Guam
AGRICULTURAL EXPERIMENT STATION

1990 ANNUAL REPORT

College of Agriculture and Life Sciences, University of Guam

ABOUT THE COVER

Okra alley cropped with
Leucaena Leucocephala
at the Inarajan Agricultural
Experiment Farm.
Photos by Lucyann Kerry

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Director's Message

In 1990, the Agricultural Experiment Station hosted the Spring Meeting of the Directors of the Western Agricultural Experiment Stations, workshop of the Entomology Committee of the Pacific Science Association and the workshop of the Plant Protection Task Force of the Agricultural Development in the American Pacific. Most of the research projects were supported by Hatch, Tropical and Subtropical Agricultural Research Program of the Special Grants, Agricultural Development in the American Pacific and the local government.

Research programs in soils, agricultural engineering, agricultural economics, horticulture, entomology, plant pathology and animal science were strengthened. Collaborative research programs with Western Land Grant Universities, South Pacific Commission and International Agricultural Research Institutes were developed.

Most of the research projects were applied in nature aimed to benefit the public in Guam, Micronesia and the tropical parts of the world.

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Small Landholders on Guam: Production Analysis and Risk- Avoiding Behaviors
J. Brown

During 1990, the major emphasis under this project was a study of the potential of hydroponic farming of greenhouse tomatoes on Guam. Hydroponic cultivation of tomatoes, lettuce and cucumbers continues to have substantial interest among investors on Guam despite its poor history of success here. We identified twelve attempts to develop a hydroponic operation on Guam over the past twenty-five years and attempted to identify the primary reason for their failures. These included:

- Low yield:
- Low prices;
- Lack of cash reserves and insufficient cash flow;
- High start-up costs;
- Labor shortages;
- Maintaining proper pH and nutrient balances in the solution;
- Pest and disease infestations;
- Destructive high winds/typhoon risk;
- Coral gravel not a viable growing medium;
- Japanese quarantine barriers against imports;
- Need for Guam based hydroponics expertise.

Despite the historical lack of success, it appears that the hydroponic cultivation of tomatoes could be a success, if the yields can be increased to levels somewhat higher than have been achieved so far on Guam. Figure 1 shows the relationship between yield and price and the operating profit of a twenty- thousand square foot hydroponic greenhouse raising tomatoes on Guam. This figure assumes that three crop cycles per year are produced, and it includes no allowance for risks to production such as typhoons. Typhoons and tropical storms have been one of the banes of greenhouse production on Guam. In any randomly chosen month, there is approximately a one percent chance of having a storm with peak gusts of over 105 knots. Based on the assumption that a storm with gusts of over 105 knots would cause damage to the farm of 25 percent of it capital investment and cause the loss of one-third of a year's production, Figure 2 was drawn. It shows the relationship between the initial capital available to the farm and the probability of going bankrupt over a simulated 10-year history. As can be seen from the figure, the better financed that the farm is, the better its chances of survival are over the period.

Guam Orchids as Carry-on Gifts: Targeting the Japanese Tourist Market

In 1990 a small grant was obtained through the Department of Agriculture from the USDA Agricultural Marketing Service. The purpose of this grant is to examine the potential for developing a carry-on market for orchids on Guam.

Since the late 1960's, tourism has been the major growth industry on Guam. Tourism is now the largest sector of Guam's economy, and it is undergoing another rapid expansion. The agricultural sector has not taken advantage of the opportunities presented by the events since World War II. Local agricultural products have not been able to penetrate either the military market or the market supplying the tourist industry, primarily because of insufficient and irregular agricultural supplies and poor quality control.

Japan accounted for 83 percent of all arrivals on Guam in 1989. The Japanese tourist typically obeys a custom called "Omiage" which entails the bringing of presents home for those who gave the tourist a going away present before the trip, "Sebetsu". This obligation to buy presents causes the Japanese tourist spend more than tourists of any other nationality on a per day basis.

Currently, one of the locally grown gifts of choice for the Japanese tourists visiting Hawaii or Southeastern Asia is orchids. The Japanese seem to love orchids. However their preferences may not coincide with the western aesthetic in terms of size, shape, color and maturity of the flowers.

Orchids have the potential to aid in the strengthening of Guam's agricultural sector. However, basic marketing and production studies need to be performed before attempts are made to develop an industry. There are three problems in the developmen of a gift market for orchids on Guam.

The first problem in marketing orchids to the Japanese tourists is simply that we do not know their tastes. It appears that the Japanese prefer light colored orchids with long spikes. Pure white orchids are in demand throughout the year. Dark colored flowers are not well accepted, but red orchids are accepted in the winter . The question of which species and hybrids to concentrate local research effort upon is only partially answered at best in the available literature.

A second problem is marketing. There are several issues to be considered and investigated before undertaking to develop an orchid industry on Guam. First, there is the question of product form. Should the flowers be sold as cut flowers, as live plants or in both forms? Which form will the tourist prefer as a gift?

The third problem is the phytosanitary issues associated with the transport of orchids. These must be resolved before an orchid industry can be built on Guam. The basic question is "what conditions will have to be met before the Japanese government will permit the importation of orchids from Guam?"

The examination of orchid markets has been undertaken infrequently. The European Community market for cut orchids was studied by Storck in 1978, and Alvensleben has reported on the marketing of ASEAN orchids in Western Europe. The export markets for Indian orchids has been examined by Bhattacharjee in 1978, and Arora in 1985. The marketing system for orchids in the Philippines has been studied by Valdellon and Lizarondo in 1983.

We know of no studies of the marketing of cut flowers or whole plants as a carry-on product, nor do we know of any studies on the Japanese markets for orchids. Studies of both aspects of the market will be of interest to all Asian and Pacific orchid producing areas.

Figure 1. Sensivity analysis of operating profit as price and yield varies.

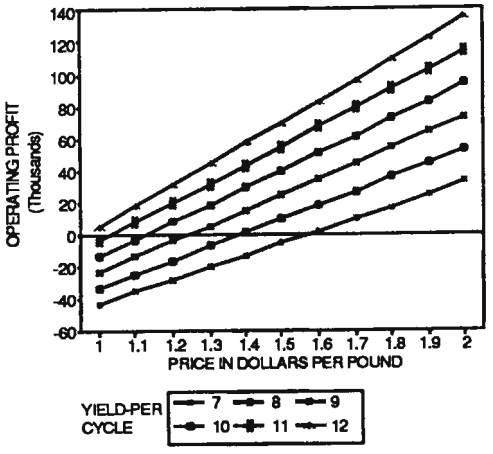
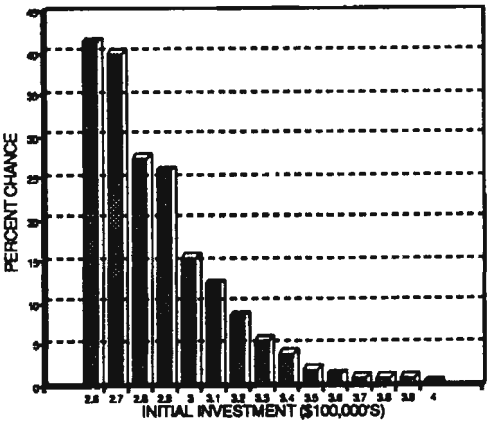


Figure 2. Simulated chance of bankruptcy as a function of the initial investment.



Micro-Irrigation for Optimum Crop Productivity and Minimum Groundwater Contamination

P. Singh, J. A. Cruz and C. T. Lee

Micro-irrigation research approach was re-evaluated during 1990. A shift was made towards automation in irrigation scheduling methods and procedures. It is intended to develop micro-irrigation systems that 1) reduce labor requirement, 2) decrease amount of water used per crop, 3) increase fertilizer use efficiency, 4) minimize ground water contamination by reducing deep seepage, and 5) relieve farmers of having to decide when to irrigate and how much water to apply.

Irrigation is mostly needed during the dry season on Guam. Rainfall is associated with thunderstorm activity. The size of these thunderstorm cells is usually small of the order of 5-10 square kilometers. This results in a patchy spatial rainfall pattern. Application of irrigation scheduling methods based on the concept of potential evapotranspiration and crop coefficients would require extensive weather data network. Automating micro-irrigation systems for irrigation scheduling using soil moisture sensors and control equipment is an attractive, cheaper and operationally efficient alternative. Such a system is ideal for high frequency irrigation and fertigation.

