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Agricultural Experiment Station
College of Agriculture and Life Sciences
University of Guam

**AGRICULTURAL
EXPERIMENT STATION**



Guam Agricultural Experiment Station has a primary focus on research funded through various sources. Our list of supporters includes Hatch, McIntire-Stennis, Tropical and Subtropical Research Program of Special Grants, National Pesticide Impact Assessment Program, Agricultural Development in the American Pacific, Center for Tropical and Subtropical Aquaculture, the Department of the Interior, and the Department of Defense. But research is not our only focus. The station faculty actively teach undergraduate courses in agriculture and graduate courses in the environmental sciences. They also conduct monthly workshops for teachers, students and the public. While this publication highlights faculty work in research, we also want to stress our efforts and commitment to serve the general public in many ways.

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Contents

Agricultural Economics	1
Agricultural Engineering	3
Agronomy	4
Animal Science	6
Entomology	7
Forestry	11
Horticulture—Fruit	12
Horticulture—Ornamentals	13
Horticulture—Vegetables	14
Nutrition	15
Plant Pathology	16
Projects	19
Publications	20
Off-Island Conferences and Meeting Attended	22

Agricultural Economics

Small Landholders on Guam

J.W. Brown

Agriculture on Guam has changed dramatically during the American period (1898 to present). During this time, agricultural production has been periodically recorded by the U.S. Census of Agriculture and more recently on a continuous basis by the Guam Department of Agriculture. The primary factor affecting agriculture during this period was the introduction of widespread employment for monetary wages during the last year of World War II, and the subsequent postwar military build-up. Prior to WWII, the economy of Guam was primarily subsistence agriculture. The major field crops were corn, sweet potatoes, taro and yams. Tobacco, cassava, rice, arrowroot and sugar cane were also reported in substantial amounts. Coconut was the primary tree crop, and copra was the dominant cash product.

In analyzing the history of agricultural production on Guam, we divided the crops into three categories. The first category was labeled as "staples." These crops have basically disappeared, either by being replaced by imports such as rice, sugar and tobacco, or because food preferences developed for items such as arrowroot and mature corn. The production of these crops decreased substantially after the war, and by 1959 these crops had almost completely disappeared from the Island's farm economy. They probably will never again play a role in Guam's agriculture.

The second category was labeled "fruits and roots." These crops were important before introduction of the cash economy and have remained relatively important for cultural or economic reasons. These include taro, yams, sweet potatoes and the tropical fruits - bananas, pineapples and papayas. Today many of these crops are commercially produced. They continue to be an important part of the island's agricultural production, both commercially and

for household use. Because of their tropical nature and history of local production and cultivation, they suffer less from import competition than temperate vegetables imported from the U.S. mainland.

The third category was labeled "commercial." These are crops such as watermelon, cucumbers, eggplant and cantaloupe, which have become important since the late 1950s. This has become the largest category of agricultural production on Guam since the mid-1960s.

Erratic supplies of local fresh vegetables and fruits encourage imports of many commercial crops to Guam. Variation in locally produced supplies stems from: periodic typhoons and tropical cyclones, rainy season saturation of clay soils in the southern end of the Island and the recurrence of newly introduced diseases and pests. The Agricultural Experiment Station at the University of Guam is working to provide advances in agricultural technology needed to overcome these constraints, especially in developing new crops and cultivars, effective pest management, mechanization and improvements in cultural practices.

Commercial Sponge Market Production

R. Croft and J.W. Brown

The government of the Federated States of Micronesia requested assistance in developing a tourist-oriented marketing effort for farm-raised sponges, focusing on Guam. A small grant was obtained from the U.S. Department of Interior for developing the marketing through the Pacific Aquaculture Association.

Sponge farming is considered to be an attractive alternative to copra production on the isolated atolls of Micronesia. Like copra, the sponges store well, once harvested, so the physical isolation of atolls presents little problem. Sponge farming is also suitable in the lagoons of high islands. Its

production requirements fit well within the island cultures since farmers can still give attention to social and cultural affairs for several days at a time.

However, commercial sponge farming is in its early stages of development in Micronesia. The first commercial farm started harvesting and processing sponges in 1992, producing less than 1,000 pieces in the first year. Others are expected to initiate harvesting in 1993-1994. Production should increase slowly. During this initial period of commercial sponge production in the Federated States of Micronesia, the quantities produced are considered too small for large wholesale markets in the U.S.

Marketing to the regional tourist trade was seen as offering a viable alternative to the bulk wholesale market. Regional tourist centers on Guam and Saipan were targeted for development. Our marketing effort focused on developing processing and packaging materials, and labels for the sponges. Processing chemicals were obtained from off-island sources, and a chemical bleaching technique was worked out for the sponges. Local artists were recruited to do the package labels; on Guam, the labels were printed in four colors. Packaging materials were obtained from Hawaii and Taiwan. Four different packages were developed. A flyer explaining the uniqueness of this farm-raised product was written, translated and printed. Finally, the packaged sponges were test marketed at the Micronesian Island Fair. They sold well, even though many consumers were not familiar with a "natural" sponge or its uses. After test marketing, a visit was made to a local retailer to start the market introduction process. This retailer also had a wholesale distribution company interested in handling distribution of sponges on Guam. Eventually, a verbal contract was made between the Pohnepian sponge farmer and the wholesaler to purchase all of the farmer's current production. By this time,



the Agricultural Experiment Station's role in the project was essentially completed. Development of a local market increased the price to an average of U.S. \$2.71 per sponge for the farmer.

Aquaculture Market Assistance for Guam

D. Crisostomo, J. Barcinas and J.W. Brown

This project was intended to promote marketing of the Asian catfish on Guam. With the decline of eels and freshwater prawns in the early 1980s, tilapia and milkfish dominated production up until the early 1990s. Production was limited to four freshwater fish groups: tilapia, milkfish, Asian catfish and carp. Catfish accounted for only 7 percent of production. Local fish farmers have experimented with the Asian catfish, finding production characteristics to be favorable. Marketing is the primary constraint with the Asian catfish; production is not a problem.

A three-pronged attack was made on the marketing problem: consumer education, preliminary marketing research and initial investigation of partial mechanization for processing the Asian catfish.

Consumer education was

needed to expand the catfish market. There were three components of the consumer education program included preparation and distribution of a guide on the proper technique for killing and cleaning Asian catfish, the creation of color-coded recipe cards and a series of cooking demonstrations/taste tests.

The pamphlet and recipe cards were distributed by the Guam Cooperative Extension. Customers were asked to taste our samples and answer a brief questionnaire. Based on a scale of zero to five, with five as excellent, the average overall rating for all groups was 3.87 for the Asian catfish and 3.82 for the Channel catfish. The majority (97%) of respondents indicated their willingness to purchase Asian catfish in the future.

The results of taste comparisons and informal discussions with respondents indicate that the Asian catfish is an acceptable product to a sizable segment of the Guam market. However, image and familiarity does not automatically result in purchasing a live fish, which then has to be killed and cleaned.

Since the primary impediment to increasing the market for Asian catfish on Guam was lack of a ready-to-cook product (as we had

anticipated at the beginning of the project), we conducted an investigation into the use of small-scale skinning, heading and gutting equipment. The cost of processing Asian catfish using minimal equipment ranged from \$0.51 to \$2.40 per kilogram, at input levels ranging from 113 to 909 kilograms per week. The cost of processing Asian catfish provides opportunity for mechanization.

The problem is in the farm-gate prices of the raw fish. Farmers can sell their current levels of production on Guam in a whole, live form, at retail prices. Normally, it would not be profitable to give up current production of these species for one that needs processing before being sold. Thus, farmers can not be expected to produce Asian catfish for processing. An exception would be if surplus ponds, currently not being used in the production of tilapia or milkfish, were available.

Agricultural Engineering

Water Crop Production Functions for Vegetable Crops

Prem Singh

A series of experiments have been conducted on cucumber and head cabbage to determine optimal soil-moisture tension in the root zone. This information can be used for scheduling irrigation to maximize crop production. Switching tensiometers measured in-situ soil moisture in the root zone. These were used to control irrigation scheduling. Cucumber experiments were conducted at the Inarajan Experiment Station, where Guam clay soil between 25 to 45 cm deep is underlain by coral. Head cabbage experiments were conducted at the Yigo Experiment Station, where Guam Cobbly Clay soil between 15 to 25 cm deep is underlain by a coral plateau.

