Guam Agricultural Experiment Station

University of Guam
Annual Report
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FROM THE DIRECTOR

There was increased international activity during 1984. The Ninth International Forum on Soil Taxonomy and Agrotechnology Transfer was conducted on Guam for the countries in Oceania. Support for this forum was received from Soil Management Support Services, U.S.A.I.D., Deutsche Stiftung Fur International Enqicklung and the Australian Centre for International Agricultural Research. Two of our faculty were on sabbatical leave in the Philippines and India. Also, grants were received from the National Science Foundation, the Fulbright Foundtion, the Food and Agricultural Organization and the Office of International Cooperation and Development, USDA.

A memorandum of understanding with International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) has been signed for mutual collaboration.

A parcel of 30 acres of land in Barrigada, Guam has been received on lease from the U.S. Navy for conduc ting agricultural experiments.

A computerized data base has been set up for insects and plant diseases of Guam and for agricultural literature in Micronesia.

W.P. LEON GUERRERO
Dean/Director

Autologging weather station installed at the Inarajan Experimental Farm. Cover design and report layout concept by Perry A. Perez. Photo by Silas E. Gould.

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Contents

Soil Science

Jefren L. Demeterio &
John T. Cope

Soil and Plant Analysis

The soil and plant analysis laboratory in Inarajan analyzed 433 soil samples, of which 131 were from farmers fields, in 1984. This compares to 314 total samples with 191 from farmers in 1983. The larger number in 1984 was due primarily to off-island research samples collected in the new 406 project on soil fertility research for Micronesia. The laboratory also analyzed 722 plant samples compared to 101 in 1983. This increase was also due to research samples analyzed for the 406 research project.

Services of the laboratory for farmers of Guam and cooperating states of the Federated States of Micronesia were offered without charge beginning in October of 1984. Fertilizer and lime recommendations based on soil analysis are made for all farm samples received. Data will be accumulated by soil type and summarized in an effort to improve soil test calibration and thereby recommendations throughout Micronesia. All soil samples are analyzed by the Mehlich I Double Acid procedure in addition to the Olsen and exchangeable cation procedures previously used. Soil test levels of P and K used in rating soils based on analysis by the two procedures are shown in Table 1.

Levels shown in Table 1 are higher than are used by many laboratories for these procedures. Since fertilizers containing phosphous or potassium will not be recommended for most crops on soils rated **High** or **Very High** in these nutrients, growers should feel safe in omitting these nutrients when they are not recommended. Additional research is needed on Guam and the other islands to further refine these calibrations and make them more accurate.

IX International Forum on Soil Taxonomy and Agrotechnology Transfer

A two week conference by the above title was held on Guam September 13-14, 1984. It was attended by more than 30 participants from Guam, Yap, Palau, Truck, Pohnpei, Kosrae, Papau New Guinea, Tonga, Western Samoa, American Samoa, Kiribati and Fiji. Resource personnel appearing on the program in addition to several contributors from Guam came from Washington, D.C., Hawaii, Oregon, Fiji, West Germany, Australia, New Caledonia, New Zealand and the Philippines. The conference offered participants the opportunity to examine the soils of Guam and to study the role of soil survey in agricultural development. Many members of the staff of the Agricultural Experiment Station and the Cooperative Extension Service contributed to the success of this international conference.

Leucaena Experiment

The leucaena intercropping experiment started in 1983 was planted to cherry tomatoes, bell pepper and cabbage during the rainy season of 1984. These three crops failed because of excessive rain and wind during the several monsoons. They were followed by a planting of Supersweet 9 sweetcorn on October 14, after all leaves from the tangantangan had been harvested and applied to the plots. After the corn began to grow, it became evident that all rows were suffering from nitrogen deficiency. The area was divided into four strips across the tangantangan plots and two of these strips received two applications of 50 lb/a of nitrogen. Corn was harvested in the roasting ear stage on December 20, December 27 and January 4. Yields and numbers of ears harvested are shown in Table 2.

As a result of the poor results from attempts to grow tomatoes, peppers and cabbage between Leucaena hedges and the failure of the Leucaena to supply adequate nitrogen for sweet corn, this experiment was discontinued in 1985. Due to the high cost of labor and the poor results found, this is not considered a practical croping system for farmers on Guam.

Peanut Variety Test

Two varieties of peanuts that are widely grown in Alabama and Georgia were compared with the variety previously grown on the experiment station on Guam.

Table 1. Soil-test Ratings and Parts per Million of P and K from Olsen and Mehlich 1 Extractions for P and Exchangeable and Mehlich 1 Extractions for K.

	Phosphorus (ppm P)		Potassium (ppm K)	
	Olsen	Mehlich 1	Ammonium acetate pH 7.0	Mehlich 1
Very Low	0-5	0-8	0-50	0-30
Low	6-10	9-15	51-75	3-50
Medium	11-20	16-30	76-125	51-120
High	21-30	31-60	126-200	121-200
Very High	30+	60+	200+	200+

Yields were as follows:

	Yield lb/a	% Increase	Shelling Percentage
Local Variety	1660	--	79
Florunner	2380	44	82
Sunrunner	2610	58	82

Table 2. Effect of 100 lb./a N on Yield, Ear Numbers and Ear Size of Sweet Corn Grown between Leucaena Rows.

	Yield lb/a	Ears per Acre	Ear Size lb.
No nitrogen	6,880	7770	.88
100lb/a Nitrogen	10,000	9380	1.12
Increase	53%	21%	27%

Nuts of all three varieties were of high quality. Seed of the two superior varieties are available commercially. This comparison will be repeated in 1985.

Response of Field Corn to Rates and Split Application of Nitrogen in Large and Small Plots, Inarajan, 1984

An experiment with five rates of nitrogen from urea on a local variety of white field corn was planted April 18 and harvested August 9. Variables included N rates of 0, 50, 100, 200 and 400 kg/ha applied at planting and also with ½ of N sidedressed. Each treatment was repeated in four replications of plots 4M x 5M. A fifth replication repeated the same treatments in small 1M x 5M plots with four replications. Yields are shown in Table 3.

The data show a response to 200 lb/a N over the 100 lb/a rate, with no increase from sidedressing over putting all N out at planting. The small plots were less satisfactory than the large plots, because of more variability as indicated by the high coefficient of variation. Accurate conclusion on rate to recommend cannot be drawn from this experiment because of the wide range between the 100 lb/a and 200 lb/a treatment. About 150 lb/a would probably be adequate for corn on this soil.

Table 3. Response of Field Corn to Rates and Split Application of Nitrogen in Large and Small Plots, Inarajan, 1984.

N Rate	Large Plots 4Mx5M			Small Plots 1Mx5M	
kg/ha	Split	Single		Split	Single
			Kg/ha		
0	1600	2190	cd	2950	2550
50	2240	cd3230	bc	3280	3160
100	2560	cd3500	abc	3150	3280
200	4620a	4800 a		2770	3750
400	4620ab	3970 ab		3920	3120
	cv 25%			cv40%	NStq

Horticulture - Vegetable Crops

Chin-Tian Lee

Horticultural research work on vegetable crops in 1984 continued to study the potential of winged bean as a crop for Guam. Two experiments involving cultural methods for winged bean were conducted. Another project was continued on screening and determining the adaptibility of major vegetable cultivars which have economical impact for Guam. Two experiments dealing with the evaluation of cantaloupe varieties were conducted.

I. The Effect of Support on Production of Winged Bean

The winged bean is commonly trained to grow on supports such as stakes, trellises and fences. Because of the cost of materials and labor for staking or trellising, the objective of this experiment was to evaluate the effect of support and no support on planting time to first flower, nodule number and green pod production for three selected winged bean cultivars.

Materials and Methods

This experiment was conducted at the Guam Agricultural Experiment Station from July, 1983 to January, 1984. The soil was clay, low in available nitrogen and phosphate and moderate in available potassium. The pH was 8.2. The experimental design was a split-plot design with six treatments replicated three times. The three cultivars (Chimbu, Tinge and Dual) were the main treatments while support and no support were the sub-treatments. Each block was divided into three main plots. Three main treatments were randomly distributed in each of the main plots. A main plot was divided into two sub-plots, each measuring 4.32m x 9.00m.

Plants in the sub-plots were grown in three rows spaced 1.44m apart and 0.45m within rows. Before planting the winged bean seeds were acid (sp. gr. 1.84) at 25° C for 5 minutes followed by a 10 minute rinse under running tap water. Three seeds were planted per hill and the seedlings were thinned to one plant per hill after 2 to 3 weeks from planting. The seeds were not treated with any inoculum.

Fertilizers were applied at the rates of 50 kg/ha N, 200 kg/ha P_2O_5 and 100 kg/ha K_2O in the form of ammonium sulfate, double superphosphate and muriate of potash, respectively. All the phosphorus and potassium dosages were applied at planting, half the dosage of nitrogen was applied at planting while the other half was applied 5 weeks after planting. The determination of nodule number was carried out at eight weeks after planting by sampling ten plants from each of the sub-plots. Data on the pod weight, number and yield of green pods were taken at each harvest (once a week).

The detailed description of the two sub-treatments were:

Support—This consisted of leucaena (*Leucaena leucocephala*) posts (1.8m high) each set at 3 meter distances with 2 no. 4 rebars fasteed to the posts, one at the top and the other near the base. Cucumber plastic net was strung between the two rebars. The plane of support for each planting row was vertical.

No Support—The plants were grown without any kind of support.

Results and Discussion:

Plant emergence was very fast

Table 1. The Effect of Cultivar and Support on Days to First Flower.

Main Treatment (cultivar)	Sub-treatment: Support	Sub-treatment: No Support	Main Treatment Mean
Chimbu	64.0	69.0	66.5
Tinge	68.0	75.0	71.5
Dual	71.0	76.0	73.5
Sub-treatment mean	67.7	73.3	

LSD 0.05 Between main treatment	2.8
LSD 0.05 Between sub-treatment mean	3.5
LSD 0.05 Between sub-treatments for the same main treatment	4.0
LSD 0.05 Between sub-treatments for the different main treatment	3.1

with an average of 5 days. Perhaps scarification of hard-coated seeds of winged bean with H_2SO_4 treatment speeded up the germination. No major disease was evident during the experimental period. The major insect pests were aphids and white flies which sucked the young leaves. Effective control of these insects was achieved with the application of Malathion E.C.

Days to First Flower:

Table 1 shows the effect of cultivar and support from planting time to first flower. Appearance of first flower ranged from 64 to 76 days. Chimbu reached first flower significantly earlier than Tinge and Dual. Non supported plants took a longer time to first flower than supported plants on all the three cultivars.

Nodule Number:

The results of nodule number per plant are presented in Table 2. Chimbu produced a higher nodule number than Tinge and Dual. Nodule number was significantly higher in the supported plants when compared to the non supported plants, while no significant difference was observed among three different cultivars within the same sub-treatment. Since nodules were for inoculation from this experiment, it was presumed that indigenous *Rhizobium* bacteria specific for winged bean were presented in the experimental area.

Green Pod Weight:

Green pod weight per pod ranged from 14.0 to 26.0 g (Table 3). There was no significant difference in green pod weight between supported and non supported plants. However, the pod weights of Chimbu and Dual were significantly higher than Tinge.

Total Number of Green Pod:

It was noticed that the pods produced from non-supported plants are much lighter in color compared to the pods from supported ones. This may be explained by the fact, that sunlight plays a major role in the color development of a pod. The effect of cultivar and support in total number of green pods per plant is presented in Table 4. Tinge produced the highest number of green pods among the three cultivars. Non supported plants produced significantly fewer numbers of green pods than supported plants.

Green Pod Yield:

Table 5 shows the effect of cultivar and support on green pod yield. There was no significant difference in yield among the three cultivars. Supported plants produced about three times more green pod yield than the non supported plants. A possible explanation for the increase in yield due to support would be the encouragement of vine growth and hence leaf area together with better leaf distribution and display to sunlight. This would allow a greater amount of photosynthate formed, thus there would be more translocation of photosynthate for pod formation.

Conclusion:

The results of this experiment indicated that supported plants increased nodule number and total number of green pods. It could be concluded that support is essential to obtain high yields of green pods.

Table 2. The Effect of Cultivar and Support on Number of Nodules Per Plant.

Main Treatment (cultivar)	Sub-Treatment		Main Treatment Mean
	Support	No Support	
Chimbu	20.20	50.12	35.16
Tinge	17.15	47.05	32.10
Dual	18.50	45.01	31.76
Sub-Treatment mean	18.62	47.39	

LSD 0.05 Between main treatment 0.97

LSD 0.05 Between sub-treatment mean 4.03

LSD 0.05 Between sub-treatments for the same main treatment 6.97

LSD 0.05 Between sub-treatments for the different main treatment ..... NS

II. The Effect of Planting Density on Winged Bean Growth and Production of Fresh Pods and Dry Seed

This experiment was to evaluate the effect of different planting densities on winged bean growth and production of fresh pods and dry seed.

Materials and Methods:

Seeds of winged bean were directly sown in the field without any treatment. Four treatments of planting densities were planted at spacings of 12.5, 25.0, 50.0 and 75.0 cm (equivalent to 13,333, 20,000, 40,000 and 80,000 plants/ha). The treatments were replicated three times in a randomized complete block design with Chimbu variety. Each experimental plot consisted of 4 rows, 4.57 meters long. The spacing adopted was 1.22 meters between rows. Side-dressing with a 10-20-20 fertilizer at the rate of 387 kg/ha was accomplished four weeks after sowing the seed. The determination of days to first flower and the number of main side branches per plant were taken from two central rows of each plot. Data on fresh pods and dry pods were taken from one of the central rows of each plot.

A preventive spraying program was followed once weekly to reduce possible insect damage. Kelthane, Malathion and Ethion were used. A rotary tiller and a garden hoe were used to control weeds. Sprinklers hung on the top of the stake were used for irrigation.

Results and Discussions:

The results are presented in Table 6 and 7. Significant differences among treatments were observed for days to first flower, number of main side-branches, total number of fresh and dry pods per plant, weights of fresh and dry pods and yields of fresh pod and dry seed. Plant spacings of 12.5 and 25.0 cm took more days to reach flower than the other two treatments. Wider spacings of 50.0 and 75.0 cm produced a significantly higher number of main side-branches per plant and bigger pods. A lower total number of fresh and dry pods were obtained from the closer spacings of 12.5 and 25.0 cm. The treatments of 50.0 and 75.0 cm spacings produced significantly higher yields in fresh pod and dry seed than the closer spacings.

Conclusions:

Wider spacings of 50.0 and 75.0 cm took shorter time to reach first flower, produced higher numbers of main side-branches and higher total numbers of fresh and dry pods, and higher yields in fresh pod and dry seed in comparison to closer spacings of 12.5 and 25.0 cm.

III. Varietal Performance Studies on Cantaloupes

Materials and Methods:

Two experiments were conducted during the dry season to evaluate the effect of environmental factors on the performance of cantaloupes. The ten cultivars of cantaloups included in the first experiment were Earlie Sweet, Roadside, Early Northern Queen, Saticoy, Crenshaw, Planter's Jumbo, Burpee's, Super Market, Market Pride F-2 and Chaco. The ten cultivars included in the second experiment were Schoon's Hard Shell, Harper, Ambrosia, Earli Dew, Stars Headliner, Dixie Jumbo, Topscore, Delicious 51, Harvest Queen and Iroquois.

Seeds were directly sown in the

Table 3 The Effect of Cultivar and Support on Green Pod Weight/Pod (g).