During wet season, high frequency low dosage fertigation can improve fertilizer usage by the crops and reduce chances of groundwater contamination by reducing deep seepage losses that otherwise occur under normal fertilization practices.

By developing automated micro-irrigation systems, we hope to be able to offer systems that aid farmers in increasing vegetable production while reducing resources input in the pacific. It is towards that goal that soil moisture sensors and control equipment was purchased during this year. The automated system was designed and installed at the experimental stations on Guam. Two experiments were conducted to develop the system parameters and to evaluate irrigation water requirements for cucumbers during dry season and high frequency low dosage fertigation effects on head cabbage production during wet season.

Irrigation Requirement of Trellised Cucumbers:

An experiment was conducted to evaluate the irrigation requirement of trellised cucumbers under Guam environmental conditions during the dry season. The experiment was conducted on a Guam clay soil during April through June. The experimental design chosen was latin square because the experimental plot was located in a rolling terrain and two-way fertility gradient was suspected. Cucumber (Cucumis sativus L., Var: Market King) seeds were planted in rows with hills 45 cm apart. Rows were 150 cm apart. Plants were thinned to two per hill. Irrigation was controlled by tensiometers equipped with switching capability which were connected to an irrigation controller and solenoid valves. The tensiometers were installed 15 cm deep and 15 cm away against hills in the vertical direction to the rows. The five treatments were to irrigate when tensiometers reached a soil moisture tension of 5, 10, 25, 45 and 75 centibar (cb) respectively. Irrigation was turned off automatically when irrigation lowered the moisture tension in a tensiometer below the preset value. The treatments were imposed after the crop had established in the field. Fertilizer was applied based on a field representative soil sample test. Phosphorous at the rate of 200 Kg/ha was banded at the time of planting. Potassium at the rate of 200 Kg/ha was

broadcast before planting. Nitrogen was injected into the irrigation water four times during the experiment. A total of 100 Kg/ha nitrogen was applied in the form of urea. Cucumbers were harvested and weighed every other day. Any diseased, deformed or otherwise unmarketable were weighed separately. Size of smallest and largest fruits were also recorded. Pesticides were applied as needed as per recommendations from specialists in the area. The experiment was concluded on June 28, 1990.

The total yield was subjected to statistical analysis. Because of the statistical design, the rows and the columns of the experimental design were treated as treatments. The analysis showed that all the treatments were highly significant. This meant that there were some fertility or other type of gradients in the row and column directions as stipulated in choosing the experimental design. Further investigation revealed organic matter and phosphorous gradients in the row direction based on soil samples analysis. These samples were taken prior to planting. But there was no apparent gradient of these variables in the column direction. The three treatments explained about 94% of the total variance. The irrigation treatment of 10 cb resulted in the highest yield of 0.9 Kg/plant (23,920 Kg/ha) while the 75 cb treatment yielded the lowest at 0.6 Kg/plant (17,760 Kg/ha). Treatment means subjected to Duncan's multiple test showed that yields corresponding to 5, 10, 25 and 45 cb treatments were not significantly different from each other at 5% probability level. One reason for this probably was that the control equipment used could not rigidly control soil moisture tension to the desired levels. This was revealed by the hourly tensiometer readings that were taken during the experiment for monitoring purposes. Irrigating trellised cucumbers at 10 cb appears to be optimum level for maximum yield.

High Frequency Low Dosage Fertigation During Wet Season:

This experiment was conducted in cooperation with Mr. J. A. Cruz during June through August, 1990. The crop, head cabbage, variety: KK Cross, was grown on a newly cleared Guam clay soil field. Complete details of the experiment are reported elsewhere in this annual report. Basic summary is as follows:

The treatments were: Irrigation (10, 25 and 45 cb irrigation),
Nitrogen (0, 60 and 120 Kg/ha)
Potassium (60 and 120 Kg/ha).
The experimental design was a split-split plot design. The crop was transplanted on June 18, 1990 and harvested on August 26, 1990. Irrigation was controlled by tensiometers and control equipment as described in the previous experiment. Nitrogen and potassium were were applied in five split dosses at approximately weekly intervals.

Irrigation treatments were not significantly different from each other. This was as expected because 45 cm of rain occurred during the growth period. One of the important point that came out of this study was that even on this highly permeable and shallow soil nitrogen treatment difference was highly significant. The implication is that during the rainy season high frequency low dosage fertigation increases fertilizer usage by the crop. This is probably achieved because high frequency low dosage fertigation improves chances of fertilizer being taken up by the crop before it is lost to deep seepage by heavy rains.

Use of Locally Available Feedstuffs and Potential Feed Sources on Guam for Poultry Feeding and Evaluation of processing indigenous feeds as substitute for imported feed

F.G. Abawi

A prelimnary study was funded by the USDA Special Grants Program for Tropical and Subtropical Agriculture Research under the Section 406 program. It was designated to conduct economic feasibility analysis and evaluate processing tropical feeds. The emphasis on this report has been on the economics aspects of utilizing local feed sources and potential feeds.

Evaluation of processing tropical feed plants require comparative study with regard to efficiency and cost. This portion of the report is in progress.

Economic Analysis

With the exception of abundant leucaena trees all over the Island which was originally introduced as a soil conservation measure, most other field crops have to compete with cash crops such as lettuce, bell pepper, tomatoes, cucumbers and cabbage before the farmers could consider growing them on a commercial scal'. Two major factors being the limited irrigated acreage and high labor costs on the island.

However, considerable acreage of rain fed marginal land not suitable for cash crops would attract interest of the farmers if they could grow a particular crop in demand with minimal labor and input requirements, cassava, coconuts and leucaena are potential candidates under this category.

Despite Guam's vast limestone deposits, to date none have been used in animal feeds. Even the feed mill on Guam during its years of operation imported ground limestone. A typical layer feed incorporates as much as 8% limestone in the formulation, which could translate into considerable reduction in feed cost if compared to imported limestone.

Our laboratory analysis of samples of three sources of limestone available in commercial quantities is summarized in the following table:

Analysis of Local Limestone*

Source	Ca %	P %	Mg ppm	K ppm	Na ppm	Price $/ton
Imported	33.84	0.02	-	-	0.06	166
Local A	33.75	0.02	1425	50	1171	25
Local B	31.25	0.03	1950	50	1390	25
Local C	28.75	0.02	1575	38	1463	25

•Values are mean of duplicate samples analyzed using atomic absorption spectrophotometry. Phosphorus was determined by colorimetric procedure. Samples were obtained from Hawaiian Rock Company, Guam.

From chemical analysis, it appears that local limestone (Local A) is quite comparable to imported limestone. With this price advantage incorporating local limestone to replace its imported counterpart could significantly reduce layer feed cost.

Cost Analysis

For the purpose of this analysis a 15% crude protein, 2990 Kcal/Kg metabolizzable energy layer feed was used as a reference. The whole sale cost of such a feed ready mix and imported was $413 during the first week of January 1991. If locally available feeds (cost of processing included) together with competitive imported feed ingredients could cost less thant $413 than, it would be economically feasible to substitutue local option for imported mixed feeds.

The feed mill on Guam, before its recent closure, was operating with an annual capacity of 12,000 metric tons per year with an annual production cost of about $320,000 in addition to the ingredients. Based upon the assumption that such an operation could be duplicated, the current costs might be roughly $500,000 per year marketing 5000 tons. This would represent a mixing cost of $100 per ton to be added to the cost of ingredients.

A typical 15% protein, 2800 Kcal/Kg metabolizable energy, 3.75% calcium, 0.94% total phosphorus were set in all the models.

Various limits were placed on leucaena leaf meal, cassava leaf meal and copra meal to minimize bulk and fiber. Fat was limited to 7% maximum. In all formulations 2% was allocated for the premix that would include vitamins, trace minerals, salt, synthetic amino acids, antioxidant, and coccidiostat. The cost of premix is $12 per ton of mixed feed which will be added to the total feed cost.

Since the cost of local leucaena leaf meal and cassava leaf meal are not presently available, they were offered in the formulations to find their $ value based upon their nutrition.