Trellised cucumbers were planted in rows 45 cm apart. There were two plants per hill, and rows were 1.52 m apart. The Soarer cultivar was transplanted on February 23, 1993. The five irrigation scheduling levels were 5, 10, 25, 45 and 60 Centibar (CB). Nitrogen at the rate of 100 Kg/ha was applied in 10 split applications on a weekly basis. This experiment was abandoned due to an uncontrollable disease/pest outbreak. However, water production function for cultivar Southern Delight was developed using data obtained from a previous experiment. Yield estimation can be made using these functions based on the amount of water to be applied or the soil-moisture tension in the root zone at which irrigation is to be scheduled. Such information is useful in limited water-supply situations, as well as for irrigation system design, to estimate peak flow rates.

Head cabbage was transplanted in rows 1.2 m apart; plants within a row were 45 cm apart. The variety tested was K.K. Cross. From the data obtained so far, head cabbage production appears to be more sensitive to water stress than cucumber, since head cabbage declines in yield even when irrigation is scheduled at 25 CB.

Nutrient Crop Production Function for Vegetable Crops

An experiment to develop crop production function for cucumber cv. Soarer was conducted from May 10 to July 23, 1993 at the Inarajan Experiment Station. The trellised cucumber received five levels of N:K nutrient levels at: 0:0, 50:40, 100:80, 150:120 and 200:160 kg/ha. Micro-irrigation scheduling was done using switching tensiometers set at 10 CB. Cucumbers were harvested every other day from June 7 to July 23, 1993. A total of 232 mm of rain and 402 mm of pan evaporation occurred during the experiment. Approximately 50 percent of the rain fell during the last two weeks. Data analysis showed all treatments were significantly different from each other. The highest yield, approximately 85,000 kg/ha, was recorded for the 200:160 kg/ha N:K treatment. The lowest yield for control with no fertilizer was approximately 8,000 kg/ha. An interesting aspect of this experiment was the scheduling of micro-irrigation based on water demand by the plants. The amount of water used increased from 225 mm for control (no fertilizer) to 495 mm for 200:160 kg/ha N:K treatment. If the amount of irrigation were kept constant, it would have resulted in excessive water application for many treatments. Trials will be repeated next year to check for replicability of these observations.

Dynamics of Root Growth, Water Uptake and Automation of Micro-irrigation Scheduling

Optimal Wetted Soil Volume (OWV) is the minimum volume of soil needing to be wet (irrigated) at any crop stage without reducing growth. It is an important parameter for the design and operation of micro-irrigation systems that maximize water application and water-use efficiencies. A pot experiment to obtain OWV for crop cucumber was conducted on Guam



Clay soil at Inarajan. Pots of 10 different sizes, containing soil from 1.4 kg in the smallest size pot to 47 kg in the largest size pot, were used. There were a total of 140 pots. Cucumbers (cv. Soarer) planted on February 25, 1993 had to be abandoned on April 19, 1993 due to disease/pest problems. A second transplanting was done on May 10, 1993 and the final harvest ended on July 23, 1993. Plant growth data (e.g., fresh and dry weight of shoots and roots, leaf area and plant height) were obtained approximately every 10 days.

Data analysis showed that OWV, as represented by pot number, started to show its influence on the growth measurements as early as 22 days after transplanting. The differences in growth increased with time. Plant leaf area, plant length and fresh weight were the most sensitive parameters. Root weight had a large random variation, masking the trend observed for other growth parameters. This was probably due to difficulties in consistently recovering all the roots during washing. Sampling variation within a pot size and between sampling dates was high. To overcome this problem in future experiments, plants of similar sizes will be tagged, and some of the growth parameters will be measured throughout the growth period without destroying the plants.

Agronomy



Alley Cropping

J.L. Demeterio

Leucaena alleys were established in May, 1991. The nitrogen treatments administered were 0, 25, 50, 100 and 200 kgm N per hectare. A split plot layout, with main plots for nitrogen treatments and subplots for alley cropping and open field cropping, was used. A drip irrigation system was laid out for irrigation. Head cabbage

seedlings grown in Jiffy 7 pots were transplanted in February 1993.

Head cabbage growing between rows of leucaena were distinctly taller and more vigorous than those grown in the open field stand [Table 1].

An attempt to quantify the weed problem was taken by counting the weeds within 2 one-meter square quadrants from each plot [Table 1]. The plots within the

leucaena were 2.9 times less weedy than the open field scheme plots.

Although the growing season was uneventful, the yield of the open field scheme was drastically reduced with the 0, 25, 50 and 100 kgm N treatments. Most plots within this treatment had no harvestable head cabbage. Since fertilizer trials are site-specific, this particular area would respond to N application only at levels above 100 kgm N/hectare. The alley cropping scheme produced higher yields.

While we are convinced of the benefits of alley-cropping, field preparation in trimming the leucaena was a problem. In 1993 we solved this by using bush cutters with a rotary cyclone blade. Leucaena was cut to ground level fairly fast. The woody stems were stripped of the green foliage by hand. The foliage was rotatilled into the rows and the stems were discarded.

Effects of Varying Nitrogen Rates on Yield of Cucumber

J.A. Cruz

Optimizing nitrogen is important for economical reasons and for addressing concerns regarding environmental pollution. A field study was established to evaluate the effects of varying nitrogen levels on cucumber yield, using a drip irrigation system. The study was conducted on Yigo soils classified as clayey, gibbsitic, isohyperthermic, tropeptic enthrustox. This soil is very shallow, well drained and calcareous. Its chemical properties on the surface to 15 cm are as follows: pH, 7.5; K 50 ppm; P, 5 ppm and organic matter at 4%.

The Soarer cucumber variety was direct seeded in 30 meter black plastic mulched rows, with a 46 cm x 150 cm plant spacing. Two weeks after germination the cucumber plants were thinned to one plant per hill.

Both phosphorus and potassium fertilizers were applied at a

Table 1. Plant height in cm., number of weeds, and yield in metric tons per hectare of head cabbage grown under two cropping schemes.

Treatment kgm/ha	Plant Height*		Number of Weeds **		Yield ***	
	Open	Alley	Open	Alley	Open	Alley
0 kgm/ha	16.8	21.3	35.6	16.1	2.0	12.7
25	18.2	24.1	53.5	21.0	1.7	15.9
50	18.8	23.1	52.1	15.4	1.3	17.4
100	21.4	23.0	47.0	14.9	11.5	19.9
200	21.7	23.6	56.6	18.9	22.9	21.9
mean	19.4	23.0	49.6	17.3	7.9	17.6

*Differences in height between the cropping schemes was highly significant at 1% probability level, c.v. at 9.37%, LSD(.10) = 4.1.

**Differences number of weeds between the cropping schemes was highly significant at the 1% probability level, c.v. at 44.19%, LSD(.01) = 30.7.

***Differences in yield as affected by cropping schemes and applied nitrogen were highly significant at the 1% probability level, c.v. at 35.63 and 27.25%, LSD(.01) = 7.9 and 6.2, respectively.



rate of 200 kg ha^{-1} , two inches below and on the sides of plant rows, two weeks before planting. Nitrogen treatments consisted of ammonium sulfate (to supply nitrogen) applied through the drip irrigation system at rates of 0, 50, 100 and 150 kg N ha^{-1} . Drip lines were placed six inches to the sides of plant rows, under the black plastic mulch. The nitrogen treatments were arranged in a completely randomized block design and replicated four times. The fertilizer injection system was calibrated at a 1:100 ratio to maintain the desired concentration levels of nitrogen. Dissolved ammonium sulfate as nitrogen fertilizer was applied through the drip irrigation system two times a week, two weeks after planting.

The cucumber was harvested twice a week and weighed on a gram balance. Results indicated that the yield increased as the nitrogen levels were increased from 0 kg N ha^{-1} to 150 kg N ha^{-1} . These nitrogen levels were highly significant at 0.1% probability level.

Animal Science

True Metabolizable Energy Value of Extruded Cassava, Leucaena (Tangantangan) and Copra Meal

F.G. Abawi and O. Diambra

An experiment was conducted to investigate effects of dry-extruder processing of cassava, leucaena leaf meal and copra meal on subsequent true metabolizable energy (TME) values, using six-month-old Rhode Island Red roosters. Each diet was force-fed to three birds in individual cages. Birds were fasted for 24 hours before the experiment and fed 20 grams administered once through a funnel to the crop. Total excreta were collected for 48 hours. The control group was fasted throughout the experiment to correct for endogenous excretions. Triplicate samples were analyzed for gross energy. Results indicated increased TME values for leucaena and copra meal when subjected to the dry extrusion process. However, cassava meal showed lower TME value when extruded.