Main Treatment (cultivar)	Sub-treatment: Support	Sub-treatment: No Support	Main Treatment Mean
Chimbu	25.0	26.0	25.5
Tinge	14.0	14.5	14.3
Dual	23.5	24.0	23.8
Sub-treatment mean	20.8	21.5	

LSD 0.05 Between main treatment 6.6

LSD 0.05 Between sub-treatment mean ..... NS

LSD 0.05 Between sub-treatments for the same main treatment ..... NS

LSD 0.05 Between sub-treatments for the different main treatment 7.7

field. A randomized complete block design with three replications was used. Each experimental plot consisted of two rows, 7.31 meters long. The spacing adopted was 2.2 meters between rows and 0.3 meters within rows. Localized application of 10-20-20 fertilizer at the rate of 897 kg/ha was applied to the planting bed of 15 centimeters deep and 30 centimeters wide then covered with 10 centimeters of topsoil over the fertilizer before sowing the seed. This method of fertilizer application was to avoid the burning effect on the seed or young plant. Side-dressing with the same fertilizer at the same rate was initiated five weeks after sowing.

A preventive program was followed twice weekly to reduce possible insect and disease damage. Lannate L. Diazinon Ag. 500 EC, Malathion 50, Dithane M-22, and Tribasic Coppers were used. A rotary tiller and garden hoe were used to control weeds. Sprinklers were used for irrigation as needed.

Results and Discussions:

a) First Experiment:

The results of the first experiment are presented in Table 8. Dixie Jumbo and Earli Dew with an average of 34.62 MT/ha signifcantly outyielded the rest of eight cultivars. Harvest Queen, Topscore and Schoon's Hard Shell were the lowest producers with only about 5.75 MT/ha. There was no siginicant difference in fruit yield among Ambrosia, Iroquois, Harper, and Delicious 51, which ranged from 15.62 to 23.65 MT/ha. Harper and Earli Dew with a sugar content of 9.8 and 10.5%, respectively, were significantly higher than the other eight cultivars. There was no significant difference in sugar content among Topscore, Dixie Jumbo, Delicious 51, Star Headiner, Schoon's Hard Shell and Iroquois, which ranged from 8.0 to 9.0%. Also no siginifcant difference in fruit weight was found among Delicious 51, Schoon's Hard Shell, Earli Dew, Dixie Jumbo, Star Headliner and Iroquois ranging from 2.31 to 2.93 kg, while Harvest Queen with 1.70 kg was the smallest.

b) Second Experiment:

The results of the second experiment are presented in Table 9. Early Northern Queen, Earli Sweet, Burpee's and Crenshaw, which ranged from 27.27 to 34.09 MT/ha in fruit yield, outyield the rest of six cultivars, and Market Pride F-2 with 26.19 MT/ha was the next highest. Chaco and Planter's Jumbo with only 6.34 MT/ha were the lowest in fruit production, and Super Market and Saticoy were the next lowest. Market Pride F-2 and Crenshaw with a sugar content of 9.5 and 11.0%, respectively, were significantly difference in sugar content among the other eight cultivars. Crenshaw with a fruit weight of 4.10 kg was the largest, while Burpee's with 2.47 kg was the next largest. The fruit weight of the rest of eight cultivars ranged from 1.31 to 2.16 kg.

Conclusion:

Based on quality and yield from the above two experiments, Earli Dew, Crenshaw and Harper were the promising cultivars.

Table 4. The Effect of Cultivar and Support on Total Number of Green Pods Per Plant.

Main Treatment (cultivar)	Sub-treatment		Main Treatment Mean
	Support	No Support	
Chimbu	29.9	81.1	55.0
Tinge	47.3	125.1	86.0
Dual	26.8	74.1	50.5
Sub-treatment mean	34.3	93.4	

LSD 0.05 Between main treatment	6.9
LSD 0.05 Between sub-treatment mean	4.5
LSD 0.05 Between sub-treatments for the same main treatment	7.8
LSD 0.05 Between sub-treatments for the different main treatment	8.8

Table 5. The Effect of Cultivar and Support on Green Pod Yield (MT/ha).

Main Treatment (cultivar)	Sub-treatment		Main Treatment Mean
	Support	No Support	
Chimbu	11.45	33.43	22.44
Tinge	10.51	28.77	19.64
Dual	9.97	28.19	19.08
Sub-treatment mean	10.64	30.13	

LSD 0.05 Between main treatment	NS
LSD 0.05 Between sub-treatment mean	2.38
LSD 0.05 Between sub-treatments for the same main treatment	4.11
LSD 0.05 Between sub-treatments for the different main treatments	4.50

Table 6. The Effect of Planting Density on the Growth of Winged Bean

Planting Density (Plant/ha)	Planting Spacing within row (cm)	Days to First Flowers	Main side-Branch Per Plant
13,333	75.0	63.0	3.8
20,000	50.0	65.7	3.6
40,000	25.0	69.3	2.9
80,000	12.5	71.0	2.4
LSD. 0.05		4.1	0.5

Table 7. The Effection of Planting Density on the Production of Green Pod and Dry Seed of Winged Bean

Planting density (plants/ha)	Planting spacing within row (cm)	Total number of fresh pod per plant	Total number of dry pod per plant	Fresh pod weight (g)	Yield of fresh pod (MT/ha)	Yield of fresh dry seed (kg/ha)
13,333	75.0	83.3	33.7	29.0	24.80	6,468
20,000	50.0	65.3	24.4	26.1	26.12	6,460
40,000	25.0	31.8	11.8	22.2	21.54	5,288
80,000	12.5	17.3	6.0	21.1	22.30	5,138
LSD 0.05		6.1	4.8	1.9	3.41	486

Table 8. Performance of Commercial Cultivars of Cantaloupes During the Dry Season of 1984.

Cultivar	Sugar content (%)	Fruit weight (kg)	Marketable fruit per plant	Marketable yield (MT/ha)
Earli Sweet	8.0	1.31	3.61	30.68
Roadside	7.5	2.16	1.41	19.93
Early Northern Queen	8.5	1.45	2.90	27.27
Saticoy	6.5	1.62	1.40	14.92
Crenshaw	11.0	4.10	1.31	34.09
Planter's Jumbo	7.0	1.65	0.82	8.79
Burpee's	6.5	2.47	1.90	30.44
Super Market	7.5	1.92	1.01	12.56
Market Pride F-2	9.5	2.11	1.92	26.19
Chaco	8.3	1.31	0.60	3.89
LSD 0.05	1.9	0.65	0.65	4.98

Table 9. Performance of Commercial Cultivars of Cantaloupes During the Dry Season of 1984.

Cultivar	Sugar content (%)	Fruit weight (kg)	Marketable fruit per plant	Marketable yield (MT/ha)
Schoon's Hard Shell	8.5	2.39	0.50	7.49
Harper	9.8	1.92	1.80	22:81
Ambrosia	8.2	1.90	1.52	18.78
Earli Dew	10.5	2.49	2.21	35.58
Star Headiner	8.3	2.78	0.91	15.62
Dixi Jumbo	5.0	2.50	2.10	33.73
Topscore	8.0	1.99	0.50	6.14
Delicious 51	8.3	2.31	1.62	23.65
Harvest Queen	7.2	1.70	0.32	3.61
Iroquois	9.0	2.93	1.10	21.47
LSD 0.05	2.4	0.71	0.32	4.75

Potato

Jose A. Cruz

Introduction

Potato (*Solanum* SPP) cultivation has been considered largely as a temperate zone crop, and is uncommon on Guam. However, potatoes grow well and can produce high yields in the hot tropics. Since Guam is located 13.5°N of the equator with an average temperature of 26° C throughout the year, selection of clones with heat tolerance is essential. Under the short day conditions in Guam (December-March) some potato cultivars can mature early and produce high yields with good crop management practices. The purpose of this project is to identify potato cultivars for fresh market production in Guam.

Materials and Methods

The experiment was conducted during the short day period, January - March 1983, in Mangilao, Guam. The soil family name at the experimental site is clayey, oxidic, isohyperthermic, Lithic Haplustalfs with pH 7.2.

Twelve cultivars were obtained for evaluation from the Plant Research Station, Victoria, Austalia by Dr. Peter Vander Zaag, Region Representative, International Potato Center, Region VII, Los Banos, Philippines. Kennebec, Russet Burbank, Red Pontiac and Sequoia are traditional varieties in the mainland USA. The 1984-18 cultivar was developed at the Asian Vegetable Research Development Center and the other varieties were developed by the International Potato Center.

A randomized complete block design was used with four replications of ten tubers/cultivars/treatment. Seed pieces were planted 75 cm between rows and 30 cm between plants spacings in 3 m long rows. Fertilizer was applied at the rate of 100-200-200 Kg/ha of N, P_2D_5, K_20, respectively in the furrows and hilled at planting time. The potatoes were harvested 88 days after planting and weighed. The yields were based on the total number of tubers harvested.

Results and Discussion

Yields ranged from 15.1 t/ha for 720088 to 5.0 t/ha for 1284-18 (Table 1). Cultivars 720088, 800226, 800223 and Kennebec were the four highest yielders with no statistical differences.

Kennebec, with a yield of 10.6 t/ha had the highest percentage of marketable tubers (59%) (Table 1). This cultivar produced large tubers.

The highest yielder, 720088, based on total numbers of tubers produced small tubers and only 26% of the tubers were marketable.

Emergence of the plants was poor due to poor tuber condition at planting time. The seed pieces were soft with 5 to 6 inches long sprouts when they arrived in Guam. Heavy infestation of thrips and leafminers developed in the experimental field 50 days after emergence.

Conclusion

The varieties Kennebec, Russet Burbank, and Sequoia have potential under Guam's humid tropic conditions.

Table 1. Results of 12 cultivars grown in Mangilao, Guam from January-March, 1984

Cultivar	Yield t/ha	Plant harvested %	Marketable %
720088	15.1	53	26
800226	12.4	85	47
800223	10.6	65	25
Kennebec	10.6	75	59
800301	9.3	83	42
Russet Burbank	8.8	90	33
Red Pontiac	8.7	85	45
Sequoia	7.5	80	56
800144	6.9	55	15
377258.1	6.3	85	46
800922	5.7	58	42
1284-18	5.0	45	34
GRAND MEAN	8.9	71	39
CV (%)	74.9	31	65
LSD (5%)	NS	NS	NS

Corn

Jose A. Cruz

Introduction

Plant spacing is an important management factor to consider in sweet corn production. Guam farmers generally plant their corn sixty centimeters between plants, and one hundred twenty centimeters between rows with three plants per hill. Although this spacing arrangement is commonly used in corn production, data are not available to support the plant density as being optimum.

This study was to evaluate yield response to sweet corn to varied plant density.

Materials and Methods

A randomized complete block design was used with three replications. The variety used in the experiment was Hawaiian Supersweet #9 sweet corn. Plots were seeded heavily, then thinned according to treatment when plants were 5.0 - 7.5 cm high. Plant spacings were maintained at 90 cm (treatment a), 60 cm (treatment b), 30 cm (treatment c), and 22.5 cm (treatment d) in 120 cm width rows which correspond to populations of 27, 778; 41, 667; 27,778 and 35,714 plants per hectare (Table 1). The plots were fertilized at the rate of 560 Kg/ha of 10-30-10 (N, P205, K20) prior to planting. The corp was sidedressed with 350 Kg/ha of 16-16-16 (N, P205, K20) 22 days after planting. All ears were hand-picked, with the husks removed to four, trimmed at the end, and weighed. The ears were harvested 71 days after planting at the milk stage for the fresh corn-on-cob market.

Results and Discussion

Yields ranged from 6.37 MT/ha for treatment d down to 4.39 MT/ha for treatment c (Table II). Treatments a, b and c had lower yields than treatment d, however not statistically different.

Table I. Plant Spacings and Population of Hawaiian Supersweet #9 Sweet Corn

Treatment	Spacing Between Plants 120 cm Width Rows	Plant/Hill	Desired Plant Population/ha
a	90 cm	3	27,778
b	60 cm	3	41,667
c	30 cm	1	27,778
d	22.5 cm	1	35,714

Table II. Fresh Cob Yield and Other Measurements of Hawaiian Supersweet #9 Sweet Corn

Treatment	Fresh Cob Yield MT/ha	Marketable Cobs Harvested/Plot	Plants Harvested/Plot
a	4.76	25	28
b	4.63	27	34
c	4.39	22	27
d	6.37	28	43
GRAND MEAN	5.04		
CV (%)	14		
LSD (.05%)	NS		

Ornamental Crops

James McConnell

Evaluation of Different Cultural Methods for Production of Ornamental Plants in Guam.

A study of orchids for use as commercial cut and lei flowers was initiated. Cultivars of *Vanda* and *Dendrobium* were collected and are currently undergoing evaluation.

A comparison of fertilizers and media is in progress using the orchid *Vanda* Miss Joaquim. *Vanda* Miss Joaquim was the first orchid chosen for advance testing. Miss Joaquim will grow in Guam in full sun. Construction of a saran structure is unnecessary as will be with many other ornamentals. This orchid is available in Guam and is readily propagated from cuttings. *Vanda* Miss Joaquim has a great potential for use as a lei flower for the tourism industry in Guam. Two media are included in the experiment: coconut husk and crushed coral aggregate. Preliminary observations indicate that orchids will grow in crushed coral even though coral has a pH of 8.8-9.0. Coral has the advantages of being readily available and does not decompose as coconut husks do. Two fertilizer treatments (Foliar 60, and Osmocote) plus a control of no fertilizer were included in the experiment to determine which type of fertilizer will be most suitable for use in Guam. An additional experiment is being initiated to evaluate the best planting densities to use for *Vanda* Miss Joaquim.

The construction of a tissue culture and seed germination lab is nearing completion. The lab will be used to propagate cultivars that are chosen as suitable for growing in Guam at a commercial level.

No experiments were concluded in 1984.

Entomology - Pest Management and Biological Control

Ilse H. Schreiner
and Donald M. Nafus

Aspects of integrated pest management and biological control were investigated in beans, corn, cucumber, and mango.

CORN

On corn, research was concentrated in the areas of host plant resistance, biological control, and a combination of chemical/cultural control.

A. Host Plant Resistance.

We continued screening corn varieties for resistance to the Asiatic Corn Borer, but this year work concentrated on sweet corn.

Methods

Plantings of sweet corn were made at Harmon and at Inarajan. At Inarajan twenty-one varieties were planted on June 14, 1984. Nine of these varieties were also planted at Harmon on June 20 plants spaced 9 inches apart. Rows were 3 ft. apart. In each replicate 10 plants were rated for tassel resistance and all plants with developed ears which were not rotted were rated for resistance to ear feeding. Tassels were rated at silk stage and ears at the milk stage. A single rating scale was used for the tassel while three scales, one each for the husk, the silk and the shank, were used to rate the ear. The rating scales used for the tassel and the ear husk were:

Tassel

1. No feeding
2. 1-2 sites with visible feeding
3. 1-3 branches with extensive feeding
4. 3 branches to ½ of tassel damaged
5. ½ to ⅔ of tassel damaged
6. Extensive feeding over whole tassel

Ear Husk

1. No feeding
2. Feeding started but stopped
3. Husk penetrated but no kernel feeding
4. Husk penetrated with kernel feeding

Table 1. Levels of infestation of sweet corn by Corn Earworm and Asiatic Corn Borer and ratings of ears for resistance to feeding by the Asian Corn Borer.