Three sets of least cost formulations are summarized in Tables 1,2, and 3. In each table $ Range/ton indicate the minimum and maximum prices below or above which the formulation will change respectively.

Least cost linear programming was performed based upon the following feed ingredient costs, inputs and sources:

Feed	Source	Cost $/ton	Shipping $/ton	Total $/ton
Yellow Corn	U.S.	228	115	343
Soybean meal(44%)	U.S.	353	115	468
Fish meal (M 60%)	U.S.	555	115	670
Cassava chips	Thailand	73	125	198
Copra meal	Philippines	80	75	-
Leucaena meal	Guam	-	0	-
Limestone	Guam	25	25	-
Dicalcium Phosphate	U.S.	476	115	591
Fat (A&V blend) U.S.		441	115	556
Cassava leaf meal	Guam	-	0	-

Table 1. Least Cost Analysis

Feed	% of mix	$Range/ton low	high
Cassava meal	50.05	61	207
Copra meal	20.00	—	246
Soybean meal	9.11	181	321
Fish meal	8.68	505	557
Limestone	8.06	—	—
Dical phosphate	2.09	646	1190
Premix	2.00	—	—

The abøve formulation costs $231/ton.
The least cost formulation did not consider the following offered ingredients at its current price but would consider if the prices were lower as indicated:

corn	$228
leucaena	$142

In the formulation presented under Table 1, copra meal was restricted to 20% maximum. Corn and leucaena did not enter into the formulation. From this analysis it is apparent that leucaena could be competitively used if it was to cost $142 or less. Under this formulation the total cost of locally mixed feed would be 231 + 100 + 12 = $343 which is $70/ton cheaper than imported mixed feed.

Table 2. Least Cost Analysis

Feed	% of mix	$ Range/ton low	high
Yellow corn	49.51	62	207
Copra meal	30.90	49	246
Limestone	8.18	—	—
Fish meal	7.06	407	990
Dical phosphate	2.36	—	2315
Premix	2.00	—	—

The above formulation costs $223/ton.
The least cost formulation did not consider the following offered ingredients at its current price but would consider if the prices were lower as indicated:

Soybean meal	$171
Cassava meal	$190

In the least cost formulation presented under Table 2, the maximum limit on copra meal was removed. In this formulation soyan meal and cassava were not considered. The total cost of this formulation would be 223 + 100 + 12 = $335 which reflect a cost advantage of $78/ton.

Table 3. Least Cost Analysis

Feed	% of mix	$ Range/ton low	high
Cassava	37.38	157	208
Cassava leaf	10.00	—	129
Copra meal	10.00	—	246
Soybean meal	8.90	312	321
Fish meal	4.75	503	557
Leucaena meal	10.00	—	142
Fat	7.00	—	570
Limestone	6.90	—	—
Dical phosphate	3.12	646	996
Premix	2.00	—	—

The above formulation costs $216/ton.
The least cost formulation did not consider the following offered ingredients at its current price but would consider if the prices were lower as indicated:

Yellow corn	$228

In the least cost formulation presented under Table 3, leucaena leaf was given a hypothetical price of $142/ton derived from formulation 1; a 10% limit was placed on copra meal, leucaena, fish meal and cassava leaf each and 7% limit on fat. The only offerred ingredient which did not enter into the formulation was corn. The total cost under this formulation would be 216 + 100 + 12 = $328/ton which offers a price advantage of $85/ton cheaper than imported mixed feed. This analysis also indicated that cassava leaf meal can competitively enter formulation at a cost of $129/ton or lower.

Conclusion

The economic study evaluating local feeds is by no means complete. Despite the set backs inflicted by typhoon Russ, preliminary results suggest that Guam can benefit from mixing locally available feed resources together with imported competitive ingredients to lower its feed cost at least to the order of $70/ton cheaper than importing mixed feeds. Precautionary limits placed on certain feeds in the analysis, if relaxed, could allow for even cheaper mixes. However, one has to bear in mind that the formulations presented theoretically meet the requirement. Biological studies are essential to test the formulations.

Cassava and copra production under the present circumstances cannot compete with the current prices offered elsewhere. However, usage and improvements in these feeds would have benefits far beyond Guam. Copra is a major source of cash income in the isolated atolls of Micronesia. The benefits could extend to these islanders, and to the other tropical areas of the world.

Aquaculture

Stephen G. Nelson and S. de C. Wilkins

Guam spends over $7 million to import seafood each year and this has provided an incentive for the local government to foster the development of aquaculture. A few farmers have established successful aquaculture operations raising primarily tilapia and milkfish. For both of these species, fry are imported from Taiwan, a situation leading to dependence on foreign supplies and increasing the probability of importing fish diseases and pathogens. Availability of juveniles for stocking has been a constraint to further aquaculture development on Guam. To address this problem the Government of Guam has established a hatchery to produce juveniles for stocking commercial fish farms. Our research project is aimed at providing assistance in reaching this objective.

Among the target species for aquaculture development on Guam are the signanids, commonly referred to as rabbitfishes. These herbivorous marine fishes are popular throughout the Pacific Islands. Our work on larval rearing, to date, has focused on *Siganus argenteus* and a new species of *Siganus* collected from Guam. The former is a popular target of small-scale fisheries within the region, and the latter is a recently discovered species on Guam. Broodstock of another species (*Siganus punctatus*) have been collected and are nearing maturity, at which time they can be spawned for future work with larval rearing.

Fertile eggs can be readily obtained from either of the species we have worked with thus far. The mature fish usually spawn spontaneously on a lunar cycle, but spawning can also be induced by injecting the broodstock with a hormone: human chorionic gonadotropin (HCG). The eggs of *Siganus argenteus* are unique among siganids in that they are freely floating, neutrally buoyant, and possess a single oil globule. Eggs of other siganids are demersal and adhesive; they also contain multiple oil globules.

Spawning usually occurs in the pre-dawn hours, and the eggs hatch from 12 to 15 hours later. The larvae are small and poorly developed at hatching. The eyes are not pigmented and, at this stage, the larvae have no digestive system or mouth. In order to survive while development proceeds after hatching, the larvae rely on their yolk-sac, which includes a single oil globule. This provides the only source of nutrition for the larvae until they are able to begin feeding.

It is the period of transition from dependence on the yolk-sac to exogenous sources of nutrition that we found to be the most critical in rearing siganids. Our initial efforts have focused primarily on this stage and on earlier stages in larval development. We have had the most success with the undescribed species and have reared this species through to metamorphosis. The common species *Siganus argenteus* has, thus far, proven to be problematic. A major focus of our research is determining the sizes and densities of food organisms (rotifers) appropriate to allow a successful transition from yolk-sac to exogenous feeding for each species.

The reasons for the differences between species in regard to the successful culture have not been fully identified. The larvae are similar in size and rats of development. However, from preliminary work, the metabolic rates of the early larvae of *Siganus argenteus* appear higher than those of the undescribed species. Depletion of the yolk-sac before the larvae have developed sufficiently to be able to feed would be detrimental: the larvae would starve. We will be exploring this in greater detail in the coming months.

Reproductive Biology of Three Commercially Valuable Sea Cucumbers

Robert Richmond

Work on the reproductive biology of three commercially valuable sea cucumber species, *Actinopyga mauritiana, Holothuria (Microthele) nobilis,* and *Thelenota ananas* has continued, with concentrated efforts on fertilization processes and larval development.

An experiment on the relationship between distance among individuals and fertilization rate during spawning indicated that eggs up to 6 meters from a source of sperm fertilized at a rate comparable to eggs within a meter of the source. This suggests that there is an attractant in the eggs which the sperm can cue in on. The role of chemical attractants for enhancing fertilization rates in spawning organisms is believed to be important, and these experiments provided the first data on sea cucumbers.

Quarterly samples for gonadal indices and oocyte diameters were continued for the database on the timing of reproduction in the three species, and was consistent with previous years. With these data, it is now possible to predict reproductive readiness with a high degree of accuracy, enabling more efficient experimentation on larval rearing.

Advances were made on the rearing of larvae, which is the ultimate goal of this portion of the research. As in previous trials, spawned eggs could be easily fertilized, while eggs dissected from ripe females could not. The type of capacitation performed by the female is still under investigation.

