species may not apply to papaya, since the species is herbaceous and plants are comprised entirely of living tissue that is more expensive to maintain than woody tissues. A greater understanding of source-sink balance in papaya is needed to understand mechanisms that control phenological processes, and may lead to improved management strategies to optimize productivity.

Source of funding — Multi-Regional Hatch

Scope of impact — National

Key theme: Plant Health

Plant Pathologist at Guam Agricultural Experiment Station researched diseases of traditional Pacific Island crop plants. The most significant diseases of Coconut, banana and taro on Guam are Coconut Tinangaja, Banana Bunchy Top, Black Leaf Streak and Panama Wilt, and Taro Leaf Blight (TLB), respectively. The aim of this project is to facilitate ways to develop control measures for these important diseases. A banana cultivar similar to local cultivar Manila was imported in tissue culture and is being propagated for testing. We hope that it will show resistance to Panama Wilt, unlike Manila, which is very susceptible. Taro germplasm (77 cultivars) were propagated in tissue culture and given to the entomologist for insect resistance testing. Some of this work is already complete and comprises a M.S. thesis for a graduate student. It is hoped that this information will be useful for the entire region and help in keeping taro cultivar names straight. When comparing cultivars from one island to the next, taros with different names may actually be the same, and vice-versa.

Impact:

Control of any of the diseases of coconut, taro or banana will have significant economic impact in the Western Pacific region.

Source of funding — Hatch

Scope of impact — Multi-state research

Key theme: Plant Health

Work continued on in vitro breeding to develop Fusarium wilt resistant banana (Musa sp.) Panama wilt is that occurs on Guam and the island of Kosrae in the Federated States of Micronesia. Finding resistance to this disease is a practical way to approach its management or control. Cultivar Saba is one of the most popular banana varieties on Kosrae. It is said to show little resistance to Panama wilt in that island. Through this project we will attempt to find a source of resistance to this disease in cultivar Saba. On Guam, one of the most popular banana cultivars is Manila, which is unfortunately susceptible to Panama wilt disease. Aside from Banana Bunchy Top, Panama wilt is the most important production problem with cv Manila on Guam. The similarity between cv's Manila from Guam and Kufwafwa from Kosrae is such that fruit from the latter is imported and readily sold in the local Guam market as Manila. Its market acceptance is a key feature in its potential for success as a new introduced variety. We want to evaluate cv Kufwafwa on Guam and see how it fares against local Panama wilt strains, as a possible replacement for cv. Manila. We will attempt to generate variants of cv SABA through cell culture techniques and look for resistance. On Kosrae we will also test Saba material from Guam, where this cultivar has little or no problem with Panama wilt.

During 2005, we planted cv Kufwafwa (introduced last year from Kosrae) at a collaborator's field on Guam, along with cv Manila for comparison. We plan to evaluate its reaction to Panama wilt. We have established the plants in the farmer's field already, and have identified a second collaborator for the same experiment.

Meanwhile, we are propagating cv Saba (also known as Palau) in vitro, collected on Guam. This cultivar has no problem with Panama wilt on Guam. We want to send it to Kosrae and have it evaluated there. Propagation of this cultivar in vitro is much slower and difficult than Manila or Kufwafwa, however.

Cell culture is not working well yet. Some growth is occurring, but most flasks are turning black, indicating that all the tissue is dying. Others are getting contaminated. Cultivar Saba is turning out to be very difficult to handle even in tissue culture, where it also grows very slowly and many explants turn black and eventually die. No pathogens have been found in affected tissues.

We finally got the orbital shaker delivered to UOG instead of Kosrae because our co-PI left Kosrae for another job. All the cell culture work he was going to do on Kosrae is now having to be done at UOG. All the work that the co-PI was supposed to do will now have to be tackled by the PI and assistants.

An extension publication has been released to help growers manage banana varieties more effectively. Another document, a compilation of banana cultivar descriptions, including photos, is being prepared for publication. This is intended to promote the use of disease resistance and to help clear up the confusion surrounding the many names given to the same banana cultivars in different islands, or even within the same island.

Impact

It is still too early to assess the impact of this project. So far, we have been successful in introducing a new cultivar to Guam and propagate healthy stock from it in tissue culture, and have regenerated plants; these are now in the field. We are preparing cv Palau from Guam to be introduced into Kosrae, if quarantine officials permit it. We have also been able to develop callus culture and cell culture from banana. This is a difficult process and is therefore quite an achievement, but we are not yet able to reproduce the results reliably in quantity enough for our needs.

Source of funding — T-STAR

Scope of impact — Multi-state research

Key theme: Plant Health

Management of the causal agent of arecanut bud rot on Guam was studied by plant pathologist. This project was conducted to address an outbreak that started to kill arecanut trees (Areca catechu) in the village of Maleso in Southern Guam towards the end of 2003. The symptoms of affected trees often included a bud rot. Thousands of trees have died as a result of this malady. The diagnosis of Phytophthora bud rot on arecanut can be a bit tricky. Typical symptoms of the disease are mimicked closely by a condition provoked by sugarcane weevil damage. The surest way to distinguish between the two, for a lay person, is to split open the tree trunk and see if there are weevil tunnels in the affected area. Otherwise, a lateral flow kit for the detection of all species of Phytophthora is commercially available. We evaluated the performance of this diagnostic kit for the detection of P. palmivora on A. catechu.

We are also studying ways of applying Fosfite, a fungicide that is recommended against Phytophthora on trees, in a way such that it will have as little environmental side effects as possible. During the year 2005, we were able to do tests in plants with Phytophthora palimvora, isolated from arecanut trees and inoculated onto healthy seedlings, to evaluate the lateral flow diagnostic kit for the genus Phytophthora. The results were quite encouraging when using infected plant tissue from still active lesions. However, results were weak or negative when testing tissue that had been infected 3 to 4 weeks earlier. The previous year we had already tested these lateral flow kits with pure cultures of the fungus and obtained good results. Therefore, we now know that the diagnostic lateral flow kits work well for the detection of P. palmivora both in vitro and in planta, but in the latter case only when testing infected tissue no more than 3 weeks after infection.

In the course of the year we also injected many arecanut trees with Fosphite, a fungicide that is recommended for use against Phyophthora diseases of trees. Studying the effect of injection of this fungicide on A. catechu, we found internal discoloration in the area of the injection. Representatives from the fungicide manufacturer have suggested other application methods, which we are now in the process of evaluating.

Another host range test was done, which included fruits of Annona squamosa, A. muricata, Artocarpus altilis, Carica papaya, Cocos nucifera, Mangifera indica, Musa acuminata, and Psidium guajava. Of the 8 species tested, only A. squamosa and A. muricata failed to become

infected and support sporulation of P. palmivora isolated from A. catechu. This suggests that the 6 other species are possible hosts for the bud rot pathogen, which could survive and propagate by infecting these species besides A. catechu.

Impact

Detection of Phytophthora bud rot on arecanut can now be achieved by lay persons with the aid of commercial lateral flow tests specific for Phytophthora. We have determined that while these kits will work properly in the case of P. palmivora on arecanut, their performance is influenced by the age of the infected tissue. Trying to diagnose old infections (more than 1 month old) can lead to false negative results.

We have stopped recommending the injection of Fosphite into trunks of arecanut trees for protection against bud rot, and are instead evaluating other application methods.

We now have evidence that P. palmivora has a broader host range than is reported in the literature, and that includes A. catechu, A. altilis, C. papaya, C. nucifera, M. indica, M. acuminata, and P. guajava.

Source of funding — T-STAR

Scope of impact — Multi-state, regional

Key theme: Plant Health

Development of PRV resistance was studied by plant pathologist. Papaya Ringspot Virus (PRV) continues to be the most damaging and limiting disease for papaya production on Guam. No resistance to PRV can be found in the species Carica papaya. Transgenic resistance has been developed for Hawaii and shows promise. Work is behind schedule due to our fields getting decimated by storms in previous years, and also due to the transfer of our collaborator, Dr. D. Gonsalves, from Cornell University to the ARS center in Hilo. One year after we had 2 storms in one season, PRV incidence declined dramatically, but again it has reached high levels throughout the island at this time. In previous years, we planted 2 experimental fields at the Inarajan Station and evaluated papaya cultivars on their reaction to PRV. The first one had to be inoculated, the second relied on natural incidence. Two transgenic accessions from HI, Sunup and Rainbow, were included in the evaluation, and both have shown increased resistance to our local strain of PRV compared to all other entries (Saipan, Dagua, Trujillo, Malaysia). Cultivar Rainbow held up very well during the 2004 and again during the 2005 growing seasons. In Yigo experiment station, a papaya collection was grown with the object of performing new crosses between cultivars to improve the most important marketing traits of existing cultivars. This year we have been evaluating the progeny of these crosses in the F2 generation at the Yigo Experiment Station. So far we have found materials that display traits of both parents regarding flesh color, fruit shape and size, tree size, and disease reaction.