Variety	Site H=Harmon I=Inarajan	Mean Number Earworm per Plant	Proportion Plants with Corn Borers		Number Corn Borers per Infested Plant		Number Plants Rated	Mean Shank	Ratings Husk	Silk
			Mean	Stdv	Mean	Stdv				
Bonanza	H	0.1	0.8	0.2	4.8	4.0	72	1.7	3.3	3.7
Bonanza	I		0.7	0.2	2.6	0.7	37	1.5	2.9	2.9
Golden Cross Bantam	H	0.1	0.8	0.1	3.9	2.0	79	1.6	3.4	3.5
Golden Cross Bantam	I		0.8	0.2	3.1	1.1	38	1.8	2.7	3.0
Goldwinner	H	0.1	0.6	0.3	1.4	0.6	79	1.2	2.4	2.6
Goldwinner	I		0.8	0.3	3.6	2.8	28	1.7	2.8	3.3
Guardian H	H	0.1	0.7	0.3	2.9	1.4	72	1.5	3.9	4.0
Guardian H	I		0.5	0.5	2.6	0.6	61	1.8	2.8	3.2
Jubilee	H	0.0	0.8	0.3	6.2	4.8	71	2.5	3.4	3.3
Jubilee	I		0.8	0.3	3.4	2.0	42	2.1	3.5	3.3
Midway	H	0.1	0.9	0.2	4.8	2.7	49	1.8	2.9	4.1
Midway	I		0.6	0.3	2.8	2.1	29	1.7	3.2	3.5
NK 51036	H	0.1	0.4	0.4	2.1	1.6	68	1.3	3.2	3.4
NK 51036	I		0.5	0.5	2.3	2.3	19	1.3	2.8	3.4
Quicksilver	H	0.2	0.7	0.2	2.9	1.7	75	1.7	2.9	3.2
Quicksilver	I		0.9	0.5	1.5	0.6	43	1.2	2.1	2.2
Stylepak	H	0.1	0.9	0.2	5.1	3.5	51	2.0	3.5	3.7
Stylepak	I		1.0	0.7	2.7	1.7	37	1.5	2.7	3.2
CR8028	I		0.9	0.1	2.2	0.3	52	2.3	1.9	3.2
Crisp & Sweet	I		0.9	0.2	3.3	2.3	47	3.4	1.9	3.8
Florida Staysweet	I		1.0	0.0	6.4	2.1	20	4.0	1.9	4.0
Golden Cross Bantam	I		0.9	0.1	2.3	0.6	11	4.1	1.3	4.0
Goldwinner	I		0.9	0.1	3.2	1.8	31	2.5	2.1	3.4
HXP2340Y	I		1.0	0.0	4.4	0.7	28	2.9	1.9	3.4
Paramount	I		1.0	0.0	5.9	3.3	67	3.1	1.9	3.6
Resistall	I		0.8	0.1	3.2	1.3	63	2.8	2.2	3.2
Supersweet 10	I		1.0	0.0	6.2	1.6	64	3.5	2.1	3.8
Supersweet 9	I		1.0	0.0	3.2	0.9	18	3.5	2.6	3.5
Terrific	I		0.9	0.1	6.2	4.6	39	3.7	2.1	3.6

The silk of each ear was rated on a 1-4 scale where 1 was: no damage and 4 was: completely consumed within the husk sheath. The shanks were rated 1 if there was no damage, 2 if a corn borer had made a short tunnel, and 3 if the shank was completely bored through. Only infested plants were rated.

Results

The infestation differed between the two test areas with Harmon having a much lighter infestation. At Harmon, over 85 percent of the plants produced ears while at Inarajan only half of the plants produced ears. Despite the lighter infestation, the husk ratings suggested more damage at Harmon than at Inarajan (Table 1). This was an artifact caused by the large number of plants which failed to produce an ear or produced ears which rotted before completing development. Since these ears were not rated, in effect, only the plants which were lightly infested were rated. None of the varieties tested showed significant resistance at the ear stage.

The tassel ratings at Harmon were lower than at Inarajan (Table 2). Varieties with higher ratings at Inarajan also tended to have higher ratings at Harmon, although the correlation was not significant (Spearman's rank correlation coefficient (rs) = 0.618). At Harmon there was a highly significant correlation between the tassel and the number of corn borers found in the ears (rs = .918, significant at 0.01 level).

B. Bionomics of *Ostrinia furnacalis*

An important aspect of breeding resistance into plants and of using pesticides effectively is a detailed understanding of where the target organism is feeding at different growth stages of the plant. To get a better understanding of the feeding patterns of the Asian Corn Borer, we dissected corn plants of different growth stages to ascertain the locations of the larvae.

Methods

In late 1983 and in 1984 we dissected sweet-corn plants on farm fields or research plots at 31 locations: Talofofo, Barrigada, and Harmon. On Nov. 5, 1983, at Talofofo, 77 thirty day-old plants were examined and the locations of each egg mass was recorded. On Nov. 15-17 forty of the plants were randomly selected and dissected. At Barrigada sixty 6-week-old plants were dissected on Oct. 7-10, 1983. At both locations growth stages of the plants and locations of each larval instar on the plant were recorded. At Harmon, Hawaii SS#9 sweet corn was planted on 8/8/84 and dissections were made on Sept. 11 (midwhorl stage), 19 (late whorl), 24 (tassel), 28 (silk), Oct. 5 (blister) and 12 (soft dough). On Sept. 11, 19 plants were dissected, on Sept. 19 and Oct. 12, 20 plants, and at other dates, 10 plants. Plants to be dissected were randomly selected from the pool of plants at the appropriate stage of development. Larval instars were determined by measuring head capsule size.

Results

Oviposition Sites

Almost all of the egg masses are laid on leaves. Out of 503 egg masses found, only one mass was on the collar of the leaf while the rest were farther out on the leaf. Most of the masses were located underneath the leaf on the basal ⅔ near the midrib. Very few masses were found on the

Table 2. Ratings of several sweet corn varieties for resistance to tassel feeding by the Asian Corn Borer.

Variety	Mean Tassel Rating Harmon Mean	Stdv	Mean Tassel Rating Inarajan Mean	Stdv
Bonanza	2.9	0.7	4.5	0.5
Golden Cross Bantam	2.2	0.2	4.0	0.2
Goldwinner	1.9	0.5	3.0	1.1
Guardian H	2.5	0.9	3.0	1.0
Jubilee	3.4	0.9	3.7	0.7
Midway	2.7	1.0	4.0	0.9
NK 51036	2.2	1.2	3.5	1.2
Quicksilver	2.1	0.6	3.4	0.6
Stylepak	3.7	0.7	4.6	0.9
CR8028			3.1	0.6
Crisp & Sweet			3.5	1.0
Florida Staysweet			5.0	0.3
Golden Cross Bantam			3.5	0.5
Goldwinner			4.3	1.0
HXP2340Y			3.2	0.8
Miracle			4.9	0.5
Paramount			3.1	0.7
Resistall			4.6	0.2
Supersweet 10			4.2	1.1
Supersweet 9			5.3	0.6
Terrific			4.4	0.8

upper surface (Table 3).

Corn borer egg masses were laid principally on the leaves whose bases were fully emerged from the whorl (Table 4). A gradual shift towards the top of the plant took place as more leaves became fully exposed, although at least some egg masses were present on all leaves. Oviposition was highest from the midwhorl to silk stages of the corn, and declined as the ear matured and the tassel dried up. No oviposition was noted on 10/12.

Larval Feeding Sites

After hatching first instar larvae typically undergo a dispersal phase before settling down to feed, although some larvae may consume parts of the eggshell and a small quantity of leaf tissure adjacent to the egg mass before dispersing. In the mid-whorl stage, the first three instars fed on the surface of leaves on sites in the whorl or on exposed leaves in sheltered areas (Tables 5, 6, 8, 9, and 10). In the whorl, feeding was concentrated on the surface of the loose leaves which were not fully pigmented. Larvae were rarely found on the tightly coiled innermost leaves or deep in the whorl. On exposed leaves, feeding was largely confined to sites where spiders, later instars of the corn borer, or other insects (mainly the corn leaf roller) had webbed leaves, or folds of a leaf together. Only rarely were larvae found feeding on the exposed parts of the leaf or on sheath or collar tissue.

At Harmon, more larvae were found feeding on the outer leaf surfaces than at Talofofo and Barrigada. In large part this was due to a much higher population of corn leaf rollers at the Harmon site. At the other areas where the roller was less abundant, over 90 percent of the larvae were inside the whorl, either on the leaves or in the developing tassel.

The tassel was of primary importance to all instars as a feeding site from the late whorl through tassel stages, but varied in importance after the tassel stage (Table 5-13). For in-

Table 3. Location of egg masses of Asian Corn Borer on leaves of 1 month old corn plants. Plants were at the whorl stage with 11-12 leaves.

Location on Leaf	Location of Egg Mass on Leaf with Respect to Distance from Stalk		
	Basal ⅓	Central ⅓	Tip ⅓
Underneath near midrib	186	208	23
Underneath away from midrib	43	22	7
Top near midrib	1	1	1
Top away from midrib	4	2	4

Table 4. Location of egg masses of Asian Corn Borer as a function of age of leaf. Leaves numbered from whorl down.

Leaf Number	Talofofo - Barrigada	Harmon				
		Plant Growth Stage				
	Mid-whorl	Mid-whorl	Late Whorl	Tassel	Silk	Blister
	0	0	2	13	18	3
1	0	2	11	31	41	4
2	4	9	15	46	18	3
3	26	18	20	46	16	4
4	44	55	36	52	29	2
5	65	82	66	58	15	6
6	49	33	92	33	3	3
7	110	2	81	5	0	3
8	86					
9	82					
10	34					
11	3					
12						

stars 1-3 the tassel was the most important part of the plant once the leaves surrounding the tassel were loose and the larvae could gain access. At Harmon during the late whorl stage, 78 percent of the first instar larvae were in the whorl area and over 80 percent of the larvae of instars 1-3 were in the tassel, but in subsequent stages, although the tassel remained of primary importance, both numbers and percentages of larvae slowly declined. Peck densities of a larvae corresponded to the period when pollen was present in the tassel, with the period of maximum abundance coming just before pollen shedding. Numbers of larvae declined sharply after shedding although those tassels which were webbed together and did not shed properly, retained more larvae. Instars 4-6 also utilized the tassel heavily during the late whorl to tassel stages, but its importance declined earlier for them than for instars 1-3 and by silk stage the stalk and ear were more important as feeding sites.

Before pollen-shedding, instars 1-3 were both inside the florets and in areas where older larvae webbed florets together. Instars 4-6 and to some extent 3, webbed florets together or bored into branches or the main stem of the tassel. In older tassels which had shed pollen, most of the early instar larvae were in webbed areas, rather than in the florets.

Larvae were found on the developing ear as soon as it emerged from the leaf sheath (Table 8). First instar larvae were found inside between the sheath leaves of the ear and to a much lesser extent, externally on the leaf tissue near where the silk will emerge later. Once the silk had developed, between 10 and 50 percent (Tables 5, 8 9, and 10) of instars 1-3 were in the ear about equally divided between the silk and the sheath. On the sheath, most of the larvae were concentrated inside the upper ⅓ of the ear between the sheath leaves. On the silk larvae were mostly in the loose external silk, although a few were in the tight bundle of silk enclosed within the sheath.

For the late instars (4-6) the stalk and the ear were the primary feeding sites after the tassel stage (Tables 6, 7, 11, 12, 13). As early as late whorl stage, fourth and fifth instars, and occasionally third instars as well, were found boring in the stalk, and by silk stage it was the dominant location for older larvae. Later, as the cob developed, the ear increased in importance as a feeding site. In the ear, feeding concentrated on the silk, both externally and internally, the sheath, and the cob. Some larvae were also found between the stalk and ear feeding on a sheath tissue. At the silk stage larvae were about evenly distributed between the sheath and the silk of the ear. At blister stage the

Table 5. Percentage of first and second instar larvae of Asian Corn Borer on different parts of the corn plant at 4 plant developmental stages, Talofofo and Barrigada farm fields.

Plant Part		Percent of Larvae in Plant Part			
		Late Whorl 1	Late Whorl 2	Tassel	Silk
Leaf					
	Surface	5.4	9.4		
	Axil	1.5			
	In Whorl	91.4	3.1		
Ear					
	Sheath			18.2	20.9
	Silk				25.6
Between Sheath and					
	Stalk				2.3
Tassel		1.5	81.2	81.8	51.2
Other			6.3		

Table 6. Percentage of third and fourth instar larvae of Asian Corn Borer on different parts of the corn plant at 4 plant developmental stages, Talofofo and Barrigada farm fields.

Plant Part		Percent of Larvae in Plant Part			
		Late Whorl 1	Late Whorl 2	Tassel	Silk
Leaf					
	Surface				
	Axil				
	In Whorl	79.9	9.3		
Ear	Sheath				9.7
	Silk				9.7
Between Sheath and					
	Stalk				6.4
Tassel		10.4	72.1	60.9	22.6
Stalk		2.2	11.6	27.3	41.9

cob and kernals were also utilized, particularly by 5th instars. Sixth instar larvae fed principally on the cob and kernels when in the ear, although occasionally they were in the silk bundle. Larvae were gregarious, often with several inside a given cavity in the stalk or ear.

Pupation seemed to take place in the site where the late instar larvae were feeding (Table 14).

C. Status of Asiatic Corn Borer and associated parasites in Micronesia

Surveys were made to determine which parasites were attacking the Asiatic Corn Borer in the Northern Marianas and Guam. Parasites were rare throughout the Marianas Islands. On Guam parasites were recovered from only 30 pupae out of more than 3600 collected. Three species were found: *Xanthopimpla punctata, Brachymeria albotibialis,* and *Tetrastichus inferens*. In the Northern Marianas Islands, *T. chilonis* was found on Saipan and Rota, but on Tinian the corn sampled was too old to have fresh egg masses. The only pupal parasite found was one specimen of *X. punctata*, reared from pupae collected in Tinian.

In Belau, the corn borer appeared to be less common than in the Marianas. Several corn fields at various stages from newly planted to early dent stage were examined and no corn borers were found. Old stalks from an abandoned field were dissected. All the pupae had emerged and no evidence of parasite exit holes was seen. Corn borers were not found elsewhere in Micronesia (Table 15).

D. Insecticide trials and cultural controls:

Insecticide Test

The insecticides Lannate, Dipel (*Bacillus thuringiensis*), and Pydrin were tested on sweet corn for effectiveness against the Asiatic Corn Borer. In Talofofo plots consisting of 4 rows 4.5m long were planted Nov. 15, 1983. Plants were spaced at 20cm intervals with 90cm between rows. From whorl stage through harvest, each plot was sprayed with one of the insecticides twice each week. Four replicates of each treatment were run.

The infestation was very heavy, and by six weeks all the control plants

Table 7. Percentage of fifth and sixth instar larvae of Asian Corn Borer on different parts of the corn plant at 4 plant developmental stages, Talafofo and Barrigada farm fields.

Plant Part		Percent of Larvae in Plant Part			
		Late Whorl 1	Late Whorl 2	Tassel	Silk
Leaf					
	Surface				
	Axil				
	In Whorl	62.5	6.4		
Ear	Sheath				
	Silk				2.7
	Cobs and Shank			2.9	3.7
Between Sheath and Stalk				4.6	
Tassel		18.8	58.1	44.1	20.2
Stalk		15.0	29.0	52.9	69.7

Table 8. Percentage first instar larvae of Asian Corn Borer on different parts of the corn plant at different plant growth stages, Harmon.

Plant Part		Percent of Larvae in Different Plant Parts					
		Mid-whorl	Late Whorl	Tassel	Silk	Blister	Soft Dough
Leaf							
	Surface	57.2	22.4	13.3	5.0		
	Collar			1.3	1.2		
	Sheath		0.2	0.3	2.0	50.0	
	In Whorl	42.5	13.7				
Ear							
	Sheath, exposed			0.1	1.7		
	Sheath, internal			1.3	4.4		
	Silk				11.7		
	Cobs						
	Ear/Stalk						
Tassel			63.6	83.7	74.0	50.0	
Stalk							
Number of Larvae		313	495	781	342	2	0

Table 9. Percentage second instar larvae of Asian Corn Borer on different parts of the corn plant at different plant growth stages, Harmon.

