AES

ANNUAL REPORT 1992

AGRICULTURAL EXPERIMENT STATION
COLLEGE OF AGRICULTURE AND LIFE SCIENCES
UNIVERSITY OF GUAM

MESSAGE FROM THE DEAN/DIRECTOR

It has been 20 years since legislation was passed in the Congress for the establishment of Land Grant Programs in Guam. This year we have initiated projects in McIntire-Stennis program. Current strength of the Agricultural Experiment Station comprises soil scientists (two), agricultural economist (one) agricultural engineer (one), horitculturists (three), entomologists (three), plant pathologist (one) and animal scientist (one).

Most of the funding for the research was received from Hatch formula, Regional Research, McIntire-Stennis, Tropical and Subtropical Agricultural Research Program administered by Pacific Basin Advisory Group, Agricultural Development in the American Pacific and Government of Guam.

This report includes brief summaries of activities and achievements carried out in different projects as well as lists of publications, projects and various off-island conferences attended by the scientists. For details of each project, kindly contact the scientists directly.

Chin-Tian Lee
Dean/Director

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FRUIT CROPS

DROUGHT STRESS OF PAPAYA

Thomas E. Marler

A series of experiments to study drought stress of papaya was begun in 1991 and was terminated in 1992. The first response of papaya plants to drought stress is closing of stomata and a concomitant reduction of net photosynthesis. As drought stress progresses, papaya plants lose capacity to efficiently use light energy and the amount of light needed to offset dark respiration is increased. The amount of water in papaya leaf tissue is maintained at a high level during drought stress according to xylem potential measurements and calculation of the relative water content. The ability of roots to absorb water is reduced following a period of drought in many plant species, however, papaya plants retain a high level of water transport following drought. Older papaya leaves turn yellow and fall off after a period of drought.

These results indicate that papaya plants adapt to periods with inadequate rainfall or irrigation by postponing water loss in the leaves. This is done by by closure of stomata and by maintaining the ability to rapidly absorb water following rewetting by rain or irrigation. Closure of stomata during the period of stress reduces net photosynthesis and thus potential growth of papaya plants. This is a short-term effect and is alleviated following rainfall or irrigation. Shedding of older leaves, however, further reduces the total leaf area available for photosynthesis. This is a long-term effect, with reduced growth and productivity theoretically occurring until the lost canopy leaf area is replaced.

ROOT AND SHOOT GROWTH PATTERNS OF MANGO

Thomas E. Marler

A cooperative project with a colleague from Miami, Florida was concluded and results were presented at the Fourth International Mango Symposium in July 1992. Root observation chambers with glass walls were used to determine the rate and timing of root and shoot growth of 'Julie' and 'Keitt' mango trees. Many tropical fruit species have sporadic canopy growth with periods of rapid shoot extension alternating with longer periods with no visible shoot extension. Root growth of some plants such as citrus species increases during periods with no visible shoot extension, so that there is an alternation of shoot and root growth. The mango trees in this study did not have a consistent pattern of root growth when compared to the alternating pattern of shoot growth. On the contrary, root growth was fairly continuous throughout the year. These results indicate that mango trees continue to grow throughout the year, even during periods with no visible growth above the ground.

VEGETABLE CROPS

IMPROVEMENTS OF PLANT DEVELOPMENT AND YIELD OF SOLANACEOUS CROPS ON GUAM

Mari Marutani

Genetic variation of 22 germlines of tomato (*Lycopersicon esculentum*) and 31 lines of *Capsicum* species and hybrids were evaluated at the Yigo Experimental Farm with soil characterized as Guam Cobbly Clay having pH of around 7.5. The tomato experiment was conducted from Feb. 11, 1992 to May 15, 1992 and pepper was tested from June 2, 1992 to Oct. 10, 1992. They were evaluated in a randomized complete block design with three replications for tomato and two replications for pepper. An accession of Asian Vegetable Research and Development Center in Taiwan, a hybrid tomato, FMTT 22, showed its superior characteristics in yield, fruit cracking and nematode resistance. The FMTT 22 will be further evaluated in various growers' fields, especially for bacterial wilt resistance which is a serious problem in southern part of Guam.

Among 31 lines of pepper, 'Cheongryong' of Korea was the highest yielder. 'Cheongryong' and 'Hot Beauty from Taiwan and 'Punjab Lal' from India showed higher plant survival rate (more than 70 percent) than others after the Supertyphoon Omar hit the island on August 28, 1992.

EVALUATION OF TROPICAL LEGUMES AS GREEN MANURES IN VEGETABLE PRODUCTION ON GUAM

Mari Marutani

An experiment to determine indigenous rhizobia populations in the three different soil regimes in Guam was initiated. Soil samples were collected from the three experimental farms in Yigo, Barrigada and Ija where the sampling sites have not been previously cultivated. The soil samples were pooled and stored at 4° C overnight. One hundred grams of the field soil sample were diluted in 900 ml sterile water. A series of 2 ml diluted sample solution was then placed in a seed germination pouch with 30 ml N-free nutrient solution. *Macroptilium atropurpureum*, *Leucaena leucocephala*, *Vigna unguiculata*, and *Glycine wightii* were used as test plants to identify rhizobia. The experiment is currently being conducted and no conclusive results are available yet. In field evaluation of legumes, a eight legumes are being tested in the three types of soils. Legumes are sunnhemp, *Crotalaria juncea*; lablab, *Lablab purpureus*; mungbean, *Vigna radiata*, desmodium, *Desmodium aparines*; siratro, *Macroptilium atropurpureum*; cowpea, *Vigna unguiculata*; and stylo, *Styloanthes* sp. In preliminary observation of this experiment, sunnhemp, mungbean and cowpea germinated after six days in all three sites. Desmodium germinated the latest with poorest germination. Canopy cover was the greatest in Barrigada, followed by Ija. Mungbean had the largest canopy, reaching 95-100 percent cover by the sixth week after sowing in the both inoculated and uninoculated plots. Sunnhemp did fairly well in Barrigada soil and in Ija soil with lime. Yellowing of leaves of cowpea, mungbean and sunnhemp was prominent in Yigo on the sixth week. The similar symptoms was observed in the younger leaves of mungbean and sunnhemp in Barrigada on the seventh week.

ORNAMENTALS

FERTILIZING ORCHIDS

James McConnell

A fertilizer experiment is underway to evaluate various levels of fertilizer on the growth and flowering of dendrobium orchids. *Dendrobium* Jaquelyn Thomas 'Uniwai Supreme' orchids are fertilized weekly with 0, 0.5, 1, 2 or 4 tablespoons of 20-20-20 water soluble fertilizer. There are subplot treatments of 5 cm and 15 cm pot sizes with crushed limestone as the growing medium. The dendrobiums are growing under full sunlight conditions and receive daily irrigation. Data are recorded for: number of leaves per pseudobulb, pseudobulb height, number of pseudobulbs, and number of racemes.

So far in the experiment, the number of leaves were not affected by fertilizer level but there were more leaves per pseudobulb for plants growing in 15 cm pots. The pot size had a greater effect on the number of leaves per pseudobulb. Pseudobulb height was affected by fertilizer level but not by pot size. The number of pseudobulbs and the number of racemes were affected by both fertilizer level and pot size.