In previous years, PRV-infected papaya leaves from Guam were collected and sent to HI under the required local and federal permits. Nucleic acids from our strain of the virus were isolated, purified, and eventually the coat-protein gene was sequenced. This sequence will be inserted into

the natural genome of a Hawaiian solo-type papaya cultivar, the same used in previous similar transformations in HI, except that the insertion will have the Guam PRV isolate sequence, and not that of HI. A local Guamanian variety will also be transformed. The "construct", that is, the intended DNA sequence to be inserted for this transformation, is ready to go and will be given to the lab of Dr. S. Ferreira by the lab of Dr. D. Gonsalves. The actual transformations will be attempted in Dr. Ferreira's lab. This material will eventually be shipped back to Guam for evaluation. This step was supposed to have been done this year but there have been some delays.

Impact

The work is not yet completed, but some impact is already visible. One of the HI transgenic accessions introduced in the course of this study has shown an adequate level of resistance to the local PRV strain. After cross-protection was abandoned for lack of a mild strain, which we used to obtain from Cornell University until they quit producing inoculum, we haven't had a practical alternative to use against PRV on Guam, until now. The cultivar, however, does not produce the desired fruit shape, size, or color that the local market demands; furthermore, the tree is too tall for our strong winds. If need be, this cultivar may be recommended to our growers; with no other choice, the market will accept Hawaiian type papayas. At least the level of resistance to the main production constraint, PRV, is adequate in cv Rainbow. Meanwhile, we will keep waiting for our own transgenic cultivars, which are under transformation in Hawaii, and which should perform better under our conditions and against our own strain of PRV.

Funding source – TSTAR

Scope of Impact: Regional.

Key theme: Plant Health

Plant pathologist at Guam Agricultural Experiment Station research breeding methods to develop Fusarium wilt-resistant bananas (Musa sp.). The banana is an important staple food in the Western Pacific. Panama wilt is a limiting factor in its production. This is particularly true today in Kosrae, where production is worth $100,000 annually. The disease is also important on Guam, where banana production reaches annual values of $121,000. Cultivar Saba the most popular in FSM has been established in tissue culture, and propagated. Banana cell cultures have already been also initiated and tested. Protocols are still being developed. On Guam, several cultivars have been propagated in vitro for tested against Panama Wilt disease in the field.

Impact:

Concern about Panama wilt of bananas, both on Guam and FSM is profound. It seems right to try to address this problem by seeking to develop resistant plants from popular cultivars.

Source of funding — USDA CSREES Special Project TSTAR

Scope of impact — Multi-state

Key theme: Plant Production

Agriculture engineer at Guam Agricultural Experiment Station researched various methods to improve crop production and water use efficiency. This project strived to improve crop production and water-use efficiency by using micro-irrigation management practice. Field experiments have shown that switching tensiometers when properly maintained and set to the proper soil matric potential for a particular crop perform better than timers in both crop yield and water-use efficiency in micro-irrigation systems. Irrigation management series publications were distributed at a workshop conducted at the end of a watermelon experiment.

Impact:

Farmers on Guam use water from the public distribution mains for irrigation. Any savings of water through micro-irrigation techniques will cut the cost for the farmers and save on the public subsidies used for the distribution system.

Source of funding — Hatch multi-state

Scope of impact — State specific

National Goal 3 . A healthy, well-nourished population.

Key theme: Food safety

Title: Food safety education and training for consumers and food establishments in the U.S. Territory of Guam was studied in 2005. The frequency of foodborne illness on Guam is much higher than that in the United States mainland. To prevent foodborne illness in private home on Guam, a food safety brochure “Key food handling behaviors to prevent foodborne illness” were developed and disseminated to communities on Guam. Workshops “Foodborne illness prevention” were conducted for consumers and school teachers and school children to reduce the risk of foodborne illness in the Western Pacific islands. Education of Hand Washing was presented in a food safety education fair sponsored by the Guam Food Safety Task Force. A food safety curriculum for school children was developed to be used in Health class or after school program in elementary schools in the future.

Impact:

Through food safety education workshops and presentations, consumers’ awareness in foodborne illness and prevention enhanced. The results of pre-test and post-test in workshops showed that the food safety knowledge and behavior attitudes of participants significantly increased after attending food safety workshops. The increase of participants’ knowledge in practice personal

hygiene, cooking food adequately, avoiding cross contaminations, and keeping safe temperature will improve consumers' food safety practice at home, resulting in possible reduction of foodborne illness at private home on Guam.

Source of funding — T-STAR

Scope of impact — regional

Key theme: Adding value to new and old agricultural products

Every year about 30 outbreaks and 90 cases of foodborne illness were reported by Guam's Department of Public Health and Social Service (DPHSS). More than 60% of foodborne illness occurred in private home. Traditional food kelaguen was a vehicle associated with 10% reported foodborne illness. To assess consumer's food safety knowledge, attitude and food handling behaviors, 400 self-administrated surveys and 24 direct observations of kelaguen preparation were conducted within Guam communities. Four hundred surveys were distributed throughout the island based on the location and population of certain villages reported from the 2000 Census. Consumers were asked by eighteen knowledgeable, thirty-two behavioral and ten attitude questions in areas of personal hygiene, cross-contamination, proper cooking, time and temperature control and unsafe food source. One hundred and eighty collected surveys indicated that consumers were knowledgeable about personal hygiene and cross-contamination but lack knowledge in proper cooking, time and temperature control and unsafe food source. Consumer's attitude in proper food handling habits was not consistent among participants. In direct observation of kealguen preparations, consumers demonstrated poor food handling practices in cooking properly and avoiding temperature danger zone. Kelaguen was observed to serve to high risk population.

Kelaguen made from raw or partially cooked meat with lemon juice or powder was one of the leading causes of foodborne illness on Guam. Most kelaguen was not served below 4°C at home. To control pathogen growth, any foods with a pH above 4.2 require time/temperature control. To provide effective food safety education on kalguen, we tested the pH of kelaguen prepared by vendors and individuals and determined the minimum amount of lemon powder or juice needed to lower kelaguen's pH to 4.2. Kelaguen was sampled from 11 vendors and individuals on Guam. Beef, chicken and shrimp kelaguen were prepared at varying percentages of lemon powder and juice, ranging from 0% to 32% by weight. Kelaguen sampled from vendors and individuals exhibited an average pH of 4.5 for beef, 4.7 for chicken and 5.0 for shrimp. The pH of kelaguen base without lemon is 5.6, 6.7 and 7.5 for beef, chicken and shrimp, respectively. The minimum amount of lemon powder needed to reach a pH of 4.2 was 3.5% for beef, 4.0% for chicken and 3.6% for shrimp. The minimum amount of lemon juice needed to attain a pH of 4.2 was 19% for beef, 22% for chicken and 24% for shrimp.

Impact:

The research results increase consumer's awareness of problems in kelaguen handling practice and the potential risk of current kelaguen recipes. The information suggests that consumer food safety education on Guam should focus on time and temperature control, proper cooking and

unsafe food source to improve consumer's food handling attitude and behavior. Consumers on Guam will also be educated to keep below 4°C before consumption and adding certain level of lemon powder or a combination of lemon powder and juice to achieve the required pH of 4.2 to control pathogen growth.

Source of funding — T-STAR

Scope of impact — State specific

Key theme: Human nutrition

In the Fall semester, 3 Scholars received $6,500 scholarship for undergraduate studies in the Higher Education Multicultural Scholars Program in the College of Natural and Applied Sciences, the University of Guam. These Scholars are 2 sophomores and 1 seniors. In the Spring semester 2006, 6 Scholars received $11,750 scholarship for undergraduate studies in the Higher Education Multicultural Scholars Program. These Scholars are 1 freshman, 1 sophomore, 2 juniors and 2 seniors. In the Fall semester 2005, scholars were assigned to use local tropical and subtropical fruits and vegetables to develop health chips as snacks for children. The scholars used the dehydration technology to develop purple sweet potato chips, banana chips and breadfruit chips. The sweet potato chips had potentials in the market. In the Spring semester, the scholars were provided trainings in food product development and assigned to work as a team to improve the quality of developed sweet potato chips to meet the consumer's need in market.