Enzyme and Amino Acid Supplementation of Leucaena Leaf Meal (Tangantangan) for Broilers

Two experiments were conducted to evaluate the effects of supplemental enzyme (cellulase) and amino acids (lysine & methionine) on diets high in leucaena (10%) fed to broiler chicks. Results indicated that diets supplemented with cellulase (from *Penicillium funiculosum*, 5 g per 100 kg) and amino acids (15% above NRC) significantly improved weight gain during the first two weeks. A tendency toward compensatory growth was observed in the non-supplemented group after the fourth week. Birds on leucaena diets had significantly ($P < 0.05$) longer intestinal tracts and heavier gizzard weights than the control group at market age.

Effect of Fiber and Feed Restriction on Body Weight and Sexual Maturity of Pullets

A study was conducted to evaluate dietary effects of feed restriction and fiber level on the sexual maturity of starting pullets. Layer chicks of "Gold-Links" commercial strain were fed commercial chick starter and grower for eight weeks. A total of 168 pullets were randomly allocated to four treatments of seven replications, six birds each. Two levels of calculated crude fiber (4 and 6%) and two feeding regimes (full & restricted) were used in a 2 X 2 factorial design. Artificial light was increased from 14 hours at 16 weeks of age to 16 hours at 20 weeks of age.

Results indicated that feed restriction (withholding feed on alternate days) was effective in controlling weight gain and onset of sexual maturity of pullets. Increasing the fiber level in the diet from 4 to 6% did not affect ($P > 0.05$) feed consumption, sexual maturity or daily weight gain. The management of pullets for early or late maturity is dictated by economic factors such as supply and demand, and price differential between medium and large eggs.

Effect of Varying Calorie and Protein Levels on Layers Fed High Levels of Leucaena

Different calorie and protein concentrations were fed to 120 commercial layers (Rhode Island Red Cross) to evaluate laying performance with 10% leucaena in the diet. Three calorie levels (2600, 2800 and 3000 kcal/kg) and two protein levels (15 and 18%) were investigated in a 3 x 2 factorial arrangement of six treatments, with five replicates of four birds each. Daily feed intake, percent of hen-day production and average daily egg-weight were recorded. Feed conversion (feed mass/egg mass) was computed. Data were collected from the onset of egg production at 21 weeks of age, to the fourth month of production. Data indicated a significant effect ($p < 0.05$) of calorie or protein concentration on feed intake. Feed intake decreased significantly ($p < 0.05$) as calorie or protein level increased. Percent of hen-day production and egg weight were similar among all treatments. Layers on low-energy feeds were able to increase consumption despite high fiber and bulk contribution of leucaena leaf meal.



Entomology



Biological Control of Bean Pests

D. Nafus

A complex of pests affects beans on Guam. One of these, the leafminer *Liriomyza trifolii*, is highly resistant to insecticides, but is controlled by a complex of natural enemies in unsprayed fields. Management programs need to be oriented towards reducing pesticide use. Towards this goal, studies on the bean fly *Ophiomyia phaseoli*, the cotton aphid, *Aphis gossypii*, the cowpea aphid *Aphis craccivora*, and the pod borer *Maruca testulalis* have been initiated to see if biological control of these species can be improved.

Studies on the biological control of the bean fly, *Ophiomyia phaseoli*, focused on delineation of species and incidence of parasitoids on Guam. Beans flies were collected in the villages of Barrigada and Mangilao, Guam, and reared for parasitoids. At least 10 species were found. Two species, *Hemiptarsenus semialbiclavus* and *Chrysonotomyia formosa*, also parasitize *Liriomyza* leafminers. Parasitization levels were highest before flowering, reaching 70%, and then declined to between 2 and 27%. Following the decline, bean fly populations increased,

and within four weeks nearly all of the petioles were infested. Six weeks after the decline, the bean flies killed nearly all of the vines, and yield dropped from over 50 kg per week to 5 kg. In comparison to treated plants, late stage infestation by bean flies decreased yield 42%.

The cotton aphid and the cowpea aphid were assayed for natural enemies in Barrigada, Guam. Test crops were beans, watermelon and cucumber. Thousands of aphids of both species were examined and reared, but no parasitoids or mummies were found. Several coccinellids and two species of predatory flies were collected feeding on the aphids. The most common coccinellid was *Menochilus sexmaculatus*. *Harmonia arcuata* was also abundant, especially early in the crop cycle, in both watermelon and beans. *Coelophora inaequalis* and several smaller species were also collected but were uncommon. The predominant fly was a syrphid. Infestations of cotton aphids and cowpea aphids built up rapidly on both beans and watermelon. In beans, by the second week after emergence over 75% of the plants were infested by cowpea aphid and 64% by cotton aphids. Leaves averaged 14 cowpea aphids and 10

cotton aphids each. Within two weeks, populations of both species collapsed due to pressure from *M. sexmaculatus*. Subsequently, aphid populations remained low until near the end of the crop cycle, when cowpea aphids increased dramatically. Populations of cotton aphids did not recover.

A survey was undertaken to determine if there were parasitoids of *Maruca testulalis* present on Guam. A braconid parasitoid was reared from the larvae. About 5% of 506 larvae were parasitized. There was no difference in the number parasitized whether the larvae were on the flowers or on the pods.

Biological control of the Poinciana Looper *Pericyma cruegeri*

Poincianas, or flame trees, normally have a synchronized mass flowering in the dry season. On Guam, flowering is disrupted by the Poinciana looper. Individual trees were monitored in the villages of Agana, Mangilao, Ipan and Dededo to determine the extent and season of flowering. Flowering was found in all months of the year but was most common from May to July. Individual branches flowered asynchronously, with a maximum of 15% of the limbs flowering at any one time. In 1992, most of the trees had less than 5% of the branches in flower during any one month, and less than 25% of the branches flowered overall. In 1993, flowering was reduced and extremely erratic. This was primarily due to a series of typhoons in the fall of 1992. Outbreaks of *P. cruegeri* took place in November 1991 and February 1992. In late 1992, typhoons defoliated the trees and the loopers were rare. Populations did not reach damaging levels until October-November 1993. In 1991 and early 1992, 250 loopers per 100 leaves were found. Heavy defoliation resulted. In 1993, populations peaked at less than 30 per 100 leaves. Most trees were not defoliated.

Surveys for natural enemies yielded no egg or larval parasitoids. Less than 1% of 1500 pupae were parasitized. *Brachymeria lasus* and *Exorista civiloides*, found in previous investigations, were present along with a species of *Echthromorpha*. *Echthromorpha* sp. was first found on Guam in 1989. Nearly 25% of the pupae died from disease or other causes.

Control of Pumpkin Beetles, *Aulacophora similis*, to Floral Odors

I. Schreiner

A test was run to determine if beetles would be attracted to odors emitted by hidden flowers. Traps were made from half-gallon plastic containers with the ends cut off and covered with plastic screening. The sides were coated with Tanglefoot. The interior of the trap was either filled with squash blossoms or empty. The traps were hung just above canopy level in a pumpkin field heavily infested with pumpkin beetles. There were four traps of each type. The traps were rebaited daily. Few beetles were attracted to the flowers, and there was no difference between baited and unbaited traps. This, in combination with the synthetic floral odor tests done previously, indicated that pumpkin beetles are more dependent on vision for locating host plants than on olfactory stimuli.

Response of Pumpkin Beetles to Different Colors of Traps

D. Nafus

Pumpkin beetles are attracted to traps. To determine the best color for catching beetles, different colors of traps were tested. Traps consisted of clear plastic cups painted with various acrylic colors. Distinct color preferences were found. Yellow and yellow greens were two to three times more attractive than reds, greens, blues and purple. Arylide yellow, which is approximately the color of a

pumpkin flower, caught 134 beetles in six weeks, compared to 59 for cadmium yellow medium, the next best color.