Larvae have been raised through both the auricularia and doliolaria stages, to settlement, but not through pentacula. In the latest set of experiments, lipid spheres where observed in the late auricularia stage, which seems to be a critical feature for success in other echinoderm species. Lipid spheres were seen in larvae raise in algal concentrations of 100,000 - 1,000,000 cells per ml, which is "green water." The use of UV sterilized seawater has greatly reduced contamination problems, allowing us to cut back on the use of antibiotics. A rotating culture system has also provided a more consistent level of water motion, and the larval surviviorship to late stages has improved substantially.

Biological Control of Siam Weed

R. Muniappan, M. Marutani and J. McConnell

Siam weed (Chromolaena odorata) in Chamorro known as masiksik is an introduced weed. It occupied pastures, roadsides, and vacant lands in Rota, Tinian, Saipan and Guam in early 1980's. However, introduction and establishment of the natural enemy, *Pareuchaetes pseudoinsulata* in these islands in mid 1980's has effectively suppressed this weed.

Currently this weed is a problem in the Philippines, Indonesia, Southern China, Vietnam, Laos, Cambodia, Malaysia, Thailand, Burma, Indian, Sri Lanka, Bangladesh, Bhutan, Nigeria, Ghana, Cameroon, Rwanda, Ivory Coast, Benin, Zaire and South Africa.

Based on the successful control of this weed achieved in the Marianas, the natural enemy *P. pseudoinsulata* has been shipped to Yap, Palau, Pohnpei, Kosrae, Thailand and Ghana. It was also shipped to Germany for research purpose. Requests have been received for shipments to Indonesia and Ivory Coast.

Recently it has been determined that this natural enemy has been established in Pohnpei and Yap.

Siam weed no longer is a serious threat on Guam. However, in the current situation of sparce distribution, it exhibits insect induced changes. *C. odorata* turns yellow upon feeding of *P. pseudoinsulata*. Yellow leaves are not palatable to larvae of *P. pseudoinsulata*. Chemical analysis of yellow leaves showed eight times higher nitrate nitrogen over the green leaves. First instar larvae of *P. pseudoinsulata* kept on yellow leaves did not feed and died eventually.

In normal conditions, *P. pseudoinsulata* larvae feed on *C. odorata* bushes at night and hide in the ground during the day time. However, when *C. odorata* leaves turn yellow, they remain on the foliage both day and night.

Studies on physical and chemical changes during the process of yellowing and the reversion back to green leaves are being studied.

Control of Cabbage Insects

R. Muniappan, M. Marutani and S. Meier

Cruciferous crops on Guam are attached by diamond back moth, *Plutella xylostella* (L.), imported cabbage webworm, *Hellula undalis*, F., cabbage cluster caterpillars, *Crocidolomia pavonana* Zeller, cut-worm *Spodoptera litura* (F.), flea hopper, *Halticus tibialis* (Reuter), corn earworm. *Helicoverpa armigera* (Hubner) leaf miner, *liriomyza* spp, fireant, *Solenopsis geminata* (F.) and garden looper, *Chrysodeixis chalcitens* (Esper).

H. undalis infects the crop throughout the season and especially it becomes a serious pest on young seedlings before and after transplanting in the field. It damages terminal shoots of seedlings resulting into the production of multiple axillary shoots and unmarketable heads. It bores into the midribs of the outer leaves in the older plants and occassionally boring into the head. *P. xylostella* and *C. pavonana* mostly infest the transplanted crop. *P. xylostella* and *H. erysimi* infest during the dry season and *C. pavonana* occurs sporadically on Guam. *S. geminata* is a problem only during the dry season. It damages newly transplanted seedlings. Other pests listed above are polyphagous and opportunistic invaders.

Trap cropping with radish, mustard and Chinese cabbage cv Tempest in the head cabbage field attracted *H. undalis*, *C. pavonana*, *H. tibialis* and *L. erysimi*.

Trap cropping was found to increase predators such as spiders, lady beetles and muddabber wasps in the field. Other parasites observed in the field were *Telenomus* sp on eggs and *Cotesia variventris* on *Spodoptera litura*. Investigations on standardization of the trap cropping procedures, biological control and chemical control are in progress.

Biological Control of *Lantana camara*

R. Muniappan, M. Marutani and T.S. Lali

Surveys conducted in Micronesia revealed the absence of lantana in Rota and Kosrae. A legislation has been introduced in the Commonwealth of the Northern Marianas Legislature to ban introduction of lantana into Rota. A similar legislation has recommended for Kosrae.

Our surveys indicated absence of Uroplata girardi in Tinian. Hence, this natural enemy was introduced to Tinian. Similarly, *Uroplata girardi* and *Teleonomia scrupulosa* were introduced to Yap. The population dynamics of natural enemies of lantana on Guam is being studied. A request for permit to introduce *Calcomyza lantanae* from Australia to Guam has been made.

Biological Control of Fruit Piercing Moth

R. Muniappan, G.R.W. Denton and M. Marutani

The fruit piercing moth, *Othreis fullonia* is a serious pest of fruit crops in the American Pacific. The adult moth feeds on the pulp and juice by piercing with its probosis. The larvae of *O. fullonia* feed on leaves of *Erythrina* sp. The parasites *Trichogramma* sp., *Telenomus* sp. and *Ooencyrtus* sp. attack the eggs of *O. fullonia*.

In addition to *O. fullonia*, the moths of *Platyja umminia, Ercheia dubia* and *Pericyma cruegeri* are recorded as primary fruit piercing moths on Guam. Larvae of *P. cruegeri* feed on leaves of *Deloni x regia*. Larval hosts of *P. umminia* and *E. dubia* on Guam are yet to be identified.

Red Coconut Scale

R. Muniappan and M. Marutani

Surveys conducted in 1990 indicated the spread of the red coconut scale throughout the island. The establishment of the parasite *Adelencyrtus oceanicus* (Encyrtidae), in Guam introduced from Caroline Islands has been confirmed.

A. oceanicus is an effective parasite of the red coconut scale. In 1990, it has established in an area of about 16 sq.km around the release site in the central part of Guam. A predaceous mite, *Pyemotes ventricosus* was observed on red coconut scale in Guam, Chuuk, Kosrae and Majuro.

Biological control of the leucaena psyllid, *Heteropsylla cubana*
Donald Nafus

The predacious lady beetle *Curinus coeruleus* was released to control the psyllid in 1986. It was only found in one release site near the University of Guam until 1989. In 1990 it spread outwards from Mangilao and established in Yona, Agat and other areas in central Guam, but little change was noted in populations of the psyllid during 1989-90. Anthocorids and other predacious bugs were abundant and appeared to be checking populations of the psyllid.

Growth rates of leucaena were compared in the different areas by measuring the change in diameter of the stems at five feet above the surface on 20 trees in each area. The presence of *Curinus coeruleus* did not have any significant impact on growth rates of leucaena. Trees in the area where the lady beetle was most abundant had the lowest growth rates of any of the trees.

Biological control of leafminers, *Liriomyza* sp.
Donald Nafus

In 1985 the parasitic wasp *Ganaspidium utilis* was released to aid in the control of the leafminer *Liriomyza trifolii*. To examine its effectiveness, two experiments were set up with untreated beans. These experiments were monitored to determine the number of leafminers and parasitoids present. The highest weekly populations were slightly over two leafminers per leaf, and the seasonal mean was 0.78 miners per leaf. This level was not high enough to depress yield significantly. *G.utilis* was the dominant parasitoid, attacking about 44% of the leafminers. *Chrysonotomyia formosa* and *Hemiptarsenus semialbiclavus* were second and third in abundance.

A few farmers continue to experience outbreaks of leafminers despite the presence of *G.utilis*. To see if outbreaks were being caused by elimination of the parasitoids by pesticides, yardlong beans were treated with cygon twice weekly regardless of the level of leafminer populations. The treated plots were compared to untreated controls. Leafminer and parasitoid populations were higher than in fields with no pesticides. In addition, there was a shift in the relative dominance of the parasitoid community. This shift in dominance took place in both sprayed plots and untreated ones. *H. semialbiclavus*, which parasitized about 40% of the leafminers in the untreated plots and 55 % in the treated ones, was the most abundant parasitoid. Its populations were similar in treated and untreated plots as was *C. formosa*. Both species probably have some resistance to cygon. *G. utilis* was adversely affected, and declined in the pesticide plots.