Impact:

Scholars in this Higher Education Multicultural Scholars program gained knowledge and research ability in food product development. Scholars presented their product development of chips at the University of Guam. The Pacific Daily New Lifestyle section reported the scholars' work to the Western Pacific Island. People on the Western Pacific islands were aware that tropical fruits and vegetables can be simply processed to health food snacks at home for children.

Source of funding — Local

Scope of impact — State specific

Key theme: Adding value to new and old agricultural products.

Food scientists at Guam Agricultural Experiment Station investigated potential for usage of food colorants. The safety of synthetic food colorants is a concern. Anthocyanins are natural pigments alternative to synthetic colorants. However, only acylated anthocyanins are stable to pH, heat and light. A Japanese purple sweet potato cultivar (Ipomoea batatas L.) cultivar "Ayamurasaki" is composed of 93% aclylated anthocyanins, and has been used as a food colorant. Anthocyanins from purple sweet potatoes also exhibit healthy benefits such as antimutagenicity and hepatitis therapy. Several purple sweet potato cultivars, originated from the Western Pacific Islands, are different from purple sweet potato cultivars in Japan. It is unknown of the stability and physiological function of anthocyanins from the Western Pacific purple sweet potato cultivars. The objective of this project is to determine potential application of anthocyanin from the Western Pacific purple sweet potato cultivars as food colorants and nutraceutical

ingredients. Fresh or steamed purple sweet potatoes (cultivar “Terlaje”) were dehydrated with freeze dry, hot air, and vacuum oven.

Impact:

Dehydration and steaming of purple sweet potatoes affect anthocyanin content in powders. The purple sweet potato powders from the Western Pacific can be potentially applied in foods. This research project promotes to utilize Western Pacific regional resource to provide national benefits for food industries and consumers. The project potentially impacts on tropical agricultural science and practice, including production, processing and exportation of purple sweet potatoes and products in the Western Pacific Islands. The project also enhances competitiveness of the project director to develop research capacity to achieve to improve crop marketing through value-added product schemes. An abstract “Anthocaynin content and color characteristics of the Western Pacific sweet potato (Ipomoea batatas) powders” was submitted to the 2005th IFT Annual Meeting for presentation in New Orleans, LA, July 16-20.

Source of funding: CSREES-USDA National Research Initiative (NRI) Grant

Scope of impact: Regional

Key theme: Human health

Food Scientists at Guam Agricultural Experiment Station tested bioavailability of biological components in Noni (Morinda Critrolia) products as affected by processing and storage.

Noni (Morinda citrifolia L) is a tropical plant that traditionally treats various diseases in the pacific islands. Noni extract is now taken by cancer patients to control cancer. Novel glycosides from noni juice exhibit free radical scavenging activity and demonstrate anti-cancer effects. Noni fruits are now commercially processed into juice or powders for disease prevention and therapies. However, it is unknown how processing and storage conditions affect the bioavailability of bioactive components and the shelf life noni products. The objective of this research is to determine how the bioactive compounds of noni products degrade during the processing and the storage. Noni fruits exhibit great radical scavenging activity and an appreciable ascorbic acid content. The effect of heat and hot-air dehydration on ascorbic acid content of noni juice was investigated. Fresh noni juice made by centrifuging noni puree was treated at 85°C in water bath for 24 hrs. Noni puree was dehydrated at 50°C, 60°C and 70°C for 24 hrs. AsA content was determined using high performance liquid chromatography with 2% acetic acid isocratic mobile phase. Fresh noni juice possessed

150 to 200 mg AsA/100ml. Heat treatment of noni juice at 85°C for 1 hour did not resulted in a significant decrease of ascorbic acid in noni Juice. Noni juice lost 15, 29, 66 and 69% of ascorbic acid content after heat treatment for 4, 8, 20 and 24 hours, respectively. Dehydration of noni puree at 50°C, 60°C and 70°C for 24 hours caused a 57%, 62% and 88% reduction of ascorbic acid content, respectively.

Impact:

Noni fruits posses high level of ascorbic acid content. Although heat treatment at 85° decreased ascorbic acids of noni juice, heat treatment such as pasteurization would not significantly cause a loss of ascorbic acid content in noni juice. To making noni powder, selecting low dehydration temperature is recommended to retain ascorbic acid in product. This research information will be useful for noni processors to select conditions to process noni juice and noni powders.

Source of funding: Tropical/Subtropical Agriculture Research (T-STAR) grant.

Scope of impact: Regional

Key theme: Adding value to new and old agricultural products.

Bioavailability of biological components in Noni (Morinda Critrolia) products as affected by processing and storage was studied in 2005. The effect of heat and light on the radical scavenging activity, total phenols and ascorbic acid of noni juice and were studied. The free radical scavenging activity was assayed by scavenging the free radical 1,1-diphenyl-2-pcrylhydrazyl (DPPH·). The total phenolic content was measured by the Folin-Ciocalteu reagent. The ascorbic acid content was analyzed using HPLC method. The fresh noni juice was prepared by centrifuging noni puree. Noni powders were prepared by dehydration of noni puree with hot air at 50°C. Noni juice and powders were treated with fluorescence light and stored at the ambient temperature for three month. Noni juice was treated in water bath at 85°C for 24 hours. Light treatment resulted in a greater decrease of radical scavenging activity and total phenols in both noni juice and powder. However, after storage for 90 days, the difference of radical scavenging activity and total phenols between light treated and non-light treated noni juice was small. The reduction of radical scavenging activity and total phenols in light treated noni powder was much greater than the non-light treated noni powder after storage for 90 days. The ascorbic acid content in noni juice decreased faster in light treated noni juice than non-light treated noni juice. However, after storage for 4 weeks, both light and non-light treated noni juice lost almost all ascorbic acid. Heat treatment at 85°C resulted in a decrease of radical scavenging activity and ascorbic acid in noni juice greater than total phenol. The results suggested noni powder possesses much longer shelf life than noni juice. For consumers to have health benefits from noni juice, storage of noni juice at the ambient temperature is not recommended.

Impact:

The research results are presented in conferences. The obtained knowledge provides instructions to manufacturers and consumers to improve functional quality of noni products in processing and storage.

Source of funding: Tropical/Subtropical Agriculture Research (T-STAR) grant.

Scope of impact: Regional

Key theme: Human nutrition

Food Scientists at Guam Agricultural Experiment Station investigated ways for improvement of thermal and alternative processes for foods. There are several foods and herbal beverages from tropical source that are gaining in popularity in temperate climates. These represent potential markets for products from the insular areas of the US. The purpose of this project is to study the effect of processing on the nutraceutical components of these products to improve their usefulness and marketability. The fresh noni juice prepared by centrifuging noni puree was treated at 65, 75, and 85 C. The bioavailability of biological components of noni products was evaluated by the total antioxidant capacity (TAC) assayed by scavenging the free radical 1,1-diphenyl-2-pcrylhydrazyl (DPPH). The total phenolic content was measured by the Folin-Ciocalteu method at 765 nm, using gallic acid as standard. The ascorbic acid was analyzed at 582 nm using 4-Chloro-7-nittrobenzofurazane (NBD-Cl). The fresh noni juice exhibited the TAC at 130-150 mg equivalent ascorbic acid (EVAA)/100 ml juice, 210 mg galic acid/100 ml juice, and 145 mg ascorbic acid/100 ml juice. After heat treatment at 65 C, 75 C, and 85 C for 10 hours, the noni juice remained 82%, 72%, and 30% of TAC, respectively. Total phenol content of noni juice decreased 37% at 65 and 75 C and 40% at 85 C after heat treatment for 24 hours. After heat treatment for 10 hours, the noni juice lost 33% of ascorbic acid at 65 C and 75 C and lost 65% of ascorbic acid at 85 C. However, heat treatment of noni juice at 65 C, 75 C, and 85 C for 4 hours did not result in significant changes of the TAC, total phenols, and ascorbic acid in the juice, indicating mild heat treatment does not significantly change the bioavailability of bioactive components in noni juice.

Impact:

The research contributes to understanding of how nutraceuticals change during processing in functional food products. Research outcomes will benefit food manufacturers to processing functional foods.

Source of funding — USDA Hatch Project Grant

Scope of impact — Multi-state integrated research

National Goal 4:

Greater harmony between agriculture and the environment.

