GUAM AGRICULTURAL EXPERIMENT STATION

ANNUAL REPORT 1979

College of Agriculture and Life Sciences
University of Guam

1979 ANNUAL REPORT
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During 1979, much of our administration effort was concentrated on taking steps to bring in some of the federal programs for which Guam was not previously eligible. Some of these programs were Section 406 of Public Law 89-808, Section 22 of the Water Resources Development Act of 1974, the Land Reclamation Act of 1902, Soil Consergation Service, Title 4, and a few others. By the time this report was sent to the printer in mid 1980, we had already begun to reap the fruit of our labor.

Additionally, we have also secured local authorization to seek $450,000 from EDA for construction of a road and to set up a food processing unit at the Agricultural Experiment Station.

We have added Agricultural Economics to this report and we will be adding a section on Ornamental Horticulture in the 1980 report.

Wilfred P. Leon Guerrero
Dean / Director

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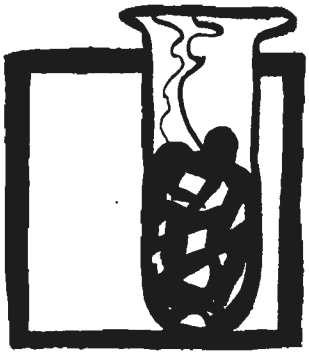


Soil Fertility

Nitrogen level and source experiments were conducted in two locations using corn and bell pepper as test crops. The corn experiment had seven treatments using different levels of nitrogen as supplied by ammonium sulfate and air-dried chicken manure. This was conducted during the dry season (January-April) in Dededo. Although yield increased as nitrogen level was increased, the yield was not statistically significant. Asiatic corn borer *(Ostrinia furnacalis)* and corn earworm *(Heliothis sp.)* attacks, which had plagued earlier corn and tomato experiments, were minimized with weekly spraying of Lannate L. (794 ml per 189 l). However, the effects of a prolonged drought, where less than three inches of rain fell during the first two months of the growing season, affected crop stand and yield. Although a follow-up study was conducted to determine residual effects, the data gathered will not be discussed pending a repeat of the experiment when drip irrigation will be used next year.

The bell pepper experiment was conducted February through May at the Agricultural Experiment Station in Inarajan where sprinklers were available to irrigate the field. The soil at the Station is Guam clay which is an Inceptisol with the subgroup *Lithic ustropepts*. This experiment is a long-term study on the effects of different nitrogen sources.

Two treatments utilized intercropping using *Leucaena leucocephala* (tangantangan) and *Arachis hypogea* (peanut CES 103 provided by the University of the Philippines at Los Banos). All rows are a meter apart and test vegetables are grown between rows. The stability of the vegetable intercrop is tested with no addition of any inorganic nitrogen source.

The *Leucaena* "hedge" was trimmed when it tended to shade the vegetable intercrop. The leaf and stem clippings were then worked into the soil. The frequency of cutting is shown in Table 2. The only turnover from the peanut intercrop was after harvest where crop residue was rotatilled within the same treatment rows.

The chemical analysis of the materials used are shown in Table 1. It should be pointed out that tangantangan leaves had the highest nitrogen

content of the materials used, although as far as micro-elements are concerned, chicken manure and the peanut residues had much higher contents than tangantangan.

The tangantangan clippings were 24% stem and 76% leaves by weight. The nitrogen input to the soils from the leaves amounted to 349 kgm and 28 kgm from the stems through the month of May. The rainy season (June to November) clipping yield amounted to 18.26 tons of leaves and stems. This is equivalent to an input of 528 kgm N and 59 kgm N from the leaves and stems, respectively. For the year, a total of 867 kgm N per hectare was added to the soil from tangantangan.

The actual treatments and yield of the bell pepper experiment are shown in Table 3. The legumes and chicken manure treatments had yield lower than the control where no nitrogen was added. This depressed yields could be attributed to nutrient uptake competition in the case of legumes. The chicken manure treatment needs further studies for any postulations. The use of inorganic nitrogen (ammonium sulfate) resulted in the near doubling of yield. The addition of chicken manure to a 100 kgm N from $(NH_4)_2SO_4$ did not significantly increase yield over the 100 kgm N alone. This implies that the N in the chicken manure was not available for plant utilization.

A residual study was carried out in July-September using tomato (N-11 variety) as the test crop. Individual plots and rows were rotatilled and cultivated by hand. Conscious efforts were made to prevent interplot or row movement of soil. This experiment was cut short after three harvestings due to heavy rains in September.

Tomato yield is shown in Table 4. The yield ranged from .68 to 2.98 tons per hectare. This is "normal" for wet season yield. The tangantangan rows were maintained. The plants growing in-between were observed to be more vigorous than the rest of the field. The stability of the vegetable intercrop with tangantangan during the wet season needs further study.

Although the initial studies show a depressed yield in the legumes intercrops, the nitrogen turnover from *Leunaena*, 867 kgm N/ha/years and from peanuts 382 kgm N/ha/cropping cannot be discounted. This is an ongoing study. Maybe subsequent results will leads to better utilization of legumes as a source of nitrogen fertilizer.

Table 1. Chemical analysis (oven-dried at 70°C) of the nitrogen source material used in the bell pepper experiment at Inarajan.

Material*		N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
1.	Leaves	5.29	.12	1.51	.75	.16	.08	157	120	58	17
	Stems	1.69	.10	1.55	.42	.12	.10	96	30	27	13
2.		3.33	.10	2.25	14	.58	.15	551	200	420	34
3.	Leaves	2.29	.09	.77	3.07	.24	.09	329	323	105	53
	Stems	1.12	.07	.75	1.34	.28	.12	363	109	38	30
	Roots	1.93	.09	.44	1.14	.12	.43	515	121	22	11

*1. Leucaena leucocephala (tangantangan)
2. Chicken manure from Flores Poultry Farm
3. *Arachis hypogea* (peanuts)

Table 2. *Leucaena Leucocephala* trimming yield of leaves and stems in tons per hectare*.

Date	Yield
January	3.270
March	2.250
April	1.697
May	1.474
June	3.680
July	2.117
August	4.316
September	4.148
November	3.042
Total	25.994

**Arachis hypogea* yielded an average of 24.213 tons per hectare of leaves, stems, and roots combined at harvest time with a total nitrogen content of 382 kgm.

Table 3. Bell pepper yield in tons/ha as affected by different nitrogen sources in plots at the Agricultural Experiment Station in Inarajan.

Number	Treatment*	Yield*
1.	Zero nitrogen	10.50
2.	*Leucaena leucocephala* intercrop	6.63
3.	*Arachis hypogea* intercrop** *	6.07
4.	6 tons/ha chicken manure	7.28
5.	100 kgmN/ha from $(NH_4)_2SO_4$	18.61
6.	100 kgmN/ha from $(NH_4)_2SO_4$ plus 3 tons/ha chicken manure	19.71
7.	200 kgmN/ha from $(NH_4)_2SO_4$	20.71
	02(.05)	7.00

*Phosphorous (treble superphosphate) and potassium (sulfate of potash) were blanket applied at 300 kgm P_20_5 per hectare and 300 kgm K_20 per hectare respectively prior to transplanting. $(NH_4)_2SO_4$ was split applied, haf at transplanting and half three weeks later.

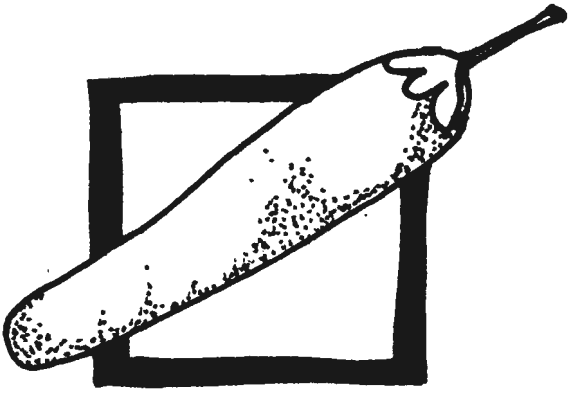
* *Significant at the 1% probability level.

* * *The *Arachis hypogea* intercrop yielded 1.883 tons of shelled peanut seeds.

Table 4. Tomato yield in tons/ha/as affected by nitrogen source in plots previously grown with bell pepper at the Agricultural Experiment Station in Inarajan.

Number	Previous Treatment	Yield*
1.	Zero nitrogen	1.18
2.	*Leucaena leucocephala* intercrop	2.54
3.	*Arachis hypogea* intercrop	.68
4.	6 tons chicken manure	.97
5.	100 kgm N/ha from $(NH_4)_2SO_4$	1.14
6.	100 kgm N/ha from $(NH_4)_2SO_4$ plus 3 tons/ha chicken manure	1.36
7.	200 kgm N/ha from $(NH_4)_2SO_4$	2.98
	$LSD_{(.05)}$	1.32

*Significant at the 5% probability level.