TURF GRASS FERTILIZATON

Mark D. Hamilton, Frank J. Cruz and James McConnell

A series of fertilizer experiments are underway to compare the effectiveness of six different fertilizers for use on turf grass. Various controlled release and water soluble formulations are included. Hybrid Bermuda grass is being used in these studies.

The first experiment was to study how the fertilizers move through three of Guam's soils. The passage of nitrate nitrogen through three Guam soils was investigated using six different fertilizers. Controlled release and water soluble forms were applied to soils in polycarbonate pots 11cm in diameter. Controls received no fertilizer application. Soil types used were Yigo silty clay and Guam cobbly clay loam from northern Guam, and Akina silty clay from southern Guam. All pots were exposed to ambient temperature and humidity but were shielded from direct sunlight and rain. All were kept near field capacity by daily applications of distilled water. Leachate was collected weekly for three months and measured using an ion selective electrode. Initial results suggest that nitrate levels were primarily affected by soil type rather than the type of fertilizer applied. Nitrate was invariably highest in Yigo silty clay, lowest in the Akina silty clay and intermediate in the Guam cobbly clay pots. Patterns of nitrate release were similar in the Yigo silty clay and Guam cobbly clay soils with peak values at the fourth and fifth week, 700 ppm and 450 ppm respectively, then falling to 300 ppm and 150 ppm respectively by the sixth week. However, Akina silty clay soils gradually increased in nitrate to 120 ppm in the last two weeks of the experiment.

Additional experiments will look at how the quality of Bermuda grass is affected by five different rates of nitrogen. Once the optimum rate is determined, different forms of nitrogen fertilizer will be applied to see which are the best to use under Guam's environmental conditions.

ALLEY CROPPING

ALLEY CROPPING

J.L. Demeterio

The same field study conducted during the 1991 rainy season was carried out during the 1992 dry season. Okra was seeded late March and harvested during June and July. Rainfall was typical of the dry season with an average of 5.22 cm for the months from March to June, with 26.56 cm during July. Drip irrigation was used.

Vigorous plant growth was observed in the alley cropping scheme. Only the 200 Kg N treatment showed the same vigorous growth in the open field cropping. As in the rainy season plantings, it was observed that weeding was less of a problem in the alley cropping scheme.

Yield results are shown in Table 1. In the open field cropping, the 0 to 100 Kg N treatments showed yields much lower than the 0 treatment in alley cropping. Supplemental nitrogen addition at the 100 kg N level in alley cropping resulted in yields almost double the alley cropping control.

While the stability of okra growing between *Leucaena* hedges have resulted in good yield increases, the labor overhead associated with establishing and periodically trimming the hedges has been criticized. Further work on alley cropping will focus on lowering cost overheads.

Table 1. Yield of Okra in tons per hectare

Cropping Scheme**

Treatment *	Open Field	Alley Cropping	mean
0 kgm N/ha	3.660	12.05	17.856
25	6.351	12.76	19.556
50	6.633	16.241	11.437
100	8.444	21.745	15.075
200	19.712	22.440	21.076
mean	8.96	17.048	

*Significant at the 5 percent level, LSD .05 = 11.347, CV = 56.63 percent
** Significant at the 1 percent level, LSD .01 = 6.756, CV = 24.77 percent

AGRICULTURAL ENGINEERING

AUTOMATION OF MICRO-IRRIGATION SCHEDULING

Prem Singh

Micro-irrigation is the most widely used method of irrigation on Guam. Water, fertilizer and pesticide should be applied in a such a way that minimal leaching occurs beyond the root zone. This is particularly required for crops grown on shallow soils over the northern Guam water lens in order to minimize chemical leaching to the groundwater. The goal can be achieved using well designed automated micro-irrigation scheduling system.

Automation of micro-irrigation scheduling has been a prime research area for the last three years. The key components of an automated micro-irrigation scheduling system are: soil moisture sensors equipped with switching devices; solenoid actuated hydraulic valves; and programmable controllers. The location, depth from soil surface and distance from a plant hill of sensors depends upon the rooting characteristics of crop and soil properties.

The automation system is being tested for two crops – cucumber and head cabbage. Cucumber is a deep-rooted crop while head cabbage a shallow-rooted crop. Based on soil depth in the experimental fields and observations on root distribution pattern, the sensor location selected were 15 cm deep and 15 cm away from crop row against a plant hill for cucumbers and 11.25 cm deep and 15 cm away from crop row against a plant for head cabbage. Experiments for cucumbers were conducted at the Inarajan experiment station. The soil depth in the experimental plot ranged 25-45 cm. While experiments for head cabbage were conducted at Yigo/Dededo experiment station.

Automated irrigation scheduling system during the dry season can be set at any soil moisture tension value (the set point) between 10-45 Centi-Bar (CB) without significantly affecting the cucumber yield. For our experimental field soil and boundary conditions, the maxima was observed towards 10 CB while the yield exhibited declining trend towards 45 CB. The results were similar for the three cucumber varieties tested: Market King, Fountain and Southern Delight. The head cabbage has been tested only for one season in a related experiment. The range tested was 10-45 CB. Head cabbage, variety KK Cross, showed significant yield decline when irrigation was scheduled at 25 and 45 CB soil moisture tension. Head cabbage yield was highest at 10 CB irrigation scheduling.

DYNAMICS OF ROOT GROWTH, WATER UPTAKE AND AUTOMATION OF MICRO-IRRIGATION SCHEDULING

Prem Singh

The location and the set point of the soil moisture sensor in the automated micro-irrigation scheduling system depends upon the system parameters, the soil parameters, and the crop parameters. The optimal wetted soil volume (OWV), the minimum volume of soil that needs to be irrigated without causing any significant yield reduction for a crop, is the system design parameter of interest in this study. The value of this parameter for cucumber crop will be obtained in pot experiments at the Inarajan experiment station using Guam clay soil as the medium of growth. Plant will be grown in pots. The pots will be grouped in 10 groups based on the volume of soil used. There will be 14 pots in each group. Growth parameters, fresh and dry weights of shoots and roots, leaf area and harvest yield, will be measured at approximately two week intervals. These data will be analyzed to obtain the OWV for cucumber variety Soarer. Experiments are currently underway. Results will be reported in the next report.

FERTILIZER

EFFECT OF NITROGEN AND POTASSIUM FERTILIZERS ON HEAD CABBAGE

Jose A. Cruz

A field experiment was conducted at the Yigo Experiment Station during the dry season (December to February) to evaluate applied nitrogen and potassium through the drip irrigation system on the yields of head cabbage. The study was conducted on the Yigo soil classified as clayey, gibbsitic, isohyperthermic Tropepic Entrustox with pH 7.5 and nutrient levels of 5.4 ppm p, 55 ppm k, and 6.0 percent organic matter.