Key theme: Integrated Pest Management.

In 2005. we continued to examine the morphological, genetic and ecological differences in *Aphis gossypii* in new aphid collections from the Federated States of Micronesia islands of Pohnpei, Chuuk and from Guam and the Commonwealth of the Northern Mariana Islands (CNMI). Additional aphid collections were made on the Hawaiian islands of Oahu, Molokai and Hawaii.

These data were combined with those from previous collections in Micronesia and North America to expand the our comprehensive aphid catalogue, with emphasis on *A. gossypii*. The presence of aphidiid parasitoids, where present, was noted and the aphidiid identified. Morphometric analysis and DNA sequencing also continued for aphids collected previously. Ants collected in association with aphids, and that may have a role in altering the effectiveness of aphidiid biological control agents, were also identified. Ongoing DNA analysis seeks to confirm previous results suggesting that genetic variation in *A. gossypii* was found to vary by host plant and then by geographic provenance of the sample, while morphometric variation was most closely correlated to geographic provenance. *A. gossypii* reared on various hosts, and then switched to a new hosts, were collected following the third generation and are presently being mounted for morphometric analysis.

A coccinellid predator, *Rhyzobius lophanthae*, of Asian cycad scale (ACS), *Aulacaspis yasumatsui*, was mass reared and released in areas throughout Guam where *Cycas micronesica* and *C. revoluta* were found infested. Sticky traps were used to monitor scale densities and estimate vagility. Tree mortality due to ACS and predation rates of *R. lophanthae* are being monitored. Another introduced pest of *Cycas* sp., *Chilades pandava* (Lycaenidae), was observed infesting new growth on *C. micronesica*, and being tended by at least four different ant species.

Impact:

We now understand the make-up of aphid-parasitoid-ant complexes on crops and ornamental plants in many of the islands of Micronesia and Hawaii. Pest managers can identify the major aphid pests they encounter at ports of entry and on crops and ornamentals on the various islands using keys developed in this activity. The association between many tramp ant species and specific aphid species has been described. *R. lophanthae* is now abundant and widespread on commercial and indigenous cycads throughout Guam. While it is too early to determine if *R. lophanthae* will exert adequate control to protect large stands of *Cycas* sp., predation rates are high and dispersal is good. We are now aware of the threat that *C. pandava* poses to the cycads of Guam, and have begun to plan for its management.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional, national.

Key theme: Integrated Pest Management.

AES entomologist investigated the influence of integrated pest management of aphids and whiteflies on cucurbits and vegetables on Guam. He has developed laboratory capabilities to rear various homopteran crop pests, and to make permanent slide mounts for use in taxonomic studies. He has initiated an activity to create a collection of slide mounted aphids, mealybugs, and whiteflies for each of the major island groups in Micronesia which will serve as a basic reference for homopteran identifications in the future. We anticipate creating a voucher set of slides for each island group that will be available to workers on that island.

Impact:

We are aware of the dearth of information on the identities, host range, and basic biology of aphids, mealybugs, and whiteflies in Micronesia, even though these pests are the most commonly

intercepted alien invasive insects during plant protection and quarantine (PPQ) inspections in the islands.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional, national.

Key theme: Integrated Pest Management.

On the subject of genetic, morphometric, and ecological variation in *Aphis gossypii* we continued to examine the morphological, genetic and ecological differences in *Aphis gossypii* in new aphid collections from the Federated States of Micronesia islands of Pohnpei, Chuuk and from Guam and the Commonwealth of the Northern Mariana Islands (CNMI). Additional aphid collections were made on the Hawaiian islands of Oahu, Molokai and Hawaii. These data were combined with those from previous collections in Micronesia and North America to expand the our comprehensive aphid catalogue, with emphasis on *A. gossypii*. The presence of aphidiid parasitoids, where present, was noted and the aphidiid identified. Morphometric analysis and DNA sequencing also continued for aphids collected previously. Ants collected in association with aphids, and that may have a role in altering the effectiveness of aphidiid biological control agents, were also identified. Ongoing DNA analysis seeks to confirm previous results suggesting that genetic variation in *A. gossypii* was found to vary by host plant and then by geographic provenance of the sample, while morphometric variation was most closely correlated to geographic provenance. *A. gossypii* reared on various hosts, and then switched to a new hosts, were collected following the third generation and are presently being mounted for morphometric analysis.

Impact:

We better understand the make-up of aphid-parasitoid-ant complexes on crops and ornamental plants in many of the islands of Micronesia and Hawaii. Pest managers can identify the major aphid pests they encounter at ports of entry and on crops and ornamentals on the various islands using keys developed in this activity. The association between many tramp ant species and specific aphid species has been described.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional, national.

Key theme: Invasive Species

Entomologist at Guam Agricultural Experiment Station researched invasive insects of Micronesia. Invasive arthropod pests pose a continuous and serious threat to agricultural, urban and natural ecosystems on Guam and in Micronesia at large. The majority of insect and mite pests on Guam are alien species accidentally introduced from Asia, from adjacent islands, or from the US mainland. These arthropod pests infest crops, vector plant and animal diseases, lead

to quarantine of plant produce, destroy houses and wood structures, and threaten the island's biodiversity. Similarly, introduced arthropod pests comprise the majority of serious crop pests in the other islands of Micronesia. With increased air and ship travel between the islands of Micronesia, and with increasing demand for products from Asia, the US mainland and from other continents and island ecosystems comes an increasing threat for the introduction and establishment of additional pests. Although previous workers have sought to catalogue the insects of Guam and other Micronesia islands, there have been no comprehensive insect surveys in Micronesia for many years. Biological control has been employed to mitigate alien invasive arthropods on Guam and in Micronesia. Part of the reason for the relatively limited biocontrol activities in the region is the lack of knowledge on which natural enemies would be best suited for release in the humid tropical islands of Micronesia. A systematic evaluation of the invasive pests present in Micronesia, coupled with a survey of possible biocontrol agents with an estimations of the risk/benefit associated with the particular host – natural enemy will allow better use the limited funds available for pest mitigation by targeting systems with the highest possibility for success. A project Website (http://frontpage2000.family-net.org/amoore/Micronesian%20Invasives%20Web/) has been established to facilitate coordination with collaborators and dissemination of information generated by the project.

Impact:

Personnel have been trained on the importance of invasive species, and how to recognize them during their inspections. Workers and other interested parties are able to access information regarding invasive species in the region by accessing the web site.

Source of funding — USDA CSREES Special Project TSTAR

Scope of impact — Multi-state

Key theme: Invasive Species

In the area of economics of invasive species, data collection for case studies on brown tree snake, *Boiga irregularis*, and on white spot syndrome virus (WSSV) in shrimp are largely completed. Data for *B. irregularis* was collected from military and civilian agencies on Guam and forwarded to collaborators at USDA-APHIS, Fort Collins, CO. Guam sponsored research on Guam by a University of Hawaii graduate student on shrimp hatchery issues during Summer 2005. Upon his return to Hawaii in the fall he conducted a literature search on WSSV and collected additional information from commercial hatcheries in Hawaii for use by the Guam case study workers. Guam hosted a visit by Dr. Hugh Bigsby of Lincoln University, New Zealand, in October 2005 to conduct interviews with administrators and technical workers on alien invasive species, including those mentioned above. Information from these interviews, and from the case studies, was used by Dr. Bigsby and Dr. Ram Ranjan of the University of Florida, to develop the conceptual framework of the model and create a preliminary working model that will be demonstrated in Spring 2006.

Impact:

A decision-making model based on information from case studies, personal interviews and observations, has been developed. Further refinements will widen the scope of its applicability to include invasive species concerns on Guam, Hawaii, Florida and Puerto Rico.

Key theme: Key theme: Invasive Species/Integrated Pest Management.