Horticulture-Vegetable Crops

The horticultural (vegetables) research work in 1979 at the University of Guam's Agricultural Experiment Station continued to focus on screening and determining the adaptability of major vegetable varieties which have economic potential and suitability for growth in the environmental conditions of Guam.

Vegetable varieties under study in 1979 were tomato, bell papper, and head cabbage. The promising variety of bell pepper was being used in conjunction with the study of the response to trickle irrigation.

I. VARIETAL PERFORMANCE STUDIES ON HEAD CABBAGE

Material and Methods. This experiment was conducted during the dry season of 1979 to evaluate the effect of environmental factors on the performance of head cabbage. Ten varieties of head cabbage from Japan, Taiwan, New Zealand, and the U.S. mainland were included in this trial, namely; Savoy Drumhead, Succession, Flower of Spring, Thway Kuany 60 day, Yates Prize Red, Copenhagen Market, Velocity Cross, Golden Acre, Ruby Ball, and Spring Light.

Seeds were sown in Jiffy-7 pellets and one-month-old seedlings were transplanted to the field. A randomized, complete block design with three replications was used. Each experimental plot consisted of three rows 4.88 meters long. The spacing adopted was 1.22 meters between rows and 0.71 meters within rows. 15-15-15 fertilizer at the rate of 897 kg/ha was broadcast and incorporated into the soil before transplanting. Sidedressing with the fertilizer at the same rate was initiated three to four weeks after transplanting.

A preventive spraying program was followed twice weekly to control possible insect and disease damage. Dibrom 8E, Malathion 50, Dipel, Dithane M-45, and Tribasic Coppers were used. A rotary tiller and garden hoe were used to control weeds. Sprinklers were used for irrigation.

Harvesting was started when the head attained sufficient size and is cut with a large knife or machete at harvesting. Marketable yield was based on the head which was free of burst, insect, and disease. The unmarketable yield was the head damaged by burst, insect, or disease.

Forming Head and Head Weight. Environmental factors, such as high day and night temperatures, were limiting head cabbage production by causing bolting and/or not forming a head. Of the ten varieties, four varieties did not form heads and six varieties formed heads.

The four varieties that did not form heads were Savoy Drumhead, Succession, Flower of Spring, and Yates Prize Red. The remaining six varieties formed heads ranging from 0.40 to 1.73 kg per head. The head weight of Spring Light was the heaviest and Thway Kuang 60 day was the second heaviest; while Velocity, Golden Acre, and Ruby Ball were the lightest.

Marketable Head Yield. Spring Light with a production of 28.60 MT/ha significantly outyielded the rest of five heading varieties; while Velocity Cross and Golden Acre with 6.76 and 6.23 MT/ha respectively, were the lowest. There was no significance in head yield among Thway Kuang 60 day, Copenhagen Market, and Ruby Ball.

Unmarketable Head Yield. The unmarketable heads were mostly attributed to bacterial soft rot disease. The forming head varieties were all susceptible to the disease, ranging from 20 to 60%. Ruby Ball was the least susceptible to soft rot disease and Thway Kuang 60 day was the most susceptible one. Ruby Ball, Golden Acre, and Velocity ranged from 4.10 to 6.25 MT/ha and showed the lowest unmarketable head yield. Thway Kuang 60 day with 22.15 MT/ha had the highest unmarketable yield.

Conclusion. Based on appearance, texture, size, and yield; Spring Light, Thway Kuang 60 day, and Copenhagen were the promising varieties per the results of the experiment conducted during the dry season of 1979. (See Table I.)

Table I. Performance of Head Cabbage During Dry Season 1979 on Guam.

Variety	Forming Head	Head Weight (kg)	Marketable Yield (MT/ha)	Unmarketable Yield (MT/ha)	Bacterial Soft Rot (%)
Savoy Drumhead	No				
Succession	No				
Flower of Spring	No				
Thway Kuang 60 day	Yes	1.44	14.42	22.15	60%
Yates Prize Red	No				
Copenhagen Market	Yes	1.04	13.05	12.94	47%
Velocity Cross	Yes	0.60	6.75	6.25	43%
Golden Acre	Yes	0.55	6.23	6.00	40%
Ruby Ball	Yes	0.40	16.20	4.10	20%
Spring Light	Yes	1.73	23.60	14.50	32%
$LSD_{0.05}$		0.25	3.30	2.75	

II. VARIETAL PERFORMANCE STUDIES ON BELL PEPPER

Material and Methods. This bell pepper experiment was conducted during the dry season of 1979. The objective was to evaluate the climatic factors on the varietal performance. Eleven varieties of bell pepper which were promising in the previous trials were selected in this experiment. They were; Twilley's Big Pack, Florida Giant, Keystone Giant, World Beater, Yan Kwang, World Giant, Nan Chin 502, ACE, Big Star, Feng Shan Ruby King, and Blue Star. Seeds were sown in Jiffy-7 pellets and one-month-old seedlings were transplanted to the field. A randomized complete block design with three replications was used. Each experimental plot was a single row of 15.24 meters long. The spacing adopted was 1.22 meters between rows and 0.91 meters within rows. A 10-20-20 fertilizer at the rate of 773 kg/ha was broadcast and incorporated into the soil before transplanting. Side-dressing with the fertilizer at the same rate was initiated immediately after the first harvesting.

A preventive spraying program was followed twice weekly to reduce possible insect, mite, and disease damage. Dibrom 8E, Malathion 50,

Kelthane, Dithane M-45, and Tribasic Coppers were used. A rotary tiller and garden hoes were used to control weeds. Sprinklers were used for irrigation.

Harvesting was started when the fruit had attained the desirable size, but were still green, waxy, and shiny. Good shape, thick flesh, good color, and fresh appearance were the criteria for initiating harvest. The harvest period lasted for about two months.

Marketable yield was based on the fruit which was free of insect and disease damage, while the unmarketable yield was the fruit damaged by insects and diseases.

Weight of Fruit. Nan Chin 502 with a fruit of 99.00 was significantly heavier than the rest of the ten varieties. There was no significance in fruit weight among World Giant, Yan Kwang, Big Star, Feng Shan Ruby King, and Florida Giant, ranging from 90.10 to 94.21 grams. World Beater and ACE were the lightest in fruit weight with an average of 70.71 grams.

Marketable Fruit Yield. There was no significance in marketable fruit yield among ACE, World Giant, Nan Chin 502, Keystone Giant, Feng Shan Ruby King, and World Beater, ranging from 15.11 to 16.05 MT/ha. Blue Star, Big Star, and Florida Giant with an average of 12.96 MT/ha were the lowest in marketable yield production.

Unmarketable Fruit Yield. Insect and disease problems that contributed to the unmarketable fruit yield were less in dry season in comparison to wet season. Yan Kwang with 0.31 MT/ha was the highest in unmarketable fruit yield, while Nan Chin 502 with 0.18 MT/ha was the lowest. The rest of the nine varieties ranged from 0.22 to 0.30 MT/ha in unmarketable fruit yield.

Conclusion. Based on the appearance, texture, size, and yield; World Beater, Feng Shan Ruby King, Keystone Giant, Nan Chin 502, World Giant, and Yan Kwang were the promising varieties as per the results of the experiment conducted during the dry season of 1979. (See Table II).

Table II. Performance of Bell Pepper During Dry Season of 1979.

Variety	Fruit Weight (gram)	Marketable Yield (MT/ha)	Unmarketable Yield (MT/ha)	Unmarketable Yield (%)
Twilley's Big Pack	82.20	14.05	0.30	2.09
Florida Giant	90.10	13.21	0.22	1.64
Keystone Giant	88.00	15.28	0.24	1.55
World Beater	71.00	16.05	0.23	1.41
Yan Kwang	92.45	14.50	0.31	2.09
World Giant	92.21	15.25	0.25	1.61
Nan Chin 502	99.00	15.26	0.18	1.17
ACE	70.42	15.11	0.22	1.44
Big Star	91.20	13.07	0.28	2.14
Feng Shan Ruby King	90.40	15.58	0.27	1.70
Blue Star	81.80	12.59	0.29	2.25
$LSD_{0.05}$	5.10	1.10	0.08	

III. VARIETAL PERFORMANCE STUDIES ON TOMATO

The Agricultural Experiment Station is cooperating with Asian Vegetable Research and Development Center (AVRDC) for tomato research. Five of the AVRDC breeding lines were eliminated from the experiment during the dry season of 1979 due to very low yields and poor growth under Guam's conditions during the wet season. Ten entries of tomato were included in the experiment of dry season of 1979. They were: CL9d-0-3-6UG, CL123-2-4UG, CL-143-0-4B-1UG, CL143-0-6-9UG, L1GS, Roma, Bonney Best, Grosse Lisse, Fire Ball, and Potentate.