The treatments consisted of ammonium sulfate to supply nitrogen and potassium sulfate to supply potassium applied at rates of 0, 60, 120, and 180 kg N & K/ha through the drip irrigation system. The fertilizer injection system was calibrated at the proper rate (1:100 ratio) to maintain the desired concentration levels of N & K. Dissolved ammonium sulfate as nitrogen and potassium sulfate as potassium fertilizers were applied through the drip irrigation system separately every seven to 10 days a week after transplant and ceased fertilizer injection 10 days before harvest. Each treatment was replicated four times in a randomized complete block design. The four nitrogen and potassium rates were factorially arranged with nitrogen treatments as main plot and potassium treatments as subplot.

Analysis of variance of the yield data indicated that the nitrogen injected at rates of 0, 60, 120 and 180 kg N/ha through the drip system did not have significant effect on the head cabbage yield. The potassium treatment was also not significant. The combined effect of injected nitrogen and potassium showed no significant response on the head cabbage yield.

ENTOMOLOGY

BEAN FLY, *OPHIOMYIA PHAESOLI* (TRYON)

D. Nafus

Research focused on determining which parasitoids are present and on developing an understanding of how they are going to be affected by an Integrated Pest Management (IPM) program now in development. Surveys showed *Opius importatus* and *O. phaseoli* were not present, confirming their failure to establish. These species are important parasitoids in other parts of the world and they should be reintroduced. Several local parasitoids are present including *H. semialbiclavus*, *Callitula* sp., *Sphegigaster rugosa* and some unidentified species. *H. semialbiclavus* also parasitizes leafminers.

To understanding how the new IPM program will affect the parasitoids, an IPM and an unsprayed field of long beans were established in December 1991. Both fields were monitored through February 1992. On one field, in Barrigada, no pesticides were used. In the second field, planted in Yigo, the IPM program was implemented to control all pests including bean flies. In Barrigada from 70 percent to 98 percent of the bean stems and petioles were infested with bean fly. In young plants, bean fly populations averaged four larvae per stem. Parasitization was about 5 percent at this stage. Primarily, the larvae at the surface of the stem were parasitized and larvae tunneling deeper were free of parasites. Later in the crop cycle, bean flies were mainly in the petioles. Populations increased from 1.7 larvae per petiole to 7.3 about three weeks after flowering. The vines were severely pruned back and most runners died. Yield was severely depressed. Parasitization rates reached 50 percent prior to the peak population of bean flies and then declined before bean fly populations declined. Bean fly populations were about 30 percent lower in the IPM field (24 percent infested seedlings) before treatments started. Pesticide treatments targeted against aphids kept bean fly infestations below 11 percent. Larval populations peaked at 1.1 miners per stem. Parasitoids quickly disappeared following the first spray. The maximal parasitization rate was 1 percent and only two species were present in the field. Leafminer populations were much higher in the IPM fields, and exceeded yield loss thresholds. Leafminers were nearly absent at untreated site.

Maruca testulalis infested 20 to 35 percent of the flowers in the untreated field and less than 10 percent in the treated field. No larval, pupal or egg parasites were found in either field.

NATURAL ENEMIES OF COWPEA APHID *APHIS CRACCIVORA* KOCH

D. Nafus

Aphis craccivora is a primary pest attacking beans and transmits blackeye cowpea mosaic virus. Studies were initiated to determine the natural enemies of aphids on beans, in preparation for possible importation of additional biological control agents. Aphid infestations were followed, periodically sampling aphids and rearing for parasitoids and predators. No parasitoids were found on 1,635 aphids collected in the field and no mummies were seen in field observations. The ladybeetles *Menochilus sexmaculatus* (F.) and *Harmonia arcuata* (F.) and two unidentified flies were found feeding on the aphids.

CONTROL OF *PERICYMA CRUEGERI* (BUTLER)

D. Nafus

The poinciana looper has been a serious pest of flame trees on Guam since 1971. Surveys are underway in Malaysia (CIBC) to search for natural enemies of the looper. On Guam, background studies are in progress. These studies are designed to provide information on how effective any new parasites are, if any are found and imported. In 1991-92, flowering patterns of poinciana were studied since flowers are the main product of this tree. This data will in used for before and after comparison studies to show how flowering changes after natural enemies are present. Loopers defoliated the poincianas two or three times: in October and November 1991 and January 1992, but not from August to December 1992. Trees were defoliated twice in 1992 by typhoons Omar and Gay. These defoliations along with the effects of several other typhoons prevented the buildup of loopers, which have been scarce since the January outbreak. Trees flowered from May through August, but did not flower synchronously as they should. Individual branches flowered sporadically over the three-month period. From 5 to 45 percent of the monitored branches flowered. Parasitization of the loopers was very low and no new natural enemies were noted.

YIELD OF CANTALOUPE IN RELATION TO ORANGE PUMPKIN BEETLES

D. Nafus and I. Schreiner

No information is available as to how orange pumpkin beetles (*Aulacophora similis*) affect yield. To examine the interaction between yield of cantaloupe and early infestation by beetles, we set up an experiment caging beetles on plants. Plants at the three- to four-leaf stage were caged under six liter buckets for one week and beetles were added at different densities for four or seven days. Cages were then removed and the plants were treated with carbaryl as often as necessary to eliminate all beetle feeding for the rest of the growing season. Treatments set up were no beetles, one male or one female for four days, one male or female for one week, and two males or two females for one week. Males showed effects of adult beetle feeding only. Females were allowed to oviposit so the effects of early oviposition on yield could be determined. Twenty-five percent of the plants caged with two females died. Examination of the roots showed nearly complete destruction of the main root by larvae. Few plants died in the other treatments. Feeding by males did not effect the number, total weight or average weight of fruit produced, suggesting that early adult feeding does not affect yield. Slightly more and larger fruits were found in the two male per plant treatments. Yields were lower in all female plots, suggesting that larval feeding on the roots is the primary cause of yield suppression. Yields were only slightly reduced on plants that had one female for four days. Plants with one or two females for one week produced fewer fruit. Plants with one female produced fewer but larger fruit than controls. Plants with two females produced fewer and smaller fruit.

USE OF YELLOW PLASTIC CUPS TO CONTROL ORANGE PUMPKINS BEETLES

D. Nafus and I. Schreiner

An experiment was set up to see if orange pumpkin beetles could be reduced sufficiently through trapping to replace insecticides. Because of limited space, the experiment was unreplicated. A watermelon field was divided into plots containing seven rows of 10 hills each. A gradient of traps was set up going from a dense number at one end of the field to no traps at the other end. The densities used were: one trap per hill (70 traps total); one trap per two hills (35 traps total); about one trap per four hills (16 traps total); about one trap per nine hills (eight traps total); about one trap per 16 hills (four traps total); and no traps. Traps consisted of 12-ounce yellow plastic cups coated with Tanglefoot. They hung on rebars about one foot above soil level. Orange pumpkin beetles and melon flies caught on the traps were counted and removed every three to four days. Orange pumpkin beetles on the plants were censused each week by counting all the beetles in two 1mm-wide transects running across all seven rows in each plot. All melons found inside the transects were examined for melon fly punctures and damage from larval beetles. All harvestable melons were counted and weighed.