Plant Part		Percent of Larvae in Different Plant Parts					
		Mid-whorl	Late Whorl	Tassel	Silk	Blister	Soft Dough
Leaf							
	Surface	35.0	50.0	4.5	8.0	13.3	
	Collar		1.6	0.4	4.0		
	Sheath			0.4	2.4	13.3	
	In Whorl	65.0	6.5				
Ear							
	Sheath, exposed				0.8		
	Sheath, internal				6.4	6.7	
	Silk				0.8	6.7	
	Cobs						
	Ear/Stalk						
Tassel			41.9	94.7	77.6	60.0	
Stalk							
Total Larvae		60	62	264	125	15	0

Table 10. Percentage third instar larvae of Asian Corn Borer on different parts of the corn plant at different plant growth stages, Harmon.

Plant Part		Percent of Larvae in Different Plant Parts					
		Mid-whorl	Late Whorl	Tassel	Silk	Blister	Soft Dough
Leaf							
	Surface	36.4	49.0	3.6	2.5	2.1	
	Collar				1.7	4.1	
	Sheath			0.6	0.8	4.1	
	In Whorl	63.6	12.2				
Ear							
	Sheath, exposed					2.1	
	Sheath, internal				0.8	6.1	20.0
	Silk				5.0	16.2	60.0
	Cobs					10.2	
	Ear/Stalk					2.1	
Tassel			38.8	95.8	85.0	46.9	
Stalk					4.2	4.1	20.0
Number of Larvae		22	49	165	120	49	5

Table 11. Percentage fourth instar larvae of Asian Corn Borer on different parts of the corn plant at different plant growth stages, Harmon.

Plant Part		Percentage Larvae in Various Parts of the Plant					
		Mid-whorl	Late Whorl	Tassel	Silk	Blister	Soft Dough
Leaf							
	Surface	18.2	17.6	11.1			
	Collar			2.8	6.9		
	Sheath				11.5	13.3	
	In Whorl	81.8	29.4				
Ear							
	Sheath, exposed						
	Sheath, internal				5.7	6.6	
	Silk				11.5	17.8	18.8
	Cobs				3.4	15.6	12.5
	Ear/Stalk			2.8	3.4	2.2	12.5
Tassel			41.2	61.1	29.9	11.1	
Stalk			11.8	22.2	27.6	33.3	56.3
Stalk			11.8	22.2	27.6	33.3	56.3
Number of Larvae		11	17	36	87	45	16

were dead (Table 16). Plant survival was highest in the Dipel treatment, but where the plants survived to produce ears, Pydrin seemed to protect the ears better than Dipel. However, even in the Pydrin plots only 49% of the ears were undamaged. Part of the reason for the failure of the insecticides was the presence of larvae inside the tassels in florets or in the tassels which were webbed together. Sprays were unable to sufficiently penetrate into these locations to provide satisfactory control of the borer.

Cultural/Insecticide Interactions

Old farmers on Guam remember that prior to the advent of insecticides, they used to detassel corn as one method of controlling corn borers. Experimental work in the Philipines had also indicated this approach might work. Two trials were set up to examine the effectiveness of detasselling as a control technique.

Methods

The first trial was planted November 8, 1983 in Barrigada. Hawaiian Supersweet #9 was planted at 20 cm intervals in rows 90 cm apart. Each block consisted of 6 rows 9 m long. A split block design was used where one half of each treatment block was detasseled and one-half was not. In the detasselled areas, 4 of the 6 rows were detasselled while the other two were left with tassels to serve as pollinators (rows 1 and 4). The treatments were Dipel at the rate of 4 lbs per 100 gallons (2 Tb/gallon), Lannate at the rate of 0.4 lbs AI per 100 gallons (2 tsp./gallon), Sevin at the rate of 0.6 lbs AI per 100 gallons (2 tsp./gallon) and an unsprayed control. Each treatment was replicated 4 times and the plots were arranged randomly. Insecticides were applied once a week with a backpack sprayer beginning December 15, a week after the corn borer infestation was first observed. The tassels were removed Dec. 20 as they emerged from the whorl. In the beginning of January 1984, counts were made of the number of corn borers in each plant. Five plants in each subplot were

Table 12. Percentage fifth larvae of Asian Corn Borer on different parts of the corn plant at different plant growth stages, Harmon.

Plant Part	Percent of Larvae in Different Plant Parts					
	Mid-whorl	Late Whorl	Tassel	Silk	Blister	Soft Dough
Leaf						
Surface		20.0		3.3		3.2
Collar				3.3		
Sheath				13.4	6.3	3.2
In Whorl						
Ear						
Sheath, exposed						
Sheath, internal						
Silk				6.7	6.2	6.6
Cobs			10.0		18.7	19.3
Ear/Stalk						3.2
Tassel		60.0	60.0	10.0	18.8	3.2
Stalk		20.0	30.0	63.3	50.0	61.3
Number of Larvae	0	5	10	30	16	31

Table 13. Percentage sixth instar larvae of Asian Corn Borer on different parts of the corn plant at different plant growth stages, Harmon.

Plant Part	Percent of Larvae in Different Plant Parts					
	Mid-whorl	Late Whorl	Tassel	Silk	Blister	Soft Dough
Leaf						
Surface			12.5			2.7
Collar						
Sheath						
In Whorl						
Ear						
Sheath, exposed						
Sheath, internal						
Silk					10.8	
Cobs					11.1	32.4
Ear/Stalk			12.5			
Tassel		100.0	12.5			
Stalk			62.5	100.0	88.9	54.1
Number of Larvae	0	3	8	9	18	37

dissected and all the corn borers were counted, with separate records kept for those found in the tassel, and those found in the rest of the plant.

The second trial was planted July 6, 1984 in Harmon. The same methods as in trial one were used. Because of space limitations, only 3 replicates were run and the Sevin treatment was dropped. A Latin Square design was used. Spraying started on August 10, two days after the first evidence of borer infestation was noted. Plots were sprayed once a week with a backpack sprayer. The corn plants were detasselled August 23, at which time ⅔ of the plants were shedding pollen and the rest of the tassels were just emerging. At the end of August plants were sampled as above to determine borer population levels. At harvest, each ear was opened to determine marketability. Fifty plants were harvested in each of the tassel subplots and in the detasselled rows of the detassel subplots. An additional 25 plants were harvested from plants with tassels in the detassel plots.

Results

Both detasselling and insectide use had a significant effect on the number of corn borers present in the plants. In the first trial, the population of

Table 14. Pupation sites of Asian Corn Borer on corn plants, Harmon.

Plant Part		Percent of Pupae in Different Plant Parts					
		Mid-whorl	Late Whorl	Tassel	Silk	Blister	Soft Dough
Leaf	Surface			100.0	50.0		3.4
Ear							
	Silk Tube						7.0
	Cobs						10.3
	Ear/Stalk						3.5
Tassel							10.3
Stalk					50.0	100.0	65.5
Number Pupae		0	0	1	2	5	29

Table 15. Insects (excluding grasshoppers) found on corn on various islands in Micronesia.

Insect	Belau	Yap	Truk	Ponape	Kosrae
Ostrinia furnacalis	X				
Heliothis sp.	X	X	X	X	
Spodoptera litura	X			X	X
Nezara viridula	X			X	
Rhophalosiphum maidis	X		X		
Adoretus sinicus	X				
Peregrinus maidis	X				
Melanagromyza spicata			X	X	X
Saccharococcus sacchari		X	X		
Marasmia trapezalis			X		
Mites			X		
Mirid sp.					X

Table 16. Effectiveness of three insecticides against Asian Corn Borer on sweet corn.

Treatment and lbs a.i./100 Gal.	Number of Plants per Plot		Number Ears per Plant	Percent Ears Damaged by Borer
	At 3 Weeks	At Harvest		
Dipel WP 4	56a*	42a	1.4a	65a
Lannate 1.8E 0.4 ...	57a	31b	0.9b	82a
Pydrin 2.4 E 0.2	50a	15c	1.4a	51a
Check	55a	0d		

*Within a column, numbers not followed by the same letter differ significantly (P=0.05) Fisher's protected LSD

corn borers was extremely high and the control plantings did not survive to produce ears (Table 17, 18). In the treated plots at least some plants survived to produce ears, but no marketable yield was produced by any treatment.

The number of corn borers per plant was reduced in all the detasselled plots as compared with the tassel plots with the same treatment. In the subplots with tassels, Sevin provided little control and few plants survived to produce an ear. A few more plants survived in the Lannate treatments and the most survived in the Dipel treatments. In the subplots with the tassels removed, over 40 percent of the plants in the detasselled rows produced ears in the Sevin treatment and over 50 percent produced ears in the Lannate and Dipel treatments.

In the second trial the population of corn borers was considerably lower although still high enough to prevent marketable yield in the untreated plots (Table 18). Plots treated with Dipel produced higher yields than those treated with Lannate. Detasselled subplots had significantly lower corn borer populations compared to subplots which were not detasselled.

Marketable yields were significantly higher in the detasseled plots compared to the plots with tassels. The number of ears produced in the rows with tassels in the detasselled plots was similar to that in the plots which were not detasseled. Detasselled plots sprayed with Dipel had an average of 62 ears per 100 plants in the detasselled rows and 40 ears per 100 plants in the rows where the tassel was left for pollination purposes. At the above planting density this would result in 11000 marketable ears per acre, as compared to 7700 ears if Dipel alone were used. We estimate that it would take about 8.5 manhours to detassel an acre of corn, resulting in a gain of 318 ears for each hour spent detasselling.

BEANS

Insecticide trials in previous years had indicated that pyrethroid insecticides appeared to be good candidates for providing control of the leafminer *Liriomyza trifolii* on beans. However, none of these insecticides are registered for use on fresh beans. A trial was set up to determine the effectiveness and the insecticide residue levels of various treatments of Pydrin on bean plantings.

Methods

Yard-long beans (*Vigna sesquipedalis*) were planted at Inarajan, Guam, on Dec. 5, 1983. The beans were planted in 10 foot rows, 4 feet apart at a density of two seeds per 9 in. Each treatment contained three rows of beans. A barrier row of sweet corn was planted between plots to reduce pesticide drift. All plots were fertilized with 10-20-20 at the rate of 150 lbs N per acre.

The treatments consisted of an unsprayed check or of Pydrin sprayed weekly or once every two weeks at two application rates: 0.1 or 0.2 lbs active ingredient per 100 gallons. The plots were set up in a randomized complete block design with four replicates. To insure uncontaminated beans for residue analysis, an additional check consisting of three forty foot rows of beans was planted about two hundred yards away from the spray trial.

Pydrin was applied with a Solo 425 backpack sprayer with 1 tsp. Triton B 1956 added to every three gallons water. Spraying began on Jan. 6, 1984.

For residue analysis, fresh beans were picked, packed in dry ice, and shipped to Hawaii on Feb. 8, 1984. The weekly treatments of Pydrin had been sprayed on Feb. 7 and once-every-two week treatments had been sprayed Feb. 2.

To measure the efficacy of the treatments, mines were counted on 36 mature leaflets on Jan. 30 and Feb. 10. Active mines and parasites were estimated by sampling 15 mature leaflets per plot and counting numbers of live miners and parasites in the leaves with the aid of a backlit microscope. Samples were taken on Jan. 30, Feb. 15 and March 7, 1984.

To measure yield, fresh beans were harvested and weighed twice each

Table 17. Interaction of detasselling corn at the tassel stage with insecticides for control of the Asiatic Corn Borer on sweet corn at Barrigada.

Treatment	Number of corn borers per plant: Detassel Total	Tassel Total	Tassel Plant less Borers in Tassel	Percent plants which made an ear: Detassel	Tassel
Dipel	46	131	59	56	21
Sevin	57	114	54	42	4
Lannate	46	140	62	54	10
Check	104	197	119	2	0

Comparison:	Total Corn Borers	Corn Borers excl. Tassel	Percent Plants with Ear
F (insecticide) =	10.53**	15.73**	13.38**
F (detasseling) =	79.41**	6.52*	74.65**
F (interaction) =	0.86	1.24	7.37**

*significant at 0.05 level, **significant at 0.01 level. ANOVA

week from all three rows for as long as the vines produced.

Results

The untreated check yielded significantly fewer beans than any of the plots except the treatment of 0.1 lbs sprayed once every two weeks. The 0.2 lb dose sprayed once a week had the highest yield (Table 19). The seasonal mean number of mines per leaflet was significantly lower than the check in all treatments except the 0.2 lbs. A.I. sprayed once every two weeks. The number of live miners, parasites and the percent parasitism did not differ significantly between treatments.

Compared to previous trials with Pydrin, the population of leafminers was relatively low and differences in yield between treatments were less. An additional complicating factor was a windstorm in early February, which stripped the older leaves from the plots on the northern and western sides of the experimental area. This area later experienced an outbreak of leafminers, which partly obscured treatment effects by increasing within treatment variances.

B. *Introduction of natural enemies*

In 1984 natural enemies were imported for control of the leafminer *Liriomyzia trifolii*, a serious pest of pole beans on Guam. These are being maintained in culture.

Methods

The leafminer colony is being reared on potted beans (cowpeas and yardlong beans). Beans are planted daily and plants are moved into the colony area as soon as the seeds have emerged from the soil. Flies are allowed to feed and to oviposit on the cotyledon leaves. Plants are harvested when the first mines reach full size in the cotyledon leaves. The beans are pulled up, the roots washed, and a bouquet of these mined plants is introduced into parasite rearing cages each day. Leaves are left in with the parasites until they drop from the plant or all miners have emerged. For parasites which pupate in the leaf, the leaves are placed in a container and held for two weeks. For parasites emerging frm the pupa, the leaves are discarded and leafminer pupae are held for two weeks. Both the parasite and the leafminer colonies are kept under constant light at about 80

Table 18. Interaction of detasselling corn at the tassel stage with insecticides for control of the Asiatic Corn Borer on sweet corn at Harmon.

	Number of corn borers per plant			Number of marketable ears/50 plants		
	Detassel	Tassel		Detasseled Plot		Tasseled Plot
	Total	Total	Plant less Borers In Tassel	Detassel Row	Tassel Row	
Dipel	2	12	4	31	20	23
Lannate	15	24	11	13	1	3
Check	8	41	17	9	5	1

Comparison:			Number Marketable Ears		
			Tass vs. Detass Trt	Detass Row vs Tass Row	Tass Trt vs Tass Row
F insecticide=	6.99*	7.90*	16.46*	17.90**	41.90**
F detasseling=	18.46**	0.80	37.92**	27.90**	0.20
F interaction=	3.95	1.89	0.22	1.79	0.53

*significant at 0.05 level, **significant at 0.01 level. ANOVA

Table 19. Effectiveness of Pydrin sprayed at different concentrations and at different time intervals for control of leafminers on beans.

Pydrin Dosage	Treatment Interval	Number Mines per Leaflet	Number/5 Leaflets Miners	Parasites	Percent Parasitsm	Yield (lbs)	Yield/Acre (lbs)	Residue (ppm)
0.1	1 week	6.4a*	17.3a	16.8a	54a	19.6bc	7127bc	0.25-0.37
0.2	1 week	5.7a	10.7a	22.3a	71a	22.5c	8181c	0.42-0.52
0.1	2 week	7.0ab	6.0a	16.1a	72a	17.7ab	6436ab	0.05-0.09
0.2	2 week	7.2ab	6.8a	26.5a	83a	21.6bc	7854bc	0.05-0.07
check	—	9.9b	11.9a	17.7a	64a	14.7a	5345a	n.d.