Seeds were sown in Jiffy-7 peat pellets approximately one-month-old seedlings were transplanted to the field. A randomized complete block design with four replications was used. Each experimental plot consisted of two rows four meters long and rows were spaced one meter apart. The seedlings were set 0.4 meters in the rows. A 10-20-20 fertilizer at the rate of 448 kg/ha was broadcast and incorporated into the soil before transplanting.

Side-dressing with the fertilizer at the same rate was initiated immediately after the first harvest.

A preventive spraying program was followed twice weekly to reduce possible insect, mite, and disease damage. Diazinon Ag 500 EC, Malathion 50, Lannate L, Kelthane, Dithane M-22 or M-45, and Tribasic Coppers were used. A rotary tiller and garden hoes were used to control weeds. Sprinkling irrigation was used whenever watering was needed.

The fruits were harvested at ripe or red ripe stage and the promising seeds were prepared and saved for the next experiment and distributed to the local farmers. Harvesting periods were seven weeks from the time of first harvest.

Growth Habit, Fruit Setting, and Fruit Cracking. All the entries, except Bonney Best, Grosse Lisse, Fire Ball, and Potentate, have determinate habit of growth. The fruit setting ability of CL143-0-6-9UG and CL143-0-4B-1UG was very high, while the four indeterminate varieties were very low. CL123-2-4UG, CL143-0-4B-1UG, CL143-0-6-9UG, and Roma had none to light cracking on fruits; while Bonney Best, Grosse Lisse, and Fire Ball had medium to heavy cracking.

Fruit Weight and Number of Fruit. The fruit weight of AVRDC breeding lines were very small to small size, ranging from 21 to 75 grams. Fire Ball with 141 grams in fruit weight was significantly heavier than the rest of the nine breeding lines of varieties, and Grosse Lisse was the next heaviest. CL143-0-6-9UG with 26 grams was the smallest in fruit weight.

The number of fruit on tomato plant is affected by fruit setting. Poor fruit setting will result in lower number of fruit. The number of fruit on CL143-0-6-9UG was the highest at 107 per plant and CL143-0-4B-1UG was the next highest with 55 fruits. The number of fruits on Roma, Bonney Best, Grosse Lisse, Fire Ball, and Potentate were the lowest ranging from 5 to 11 fruits per plant.

Marketable Fruit Yield. CL143-0-4B-1UG and CL143-0-6-9UG with a production of 68.31 and 66.9 metric tons per hectare, respectively, significantly outyielded the other eight entries; and CL9d-0-3-6UG was the next highest in fruit yield. Roma, Bonney Best, Grosse Lisse, and Potentate with an average of only 7.45 metric tons per hectare were the lowest in marketable fruit production.

Unmarketable Fruit Yield. Unmarketable fruits were attributed to fruit cracking, insect or disease damage. Roma, with 0.48 metric tons per hectare, was significantly lower than the rest of the nine entries in unmarketable fruit production, while Fire Ball with 17.82 metric tons per hectare was the highest. CL123-2-4UG, CL143-0-4B-1UG, and CL143-0-6-9UG with an average of 2.67 metric tons per hectare were the next lowest in unmarketable fruit yield.

Conclusion. Based on the appearance, texture, size, and yield,

CL143-0-4B-1UG and CL143-0-6-9UG were the most promising lines as per the results of the experiment conducted during the dry season of 1979. (See Table III.)

Table III. Performance of AVRDC's Tomato Breeding Lines or Commercial Varieties of Tomatoes During Dry Season of 1979.

AVRDC Breeding Line or Commercial Variety	Growth Habit	Fruit Setting	Fruit** Cracking	Fruit Weight (gram)	No. of Fruit	Marketable Fruit Yield (MT/ha)	Unmarketable Fruit Yield (MT/ha)
CL9d-0-6UG	determinate	3.2	2.0	71	33	50.51	6.91
CL123-2-4UG	determinate	3.0	1.7	75	20	31.93	2.23
CL143-0-4B-1UG	determinate	4.3	1.0	58	55	68.31	2.36
CL143-0-6-9UG	determinate	4.7	1.1	26	107	66.19	2.43
L1GS	determinate	3.8	2.2	83	24	42.14	6.88
Roma	determinate	2.4	1.3	62	10	10.00	0.48
Bonney Best	indeterminate	2.0	4.5	82	6	5.18	5.37
Grosse Lisse	indeterminate	2.1	4.3	129	5	6.98	5.16
Fire Ball	indeterminate	2.7	4.2	141	11	23.41	17.82
Potentate	indeterminate	2.2	2.4	75	8	7.64	6.83
$LSD_{0.05}$				12	6	7.74	1.91

* Fruit Setting:
1 = No fruit to light setting
2 = Light to medium setting
3 = Medium setting
4 = Medium to heavy setting
5 = Heavy setting

** Fruit Cracking
1 = None to light cracking
2 = Light to medium cracking
3 = Medium cracking
4 = Medium to heavy cracking
5 = Heavy cracking

HORTICULTURE - POMOLOGY

The pomology program was initiated in 1978 with the production of a variety of local and imported fruit crop and miscellaneous tree seedlings. Most of these seedlings were planted at the Experiment Station in 1979.

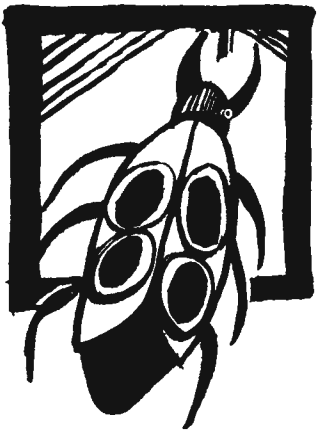
During the year, several additional varieties of fruit trees and ornamental seeds were germinated. Some air layerings and cuttings were also produced from available local materials. The bulk of these seedlings will be ready for planting next year.

There has been some plant mortality due to rasping by hermit crabs. Although mortality has been minimal, atis (*Annona reticulata*) and sour sop (*Annono muricata*) were observed to be most affected.

Production of seedlings has increased considerably during the past two years. At present, the stock of trees maintained by the Experiment Station consists of 42 varieties of fruit trees.

Plants found to be doing well at the Experiment Station are:

Dogdog (Seeded breadfruit)
Mango
Citrus (lime)
Egg & fruit
Avocado
Solo papaya (Kapoho var.)
Solo papaya (Homestead)
Mulberry (local cuttings)
Malay apples
Atis
Longan (imported)
Adonsonia (Hawaii)
Gaobgaob (Monkey bread - Hawaii)
Pomegranate
Chinese chestnut
Rose apple (imported)
Macadamia nut (Hawaii)
Guava (grafted, Hawaii)
Bay rum
Surinam cherries (imported)
Bananas
Pineapples (Sri Lanka)
Horseradish trees
Strawberry guava (Hawaii)
Chaya (Kadagan)
Calaman limes
Java Plum (Lumboy)
Lemon
Pigeon peas (imported)
Roselle (edible hibiscus - imported)



Entomology

Entomology research continued to focus on integrated control methods. These methods are biological control sampling techniques, the proper use of insecticides, resistant varieties and cytogenetic studies.

Pests of Cruciferous Vegetables

Host Resistance Trials. A factorially designed experiment was conducted jointly by Drs. Stevens (Entomology), Lee (Horticulture), Beaver (Plant Pathology) to determine the effects of the factors of two varieties, two plant spacings, and three levels of disease control measures, plus a control. Examined with the results of an earlier trial (Table 1), it appears that Ruby Ball compared to C-0 is a non-preferred host for insects in the case of *Heliothis sp., Crocidolomia binotalis, Hellula Undalis, Chrysodiexis chalcites,* and *Spodoptera litura*; although some non-preference may be marginal. In the case of *Plutella xylostella*, no difference was noted between the two varieties. Spacing seemed to have little effect on insect distribution, but the possibility exists that a 2 ft. spacing is generally more attractive to these insects. It was noted in the 1979 trial that an early and high population infestation rate of *H. undalis* and/or *P. xylostella* may have led to a bacterial soft rot disease infestation rate higher than in the 1978 trial.

Control of Diamondback Moth on Cabbage. Eight plots of cabbage (4 plots Ruby Ball and 4 plots C-0) were used in a test of the effect of Orthene when applied to control *Plutella xylostella*. Two C-0 plots and 2 Ruby Ball plots received the Orthene treatment and 2 plots of each variety were controls. Application was with a solo backpack sprayer. Orthene appeared to demonstrate some control of t diamondback larvae, but not control at the economic level (Table 2).