In a mixed intercrop of untreated pole beans, yardlong beans, cucumber, pechay, and tomato, *G. utilis* parasitized 40% or more of the leafminers in all crops and was the dominant parasitoid. *L. trifolii* showed distinct host preferences, having the highest densities on *Vigna* beans and a lesser abundance on *Phaseolus*. It was uncommon on pechay, tomato and cucumber.

Biological control of the mango shoot caterpillar, *Penicillaria jocosatrix*
Donald Nafus and Ilse Schreiner

Work on the mango shoot caterpillar was largely finished in 1990. The program had a high degree of success. Both *Euplectrus* sp. and the tachinid *Blepharella lateralis* have persisted, indicating permanent establishment, and they were effective in controlling the noctuid caterpillar *P. jocosatrix*. Caterpillar population levels (0.18 caterpillars per shoot)

were approximately the same as in 1988 (0.16 caterpillars per shoot) and 1989 (0.24 caterpillars per shoot), and continued to be significantly less than pre-release populations (0.80 caterpillars per shoot). Fruit production has been similar over the last three years; 3.3, 1.7, 2.9 fruits per shoot in 1988, 1989, and 1990 respectively. This production was much higher than in the pre-release years, when yields of 0.11 fruits per branch in 1986 and 0.03 fruits in 1987 were obtained.

In 1989-90, mortality of the caterpillars from all parasitoids was ranged from 24 to 98%. *Euplectrus* sp. was the dominant parasitoid, but as in 1988-89, it declined in the wet season and resurged in the drier periods. *B. lateralis* was most abundant during the wet season, but overall did not contribute as much mortality as *Euplectrus* sp.

The geometrid caterpillar *A. illepidaria* continued to be abundant in 1989-90, indicating biological control of the mango shoot caterpillar has had a long term affect on the other species of *Lepidoptera* feeding on young mango leaves. Other species including *Thalassodes* continue to be present at noneconomic levels.

Reduction of Cucumber Pests by Use of Mulches

I. Schreiner, D. Nafus, A. Moore and L. Yudin

An experiment testing a variety of materials as mulch on cucumbers was run. The materials tested were bare ground, black plastic mulch, silver plastic mulch, black plastic mulch painted silver with roofing paint, black plastic mulch painted white, aluminum roofing tile, and cardboard boxes. The effect of these mulches on various insects was measured. The effect on aphid landing rates was measured with small sticky traps attached to the leaves early in the crop cycle. Numbers of adult orange pumpkin beetles, *Aulacophora similis*, and melon worms, *Diaphnia indica*, were measured by counting the number on individual plants or leaves respectively.

The mulch affected aphid landing rates. The more reflective the mulch compared to the bare ground, the less likely the aphids were to land on the plants growing on it. This result has been supported by several other experiments on Guam and in Hawaii. No clear cut effects of mulch type on adult beetle or melon worm populations were observed.

Orange pumpkin beetle larvae were sampled in the soil under the plants that were not mulched and those mulched with black plastic. The number of beetle eggs found was reduced by about a third if mulch was present, and the number of larvae even more, by about two-thirds. Beetle populations were very high in this study. Overall, we estimated there were an average of 406 eggs and 176 larvae within a 30 cm radius of each unmulched plants. In comparison, the number of beetles around the plants mulched with black plastic was significantly lower. We estimated that there were 292 eggs and 55 larvae within a 30 cm radius of these plants. The number of beetle larvae was very high in this experiment, as it was the third unsprayed cucurbit plot planted in the same general area, and beetle populations had built up to very high levels.

Control of Adult Orange Pumpkin Beetle on Watermelons by Spraying only part of the Field

I. Schreiner and D. Nafus

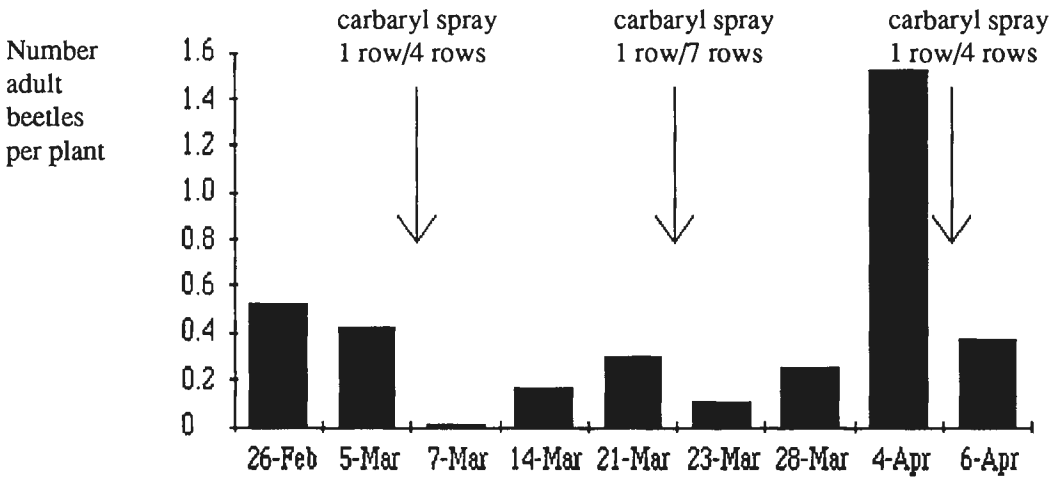
An insecticide experiment run in 1989 had shown that good control of adult orange pumpkin beetles, *Aulacophora similis*, could be obtained even when only half of the field was sprayed with carbaryl. The adults beetles are very mobile and evidently move around from plot to plot enough during one day so that if at least half the field is treated, they are likely to contact the insecticide and die.

In 1990, we performed a second experiment to determine just how small of a portion of a watermelon field needed to be treated to obtain control of the beetle. A field was planted and sprayed on three occasions when the number of beetles was high enough to provide meaningful result. In the first spay test, one out of every four rows was treated, in the second, one out of every seven rows was treated, and in the third test, again one out of every four rows was treated. It was found that spraying one row out of every four resulted in more than 90% reductions in beetle numbers (Figure 1). Spraying one row out of seven also reduced beetle numbers in the whole field, but only by about 60%. The second time one row out of four was treated there was less effective reduction in beetle numbers, but by this time there was emergence of beetles from larvae within the field. Some of these beetles probably emerged after the insecticide was sprayed and so

were not affected. Earlier in the season, all beetles are immigrants into the field.

Granular diazinon applied preplant was tested in both 1989 and 1990 to determine its efficacy against beetle larvae. In both experiments, the number of beetle larvae was higher in the plots treated with insecticide than in the untreated plots, although in neither case was the difference significant. Possibly the insecticide had more effect on ants or other predators which might feed on beetle eggs and larvae than it did on the beetles themselves.

Figure 1. Effect of Partial Insecticide Treatment of Watermelon Field



Alternative Hosts of Orange Pumpkin Beetles
D. Nafus and I. Schreiner

Orange pumpkin beetles, *Aulacophora similis*, seem to be among those pests on Guam which are normally limited in numbers by the difficulty in finding sufficient host material. Normally they are present in fairly low numbers but if a farmer plants cucurbit crop following cucurbit crop, they may build up to very high numbers and cause significant damage. It is important therefore to know what hosts they utilize in the natural environment and if any of the feral cucurbit species may be particularly important in carrying over beetle populations.

A field with various types of cucurbits was planted, and beetle numbers and feeding on the various types of plants was measured. Zucchini attracted the most beetles followed by pumpkin, honeydew, and cantaloupe. Cucumber, pepino, luffa, and bittermelon were not as attractive in the seedling stage. Once the plants developed full-sized leaves, preferences shifted slightly with local pumpkin, zucchini, honeydew and cantaloupe the most favored. Cucumber, pepino, luffa, and watermelon continued to be less attractive hosts. Bittermelon never had any beetles on it . Zucchini had the most feeding sites followed by honeydew, cantaloupe, watermelon, cucumber, and pepino. Pumpkin had slightly less damage. Neither luffa, which consistently had a few beetles on it, or bittermelon, had any feeding damage. Beetle eggs were found in some numbers around zucchini plants, and also occasionally around the various melons and pumpkins.