*Numbers followed by the same letter within a column do not differ significantly (Fisher's protected L.S.D.)

n.d.=not detectable

degrees F.

The parasites are reared in 2x2x2 foot plywood boxes painted with white latex. The top is covered with a clear plexiglass lid and flourescent lights are mounted about 2 feet above the box. Access is provided through a cloth mesh screen in one side. Honey water is continuously available.

In June, 6 species of parasites, *Chrysocaris parksi, C. giraulti, Halticoptera patellana, C. punctiventris, Cothonaspis* sp., and *Opius dissitus* were imported from Hawaii for potential release as biological control agents. All species but *C. parksi* were established in culture. *Cothonaspis* was released. The other cultures were lost during the power failure following Typhoon Bill.

CUCUMBER

A new pest of cucurbits, *Thrips palmi*, first became a serious problem in 1984, and work was begun on methods to try to control this insect. Also, the experiment to determine the effects of trellissing on the cucumber fauna was repeated.

A. Insecticide trial

T. palmi was first noted on Guam in 1983, and by the fall of the year it was sufficiently numerous as to damage cucurbit plantings. Farmers reported difficulty in keeping the thrips from damaging crops with the currently used insecticides.

Methods

To investigate whether commonly available insecticides were controlling this insect, cucumbers, var. Victoria, were planted May 11, 1984, and treated with several different insecticides. Treatment plots consisted of two 10 foot rows with 4 feet between rows. Plots were separated by 6 feet and the cucumbers were trained to grow within their own plot. Each row had 6 hills 2 feet apart. Six seeds were planted per hill and then thinned to 3 plants. the plots were fertilized preplant at the rate of 1000 lbs. 10-30-10 per acre. Treatments were replicated 4 times in a random block design. Insecticide treatments (Table 20) were sprayed once a week beginning May 30. Pesticides were applied with a Solo backpack sprayer with Triton B-1956 added as a sticker.

Thrips populations were estimated as follows: In the first sample, 10 tips were chosen at random, and the third leaf back from the first fully separated leaf was taken. In the laboratory, the numbers of thrips within a 45cm² diameter circle centered on the leaf were counted. In the second and third samples, twenty tips were chosen at random in each plot, and the eighth leaf back from the tip was removed and processed as above. Samples were taken June 11, June 27 and July 10. To measure yield, all the cucumbers produced in each plot were picked and weighed.

Results

None of the insecticides appeared to have any effect on the number of thrips present (Table 20). The number of aphids was reduced by all insecticides. Predatory mites were observed eating thrips. Mite populations were highest in the check and Dibrom plots. Some of the plots were affected by a stunting factor, possibly powdery mildew, which greatly reduced yields.

B. Effects of Trellissing.

Methods

To determine the effects of trellissing cucumbers on the insect fauna, trellissed and untrellissed plots of cucumbers, var Victoria, were planted Jan. 27, 1984 at the agricultural experiment station in Inarajan. Cucumbers were planted in plots consisting of five 18 ft. rows, 4 ft apart. The plants within each plot were either allowed to grow on the ground or trained up a nylon net trellis. Each treatment was replicated 4 times, and the treatments were arranged in an alternating design, one trellissed, the next one not. The plots were fertilized preplant with 10-30-10 at the rate of 1000 lbs per acre.

The numbers of thrips and aphids and predators present on the leaves were estimated on March 22 and April 4 by randomly choosing two tips in each row. Predator numbers were sampled by counting the numbers of lady beetles, syrphid larvae and anthocorid bugs present on the 12th, 13th and 14 leaf of each tip chosen. The thirteenth leaf was brought back to the laboratory and the number of insects inside of a 45 cm² area was counted under a binocular microscope. On March 28, the number of leafmines per leaf was estimated by taking the thirteenth leaf back from 40 randomly chosen tips, and counting the number of mines present on the leaf. Yield was taken

Table 20. Effect of insecticides on Thrips palmi, aphids, and predatory mites on cucumber.

Treatment- lbs. A.I./100 gallons	Seasonal Mean Number Thrips per leaf	Aphids per Leaf	Predatory Mites per 20 Leaves	Yield (lbs/AcreX1000)
Pydrin 2.4 EC 0.1	13.2a	0.4a	0.3a	21.1a
Malathion 5 EC 0.65	17.6a	0.2a	1.5a	22.9a
Lannate 1.8 EC 0.9	10.8a	0.1a	1.3a	24.1a
Dibrom 8 EC 2.1	14.1a	0.1a	10.6ab	24.4a
Check	8.8a	4.3b	16.9b	27.9a

Numbers followed by the same letter within a column are not significantly different at the 5% level (ANOYA and L.S.D.).

from all rows. The number of cucumbers with no insect damage was counted and then weighed. The number of cucumbers with melon fly punctures and the number of melon fly punctures per cucumber were also counted. By April 4 the vines were nearly dead due to damage from thrips and aphids and the experiment was discontinued.

Results

Thrips *(T. Palmi)* were slightly more abundant in the trellissed plots, and aphids *(Aphis gossypii)* in the non-trellissed plots, but the difference was not significant. Syrphid larvae, which are primarily aphid predators, were significantly more abundant in the untrellissed plots on both sample dates. Anthocorids and lady beetles were more abundant in the trellissed plots, but the difference was not significant. There were no differences in the yield, the number of damaged cucumbers, or the number of melon fly punctures per cucumber between treatments (Table 21).

OTHER VEGETABLE CROPS

Surveys of leafminers and their parasites were carried out in a number of locations on different crops and one weed.

Methods

Field collected samples of 300 leaves infested with leafminer were randomly picked and held in the laboratory for leafminer and parasite emergence. Leaves were held in a paper bag for 6 hours to dry leaves slightly and retard the growth of fungus, and then tranferred to a plastic container covered with fine

Table 21. Number of insects on trellissed and untrellissed cucumbers on two sample dates.

	Unit Sampled	Date Sampled	Number per Sample Untrellissed	Trellissed	"t"
aphids	leaf	3/22	23.7	11.3	0.85
aphids	leaf	4/4	7.8	1.8	2.08
thrips	leaf	3/22	13.3	36.8	1.32
thrips	leaf	4/4	3.3	2.7	0.29
leaf mines	leaf	3/28	2.0	3.3	1.21
syrphids	30 leaves	3/22	12.8	1.5	3.83*
syrphids	30 leaves	4/4	14.2	0.8	4.80*
ladybeetles	30 leaves	3/22	3.2	10.2	2.26
ladybeetles	30 leaves	4/4	2.0	7.2	1.47
anthocorids	30 leaves	4/4	33.8	57.8	1.22
melon fly sites	fruit	total harvest	1.5	1.5	0.16
number undamaged fruit		total harvest	247	182	0.98
number damaged fruit		total harvest	71	78	0.25
weight fruit	lbs.	total harvest	138	100	0.84

*Significantly different at 0.05 level, Student's "t" test.

Table 22. Species of leafminers and their parasites on various crops

Host	Parasite species: Liriomyza trifolii Number	Liriomyza sativae Number	Liriomyza sativae % Para	H. semi-albiclavus Number	H. semi-albiclavus % Para	C. formosa Number	C. formosa % Para	Eucoilidea sp. morpha Number	Eucoilidea sp. morpha % Para	Total Para %
Tomato	53	0		1	1.5	10	15.6	0	0.0	17.1
Beans	748	0		35	3.9	109	12.2	0	0.0	16.1
Honeydew	0	0		31	42.9	2	28.6	2	28.6	100.0
Cantalope	13	0		7	31.8	0	0.0	2	9.1	40.9
Watermelon	147	1		79	29.6	14	6.4	23	8.6	37.6
Pumpkin	0	1		1	25.0	0	0.0	2	50.0	75.0
Cucumber	4	25		3	5.8	20	38.5	0	0.0	44.3
Bidens	6	0		16	26.7	38	63.0	0	0.0	89.7

mesh screen. The container was darkened with a piece of cardboard placed over the screen. Emerging insects were collected in a funnel trap attached to the mesh screen. Crops sampled were beans, tomatoes, and various curcubits. One weed, *Bidens* sp. was also sampled.

Results

Several species of parasites were collected from the host plants sampled. These were *H. semialbiclavus, C. formosa,* and *Eucoilidea sp.* (Table 22). These parasites were widespread but their dominance and rate of parasitism varied with the host plant. On beans, tomatoes, cucumbers, and bidens, *C. formosa* dominated followed by *H. semialbiclavus.* On cantalope, honeydew, and watermelon, *H. semialbiclavus* was the dominant parasite. *Eucoilidea sp.* were principally found on the cucurbitacious crops.

L. trifolii was found on all the crops sampled, but *L. sativa* was only recovered from cucurbits. Parasitization rates were low on beans and tomatoes, intermediate on cantalope, watermelon, and cucumber, and high on *Bidens* honeydew, and pumpkins. These last three plants had low levels of leafminers and active mines were relatively rare.

MANGO

A comparison of treated and untreated trees last year indicated that the moth *Bombotelia jocosatrix* can cause considerable defoliation of mango foliage, and that regular spraying with Sevin can reduce moth numbers substantially. A study was initiated to determine in more detail the impact of the moth on mango trees.

Methods

A mango orchard in Santa Rita with trees of various ages and varieties was used for the test area. Eight trees of similar size were selected, and four were treated once every two weeks with Sevin and the other four were not sprayed. On each tree 25 shoots were marked. Five of the shots were at the base of the canopy, 10 in the middle of the canopy, and 10 near the top of the tree. Each shoot was examined to determine whether it had flushed or not and the number of caterpillars on it were counted. At the end of one year the total amount of shoot growth of each internode and the terminal shoot was measured.

Results

Untreated mangos suffered heavy damage from the caterpillar, and many new shoots were completely consumed. Since mangos respond to damage by producing a new shoot, the untreated mangos flushed almost twice as often as the treated ones (Table 23). The treated mangos flushed twice during the course of the year, with almost all the branches on a given tree flushing at the same time. The four treated trees all flushed within a few weeks of each other. In contrast, the unsprayed trees almost always had at least a few branches flushing, thus providing a continuous food suuply for the caterpillars (Figure 1). The total yearly growth of the shoots formed by the two sets of mango trees did not differ significantly (Table 23), partly because the trees compensated for consumed growth by producing extra internodes. The length of the internodes in the sprayed trees was almost twice that of the unsprayed trees, but the variance was high and the difference was not significant.

Table 23. Impact of mango shoot moth on mango trees.

Treatment		Number branches flushing	Number dates flushing	Number branches flowering	Length shoots (in.)
check	mean	88.25	13.5	3.25	4.45
	stdv	15.86	4.20	6.5	1.48
Sevin	mean	52.25	6	8.75	8.02
stdv	6.13	2.16	9.14	2.92	
t		4.48	3.36	1.53	1.54

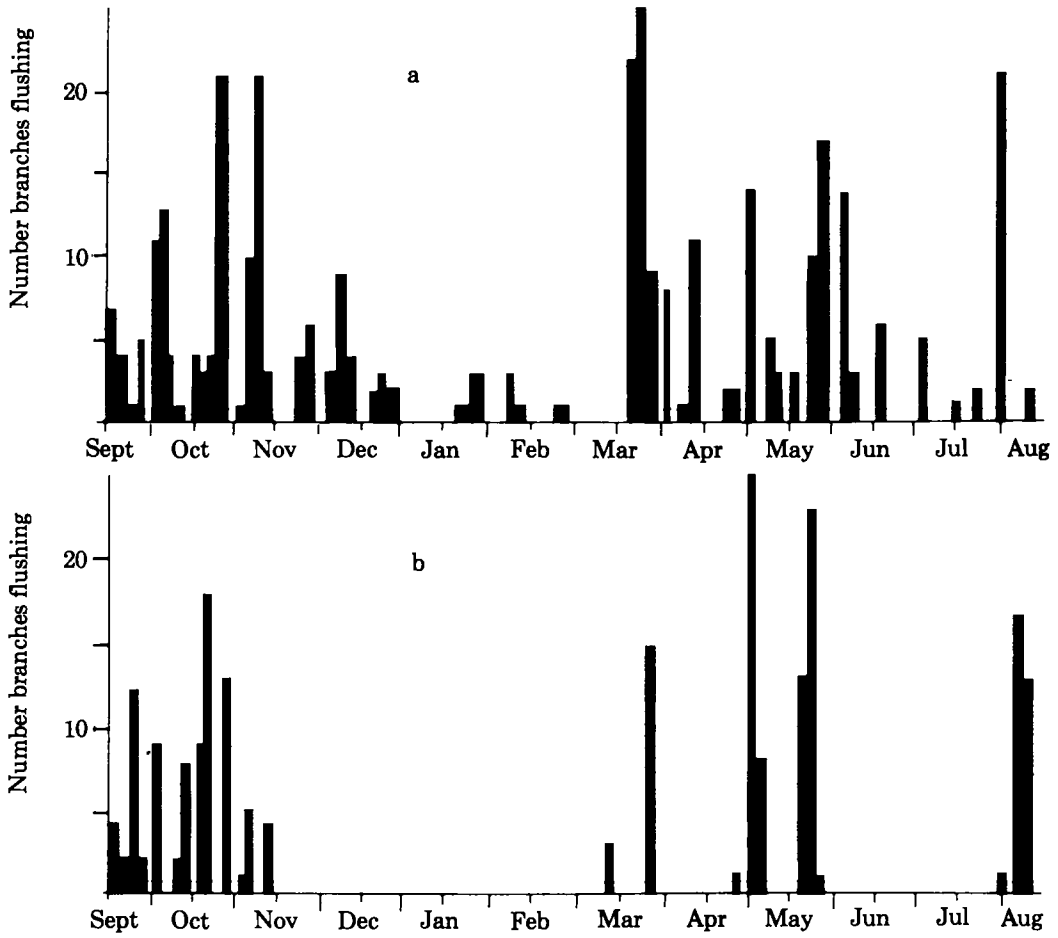


Figure 1. Comparison of number of branches of mango trees flushing during the year under heavy (a) or light (b) infestation by *Bombotelia jacosatrix*.

Biological Control

Thomas Seibert

I. Biological Control of *Chromolaena odorata*

Introduction

The first record of the weed, *Chromolaena odorata* (previously *Eupatorium odoratum*), was from a University of Guam herbarium specimen collected at Apra Harbor in 1963. It is unclear how long the weed was here prior to this time. In the past two decades, *C. odorata* has become an increasingly serious problem affecting unimproved pastures of the Northern Marianas as well as untended lands of all the Mariana Islands including Guam. This species forms dense stands that out-compete other forms of open-terrain vegetation. During the dry season the weeds may die back to their root and become an extreme fire hazzard due to highly flammable chemicals present in the dead stem material. The purpose of this project is to study the distribution and biology of *C. odorata* in the Mariana Islands and to establish insect enemies of the weed from its native range in the neotropics. By reducing the vitality of the weed via attack by natural enemies, other species of plant on Guam would be able to more effectively compete and reduce the stature of the weed in the plant community.

Distribution

Guam: In 1981 Dr. J. Nechols, then an AES scientist, surveyed Guam for *C. odorata*. The technique of reconnissance involved driving all major roads from Rt. 17 north, noting every .1 mile the presence or absence of the weed and ranking the abundance of the weed at that location as continuous or patchy. Roads further south were not surveyed. The weed was widely distributed over the northern half of the island. In late 1983 and early 1984 Guam was again surveyed using the same technique as Nechols. The distribution of the weed overall is unchanged. The 1984 survey included all of Guam and Cocos island. The major difference between the two survey years is of the degree of infestation. The frequency of hits on *Chromolaena* in both surveys was used to generate a coarse indication of change in the coverage of the weed between sample periods. *C. odorata* is increasing its coverage of areas surveyed in 1981, and now dominates the roadside vegetation in the most heavily infested zones (ie. roadsides and open fields of Northern Guam).