Control of *Hellula undalis* and Diamondback Moth on Cabbage. Eighteen plots of cabbage were utilized in a test of five insecticides to control *Hellula undalis* and diamondback moth. A randomized complete block design with three replications was used. Treatments were applied using a Solo backpack sprayer. Pydrin, Pounce, Ambush, and SAN 240 I WP 74,

plus the adjuvant SAN 285 AD WP 76 at the rate of 1.0 lb./acre appeared to perform about the same in control of *H. undalis,* although the effect of the latter material may be merely an unusual event, statistically, since the material is a virus used to control *Heliothis spp.* Clearly superior in the control of *H. undalis* on cabbage is Orthene. Orthene in the control of *P. xylostella* appeared to be less effective than the pyrethroids; Pydrin, Pounce, and Ambush. There are few *P. xylostella* present, but analysis indicates an unusually high number of infested cabbage heads in plots treated with Orthene (Table 3).

Integrated Pest Management

Survey of the Banana Aphid. In order to determine the natural enemies present and the correlation between bunchy top disease incidence and the infestation of te banana aphid, *Pentalonia nigronervosa* (the disease vector), a study was conducted over a period of 3 months using 9 sites. It was found that the presence of aphids is often accompanied by the presence of bunchy top, but usually at a lower infestation rate than the aphid infestation rate. The relationship between the insect and disease infestation rates is not clear but it may be assume that (either) the typical aphid here is not transmitting the disease (or) the development of the diseased plant itself may be very slow in showing symptoms. Thus, spraying the aphid will not be as useful as a systematic, continuous destruction of disease plants. Few known natural enemies were noted, but a brown lacewing was present. From this type of data, it also may be possible to estimate whether or not a whole stand of bananas infected at a certain rate by bunchy top disease should be completely destroyed since the probability may be high that the remainder of healthy appearing plants are also infected.

Control of the Banana Aphid by Insecticide and Dimethyl Sulfoxide Injection. Dimethyl Sulfoxide (DMSO) 'Baker Analyzed' Reagent $(CH_3)_2SO$ was injected with Lorsban 50EC into bananas for the purpose of controlling the banana aphid, *Pentalonia nigronervosa.* The results show some promise and this test should be repeated.

Integrated Control of the Coconut Beetle. Coconuts infested with *Brontispa palauensis* are partially protected by the parasite, *Tetrastichus brontispae.* To test a method of control that would not harm the parasite, Furadan Medicaps (FMC) and injection of DMSO were tested. The results have not been statistically examined. A second test for the control of the coconut beetle was conducted using Lorsban, Systox, Geofos, Cytrolane, Metasystox, Temik, Di-Syston, Furadan and Nuvacron. These insecticides were injected into the trees, except Temik, which was applied via holes in the ground above the root system. Preliminary examination of the data indicates that the effect of Lorsban and Geofos may be of teh most interest.

Corn Pest Management. A corn pest management experiment designed to control the Asiatic corn borer, *Ostrinia furnacalis,* and *Heliothis* spp.

was performed. Orthene was applied to corn when a single egg mass of the Asiatic corn borer was encountered at a level of p=0.03 during a systematic sample. The data is still being examined.

Bagworm Control. The bagworm that is a pest of ornamental plants on Guam due to the habit of maturing individuals fastening to walls of man-made structures, tress and permanent vegetation is now being controlled by an unidentified chalcid wasp in addition to the tachnid, *Stomatomyia* sp. This chalcid has been sent for identification. It appears that the percentage of bagworms parasitized by this wasp is quite high and is a controlling factor.

Mealybugs on tangantangan. In addition to *Ferrisia virgata* (Cockerell), *Nipaecoccus vastator* (Maskell), and *Phenacoccus* sp. have also been recovered on tangantangan, *Leucaena leucocephala*. *N. vastator* population outbreaks have been most severe during the drier summer months on Guam, but subside with the advent of the rainy season. A study of the arthropods associated with the mealybugs was undertaken and specimens sent for identification. It is known that Guam already has a eulopid parasite, (Entedontinae), and the coccinellid beetle, *Nephus roephei* as natural enemies of these mealybugs. The additional encyrtid parasite, *Anagyrus dactylopii* How. is being obtained from Hawaii where it is known to control *N. vastator*.

Biological Control

Predatory Mites. The predatory mite, *Amblyseius californicus,* obtained from the University of Hawaii, was released. Release sites were Mangilao and Inarajan, Guam.

Systemic Pesticide Control of the Poinciana Looper. The poinciana looper, *Pericyma cruegeri,* a pest of the ornamental flame tree, *Delonix regia,* appears to be controlled by *Bacillus thuringiensis*. However, the cost of application every 10 days is expensive, so systemic insecticides were tested as an alternative compatible with biological control agents. Di-Syston, Metasystox, Systox, Hosdon, Geofos, Cytrolane, Temik, and also Lorsban were either injected approximately every 6 inches around the tree to a depth of 1 inch into the tree, applied into the ground via 6 inch deep holes around the drip line of the tree, or painted onto the bark. Counts of looper larvae were made on 4 limbs (3 foot lenghts counted from the tip inward) per tree. The results of this experiment have not been adequately examined yet. Simple observation of the experimental trees indicates little success is expected. A second systemic experiment using Furadan Medicaps and Dimethyl Sulfoxide also appears to be showing little control of the poinciana looper.

Population Study of the Poinciana Looper. The looper has become more seasonal and appears to have a samller population season by season. An all year study indicated that loopers are present all year, but only at low levels during the prolonged dry periods.

Predators and Parasites of the Poinciana Looper. If the pupal parasites, *Brachymeria albotibialis* and *Exorista civiloides* are present, it is only at very low levels. The praying mantid, *Hierodula patallifera,* is usually present. The consumption of different instars of the looper by different sizes of the mantid species was observed to determine the role of the mantid in control of the pest. It appears that there is need for a new introduction of *B. albotibialis* and other known parasites of the poinciana looper from Papua New Guinea.

Study of Trichogramma spp. on Guam. This study is intended to determine the incidence of *Trichogramma spp.* parasitizing different host insects on different host plants. The host plants upon which a good deal of success has been achieved are three taros, *Colocasia esculenta, Alocasia* sp. and *Xanthosoma sagitifolia, Morinda citrifolia,* morning glory, *Erythrina variegata* and *Terminalia catappa.* The taro, morning glory and *M. citrifolia,* are attacked by three different species of hornworms, the species of which are not yet verified. It is suspected they are *Agrius convolvuli* on morning glory and *Chromis erotus eras* on *M. citrifolia.* The species on *Terminalia catappa* and *Erythrina* are yet to be identified, but it is suspected the latter is *Orthreis* sp. The data collected to the date of May 31, 1979 are presented in Table 4.

Kairomone Work. To explore the possibility of a kairomone attractive to *Trichogramma* sp. being present in either *Chromis erotus eras* or *Agrius convolvuli,* hexane extracts from adults of both species were collected and stored in a revco freezer. These extracts were applied into cotton wicks attached to sweet corn at 2 to 6 day intervals with the objective of luring *Trichogramma* into the field where they would subsequently parasitize the Asiatic cor borer, *Ostrinia furnacalis.* This data has not been examined yet.

Genetic Taxonomy and Genetic Control.

Epilachna philippinensis: Karyotype and six-determining system (8AA+XX in female, 8AA+Sy_p in male) of Guam population have been established.

Cylas formicarius: Chromosomal and isozymic variations are found among cultures from Louisiana, Hawaii, Guam, Tinian, Rota, and Taiwan. Although specimens from these cultures are remarkably similar in both external characters and male genitalia, cytological and isozymic evidence indicates that *Cylas formicarius elegantulus* should be raised to specific status.

At least three six chromosome systems exist among these cultures. The reproductive incompatibility between cultures with different six chromosome systems and its application in genetic control will be further investigated.

Trichogramma spp.: Karyotype and isozyme analyses have been carried out in *Trichogramma* for biosystematic purposes. So far, no significant differences have been detected among karyotypes of *T. pretiosum, T. nubilale,* and *T. chilonis,* although these species can be readily distinguished on zymograms.

Table 1. Summary of Insect Infestation Rates (in Percentage) Per Head in Two Varieties and Spacings of Cabbage, Guam, 1979.

Experiment	Variety	Spacing in Fleet	*Crocidolomia binotalis*	*Hellula undalis*	*Heliothis spp.*	*Chrysodiexis chalcites*	*Spodoptera litura*	*Plutella xylostella*
1978	Ruby-Ball	1	1.0	8.5	3.9	0.3	13.4	22.9
		2	0.9	12.3	3.9	1.5	14.7	24.0
1979		1	0.6	54.2	2.2	0.6	8.4	20.7
		2	5.1	61 5	5 1	0 0	12.8	18.0
1978	C-O	1	2.7	16.2	8.8	1.0	39.2	19.3
		2	3.0	17.6	10.0	2.0	42.9	17.9
1979		1	3.4	51.3	14.5	0 9	18.0	36.8
		2	0.0	47 0	20.5	0 0	24 1	22.9

Table 2. Control of Diamondback Moth on Cabbage by Orthene 75SP

Treatment and lb. ai/acre	*P. xylostella* % of infested plants
Orthene 75 SP 0.890	43.1 b
control	68.8 a

% separation by chi square, means followed by the same letter not significantly different at the 5% level.

