GUAM AGRICULTURAL EXPERIMENT STATION

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COLLEGE OF AGRICULTURE AND LIFE SCIENCES
UNIVERSITY OF GUAM

Cover photograph by Ed Gould

1978 Annual Report
Guam Agricultural Experiment Station

A significant accomplishment during 1978 was receiving the deed to a 50-acre site at Ija for the Agricultural Experiment Station. We hope to develop this land within the next year or two to accommodate the increased demand for more space for research activities.

We have also entered into cooperative research projects with the Marine Laboratory and the College of Arts and Sciences within the University of Guam.

Three years ago, when we began to staff the Station, our emphasis was primarily on improving the vegetable crops grown on Guam. Later, we expanded to include fruit crops. Now, research is also being conducted on animal nutrition, aquaculture and irrigation.

In the future, we will continue to strengthen existing programs as we begin research in ornamental horticulture to meet the demand for tropical ornamental plants locally, and for export markets.

Wilfred P. Leon Guerrero

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Dean/Director

Contents

Tomatoes intercropped with tangantangan

Soil Fertility

Soil fertility studies were concentrated in northern Guam. Guam clay is the major soil type which blankets the limestone plateaus. A typical analysis is shown in Table 1. Guam clay has been classified as an Inceptisol with the subgroup *Lithic Ustropepts* according to the U.S. Soil Taxonomy System.* With proper irrigation, farming is possible year round.

Phosphorus, nitrogen, and potassium studies were carried out on Guam clay. Results for potassium using bell pepper were inconclusive and are not reported here.

Phosphorus. This is the main limiting macro-nutrient in all soils of Guam. Phosphorus fertilizer studies were conducted in the field and pot experiments using tomato cultivar N-11 as test plants.

After evaluating four extractants for phosphorus, 0.5 M $NaHCO_3$ at pH 8.5 was selected for all Guam soils. Soil test data have consistently shown phosphorus to be below 10 ppm. This level was arbitrarily selected as the lowest acceptable limit for optimal plant growth on Guam.

A field experiment was conducted during the rainy season (July to October) on the Ramon San Agustin farm in Dededo. This experiment involved five phosphorus levels and four replications in a randomized complete block design. Phosphorus from treble superphosphate (0-46-0) was banded with 300 kg/ha K_2O from

*M.E. PARK. 1978, Soil Survey of Guam. Department of Commerce, Government of Guam.

potassium sulfate (0-0-52) prior to transplanting the tomato seedlings. Nitrogen from ammonium sulfate (21-0-0) at 100 kg/ha N was split applied at transplanting, and side-dressed at flowering. Previous studies using tomato as the test crop were nullified by corn earworm *(Heliothis* sp.) damage. This problem was eliminated by weekly spraying of Lannate L.(794 milliliters per 189 liters) commencing at the flowering stage.

Pot culture experiments with identical treatments were conducted concurrently at the Department of Agriculture compound in Mangilao.

Marketable tomato fruit yield as affected by phosphorus fertilization is shown in Table 2. The yield doubled at 150 kg P_2 0_5 in the field study. Pot experiment response was observed to be significant at the 300 kg level. Field response was significant at the 150 kg P_2O_5 level. To build phosphorus reserves in soils testing below 10 ppm phosphorus, it is recommended that 300 kg/ha P_2O_5 be applied before planting any crop.

Nitrogen. A nitrogen source study using native corn was conducted at the San Agustin farm. This study was done in conjunction with the East/West Center (Honolulu, Hawaii) Fertilizer INPUTS Project III. A twelve treatment, three replication, randomized,

Table 1. Chemical properties of Guam clay.

pH	7.25
Organic matter	6.69%
Total nitrogen	0.31%
Total inorganic nitrogen	0.03%
Cation exchange capacity	22.6 meq/100 grams
Cation exchange capacity (less due O.M)	14.8 meq/100 grams
Available* P	5.5 ppm
" K	120 ppm
" Ca	2703 ppm
" Mg	86 ppm
" Cu	not detectable
" Fe	4.4 ppm
" Mn	451 ppm
" Zn	4.8 ppm

*P was extracted with 0.5 M $NaHCO_3$ at pH 8.5; Ca, Mg, Na, and K with 1N NH_4Ac at pH 7; Fe, Mn, and Zn with 0.2N HCl; and Cu with 1N HCl.

Table 2. Tomato yield in tons/ha as affected by phosphorus fertilization.

TREATMENT	YIELD	
Kg P_2O_5/ha	Field*	Pot*
0	16.47	20.11
75	26.44	24.19
150	33.14	25.57
300	33.40	28.26
600	33.67	33.32
	L.S.D.(0.05)12.19	7.96

*Significant at the .05 probability level

complete block design experiment was carried out.

Sources of nitrogen evaluated were inorganic nitrogen using ammonium sulfate (21-0-0), dried chicken manure from Flores Poultry Farm in Inarajan, and nitrogen fixed by legumes (peanuts and mungbeans).

Nitrogen treatment levels are shown in Table 3. Ammonium sulfate was split-applied at planting and flowering. Chicken manure

Table 3. Tomato yield in tons/ha from plots previously grown to corn and legumes.

	Past Treatment		
Number	Nitrogen rate and source	Crop grown	Yield
1	Zero nitrogen	Corn	11.41
2	75 kg N/ha, 21-0-0	Corn	11.09
3	150 kg N/ha, 21-0-0	Corn	12.34
4	300 kg N/ha, 21-0-0	Corn	13.05
5	5 Tons/ha, 3% N C.M.*	Corn	11.79
6	10 Tons/ha, 3% N C.M.	Corn	14.65
7	20 Tons/ha, 3% N C.M.	Corn	15.30
8	75 kg N/ha, 21-0-0	Corn/Peanuts	10.76
9	Zero nitrogen	Corn/Peanuts	7.88
10	Zero nitrogen	Peanuts	8.34
11	Zero nitrogen	Corn/Mungbeans	8.55
12	Zero nitrogen	Mungbeans	5.78
		L.S.D. (0.05)	5.98

* C.M. Chicken manure

was banded along with phosphorus and potassium at 300 kg/ha P_2O_5 and K_2O respectively, four weeks before planting.