Control of Pumpkin Beetles by Trapping

I. Schreiner and D. Nafus

In 1992 and again in 1993, experiments were run to test whether or not pumpkin beetles could be controlled by trapping. We compared beetle populations and yield in plots with different densities of traps: one trap per watermelon hill (total 70 traps), one trap every other hill (35 traps), one trap per four hills (16 traps), one per eight hills (eight traps), one per 16 hills (four traps) and a check with no traps. Traps consisted of 12-ounce yellow plastic cups coated with a sticky glue (Tanglefoot). Traps were placed on rebar about one foot above the soil level.

In 1993, 103 beetles were caught in the 70-trap plot and 35 or less in the other plots. The 70-trap plot had the fewest beetles on the leaves. The number of beetles was highest in the 16-trap plot. Low populations of beetles were found in the four, eight and zero-trap plots. In part, this was caused by strong directional migration of beetles from a field adjacent to the 70-trap plot. Many of the beetles were trapped in the 70-trap plot, and few reached the zero-trap end of the field.

The total weight of harvested melons produced in each plot increased linearly with the number of traps, except for the 70-trap plot, which produced little yield. This was caused by a severe infestation of fire ants that damaged many plants and delayed growth. The other plots were less affected. Consequently, yields for the 70-trap plot are probably not valid. In 1992, the plot with no traps produced 114 kg of melons compared to 315 kg of melons in the plot with 70 traps. Plots with four, eight, 16 and 35 traps had intermediate yields. In 1993, the

zero-trap plot produced 115 kg of melons, compared to 155 kg produced in the 35-trap plot.

Trapping of Natural Enemies of Aphids on Pumpkin Beetle Traps

D. Nafus

Pumpkin beetle traps catch insects other than pumpkin beetles. In 1993, I monitored populations of aphid predators caught on traps in plots with different trap densities. Populations of aphids and their predators on watermelon leaves were also monitored to see if biological control of this pest was affected.

Coccinellids were strongly attracted to the traps. Over 400 *Menochilus sexmaculatus* were caught in a plot with 70 traps and nearly 150 in a four-trap plot. The number of coccinellid larvae on leaves showed an inverse relationship between trap number and larval density. About 1.5 lady beetles per leaf were found in the plot with no traps. This dropped to less than 0.25 per leaf in the plot with 70 traps. Syrphids were less attracted to the traps. Aphid populations were similar in all plots despite reductions of coccinellids in the high trap density plots. In part, this may have been due to an increase of syrphids in the higher density plots, suggesting that there may be some antagonistic relationship between the coccinellids and the syrphids. No parasitoids were found in any plots.

Floating Row Covers as Barriers to Pumpkin Beetles

I. Schreiner and D. Nafus

In January 1993, an experiment was set up to see if floating row covers could be used to protect cantaloupe from early season pumpkin beetles. Floating row covers are sheets of thin polyester cloth laid over the crop. The cloth permits 85 to 95% light transmission and allows some air

movement, but forms a barrier that excludes or repels many insects.

Test plots consisted of two 20-meter rows of cantaloupe. Half the plots were covered with floating row covers until female flowers were found, and half were left exposed. The floating row covers were removed when female blossoms appeared, permitting pollination. After the floating row cover was removed, all plants were treated weekly with dimethoate to prevent melon fly damage. Beetles were first observed in the first week of February when the plants were producing their first male flowers. At the time the row covers were removed, uncovered plants averaged about one beetle per plant. Adult beetles were observed crawling through tears in the row cover and feeding on the plants underneath, but the number of beetles entering was small and there were few tears. Melons were turned over in all plots to check for beetle larvae and damage, but little damage was observed. To sample larvae, soil cores were taken adjacent to the main root a week before harvesting began. Four samples per plot were taken. Beetle larvae were only found in one uncovered plot. The incidence of virus was very low in the uncovered plants, and absent in the covered ones (ELISA assay). On all dates sampled, plants in the covered plots were significantly larger. Yield was higher in the covered plots, and the fruit matured about four days earlier. No difference in the incidence of diseased melons or foliar diseases was found.

Impact of Cowpea Aphids and Bean Flies on Yield of Yard-long Beans

I. Schreiner

Yard-long beans were planted March 26, 1993 at Barrigada, Guam. Plots were seven rows, six feet long and four feet apart. Because of previously observed difficulties in obtaining bean fly infestations when treated plots

were interspersed with untreated plots, a treatment gradient was set up. Three plots at one end the field were treated weekly with dimethoate, three plots in the middle of the field were treated for the first two weeks but not thereafter, and the last four plots were not treated with dimethoate. An attempt was made to control a severe infestation of cowpea aphids, which appeared in the completely untreated plots with Safer insecticidal soap; however, this did not control them. Aphid and bean fly infestations were estimated weekly by examining 28 petioles of recently matured leaves in each plot and determining whether or not that petiole had bean-fly damage or aphids on it. A regression between the seasonal mean number of aphids and bean flies showed both were highly correlated with yield, although the aphid populations were more so. However, the aphid and bean-fly populations were also highly correlated since both are quite susceptible to dimethoate. The bean-fly population did not become high until the very end of the harvest season. At the time the harvest began, aphid infestation was highly correlated with final yield whereas bean-fly number was not, suggesting the aphids were the more important determinants of yield. The impact was severe, e.g., an aphid infestation that increased from none to 50% of the tips having aphids readily visible on them cut the yield by two-thirds.

Test of Various Formulations of *Bacillus thuringiensis* for Control of Corn Borer

I. Schreiner and L. Dumaliang

Bacillus thuringiensis (Bt) is a microbial product used as an insecticide to control various types of caterpillars. It is non-toxic to humans and most other organisms in the environment, but is not always favored as an insecticide of choice because it breaks down quickly and is often less effective



on older caterpillars. Previous tests on Guam have shown that Bt can be very effective against the Asian corn borer *Ostrinia furnacalis*, but was not consistently reliable when corn borer densities were high. New formulations of Bt have recently come on the market; these were tested against the previously used product, Dipel.

Two experiments using sweet corn, 'Hawaiian Supersweet No. 9,' were done. The first was planted January 6, 1993. Plots consisted of three 5 m rows planted 1.2 m apart. Each treatment was replicated four times in a randomized block design. Three formulations of *Bacillus thuringiensis* var. *kurstaki* were tested using Dipel, Javelin and MVP. Treatment plots were sprayed twice weekly beginning January 28, 1993, at which time signs of corn borer infestation were evident throughout the field. Treatments were continued until harvest. All materials were applied at the midpoint of the label rate (at five Tbs./ gal). Five plants per plot were harvested at silking and dissected, and all corn borer larvae were counted. All ears were harvested at the milk stage, and examined for damage caused by corn borers. The second experiment began June 12, 1993. The experimental design was the same except that the materials used

were Dipel, Xentari, and MVP. Treatments began July 12, 1993.

In the first experiment, the number of corn borers counted on plants was significantly lower in the Dipel and Javelin treatments, intermediate in those treated with MVP, and highest in the untreated plots. The total number of ears did not differ among treatments. Only 25% of the ears were undamaged in the untreated plots whereas about half the ears were undamaged in the treated plots. There was no difference among the different Bt formulations. In the second experiment, the number of corn borers counted on plants was significantly lower in the Dipel and MVP treatments, intermediate in those treated with Xentari, and highest in the untreated plots. There was no difference in the total amount of ears among the treatments. A slightly higher proportion of ears were undamaged in the treated plots as compared to the untreated ones (45% vs. 50%).

Siam Weed

R. Muniappan and I. Silva-Krott

The Third International Workshop on Biological Control and Management of the Siam Weed, *Chromolaena odorata*, was orga-

nized and held in Abidjan during November 15-19, 1993. A total of 40 members from 20 countries were present at the workshop, and 20 manuscripts were processed for the proceedings.

The University of Guam had been working on biological control of *Chromolaena odorata* since 1983. Large areas on Guam were covered by the tropical pasture weed. A host specific insect, *Pareuchaetes pseudoinsulata*, a caterpillar introduced in 1985 to the island, caused widespread defoliation of the weed.

C. odorata leaves developed marked chlorosis when infested by the caterpillars. When no longer infested the leaf color returned to green, with a concomitant increase in chlorophyll. Leaf chlorosis studied in histologic sections of fresh yellow leaves showed diffuse loss of chlorophyll and chloroplasts of mesophyll cells in all portions of the leaf. Cells devoid of chloroplasts exhibited increased variation in shape and diameter. During the recovery stage, uneven distribution of chloroplasts in mesophyll cells was observed.