The 70-trap and the 35-trap plots caught the most beetles (279 and 251) and melon flies (226 and 273). More than 100 beetles and melon flies were caught in the plots with four and eight traps. At the beginning of the season, the number of beetles on the plants was similar in all plot, but later in the season and especially as the second generation of beetles began emerging, beetle numbers were considerably higher in the plots with the fewest traps. The 70-trap plot consistently had the fewest beetles on the leaves. The proportion of melons punctured by melon flies did not differ greatly in the different plots, although the plot without traps had the highest proportion of damaged melons. The 70-trap plot usually had the fewest damaged fruit. The yield increased linearly with the density of traps, with the no-trap plot producing the least fruit (114 kg) and the 70-trap plot producing the most (315 kg). Because the experiment was unreplicated, results will have to be verified in 1993.

DO FLORAL SCENTS ATTRACT ORANGE PUMPKIN BEETLES?

I. Schreiner and D. Nafus

Orange pumpkin beetles (Chrysomelidae: tribe Aulacophorini) are distantly related to corn rootworms and cucumber beetles (tribe Diabroticini). Both groups of beetles have similar ancestral habits, being attracted to cucurbit plants and using cucurbitacins as feeding stimulants. Corn root worms and other Diabroticini use various floral scents derived from squash blossoms as long distance attractants to their hosts. Several of these long-distance attractants for species of Diabroticini were tested for their ability to attract *A. similis*. The attractants tested were *trans*-cinnnamaldehyde; 1,2,4-trimethoxybenzene; indole, 4-methoxycinnamonitrile; cinnamyl alcohol and a mixture of equal parts of 1,2,4-trimethoxybenzene, indole and *trans*-cinnnamaldehyde (TIC). Cotton dental wicks were soaked in mineral oil and then 90 mg of the test attractant was applied. Liquids were applied directly and solids were dissolved in acetone first. The wicks were placed on the top of 12-ounce yellow plastic disposable cups. The cups were mounted on rebars about one foot above the

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ground and placed in cucurbit fields infested with orange pumpkin beetles. Traps were placed at least three meters apart. All chemicals plus an untreated control were tested in each trial. Trials was done twice each in cantaloupe, cucumber and pumpkin fields.

A. similis did not respond strongly to any of the attractants. The best trap attractant was cinnamyl alcohol, which caught about twice as many beetles as the other chemicals and the untreated trap.

EFFECTS OF FERTILIZER, WEEDING AND DESUCKERING ON YIELD AND PEST POPULATIONS OF TARO

I. Schreiner and D. Nafus

A second trial of the experiments on the effects of fertilizing, weeding, and removing suckers on taro yield and taro insect populations was run this year. The field was planted at Barrigada on July 9, 1990, using the common local variety, 'Sunin agaga'. Fertilizer was applied at planting at the rate of 300 lbs/acre of 16-16-16. Plots were weeded in the first week of September, in October and the first week of December. Suckers were removed in October and December. In late December, about three weeks before harvest, pigs invaded the field and consumed many corms. To estimate yields, all tops were collected and the width of the base of the stem was measured. Undamaged plants were then collected, the width of the base of the stem was measured, and the corm was weighed. A regression of corm weight to stem base width was determined and used to estimate the weights of damaged corms. All undamaged plants were harvested in early January.

Barrigada yields varied from 640 to 6278 kg/ha among individual plots. Without adjusting for pig damage, no difference in yield was found among any of the treatments. Pigs consumed significantly more corms in weeded plots than unweeded ones and apparently preferred desuckered plots to ones in which the suckers were left. When the data were adjusted to compensate for corms consumed by pigs, yield was significantly higher in the weeded plots than in the unweeded ones. Fertilizer did not effect yield in this experiment but heavy rainfall in August caused sheet erosion, which probably masked any fertilizer effects.

None of the cultural practices had any significant effects on the insects at the pest densities observed in these experiments. Most of the insects appeared to be under good control by natural enemies at least during the rainy season. Aphids become abundant on some plantings in the dry season when fungus epidemics were not prevalent. Taro planthoppers were not a problem in these plantings although they can be abundant in Guam taro fields.

DO BEAN FLIES REDUCE YIELD OF YARD-LONG BEANS?

I. Schreiner

The larvae of the bean fly, *Ophiomyia phaseoli*, tunnel in the stems of various species of legumes including yard-long beans. They mine seedlings and can cause severe stunting and death of seedlings. As the plant matures, the larvae mine the leaf petioles. The mining causes scarring and distortion of the stems. The bean flies can be controlled by applications of the insecticide dimethoate.

An experiment was set up to determine the impact of bean flies on yield of yard-long beans. Plots consisted of two rows, 15feet long and five feet apart. There were four treatments. In Treatment 1, the plants were treated with the standard rate of dimethoate once one week after emergence of the seedlings. In Treatment 2, the beans were treated weekly beginning 14 days after emergence. In treatment 3, the beans were sprayed weekly throughout the season. Treatment 4 was an unsprayed control.

The infestation was spotty, severe only in those plots closest to the old bean plot. Three plots were 95-100 percent infested in the first week: two untreated control plots and one plot in Treatment 3 which was not treated the first week. In one control plot, the plants eventually died and no yield was obtained, but in the other, the plants recovered and yielded moderately. Two plots in Treatment 2 were 100 percent infested after the first week. One became stunted and never yielded, but the second recovered and yielded well. There were observable differences in the severity of infestation at the seedling stage between the plots where

the plants recovered and those where they did not, but the differences were not quantified. Except for those plots killed at the seedling stage, no correlation between yield and bean fly infestation level was observed. In all plots, including the untreated ones, bean flies became scarce about the time the plants flowered.

USE OF INSECTICIDES TO CONTROL BEAN POD BORERS

I. Schreiner

Bean pod borers, *Maruca testulalis* are known to damage 5-50 percent of beans in yard-long bean fields in Guam. Few insecticides are registered for use on fresh beans. Among the registered materials, naled and B.t. are known to be effective. A test was initiated to determine how often they needed to be applied to impact yield. Yard-long beans were planted on March 10, 1992 in Barrigada. Plots consisted of three rows, five feet apart and 12 feet long. The whole field was treated as needed for aphids, which occurred only once before flowering. On April 24, 1992, weekly sulfur sprays were initiated to control powdery mildew. Once flowering began, plots were treated either once or twice weekly with *Bacillus thuringiensis* (Dipel) (2 tb/gal) or naled (Dibrom)(1 tsp. gal). Every two weeks 20 flowers per plot were sampled and damage and caterpillars in the flowers were recorded. Yield was harvested from all plots and data were kept on the incidence of beans damaged by borers.

The pod borer infestation was very low in this trial. Even in the untreated check plots, only 2 to 6 percent of the beans had holes due to pod borers. Inspection of the flowers showed that both *M. testulalis* and the bean butterfly *Lampides boeticus* were damaging the flowers. Early in the season, about half the caterpillars found were *L. boeticus* but these became rare and, overall, most of the caterpillars found were *M. testulalis*. No differences among treatments were observed in relation to the percentage of flowers infested or damaged. Overall, about 17 percent of the flowers showed signs of caterpillar damage, although only half of those had caterpillars in them. In the plots treated twice weekly with B.t., about 2.7 percent of the harvested beans had holes as compared to 4.5 percent average for all the other plots. Furthermore, the yield of the plots treated twice weekly with B.t. was higher, about 9.2 kg/plot as compared 7.7 kg average for all the other plots. However, none of the treatments differed statistically from the untreated check.