The peanut plants showed an abundance of root nodules signifying the presence of native Rhizobium. The mungbean roots showed sparse nodule formation in the roots. Neither legume seeds were innoculated prior to seeding.

Although corn was grown to maturity, the field was ravaged by Asiatic corn borer *(Ostrinia furnacalis)* and corn earworm *(Heliothis* sp.). No yield was recorded. The pest attacks were counteracted by a mixture of Sevin and Dibrom using a small backpack sprayer. Apparently, this was insufficient. This was the third field attempt to grow corn thwarted by insect depredation.

In an attempt to examine the residual effects of previous nitrogen applications, the corn stover was cleared from the field and the legumes plowed in. The plots were maintained, but reduced from 7 x 4 to 4 x 4-meter plots. This was done to allow access for a power sprayer mounted on the back of a pick-up.

The plots were rototilled and cultivated with a hoe. Attempts were made to keep rows intact and lessen plot-to-plot contamination. Tomato, which is susceptible to *Heliothis*, was selected as the test crop. After six weeks, the field was planted with N-11 tomato seedlings.

The yield of marketable tomatoes is shown in Table 3. Corn earworn damage was kept to a minimum by application of Lannate L.

The yield data were significant at the 0.1 percent probability level. This is a reflection of the tremendous variability of Guam clay. Soil depths in the field varied from one to 30 centimeters with broken limestone strewn all over. Pure limestone rock under-

Table 4. Tomato yield in tons/ha as affected by nitrogen source in plots previously grown to corn and legumes.

Previous Treatment		
Number	Nitrogen source	Yield*
1	Zero nitrogen	11.41
2	Inorganic N, 21-0-0	12.17
3	Organic N, 3%N C.M.	13.91
4	Legume fixation	7.77
	L.S.D.(0.05)	4.32

*Significant at the .05 probability level.

lays the whole field. This is true for all Guam clay soils.

Yield from plots supplied with chicken manure was generally higher than the plots treated with inorganic nitrogen and the control. However, such yield differences were statistically insignificant.

The plots intercropped or monocropped with legumes showed consistently lower yields, Table 4. This depression in yield by legumes can be attributed to low nitrogen fixation and turn over from legumes.

Nitrogen timing study. Environmentalists have been concerned with movement of NO_3-N from fertilizer beyond the root zone of cropped plants to the fresh water lens in northern Guam. The standard method of applying nitrogen fertilizer in two doses, one at planting or transplanting, and the other at the flowering stage, was evaluated in a lysimeter study. N-11 tomato seedlings were grown in cement lysimeter pots filled with Guam clay soils. The treatments were replicated three times. Leachates were periodically drawn and analyzed for NO_3-N.

The nitrogen rate and timing schedule along with the yield is presented in Table 5. There was no response to a single application of 50 kg/ha N. When this amount was split, 25 kg/ha at planting and 25 kg/ha at flowering, yield increased dramatically. A single application of 100 kg/ha doubled the yield over the control. When this amount was split equally, yield observed was the highest. Yet, when 100 kg/ha was split four times, the results were similar to the single application of 100 kg/ha.

The traditional splitting of nitrogen fertilization into two equal applications is justified. It was also observed that NO_3-N in percolates was negligible when plants were growing vigorously.

Horticulture, Vegetable

The horticultural (vegetable) research work in 1978 at the Agricultural Experiment Station continued to focus on screening and determining the adaptability of major vegetable varieties which have economic potential and suitability for growth under the environmental conditions of Guam.

Vegetable varieties under study at the present time are bell pepper, head cabbage, and tomato. These vegetables are also being used in conjunction with trickle irrigation studies.

Bell pepper experiment

Materials and methods. This bell pepper experiment was conducted during the dry season. The objective was to evaluate the climatic factors on the varietal performance. Eight varieties of bell peppers were included in the experiment. They were: Yang Kwang No. 3, Yang Kwang, World Giant, California Wonder, Nan Chin 501, Nan Chin 502, Express Bell and ACE.

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. The spacing adopted was 1.22 meters between rows and 0.91 meters within rows. A 10-20-20 fertilizer was broadcast at the rate of 773 kg/ha and incorporated into the soil before transplanting. After the first harvesting, a side-dressing was applied at the same rate.

A preventive spraying program was followed twice weekly to reduce possible insect, mite, and disease damage by using Dibrom 8E, Malathion 50, Kelthane, Dithane M-45 and tribasic coppers. A rotary tiller and garden hoe were used to control weeds. Sprinklers were used for irrigation.

Harvesting began when the fruit reached the desirable size, and were still green, waxy, and shiny. The criteria for initiating harvest were good shape, thick flesh, good color, and fresh appearance. The harvest period lasted for about two months.

Fruit size. The fruit size of Nan Chin 502, weighing 102.06 grams, was significantly larger than the other six varieties, except Nan Chin 501. There was no significance in fruit weight among Nan Chin 501, World Giant and Yan Kwang, ranging from 87.81 to 96.39 grams. Express Bell was the smallest fruit, weighing 42.53 grams.

Table 1. Performance of bell pepper during dry season 1978

Variety	Fruit Weight (gram)	Marketable Yield (MT/ha)	Unmarketable Yield (MT/ha)	Unmarketable Yield (%)
Yang Kwang No. 3	76.55	13.80	0.14	0.88
Yang Kwang	94.97	15.66	0.24	1.52
World Giant	96.39	16.56	0.16	0.96
California Wonder	87.89	15.00	0.18	1.19
Nan Chin 501	100.64	13.80	0.24	1.58
Nan Chin 502	102.06	16.52	0.12	0.72
Express Bell	42.53	20.00	0.18	0.90
ACE	73.71	16.22	0.16	0.98
LSD 0.05	5.67	1.24	0.04	

Head cabbage varietal trial

Marketable fruit yield. Express Bell, with a production of 20.00 metric tons per hectare, significantly outyielded the other seven varieties. There was no significance in the fruit yield among Yan Kwang, ACE, and Nan Chin 502. ACE and Yan Kwang ranged from 15.66 to 16.56 metric tons per hectare. Yan Kwang No. 3 and Nan Chin 501 with 13.80 metric tons per hectare showed the lowest yield.