Survey of Alien, Invasive Insects in Micronesia continued in 2005. We continued the comprehensive survey for invasive insects in the islands of Micronesia, concentrating this year on Guam, CNMI, Pohnpei and Chuuk. Collecting trips were made to Pohnpei and Chuuk in April where a workshop sponsored jointly by this project and the Secretariat of the Pacific Community (SPC) was held for agriculturalists and agriculture administrators. A second collecting trip was made to Pohnpei in August. Collected insects have in many cases been successfully identified, while unidentified insects have been referred to experts for assistance. Dr. Richard Zack, curator of the James Entomological Collection at Washington State University, traveled to Guam during the spring to further assist in collecting Marianas fauna, and to assist us in organizing our Guam Territorial Insect Collection and establishing an electronic database that provides a reference foundation for subsequent collections. Because most of the invasive insects we have encountered are Homoptera, we developed laboratory facilities for clearing and mounting them on microslides, an essential first stem in the identification of many aphids, scales and mealybugs. Participation in USDA-APHIS and Western Pest Diagnostic Network workshops have enabled us to identify many of the homotperans encountered during the survey and become acquainted with experts who will assist with difficult identifications. Miller and Moore actively participated in the Guam Invasive Species Advisory Committee (GISAC). Moore designed a wiki (a website that can be edited online) for GISAC to facilitate compilation and access to information on Micronesia's invasive species. The wiki is located at http://GISAC.Guam.net. Within a few months of operation, the wiki was adopted by the Western Micronesian Invasive Species Council as a regional resource. Several new invasive insects were detected within the past year on Guam. These were: Oleander hawk moth, *Daphnis nerii*, (Lepidoptera: Sphingidae); the cycad blue butterfly, *Chilades pandava*, (Lepidoptera: Lycaenidae); the velvet shore bug, unidentified species, (Hemiptera: Hebridae); the Erythrina gall wasp, *Quadrastichus erythrinae*, (Hymenoptera: Eulophidae). A major emphasis in this years work was on the biological control of cycad Aulacaspis scale (ACS), *Aulacaspis yasumatsui*, on Guam. ACS was detected on Guam during the last quarter of 2003 on ornamental cycads. During 2004, it rapidly infested Guam's wild, endemic cycads throughout most of the island. Uncontrolled infestations of this scale insect kill cycads within one year. In an attempt to protect some of Guam's cycads, a predaceous lady beetle, *Rhyzobius lophanthae*, was imported from Maui in November 2003. Beetles were mass reared and released at Ritidian Point. Adult beetles became numerous at the release site within three months. Sticky traps are being used to monitor beetles, scale crawlers, and scale males at the release site. Following successful establishment of *R. lophanthae* at Ritidian, laboratory beetles and field collected beetles were distributed on infested cycads throughout the island. To date, 8124 beetles have been released at 163 sites. Although it is too soon to claim success, *R. lophanthae* is well established on Guam and most samples of CAS currently show heavy predation by this beetle.

Impact

Four new invasive insect species were detected on Guam during the past years, and mitigation procedures initiated where warranted. The GISAC wiki was established to facilitate the rapid exchange of information on invasive species between islands within Micronesia as well as outside of the region. Due in part to information generated by this project, and to participation by project scientists, Guam developed a draft emergency response plan which contains a protocol for managing biotic invasions. The agricultural community and general public are better informed on the impact of invasive species through attendance at several workshops held during the last year. Thirty eight people on Guam were certified as "First Detectors" following the training session in October, 2005.

Source of funds: TSTAR: USDA, Tropical & Subtropical Agricultural Research Special Grant

Scope of Impact: Regional, national.

Key theme: Integrated Pest Management.

Entomologist at Guam Agricultural Experiment Station investigated impact of Aphis gossypii on crops and ornamental plants in the tropical Pacific Basin. While confined primarily to glasshouses in cooler climates, in the tropics and subtropics A. gossypii is a major pest of cotton and cucurbits, where its high reproductive rate allows it to rapidly build up high populations and kill otherwise healthy plants by direct feeding or through the transmission of over 50 virus species. Despite the abundance of past work on A. gossypii, its taxonomic status is still poorly understood The lack of certainty in identifying A. gossypii renders interpretation of biological information, including host plant-herbivore-natural enemy relationships, questionable. Lack of understanding about the specific identity of A. gossypii populations lessens the chance for successful natural enemy introductions against them in classical biological control programs. Similar taxonomic confusion may also exist among the aphid's aphidiid parasitoid complex, further reducing the chances of successfully establishing an introduced parasitoid on a specific target host while avoiding unanticipated and undesirable nontarget activity. Aphis gossypii was collected from a range of crop and non-crop plant hosts and at various times during the year on Guam. A. gossypii was also collected from a range of crop and non-crop plant hosts in the Commonwealth of the Northern Marianas islands of Saipan, Tinian and Rota, and from the Republic of Palau islands of Koror and Babeldaup. In addition, A. gossypii collections were obtained from five of the Hawaiian Islands, Japan, Canada, the USA, Syria, and the Republic of the Marshall Islands. Plant hosts were determined and ant/aphis associations describe Aphid collected were morphometrically analyzed from slide mounted specimens using principal components analysis. These analyses suggested that aphid variation was most closely related to geographic provenance, followed by host plant. Results from microsatellite flanking region analysis (MFRA) performed on aphids from these same collections, but which had been preserved in 95% ethanol, suggested that the majority of genetic variation observed among aphid samples was most closely related to the host plant they had been collected from.

Field observations made on Guam suggest that the physical appearance of aphids in subsequent generations may be altered by altering the host plant upon which the aphids develop. Aphid

collections from various sites continue, as does refinement of both morphometric techniques, DNA sequencing and data analysis.

Impact:

Conducted research improved knowledge about Aphis gossypii biology as well as helped in plant protection.

Source of funding - Special Grants

Scope of impact – Multi-state extension- GU NM HI

Key theme: Integrated Pest Management

Key theme: Biological control

Entomologist at Guam Agricultural Experiment Station investigated biological control of ivy gourd (Coccinia grandis). Ivy gourd is a perennial vine native to Africa that thrives in warm, humid tropical regions. In its native habitat, it presents little or no threat to cultivated crop land or native vegetation because it is kept in check by competing plants and effective natural enemies. However, in recent years, it has become a serious pest in the Hawaiian and Mariana Islands, by out competing native plants, suppressing roadside vegetation, forest plantations, and ornamental and fruit farms. It was accidentally introduced to the Marianas in the 1980's and is a serious problem in Saipan and Guam. This weed is a problem for the following reasons: (1) Interferes with cultivation of plantation crops. Ivy gourd vines smother cultivated ornamental plants and fruit crops including mango, guava, banana, breadfruit, citrus and coconut, (2) Invasive: Ivy gourd infests vacant lots, roadsides pastures, forests, natural resources and power poles. (3) Results in negative effects on the ecosystem. Ivy gourd climbs on natural vegetation in forests and natural reserves and disinfects them. (4) Serves as a host for pests of melons. Several pests of cucurbitaceous crop multiply on ivy gourd. Suppression of ivy gourd is a prerequisite for starting a program to eradicate melon fly in the Marianas. It has been estimated that over 15,000 acres in Saipan, 500 acres in Guam and 5 acres in Rota are now infested and infestations continue to spread. There is a need for a host-specific, self-perpetuating, biological control agent for this invasive species. Successful control of this weed has occurred in the Hawaiian Islands by releasing Acythopeus cocciniae (Coleoptera: Curculionidae), Melittia oedipus (Lepidoptera: Sessidae) and Acythopeus burkhartorum (Coleoptera: Curculionidae). The leaf mining weevil, Acythopeus cocciniae of East African origin imported from Hawaii was host specificity tested against the endemic melon plant, Zehnaria guamenis. An Environmental Impact statement was prepared and published in the Federal Register. A leaf mining weevil, Acythopeus cocciniae and a gall forming weevil, Acythopeus burkhartorum have been released in Guam and Saipan after conducting host specificity studies. A third natural enemy, Melittia oedipus is being reared in the quarantine for host specificity studies.

Impact:

Acythopeus coccinae has been defoliating the ivy gourd in the release sites. It will take another year or two to notice the decline of the ivy gourd. When A. burkhartorum is released, it will complement the effects of A. cocciniae.