Wild bittermelon does not serve as a host to maintain orange pumpkin beetle populations and luffa also seems to be unimportant, but it appears that feral pumpkin vines which are common in many locations in Guam may be an important reservoir of beetles. As pumpkins are also known to be very infective sources of zucchini yellows mosaic virus, they should be removed from the vicinity of commercial cucurbit plantings.

Injury Levels of Bean Pests
I. Schreiner

A variety of invertebrate pests attack yard-long beans. Experiments performed over the last several years have been conducted to try and determine which pests have an important effect on yield and at what level they are important. Two pests, pod borers, *Maruca testulalis*, and cowpea aphids, *Aphis craccivora*, are direct pests in that they attack the bean pods and make them unmarketable. Other pests such as bean fly, *Ophiomyia phaseoli*, leafminers, *Liriomyza trifolii*, and also cowpea aphids, do their damage by attacking leaves and stems. The plant may be expected to be able to to compensate for some of this damage.

Experiments were performed by planting yardlong bean fields and dividing them into plots. Several different insecticide treatments were applied in to try to vary the number of the pests among plots. In all three years, leafminers were found to be significantly negatively correlated with yield. That is, the higher the number of mines per leaf, the lower the yield. Bean flies, which attack the petioles of the leaves, had no effect on yield even when half of the leaves in the field were affected. Therefore we feel that in most fields they can safely be ignored once beans are past the seedling stage. Spider mites up to 300 per leaf also had no effect on yield. Aphids were found to have an effect on total yield in only one of the three tests conducted. Their impact on total yield is perhaps more important as vectors of virus diseases. However they also

aggregate on bean pods, disfiguring them, so control may be needed to prevent this from occurring. Bean pod borers did not reduce total yield, but of course, beans with holes in them are not marketable. In all three of the experiments, the untreated plots only suffered about a 10% loss of beans due to pod borers. Some farmers may wish to consider if it is more economical to sort out these damaged beans than to spray twice a week during the whole flowering stage to try to prevent this level of damage.

Biological Characterization of *Pediobius foveolatus*, a Parasite of the Philippine Lady Beetle, *Epilachna viginctisexpunctata*

I. Schreiner and D. Nafus

A parasite currently characterized as *Pediobius foveolatus* was imported to the Marianas from the Philippines in the 1950s to control the Philippine ladybeetle. It was apparently never tested for host specificity. *P. foveolatus* has been extensively tested for specificity to *Epilachna* prior to entry to the United States, but the parasite strain tested there is different as it attacks larvae, and emerges from larval mummies, whereas the one on Guam emerges from pupal mummies. Prior to initiating a program to export the Guam *P. foveolatus* to American Samoa in an attempt to control *Epilachna cucurbitae* there, it was decided that it was necessary to characterize the strain on Guam to be certain that it did not attack beneficial ladybeetle species. Some strains of *P. foveolatus* in India are reported to have been collected from beneficial ladybeetle species.

Individual *P. foveolatus* parasites which emerged from pupae of *Epilachna* on Guam were exposed to various ages of immature *Epilachna* for 24 hour period. Parasites were only able to attack pupae or larvae which moulted to the pupal stage while they were being exposed to the parasite. They were unable to attack younger larvae. This indicates indicates that the Guam *P. foveolatus* are a different biotype or perhaps species than the *P. foveolatus* used to control Mexican bean beetle in the US. A biotype which attacks the larvae is also known to be present on Guam but it is quite rare and has not been found in the field during the course of these experiments.

Because the Guam *P. foveolatus* is different from the US one, checks are being made to determine whether it is specific to *Epilachna* or whether it can also attack beneficial species of ladybeetles. Surveys of the pupae of beneficial ladybeetles are continuing in Guam. To date almost 200 *Menochilus sexmaculatus*, 16 *Cryptolaemus montrouzieri*, 8 *Harmonia arcuata*, 21 *Coelophora inaequalis*, 2 *Chilocorus nigritus* and 1 *Olla v-nigrum* pupae have been field collected and reared. A Eulophid parasite emerged from *M. sexmaculatus*, *H.arcuata* and *C. inaequalis*, but was a species different from *P. foveolatus* and was tentatively identified as *Aprostocetus* sp.

Although it does not appear that the strain of *P. foveolatus* on Guam attacks beneficial species, checking will continue for several months concentrating on the species where only a few pupae have yet been sampled.

Ornamental Horticulture

James McConnell

The emphasis of the ornamental horticulture program has been to evaluate and select specific ornamental plants for their potential development as commercial crops in Guam and to determine the cultural methods for optimum production in the tropics. Past research has concentrated on commercial cut flower production. The production aspects have been broken into two areas: cultivar evaluation and crop management. Several cultivars of orchid genera have been chosen for advance testing. More recently the production and culture landscape plants has also been added.

Orchids

Cultivar collection and evaluation

Flasks of 40 cultivars were recently obtained in Thailand. There were 20 different cultivars of dendrobiums and 20 vandaceous cultivars including vandas, arandas, and mokaras. The seedlings from these flasks were transplanted and being grown to flowering size plants.

Orchids from flasks are very delicate and require more care than other stages of orchid growth. It was found that the handling of vandaceous seedlings and dendrobium seedlings requires different potting methods from when they are removed from flask. The growth habits of dendrobiums and vandas are different

Vandaceous seedlings did best in small plastic baskets with no medium. The dendrobiums did better in plastic baskets with 1/2" of tree fern fiber. The seedlings were grown in the baskets for approximately 2 months.

Dendrobiums were transplanted to 2" pots with crushed limestone aggregate (1/4") for medium. The vandaceous seedlings were tied to a narrow piece of bamboo which was inserted into a 2" pot.

The seedlings will be grown to flowering size and evaluated for flower quality, yield over two years and vase life. The seedlings will be grown in 30% shade and full sun.

Seasonal Flowering

Phenological data was recorded for *Dendrobium* Jaquelyn Thomas 'Uniwai Supreme' at different stages of development. There were 40 den-drobiums growing in 30% shade and 40 plants in full sun.

This data includes the dates of growth initiation, termination and dates of flower initiation and harvest.

In addition data was recorded for number of leaves per growth, length of the tallest pseudobulb, leaf color, petal color, diameter of the flowers, length of the scape and raceme and the number of flowers.

The weather factors recorded by the loggers are: solar radiation, rainfall, air temperature (high, low, and mean). The weather data is recorded in the field by electronic loggers. These loggers are connected to radios which communicate with a computer where the data is stored.

The weather data and the data on the plants is being compared to identify how the changes in the climate through the year affects the growth and flowering of *Dendrobium* Jaquelyn Thomas 'Uniwai Supreme'. Preliminary analysis of the data indicates that the number of racemes produced from plants in full sun is twice the number of those produce by plants in 30% shade. The number of flowers per raceme is slightly less and the lavender tinge is lighter from plants in full sun.

Culture of dendrobiums

As a result of the higher yields in plants growing in full sun, an experiment was initiated to evaluate the effects of different fertilizer levels and pot size on flower production.

Twenty-four *Dendrobium* Jaquelyn Thomas 'Uniwai Supreme' are used in this experiment. Twelve of the plants were planted in 2" pots and twelve were planted in 6" pots. The plants are being fertilized with one of 5 fertilizer treatments (0, 1/2, 1, 2, or 4 tablespoons of fertilizer/gallon applied at two week intervals).

Data is being recorded on the number of racemes produced per plant and the number of flowers per raceme The number of growths, number of leaves, and pseudobulb height, leaf color and flower color are also recorded.

The information from this experiment will help determine the optimum way to grow dendrobiums for cut flower production.

Propagation of Ornamentals

Tabernaemantuna divaricata (L.) is used as a landscape plant in Guam. Crape jasmine is a shrub which grows up to 8 feet. In general, nurseries in Guam do not utilize mist systems in propagation. This results in the loss of leaves if green or soft tip cuttings are used. Green stems also readily desiccate. Hardwood cuttings are more resistant to desiccation. The purpose of this study was to evaluate the use of indole butyric acid (IBA) to promote rooting on three types of cuttings: terminal, semi-hardwood, or hardwood propagated without mist.