Unmarketable fruit yield. Insect and disease problems contributing to the unmarketable fruit were less in the dry season than in the wet season. Yan Kwang and Nan Chin 501, with 0.24 metric tons per hectare, had the highest unmarketable fruit yield. Nan Chin 502, ACE and World Giant yielded significantly less unmarketable fruit with an average of 0.14 metric tons per hectare.

Conclusions. Based on the appearance, texture, size and yield, Nan Chin 502, World Giant, ACE and Yan Kwang were the promising varieties per the results of the experiment conducted during the dry season of 1978. See Table 1.

Head cabbage experiment

Materials and methods. This experiment was conducted during the dry season of 1978 to evaluate the effect of environmetal factors on the performance of head cabbage. The 11 varieties of head

Table 2. Performance of head cabbage during dry season 1978.

Variety	Forming Head	Head Weight (kg)	Marketable Yield (MT/ha)	Unmarketable Yield (MT/ha)	Bacterial Soft Rot (%)	Burst (%)
O-S	Yes	1.55	32.02	8.22	21.0	0
C-O	Yes	1.69	34.56	9.48	10.0	23.3
K-Y	Yes	1.13	14.36	16.68	52.7	0
S-D	Yes	0.95	12.84	12.98	48.7	0
Express 60	Yes	1.14	11.44	21.70	62.3	0
C-G	Yes	1.16	17.30	14.90	10.0	44.7
K-K	Yes	1.49	28.86	10.14	27.7	0
A-S	Yes	1.10	20.84	7.06	29.0	0
Early Summer No. 1	Yes	1.30	25.24	9.76	28.0	0
General No. 2	Yes	1.06	16.02	12.36	43.3	0
Early Yoshin Summer	Yes	0.71	9.74	7.26	48.7	0
LSD 0.05		0.23	4.70	3.14		

cabbage included in this trial were O-S, C-O, K-Y, S-D, Express 60, C-G, K-K, A-S, Early Summer No. 1, General No. 2, and Early Yoshin Summer.

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. Side-dressing with the fertilizer at the same rate was initiated three to four weeks after transplanting.

A preventive spraying program was followed twice weekly to reduce 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.

Marketable yield was based on the head which was free of burst, insects and disease. The unmarketable yield was the head damaged by burst, insects, or diseases.

Forming head and head weight. All 11 varieties formed heads ranging from 0.71 to 1.69 kg per head. C-O, O-S, and K-K varieties had the largest heads with an average of 1.58 kg per head. There was no significance in head weight with an average of 1.12 kg among Early Summer No. 1, C-G, Express 60, K-Y, A-S, General No. 2, and S-D. Early Yoshin Summer with 0.71 kg per head was the smallest.

Marketable head yield. C-O, O-S, and K-K with a production average of 31.82 MT/ha (metric tons per hectare) significantly outyielded the rest of the eight varieties. Early Yoshin Summer, Express 60, S-D, and K-Y ranging from 9.74 to 14.36 MT/ha were the lowest.

Unmarketable yield. Bacterial soft rot disease caused by a soil inhabiting bacterium, *Erwina caratovora* caused most of the unmarketable heads. The infected head became watery and soft, turned light to dark brown, became mushy or slimy, and usually had a putrid odor. C-O and C-G varieties were the least susceptible to bacterial soft rot disease but very susceptible to burst after maturity. K-Y, S-D, Express 60, General No. 2, and Early Yoshin Summer were very susceptible to the bacterial soft rot disease. C-G, K-Y, and Express 60 ranged from 14.90 to 21.70 MT/ha, and showed the highest unmarketable yield. Early Yoshin Summer, A-S, O-S, and C-O, with an average of 8 MT/ha, had the lowest unmarketable yield.

Conclusions. Based on appearance, texture, size, and yield, C-O, O-S, and K-K were the promising varieties per the results of the experiment conducted during the dry season of 1978. See Table 2.

Tomato Experiment

Materials and methods. AES is cooperating with the Asian Vegetable Research and Development Center (AVRDC) for tomato research. AVRDC has been charged with the vital task of developing appropriate technologies and improving production of tomatoes. Ten breeding lines of tomatoes are included in this trial. They

Table 3. Performance of AVRDC's tomato breeding lines during wet season 1978

AVRDC Selection	Growth Habit	Fruit Set Rating	Fruit Weight (grams)	Marketable Yield (MT/ha)	Unmarketable Yield (MT/ha)
CL 8d-07-1 GS	determinate	1.2	61.00	1.38	2.95
CL 9-0-0-1 UG	determinate	2.5	35.19	2.66	2.60
CL 9d-0-3-6 UG	determinate	2.5	38.13	1.73	5.26
CL 11d-0-2-2-0-3UG	determinate	1.0	50.50	0.22	0.92
CL 32d-0-1-19 GS	determinate	1.5	60.00	0.48	2.30
CL 123-2-4 UG	determinate	2.5	40.00	3.04	3.52
CL 143-0-4B-1 UG	determinate	3.5	42.81	6.65	2.93
CL 143-0-6-9 UG	determinate	4.5	18.17	11.43	4.35
L 387 UG	indeterminate	1.0	42.00	0.18	0.50
L 1 GS	determinate	3.0	38.82	3.29	4.07
LSD 0.05			6.76	0.50	0.58

are: CL 8d-07-1 GS, CL 9-0-0-1 UG, CL 9d-0-3-6 UG, Cl 11d-0-2-2-0-3 UG, CL 32d-0-1-19 GS, CL 123-2-4 UG, CL 143-0-4B-1 UG, CL 143-0-6-9 UG, L 387 UG, and LIGS. This experiment is to select the variety that will set fruit during the hot, rainy season in the tropics and have high resistance to such diseases as bacterial wilt, tobacco mosaic virus and to a number of fungus diseases.

Therefore, this experiment was conducted during the wet season on Guam. The experimental design used was a randomized complete block with four replications. Each experimental plot was two rows measuring four meters long with 0.4 meters between plants and one meter between rows. Seeds were sown in Jiffy-7 pellets and one-month-old seedlings were transplanted to the field. 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 three weeks after the second harvest. Rotary tiller and garden hoe were used to control weeds. Dithane M-45, Tribasic coppers, Lannate L, Diazinon 500 EC, and Malathion 50 were used to control disease and insect problems.