Source of funding – USDA CSREES Special Project TSTAR

Scope of impact – Multi-state research and extension

Key theme: Biological control

Entomologist at Guam Agricultural Experiment Station researched the New Guinea sugarcane weevil (Rhabdoscelus obscurus) in Guam. New Guinea sugarcane weevil (NGSW) is an introduced pest to Guam. It attacks sugarcane, coconut, betel nut and other ornamental palms. A survey of palms in Guam revealed that this weevil causes serious damage to Pitchardia and Champaign palms. Another survey conducted using aggregation pheromone indicated that this weevil population is greater in Dededo and Tumon than other parts of the island. This directly coincides with the concentration of ornamental nurseries in these areas. A laboratory rearing of the New Guinea sugarcane weevil Rhabdoscelus obscurus has been developed. Population density of the weevils in different parts of the island was assessed and it was found that there was a high concentration of the weevils in the villages Tamuning and Dededo corresponding with the commercial nursery business. Lures of aggregation pheromones of the Australian and Hawaiian populations of New Guinea sugarcane weevil, with other semiochemicals were used to clarify the identity of the weevil population in Guam. In a field experiment at eight different locations (Dededo, Tumon, Yigo, Hag*t*a, Mangilao, Yona, Agat and Malesso), plastic bucket traps baited with the lure of the Australian R. obscurus population in combination with a food volatile compound (ethyl acetate) and cut sugarcane captured significantly more weevils (total of 348) than traps baited with pheromone lure of the Hawaiian R. obscurus population in combination with food volatile and cut sugarcane which caught a total of 128 weevils. Traps baited with lure containing only the food volatile and cut sugarcane or only cut sugarcane captured significantly fewer weevils (total of 36 and 30, respectively) than those baited with pheromone compounds. Data from trap catches indicate that the Guam population of R. obscurus responded significantly more to the pheromone lure of the Australian population than to pheromone lure of the Hawaiian population, indicating that the Guam R. obscurus population is related more closely to the Australian population. Trap catches at the Tumon and Dededo locations were greater than those in Yigo, Yona, Mangilao, Hag*t*a, Agat, and Malesso. Rainfall had a low correlation with trap catches at all locations except at Yigo where it positively correlated to the Australian population lure treatment.

Impact:

A technique for rearing NGSW in the laboratory has been developed. An APHIS, USDA permit to import the parasitoid, Lixophaga sphenophori was obtained. Pheromones are being used to trap the weevils in the commercial nurseries. Development of the rearing and trapping techniques will aid in rearing and release of the parasitoids that have been planned for importation from Hawaii.

Source of funding — USDA CSREES Special Project TSTAR

Scope of impact — State specific

Key theme: Soil Erosion

Soil Scientist at Guam Agricultural Experiment Station investigated methods of restoring and conserving soil quality in degraded lands of the Pacific Islands.Accelerated erosion as a consequence of poor soil quality threatens both the soil resource base and downstream environment in the island of Guam. These threats are manifested more seriously in the southern part of the island The challenge facing soil and agricultural scientists therefore is to develop conservation strategies that restore the soil and improve their quality for crop production and environmental quality. Similar challenges are facing the island of Hawaii and therefore this research project is also being conducted at the University of Hawaii by our collaborators as part of this grant. In this investigation the extent of soil erosion and its effect on soil physical and chemical properties is being evaluate By using rainfall simulators the parameters of erosion and sediment losses will be measured and determined for further assessment of the environmental impact of erosion and the effectiveness of the applied conservation techniques on these soils. In this regard, we are evaluating the plant residue management such as no-till and reduced till planting as soil erosion control techniques on typical degraded soils in southern Guam. We also use sunnhemp in rotation to the corn crop to maintain surface cover between planting and also improve the quality of soils under study. The principal method of controlling soil erosion and its accompanying rapid water runoff is to maintain adequate vegetative cover at all times which is the main objective of this project. An integrated approach is designed to evaluate the effect of conservation tillage, crop rotation with leguminous plant for organic matter build up, and residue management for soil re-habilitation and restoration of severely eroded soils of southern Guam. We anticipate that the results of these studies not only provide good database for assessing the extent of soil erosion but the data will provide information on effectiveness of restoration techniques being applied to conserve soils and prevent water erosion in Guam and the other islands of Western Pacific with similar climatic conditions.

Impact:

The educational impact of this project already have proven to be of a great value since some farmers started to consider rotating their corn crop with sunnhemp and use sunnhemp as green manure and cover crop during the rainy seasons. The educational impact of this investigation will prove to be of great value not only to farmers but also the other members of the communities

of the Pacific islanders whom are concerned about the degradation of soils and the impact of water erosion on natural resources of these islands.

Source of funding - Special Grant

Scope of impact – Local, regional

Key theme: Rangeland/Pasture Management

Soil Scientist at Guam Agricultural Experiment Station investigated use of composted organic waste to enhance soil quality of the rangelands in Southern Guam. Rangeland soils of southern Guam are severely eroded mainly due to lack of organic matter content and poor soil quality. In this extension project we have applied composted organic waste as an amendment to improve the quality of these soils hence, reducing the risk of erosion by water. This project produces composted organic waste mostly from is from typhoon debris, animal manure, and other organic wastes available at the University of Guam Agricultural Experiment Stations and near-by ranches. The composting and the application of compost on farm and rangeland are documented for educational purposes. Composting facilities are used for class activities as part of lab project for graduate and undergraduate students of Soil and Environmental Science courses at the University of Guam. Also, an extension bulletin is being developed on composting and the effect of compost application on farm and rangelands of southern Guam. Presently about an acre of land that is being used as research plots will be impacted by this project. However, the result of this research/extension project will be implemented throughout the Island of Guam and other islands of the Western Pacific affecting many acres of farms, rangelands, and public and recreational areas. The result of this project is being disseminated at educational events and workshops that are conducted as part of the outreach program of the project.

Impact:

Soil quality degraded to an alarming stage in most regions of Guam, was improved with compost especially in southern Guam where most rangelands are located. Use of compost helped to build good soil texture, structure and qualities that enable soil to retain nutrients, moisture and air for the support of healthy crop growth. Compost is also used to protect the surface of the eroded soils and as organic amendments for enhancement of rangeland productivity, sustainability and maintenance of soil productivity. This benefits farmers and ranchers, landowners as well as the general public who use ranches and other public lands as recreation areas.

Source of funding - Special Grants

Scope of impact – Multi-state extension- GU NM HI

Key theme: Forest Resource Management

Plant Scientists at Guam Agricultural Experiment Station researched selected cultivars of the native tree Eleaocarpus joga to be vegetatively propagated for use in the landscape and for reforestation. Due to increased clearing of forested areas and typhoon damage, the population of Elaeocarpus joga Merr. has reduced in numbers. E. joga is an attractive tree which is indigenous to the region. Yoga has great potential for use as a specimen landscape plant and for reforestation. Variation in leaf shape, color and texture as well as variation in canopy characteristics makes it necessary to vegetaively propagate selections. Previously trees were only successfully propagated from seed. Hardwood, semihardwood and softwood cuttings were treated with acid and salt forms of IBA and/or NAA at several concentrations. The cuttings were treated with one of the following: acid form at 05 mL IBA/L + 0.25 mL NAA/L, 1 mL IBA/L + 0.5 mL NAA, 2mL IBA/L + 1 mL NAA/L; salt form at 1, 3, or 8 g IBA/kg. Rooting was compared after 8 weeks. The best rooting (occurred with the salt form of IBA at 3 g/kg. The acid form containing both IBA and NAA produced poorer results.

Impact:

Selected plants are being propagated for use in the landscape and in tree planting ceremonies.

Source of funding — McIntire-Stennis

Scope of impact — State specific

Key theme: Plant germplasm

Scientists at Guam Agricultural Experiment Station Plant researched germplasm collection for improvement of local crop production. The project was initiated to collect local and international plant germplasm and to propagate selected cultivars by seed and tissue culture. The project will improve plant acquisition and management system for germplasm and plant propagation program by advancing technology of the Guam AES Horticulture Laboratory. Activities for this year included (1) to collect local and international plant germplasm and propagate selected cultivars by seed production and in-vitro propagation for conservation of germlines and distribution, (2) to evaluate field performance of collected germplasm for tropical climate adaptation, pest resistance, and other desirable characters for consumers in Guam, and (3) to improve a plant acquisition and management system for germplasm collection and plant propagation program by advancing technology. A crop evaluated in 2005 was hot pepper (Capsicum annuum) in Guam cobbly clay soil. Two field experiments were terminated due to plant damage by slugs. Currently the third trial is being conduced including 7 germlines. Two sweet potato accessions of the University of Guam were deposited toUSDA-ARS, PSI-FL Plant Germplasm Quarantine in Beltsville, MD. They were Ipomoea batatas cv. OTerlaje[1] originated

from Guam, and cv. OKuri[1] of Saipan origin. Those cultivars will be kept in the quarantine until 2005, and will be distributed to the Tuskegee University.

Impact:

Conservation of local white corn was the main effort for this year. Production of its seeds was achieved, and distribution of seeds to growers was done at the workshop. A local newspaper article on traditional uses of corn and the workshop conducted successfully drew people's attention on this corn.