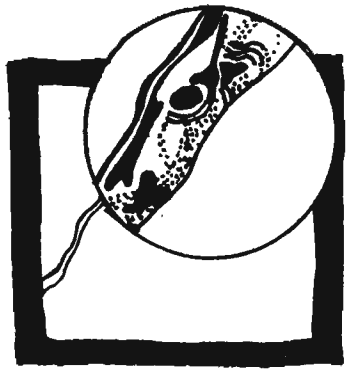
Table 3. Control of Cabbage Borer and Diamondback Moth on Cabbage by Five Insecticides.

Treatment and lb. ai/acre		*P. xylostella* % of infested plants	*H. undalis* % of infested plants
Pydrin 2.4 EC	0.047	0.0a	36.5a
Pounce 3.2 EC	0.047	0.0a	28.3a
Ambush 2 EC	0.047	0.0a	27.1a
Orthene 75 SP	0.890	6.6b	01.2b
SAN 240 I; plus adjuvant	0.25	0.0a	31.2a
Control		0.6a	50.6c

% separation by chi square, means followed by the same letter are not significantly different at the 5% level.

Table 4. Percent parasitism by *Trichogramma* spp. of various host insects on various host plants, Guam, 1979.

Host Plant	Host Insect	Total No. of Eggs	% Eggs Parasitized by *Trichogramma sp.*	% Eggs Parasitized by Other Species	% Not Noted as Parasitized
Morinda citrifolia	*Chromis erotus eras*	75	37	13	49
Terminalia catappa (Indian Almond)	Unidentified	111	6	48	46
Erythrina variegata	*Orthreis* sp.	1045	11	48	40
Xanthosoma sagittifolia (Honolulu Taro)	Unidentified	15	40	0	60
Colocasia esculenta (Red Taro)	Unidentified	20	55	0	45
Alocasia sp (Wild taro)	Unidentified	286	30	27	43
Ipomoea indica Morning glory)	*Agrius convolvali*	21	10	0	90
Ipoloea Spp Morning glory)	*Agrius convolvuli*	46	24	4	72
Operculina tuberosa (Small wood rose)	*Agrius convolvuli*	145	65	0	35
Operculina peltata (Large wood rose)	*Agrius convolvuli*	3	0	0	100
Ipomoea batata (Sweet potato)	*Agrius convolvuli*	10	70	0	30
Ricca cida (Iba Tree)	Unidentified	1	0	0	1



Plant Pathology

Research in plant pathology focused on the identification of diseases of crop plants and methods of disease control suitable for Guam growing conditions.

The areas of research currently underway include the following:

1. Identification of Plant Diseases on Guam. Table 1 lists the host/pathogen complexes identified as of January 1980. This list is expanding as other plant diseases are identified.

2. Bunchy Top Disease of Banana. Bunchy top disease of banana has reduced banana production on Guam by as much as 75%. Efforts are currently underway to eradicate diseased banana plants. New staining techniques are being developed which will facilitate disease diagnosis prior to symptom development. The use of antibiotics is being screened to detemine their effects on disease development.

3. Dasheen Mosaic Virus (DMV) in Taro. Studies are currently underway to determine the effects of DMV on yield and quality in *Colocasia* spp. and *Xanthosoma* spp. A comparison of tuber weight and quality between visibly healthy plants and plants showing symptoms of DMV is underway. Confirmation of the presence of virus particles in leaf tissue showing symptoms was received from Mr. A.P. Martinez and Dr. M. Ishii, Cooperative Extension Service, University of Hawaii. Dr. F.W. Zettler, IFAS, University of Florida, confirmed visible symptoms as being DMV based on color photographs.

4. Disease Complex on Papaya. Phytophthora blight is an infrequent problem on young papaya on Guam. *Phytophthora* spp. and *Fusarium* spp. are consistently isolated from infected tissue. At this time, field symptoms that include both organisms have not been successfully reproduced under controlled conditions. Further studies are being conducted to clarify the relationship between these two organisms.

5. Biological Control of Soil-Borne Diseases of Tomato and Cucurbits. Race 1 of *Fusarium oxysporum f. lycopersici* is present on Guam. At this time, no other race has been identified. Studies have been initiated to iden-

tify soils and soil components inhibitory to *Fusarium oxysporum* and *Rhizoctonia solani.*

Levels of *F. oxysporum f. lycopersici* were reduced in screenhouse soils by amendments of pig manure and composted, chopped weeds. The organic material added was approximately 25% by volume of the total soil in the growing beds. *Fusarium* levels dropped from 787 to 291 propagules/gm soil based on soil dilution plate counts. Replicated soil amendment trials will be established to confirm these preliminary findings.

6. Panama Wilt of Banana. Panama wilt *(Fusarium oxysporum f. cubense)* was first identified on Guam in 1978. The disease is spreading slowling within the two plantations where the disease was initially found. Resistant varieties are being recommended wherever new plantations are being established.

Cultures taken from several plants indicate a bacterium, probably a *Pseudomonas* spp., also involved in the disease syndrome in at least some plants.

Table 1.

PLANT DISEASES ON GUAM

VEGETABLES

A) Beans - *Phaseolus vulgaris*
   1) Angular leaf spot - *Isariopsis griseola*
   2) Anthracnose - *Colletotrichum lindemuthianum*
   3) Bacterial blight - *Xanthomonas phaseoli*
   4) Crown and root rot - *Rhizoctonia solani*
   5) Damping-off - *Pythium ultimum*
   6) Powdery mildew - *Oidium* sp.
   7) Rust - *Uromyces phaseoli*
   8) Virus - Bean mosaic

B) Beans - *Vigna sesquipedalis*
   1) Bacterial spot - Pseudomonas syringae
   2) Damping-off - *Rhizoctonia solani*
   3) Leaf spot - *Mycosphaerella cruenta*
   4) Powdery mildew - *Erysiphe polygoni*
   5) Southern blight - *Sclerotium rolfsii*

C) Bitter Melon - *Momordia charantia*
   1) Powdery mildew - *Oidium* sp.

D) Cassava - *Manihot esculenta*
   1) Anthracnose - *Gloeosporium manihotis*
   2) Leaf spot - *Cercospora henningsii*
   3) Root knot - *Meloidogyne* sp.
   4) Root rot - *Rhizoctonia solani*

E) Cabbage - *Brassica* sp.
1) Bacterial black rot - *Xanthomonas campestris*
2) Bacterial leaf spot - *Pseudomonas maculicola*
3) Bacterial soft rot - *Erwinia carotovora*
4) Blackleg - *Phoma lingam*
5) Club root - *Plasmodiophora brassicae*
6) Damping-off - *Rhizoctonia solani*
7) Downey mildew - *Peronospora parasitica*
8) Grey leaf spot - *Alternaria brassicae*
9) Grey mold - *Botrytis cenerea*
10) Leaf mold - *Heterosporium variabile*
11) Leaf spot - *Cercosporella brassicae*
12) Nematodes - *Heterodera* sp.
- *Pratylenchus* sp.
- *Meloidogyne* sp.
13) Powdery mildew - *Oidium* sp.
14) Rot, cottony - *Sclerotinia sclerotiorum*
15) Rot, soft - *Rhizopus stolonifer*
16) Rot, root - *Phymatotrichum omnivorum*
17) Southern blight - *Sclerotium rolfsii*
18) White spot - *Mycosphaerella brassicicola*
19) Yellow wilt - *Fusarium oxysporum*

F) Chinese leeks - *Allium porrum*
1) Root rot - unknown

G) Corn - *Zea mays*
1) Bacterial wilt - *Xanthomonas stewartii*
2) Corn smut - *Ustilago maydis*
3) Corn rust - *Puccinia polysora*
4) Corn stripe virus - Viral
5) Leaf blight - *Helminthosporium turticum*

H) Cucumber - *Cucumis sativus*
1) Anthracnose - *Colletotrichum lagenarium*
2) Bacterial leaf spot - *Pseudomonas lachrymans*
3) Bacterial wilt - *Erwinia tracheiphila*
4) Cucumber mosaic virus - Viral
5) Crown and root rot - *Rhizoctonia solani*
6) Downey mildew - *Pseudoperonospora cubensis*
7) Powdery mildew - *Oidium* sp., *Sphaerotheca fuliginea*,
- *Erysiphe cichoxacearum*
8) Leaf spot - *Cercospora cucurbitae*
9) Root knot - *Meloidogyne* sp.
10) Southern blight - *Sclerotium rolfsii*
11) Wilt - *Fusarium oxysporum*

FRUIT DISEASES

A) Avocado - *Persea* sp.
   1) Anthracnose - *Glomerella cingulata*
   2) Nematode - *Radolphus similis*
   3) Root rot - *Phytophthora cinnamomi*

B) Banana - *Musa* sp.
   1) Black leaf streak - *Mycosphaerella fijiensis*
   2) Bunchy top - Mycoplasm/Virus
   3) Burrowing nematode - *Radopholus similis*
   4) Freckle - *Phyllostictinia musarum*
   5) Lesion nematode - *Pratylenchus musicola*
   6) Moko - *Pseudomonas solanacearum*
   7) Panama wilt - *Fusarium oxysporum* f. *cubensis*
   8) Root knot - *Meloidogyne* sp.
   9) Sigatoga - *Mycosphaerella musicola*

C) Beetlenut - *Areca catechu*
   1) Sooty mold - *Capnodium* sp.