The fruit was harvested at ripe or red-ripe stage. Harvesting period lasted about two-and-one-half months from the time of first harvest.

Growth habit and fruit set. All breeding lines except L 387UG have determinate habit of growth. The fruit-setting ability of CL 143-0-6-9 UG was the highest and L 387 UG, CL 11d-0-2-2-0-3 UG, CL 8d-0-7-1 GS, and CL 32d-0-1-19 GS were the lowest. L1GS and CL 143-0-4B-1 UG were the next highest fruit-setting lines.

Size of fruit. The fruit size of CL 8d-0-7-1 GS, CL 32d-0-1-19 GS, and CL 11d-0-2-2-0-3 UG averaged 57.17 grams in weight, and were significantly larger than the rest of the six breeding lines. CL 143-0-6-9 UG and CL 9-0-0-1 UG with 18.71 grams were the smallest in fruit size.

Marketable fruit yield. CL 143-0-6-9 UG and CL 143-0-4B-1 UG with a production of 11.43 and 6.65 MT/ha, respectively, significantly outyielded the rest of the breeding lines. There was no significance in yield between L1GS and CL 123-2-4 UG with 3.29 and 3.04 MT/ha, respectively. Yields were very low among CL 90-0-1 UG, CL 9d-0-3-6 UG, CL 8d-0-7-1 GS, CL 32d-0-1-19 GS, CL 11d-0-2-2-0-3 UG and L 387 UG, ranging from 0.18 to 2.66 MT/ha.

Unmarketable fruit yield. CL 11d-0-2-2-0-3 UG and L 387 UG had significantly less unmarketable fruit yield with 0.92 and 0.50 MT/ha, respectively. CL 9d-0-3-6 UG, CL 143-0-6-9 UG and L1GS showed the highest unmarketable yield with an average of 4.56 MT/ha.

Conclusions. Based on the appearance, texture, size and yield, CL 143-0-6-9 UG, CL 143-0-4B-1 UG, L1GS, and CL 123-2-4

UG were the promising lines per the results of the experiment conducted during the wet season of 1978. See Table 3.

Publications

Lee, C.T. 1978. *Growing Eggplant on Guam.* Cooperative Extension Service pamphlet.

Horticulture, Fruit

As site improvement is important for planting fruit crop seedlings,much of the time during this year was spent on digging trenches and filling them with organic matter. Trenches are dug and filled all around the AES at Inarajan. A shed for raising seedlings was also

Tropical fruit crop seedlings ready for planting in the field

completed. The following fruit tree seeds were obtained from different parts of the world and are presently all in the seedling stage.

The South Pacific Commission approved a small grant proposal providing for part time student assistance in raising the fruit tree seedlings.

Miscellaneous fruit and ornamental plant seeds were also received from J.L. Hudson, Seedman, Redwood City, California.

CROP	SOURCE
Bligia sapida	USDA-Miami
Myrciaria cauliflora	USDA-Miami
Euphoria longana	USDA-Miami
Litchi chinensis "Sweet Cliff"	USDA-Miami
Mangifera indica "Carabao"	USDA-Miami
Mangifera indica "Ono"	USDA-Miami
Mangifera indica "19-50"	USDA-Miami
Mangifera indica "Cambodiana"	USDA-Miami
Syzygium jambos	Western Samoa
Citrus aurantifolia	Niue Island
Citrus reticulata	Western Samoa
Citrus spp. "Roug Lemon"	New Caledonia
Carica papaya	Hawaii, Malaysia, Kenya, Puerto Rico, Florida
Cyphomandra bataceae	Hawaii, Kenya
Eugenia cauliflora	Hawaii, Kenya
Averrhoa bilimbi	Hawaii, Kenya
Averrhoa carambola	Hawaii, Kenya
Eugenia uniflora	Hawaii, Kenya
Passiflora edulis-flavicarpa	Hawaii, Kenya
Malpighia glabra-3 cultivars	Hawaii, Kenya
Psidium guajava "Beaumont"	Hawaii, Kenya
Punica granatum	Hawaii, Kenya
Dovyalis hebecarpa	Hawaii, Kenya
Annona squamosa	Hawaii, Kenya
Annona muricata	Hawaii, Kenya
Physalis peruviana	South Africa, Kenya
Passiflora laurifolia	Florida
Pouteria campechiana	Florida

Entomology

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

The Station also engaged in an informal project with Dr. V.E. Gracen, Cornell University, and W.R. Wiseman, Southern Grain Insects Research Laboratory, Tifton, Georgia, in which promising corn lines are screened for resistance to the Asiatic corn borer, *Ostrinia furnacalis* and also the corn earworm, *Heliothis* sp.

Pests of cruciferous vegetables

Host resistance trials. Three field trials to detect cabbage variety resistance to *Heliothis* sp., *Crocidolomia binotalis, Hellula undalis, Chrysodiexis chalcites, Plutella xylostella* and *Spodoptera litura* were conducted. In the first trial, the variety O-S was compared to Ruby Ball. In the second trial, the variety C-O was compared to Ruby Ball and in the third trial, the variety C-O was compared to Ruby Ball in a factorially designed experiment conducted jointly by an entomologist, horticulturist, and plant pathologist to determine the effects of the factors of two varieties, two plant spacings, three levels of disease control measures, plus a control.

In the first trial, Ruby Ball appears to be a nonpreferred host for insects when compared to O-S. Also, O-S is very susceptible to a bacterial soft rot that renders the head unsalable. Therefore, in the second trial, the variety C-O was used. However, in the second trial, black stem rot infected a number of plants including Ruby Ball. Despite this damage, Ruby Ball still appeared to be a nonpreferred host for insects. In the third trial, compared to C-O, Ruby Ball again appeared to be a nonpreferred host for insects.

A fourth trial identical to the third trial will be repeated in the coming year.