Northern Marianas: A survey of *C. odorata* on the Northern Mariana Islands found the weed abundant on all islands visited: Rota, Saipan and Tinian.

On Rota, the weed has eliminated virtually all palatable plants for cattle on the range lands and open forest. The only part of the island not severely impacted by the weed was the higher elevation savanna and dense forest at all elevations. Previously grazed lands were completely overgrown by *C. odorata* and in most cases the pasture is now a monotypic

stand of the weed.

Saipan has the weed growing throughout the island. It is primarily along roadsides, but it can be found on most disturbed lands as well. The infestation was in general not as severe as on Rota or Tinian, probably because the land is not used for grazing cattle as extensively as it is on the other two islands.

Tinian was heavily infested with the weed. Many unimproved pasture lands were vacant of vegetation besides *C. odorata*.

Natural Enemies:

Insects occurring on Guam that attack *C. odorata* are few and their damage insignificant. Table 1. lists these insects and the type of damage they cause. Species identifications are being made by the USDA Systematics Research Laboratory in Beltsville, Maryland.

No pathogens of the weed were observed. When flowering begins in late November, resources stored in the leaves are used for reproduction. Two fungi were identified from these senescing leaves as *Colletotrichum gloeosporioides* and *Phomopsis vexans* by V. Russo (AES). Since these fungi attack only senescing leaves and in no way appear to interfere with the plant's growth or reproduction, they are not believed to be of any value in the natural control of the weed.

Imported Natural Enemies:

The native range of *C. odorata* includes the neotropics from S. Florida to N. Argentina. Crutwell (1972) studied natural insect enemies of the weed and screened several for host specificity, recommending four for introduction into the old-world tropics to attempt biological control of *C. odorata*. Two of these, *Apion bruneonigrum* (Curculionidae) and *Pareuchaetes pseudoinsulata* (Arctidae) were imported from Trinidad, W.I. to Guam in early 1984. The shipments are listed in Table 2.

A. bruneonigrum individuals were field released. A colony of *P. pseudoinsulata* was set up in the laboratory. After one generation no viable eggs could be obtained and the colony was lost. The cause of the failure of eggs to hatch is unknown.

In November 1984 a trip to Trinidad, W.I. was made to collect a third species of insect screened for the biological control of *C. odorata*. This species, *Mescinia? parvula* (Pyralidae) is a stem borer capable of destroying growing tips of the plant. Two shipments of *Mescinia* and one of *P. pseudoinsulata* were brought to Guam (Table 2). The *Mescinia* were held in captivity and attempts to obtain eggs were made in 5x5x5ft. mating cages. The moths would not lay on the artificial substrate provided, (ie. paper toweling or wax paper), and only a few eggs were laid on live *C. odorata* stem tips. These eggs did not develop. Seventy three of eighty one adult *Mescinia* died before verification of a voucher specimen by the USDA systematic identification laboratory could be obtained. Dr. Ferguson of IIBIII, said the *Mescinia* I had was an undescribed species, not *M. parvula*. However, it was the same species in his collection from

Table 1. Local insects found feeding on Chromolaena odorata, their feeding damage and impact on the plant.

Insect	Feeding damage	Impact on plant
Aphididae	causes curling of apical leaves	insignificant
Agromyzidae	mines leaves	insignificant
Pseudococcidae	sap sucker	insignificant
Noctuidae	leaf roller	insignificant
Tettigoniidae	chews leaves	insignificant
Acrididae	chews leaves	insignificant
Membracidae	sap sucker	insignificant

Table 2. Shipment information for insects sent to Guam from Trinidad in 1984 for the biological control Chromolaena odorata.

Species	Date sent	Date received	No. Sent	Stage	No. Alive	Comments
P. pseudoinsulata	15 Jan 84	18 Jan 84	2300	egg	20	Most eggs had molded
P. pseudoinsulata	19 Jan 84	25 Jan 84	2500	egg	0	All eggs molded
P. pseudoinsulata	22 Jan 84	25 Jan 84	3500	egg	3000	Packed in tissue
P. pseudoinsulata	12 Feb 84	17 Feb 84	78	pupa	0	All were dessicated
P. pseudoinsulata	27 Mar 84	4 Apr 84	60	pupa	5	Died before mating
P. pseudoinsulata	27 Nov 84	30 Nov 84	25	pupa	12	Established lab colony
P. pseudoinsulata	27 Nov 84	30 Nov 84	30	larva	20	Established lab colony
A. brunneonigrum	15 Jan 84	18 Jan 84	150	adult	150	Field released
A. brunneonigrum	19 Jan 84	25 Jan 84	250	adult	250	Field released
A. brunneonigrum	22 Jan 84	25 Jan 84	370	adult	370	Field released
A. brunneonigrum	12 Feb 84	17 Feb 84	90	adult	90	Field released
M. parvula	20 Nov 84	25 Nov 84	41	pupa	41	(Lab mating failed,
M. parvula	27 Nov 84	30 Nov 84	30	pupa	40	8 field released)

C. odorata on Trinidad, and therefore the remaining eight individuals were released.

Biology of *C. odorata*:

Every three weeks fifteen $1m^2$ quadrat samples of a roadside population of *C. odorata* are being sampled to record pre-release *C. odorata* parameters that would be useful in determining the impact of introduced insects on the plants. These parameters include density, and resource allocation to roots, stems, leaves and reproductive parts. Three plants are randomly taken from each randomly located quadrat. The roots, stems, leaves and reproductive parts are separated, dried in an 70°C oven and weighed. It is expected that changes in resource allocation and density will show before the weed population visibly begins to be affected.

The weed invades new areas via seeds, which it produces in great quantities. Roadsides are often disturbed and the seeds find "safe sites" for germination in this type of habitat. The aggressive spread of this weed once it has colonized an undisturbed area is believed to be a combination of allelopathy and rooting at stem nodes that contact the ground. Patches of the weed developing on land already overgrown with other plants were examined to determine the mode of patch expansion. In all cases the patch had a large central stalk and the outer rooted stalks were smaller with many still maintaining their attatchment to the original parent stem from the main rootstock. As the stem elongates, it grows over the surrounding vegetation and eventually kills the vegetation beneath it. The stem soon contacts the ground and roots at a node beginning the cycle again.

A typical roadside weed that is replaced by *C. odorata* on Guam is *Biden pilosa*. An experiment to evaluate the presence of allelopathic chemicals in *C. odorata* that could affect *B. pilosa* was conducted. Seeds of *B. pilosa* were placed on filter paper. The control treatment was watered with distilled water, while the experimental group was watered with an equivalent volume of extract of *Chromolaena* leaves (10 gms *Chromolaena* leaves blenderized in 100 ml. distilled water and then filtered). After one week the number of seeds from each treatment that germinated were recorded. The extract of *C. odorata* significantly reduced germination of *Biden* seeds (Table 3).

C. odorata on Trinidad:

In general the habitats in which the weed occurs are the same as those on Guam (ie. disturbed sites along roads, in areas of new construction, pastures and similor sites. It can be found at low and high elevations. The weed is rarely dense and never was observed to obtain the large size or monotypic stands as commonly observed in the Mariana Islands. Additionally, the weed does not persist at one site as it does here. It is always replaced by other vegetation.

C. odorata on Trinidad does not root at the stem nodes. The heavy attack of stem tips by insects prevents the plants from growing to the length necessary for it to lay next to the ground where it could root. This stunting of stem tips is the objective of introducing *M. parvula*.

II. The impact of *Anagyrus indicus* on the mealeybug *Nipaecoccus vastator*

Dr. James Nechols left the project to take a position at Kansas State University. Before leaving the following papers were prepared for publication:

1. Nechols, J.R. and R.S. Kikuchi. 1985. Host selection of the spherical mealybug (Homoptera; Pseudococcidae) by *Anagyrus indicus* (Hymenoptera: Encyrtidae): Influence of host stage on parasite oviposition, development, sex ratio and survival. Environmental Entomology 14(1):32-37.
2. Nechols, J.R. AND T.F. Seibert. 1985. The use of ant interference to experimentally evaluate natural enemies of the spherical mealybug, *Nipaecoccus vastator* (Homoptera: Pseudococcidae). Environmental Entomology 14(1):45-47.

Currently, two experiments have been initiated on the interactions of *A. indicus* and *N. vastator* as an extension of the host selection studies conducted in the past.

The first examines the fecundity of *N. vastator* when parasitized at different ages by *A. indicus*. It is commonly assumed that once parasitized a host no longer contributes offspring to the next generation. *N. vastator* clearly does. To quantify this, female mealeybugs are exposed to parasites as third and fourth instars for three days and then isolated and allowed to develop. The last two instars were chosen for study as these are the preferred host stges of the parasite. Two weeks prior to the hatch of new crawlers, the ovisac of the female is removed and placed in 95% alchohol to disolve the ovisac and facilitate counting of the eggs produced. The female is returned to the plant and the procedure repeated until the female dies. The results are pending.

The second experiment looks at the oviposition patterns of *Anagyrus indicus*. Nechols established that this parasite is widely dispersed and can

Table 3. Results of an allelopathy experiment using an extract of *Chromolaena* leaves to water the experimental (extract) treatment and distilled water for the control (water) treatment. Values in parentheses were produced from arcsin transformed data. The calculated t-values of transformed and non-transformed data were significantly different from the table value at the .01 level.

Treatment	N replicates	Mean no, seeds germinated	Std Dev	Std Error
Extract	5	26.75% (.2793)	24.21 (.2593)	10.82 (.1159)
Water	5	76.75% (.8774)	4.25 (.0706)	1.90 (.0316)

locate most mealeybug patches. However the dynamics of parasitism within a patch remain unclear.

Plants of *Jatropha integerimus* infested with *N. vastator* are placed in 6x6x6 ft. outdoor cages with parasites of *A indicus*. After one week, mealeybugs are dissected to look for life stages of parasites. The size of the cluster of mealeybugs is recorded and the probability of being parasitized determined.

III. Coconut Insect Survey

Cadang cadang is a viroid disease of coconut palms that attacks coconuts in Guam and the Phillipines. A major obstacle in dealing with the disease is that the mechanism of disease spread from palm to palm is unknown. One of the hypotheses about disease spread is that it is vectored by an as yet unknown insect or insects. The FAO requested that a year long survey be done to identify insects feeding on Guam coconut palms so that the list of potential vectors could be compared with lists from the Phillipines in hopes of finding common phytophagous insects to focus future vector studies on. Four areas around the island are being sampled sequentially each two weeks using sticky traps and hand-collection with aspirators and sweep nets. The insects will be identified when the field portion of the study is completed.

Plant Pathology

Vincent M. Russo

I. Identifcation of Plant Diseases

The construction of a data base to aid in the entering, retrieval and analysis of the sightings was completed in 1984. These programs use the procedures described in the Statistical Analysis System manuals. Better than 500 entries are on file. These comprise reports dealing with pathogenic organisms found on 123 plant genera which include agronomic, ornamental and noxious weed hosts. A total of 79 parasite genera, 10 viruses and one viroid are represented. A copy of this list is available upon request.

II. Control of Soil-borne Plant Diseases

Fusarium oxysporum f. sp. *lycopersici* and *Rhizoctonia solani* were grown in a complete 1.0 mM nutrient solution, and in solutions where Ca, Fe, K, Mg, N, and S were either excluded (O.OmM) or included at depleted levels (0.1mM) while all other constituents were maintained at 1.0mM levels. Dry weight of both fungi were determinded. For both fungi some of the lowest dry weights were recorded for samples grown in the complete solution. Exclusion of K, Mg, and S significantly increased dry weight of *Fusarium*. Inclusion at the 0.1mM level of most components significantly increased *Fusarium* dry weight over values for both the complete and corresponding excluded nutrient solutions. The exception was S where there was no difference between excluded and 0.1mM solutions. For *Rhizoctonia*, dry weights in Fe excluded solutions were less than the complete solution, while dry weights in S excluded solutions were greater than the complete solution. At the 0.1mM level Fe, K, and Mg dry weights were significantly increased over the dry weights produced in both the complete and deficient solutions.

III. Evaluation of Fungicides for Mildew Control in Cantaluope.

Both Downy and Powdery mildews are endemic on Guam. The experiment was conducted in a commercial field, in which cantaloupe and other melons are part of a rotation schedule, in Barrigada, Guam. The soil is a Saipan series clay loam (7-18-75, sand-silt-clay; pH 6.8). The

Treatment and Rate/A	Vigor*	Mean No. Marketable Fruit/Plant	Yield in T/A	
			Total	US#1
Control Sevin 50 WP 1 lb; Dibrom 8 EC 1 pt	3.8**	1.6a	5.1a	3.8*
Captan 50 WP 1 pt	4.4a	2.1a	6.2a	5.1a
Dithane M-45 80WP 1.2 lbs	4.6a	1.6a	4.5a	4.0a
Benlate 50 WP 1.5 oz., alternating weekly with Karathane WD 20 WP oz	4.0a	1.6a	4.7a	3.8a
Captan plus Benlate or Karathane, alternating weekly	4.0a	1.9a	5.3a	4.4a
Dithane plus Benlate or Karathane, alternating weekly	3.8a	1.5a	4.0a	3.5a

* Vigor index: 0=dead, 3=moderate and 5 excellent

** Values followed by the same letter are not significantly different p=0.05 (Duncan's Multiple Range)

land was deep plowed, disked twice and furrowed, and fertilizer (10-20-20), 250 lbs/A of P and K; 125 lbs/A of N) applied in-furrow during the week of 9 January 1984. Seed beds were prepared and drip irrigation lines laid in. Sufficient water was supplied to maintain plant tugor. Prefar (6 lbs/A a.i.) was applied preplant to the soil on 13 January and seed were planted on the same day in 25 ft. rows at a 2 ft. spacing. Rows were approximately 36 in. apart. Thinning to 1 plant/hill was accomplished by 2 weeks after emergence. Treatments were replicated 5 times. Weeding following planting was by hand. Sulfate of Ammonia (21-0-0, 75 bls/A of N), and Sulfate of Potash (0-0-51, lbs/A of K), was applied through the irrigation system four weeks after planting. Sevin was applied beginning 2 days after emergence and was continued weekly for the extent of the experiment. Dibrom was added to Sevin beginning at fruit set. Fungicide applications were begun two weeks after emergence, and continued at weekly intervals. The period January through April registered approximately 2.0 in. of rainfall below normal and 3.4°F above normal temperatures. Vine vigor was measured weekly beginning approximately 1 month prior to the first harvest which was 6 April.

Yields were not affected by treatment. Although Downy mildew was present, Powdery mildew was not. Lower than normal rainfall and higher than normal temperatures probably contributed to reduced disease pressure.

IV. Cultural Methods in Bell Pepper and Effects on Yield and Disease Control

Bell Pepper *(Capsicum annuum* L. cvs. 'Express Bell' and 'Keystone Giant') were planted in the 1983 and 1984 dry seasons and the 1983 wet season either in a north-south or east-west orientation, with or without black plastic mulch, with or without fungicides, and in three in-row spacings. Total yield, marketable yield, average fruit weight, and weight per plant were determined. Plant mortality, plant dry weight, and formation of reproductive structures were also recorded. Seasonal variation indicated large differences in total and marketable yield between the wet and dry seasons and significant differences between dry seasons. Total and marketable yield were affected by variety, fungicide treatment, spacing and interactions of these sources of variation. Plant mortality was not consistently affected by treatments. Heaviest plants were found in fungicide treated plots. Variety (Express Bell), field orientation (north-south), and season (dry) allowed formation of the greatest number of flowers. Dry season planting seemed to benefit fruit set with Express Bell having a higher overall percent of fruit set than Keystone Giant. Yield appeared to be related to precipitation and factors affecting amounts of precipitation.