Electron microscope examination of the sections of green and yellow leaves showed deterioration of chloroplasts in the yellow leaves. Also, regeneration of

chloroplasts was noted in the leaves that were turning from yellow to green. Chloroplasts were normal in sections of green leaves.

Trap Cropping to Control Cabbage Insects

R. Muniappan and T.S. Lali

The major pests that attack head cabbage on Guam are diamondback moth, *Plutella xylostella*, cabbage webworm, *Hellula undalis*, cabbage cluster caterpillar, *Crociodolomia pavonana*, cutworm, *Spodoptera litura*, mustard aphid, *Liphaphis erysimi* and the flea hopper, *Halticus tibialis*. A trap cropping system consisting of mustard (Indian variety), Chinese cabbage cv. Tempest and radish cv. Minowase #3, grown on either sides of the head cabbage field, attracted *H. undalis*, *C. pavonana*, *L. erysimi* and *H. tibialis*, thus reducing the need to use insecticides on head cabbage to control these insects.

The egg parasite, *Trichogramma chilonis*, recovered from the eggs of *P. xylostella* and *C. pavonana*, is being mass multiplied and field released. A larval parasite of *S. litura* has been identified as *Euplectrus xanthocephalus*. This parasite has been shipped to the Biological Control Laboratory, ARS, USDA, Columbia, MO., to develop mass multiplication techniques that can then be transferred to Guam.

Initial experiments to evaluate floating row cover on head cabbage indicated that, although the row cover protected the cabbage from insect attacks, it slowed plant growth.



Forestry

Reproduction of Trees in the Limestone Forest of Guam

I. Schreiner

It has been suggested that a number of trees found in the forests of Guam are rarely observed to reproduce. It is thought that high populations of deer and pigs, especially on the military bases, may contribute to lack of reproduction through their browsing and rooting activities. In order to begin studying this phenomenon, first those species of trees not producing young trees must be identified. A study was begun to determine incidence of various size classes of trees. The species surveyed were *Macaranga thompsonii* and *Elaeocarpus joga*, which are both species endemic to the Marianas, and *Tristiropsis obtusifolia*. Surveys were done by measuring the diameter at breast height of 50 trees in an area. In order to determine whether young trees were being missed by this method, two 100-square-meter quadrants in the same area were also measured out, and all trees within the quadrant were sampled. For both *Macaranga* and *Tristiropsis*, trees with a diameter of less than 10 cm were common. Numerous seedlings of *Macaranga* were found at one site, and of *Tristiropsis* at three sites. Forty

seedlings at each site were tagged and will be followed to determine mortality and causes, if possible.

Though uncommon, young *E. joga* were found at one site. Some of the trees of small diameter were observed to be suckers of the roots of larger trees, although this was not determined to be the case for all those observed. Seedlings were not noted. For all three species, small trees were less common at sites sampled on Andersen AFB than sites off-base.

An additional study was begun on the Guam endangered species, *Heritiera longipetiolata*. Given that the species prefers extreme karst landscapes as a habitat, a population was located in a moderately accessible location. A number of seedlings were present; these were tagged so that mortality can be assessed in the future. Branch tips of older trees have also been tagged in order to follow the leafing and fruiting phenology.

Micro-propagation of Ifil and Flame Tree

M. Marutani, J. Entilla and E. Manalastas

The first study on *in-vitro* propagation of ifil, *Intsia bijuga* (Colebr.) O. Kuntze, and flame tree, *Delonix regia* (Boj.) Raf., was done to identify suitable explants and

growth medium for the initial stage of tissue culture. Preliminary observations of *I. bijuga* indicated enlargement of an embryo in White's solid medium. A young stem segment or petiole placed in half-strength Murashige-Skoog liquid medium induced swelling of (tissue) cut surfaces. Due to the unavailability of ifil seeds, petioles and young leaves with midrib were tested as explants on McCown's media + polyvinyl pyrrolidone (PVPP) with three combinations of 6-benzylaminopurine (BA) and naphthalene acetic acid (NAA) (mixture concentrations in mg/l of BA:NAA were 1:6, 1:8 and 2:6). Nearly all petioles in the three treatments showed swelling of cut surfaces, whereas young leaf tissues with a midrib responded to the higher concentration of growth regulators. In the second experiment, petioles were used as explants in media with combinations of BA and NAA in McCown's media plus PVPP. BA concentrations were 0, 0.5, 1.0 and 2.0 mg/l. NAA ranged from 0 to 6 and 8 mg/l. No callus formation was observed in any treatments; however, swelling of tissues was observed. Studies on the use of higher concentrations of PVPP as an antioxidant to remove phenolics produced by explants, or studies on other antioxidants and adsorbents, are needed for a successful tissue culture of ifil tree.

For *D. regia*, young rachis and petioles were used as explants. The same media and combination of growth hormones (BA and NAA) mentioned above, were tested. Unlike ifil tree, callus was formed with higher concentrations of growth regulators, and plant tissues responded especially well to higher concentrations of NAA (6 and 8 mg/l).



Horticulture — Fruits

Starfruit Trees are Highly Adapted to Various Light Conditions

T. E. Marler

The starfruit, or carambola (*Averrhoa carambola* L.), is a common fruit tree in the yards of Guam. A study was conducted with this species to determine how well it adapts to various levels of sunlight. Trees growing under heavy shade developed leaflets that were larger in area but thinner than those exposed to full sun. In addition, the branches of shaded trees grew in a horizontal direction rather than an upright direction, as was the case in full sun trees. Trees growing in full sun responded to high light conditions with increased leaf area per unit canopy area, increased stomatal density, and other common forms of adaptation. The full sun plants also exhibited an ability to move their leaflets in order to minimize exposure to the midday sunlight.

Several physiological adaptations occurred in heavily shaded trees. The leaflets of these trees exhibited reduced dark respiration and light compensation point. These plants were much more efficient than full sun plants in using very low levels of light. Measurements of chlorophyll fluorescence indicated that, when compared with full sun plants, shaded plants were able to use a higher percentage of the energy absorbed from sunlight for beneficial processes.

The numerous physiological and morphological adaptations that starfruit trees exhibited in the two extremes of heavy shade or full sun indicated that this species is highly adapted to various light conditions. Among the tropical fruit species, starfruit trees could be expected to grow and develop well in either shady or sunny locations.



Introduction of Woody Perennial Fruits to Guam

A major accomplishment for the advancement of tropical fruit culture on Guam has been the introduction of more than 75 high-quality selections of various woody perennial tropical fruits during 1993. Among this group are 15 new selections of mango (*Mangifera indica* L.). The selection criteria for determining these introductions were the ability to flower erratically throughout the year in other climates, and an apparent resistance to anthracnose. Field planting of these mango trees will determine their potential for consistent flowering in the lowland tropical climate of Guam and their ability to withstand the pressure of anthracnose under the favorable conditions of heavy rainfall and high humidity.

Also introduced were four commercial selections of starfruit (*Averrhoa carambola* L.). These selections have proven to be heavy bearers of high quality, sweet fruit in other geographic regions.

Avocado (*Persea americana* Mill.) selections were also introduced. The selection criteria for avocado were season of maturity. Many high quality avocado trees are being grown on Guam, but the majority of the fruit becomes mature during a short time period. Introduced selections are being grown in the field to determine if the period of fruit maturity will allow the production of avocado for an extended period throughout the year.

These introductions will be used to expand field plantings on the Yigo, Inarajan and Ija Agricultural Experiment Stations. Long-term evaluation will be used to determine the potential for growing these various woody perennial fruits under the soil and climatic conditions of Guam.

Horticulture — Ornamentals

Growing Orchids

J. McConnell

Vanda cultivars were grown to first flower in two-inch pots with no medium. The pots were affixed to fencing which was mounted vertically to posts. Dendrobium were grown in two-inch pots with 1/4-inch crushed limestone aggregate. Peak flowering for various dendrobium hybrids was November through January. Sprinkler irrigation was directed toward the pots. Irrigation water was kept away from the flowers due to the heavy calcium deposits in tap water.

Dendrobium cultivars were compared for floral characteristics using image analysis. Flowers are digitized either by Photo CDs or video. The computer software used allowed measurements of the total area, petal and sepal width, petal roundness, petal and sepal length. Degrees of petal and sepal curling can be estimated by comparing the area of a flattened, spread flower with the same flower digitized with its natural curl.