CONTROL OF CABBAGE INSECTS

R. Muniappan

Two major pests of cruciferous crops that are yet to be tackled are the diamondback moth, *Plutella xylostella* (L.), and the cut worm, *Spodoptera litura* (F.). An egg parasite Trichogramma chilonis was field collected from the egg of *P. xylostella*. This parasite was reared in the laboratory on eggs of *Corcyra cephalonica*. A simple method of mass rearing *C. cephalonica* in the laboratory has also been developed.

The diamondback moth population on Guam was found to be resistant to most of the carbamnate, organophosphorus and Bt formulations. Mustard, reported as an effective trap crop in India, did not attract diamondback moth in head cabbage fields.

Mass rearing of *Telenomus* sp for control of *S. litura* is also being tried. Other pests of head cabbage have been effectively checked using Chinese cabbage cv. Tempest, radish and mustard as trap crops.

BIOLOGICAL CONTROL OF *LANTANA CAMARA*

R. Muniappan and T.S. Lali

Lantana is one of the top ten worst weeds in the world. Natural enemies of lantana introduced and established on Guam in the past are lantana tingid, *Teleonomia scrupulosa*, lantana hispid, *Uroplata girardi*, and lantana pod fly, *Ophiomyia lantanae. Lantanophaga pusillidactyla and Epinotia sp.* established fortuitously on Guam.

On March 4, 1992, a shipment of the lantana leaf miner *Calcomyza lantanae* pupae were received from the Alan Fletcher Research Station, Queensland, Australia and field released. In July 1992, the flies were found well established in Mangilao and Agana and causing severe damage to lantana leaves.

SIAM WEED

R. Munippan, M. Hamilton and J. McConnell

Insect induced biocontrol and physiological changes were observed in *Chromolaena odorata* when *Pareuchaetes pseudoinsulata* fed on it. The rate of photosynthesis and chlorophyll contents were reduced in *P. pseudionsulata* infested plants. Ribulose – 1,5 lhisphosphate carboxylose was present in reduced quantity in yellow insect induced leaves.

Both green and yellow leaves of *C. odorata* were allelopathic to tomato, radish and mung bean seeds germination. However, extracts of green leaves was more allelopathic to tomato seed germination than the extract of yellow leaves.

PLANT PATHOLOGY

SUPPRESSION OF SOIL BORNE PLANT PATHOGENS

G.C. Wall

Work planned for 1992 was interrupted by the unusual typhoon season of 1992. We had planned to verify results from last year's experiments. Last year, we found a bacteriophage of *Pseudomonas solanacearum* occurring in farmers' fields. Their numbers were higher in fields where this pathogen does not cause wilt problems on solanaceous crops (tomatoes, pepper, eggplant). We had also intended to test the type culture of *P. solanacearum* with the newly found bacteriophage. All this work will have to be done in 1993. We managed to accomplish a test of induced resistance for *Rhizoctonia solani,* a common soil fungus which attacks many vegetable plants. Watermelon seedlings were first exposed to heat-attenuated colonies of *R. solani,* then challenged again with virulent inoculum of the same fungus. Controls consisted of plants not exposed to the heat-attenuated inoculum and challenged with virulent inoculum, plants exposed to heat-attenuated inoculum and not challenged with virulent inoculum, and uninoculated plants. Results were that watermelon seedling death and rate of infection were reduced by exposing seedlings to heat-attenuated inoculum prior to challenging with virulent inoculum of *R. solani.* It appears the seedlings exposed to the weakened (heat-attenuated) fungus were able to react, and by the time they were exposed to the virulent fungus, they were more able to resist infection.

CUCURBIT DISEASES

G.C. Wall

Twenty-six watermelon cultivars were compared in seedling tests for blotch resistance. Seed were dipped in a bacterial suspension of *Pseudomonas pseudoalcaligenes* subsp. *citrulli,* then planted in small pots. Blotch symptoms appeared on cotyledons soon after emergence. Disease incidence was recorded as well as percent emergence and post-emergence seedling death. There were statistically different reactions in blotch incidence between cultivars. The experiment was repeated, with similar results.

In another test, zucchini plants growing outside in planting beds were sprayed with 1 percent fine agricultural oil (SunSpray) plus 0.5 percent baking soda (w/v) on a weekly basis. Powdery mildew (*Oidium sp.*) was effectively controlled, while unsprayed control plants were defoliated by this disease. Powdery mildew is one of the two most important disease problems of zucchini on Guam. This disease also affects all other cucurbit crops, such as watermelon, melon, bittermelon and cucumber. Furthermore, the other important disease was also controlled. Zucchini Yellow Mosaic Virus (ZYMV) causes a very destructive disease on zucchini squash and other cucurbit crops. ZYMV incidence was near 80 percent in the unsprayed plants, while it was 0 percent in the sprayed plants. This will be further tested in 1993.

PAPAYA RINGSPOT VIRUS

G.C. Wall

All our field experiments during 1992 were ruined by the severe typhoon season. Work completed, however, included evaluations of cultivars in growers' fields for agronomic traits. Tainung No. 2 and Tainung No. 5 are best adapted to Guam's conditions.

An evaluation of papaya cultivar Waimanalo Low-bearing in screenhouse was carried out. Four treatments were compared: unprotected controls, cross-protected seedlings, cross-protected and challenge-inoculated, and unprotected, challenge-inoculated controls. Cross-protection is a phenomenon that occurs on plants where a mild strain of a disease-causing microorganism or pathogen is used to infect plants and when the plants are exposed to a more severe strain of the same organism, they resist infection. In our experiments, cross-protection was provided via a mild papaya ringspot virus (PRV) strain from Cornell University and the challenge inoculation was with Guam's wild PRV strain. Symptoms

were graded by a scale (0-4, no symptoms to severe ones, respectively). Plants in Treatment 1 rated 0 (no symptoms), Group 2 rated one, Group 3 was graded three, while Group 4 rated four (the most severe symptoms.) Therefore some protection was provided by the mild strain. Field testing of cross-protected plants is planned to continue for 1993-1994.

A spatial lag study of the epidemic development of PRV was completed in a grower's field, for the second consecutive year. In such an analysis, the effect of one diseased tree on its neighbors is studied. It showed that one infected tree can influence up to 10 trees down the row or across rows. These results strongly suggest that rogueing of diseased trees is advisable; that is, any PRV-diseased papaya seedling or tree should be pulled out and destroyed to reduce further spreading of the virus in a papaya orchard. Rogueing should stop after fruit setting, because the fruit that are formed before infection will not be affected in taste or appearance.