Source of funding – Hatch multi-state research

Scope of impact – State specific

Key theme: Agricultural Waste Management

Animal Scientist at Guam Agricultural Experiment Station researched utilization of Animal Waste. Laying hen houses produce nutrient rich waste that if not properly managed can result in water pollution and overgrowth of tropical coral reefs by algal blooms.

Impact:

Results of this project enable to reduce the phosphorus level in poultry wastes in tropical environments.

Source of funding — Hatch

Scope of impact — State Specific

Key theme: Sustainable agriculture

Plant pathologist and entomologist at Guam Agricultural Experiment Station researched insect- and disease-resistant taro. Taro. The purpose of the research is to: Identify sources of resistance

in regional taro cultivars to the aphid A. gossypii and taro leaf blight, Phytophthora colocasiae (TLB). In conjunction with this activity an insect/disease resistant taro germplasm collection will be assembled on Guam for use in on-island field trials and for eventual distribution to interested parties throughout the Pacific region. Adapt and refine conventional aphid field screening techniques for use in screening for host resistance in taro cultivars for the serious homopteran pest, the taro planthopper, Tarophagus proserpina. Create germplasm nurseries for future use in developing molecular markers for aphid resistance, and for evaluation of potential commercial cultivars. Aphid and TLB resistant taro lines identified in this project will be made available to breeders and growers to hasten the development of commercially suitable taro varieties for US and Pacific region growers. Primary aphid and disease screenings and work on T. proserpina will be performed on Guam, while a taro nursery with differential aphid resistance will be created through collaboration with University of Hawaii-Maui. Fifty-nine varieties of taro, Colocasia esculenta (L.), obtained from the Western Pacific and Hawaii have been screened for aphid resistance on Guam by evaluating the extent of naturally occurring infestation by Aphis gossypii Glover, by assessing survivorship and reproduction of A. gossypii caged on the leaves, and by assessing preference using leaf disks in laboratory choice trials. Significant differences were observed among taro varieties in the number of aphids naturally infesting plants in the field. Similarly, significant differences in reproductive rate and longevity were observed between taro varieties. Aphids also showed preferences for certain varieties of taro, as shown by controlled laboratory choice tests. Data have been analyzed and prepared for use by plant breeders seeking to improve the genetic resistance to aphids of commercial taro varieties.

Impact:

Resistant varieties identified in this study may be used as parents in crossing blocks designed to combine A. gossypii resistance with other desirable agronomic traits such as disease resistance and yield, and as a foundation for generating markers for molecular marker-assisted selection.

Source of funding — Hatch funds

Scope of impact - regional

Key theme: Water Quality

Agricultural engineer at Guam Agricultural Experiment Station investigated efficiency of drip irrigation alternatives in watermelon crops. Field experiments were conducted to evaluate drip system design parameters – drip spacing, and number of drip lines per row for watermelon crop.

These are important parameters for very shallow soils (15 to 30 cm deep) of northern Guam situated over the sole-source fresh water lens which supplies potable water. One, two, three, and four drip lines per row with a 200 cm spacing were tested for yield and leachate. Based on in-situ soil moisture irrigation scheduling at 20 centibar, no differences in yield were observed and there was no leachate under any of the treatments. However, data indicated that the frequency of irrigation was inversely related to the number of drip lines per row.

Dissemination of information was done via a farmer's workshop at the field site just before final harvest. About 70 farmers, gardeners, teachers and entrepreneurs attended the workshop. An article in a local newspaper to reach a wider audience covered the workshop activities. There were 25 requests for information made at the time of the workshop. One high school student received summer apprenticeship training during the summer of 2005, while the field experiments were in progress. In addition a legislative group, University of Guam students and High School students visited the experimental field and learned about the irrigation system, irrigation controllers, tensiometers, watermelon crop, and weather station.

Impact:

Drip irrigation systems will help conserve water, save money and increase crop yield.

Source of funding — USDA CSREES Special Project TSTAR

Scope of impact — State specific

Key theme: Weather and climate

Agricultural engineer at Guam Agricultural Experiment Station evaluated Guam agricultural weather stations. Weather stations provide important climatic information to the agricultural community. The Guam Agricultural Climatic Data System (GACDS) has been created to assist scientists, students, golf course managers, farmers and gardeners. Climatic data from two weather stations (northern and southern Guam) are collected on a daily basis. Rain, temperature, relative humidity, wind speed, wind direction, total solar radiation, photosynthetic radiation, pan evaporation, and estimated turf grass evapotranspiration are measured via sensors and a datalogger.

Impact:

This data is regularly used in agricultural engineering field research and there have been many requests for its use by the University of Guam research community.

Source of funding — Hatch

Scope of impact — State specific

Key theme: Soil erosion

Ways to **r**estore and conserve soil in degraded lands of the Pacific Islands was investigated by Soil Scientist. Accelerated erosion as a consequence of poor soil quality threatens both the soil resource base and downstream environment in the island of Guam. These threats are manifested more seriously in the southern part of the island. The challenge facing soil and agricultural scientists therefore is to develop conservation strategies that restore the soil and improve their quality for crop production and environmental quality. In this investigation, the effectiveness of the applied conservation techniques on controlling runoff and hence reducing soil erosion is being evaluated. Cropping systems such as no-till and reduced till planting as soil erosion control techniques on a typical degraded soils in southern Guam are being evaluated. Also sunnhemp is being used in rotation to the corn crop to maintain surface cover between planting and also as green manure in order to improve the quality of soils under study. The principal method of controlling soil erosion and its accompanying rapid water runoff is to maintain adequate vegetative cover at all times which is the main objective of this project.

Two sets of twelve field plots (28 X 33ft^2) were set up at the University of Guam Ija and Inarajan Experiment Stations in Southern Guam for this project. Plots were planted with sunnhemp seeds to provide nitrogen source and surface cover before corn planting in November of 2002. Control plots however were left fallow and without cover at all times before planting. As the result of devastating effect from Typhoon Pongsona in December of 2002 and related aftermath problems the plots were abandon temporarily. However, soon after the damage assessment processes were completed we proceeded with the project in late February 2003. Sunnhemp was planted again as green manure to provide initial nitrogen supply and it was kept maintained while plan for corn planting was scheduled to start in June of 2003. Sunnhemp was cut using bush cutter after it reached flowering stage. The sunnhemp residue was disked in just before the corn was planted. In order to avoid problems associated with irregular rain events, irrigation lines were laid out immediately after the sunnhemp was cut and before the corn seeds were planted. Soil samples were taken and analyzed for initial chemical and physical property evaluations (table 1). Corn was planted on July of 2003. Two shots of fertilizer (triple 16) were applied once as starter fertilizer and once during the vegetation production stage via irrigation lines. Two set backs and problems arose following the corn plantation during the growing seasons in 2003. First there was another major storm event that washed off the majority of newly germinated corn plants and required re-planting about three weeks after the first planting. The irrigation lines were re-established and starter fertilizer was applied again in all of the treatment plots. The second problem was associated with sever weed growth in all treatment which wiped out the yield despite the measures that were taken to control its growth.
In any event the sunnhemp was planted in summer of 2005 in order to maintain a surface cover crop during the rainy seasons. Sunnhemp was bush cut late December of 2005 and rotated with corn following its cut during the month of January of 2005. Presently corn is being grown and

monitored for its performances. The corn plants are growing well despite challenges of combating insects as well as weed population. Another problem that recently presented itself is damage to the study plots by wild pigs and deer. In order to keep the pigs and the deer off the study plots we have fenced all around the area containing these plots. However, we are hoping to overcome these problems this season and harvest the corn for yield evaluation. The crop yield showed a mix result indicating that the soils under treatments are not yet settled to demonstrate the effect of each treatment on yield . In a companion study conducted in Inarajan research station, after the application of composted organic waste crop yield was measured for yield evaluation. Soil samples were taken and analyzed to evaluate the effect of compost application on soil quality. Rainfall simulator was used to measure the infiltration as one of the components of soil quality indices and also to assess the effect of compost as an erosion control technique. All the obtained results will be reported at the end of these investigations.