Turf Grass Fertilization

M.D. Hamilton, F.J. Cruz and J. McConnell

Sixty pots, simulating golfing greens, were used for fertilizer performance trials. The following fertilizers were applied as a single three-month dose at a rate of one lb/1000ft²/month to established bermuda grass: 1. Urea (46-0-0); 2. IBDU (31-0-0); 3. Ammonium Nitrate (21-0-0); 4. Sulfur Coated Urea (37-0-0); 5. Nitroform Urea (38-0-0) and 6. Nutralene (40-0-0).

The turf was visually rated. Leachate was also sampled to compare levels of nitrate present. Leachate was measured to determine what fertilizer level passes through the grass without being absorbed. IBDU, Nutralene, and SCU had nitrate levels of 40.6, 23.2 and 17.0 ppm, respectively, during peak leaching periods. IBDU treatments had the highest levels four weeks after application, while



turf treated with Nutralene and SCU peaked at two weeks after application. Turf quality began to diminish approximately six weeks after the experiment began.

Levels of ammonium nitrate application were compared to determine which application rate of this water soluble fertilizer results in leachate with elevated nitrate levels. Ammonium nitrate was applied at 6, 4, 2, 1, 1.5, 0.5, 0.375 and 0.25 lbs/1000ft²/month. It was found that rates of six and four lbs/1000ft²/month resulted in leachate nitrate levels of 38.2 and 42.7 ppm NO₃⁻-N, respectively. The lower rates had leachate nitrate of 9 ppm or less. The rate of two lbs/1000ft²/month appeared to produce the highest quality turf with minimal nitrate leaching (< 1 ppm).

Insect problems continued to be a significant problem in the maintenance of quality turf grass. The major pests included armyworms, sod webworms and ants.

Print on Demand System for Disseminating Agricultural Information

J. McConnell

The common approach to producing and disseminating agricultural extension and educa-

tional materials often requires printing large numbers of copies at once using commercial printers. This method frequently results in more copies of publications being produced than are needed. There are also delays to disseminating the information while the publication is printed. Also, storage can be a problem when fact sheets are produced in bulk. The combination of storage problems and budgetary restraints limit the number of different information flyers that can be produced.

A system for the fast production of flyers or fact sheets by using a Print on Demand (POD) system was developed. A basic POD system consists of a computer, hard disk storage, a CD drive and a printer. While any printer can be used, a color printer has been found to be the most effective. Documents such as fact sheets can be produced utilizing video captured images, images scanned from slides and images digitized on photo CDs. The fact sheets can be produced by combining text files and high-resolution color pictures. These files can be stored on hard-disk drives and would be available to be printed on demand as needed. Information can easily be updated, as needed, avoiding the waste of commercially printed materials that become obsolete when modifications are needed. The POD system allows efficient production of publications. A specific fact sheet can be loaded from disk and customized for a specific use.

Horticulture — Vegetables

Improvement of Plant Development and Yield of Solanaceous Crops in Guam

M. Marutani and E. Manalastas

Based on results of a 1992 experiment, 10 tomato (*Lycopersicon esculentum* L.) cultivars and breeding lines were evaluated in a randomized block design with three replications. The study was conducted at a field in Talofofo infested with bacterial wilt (BW). Tested plants included commercial cultivars 'Dynamo,' 'Solar Set,' 'N-52,' 'King Kong,' 'Vanguard' and AVRDC breeding lines of FMTT 22, FMTT 138, FMTT268, FMTT 269 and FMTT 301. Except for 'Solar Set' and 'N-52,' all germplines have been bred for bacterial-wilt resistance.

After transplanting, the percentage of wilting plants was recorded on June 1 (at flowering stage) and June 7, 1993. Harvest yield was taken from June 30 to July 26, 1993. Resistance was found in 'Dynamo,' 'King Kong,' 'FMTT 268,' 'FMTT269,' 'FMTT 301' and 'FMTT 138'. The most susceptible lines were 'N-52,' 'Solar Set' and 'FMTT 22'. Top marketable yields were produced by 'FMTT 268' (1.4 kg/plant), followed by 'FMTT 269' (1.2 kg/plant) and 'FMTT 301' (0.8 kg/plant). Although 'Vanguard' showed a slight

resistance to BW, marketable yield was very low due to fruit cracking problems. The isolated bacterium *Pseudomonas solanacearum*, from 'N-52,' was identified by G.C. Wall as race 1 biotype 3.

Six eggplant (*Solanum melongena* L.) cultivars, planted in calcareous soils, were evaluated in a randomized block design with three replications. Seedlings were transplanted to the field on February 10, 1993 and harvest data were taken from March 24 to October 1, 1993. Two 'Nitta' hybrids, 'Nitta' x 'Waimanalo' (13.5 kg/plant) and 'Nitta' x 'Molokai' (12.4 kg/plant), exceeded the production of the other four cultivars: 'Large Fruited No.29' (6.9 kg/plant), 'Farmer's Long' (4.4 kg/plant), 'Pingtung' (3.3 kg/plant) and 'Long John' (2.7 kg/plant).

Seed production of the two hybrids is being attempted for local distribution.

Evaluation of Tropical Legumes as Green Manure in Vegetable Production on Guam

A survey of indigenous rhizobia populations in Guam was conducted by the most probable number (MPN) method. Soil samples were taken from eight villages: Yigo, Dededo, Barrigada, Yona, Talofofo, Inarajan, Ija and

Merizo. The study indicated that, during the wet season, soils from Yigo had a higher population of *Rhizobium* spp. than *Bradyrhizobium* spp. This is in contrast to the soil sample from Merizo, which had more *Bradyrhizobium* spp. In general, soil samples from each site revealed a dominant occurrence of either *Rhizobium* or *Bradyrhizobium*.

The decomposition rate of *Crotalaria juncea* L. was examined. Cut pieces of leaves and stems (150 g) were placed in 20 cm x 25 cm flat bags of nylon-fabric mesh and buried in the plow layer of the soil at three different sites, each site representing a different soil type. Starting November 3, 1993, sample bags were removed every two weeks from the soil, and fresh as well as dried weights of remaining residues were recorded. The original weight of dried plant tissues was 47.6 g. At all three locations, within two weeks after being buried in soils, leaf tissues decomposed very rapidly to about 33 g dried weight. In the 12th week, the dried weight of remaining materials was reduced to 14.8 g (Barrigada) and 18.6 g (Yigo and Ija), leaving only stems. The decomposition was slightly faster in Barrigada than Yigo and Ija. The total nitrogen of the remaining dried tissues is being analyzed to find the rate of nitrogen mineralization.



Nutrition



adequacy. This questionnaire will be specifically designed for children living on Guam.

Development of a Culturally Appropriate Diet Assessment Instrument for Children on Guam

R.S. Pobocik

No information is available about the diet and eating habits of children on Guam. Furthermore, there is no quick and easy method of determining dietary adequacy for these children. In order to address both of these issues, a study was initiated with the Guam Department of Education. Permission was granted to conduct this nutrition research in the island's public schools with fifth-grade students. The first phase of the study was to collect a one-day diet record from students during the rainy season. Fifteen of the eligible schools (75%), totalling 69 fifth grade classes, participated in the first phase. Schools were selected from every village and included students from all ethnic groups.

Orientation meetings were held for school principals, who were uniformly supportive of the nutrition research. Regional training sessions were conducted for school nurses and fifth-grade teachers. The training prepared teachers and nurses to instruct students on how to complete a 24-hour food record, including lessons

on food descriptions and quantification. Food record forms and protocols were developed, pilot tested and then revised. Briefly, a food record is a list of food and beverages consumed, recording the amounts. The records are kept for one day, with students recording the food as soon as it is eaten. This method is more accurate than remembering what was eaten and recording it later. Quantification, or estimating portion size, was done by using two-dimensional food models from the Food Intake Analysis System[®] (FIAS). The food records are currently being tallied, and the data will be entered into a computer for nutrient analysis. The food-record collection will be repeated in the dry season.

Results of the food record will provide a description of foods eaten by children on Guam, as well as an estimate of the nutrients provided from these foods. To assist with nutrient analysis, 67 traditional local recipes have been identified and added to the FIAS data base. Commonly eaten food items not in the data base are being identified and will be added as the research progresses. For the second phase of this study, a questionnaire will be developed from the nutrient information, to be used to determine dietary

Plant Pathology

Biological Suppression of Soil-borne Plant Pathogens

G.C. Wall

Work continues on finding bacteriophage specific for *Pseudomonas solanacearum* local isolates (the bacterial wilt pathogen). Also, comparison of local bacterial isolates is being made through the use of Biolog GN plates, which allow the comparison of bacterial cultures by their utilization of 95 different carbon sources. So far, two different isolates have been found in southern locations, both capable of infecting tomato, pepper and eggplant. One isolate can utilize nine more carbon sources than the other, including D-sorbitol and D-mannitol, which makes the one similar to Hayward's biotype 2 and the other like biotype 3.