Control of *Heliothis* sp. by a viral insecticide. The *Baculovirus heliothis* material, SAN 240 I WP 74 (SANDOZ) and the adjuvant SAN 285 AD WP 76 were tested at the .178 and .355 kg ai/hectare levels for control of the *Heliothis* species on K-Y cabbage. Results of this experiment did not offer enough information about the control of *Heliothis* sp. because the level of the insect population was generally low, and bacterial soft rot decimated the cabbage later in the experiment. It did appear that fewer *Heliothis* were in the sprayed plots than in the unsprayed plots.

Integrated pest management

Elimination of an insect vectored disease of bananas. An aphid, *Pentalonia nigronervosa* Coq., is the vector of bunchy top disease

of bananas. Since it is known that the disease cannot be cured, and that the aphid is difficult to economically control by chemical or biological means, a method of eradicating the infected plant host was sought. This method was found in use of the herbicide material K-pin (Nihon Nohyaku), a potassium salt of 4-amino-3, 5, 6-Trichloro-Picolinic acid (Picloram), permeated into the head of a 5 cm-long toothpick to be inserted into the plant.

K-pin was found by entomology and plant pathology personnel to kill the corm of the infected bananas with little side effect on the soil. Additional information that may affect the transmission of bunchy top disease is that *P. nigronervosa* is also found on the plant *Dieffenbachia*.

In cooperation with the College of Agriculture and Life Sciences, the Guam Department of Agriculture sought an emergency exemption for the use of K-pin to eradicate the bunchy top diseased bananas. This emergency exemption has been granted.

Resistant corn lines. European corn borer resistant corn lines were assessed for resistance to the Asiatic corn borer, *Ostrinia furnacalis*.

Twenty-five recombinant corn lines supplied by Dr. V.E. Gracen, Cornell University, were tested in two separate trials. Data collected included a damage rating according to Gutherie's 1-9 scale, the number of ovipositions per plant, and the number of borers per ear. Results so far indicate that corn lines showing resistance to the European corn borer may not show resistance to the Asiatic corn borer. More trials are needed for a conclusion.

Heliothis sp. resistant corn lines supplied by W.R. Wiseman, Southern Grain Insects Research Laboratory, Tifton, Georgia, were also assessed. Zapalote chico, Dixie, Antigua and Cactiuacintle were relatively free of *Heliothis*, but badly damaged by *O. furnacalis*.

Bagworm control. An unidentified bagworm (Psychidae) is an ornamental pest on Guam due to the habit of mature individuals fastening to walls. This bagworm is controlled by the application of Dipel, at the recommended level, on lawn grass which is a preferred food. The use of Dipel allows the survival of the tachnid, *Stomatomyia* sp., which attacks the bagworm larva.

Control of *Heliothis* sp. on tomatoes. An experiment with three replications using the insect virus, SAN 240 I (SANDOZ), Dibrom, and Sevin to control *Heliothis* sp. on tomatoes indicated that the three insecticides performed about the same. The level of control was not satisfactory. Among ripe fruit the percentage of damaged fruit was 28 percent (119/423) for Sevin, 22% (63/293) for Dibrom, 31 percent (98/318) for SAN 240 I, and 48 percent (126/261) for the control. Perhaps more work is needed to improve the adjuvant SAN 285 AD WP76 used with the virus. We also used SAN 240 I and SAN 285 AD WP76 in a corn experiment. The material did not ap-

Coconut beetle

pear to effectively control *Heliothis* sp. on corn.

Integrated control of coconut beetle. Coconuts infested with *Brontispa palauensis* are partially protected by the parasite *Tetrastichus brontispae.* To achieve an integrated control, several insecticides, Systox, Metasystox, Di-Syston and Lorsban were injected via a bored hole at ground level into coconut trees. The results so far indicate that further research is needed.

Integrated control of Philippine lady beetle. The imported Eulopid parasite, *Pediobius foveolatus,* has been recovered from the Philippine lady beetle, *Epilachna philippinensis,* a pest of tomato and eggplant. This larval parasite along with the pupal parasite *Pleurotropis epilachnae,* is expected to exert control upon the population of *E. philippinensis.* The use of insecticides with short periods of effectiveness permits control by *P. foveolatus* since the unemerged parasites are protected from such materials as Sevin.

Corn pest management. A corn pest management experiment designed to control the Asiatic corn borer, *Ostrinia furnacalis*, and *Heliothis* sp., was performed using Orthene, Orthene and the virus SAN 240 I with SAN 285 AD WP76, and SAN 240 I with SAN 285 AD WP76. Plots with the virus alone as a treatment were sprayed every three days. The plots with Orthene as a treatment were sprayed on a decision basis. An inverse sampling plan was developed using p=.05 and p=.03. There were two separate block designs, each with five replications and four plots. One block design was assigned to each threshold (p=.05, p=.03). The decision making factor was finding one egg mass of *O. furnacalis* in 30 plants (p= .05) or in 50 plants (p=.03). If one egg mass was found, Orthene was applied without examining more plants.

As the experiment progressed, sprays of Orthene became rare. However, an egg parasite, *Trichogramma* sp., was present in great numbers in the single eggs of a hornworm, *Agrius convolvuli* (L.), which fed on the adjacent morning glory. Parasitized Asiatic corn borer egg masses were noted but excluded from the inverse sampling count. At harvest, the sweet corn ears, Golden Bantam, were quite good considering an outbreak of a stripe corn disease, probably vectored by the leaf hopper *Peregrinus maidis*, was present on all corn plants.

Mealy bugs on tangantangan. *Ferrisia virgata* (Cockerell) is a mealy bug pest on tangantangan, *Leucaena leucocephala*. Outbreaks of this mealy bug have been observed. An unidentified Eulopid parasite (Entedontinae) and the coccinellid beetle *Nephus roephei* (Fluiter) are found in association with *F. virgata*. The interaction between these insects needs more documentation.