Impact:

An integrated approach is designed to evaluate the effect of conservation tillage, crop rotation with leguminous plant for organic matter build up, and residue management for soil re-habilitation and restoration of the badlands in Southern Guam. In our companion study we are using composted organic waste not only as organic amendments for enhancement and maintenance of soil quality and productivity but also for reducing the erodability of these degraded soils. We anticipate that the results of these two companion studies not only provide good database for assessing the extent of soil erosion but the data will provide information on effectiveness of the restoration techniques being applied for soil conservation on these and other similar soil condition in the Western Pacific islands.
The educational impact of these projects already have proven to be of a great value since some farmers started to consider rotating their corn crop with sunnhemp and use sunnhemp as green manure and cover crop during the rainy season. Also some farmers have started using compost as soil amendments and are pleased with the results. The educational impact of this investigation will prove to be of great value not only to farmers but also to ranchers and the other members of the communities of the pacific islanders whom are concerned about the degradation of soils and the natural resources of these islands.

Source of funding — T-STAR

Scope of Impact — Multi-state

Key theme: Soil Improvement

Soil Scientist at Guam Agricultural Experiment Station researched management of eroded soils for enhancement of productivity and environmental quality. Accelerated erosion as a consequence of poor soil quality threatens both the soil resource base and downstream environment in the island of Guam. These threats are manifested more seriously in the southern part of the island. The challenge facing soil and agricultural scientists therefore is to develop restoration strategies that improve the quality of these soils and address crop production needs

within a framework of increasing environmental and financial constraints. Compost application as soil amendment can have a significant impact on increasing soil organic matter and enhancing the soil quality of these degraded soils and preventing erosion in southern Guam. The objectives of this project therefore are to evaluate the use of composted organic waste as soil amendments for the enhancement and maintenance of soil quality, and also to evaluate the use of composted organic waste on crop productivity. Twelve field plots (25ft X 18ft) were set up at the Inarajan experiment station to evaluate the effect of compost application on soil quality and crop productivity. Composted organic wastes were produced and applied for increasing the organic matter content and to enhance the soil quality of these eroded soils. Corn was planted following the application of compost. As the result of a devastating typhoon (Chata`An) in July of that year all the newly established corn that were planted for this project were completely washed off the field and/or destroyed. The irrigation settings and plot markings were all scattered and disassembled. However, soon after the damage assessment processes were completed we proceeded with the project using composted organic waste as soil amendment to evaluate the effect of compost material on organic matter build up on these soils. Sweet corn was established on plots receiving compost and water was provided using drip irrigation systems. Four different application rates; 0 tons per acre, 30 tons per acre, 60 tons per acre and 120 tons per acre were used to evaluate the effect of application rate on soil quality and corn yield. Preliminary results from this experiment indicated that the organic matter content of the soils receiving composted organic waste were the highest as compared to the control treatments. The project was continued and sweet corn was replaced by the field-corn in August of 2005 to evaluate the effect of different application rates on soil quality and field corn production. Results have indicated that organic matter content was the highest for the plots under 120 tons per acre of compost application. Corn yield however was shown to be the highest under 60 tons per acre of compost application.

Impact:

In humid tropical, the warm, humid climate obviously causes a more rapid decomposition of crop biomass hence depleting the organic content of the soil. Additional biomass provided from composted organic waste is often needed to maintain or increase soil organic matter levels. Conducting studies such as this is urgently needed to improve soil quality and maintain the sustainability of the agricultural lands in Guam as well as the islands of the pacific region. Our study results have shown that using compost can help build good soil structure, and qualities that enable soil to retain nutrient, moisture, and air for the support of healthy crop growth. Compost also helps control erosion that otherwise would wash topsoil into waterways. The educational impact of this project has proven to be of a great value to the farmers as well as other members of the communities of the pacific islanders whom are concerned about the degradation of soils and the natural resources of the island

Source of funding — Hatch

Scope of impact — State Specific

Key theme: Natural Resource Management

Pomologist at Guam Agricultural Experiment Station investigated phenology and toxicology of the Guam cycad. Cycas micronesica has the potential to become a dominant component in the urban landscape on Guam, since it is one of the native species that is highly prized. This is Guam's only botanical natural resource that is familiar to the international community, and strategies for conservation are not known. One factor that has held back expanded use of this cycad is the putative link between the presence of this plant and the very high incidence of amyotrophic lateral sclerosis-parkinson's dementia complex (ALS-PDC) on Guam. It is possible that some forms of neurodegenerative diseases in the United States involve dietary factors. So the implications of this research are far-reaching. Moreover, any increase in our understanding of cycad biology will aid in the efforts in cycad conservation worldwide. The decades of research on neurotoxins from this plant has never asked critical questions such as, “What are base-line toxin levels in various organs, what is the seasonal variation of toxin levels, do toxin concentrations support any of the hypotheses around natural defensive compounds?” This medical research will undoubtedly continue for many years to come. Baseline information from this proposed project will establish a protocol for collection of tissue will greatly improve accuracy and efficiency of this future research

Impact:

All of the objectives of this project are long-term, and we continue to make progress in understanding reproductive and vegetative phenology. We are also identifying the sex of every individual within established plots. These data will be used to determine demography and allometry characteristics of the natural populations. Our field sampling methods this past year have allowed identification of seed age as we continue to determine the possible causes for the heterogeneity of toxin concentration from sample to sample. The Shaw lab at the University of British Columbia has made great progress this year in determining the influence of sterol glucosides in cycad seeds on various histological and biochemical indices of neuronal dysfunction. The protocol to mimic most of the key behavioral, biochemical, and histological features of ALS-PDC via cycad seed ingestion has been established. This work was done in the absence of the known water-soluble toxins, which indicates the water-insoluble mixture of sterol glucosides that were recently identified are probably causal.

These results will aid in understanding resource partitioning and use in perennial species with conservative growth habits. Greater understanding of the dietary factors that influence ALS-PDC in the Guam population may translate to a greater understanding of neurodegenerative diseases.

Source of funding — USDA CSREES Special Project TSTAR

Scope of impact — State specific

B. Stakeholder Input Process

Actions taken to seek stakeholder input

For the most part, our professionals know the primary stakeholders in their particular disciplines, and interact with them regularly in the course of their normal university duties. Input from these interactions allows the faculty to tailor their programs to the unique needs of Guam's diverse community. Agriculture Experiment Station faculty within the College of Natural and Applied Sciences maintain regular contacts with Guam EPA, Northern and Southern Water District, and NRCS. Most of AES scientists know the farmer's needs and make their programs relevant to the various University of Guam stakeholders needs. We feel our informal and formal contact system with our stakeholders works quite well. Due to the close contact extension and research scientists maintain with local growers, and because of the breadth of experience on other islands in the region, UOG-CNAS scientists are able to identify, characterize and provide a rational method of management for insects, diseases and other problems.

C. Program Review Process

Significant changes in the program review processes

There have been no significant changes in Guam's program review processes since our 5- year plan of work.

D. Evaluation of the Success of Multi and Joint Activities

The University of Guam continued participation in four multi-state research projects in FY 2005. These were W-1185 - biological control in pest management systems of plants, W- 128 - microirrigation management practices to sustain water quality and agricultural productivity, NC-1142 - regulation of photosynthetic processes, S-009 - plant Germplasm. S-1000 - Animal Manure and Waste Utilization, Treatment and Nuisance Avoidance for a Sustainable Agriculture and NC 136 - Improvement of Thermal and Alternative Processes for Foods. We also participated in four multi-state coordinating committees. They were WCC- 011 - turfgrass research, WCC-067 - western coordinating committee for sustainable agriculture, WCC-205 -

integrated water quality research and extension program for the western United States and WCC-206 - Pacific Basin tropical agriculture.

Our planned programs focus on tropical agriculture, and our farmers and general population on Guam are generally under-served by the U.S. agricultural research and extension system as well as under-served based on economic, social and ethnic criteria. All populations on Guam are ethnic minorities. Most of our farmers are Asian/Pacific Islanders. We are striving to address their unique needs by adapting the framework provided under the US agricultural research and extension system.

We feel that the multi-state programs generally do a good job of describing their expected outcomes and impacts in their initial proposals to the regional directors associations and in their progress reports as a whole. In their local Plans of Work and AREERA reports, however, individual scientists vary considerably in their success in meeting this goal. Some have a good understanding of what are outcomes and impacts, and do a good job of reporting, and some perform poorly. We will continue to work with our faculty to improve their understanding and performance in this area.

Our membership in multi-state projects and committees allows our researchers to interact with counterparts from within the region and around the country. Because Guam is isolated, and we have no more than one or two faculty in each discipline, annual and ongoing interactions are critical to maintaining our programs' performance standards and ensuring that our activities are relevant and effective. On an individual basis, we are working with the PI of one of our projects to improve the outcome and impact of the project. If we do not see improvement in the local management and results of this project we will terminate out participation in it during the coming year.