What this means in terms of field planting is that we may need different sources of resistance for these different bacterial isolates. Any tomato or other solanaceous plants that are supposedly resistant to bacterial wilt elsewhere, need to be tested in various locations here.

Identification of Economically Important Diseases of Cucurbit Crops on Guam and Development of Strategies for their Control

Seeds were harvested from blotched watermelon and have been stored at 5°C for the past year. Upon germination, these year-old seeds were still affected by the fruit blotch bacterium. Fruit blotch continues to show up in growers' fields. In the Dandan area where it previously occurred, the fruit blotch appears from time to time, depending on favorable weather conditions (wind and rain). Therefore, it is important to practice crop rotation to control this seed-borne bacterial disease of watermelon and other cucurbits. Rotations should avoid cucurbit crops in infested fields for 3 years.

An important disease of

zucchini squash, powdery mildew, was effectively controlled by weekly sprays of Sunspray plus sodium bicarbonate or baking soda (1% and 0.5 % w/v, respectively). Experiments carried out on campus using the same spray treatment during the dry season resulted in excellent control of ZYMV, an aphid-borne virus disease. This treatment was tried again at the Radio Barrigada Experiment Station in a larger field under natural, heavy inoculum pressure during the rainy season. However, control of PRV-w, another aphidborne, non-persistent virus, was unsatisfactory. Yet, powdery mildew was controlled quite effectively in this trial.

For crops which have no genetic resistance to powdery mildew, like zucchini squash, the recommended control is Sunspray plus baking soda, at the rates indicated above.

Development and Evaluation of Effective Control Techniques for the Papaya Ringspot Disease on Guam

G.C. Wall, L.S. Yudin, S.A. Ferreira and D. Gonsalves

Papaya seedlings that were cross-protected with the mild strain of ringspot virus (PRV HA-5-1) were challenged or inoculated with the severe strain of PRV-p that occurs on Guam. These were then compared to unprotected and healthy controls, which were also challenged, and to cross-protected, unchallenged controls. The mosaic reaction of the seedlings one month later was visually rated for severity. Cross-protected, challenged seedlings rated intermediate between the milder reaction of the cross-protected, unchallenged controls and the severe reaction of the unprotected, challenged ones. Chlorophyll content (measured with a Minolta SPAD meter) of the test seedlings was no different from the cross-protected, unchallenged controls and intermediate between healthy and unprotected, challenged controls. Plant height

and stem diameter was also found to be intermediate, no different from the cross-protected, unchallenged controls.

Final results of this study require field observations, which are still not concluded. So far, however, it looks like cross-protection with the mild strain of PRV may work satisfactorily under low-disease pressure.

Control of Important Viral Diseases of Cucurbits in the American Pacific Islands

G.C. Wall, L.S. Yudin, and J.J. Cho

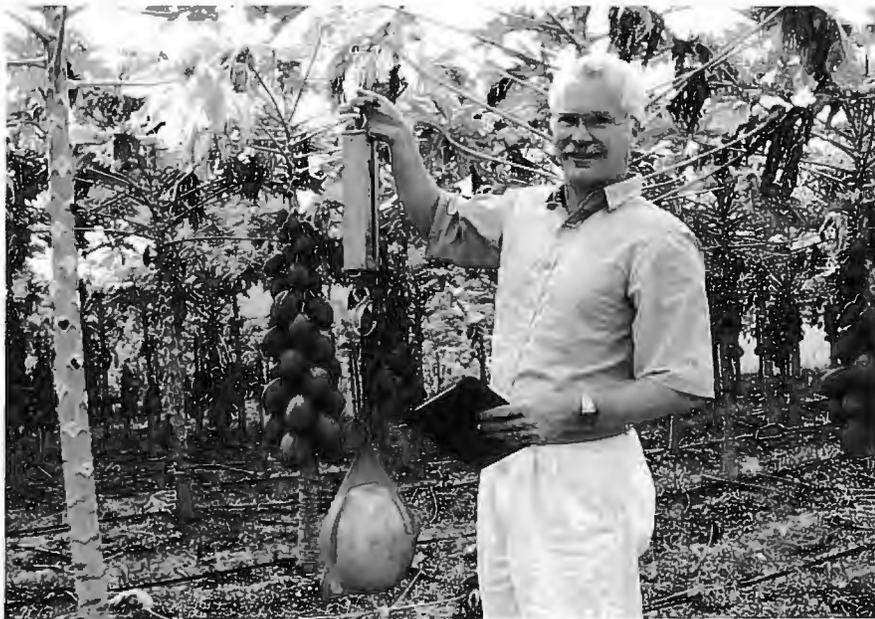
A research assistant has been hired to carry out the field work on viral diseases of cucurbits on Guam. Permits have been obtained from USDA and from the Guam Department of Agriculture for the introduction of a mild strain of zucchini yellow mosaic virus, ZYMV (ZYMV-wk), from the French Institute of Agricultural Research (INRA), and a mild strain of papaya ringspot mosaic virus-papaya strain, PRV-p (HA-5-1), from Cornell University. We have already obtained the mild PRV-p from Cornell; the ZYMV-wk has not been received yet. The mild strain of PRV-p is being kept on papaya seedlings in aphid-proof cages.

A mild strain of papaya ringspot virus-watermelon strain, PRV-w, has already been identified in Maui, HA. This mild strain will be inoculated onto watermelon, melon and zucchini plants, then challenge-inoculated as above.

Epidemiology of Virus Diseases on Watermelon in the Mariana Islands

G.C. Wall

Watermelon plots mechanically inoculated with PRV-w, the most common cucurbit virus on island, were compared with healthy plots to determine the amount of yield loss caused by this virus. The experiment was carried out in Radio Barrigada. One treatment was inoculated with the virus when



seedlings were transplanted to the field. Another treatment was inoculated two weeks later, when the vines were 25 centimeters long (10 in). A third treatment was inoculated with the virus when female flowers first appeared. Control plots were not inoculated with the virus. The entire experiment was protected against aphids and other insect pests with floating crop covers. The covers were removed when female flowers were present, to allow bees into the plots to pollinate the flowers. The covers were left off afterward to avoid trapping insect pests that could cause damage to plants under the covers.

The highest watermelon yields came from the healthy plots, which produced 50.5 T/ha (22.9 tons per acre). The average yield of the virus-infected plots was 34.5 T/ha (15.6 tons per acre), only 68% of the healthy. In other words, the virus disease reduced yields by an average of 32% (almost one third) when plants were infected before flowering. In monetary terms, at current watermelon retail prices, the virus reduced profits by some \$14,600 per acre.

The use of floating crop covers proved to be quite profitable, both because they prevented the watermelon crop from infection by

viruses carried by aphids, and because they protect against a number of other insect pests, including the cucumber beetle, leaf miners, spider mites and various worms. Not only does the crop not suffer damage from these pests, but the farmer doesn't have to spray it. An economic comparison of the benefits derived from these crop covers, compared to using pesticides, resulted in a net profit of \$33,600 per ha (\$13,603.24 per acre), in favor of the crop covers.

Plant Virus Distribution

D.E. Ullman, J.J. Cho, G.C. Wall and L.S. Yudin

A new technique was developed for detecting plant viruses. The technique, called NCM-ELISA, permits the legal transportation of plant samples from remote locations to a central lab for analysis. It is based on the use of nitrocellulose membrane (NCM) and specific antisera of the viruses to be assayed. Samples are collected in the field, then their sap is blotted onto NCM and allowed to dry. The immobilized plant sap no longer presents a quarantine problem and can be shipped through the mail, or can be hand-carried on international flights.

Using this technique, the Commonwealth of the Northern Mariana Islands and the Federated States of Micronesia were surveyed, focusing on cucurbit crops. Results of the survey showed that the most prevalent viruses on cucurbit crops and weeds are Zucchini Yellow Mosaic Virus (ZYMV) and Papaya Ringspot Virus, watermelon strain (PRV-w). This information gives cucurbit growers in the Pacific region an opportunity to select the proper cultivars before they purchase seeds. Selection of cultivars with resistance to these two viral diseases will ensure growers have fewer problems with these important pests, which can considerably reduce their yields (see report on epidemiology).