PLANT DISEASE DATABASE

G.C. Wall

A shell program with graphics capabilities was developed for a plant disease database currently containing some 950 records of diseases on tropical and subtropical vegetables, fruits and root crops. The pre-existing database was in DOS (for IBM-type computers) and was developed at the University of Guam in 1989-90 under separate funding. The shell program now developed allows its use in a Macintosh computer. Future plans call for each record having a graphic illustration of symptoms which can be viewed on screen or typed into a fact sheet format in high resolution color. The database will be accessible by phone or sattellite link from within the Pacific region.

DETECTION OF CUCURBIT VIRUS

G.C. Wall

A new technique for identifying viruses was developed in this research project, which enables scientists to travel to remote sites and bring back samples for analysis in a laboratory. The technique poses no plant quarantine problems because all that is needed is some plant sap blotted onto a special kind of paper. Nitrocellulose membranes were pre-coated with specific antibodies for five different cucurbit viruses at the University of Hawaii, then sent to Guam for surveying purposes. The viruses tested were Cucumber Mosaic Virus (CMV), Papaya Ringspot Virus, watermelon strain (PRV-w), Zucchini Yellow Mosaic Virus (ZYMV), Watermelon Mosaic Virus II (WMV II), and Squash Mosaic Virus (SqMV). Researchers from CALS travelled to Saipan, Rota, Tinian, Chuuk (Moen and Ferfan), Ponape and Kosrae. In addition, Guam cucurbit crops and weeds were also sampled.

Cucurbit samples were taken from growers' fields, then plant sap was blotted onto the specially treated papers. These were then placed in a plastic container with dessicant to prevent mold formation. All these specially treated papers were then shipped to Hawaii via express mail and were processed at the University of Hawaii. Results revealed that the most abundant viruses throughout the region are PRV-w and ZYMV. Many cucurbit weeds were found to be infected with these viruses, which means that they act as sources of infection for growers' crops. This information is essential for future efforts to control these destructive virus diseases on cucurbit crops.

EPIDEMIOLOGY OF VIRUS ON WATERMELON

G.C. Wall

Studies to determine the affect of virus infection on different growth stages of watermelon were started. Work will not be completed until next year. Results of these tests will be used in the intergrated pest management model developed by the ADAP (Agricultural Development in the American Pacific) program.

AGRICULTURAL ECONOMICS

SMALL LANDHOLDERS ON GUAM

J.W. Brown

The common name taro is used to refer to *Colocasia, Xanthosoma, Cyrtosperma,* or *Alocasia.* Today, taro remains an integral part of the farming systems and diets of many people living on Pacific Islands. Although Oceania only produces about 5.5 percent of the total taro produced worldwide, the crop is important for the people the region. In the tropics, staple food crops such as taro are often planted in small amounts on a continual basis. Large scale production is not as common as planting smaller sections in intervals. One advantage of this method is it allows the grower to plant and harvest taro continuously throughout the year.

Taro is an important cultural crop to many farmers in Guam. Much of the taro is produced for family use only. It is an important part of many social functions of the indigenous Chamorro people. In a sense, taro's importance as a crop stems from the desire for the farmers and the Chamorro population in general to preserve their culture.

Planting taro in Guam is mostly done by hand although mechanical planting has been used in some cases. A common plant spacing is 3 by 3 feet yielding 4,785 plants per acre. The cropping cycle for taro is variable but usually ranges from six to eight months. Taro is most often planted after the dry season, and its harvest is often planned to correspond with the Christmas season. Fertilizers are used in a non intensive way, usually some formulation of N-P-K is applied during the first three months of growth. The use of other agrochemicals is currently done on an irregular basis. Cultivation is often done by rototiller or tractor between rows and by hand between plants.

Farm prices for taro have been reported as high as $2.00 per pound in Guam. Farm gate prices ranged from $1.08 to $2.00 depending largely on quality.

Information on the costs of production of taro on Guam was developed from information provided by Joe Cruz of the Agricultural Experiment Station and Frank Cruz of the Cooperative Extension Service. In depth interviews were also conducted with three commercial farmers.

Variable costs were $2,133 and fixed costs were $2,598, giving a total cost of $4,731. This is the second highest cost of the five areas studied. Revenue is $10,604 based on a yield of 7,779 pounds per acre. Giving the highest returns to management of any of the five areas studied at $5,873 per acre. Of the variable costs, labor was the largest component at $1512 or 32 percent of total costs. Breakeven yield was 3,478 pounds and breakeven price was $0.61 per pound.

GUAM ORCHIDS AS CARRY-ON GIFTS: TARGETING THE JAPANESE TOURIST MARKET

J.W. Brown and J. McConnell

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

One potential area of opportunity is the development of a local orchid industry catering to the tourist trade. There are at least three possible approaches open for development. First, an orchid garden or farm could be developed as a day-trip destination. Second, orchids could be sold to the hotel and restaurant industry for decoration and atmosphere. Third, orchids could be marketed directly to the tourists for use on-island or to carry home as gifts. Currently, one of the locally grown gifts of choice for the Japanese tourists visiting Hawaii or Southeastern Asia is orchids. The Japanese love orchids. However, their preferences and gift-giving patterns do not necessarily coincide with the western aesthetic.

A poster display and survey instrument using a conjoint analysis methodology were designed to investigate the differences between Japanese and Western aesthetics for orchids. Arrangements were made to place the poster display in the exit lobby of the Antonio Won Pat International Airport for a two week

period starting February 3, 1992. Three native speaking Japanese students with various level of English skills and one bi-lingual local student were hired as enumerators.

The Japanese tourists responded much more strongly in favor of a pure white orchid than did the western group. The Japanese also were more negative towards spotted or striped color patterns on the flowers. Both groups preferred darker colors to lighter ones, and for both groups, yellow was the least preferred color. Red was slightly favored by the Japanese, while purple was slightly favored by the western group. The was a wide variety of individual responses in both groups. The wide variety of responses to our survey indicates that there will always be room in the market place for many varieties of orchids in both the West and in Japan.

Overall, the marketing of cut-orchids to the Japanese tourists is feasible on Guam. The are not significant plant quarantine barriers, and there was an overall favorable response from the tourists surveyed on the concept of cut-orchids as a gift. The primary problem does not seem to be one of marketing, but rather of production. Some mechanism for dealing with the recurrent typhoons and tropical storms which plague the island will have to be developed before such a venture can be successful.

AN ECONOMIC ANALYSIS OF SIGANID CULTURE IN GUAM,THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS AND THE FEDERATED STATES OF MICRONESIA

J. W. Brown and D. Crisostomo

Rabbitfish (*Siganidae*) are a traditional and highly valued food fish in the Indo-Western Pacific. They are often preferred over other popular reef fish such as parrotfish (*Scaridae*) and surgeonfish (*Acanthuridae*). Rabbitfish are currently cultured by traditional methods in the northern Philippines, often in a polyculture with milkfish. They are also cultured in Taiwan and in Saudi Arabia.

Early work on the potential use of rabbitfish in mariculture was done at the University of Guam Marine Laboratory and the Micronesian Mariculture Demonstration Center in Palau. This work was abandoned because, at that time (the mid-1970s), it was concluded that rabbitfish culture was not an economically viable enterprise in the Western Pacific.