Agricultural Engineering

Calvin A. Saruwatari and
Chin-Tian Lee with
Jose A. Cruz

Introduction

Research continued in agricultural engineering to study the aplications of trickle irrigation to vegetable crops. Field trials were carried out to determine the water requirement under trickle irrigation for watermelon and bellpaper on private farm fields in conjunction with the Cooperative Extension Service field demonstrations. For all trials domestic water was used.

Description of Experiments

Experiment 1: Watermelon

A random block design with four water treatments and four replications was initiated on a watermelon (Top-Yield) field in February, 1984. Treatments 1, 2, 3, and 4 were set at 2 hours, 3 hours, 4 hours, and 5 hours every other day, respectively. The discharge rate of the RIS Biwall was one gallon per minute (227.10 litters per hour) per 400-foot (121.92 meters) lateral with a 24-inch (0.61 meter) spacing. Due to labor problems and government diversion of the water during a domestic water supply shortage, the schedule was discontinued and the field wetered overnight for 12 hours as water was avaliable. Pre-plant fertilizer was applied at a rate of 4 oz. (113.4 grams) per hill of 10-20-20 and a side dress was applied at the same rate of 16-16-16 with Urea. Insects (thrips and cucumber beetles) and plant diseases (anthracnose, powdery mildew, blossom-end rot) were noted and treated with Dibrom, Malathion Sevin, and Benlate as part of the farmer's spraying program.

Experiment 2: Watermelon

A random block design with four water treatments and four replications was used on a watermelon (Top-yield) field in March, 1984. Treatment 1 (4 hours every other day) and treatment 3 (8 hours every other day) were set for one day while treatment 2 (6 hours every other day) and treatment 4 (10 hours every other day) were set for the following day due to the length of time needed to complete one cycle. The discharge rate of the RIS Biwall was 1.52 gallons per minute (345.20 liters per hour) per 400-foot (121.92 meters) lateral with a 12-inch (0.30 meter) spacing. Preplant fertilizer was applied at a rate of 4 oz. (113.4 grams per hill of 10-30-10 and a side dress was applied at the same rate of 16-16-16 fertilizer. Insects (thrips and grasshoppers) were noted and treated with Dibrom and Sevin as part of the farmer's spraying program.

Experiment 3; Watermelon

An experiment with watermelon (Top-yield) was conducted to determine the acceptability and long-term performance of yarious trickle irrigation laterals in March, 1984. The laterals/emitters tested (four replications) were the Submatic E-2 (2.98 gallons per minute/676.76 liters per hour), RIS Biwall (0.59 gallons per minute/133.99 liters per hours), Chapin Micro-dripper (2.39 gallons per minute/542.77 liters per hours), and Agrifim (2.50 gallons per minute/567.75 liters per hour) (all per lateral). The lateral length was 200 feet (60.96 meters) and the emitter spacing was 18 inches (0.46 meters).

The irrigation schedule was every other night, all night or every other day, four hours in the morning depending of the avaliability of water. Preplant fertilizer was applied at a rate of 9 lbs. per 100 feet (4.08 kilograms per 30.48 meters) of 10-30-10 and a side dress was applied at a rate of 6 lbs. per 100 feet (2.72 kilograms per 30.48 meters) of 16-16-16. Insects (thrips, grasshoppers, and cucumber beetles) and plant diseases (powdery mildew) were noted and treated with Dibrom, Sevin and Benlate as part of the farmer's spraying program.

Experiment 4: Bellpepper

A field trial on supplemental irrigation of bellpeppers (ProBell) under trickle irrigation during the rainy season was conducted using the RIS Biwall (0.24 gallons per minute/53.76 liters per hour) in July, 1984. A 100-foot (30.46 meters) lateral with an 18-inch (0.46 meter) spacing was used. The system was turned on if the three day average rainfall was less than 0.50 inches (1.27 centimeters). If the four day total included a day with more than 2 inches (5.08 centimeters) of rain or the irrigation system had been turned on, the system was not activated. Rainfall was measured on-site. The five irrigation treatments replicated three times were 1.0 hour, 1.5 hours, 2.0 hours, 2.5 hours, and 3.0 hours. A continuous function design was used. Preplant fertilizer was applied at a rate of 10 lbs. per 100 feet of 10-30-10 fertilizer. A side dress was applied at a rate of 10 lbs. per 100 feet (4.54 kilograms per 30.48 feet) of 16-16-16 and a second side dress was applied at a rate of one pound per 100 feet (0.45 kilogram per 30-48 meters) of 21-0-0 fertilizer. Insects (thrips, leafminers, and mites) and plant diseases (Southern blight, tobacco mosaic virus, and unidentified fungal disease) were noted and treated with Ethion, Kelthane, Dibrom, Captan, Terachlor, Dithane M22 and Tribasic Copper Sulfate as part of the farmer's spraying program.

Results and Discussion

Experiment 1: Watermelon

Data was collected from 100-foot (30.48 meter) sections of the middle two rows for each treatment. The marketable yield was divided into three classes. Class 1 was any marketable fruit at least ten pounds (4.54 kilograms) in size. Class 2 was any marketable fruit at least 15 pounds (6.80 kilograms) in size. Class 3 was any marketable fruit at least 20 pounds (9.08 kilograms) or more in size. The unmarketable fruits include fruits that showed signs of disease, water stress or were too small at the time of the data collection.

Analysis of the watermelon yield found that of all fruits formed, only 58 percent were marketable (Table 1). The relatively high yield of Treatment 1 was believed to be due to better pollination since its upper third was located next to several large mango trees as compared with the rest of the treatments which were in the open

Table I: Watermelon 1984

Treatment number	Total number of unmarketable Fruits	Total number of marketable (Class 1)	Total number of marketable (Class 2)	Total number of marketable (Class 3)	Total number of marketable Fruits	Percent marketable to total Fruits
T1	56a	59	39	23	121	0.68
T2	81	50	31	4	85a	0.51
T3	58a	37	34	12	83a	0.59
T4	60a	47	20	3	70a	0.54
Totals	255	193	124	42	359	0.58
LSD (0.05)	11.81				27.18	

*Means flanked by the same letter are not significantly different at the 5% level

Table 2: Bell Pepper 1984

Treatment number	Total number of unmarketable Fruits	Total weight of unmarketable (kilograms)	Total number of Marketable Fruits	Total weight of Marketable (kilograms)	Average diameter of Marketable (cm.)	Average length of Marketable (cm.)	Average weight of Marketable (grams)
T1	28a	0.746a	259a	9.957abc	6.3	7.2	38.4
T2	29a	1.091bc	267a	10.768bc	5.5	7.3	40.3
T3	33ab	0.994ab	272a	11.458c	6	6.7	42.1
T4	30ab	0.974ab	242a	9.173a	5.9	6.9	37.9
T5	38b	1.399c	272a	9.790ab	6	7.9	37
LSD (0.05)	8.57	0.32	52.75	1.53			

*Means flanked by the same letter are not significantly different at the 5% level

field. However, the sampling was done across the lower half of the field and away from the mango trees and therefore the greater yield of Treatment 1 can not be attributed to better pollination. The incidence of blossom-end rot was less pronounced on this field than on an adjoining plot where water was applied by a tractor-drawn water barge.

Experiment 2: Watermelon

The experiment was discontinued in April after infestations of thrips (specied unidentified) and grasshopers (specles unidentified) could not be controlled on the watermelon. A subsequent experiment begin in April, 1984 following the same experimental design on the same field was also terminated in May due to the same reasons.

Experiment 3: Watermelon

Initial perference was for the Agrifim. No yield data was obtained due to theft of the watermelon crop in early July.

Experiment 4: Bellpepper

The experiment was discontinued due to typhoon damage to the bellpepper plants in November. The total rainfall was 46.00 inches (116.63 centimeters) or approximately 0.50 inches (1.30 centimeters) per day prior to the typhoon. No significant difference was found between the treatments after two harvests (Table 2). However, Treatment 3 had the largest total weight and the highest average weight of good (marketable) fruits. The total weight and average weight per fruit increased from Treatment 1 to Treatment 3 and then decreased from Treatment 3 to Treatment 5. Although there was no significant difference between the treatments due to a high within treatment sum of squares, the results indicate that the optimum water treatment should be Treatment 3 with a total water application of 482.92 gallons (1827.84 liters) for the season applied at rate of 0.24 gallons per minute (53.76 liters per hour) per 100-foot (30.48 meter) lateral (plus 0.5 inches (1.30 centimeter) of rainfall per day). However, the applied water is only 2.58 inches (6.55 centimeters) additional water or an average of only 0.03 inch (0.07 centimeter) additional per day.

Conclusions

The results of the experiments on watermelon show the importance of proper irrigation to the production of watermelon. The fields used in the first and third experiments on watermelon showed a greater vigor and had the potential of a greater yield than other non-irrigated or poorly irrigated fields. in production at the same time. The number of fruits per unit distance seemed greater (approximatelly 3 to 1 based on a visual estimate) and the incidence of blossom-end-rot was lower in the irrigated fields.

The results of the experiment on bellpepper showed that the irrigatin schedule used is one that can be used for the supplemental irrigation of bellpepper during the rainy season. The system was turned on if the three day average rainfall was less than 0.50 inches (1.27 centimeters). If the four day total includes a day with more than 2 inches (5.08 centimeters) of rain or the irrigation system had been turned on, the system was not activated. Although the data showed no significant difference between the treatments the fact that Treatment 3 had the highest total weight and highest average weight of marketable fruit indicates that the other irrigation treatments are either a little too low or too high. Therefore, if the irrigation application during the rainy season can supplement rainfal such that at least 0.50 inch (1.27 centimeter) is applied per day, it should be sufficient to meet the irrigation needs of the crop.

Animal Sciences

Anastacio L. Palafox

In 1984 the Animal Research Center (ARC) at the Inarajan Agricultural Experiment Station was completed. Included in the research facility are ten pens. Removable partitions were provided each pen in order to meet the requirements of larger experiments. The facility also includes three large pens for farrowing swine. The same three pens could also be used for experiments with poultry. Pure breeds of swine (Yorkshire, Chester White, Hampshire) were obtained for research purposes.

I

Performance of 45.kg pigs fed 10%-16% protein.

Introduction:

Guam is dependent on imported feeds for the swine industry. Protein concentrates is specially expensive. Hence a study was designed to determine the minimum level of dietary protein which may be used in swine grower rations without significantly affecting daily weight gain and feed efficiency.

Materials and Methods:

An experiment (S13.1) was conducted with 45-kg pigs to determine the effects of 10, 14 and 16 percent protein on feed consumption, weight gain and feed efficiency. A "Latin Square Changeover" experimental design was used. There were three treatments (diets) and three 14-day periods. All the animals received the corn-soybean diets, one in each period. There were nine pens of animals with similar weights in each three pens. Two days were omitted between periods from data collection to reflect "new treatment" effects without contamination with "old treatment." There were as many pens of animals as treatments in each of the three 14-day periods. The pigs were distributed at random by weights into nine pens. Body weight and feed consumption were obtained. Feed and water were provided ad libitum.

Results and Discussion:

Table 1 shows the results of feeding 45-kg pigs with grower diets containing 10, 14 and 16 percent crude protein (mainly from soybean meal). It can be seen that during period 1, the daily feed consumption was similar among treatments. However, the daily gain and feed per unit of gain were significantly affected by the level of protein in the diets. Pigs fed ten percent protein were signifcantly inferior to those fed 14 and 16 percent in daily

weight gain and feed consumed per unit of gain. Pigs fed 14 and 16 percent protein were similar in daily weight gain and feed efficiency (feed/gain).

In period 2 the observed data was similar to those of period 1. Feed consumption among pigs 10, 14 and 16 percent protein were similar. However, pigs fed 14 and 16 percent protein were similar in weight gain and feed efficiency.

The observations in period 3 were similar to those of periods 1 and 2. It was noted, however, that in period 3 the daily weight gain and feed efficiency of pigs fed ten percent protein improved over those of periods 1 and 2. The improvement was probably attributable to the increasing age of the animals. It is known that protein requirement of growing animals decreases with age.

Table 1 also shows the summary of the combined data from periods 1, 2 and 3. The combined average daily feed consumption during the duration of the experiment was similar. This was also true with data obtained in each of periods 1, 2 and 3. The data summary of the three periods for daily weight gain and feed efficiency was significantly affected by the level of protein in the grower diet. Pigs fed 10 percent protein gained significantly less than those fed the 14 and 16 percent protein diets. Feed per unit of gain was also significantly superior for pigs fed 14 and 16 percent over those of 10 percent protein. The data also showed that pigs fed 14 and 16 percent protein were similar in daily weight gain and feed conversion.

Conclusion:

The data suggests that 14 percent instead of 16 percent protein may be fed to 45-kg growing pigs for optimum productive performance.

II

Research was continued on the "Potential of Cassava as a Crop, Food and Feed in Micronesia:" Supported by P.L. 89-808, Section 406.

Root Yield of Saipan, CNMI *M. esculenta* asscessions.

Introduction:

An experiment was conducted to determine the productive performance of **Manihot esculenta** (mandioca) growing in Saipan, Commonwealth of the Northern Mariana Islands (CNMI).

Materials and Methods:

Seven accessions of mandioca from different villages of Saipan, CNMI were compared with two accessions (8, 9) from the territory of Guam, USA. The nine accessions were tested at the Kagman Agricultural Station (KAS). A randomized block design was used. There were nine accessions and four replicate plots of 6 plants each. Seed pieces with five nodes or more were used. The rows were 1 meter apart. The plants were also 1 meter apart. The field was mowed, plowed, discked and then ridged. The seed pieces were planted diagonally. Border cassava seed pieces were planted. A sprinkler system was used for watering. The field was weeded and watered as needed. Duration of the study was 32 weeks. Data were obtained on: 1) color of roots, stem and leaves, 2) weight of tubers and parts of the plant above ground level and 3) tuber circumference, length and diameter.

Results and Discussion:

Table 2 shows the data obtained on root yield (t/ha), length, circumference and diameter. Root yield ranged from 16.85 to 31.94 t/ha. Accession 8 from Guam produced the heaviest roots, whereas accession 7 from Saipan produced the lightest. Accessions 3, 6 and 7 from Saipan produced significantly lighter roots than those of accession 1, 2, 4 and 5 from Saipan and accessions 8 and 9 from Guam.

Root length ranged from 20,84 to 27.52 cm. There was a significant dif-

Table 1. Summary of data obtained with 45-kg pigs fed 10, 14 and 16 percent protein (S13.1)

Period	Protein	Feed/day	Gain/day	Feed/gain
	%	kg	kg	kg
1	10	1.91	0.29b	7.8lb
1	14	1.66	0.64a	2.58a
1	16	1.95	0.67a	2.97a
2	10	1.97	0.42	6.34b
2	14	1.99	0.88	2.45a
2	16	2.31	0.81	3.07a
3	10	1.93	0.47	6.23
3	14	2.14	0.78	2.78
3	16	1.82	0.78	3.58
1,2,3,	10	1.93	0.39b	6.30a
1,2,3	14	1.93	0.76a	6.30a
1,2,3	16	2.03	0.75a	3.21

1. Means with different letters in a vertical line in each period are significantly different (P 0.05).

ference in root length among the nine accessions. Accessions 4 and 5 tubers were the longest whereas those of accessions 6 and 9 were shortest. There were no significant differences in the length of tubers from accessions 2, 4, 5, 8 and 9.