A workshop for the Pacific region was organized and held at UOG in January 1993. Nearly 20 participants from the CNMI, Guam, the FSM and Samoa attended. They learned, hands-on, how to use the newly developed technique of NCM-ELISA for detecting plant viruses and took survey kits home for future use.

Plant Disease Database

G.C. Wall and J. McConnell

A database containing nearly 1,000 records of tropical plant diseases, with the capability of matching written records with digitized photographs, was developed. Some 50 photos have been digitized and incorporated into the database.

Each record contains the following information:

- Host scientific name (that is, the latin name of the diseased plant)
- Host common name
- Name of the disease
- Name of the pathogen, or causal agent
- Type of pathogen (whether it is a fungus, bacterium, virus, etc.)
- The source from which the information was obtained
- Distribution of the disease, as reported in the literature

- Diagnostic symptoms
- Control recommendations.

The database is formatted for a Macintosh™ system. The program is compatible with a remote-operating program called Timbuktu, which allows anyone with another copy of this remote-operating program and Appletalk Remote Access to contact the host computer at CALS/AES via a 9600-baud telephone modem, log in and operate the database. The database can be viewed, including the digitized photographs of disease symptoms. A print queue allows users to request a color print-out of fact sheets for each record requested. These can then be mailed to the user.

Projects

HATCH PROJECTS

- General administration of federal research grants - R. Muniappan
- Developing pest management systems for vegetables compatible with *Liriomyza* management - I. Schreiner
- Diseases on cucurbit crops on Guam and development of strategies for their control - G. Wall
- Development of cultural, chemical and biological control methods for pests of cruciferous crops on Guam - R. Muniappan
- Use of locally available feedstuffs and potential feed sources on Guam for poultry feeding - F. Abawi
- Small land-holders of Guam: Production analysis and risk-avoiding behaviors - J. Brown
- Evaluating alley cropping for low-input sustainable head cabbage production on Guam - J. Demeterio
- Development of cultural methods for Vandas and Dendrobiums in Guam - J. McConnell
- Improvement of plant development and yield of solanaceous crops on Guam - M. Marutani
- Introduction and evaluation of cultivars and rootstocks of woody perennial fruits on Guam - T. Marler
- Development of a culturally appropriate diet assessment instrument for children on Guam - R. Pobocik
- Balanced N & K fertilization through drip irrigation systems on cucumbers - J. Cruz
- Biological control of bean fly and pod borer on Guam - D. Nafus

ADAP PROJECTS

- Dietary Guidelines - R.S. Pobocik
- Diet Assessment - R.S. Pobocik and J. Brown
- Agroforestry Training - F. Cruz, T. Marler and R. Wescom

REGIONAL RESEARCH PROJECTS

- Micro-irrigation for optimum crop productivity and minimum groundwater contamination - P. Singh
- Biological suppression of soilborne plant pathogens - G. Wall
- Biological control in pest management systems of plant - D. Nafus
- Regional research coordination - C.T. Lee and R. Muniappan

SECTION 406 PROJECTS

- Effect of insect induced changes in the Siam weed on three trophic levels - R. Muniappan
- Evaluation of processing indigenous feeds as substitute for imported poultry feed - F.G. Abawi
- Development and evaluation of effective control techniques for the papaya ringspot - G.C. Wall, L.S. Yudin & S.A. Ferreria
- Turf grass fertilization in Guam - J. McConnell and F.Cruz.
- Evaluation of tropical legumes as green manures in vegetable production on Guam - M. Marutani
- Dynamics of root growth, water uptake and automation of micro-irrigation scheduling - P. Singh
- Control of pumpkin beetles, *Aulacophora similis*, by techniques using little or no insecticide - D. Nafus
- Development of diamondback moth and cutworm management program for head cabbage - R. Muniappan
- The papaya root system - characterizing for optimum cultural management - T. Marler
- Control of important viral diseases of cucurbits in the American Pacific Islands - G. Wall, L.S. Yudin and J.J. Cho

MCINTIRE-STENNIS PROJECTS

- Causes of failure of regeneration of native trees in limestone forests of Guam - I. Schreiner
- Control of the poinciana looper on Guam - D. Nafus
- Nitrogen fertilization of ironwood and mahogany trees used as wind-breaks on Guam - T. Marler
- Micropropagation of two tropical leguminous trees in the Mariana Islands - M. Marutani

NAPIAP

- Screening pesticides against pests of head cabbage crop on Guam - R. Muniappan

OTHER GRANTS

- Protecting Guam's cultural and biological resource - the ifit tree - T. Marler

Center for Tropical and Subtropical Aquaculture.

- Aquaculture marketing assistance for Guam - D. Crisostomo, J. Barcinas and J. Brown

Pacific Aquaculture Association

- Commercial sponge market promotion - R. Croft and J. Brownz

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Off-Island Conferences and Meetings

Abawi, F.G.	Annual Mtg., Poultry Science Assoc. Michigan July 26-29, 1993	Muniappan, R.	Western Directors Mtg. Wyoming July 5-9, 1993
Brown, J.W.	Annual Meeting, ASHS. Tennessee July 24-29, 1993	Muniappan, R.	Agricultural Development in Micronesia. Saipan June 10-12, 1993
Brown, J.W.	Pacific Science InterCongress. Okinawa, Japan June 28-July 2, 1993	Nafus, D.	Pacific Science InterCongress. Okinawa, Japan June 28-July 3, 1993
Brown, J.W.	Tech. Comm. Center for Tropical Aquaculture. Honolulu, HA. April 17-20, 1993	Pobocik, R.S.	Consumer and Family Sciences Articulation Meetings Hawaii March 8-11, 1993
Brown, J.W.	Presentation at the International Symposium on the Socioeconomics of Aquaculture Taiwan Dec. 11-17, 1993	Pobocik, R.S.	ADAP Extension Convocation Hawaii April 26-28, 1993
Marler, T.E.	Fairchild Tropical Garden Miami, FL Jan. 6, 1993	Pobocik, R.S.	USDA-ES Nutrition Special Projects Mtg Washington D.C. July 29, 1993
Marler, T.E.	Tropical Flowering Tree Society. Miami, FL Jan. 11, 1993	Pobocik, R.S.	American Dietetic Assoc. Annual Mtg. Anaheim, CA. October 25-28, 1993
Marler, T.E.	Annual Meeting, ASHS. Tennessee July 29, 1993	Schreiner, I.	Pacific Science InterCongress. Okinawa, Japan June 28 - July 3, 1993
Marutani, M.	Sakata Seed Co. Japan July 19, 1993	Singh, P.	CBAG/BAG Workshop on Sustainable Agriculture Planning Comm. Mtg. Atlanta, GA. January 22-23, 1993
Marutani, M.	Takii Seed Co. Japan July 20, 1993	Singh, P.	W-128 & S-247 Annual Technical Committee Meeting Bradenton April 28-May 1, 1993
McConnell, J.	Pacific Science InterCongress. Okinawa, Japan June 28-July 3, 1993	Singh, P.	Science & Sustainability Conference & CBAG/BAG Workshop on Sustainable Agriculture Planning Committee Mtg. Bellevue, WA. Oct. 24-26, 1993
McConnell, J.	Annual Meeting, ASHS Tennessee July 24-29, 1993	Singh, P.	W-128 Annual Technical Committee Mtg. San Diego, CA Oct. 28-30, 1993
McConnell, J.	Soil Testing & Plant Analysis Symposium Washington August 14-19, 1993	Singh, P.	International Irrigation Association Exposition & Technical Conference San Diego, CA Oct. 31- Nov. 3, 1993
McConnell, J.	ADAP/SPC Database Workshop Fiji September 23-October 4, 1993	Wall, G.C.	Int'l Taro Blight Conference. Western Samoa Nov. 26-29, 1993
Muniappan, R.	3rd International Workshop on <i>Chromolaena o.</i> Cote d'Ivoire Nov. 15-19, 1993	Wall, G.C.	American Phytopathological Society, Caribbean Division El Salvador Sept. 28-29, 1993
Muniappan, R.	Sustainable Farming and Environment Workshop. India April 28-30, 1993		

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