D) Breadfruit - *Artocarpus altilis*
   1) Anthracnose - *Colletotrichum* sp.
   2) Fruit rot - *Phytophthora palmivora*
   3) Soft rot - *Rhizopus stolonifer*

E) Citrus - *Citrus* sp.
   1) Albinism - *Aspergillus flavus*
   2) Brown rot - *Phytophthora citrophthora*
   3) Citrus canker - *Xanthomonas citri*
   4) Citrus Scab - *Elsinoe fawcetti*
   5) Damping-off - *Rhizoctonia solani*
   6) Greasy spot - *Glomerella cingulata*
   7) Gummosis - *Phytophthora* sp.
   8) Melanose - *Diaporthe citri*
   9) Nematode - *Radopholus similis*
   10) Penicillium molds - *Penicillium* sp.
   11) Southern blight - *Sclerotium rolfsii*
   12) Viral - Exocortis, Psorosis, Tristeza

F) Coconuts - *Cocos nucifera*
   1) Bud rot - *Phytophthora palmivora*
   2) Leaf spot - *Pestalotiopsis polmarum*
   3) Sooty mold - *Capnodium* sp.
   4) White threadblight - *Corticium penicillatum*

G) Grape - *Vitus rotundifolia*
   1) Rust - *Phakopsora vitis*

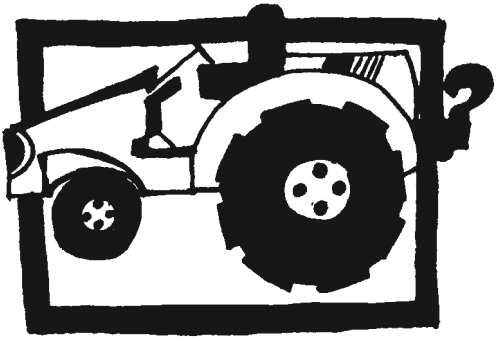
H) Guava - *Psidium* sp.
   1) Anthracnose - *Glomerella cingulata*
   2) Nematode - *Radopholus similis*
   3) Root rot - *Phytophthora* sp.

I) Mango - *Mangifera indica*
   1) Anthracnose - *Glomerella cingulata*
   2) Algal leaf spot - *Cephaleuros virescens*
   3) Powdery mildew - *Oidium mangifera*
   4) Sooty mold - *Capnodium* sp.

J) Papaya - *Carica papaya*
   1) Anthracnose - *Glomerella cingulata*
   2) Damping-off - *Phythium aphanidermatum*
   3) Leaf spot - *Asperisporium caricae, Cercospora* sp.
   4) Powdery mildew - *Oidium* sp.
   5) Mosaic virus - Viral
   6) Ring spot virus - Viral
   7) Root rot - *Phymatotrichum omnivorum*
   8) Root & Stem blight - *Phytophthora palmivora*
   9) Stem rot - *Fusarium* sp., *Phytophthora* sp.

K) Pineapple - *Ananas comosus*
   1) Crown rot - *Phytophthora infestans*
   2) Mealybug wilt - Virus
   3) Root knot - *Meloidogyne* sp.

L) Soursop - *Annona muricata*
   1) Root rot - *Phytophthora infestans*



Agricultural Engineering

In 1978, the University of Guam Agricultural Experiment Station initiated a research project to determine the effectiveness of trickle irrigation on plant growth and quality production as affected by irrigation frequency and amount including minimum requirements for optimum production, fertility practices, irrigation scheduling, water distribution patterns in the soil, diseases, pests and weed control on Guam.

Since previous agricultural development studies have recommended vegetables as primary cash crops, bell pepper was selected for the experiment. Trickle irrigation is considered to be important for vegetable crop production, particularly for farmers in Northern Guam who face recurring problems of limited water supply. Therefore, the site chosen was located in Dededo, Northern Guam. The first experiment was to study the response of bell pepper to trickle irrigation.

The main types of soils on Guam are: Guam Association in the northern part and Atate-Agat Association in the southern portion. Guam Association consists of well-drained, fine textured soils overlying porous hard limestone. Depth of soil to bedrock is irregular, from 3 cm to 91 cm or more. The Association covers 38% of the island.

Description of Experiment: An area of 0.15 hectare was planted with one-month-old seedlings of hybrid Yan Kwang bell pepper (imported from Taiwan) on May 8, 1979. There were 12 plots and each plot consisted of 3 rows of 24 plants spaced at 0.45 m X 1.22 m.

Four irrigation treatments were selected and randomly distributed in 3 replications. The treatments were trickle and sprinkler irrigation with infrequent water application (when 30 cm depth tensiometer reached 70 centibars) and frequent water application (when 30 cm depth tensiometer reached 30 centibars). The low pressure sprinkler irrigation was utilized because it could possibly be another method of irrigation to be taken into consideration on Guam.

Irrigation equipment available on the island was used for the experiment. For the trickle irrigation system, Bi-Wall tubing with water distribution orifice spacing of 0.45 m with a discharge of approximately 1.5 litre per hour/orifice at 0.7 atm. was utilized. The laterals were buried at 10 cm near

the rows of bell pepper. For the sprinkler irrigation system, a full coverage sprinkler was used to wet a circle of 11 m in diameter with a flow of about 0.1 l/s at 1.5 atm.

Due to the lact of a separate water irrigation network on Guam, drinking water delivered by a special agricultural meter was used. The trickle system included a pressure regulator and a 100 mesh screen filter.

All plots received an equal amount of fertilizer at planting and during the growing season.

Data and Discussions: Bell pepper seedlings were started about 4 weeks before planting. The field was prepared for planting with plowing at a distance of about 20 cm. About 2 pails (40 litres) of chicken manure per row and 1,016.4 kg/ha of 10-20-20 fertilizer was applied.

Readings of tensiometers installed in each plot at a depth of 30 cm were normally taken every two days. The irrigation water was applied in equal quantities in all treatments and replications after planting. The frequency and amount of irrigation was function of rains on the transition season.

Sidedressing with 0.680 kg of 10-20-20 fertilizer per row was applied 3 times during the growing season. Foliar fertilizer with major and trace elements was applied twice.

An attack of fungus, *Sclerotim rolfsii,* was noted, especially during the first period after planting, causing Southern blight. Diseases caused by bacteria: *Pseudomonas solanecerum, Xanthomonas vesicatoria;* fungus: *Cercospora capsici* and *Gloeosporium piperatum;* and a mosaic virus were detected in a few plants, especially in the plots with frequent sprinkler irrigation.

Chemical control of diseases was done through applications of Dithane M-22, Copper Sulfate, and Captan 50%. A few attacks of aphids, corn boreres, spider mites, and flea beetles were also noted. These pests were controlled with applications of Malathion, 50% EC, Kelthane, and Dibrom.

Periodic cultivation was employed for weed control.

Bell pepper was harvested from June 28 to September 17 weekly, and every 10 days in the last period.

The marketable yield was greater with treatment of frequent trickle irrigation, but there were no significant differences among treatments. In frequent sprinkler irrigation, the number of fruits per plant was less, but with a larger fruit compared to other treatments. The bell pepper plants in the frequent trickle irrigation areas were better developed, but the maximum crop height at the end of the harvesting period was achieved in the frequent sprinkler irrigation area.

Irrigation was applied more frequently during the first half of the growing season and less frequently in the second half when 300-330 mm monthly precipitations occurred.

Conclusions: The results of the 1979 experiment indicate that trickle irrigation required 54% less water than the sprinkler method and presented

the highest irrigation water use efficiency, although there was not a significant increase in yield.

It was noted that full coverage sprinkler gave non-uniform water application because of variation in wind velocity.

Profiles in the root system area indicate that the manure should be incorporated in bands before planting. Fertilization during the irrigation season should be augmented.

Diseases and pests were found in small quantities, except Southern blight and Masaic. The latter was encountered, especially in the frequent sprinkler irrigation treatment.

Table 1. Effect of different irrigation Methods on the characteristics and yield components of bell pepper in 1979.