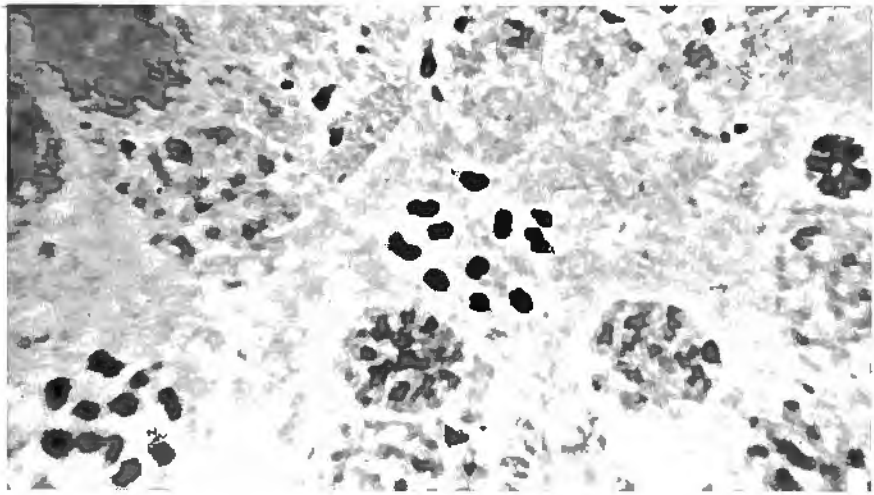
Biological Control

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

The poinciana looper. The poinciana looper *Pericyma cruegeri*, a pest of the ornamental flame tree *Delonix regia*, can be controlled by Dipel, a commercial insecticide consisting of *Bacillus thuringiensis*. However, the cost of application every 10 days is expensive, so systemic insecticides were tested as an alternative. Di-Syston, Metasystox, Systox, Hosdon, Geofos, Cytrolane, Temik and also Lorsban were either injected approximately every six inches around the tree to a depth of one inch, applied into the ground via six-inch deep holes around the drip line of the tree, or painted onto bark.

Counts of looper larvae were made on four limbs (three-foot lengths counted from the tip inward) per tree.

The results of this experiment have not been adequately examined to determine the efficacy of these insecticides in controlling



Chromosomes

the looper. Simple observation of the experimental trees indicates that little success can be expected.

An all-year survey indicated that loopers are present on flame trees year-round, but only at low levels during the 1977 dry season (February to September).

In addition to the survey, AES did some life table work. It appears that the pupal parasites *Brachymeria albotibialis* and *Exorista civiloides* are present only at very low levels. The praying mantid *Hierodula patallifera* is present in large numbers and does eliminate loopers, albeit not enough for control at an economic level except during the dry season.

The failure of the present parasites and predators to control the wet season population outbreak led to the conclusion that additional means of control, such as other imported parasites, or behavioral manipulation of parasites and predators already on Guam, would be useful.

Trichogramma sp. The *Trichogramma* sp. parasitizes the eggs of the Asiatic corn borer *Ostrinia furnacalis,* possibly *Heliothis* sp. and *Spodoptera litura,* three major pests. However, it appears the *Trichogramma* sp. (likely *T. chilonis* Ishii) prefers to parasitize hornworms, e.g. the morning glory hornworn *Agrius convolvuli* and two other hornworms found on *Morinda citrifolia* and taro. Work is presently underway to utilize behavioral manipulation of the *Trichogramma* sp. to control *O. furnacalis* and *Heliothis* sp. in corn and tomato respectively. There is also the possibility that these parasites can be manipulated to control the flame tree looper.

Cytogenetics and pest control. This research began in 1978. Chromosome formulae of the following three pests were obtained.

Epilachna philippinensis: male, 8 II + Xy_p; female, 8II + XX
Cylas formicarius: male, 10 II + Xyp; female, 10 II + XX
Pericyma cruegeri: female, varies from 23 I to 63 I, and even 45 II has been observed.

A photomicrographic system is being established for karyotype analysis of the chromosomes of these three species.

Isozyme studies will be carried out as soon as insect cultures are started and all equipment and chemicals are procured.

Publications

Stevens, L.M. and R. Muniappan. 1978. *Insects of Cruciferous Crops and Their Control on Guam.* Guam Agricultural Experiment Station Bulletin 4.

Muniappan, R. and L.M. Stevens. 1978. *Biological Control of Insects.* South Pacific Bulletin. 1st Quarter.

Plant Pathology

Research in plant pathology is being focused on the identification of diseases and methods of control. Guam's unique tropical environment necessitates reevaluation of control measures for most host-pathogen complexes.

There are seven current plant pathology research areas.

Identification of plant diseases on Guam. An islandwide survey of plant diseases started in July 1978. Table 1 lists the results of this survey as of January 1, 1979. This list is expanding as other host-pathogen complexes are identified.

Eradication of bunchy top disease of banana. A cooperative effort is currently underway between the UOG College of Agriculture and Life Sciences and the Guam Department of Agriculture to effect an islandwide eradication program. K-pin, a Japanese formulation of picloram, was found to be highly effective and economical in destroying diseased bananas. The EPA has granted permission for emergency use of K-pin for this effort.

Resistance in cabbage to black and soft rots. A cooperative study is currently underway with the vegetable horticulturist to identify resistant or tolerant varieties. Chemical control of insect pests and diseases is also being evaluated. At this time, the variety Ruby Ball looks very promising under Guam conditions.