Thirty-six cuttings of *T. divaricata* were cut and grouped into three categories: terminal, semi-hardwood, or hardwood based on stem thickness. The terminal cuttings each had approximately 10 leaves and were of semi-hardwood. The hardwood cuttings did not have leaves. The cuttings were approximately 25 cm long. Three levels of IBA were compared along with the control of no IBA. The levels used were 2000, 4000 and 8000 ppm. There were three replications. The IBA was mixed in 50% alcohol. The cuttings were dipped for 10 seconds and planted in a peat moss mix. The cuttings were placed in a covered location with a light intensity of 1'5μ mol.m.$^{-2}$.s^{-1}. Irrigation was for 10 minutes twice per day. Data taken included the number of roots per cutting, length of longest root, and the number of shoots. In addition, the diameter of the cuttings was measured.

Hardwood cuttings were found to produce a greater number of roots and an increased number of shoots over the terminal cuttings. Most of the leaves on the terminal cuttings had mostly dried and withered. The IBA treatments did not affect the number of roots.

Diseases of Cucurbit Crops on Guam, and Development of Strategies for their Control

G.C. Wall

The fruit blotch disease of watermelon continues to be a threat to production of this crop on Guam and other areas of the world. The causal organism was identified on Guam in recent years as a bacterium, *Pseudomonas pseudoalcaligenes* subsp. *citrulli*. If a resistant variety were found, the use of it would reduce the danger of suffering losses from this disease. One objective of this project is to screen watermelon varieties for resistance to fruit blotch; to do so, it is first necessary to develop a technique. During this past year, a technique was developed on Guam for inoculating the fruit blotch bacteria onto watermelon in field plots, consisting of bacterial preparations grown in the lab and sprayed onto test plants at a time of day when the stomates on the fruits are open. Stomates are small openings in the surface of plants. Bacteria can then enter the plant tissues and cause infection. A screening test in the field, in which this technique was to be used on 28 cultivars, was destroyed by Typhoon Russ and will have to be re-planted.

A Study of the Disease of Beans on Guam, their Importance and Control

Our efforts in this project are being concentrated on the yard-long bean, which is named *Vigna unguiculata* subspecies *sesquipedalis* in latin. Records of previous years show that the most important diseases of yard-long bean on Guam are a mosaic disease and powdery mildew. Therefore research under this project is aimed at finding solutions for these two disease problems.

Powdery mildew, caused by the fungus *Oidium sp.*, is an important disease of yard-long beans on Guam and throughout the Mariana Islands. It causes defoliation of the plants, and loss of production. Two experiments (replicated 3 times) were planted at the Inarajan station to determine which fungicide gives best control of this fungus. Spreader rows were planted two weeks ahead of time between the test plots, and were allowed to develop the disease. This insured that we had a good amount of disease in our test plots, which consisted of 3 rows each. The first experiment was prematurely ended as a consequence of Typhoon Koryn. The second one was completed, however, and it showed that, out of five fungicides tested (Bravo, Kocide, Kolospray, Super Six and Tri-Basic) the sulfur fungicides Super Six and Kolospray resulted in higher bean production than the other fungicides tested.

This year, various tests were completed on the mosaic disease of yard-long bean, which is so widespread on Guam and Saipan. Previous work has already shown that this mosaic disease is infective, and can be transmitted by contact (mechanically) or by aphids. The following are summaries of these studies.

Identification

Symptoms and behavior of this disease gave strong indication that it might be caused by a virus. Viruses are so tiny that they cannot be seen under conventional microscopes; electron microscopes are needed to see them. We have no such microscopes on Guam, and efforts to have our samples analyzed by other labs that do have these instruments have not worked out. However, there are several serological techniques available to identify plant viruses today. One of these techniques, called protein A sandwich ELISA (for enzyme-linked immunosorbent assay), was used on samples of diseased yard-long bean. Several antisera were tried. The tests were positive for our diseased plant samples, and negative for healthy plant samples, with antisera specific for Blackeye Cowpea Mosaic Virus. Therefore, considering all the results from our various tests, we conclude that our mosaic disease on yard-long bean is caused by this virus, abbreviated BlCMV.

Host range

It is important to know which other plants are affected by this virus. Sixty-

one kinds of plants were inoculated with sap from diseased yard-long beans. These plants were then tested for BlCMV with the ELISA technique described above. Of these, 31 plants in the legume family tested positive, and 9 plants in other families also tested positive. More details are given in Tables 1 and 2. This means that 40 kinds of plants, out of the 61 that were tested, can become infected by BlCMV, the virus infecting yard-long bean. These plants may be important in maintaining the virus when there are no yard-long beans in farmers' fields, acting as a reservoir. From there, disease can again spread back to yard-long bean. This information is important for the control of the virus.

Biological Suppression of Soilborne Plant Pathogens

Soil samples from different locations throughout the island were collected and brought to the lab. Soil microorganisms were grown out on Czapek's culture medium and these were tested in vitro for antagonistic effect on *Psudomonas solanacearum*. No antagonism was found for the wilt bacterium, although most samples came from fields where this disease is not known to be a problem.

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

A research assistant was hired to work on this project; he traveled to UH to receive training on cross-protection of papaya with the mild strain of Papaya Ringspot Virus (PRV). An island-wide survey of wild and cultivated papaya was completed; samples were subjected to ELISA to verify PRV infection. Seedlings have been inoculated in the greenhouse. Additionally, preliminary testing has shown that the watermelon strain of PRV (PRV-W) does not infect papaya, and so far, our PRV-P strain has not been shown to infect cucurbits. A collection of papaya cultivars has been started, and will serve to screen for field resistance or tolerance to PRV.

Fungicide Control of Citrus Foot Rot During Guam's Rainy Season.

Sufficient fungicide was procured, and with the help of extension agents, two citrus growers were contacted on whose land it would be possible to carry out trials. The experimental design was laid out in the field, but the money for this small project was never appropriated until the dry season was well under way. It was therefore not possible to hire a part-time assistant to carry out the applications and data collection in time to finish the work on schedule. A second year of funding was sought, and work was resumed in time to do the study in the wet season, which is now in progress.

Two citrus orchards were identified as ideal experiment sites; one in the northern coral plateau in Yigo, and the other in the southern volcanic soils of Talofofo. The fungicide Aliette is being tested as a soil drench, as a foliar application, and as a combination of both. So far, two applications have been completed, and results look promising. Four months of data have already been collected. However, damage due to Typhoon Russ is expected to confound future data. No statistical analyses have been performed yet, but it is possible we may have useful information already. This study will conclude in June 91.

TABLE 1. Host range of a virus of yard-long bean, *Vigna unguiculata* ssp. sesquipedalis

Family species Cultivar	Reactions Local	 systemic
Aizoaceae		
Tetragonia expansa		
New Zealand Spinach	+	
Amaranthaceae		
Amaranthus spinosus	-	-
Beta vulgaris		
Detriot Dark Red	-	-
Gomphrena globosa		
Mixed	-	Mot
Plant Virus	+	-
Spinacia oleracea		
Bloomsdale Long Standing	+-	+-
Araliaceae		
Polyscias sp.	-	-
Asteraceae		
Synedrella nodiflora	*	+-
Bignoniaceae		
Tecoma stans	-	-
Chenopodiaceae		
Chenopodium amaranticolor	YLL	*
Chenopodium quinoa	YLL	*
Cucurbitaceae		
Cucumis sativus		
Hybrid Sweet Salad	-	-
Chicago Pickling	-	-
Cucurbita pepo		
Ambassador	-	-
Luffa acutangula		
Luffa gourd	-	-
Fabaceae		
Arachis hypogaea		
Spanish Peanut	-	-
Starr	-	-
Cassia alata	-	-
Crotalaria juncea	-	-
Tropic Sun Sunnhemp	NLL	Mot, LR,LC
Glycine max		
Bragg	+	-
Vinton	+-	-
Medicago sativa		
Du Puis	-	-
Pachyrhizus erosus	*	+-
Phaseolus aureau		
Berken Mung Bean	-	Mot
P. lunatus		
Henderson Bush Lima	RVB,NS,N	M,C,Dw,N
P. vulgaris		