TREATMENT	CROP HEIGHT cm	FRUIT SIZE kg	NO. Of FRUITS PER PLANT	YIELD PER PLANT kg	MARKETABLE MT/ha	UNMARKETABLE MT/ha	UNMARKETABLE % of TOTA
TRICKLE (Infrequent)	59.7	45	16 4	0.744	13.318	2 431	15 4
TRICKLE (Frequent)	58 7	47	16.7	0.787	14.103	2.814	16.6
SPRINKLER (Infrequent)	53 0	46	16.4	0.754	13.515	2.215	14 1
SPRINKLER (Frequent)	63.3	53	14 1	0.749	13 422	1 942	12 6
$LSD_{0.05}$	10.1	7	5 2	0 289	5 182	0 660	

Table 2. Irrigation water use efficiency on marketable yield of bell pepper in 1979

TREATMENT	MARKETABLE YIELD Y kg ha	IRRIGATION I mm	IRRIGATION WATER USE EFFICIENCY Y/I $kg\ ha^{-1} mm^{-1}$
TRICKLE (Infrequent)	13.318	19.0	700.9
TRICKLE (Frequent)	14.103	44.2	319.1
SPRINKLER (Infrequent)	13.515	23.0	587.6
SPRINKLER (Frequent)	13.422	91.3	147.0
$LSD_{0.05}$	5.182	0	193.2

Agricultural Economics

STUDY ON MARKETING POTENTIAL OF CERTAIN AGRICULTURAL PRODUCTS IN THE GUAM TOURIST INDISTRY:

Nearly one million foreigners visited Guam, Hawaii, Puerto Rico, the Virgin Islands, American Samoa, and the Trust Territories in 1977. These visitors represented just over five percent of the total U.S. international arrivals.

Although the origin of tourism on Guam could be traced back to 1521 when Ferdinand Magellan first visited Guam, the real start took place in 1963 when the government decided to initiate a vigorous program designed to establish tourism as a factor in an expanding effort to diversify Guam's economic base. Since then, Guam has attracted a large number of tourists, largely from the neighboring country of Japan.

Tourism on Guam has been regarded as one of the island's most important industries. Experts estimate that tourism is second only to U.S. military spending in providing direct income to the island. Tourism has been labeled an 'invisible' export offsetting approximately one-half of Guam's trade deficit. Although many of the estimates are questionable, economists Mayer, Mak, Mikhius Farrer and Stanford Research Institute have attempted to estimate the impact of Japanese visitors on the economy of Guam. Each of the studies have shown that tourism is extremely beneficial without analyzing the actual benefits accrued to Guam. It might be possible that Guam is actually getting very little return from tourism. The experience of the Cook Islands could serve as a comparable example.

As compared to 1967 when only 6,600 people visited Guam, the total number increased to 232,000 in 1978. Because of the large number of visitors on Guam, it has been believed that the tourist industry would be one of the most important markets for Guam's agricultural products.

The tourist industry could indeed constitute a large market as it is over two times greater than Guam's permanent resident population of approximately 100,000. However, to properly benefit from this vast market, Guam needs to know the types of fruits and vegetables that are most highly desired by these visitors and to estimate the total volume needed to meet the addi-

tional demand. But most importantly, Guam must be able to produce this volume in addition to meeting local needs. Currently, from 60 to 70 percent of all fruit and vegetable products are imported either from the U.S. mainland, or Japan and other areas.

The Guam Department of Agriculture report shows that Guam has increased its agricultural production in recent years. For example, the total market value of local products increased from $4.8 million in 1977 to $7.2 million in 1978. However, the level of production is still relatively insignificant even to meet the total local need. Two of the most serious problems of agricultural production on Guam are the lack of basic incentive programs for expansion of production, and a non-existent marketing system to handle local produce. Most of the hotels catering to tourists import from Japan and the U.S. mainland because of the lack of supply reliability and the inadequacy of volume.

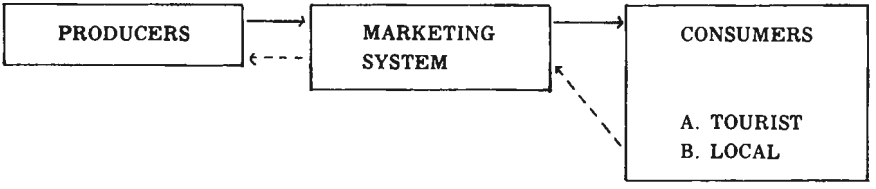
One of the reasons local experts give for this low production has been the lack of adequate markets for produce from local farms. The general feeling is that farmers would expand production if the tourist market is tapped, instead of just relying upon the local population. Therefore, the present project was initiated in April of 1977 by the College of Agriculture and Life Sciences to identify the market. Since 95% or more of the tourists coming to Guam are from Japan, the research focused attention upon this segment only. After initial funding was identified, the project was provided staff and support services in April of 1979. Subsequently, an attempt was made to refine the obsectives to make the project more successful and manageable. The revised objectives are:

A. To identify Guam agricultural commodities most desired by Japanese tourists,

B. To determine the total volume needed to meet tourist demand,

C. To analyze the policy implications.

As shown in Figure 1, the basic idea of the research is to obtain the consumer's preference information and to use this to produce the needed outputs.



Traditional Approach: ( ) Producers supply to the market and they sell to consumers

Improved Approach: ( ) Determine or identify what consumers want and use the information to direct production and marketing efforts.

FIGURE 1. RESEARCH IDEA IN A MODEL

METHODOLOGY: The procedures, which were not present in the earlier description of the project, were outlined to achieve the above objectives.

Theoretically, the situation could be looked at as a marketing problem. Using the market oriented approach, the goals are (1) to segment the market in order to identify homogenous group of potential consumers; (2) to identify the four P's of marketing - **PRODUCT** that is most desired by the target market; **PLACE** that is most suitable to satisfy the target market; **PROMOTION** that is informative to the target market; and **PRICE** that is fair and right. However, the present research looks only at the first and the product part of the second. The rest - price, place, and promotion will be discussed as a policy consideration only.

Further, the situation could also be viewed as an economic problem of consumers (i.e., Japanese tourists). Generally, these consumers are rational and have a utility function (i.e., deriving satisfaction), and they have a budget constraint. Mathematically:

UTILITY FUNCTION: $U = 0(X_1, X_2, \ldots, X_N)$

BUDGET LIMITATION: $Y - P_1X_1 + P_2X_2 + \ldots + P_NX_N)$

In other words, consumers obtain satisfaction by consuming, X_1 (food), X_2 (lodging), X_3 (entertainment) and so on, but they have a fixed travel budget (Y). Depending upon the prices of food (P_1), lodging (P_2), and entertainment (P_3), they can buy each of these in such a way that the total is equal to or less than the budget Y. Out of the total food budget Y_1, which is equal to P_1X_1, they try to buy goods that most satisfy their needs. As such, they would have a preference function, i.e., ranking of goods in terms of satisfaction. For example, if they are willing to buy more of X_{11} (apples) and X_{12} (bananas), it can be said that they prefer X_{11} more than X_{12} or $X_{11}X_{12}$, and if they do not discriminate between X_{13} and X_{14}, the they are indiscriminant or $X_{13}IX_{14}$

Faced with a fixed Y_1 food budget, the consumers will select those goods that they like the most, and ignore or not buy those which they do not like. In other words, the food budget could be used for buying apples (X_{11}), bananas (X_{12}), and so on, but, because of food budget limitations, they select X_{11} (apples), X_{12} (bananas), an so on, until the budget is exhausted. Or:

$$Y_1 = P_{11}X_{11} + P_{12}X_{12} + \ldots + P_{1N}X_{1N}$$

In this way, if they do not like X_{14} (taro), then $P_{14}X_{14}$ would be equal to zero.

From this consumers' behavior, the farmer and middlemen could then identify the most desired items and devote a majority of time and resources to produce and distribute these, instead of producing and distributing everything.

It should be pointed out that the actual consumption pattern differs based on demographic factors (such as age and sex), or socio-economic factors (such as income level and education).

The next step was the survey design and outline of the procedures. Briefly, it included:

(A) Identification of preferences based on the cross-sectional sample of Japanese tourists. Only one member of the family who is 18 years of age or over has been included as a sample.

(B) Use of self-administered questionnaires to collect information. The questionnaires will be written in Japanese and an English version will also be included.

(C) Design of the questionnaire to identify demographic characteristics, such as family size, age, sex, and location; socio-economic characteristics, such as family size, income level, occupation, and education level; product-related characteristics, such as fresh versus frozen products, types and quality of produce, and spending patterns.

(D) Outline of sampling process:

1. **Population** - Was defined as all Japanese tourists, 18 years and over visiting Guam during 1979/80.

2. **Sampling Frame** - Since no list existed, Japanese guests registered in a hotel have been used as a sampling frame.

3. **Sampling Method and Plan** - The lack of a sampling frame prevented a priority selection of random samples. The randomness was to be achieved by selecting the first number and distributing questionnaires to every fifth member of a tour group and limiting distribution to no more than 30 per group. Three or more different groups were given the questionaire in several weeks.