Table 1. Disease identified on Guam

Common Name	Scientific	Type of Disease	Causal Agent
Eggplant	*Solanum melongena*	Bacterial wilt	*Pseudomonas solanacearum*
Tomato	*Lycopersicon esculentum*	Bacterial wilt	*Pseudomonas solanacearum*
Banana	Musa sp.	Bunchy top	Mycoplasma
Corn	*Zea mays*	Stripe	Virus
Cantaloupe	*Cucumis melo*	Wilt	*Fusarium oxysporum f. melon*
Cantaloupe	*Cucumis melo*	Virus	CMV
Papaya	*Carica papaya*	Virus	Papaya Ringspot Virus
Taro	*Colocasia* sp.	Unidentified corm rot	Unknown
Bittermelon	*Momordica charantia*	Mildew	*Oidium* sp.
Watermelon	*Citrullus vulgaris*	Virus	CMV
Cucumber	*Cucumis sativus*	Virus	CMV
Cucumber	*Cucumis sativus*	Mildew	*Oidium* sp.
Taro	*Xanthosoma* sp.	Virus*	Unknown virus
Taro	*Colocasia* sp.	Leaf blight	*Phytophthora colocasiae*
Cabbage	*Brassica oleracea*	Black rot	*Xanthomonas campestris*
Tomato	*Lycopersicon esculentum*	Wilt	*Sclerotium rolfsii*
Tomato	*Lycopersicon esculentum*	Wilt	*Fusarium oxysporum f. lycopersici*
Bush Bean	*Phaseolus vulgaris*	Crown rot	*Rhizoctonia solani*
Bush Bean	*Phaseolus vulgaris*	Angular leaf spot	*Isariopsis griseola*
Banana	*Musa* sp.	Panama wilt*	*Fusarium oxysporum f. cubense*
Banana	*Musa* sp.	Black leaf streak	*Cercospora* sp.
Papaya	*Carica papaya*	Blight	*Phytophthora palmivora*
Sweet Potato	*Ipomoea batatas*	Anthracnose	*Elsinoe batatas*
Cucumber	*Cucumis sativus*	Root knot	*Meloidogyne* sp.
Cabbage	*Brassica oleracea*	Soft rot	*Erwinia caratovora*
Bell Pepper	*Capsicum annuum*	Bacterial spot	*Xanthomonas vesicatoria*
Corn	*Zea mays*	Rust	*Puccinia polysora*
Mango	*Mangifera indica*	Anthracnose	*Glomerella* sp.
Avocado	*Persea americana*	Anthracnose	*Glomerella* sp.
Citrus	*Citrus* sp.	Sooty mold	*Capnodium* sp.
Citrus	*Citrus* sp.	Bacterial canker	*Xanthomonas citri*
Guava	*Psidium guajava*	Root rot*	Unknown

Identification of taro virus. An islandwide survey of 71 taro fields was conducted in cooperation with the Cooperative Extension Service. Eighty-two percent of the 131,853 plants inspected exhibited symptoms of virus infection (Figure 1). Figure 2 shows the survey results by area.

Virus symptoms were first noticed in August 1978. This problem has not been previously reported on Guam, although results of an islandwide survey suggest a long-standing problem. A program to assess quality and yield reduction is anticipated in the near future.

Disease complex on papaya. *Phytophthora* blight is a moderate problem on young papaya. This problem appears to be enhanced in certain cases by the presence of other fungi. Studies are being initiated to identify the members of this complex and to determine their role in the disease syndrome.

Biological control of soil-borne disease of tomato and cucurbits. Studies to decrease the incidence of *Fusarium* wilt in tomato are being conducted with cooperating growers. Various combina-

Figure 1. Virus symptoms on taro leaves

tions of soil amendments and soil fumigation are being evaluated for their effect in reducing disease incidence in screenhouse grown tomato. Initial tests indicate at least race 1 of *Fusarium oxysporum* f. *lycopersici* is present.

Field evaluation of pesticides. Records are being maintained on the effectiveness of various fungicides under field conditions for various crops. An evaluation of effectiveness will be made after sufficient data have been collected.

Report of new disease

Panama wilt of banana *(Fusarium oxysporum* f. *cubense)* was identified at two separate locations. This disease has not previously been reported on Guam. The race(s) of the pathogen have not been identified, however, two plantations have been severely damaged and the disease appears to be spreading. Further monitoring and studies are underway.

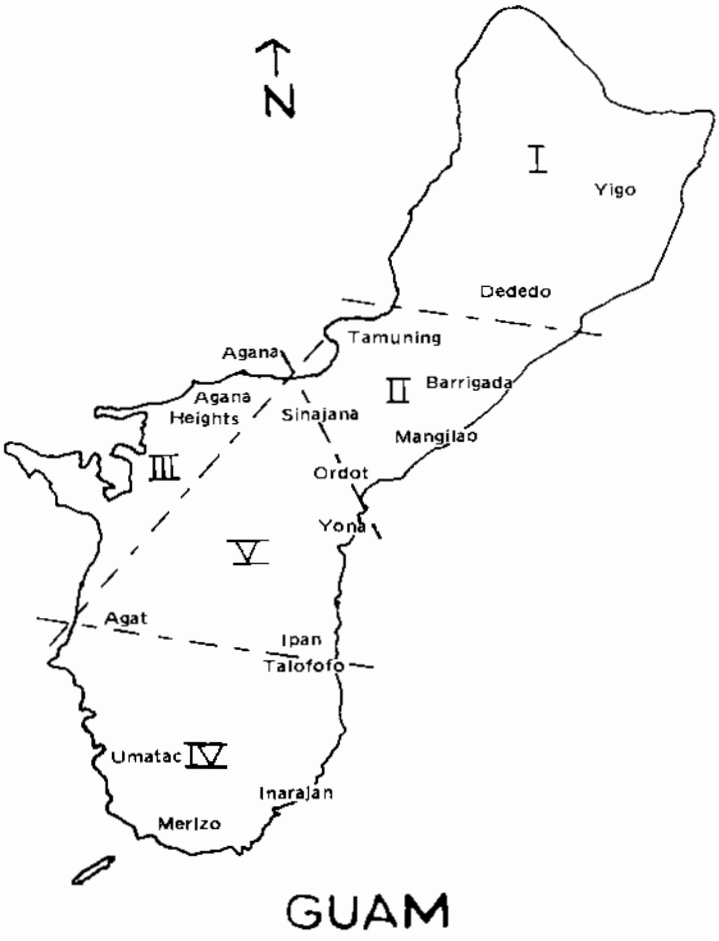


Figure 2. Taro virus survey areas

Animal nutrition lab

Animal Science

Swine Nutrition

There has been a great need and interest among swine producers on Guam for the development of a swine nutrition program to find a practical, economical, and nutritionally sound diet.

Most swine producers on the island are currently using costly imported pelleted feed as the total diet. Because of this, many have either reduced their production or gone out of business. Pork is a major source of meat on Guam with per capita consumption now over 40 pounds per person, annually.

To meet the consumer demand, hog feed must be cheaper and readily available. An animal scientist was recruited in August 1978, to study the possibility of using swine feedstuff available on Guam. In December 1978, a research proposal "Use of Local Feedstuffs Available on Guam for Swine Production" was approved by the Cooperative Research, Science and Education Administration, USDA.