Since the mid-1970s, the economies of Guam and the Commonwealth of the Northern Mariana Islands have undergone vast changes. Both economies are thriving under a tourism-driven boom and conclusions made in the mid-70s about the economic feasibility of rabbitfish culture need to be re-evaluated. Rabbitfish culture techniques have been refined, and a recently described species, *Siganus randalli*, has yielded good results in preliminary aquaculture trials. The purpose for this reappraisal is to provide potential investors, researchers and funding agencies with an analysis of the feasibility of culturing rabbitfish throughout the western Pacific islands.

On 12 December, 1991, a group of 134 *S. randalli* juveniles which had been spawned and raised by Dr. Steven Nelson of UOG at the GADTC hatchery to 93 days of age, were anesthetized, weighed and measured. These fish were then placed in a two 0.9 m^3 cages in a 3 m x 65 m x 1 m flow-through raceway. Nine days later, the surviving 128 fish were randomly placed in one of four 0.9 m^3 PVC-framed, half-inch plastic mesh cages. Two cages had "low" densities (i.e., 20 and 28 fish) and two cages had "high" densities (40 fish each.) Fish in each cage were fed by placing a commercial pelletized feed in a feeding tray placed on the bottom of each cage. A commercial catfish feed (36 percent protein) was originally used by itself. Eventually this was supplemented with an addition of 7.5 g/fish/day of *Enteromorpha* spp., a green filamentous algae which the fish eat in the wild and which is readily available on the reef flat before the annual recruitment of juvenile rabbitfish in late spring. The growth trials began on December, 21, 1991 and lasted until April 14,1992, a total of 112 days.

After the initial mortalities during the conditioning period, survival was excellent. No fish were lost to natural mortalities. A total of 124 fish remained at the end of the experiment.

The fish initially weighed an average of 13.6 grams and averaged 121.7 grams at the conclusion of the experiment. This is an average weight gain of 0.97 grams per day. The specific daily growth rates (calculated as (final weight/initial weight) $^{1/days}$ -1) generally declined as the fish grew. The overall specific growth rates from the four consecutive 28-day growth periods were 2.6, 2.5, 1.2 and 1.6 percent body weight per day. The fish averaged 2.0 percent body weight gain per day for the entire period.

Rabbitfish are not yet ready for commercial

AGRICULTURAL ECONOMICS

CONTINUED

production in Micronesia. The culture system technology is still very much unproven. Neither cage nor pond culture has been demonstrated at densities high enough to make either venture commercially viable. More importantly, the production of juveniles has not been perfected and any present commercialization would be dependent upon the naturally occurring and highly unreliable annual recruitment events.

However, rabbitfish do appear to have commercial potential at densities that are realistically attainable in both pond culture on Guam and in cage culture in Saipan, Chuck and Yap. Pohnpei and Kosrae are too far removed from the primary markets in the Mariana Islands to make cage culture commercially viable on these islands.

Marketing will not be a problem. Siganids are highly prized fish that bring a good price in the market. The economics of their culture is promising. There are two problems, larval rearing and nutrition, which will have to be resolved before commercialization can be realized. Demonstrating the feasibility of rabbitfish culture at the higher densities necessary for commercial viability is a project worthy of governmental sponsorship. However, the unresolved problems of larvae production and feed formulation should be resolved before further attempts are made at demonstrating methods for higher density culture.

COMMERCIAL SPONGE MARKET PROMOTION

R. Croft and J. W. Brown

Prior to 1940, the Japanese in Micronesia experimented with culturing commercial sponges.

The feasibility of farming commercial sponges again is being demonstrated on Pohnpei. Training potential sponge farmers and assisting them in starting their own farming is also underway. Since mid-1984, Richard Croft has been experimenting with culturing commercial sponges within the lagoon of Pohnpei.

While there is at least one species of commercial sponge growing within Micronesia, there may be three to four other species with commercial value. Island residents harvest at least one species and highly value it for bathing infants. Worldwide the demand for natural sponges continues to be high. However, the world production for all species of commercial sponges has dropped from an average of 1,346 tons per year from 1927 to 1936 to an average of 222 tons per year from 1977 to 1980. In recent years, major sponge supplies have been from the Mediterranean, but blight is seriously damaging these sources.

The purpose of this project is to explore the various immediate and initial markets for commercial sponges, to include tourist markets on Guam, Saipan and Pohnpei. This will be done to determine the best markets for islanders to enter considering our location, our small size, and our production limits in the next few years.

The project will promote the establishment of a viable commercial sponge aquaculture industry within the region. The development of a high priced regional market for sponges can allow mariculturists to incur the risks of starting culture of other species. It also can remove some of the pressure from over-harvesting other marine products. Sponge culture is also very appropriate for outer island development.

ANIMAL SCIENCE

CRUSHED CORAL FOR LAYING HENS

F.G. Abawi and O. Diambra

Two experiments were conducted to evaluate suitability of feeding local limestone (crushed coral) as a source of calcium for poultry. Laboratory analysis indicate that local limestone deposits on Guam contain an average of 33.75 percent calcium which is quite comparable to imported commercial limestone. In Experiment 1, 128 layers of a commercial cross were randomly assigned to four dietary treatment groups of 32 birds each. Two levels each of commercial and local limestone (3.8 percent, 4.5 percent) were evaluated. Experiment 2 was conducted on older layers after the first molt. treatments consisted of three levels of calcium from local source (4, 4.5, and 5 percent) and two levels of calcium from a commercial source (4 and 5 percent).

Results of Experiments 1 and 2 clearly indicate that with respect to egg production, feed efficiency, egg weight, shell thickness, shell weight and shell strength, local crushed coral is as good a source of calcium for poultry as commercial limestone. Crushed coral at a slightly higher inclusion rate (4.5 percent) significantly improved feed consumption of laying hens as compared to commercial source with no apparent signs of toxicity.

TANGANTANGAN *(LEUCAENA)* FOR LAYING HENS

F.G. Abawi and O. Diambra

Two experiments were conducted to evaluate leucaena leaf meal (LLM) with or without crushed coral as a source of calcium and to compare LLM's merit with commercial dehydrated alfalfa meal (AAM). In Experiment 1, 128 layers of the commercial "Gold Links" cross were randomly assigned to four dietary treatment groups of 32 birds each in a completely randomized design. Treatments consisted of 3 percent alfalfa meal (AAM), 3 percent leucaena leaf meal (LLM), 0.1 mg/kg supplemental riboflavin, and a control. In Experiment 2, post-molt layers were randomly assigned to four dietary treatments that consisted of two levels of LLM (0, 3 percent) and two sources of calcium (commercial limestone, crushed coral). Results of Experiment 1 indicate that LLM, at 3 percent inclusion without supplemental iron salts, is comparable to imported AAM. Both LLM and AAM diets significantly improved feed consumption ($p<0.05$). In Experiment 2, LLM significantly improved feed consumption and hen-day egg production ($p<0.05$). However, shell thickness was significantly decreased ($p<0.05$). Hens receiving crushed coral diets maintained significantly higher egg production and body weight ($p<0.05$), compared to those on commercial limestone. Source of calcium and source of calcium x LLM interaction were also significant ($p<0.05$) with respect to body weight.