4. **Sample Size** - Based on a 90% level of confidence, the estimated population standard deviation of 3,780 people per month and with the specification of error of 200, the actual number of sample size was determined to be 960. Assuming an 80% response rate, about 1,200 samples would result in the desired 960 responses.

PROGRESS-TO-DATE: The research is at the questionnaire collection stage, and as soon as they are collected, then the process of compilation, coding, and analysis will be undertaken.

In addition to the above-mentioned outline of the methodology, progress has been made in several areas thus far. First, an attempt was made to initiate the review of literature. In addition to local resources, a literature search was made through AGRICOLA, CRIS, and CALS of the U.S. Department of Agriculture. The search was, however, unsuccessful in locating any current and past research dealing with tourism on Guam.

Second, the collection of all pertinent secondary data, such as the availability of land, the number and sizes of farms, the production and sales of various crops, the total number of visitors, and so on, has been completed.

Third, the survey instrument (i.e., questionnaire), was designed in order to obtain the necessary information and achieve the objectives. The questionnaires were first written in English and then translated into Japanese. About 40 questionnaires were distributed to tourists in different hotels with the help of the president of the Japan Tour Operators Association, in order to field test them for effectiveness.

After the responses were evaluated, the questionnaires were redesigned to facilitate response and coding. The questionnaires were again translated and set in type for better appearance. For increased response, about 1,200 questionaires were printed. In addition to the Japanese version, an English version of the questionnare was also included. Additionally, it carried a cover letter urging the tourists to cooperate in the study and indicated that all responses were to be kept confidential.

Fourth, attempts have been made to compile the food procurement of each of the five major hotels which would be utilized in verifying the amount estimated from the sample.

Since the beginning of December, 1979, tour operators were given 1,260 questionnaires to distribute to the Japanese tourists. Based on their activity and current status, 13 oprators from the Japan Tour Operators Association participated. Each tour operator was given 100 qustonnaires, except one travel service which was given the remaining 60 questionnaires.

Prior to actual delivery of the questionnaires, permission of the Japanese tour operators was solicited for distributing the questionnaires. As a result, the purpose and use of the questionnaires and the study was presented at two meetings of tour operators.

These operators distributed and collected the completed questionnaires. Frequent attempts are being made to go to each of the 13 tour operators to collect completed questionnaires. At the time of this writing, 140 completed and usable questionnaires have been collected.

To summarize, the progress so far includes the writing of the methodology, theoretical analysis, literature search, survey design, construction of a survey instrument, a field test, redesign of the instrument, printing, and distribution of the questionnaires to the tour operators for dissemination to the tourists. The research is at the questionnaire collection stage and the compilation, coding, and analysis will be done after questionnaires have been collected.

Land Use

Geographical research of Guam continued at the Agricultural Experiment Station. Two critical spatial distributions were examined for the entire island. The two features studied were surveyed farms (116), and the residential population of both the civilian and military sectors. The geographical association between the people of Guam, that is where people reside, and the existing agricultural operations of the island community suggests a close causal relationship.

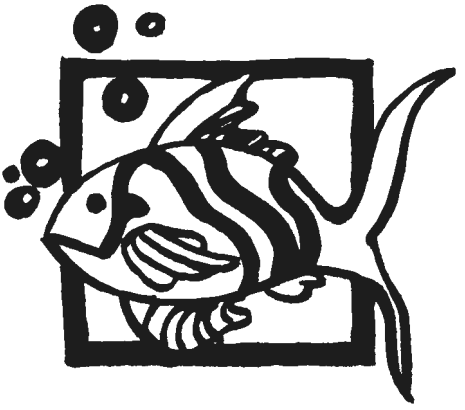
The regional investigation measured the locational variations of people and farms. While the study focused basically on two geographic phenomena, other features of the landscape and their distributions and interrelationships also impact upon population and farms. Nevertheless, the study represents a contemporary addition on the theme, "Changing Agricultural Patterns of Guam".

Field work results covering a five year period (2974-79) disclose that Guam's agricultural base contains less than 300 operative farms. As a result of the intensive survey, 116 individual farms were located and mapped throughout the entire area of Guam (212 square miles). The distribution of these farms referenced on the locational map show a tri-regional pattern: North, Central and South with 43, 30 and 43 operative farms, respectively.

The study found that the distribution of population on Guam is highly regionalized and that the most heavily concentrated areas of the island's population occur in the Central and Northern regions. Approximately 75 percent of the present population lives in the northern geographical half (102.6 mi^2) of Guam. Precise measurements of the relative population

changes by percentages, and densities (persons per km^2) by administrative district reveal that the major population growth exists near identified farms. Those identified districts are predominately in the North: Dededo, Yigo, Barrigada and Mangilao.

Verification of the geographical association between Guam's active farms and the location of the population, especially the growth areas, consisted of selected quantitative methods. A correspondence exists between the surveyed farms by district and district total populations by applying the Pearson Product Moment Coefficient or correlation (r 03 .61). A scatter diagram visually shows this coincidence. However, when utilizing a migration test and a 35 areal settlement design no such correlation was found. However, a pre-test migration study conducted with University of Guam students, although not quantitatively significant, supports the research thesis that the higher the number of farms in the districts of Guam the higher the rates of population growth. For the northern areas, the tendency for the most migration into the districts with the highest numbers of farms with indicated. Conversely, the southern districts with the largest number of farms showed moderate to low migration values on the student survey.
because it could probably be another method of irrigation to be taken into consideration on Guam.



Aquaculture

FRESHWATER PRAWNS

During the past year, research efforts were directed toward examination of nitrogen assimilation and ammonium excretion by the freshwater prawn *Macrobrachium lar* in relation to diet. This prawn, which is known as the Guamanian or Tahitian Prawn, is indigenous to Guam and many of the Pacific Islands. Although it has been suggested as a potential species for aquaculture, its use, thus far, has only been experimental. Research efforts are, in part, designed to provide a basis for comparison of this species with the Malaysian prawn, *Macrobrachium rosenbergii,* which is currently being cultured on Guam.

Both prawns are omniverous and will readily ingest a wide range of both plant and animal tissues. An analysis of the stomach contents of *M. lar* from the streams of Guam indicated that they ingest a high proportion of detritus and plant material. In the laboratory, it was found that they would readily ingest fish, shrimp, freshwater snails, filamentous freshwater algae (*Microspora* sp. and *Cladophora* sp.), some seaweeds (*Enteromorpha clathrata* and *Gracilaria edulis*), chicken feed, pig feed, and copra cake. Less readily acceptable were the more fibrous plants such as water lettuce (*Pistia stratiotes*), green pods of tangan-tangan (*Leucaena leucocephela*) and the decaying stems of water hyacinth (*Eichhornia crassipes*). The shrimp would not accept the fresh leaves of tangan-tangan (*L. leucocephela*).

The rates of ammonium excretion by *M. lar* are affected by the weight of the prawn and by its recent feeding history. An example of how ammonium excretion is affected by diet is shown in Table 1. The mean ammonium nitrogen excretion rate ranged from 0.042 to 0.098 mg NH_4^+ • (gram dry weight)$^{-1}$ • hr. .The algae diet has the lowest nitrogen content (1.79%) and yielded the lowest ammonium excretion rate. the fish diet, with the highest nitrogen content (17.61%) produced an intermediate rate of am-

monium excretion, while the shrimp diet (15.16% nitrogen) produced the highest rate of excretion.

Efforts are continuing to explore the relations between the protein: calorie ratio of the diet, the rate of ammonium excretion, and the efficiency of nitrogen assimilation by the prawns.

Publications

Nelson, S.G. 1979. The role of the freshwater prawn *Macrobrachium lar* (fabricus) in the processing of nitrogen in Pacific Island Ecosystems. (Abstract). Presented at the XIV Pacific Science Congress, August 29 to September 1, 1979, Khabarovsk, U.S.S.R.

Nelson, S.G. 1980. The aquaculture potential of the giant Malaysian Prawn *Macrobrachium rosenbergii* on Guam. (Mimeo) presented at the Sea Grant Marine Advisory Program Workshop "Prawn Culture on Guam: Outlook for the 80's", January 23, Mangilao, Guam.

Table 1. Nitrogen content (% N) or three diets and mean rates of ammonium-nitrogen excretion mg NH_4^+-N:(gram dry weight)$^{-1}$ • hour^{-1} by *Macrobrachium Lar.*

Diet	Mean ± Standard Deviation of % Nitrogen	Replicates	• Mean ± Standard Error of Excretion Rate	N
Starved	–	–	0.050 ± 0.008	39
Algae	1.79 ± 0.20	6	0.042 ± 0.012	23
Fish	17.61 ± 0.57	6	0.059 ± 0.013	23
Shrimp	15.16 ± 0.59	6	0.098 ± 0.013	24

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