A nutrition laboratory for basic feed analysis (crude protein, crude fiber, fat, nitrogen-free extract, and minerals) has been established at the Agricultural Experiment Station, at Inarajan. All locally grown and economical feedstuff will be analyzed for their nutritional values. Combinations of these feeds will be used in trials (beginning May 1979) to determine the most practical, economical and efficient diets. Criteria for comparison will be average daily weight gain, feed/gain ratio, weight and number of pigs per litter, mortality, meat quality, and weight at birth. In the future, blood, urine and feces samples will also be used in special metabolic trials. Statistical analysis will be carried out in all trials.

Since AES does not have a piggery for conducting nutritional experiments, the Guam Department of Agriculture has agreed to loan their piggery facilities. In the future, the Agricultural Experiment Station will build swine units for breeding, farrowing, weaning and finishing at Ija. In the meantime, 40 weanlings, provided by the Guam Department of Agriculture, will be put on nutritional trials. They will be bred, and a selected herd will be used in future experiments. Local feedstuff to be used in the nutritional trials are cassava (*Manihot* sp.), coconut meal, garbage, poultry waste, fishmeal, breadfruit(*Artocarpus* sp.), taro *(Xanthosoma* sp.), tangantangan *(Leucaena leucocephala),* sweet potatoes, and bakery waste.

Agricultural Engineering

Trickle irrigation

Research relating to trickle irrigation is being conducted throughout the world. To date, the application of this irrigation method on Guam has been considered. Since the trickle system can operate with low water pressures, it should bring cost saving in vegetable crop production.

The administrative advisor for the Regional Research Project W-128 approved the AES request to join the project in 1978. AES is beginning to conduct the project. C.T. Lee and J.Cruz allocated 15 percent and 25 percent respectively for this project. Some of the necessary equipment and supplies have been purchased locally. Orders have been placed for those not available on the island.

Trickle irrigation system

Land Use

Geographical research at the Agricultural Experiment Station identify and assess the major socio-ecological resources of the island. Several spatial components of the food base were examined this past year. From field work results in late 1977, a location map shows 14 additional operative farms; the majority were in northern Guam. Besides field interviews, special planning focused on integrating population compilations analyzed from a survey conducted by the Bureau of Labor Statistics in mid-1978.

It is shown that the distribution of population on Guam is highly regionalized; the most heavily concentrated areas occur in the central and north regions. In fact, 75 percent of the present population lives in the northern half of Guam. Measurements of the relative population changes and densities by administrative district reveal that the major population growth areas exist near identified farms, especially in Dededo, Yigo, Barrigada, and Mangilao. These urbanizing trends will further cause farm declines.

While imported food remains the predominant source of most people's diets, local food production activities remain steady. Approximately one percent of the work force stays employed in farming operations. Nearly 1700 acres of cropland provide about one-quarter of the fruit and vegetable produce demanded in the marketplace. That production impact however, must increase at an increasing rate of growth to insure a successful future. Basic problems for rapid agricultural development continue to plague the farming sector.

Land Use Competition. Historically, alienation of land has been a major obstacle of sustained agricultural development, but other economic factors exist to offer competition. Coastal lowlands and other accessible shoreline areas were found to possess few operative farms. Military, commercial, residential and other urban land uses prevailed in those prime rent areas. However, more recent competition occurs from population pressures and corresponding housing developments. For example, in the north, particularly in the Dededo district, several new government housing developments compete for the open space. According to the Bureau of Planning's Master Land Use Plan 1978, conservation land corresponds to the northern water lens; yet urban land uses at the present rate of growth offer the greatest pressures on the Dededo area.

Water Problems. Estimates indicate an average of nearly one billion gallons of rainfall occur each day over the entire landmass of the island. In 1975 water consumption for the entire community amounted to just over four billion gallons for the year. Farmers

frequently encounter problems receiving adequate water supplies at a reasonable price. Without the proper water infrastructures and supplies for the rural areas, little expansion is possible for long term agricultural development.

Taxes on Agricultural Land. Comparable data on farm real estate taxation in the United States reveals that Guam's taxes on agricultural land is relatively high. The average tax on a statewide basis in Hawaii for 1975 on agricultural land per acre was 33 cents less than Guam's average. A total of 29 states in the U.S. in the same year taxed their agricultural real estate at a lesser per acre rate. To insure a favorable agricultural policy, new tax incentives are necessary.

Aquaculture

Freshwater prawns

The prawn project was designed to develop methods for diet evaluation based on the physiological responses of the cultured organism. The proposed strategy was to monitor aspects of the nitrogen budgets of prawns which were fed specific dietary items.

In order to prepare for these experiments, it was first necessary to construct facilities to hold and acclimate the experimental animals. During this early stage in the project much of the efforts were focused on development of holding facilities and larval rearing systems. These systems were designed to maintain the experimental animals through short periods of power outage since this is a frequent occurrence on this island.

A large, flow-through cement raceway was constructed at the University of Guam Marine Laboratory. This system is capable of holding a large number of prawns without stress from crowding. A recirculating plywood holding system was also constructed. This system consists of a shallow tray and a biological filter. Water flow is maintained with a submersible pump.

Two types of larval rearing systems were constructed and tested. One is a recirculating-tank system which was designed to operate by an air lift pump, and to maintain both the larvae and the food particles in suspension. A larger larval rearing system was also

Courtesy of Pacific Daily News

Freshwater prawns

set up and operated by the Guam Department of Agriculture. This system was used to produce larval shrimp which were supplied to the ponds of several shrimp farmers on Guam. Typhoon damage to the seawater system of the Marine Laboratory and other problems caused a temporary break in this service.

A survey of potential aquaculture development on Guam was undertaken and results were presented at the annual meeting of the World Mariculture Society.

Experiments are in progress which concern the relation of the rates of ammonia excretion to body weight, diet, and quantity ingested. Results of these experiments will be presented at a later time.

Publications

FitzGerald, W.J., Jr. and S.G. Nelson. In press. *Development of aquaculture in an island community, Guam, Marianas Islands.* Proceedings World Mariculture Society.

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*Left in 1979
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