EFFECT OF FEED PROCESSING AND ENZYME SUPPLEMENT ON BOILER PERFORMANCE

F.G. Abawi and O. Diambra

In a preliminary study the effect of dry-extruding process, on a mixture of local feed ingredients, was evaluated using broiler chicks. Eighty birds (straight run) were randomly assigned to four dietary treatments with five replicates of four birds each at 28 days of age. The local feed mixture was composed of cassava meal, full fat copra and leucaena leaf meal in a ratio of 3.75:2.5:1. The experimental diets consisted of unprocessed mixture, dry-extruded mixture, and extruded mixture with added cellulase enzyme. A corn-soybean meal-based diet served as the control. Data were collected for 21 days. Feed efficiency was significantly ($p<0.05$) improvement for the extruded mixture and depressed for the un-extruded local mixture. Enzyme addition did not have any significant effect on feed efficiency. Daily feed consumption, weight gain and abdominal fat pad weight were not affected by treatments. This study suggest possible improvements in nutritive value of tropical feed based diets for growing finisher broilers by dry-extrusion process.

PROJECTS

HATCH PROJECTS

•Improving the status of tropical fruit crops through selection, introduction and breeding - T. Marler
•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.C. Wall
•Development of cultural, chemical and biological control methods for pests of cruciferous crops on Guam - R. Muniappan
•Nitrogen and potassium interaction on the production of selected vegetables - J.A. Cruz
•Use of locally available feedstuffs and potential feed sources on Guam for poultry feeding - F.G. Abawi
•Small landholders of Guam: Production analysis and risk-avoiding behaviors - J. Brown
•Evaluating alley cropping for a low input sustainable head cabbage production on Guam - J.L. 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

NAPIAP

•Comparison of different formulations of *Bacillus thuringiensis* for management of Asian corn borer - I. Schreiner

1992 REGIONAL RESEARCH PROJECTS

•Establish, improve and evaluate biological control in pest management system of plants - D.M. Nafus
•Water nutrient managment of crops under micro irrigation - P. Singh
•Biological suppression of soilborne plant pathogens - G.C. Wall

PACIFIC AQUACULTURE ASSOCIATION

•Development of markets for Micronesian sponges - J. Brown and R. Croft

USDA CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

•Aquaculture marketing assistance program - D. Crisostomo and J. Brown

TROPICAL AND SUBTROPICAL AGRICULTURAL RESEARCH PROGRAM

(formerly SECTION 406)

•Effect of insect induced changes in the Siam weed on three trophic levels - R. Muniappan, J. McConnell, M. Marutani and G.R.W. Denton
•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 and D. Gonsalves
•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 - I. Schreiner and D. M. Nafus

ADAP PROJECTS

•Biological control of the fruit piercing moth, *Othreis fullonia*, in the American Pacific - R. Muniappan
•Mass rearing, introduction and assessment of *Pediobius foveolatus*, parasite of *Epilachna* sp. – I. Schreiner, D. Nafus and A. Vargo
•Assessment, mass rearing, and introduction of *Gryon pennsylvanicum*, a parasite of *Leptoglossus australis* - I. Schreiner, D. Nafus, N. Esguerra, and A. Vargo
• Epidemiology of virus on watermelon – G.C. Wall
• Plant Diseases Database – G.C. Wall

USDA MARKETING RESEARCH SERVICE

•Guam orchids as carry-on gifts: targeting the Japanese tourist market – J. Brown and J. McConnell

TRAVEL

Conferences and Meetings Attended

Abawi, F.	Infomation on animal production Chuuk, Pohnpei, Kosrae, Marshalls June 22 - July 3, 1992
Abawi, F.	Information on animal production Saipan, Rota, Tinian July 7-11, 1992
Brown, J.W.	Orchid Conference Nagoya, Japan March 10-15, 1992
Brown, J.W.	Rabbit Fish Project Mtg. Pohnpei April 22-26, 1992
Brown, J.W.	World Aquaculture Soc. Mtg. Orlando, Fl. May 21-25, 1992
Brown, J.W.	Sponge Farming Mtg. Pohnpei Sept. 22-26, 1992
Brown, J.W.	To test catfish processing Mississippi Nov. 8-19, 1992
Brown, J.W.	Manuscript preparation on tourism Honolulu, HI Nov. 8-19, 1992
Marler, T.	Plant Stress Workshop Kona, HI Sept. 20-25, 1992
McConnell, J.	Biocontrol of Weeds Conf. Christ Church, NZ Feb. 2-7, 1992
McConnell, J.	Orchid conference Nagbya, Japan March 10-15, 1992
McConnell, J.	Am. Soc. Horticultural Science Honolulu, HI August 1-6, 1992
Muniappan, R.	Biocontrol of Weeds Conf. Christ Church, NZ Feb. 2-7, 1992
Muniappan, R.	O.S.U. Entomology Alumni Mtg. Stillwater, Okla. Feb. 12-14, 1992
Muniappan, R.	Section 406 meeting Honolulu, HI April 8-9, 1992
Muniappan, R.	Entomology Congress Beijing, China June 28 - July 4, 1992
Muniappan, R.	Western Agrl. Expt. Station Directors Meeting Monterey, CA July 19-22, 1992
Muniappan, R.	Plant Stress Workshop Kona, Hawaii Sept. 20-25,1992
Muniappan, R.	Erythrina workshop Costa Rica October 19-23, 1992
Marutani, M.	Visit to NifTAL Project Maui, HI Aug. 24-27, 1992
Marutani, M.	Plant Materials Center, SCS Molokai, HI Aug. 28, 1992
Marutani, M.	Plant Stress Workshop Kona, HI Sept. 20-25, 1992
Marutani, M.	Visit to AVRDC Shanhua, Taiwan Nov. 28 - Dec. 5, 1992
Nafus, D.	Entomology Congress Beijing, China June 28 - July 4,1992
Nafus, D.	Western Regional Biocontrol Mtg. Honolulu, HI Oct. 14 - 16, 1992
Schreiner, I.	Entomology Congress Beijing, China June 28 - July 4, 1992
Schreiner, I.	Taro Conference Honolulu, HI Sept. 24-25, 1992
Singh, P.	Plant Stress workshop Kona, HI Sept. 20-25, 1992
Wall, G.C.	Am. Phytopathological Soc. Annual Mtg. Portland, OR August 8-12, 1992
Wall, G.C.	Int'l Bacterial Wilt Symposium Kaohsiung, Taiwan Oct. 28-30, 1992

PUBLICATIONS

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Marutani, M. and R. Muniappan. 1992. Host preference of pests on cruciferous crops on Guam. In: Schreiner, I. and D. Nafus (Eds.). Crop Protection in the American Pacific. Proc., Second ADAP Crop Protection Conf.; Univ. Guam. pp. 41-47

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Funding for this publication has been provided by the Hatch Act administered by the Cooperative State Research Service, USDA and the Government of Guam.

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This publication was produced by the staff of the Media Unit, College of Agriculture and Life Sciences, 1993. Special thanks to Dr. James McConnell for computer assistance.