Black Turtle Bean	Mot	Mot, Dw,N
Greencrop	+	Mot, Dw,N
Pisum sativum		
Perfected Wales	-	+-
Wando	*	-
Psophocarpus tetragonolobus	*	M
Trigonella foenum-graecum	+	+
Vicia faba		
Fava Bush Long Pod	RLL	+
V. faba minor		
Bell Bean	RLL	-
Vigna unguiculata		
California Blackeye #5	+	Mot
Mississippi Silver	+-	+
Purple Hull	-	-
Queen Ann	+-	+-
V. unguiculata		
subsp. *sesquipedalis*		
Burpee Asparagus Bean	*	M, VB, Rug
Dow Gauk	*	M, VB, Rug
Extra Long Red Seed	*	M, VB, Rug
Green Arrow	*	M, VB,Rug
Green Pod Kaohsiung	*	M, VB, Rug
local black	*	M, VB, Rug
local bush	*	M, VB, Rug
local green	*	M, VB, Rug
local green	*	M, VB, Rug
local red	*	M, VB, Rug
local white	*	M, VB, Rug
Maagap	*	M
Mabun JI	*	M, YS
Sandigan Pole	*	M
Sumilang	*	M, Mot
Surinam	*	M
Lamiaceae		
Ocimum basilicum		
Sweet Basil	*	-
Poaceae		
Triticum aestivum		
Minter Winter Wheat	*	-
Solanaceae		
Datura stramonium		
Plant virus	-	-
Lycopersicon esculentum		
Marglobe	-	-
Nicotiana benthamiana	*	M, VG, Rug
N. glutinosa		
N. tabacum		
Hicks Broadleaf	*	-
Samsun NN	-	-
Petunia hybridum		
Plum Pudding		

Legend:

C	chlorosis of leaves
D	leaf deformation
Dw	dwarfing of leaves
LC	leaf curls downward
LR	leaf rolls upward
M	mosaic
Mot	mottle
N	necrosis of plant
NLL	necrotic spots
RLL	red local lesions
Rug	Rugosity
RVB	red vein banding
VB	dark green vein banding
YLL	yellow local lesions
YS	yellow spots

\+ symptomless infection (positive in back inocultation or ELISA)

\+ no symptoms (negative in back inoculation or ELISA)

+- positive in some but not all back inoculations or ELISA

* no symptoms, no back inoculation or ELISA

Table 2. Results of yard-long bean virus host tests on weeds and local crops of Guam.

Species	Common name	Host Status
Amaranthus spinosus	Spiny amaranth	-
Tecoma stans	Tecoma	-
Cassia alata	Taki biha	-
Polyscias sp.	——	-
Psophocarpus tetragonolobus	Wing bean	+
Synedrella nodiflora	——	+-
Pachyrhizus erosus	Yam bean	+-

\- Non-host
\+ Host
+- Possible host

Nitrogen and Potassium Interactions on the Production of Selected Vegetables

J.A. Cruz and P. Singh

A fertilizer and drip irrigation trial was conducted at the Yigo station during the wet season June through August 1990. The objective of this experiment was to assess the effects of various nitrogen, potassium and drip irrigation levels on head cabbage yield.

The soil at the Yigo station has been classified as clayey, gibbsitic, iso-hyperthermic, tropepitic eutrustox, typically a well drain reddish brown cobbly clay soil on limestone plateaus. The initial soil test result from the site indicated a pH of 7.50. Nutrient levels were 5.40 ppm P, 120 ppm K and 11.8% organic matter.

The experimental design was a split-split plot treatment, randomized complete block, design. The three irrigation, three nitrogen and two potassium levels were arranged factorially with irrigation as main plots, nitrogen as sub-plots, and potassium as sub-subplots. The drip irrigation levels were 10, 25, and 45 cb. The nitrogen rates 0, 60 120 kg ha -1 were applied as ammonium sulfate and potassium rates 60 and 120 kg ha -1 were applied as potassium sulfate. Both nitrogen and potassium sources were injected through the drip irrigation system in five split applications. Treble superphosphate was applied at 200 kg ha^{-1} at planting time.

Analysis of variance of the yield data indicated that the irrigation treatment was not significant. This result was expected due to high rainfall during the growing period. The nitrogen treatment was highly significant at 0.01 probability level. Average head weight for 0, 60 and 120 kg ha^{-1} N levels were 0.82, 0.99 and 1.06 kg/plant. Potassium treatment was not significant. The initial soil test result for extractable K indicated adequate soil K level at the site. There was no significant effect of nitrogen and potassium (N x K) level on head yield.

Alley Cropping

J.L. Demeterio

The Hatch Project on alley cropping is a sustainable agriculture scheme was approved in September 1990. Alley cropping using *Leucaena leucocephala* Lam (de Wit) was a component in a long-term nitrogen source study at the Inarajan, AES. Preliminary results have shown consistently higher yield when corn was intercropped with *Leucaena*. However, when head cabbage which is a priority crop of Guam was grown between hedges, yield was lower compared to traditional open cropping. Further testing on beneficial effect of alley cropping is ongoing.

HATCH PROJECTS

GU0020 Improving the status of tropical fruit crops through selection, introduction and breeding - vacant
GU0030 Evaluation of different cultural methods for production of ornamental plants in Guam - J. McConnell
GU0059 Reproductive biology of three sea cucumber species of potential commercial value - R. Richmond
GU0060 Bioenergetics and behavior of larval rabbitfishes (*Siganus* spp.) - S.G. Nelson
GU0063 Developing pest management systems for vegetables compatible with *Liriomyza* management - I. Schreiner
GU0064 Identification of economically important diseases on cucurbit crops on Guam and development of strategies for their control - G.C. Wall
GU0065 Development of cultural, chemical and biological control methods for pests of cruciferous crops on Guam - R. Muniappan
GU0067 Nitrogen and potassium interaction on the production of selected vegetables - J.A. Cruz
GU0068 Use of locally available feedstuffs and potential feed sources on Guam for poultry feeding - F. Abawi
GU0072 Small landholders of Guam: Production analysis and risk - avoiding behaviors - J. Brown
GU0077 Evaluating alley cropping for a low input sustainable head cabbage production on Guam - J.L. Demeterio

REGIONAL RESEARCH PROJECTS

GU0015 Establish, improve and evaluate biological control in pest management systems of plants - D. Nafus
GU0022 Water nutrient managment of crops under micro irrigation - P. Singh
GU0026 Biological suppression of soilborne plant pathogens - G. Wall
GU0066 A national agricultural program to clear pest control agents and animal drugs for miner uses - R. Muniappan

Section 406 Projects

GU0054 Biology and control of mango pests on Guam. - I. Schreiner & D.M. Nafus
GU0057 Biology of biological control of the red coconut scale, *Furcaspis oceanica* Lindinger. - R. Muniappan & M. Marutani
GU0058 Environmental factors affecting flowering in some Vanda and Dendrobium hybrids in the tropics - J. McConnell
GU0061 Biological control of *Lantana camara* in the Mariana Islands - R. Muniappan, M. Marutani & G.R.W. Denton
GU0062 A study of diseases of beans on Guam, their importance and control - G.C. Wall
GU0070 Development of techniques for the mass production of larval rabbitfishes (Siganidae) - S.G. Nelson
GU0071 Biology and control of *Aulocophora similis* and *Diaphania indica* - D.M.Nafus and I. Schreiner
GU0074 Effect of insect induced changes in the Siam weed on three trophic levels.- R. Muniappan, J. McConnell, M. Marutani & G.R.W. Denton
GU0075 Evaluation of processing indigenous feeds as substitute for imported poultry feed - F.G. Abawi
GU0076 Development and Evaluation of effective control techniques for the papaya ringspot. - G.C. Wall,L.S. Yudin & S.A. Ferreria

Special Grants Project

GU0073 Fungicide control of citrus foot rot on Guam - G. C. Wall

PUBLICATIONS

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Kimmons, C.A., G.C. Wall, D.A. Nelson & B.B. Reddick. 1990. Occurrence and characterization of a virus infecting yard-long bean (*Vigna unguiculata* subsp. *sesquipedalis*) on Guam. Phytopathology 80: 1060.

Marutani, M. & J.A. Cruz. 1990. Evaluation of storage methods on storability and subsequent field performance of potatoes (*Solanum turberosum* L.) in Guam. Asian Potato Journal 1:29-32.

Marutani, M. & R. Muniappan. 1990. A new natural enemy of *Chromolaena odorata* in Micronesia. *Chromolaena odorata* Newsletter No. 3. p.7.

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