The average root circumference ranged from 10.84 cm to 14.73cm. Tubers from accessions 1, 2, 8 and 9 showed the longest circumference. Accessions 4 and 6 showed the shortest circumference and were significantly inferior to that of accessions 1, 2, 4, 5 and 7.

Root diameter also showed significant differences among accessions. The average ranged from 6.67 to 4.80 cm. Diameters of roots from accessions 1, 2, 4, 5, 8 and 9 were longer than those of accessions 3, 6 and 7.

Table 3 shows the correlation coefficient of root yield, length, circumference and diameter. The data show that the four parameters were highly correlated ($P<0.01$). The longer the length, circumference and diameter of the tubers the higher the yield.

Conclusion:

Root yields of 2 accessions from Guam (8 and 9) and 4 accessions (1, 2, 4 and 5) from Saipan were similar. Their root yields ranged from 26.58 to 31.94 t/ha. Accession 8 from Guam produced the highest yield, whereas accession 1 from Saipan produced the lowest. Root yield increased with root length, circumference and diameter. The four root parameters were positively and significantly correlated at the one percent level of probability.

III

Feedstuffs: Cajus cajan, Colocasia, and Deoscoria.

My participation at the United Nations Development Program/Food and Agricultural Organization -South Pacific Commission (UNDP/FAO-SPC) workshop on "Sub-regional root crop breeding and germplasm" held in Suva, Fiji in September 1984 gave me the opportunity to obtain plant varieties that may be used as potential sources of foods and feeds through the courtesy of Dr. Sivan Paran, Director, Fiji Agricultural Experiment Station.

Plant materials were obtained and cleared through the Honolulu, Hawaii Plant Quarantine Service. The plant materials are being propagated for further studies at the Inarajan Agricultural Experiment Station:

A. One variety of pigeon pea (Cajus cajan).
1. Dwarf (D)

B. Three varieties of sweet taro **(Colocasia).**
1. Tausala Ni Samoa (TSN)
2. Samoa Hybrid (SH)
3. Samoa (S)

C. Five varieties of yam **(Deoscoria).**
1. Uvini Futura (UV)
2. Taniela Vula Leka (TVL) - (R)
3. Kivi
4. Mura Poi
5. Taniela Vula Leka (S)

Table 2. Performance of cassava accessions tested at the Kagman Agricultural Experiment Station; Saipan, CNMI (Exp. M 9.1)[1]

Accession	Root Yield	Root Length	Root Circumference	Root Diameter
	t/ha	cm	cm	cm
1	26.58a	23.73bcd	14.04ab	4.75a
2	28.45a	26.81ab	14.73a	4.80a
3	20.43b	23.31cd	11.50d	3.89b
4	28.31a	27.51a	13.30bc	4.61a
5	29.98a	27.52a	13.27bc	4.53a
6	17.67	20.84d	10.84d	3.67b
7	16.85b	22.97d	12.94c	4.01b
8	31.94a	26.53abc	14.44a	4.78a
9	29.31a	26.32ab	14.02abc	4.69a

[1]Means on the same vertical line bearing different superscript letters differ significantly ($P<0.05$).

Table 3. Correlation of yield, length, circumference and diameter cassava grown at the Kagman Agricultural Station, Saipan, CNMI (Exp. M 9)[1]

Root	Root Yield	Root Length	Root Circumference	Root Diameter
Root yield	1.0000[1] 0.0000[2]	0.6921 0.0001	0.7269 0.0001	0.7513 0.0001
Root length	0.6921 0.000	1.0000 0.0000	0.4950 0.0001	0.5025 0.0001
Root circumference	0.7629 0.0001	0.4951 0.0001	1.0000 0.0000	0.8959 0.0001
Root diameter	0.7513 0.0001	0.5025 0.0001	0.8959 0.0001	1.0000 0.0000

[1]Correlation coefficient = r
[2]Probability

Saipan, CNMI
1984 Annual Report (406) p. 37 Exp. 15 II

Aquaculture

Stephen G. Nelson

This past year physiological studies of brackish water species were continued. The primary objects of attention were species of *Gracilaria*, agar-bearing seaweeds with potential for culture on Guam, and tilapia, introduced cichlid fish which are currently being cultured here.

Seaweed studies

An important offshoot of the work arose from preliminary attempts to

Table 1. The eight mathematical expressions for simulation of light saturation curves.

Equation Number	Equation
1	$P = \alpha,\ I < Pmax\ \alpha^{-1}$ $\alpha Pmax,\ I > Pmax\ \alpha^{-1}$
2	$P = Pmax\ \alpha I\ (Pmax + \alpha I)^{-1}$
3	$P = Pmax\ \alpha I\ [(Pmax)^2 + (\alpha I)^2]^{-1/2}$
4	$P = \alpha I exp\ (-\alpha I\ Pmax\ e)$
5	$P = \alpha I exp\ (-\alpha I\ Pmax^{-1}\ e),\ I < Pmax\ e\ \alpha^{-1}$ $\alpha Pmax,\ I > Pmax\ e\alpha^{-1}$
6	$P = Pmax\ [1 - exp\ (-\alpha\ Pmax^{-1})]$
7	$P = \alpha I - (\alpha I)^2\ (4\text{-}Pmax)^{-1},\ I \leq 2\ Pmax\ \alpha^{-1}$ $Pmax,\ I > 2\ Pmax\ \alpha^{-1}$
8	$P = Pmax\ tanh\ (\alpha I\ Pmax^{-1})$

relate aspects of the light-photosynthesis relation of *Gracilaria* thalli to the nitrogen and phycobiliprotein content. The light saturation curves proved not to be related in any simple manner to either nitrogen or phycobiliprotein content of the thalli; however, the data generated in these trials were used to compare several mathematical formulations of the relation between photosynthesis and light. Since the use of a number of such formulations can be found in the literature, it is useful to examine their merits in regard to their abilities to accurately describe experimental data.

The expressions of the relation between the rate of apparent photosynthesis (P) and photon flux density (I) were formulated as functions of the maximum rate of photosynthesis (Pmax), at the horizontal assymptote of the P vs I curve, and of the initial slope (α) of the curve. The eight equations which were compared are presented in Table 1. Photosynthesis was determined as O_2 produced per salt-free dry weight (g) of the thalli.

The parameters of the models were estimated by a non-linear iterative curve-fitting program, based on the method of the least-squares. The statistical program (BMDP3R, from the Health Sciences Computing Facility at UCLA) was compared to a similar program developed by the Statistical Analysis Systems (SAS) Institute Inc. Results of the two programs were identical. Those from the BMDP analyses are presented here.

The parameter estimates and residual mean squares produced by 4 of the equations are shown in Table 2 for 5 of the data sets of a species of *Gracilaria* collected from Saipan lagoon. Similar tables were generated for two other species of *Gracilaria*.

The results of the comparisons led us to conclude that equations 3 and 4 are the most appropriate models for simulating photosynthesis - light relations for species of *Gracilaria*.

Tilapia Studies

Studies have begun to determine the effect of feeding rate on conversion efficiency and to compare methods for measuring assimilation efficiency of tilapia. However, at this time the results are unavailable.

The emphasis of this project will shift to studies of tilapia in the coming year since tilapia culture has recently become quite successful on Guam.

Publications

Nelson, S. G. and R. K. Kropp. 1985. Nitrogen excretion and asimilation by the freshwater prawn *Macrobrachium* (Crustacea, Palaemonidae) in relation to diet. Comparative Biochemistry and Physiology Vol. 81A No. 3, pp. 699-704.

Table 2. Estimates of P max and α produced by 4 of the mathematical expressions for 5 data sets. These data are for a species of *Gracilaria* found in Garapan Lagoon, Saipan. Also displayed are the correlation coefficient (r^2) and the residual mean square of the estimate (RMS).

Thallus Number	1	2	3	4
1. (n = 9)	Pmax = 6.76 α = 0.058 r^2 = 0.8014 RMS = 1.463	Pmax = 4.634 α = 0.055 r^2 = 0.8030 RMS = 1.452	Pmax = 4.235 α = 0.045 r^2 = 0.8055 RMS = 1.433	Pmax = 3.989 α = 0.039 r^2 = 0.8070 RMS = 1.244
2. (n = 11)	Pmax = 2.030 α = 0.076 r^2 = 0.8045 RMS = 0.218	Pmax = 1.719 α = 0.059 r^2 = 0.8133 RMS = 0.208	Pmax = 1.690 α = 0.045 r^2 = 0.8168 RMS = 0.204	Pmax = 1.559 α = 0.041 r^2 = 0.8107 RMS = 0.211
3. (n = 8)	Pmax = 5.340 α = 0.056 r^2 = 0.9649 RMS = 0.1126	Pmax = 3.648 α = 0.053 r^2 = 0.9697 RMS = 0.081	Pmax = 3.349 α = 0.044 r^2 = 0.9774 RMS = 0.081	Pmax = 3.091 α = 0.037 r^2 = 0.9902 RMS = 0.035
4. (n = 8)	Pmax = 3.194 α = 0.097 r^2 = 0.9175 RMS = 0.371	Pmax = 2.634 α = 0.081 r^2 = 0.9279 RMS = 0.324	Pmax = 2.595 α = 0.063 r^2 = 0.9354 RMS = 0.290	Pmax = 2.536 α = 0.054 r^2 = 0.9433 RMS = 0.254
5. (n = 10)	Pmax = 3.756 α = 0.110 r^2 = 0.9400 RMS = 0.350	Pmax = 3.125 α = 0.091 r^2 = 0.9449 RMS = 0.321	Pmax = 3.078 α = 0.071 r^2 = 0.9487 RMS = 0.299	Pmax = 3.029 α = 0.061 r^2 0.9518 RMs = 0.281

Agricultural Economics

Thao Khamoui

I. GUAM AGRICULTURAL PRODUCTION CONSTRAINTS

In 1983 a study was made on the produce market potentials on Guam. In 1984 another study was focused on production constraints. There are several constraints inhibiting agricultural development on Guam. This report will discuss those that affect crop production. They can be grouped into natural and institutional constraints, while some fall under both categories.

The main physical constraints are the underdevelopment of major agricultural resources and infrastructure such as access roads and irrigation systems and other supporting facilities much as storage and cooling facilities. Institutional constraints include the land tenure system and the lack of supporting services such as agricultural production and marketing information, financing, farm workers, transportation, production specialization and market coordination.

Land Ownership and Tenure

The total land area of Guam is 212 square miles or 135,680 acres. The Government of Guam and the Federal Government respectively own approximately 18.4 and 32.8 percent, while the remaining 48.8 percent is privately owned.

Land tenure greatly affects investment, the type of management and technology adopted, and the incentives of the farm operators. Because land ownership is considered a heritage and a source of pride for the people of Guam, it is often held in multiple ownership or subdivided among family members who may be reluctant to sell or lease their land. This has resulted in decreasing the size of private holdings which may hinder the development of large scale farm operations. Table 1 shows that over 90 percent of private lands are not larger than five acres.

Land Lease Programs

The Government of Guam has two agricultural land lease programs. The Land Use Permit Scheme administered by the Department of Land Management is a short term program involving small lots. Although intended for bonafide farmers, much of the agricultural land in the north is leased to non-farmers on a year-to-year basis. Some people use the lands only for weekend barbecues, leave them undeveloped, or erect small shelters. Other leaseholders built small structures, and later permanent dwellings, eventually attempting to gain title to the land.

A long-term lease program is administered by the Department of Agriculture. Leases can be made up to 50 years and lessees may be exempted from payng rent for the first five years. Maximum lot size is 16 acres. Most land available under this program is in northern Guam, where underground water lens contamination is a major concern and urbanization is an important factor.

The programs have experienced some serious problems. Beside the lack of irrigation water, the programs have not been successful in making leases to bonafide farmers. Most people who participated in the programs are not concerned about agriculture but are interested primarily in establishing a residence on government land. Ineffective administration of the program has contributed to the limited success in promoting agricultural development in the designated areas. In the absence of controls, leased lots are not used for farming and the intent of the programs have not materialized. In order to successfully administer a land lease program, political considerations must be minimized whenever possible in the selection of lessees and the enforcement of the terms of lease.

Real Property Tax

Another constraint, ironically, is the very low property tax which has resulted in arable land being left unused. the existing real property tax rate on Guam is unproductive and probably counterproductive as far as agricultural development is concerned. Currently, the tax rate for land is 0.5 percent of the assessed value, which is 35 percent of the market value. For this reason many agricultural lands are not in productive uses because the costs of leaving them idle are negligible. It has been recommended that a revised differential assessment system with favorable rates for land in productive use would provide incentives for agricultural development.

Irrigation

Guam has two distinct seasons. The dry season generally begins in January and ends in June and the rainy season usually lasts from July to December. The seasonal variations often cause water shortages and severe draughts during the dry season. An irrigation system which would provide a regular and ample supply of water is urgently needed on

Table 1
Patterns of Land Ownership on Guam

Size of Land	Private Owners (in Percent)
Less than 1/14 acres	6,378 (63.5%)
¼ to 5 acres	3,000 (30.0%)
5 to 300 acres	600 (6.0%)
More than 300 acres	60 (0.5%)
Total	10,038 (100%)

Source: Overseas Bethel, Inc., **Guam Economic Development Master Plan** November, 1975, pp.5-25.

Guam to raise agricultural productivity and total output.

Several methods of serving water to agricultural lands were discussed in a recent study conducted by the U.S. Bureau of Reclamation. One potential source of agricultural water in the south is through the municipal system. The major advantage for this surce of supply is that the mechanism is already in existence although not functioning optionally and land could be developed in small parcels. Groundwater wells are another source of irrigation water for small development. Although pumping costs would be much less in the south, exploration costs would be quite high since little is known about the aquifer and groundwater is much less readily available in this region. Considering the very small acreage of land that is likely to be developed at any one time and high costs of large dams, small impoundments such as small reservoirs, diversion dams, and farm ponds show considerable promise. However, Guam leaders are more interested in large projects such as The Ugum Dam involving considerable expenditure of federal funds. A large impoundment would provide more municipal, industrial and irrigation water than could be utilized for years to come, making it very costly to develop.

Farm Loans

The extremely limited supply of capital for agricultural loans is also a constraint for agricultural development of Guam. The government funded programs seem to be the primary source of capital at the present time. The Farmers Small Loan Revolving Fund administered by the Guam Department of Agriculture has a total amount of $250,000. The maximum loan made under this fund is $10,000 at an interest rate of 2 percent. The total amounts of $113,550 and $107,000 were made to farmers in 1980 and 1982, respectively. Loan repayments in 1982 and 1983 were $17,762 and $35,839. This program has had limited success due to limited funds available and poor loan repayment. In 1980, only 13 loans were approved because of inadequate funds.

The other programs administered by the Guam Economic Development Authority (GEDA) are The Agricultural Development Fund, and the more general Guam Development Fund. The former was initially funded at $100,000 and has made loans to eligible farmers at an interest rate of 3 percent. The latter was federally funded with total resources of five million dollars of which up to 15 percent or $750,000 can be allocated to agriculture at 9.375 interest rate.

Government loan funds are not available to agriculture in sufficient amounts and individual loans are not large enough to assist commercial operations. Very few farmers have obtained agricultural loans from commercial banks or the Farmers Home Administration (FmHA) due to various reasons. They may not be well informed concerning the availability of different financial programs provided by the FmHA. Inadequate bookkeeping may also make it difficult for them to obtain loans. The desires of some farmers to avoid involvement and interference of creditors in their farm operations may also be another reason for not utilizing the available services.

Farm Labor

The shortage of farm labor is acute but seldom discussed. The shortage is caused mainly by the low esteem held for farm work as well as low wages and benefits in farming compared to government jobs. The Government of Guam is one of the largest employers on the island. Farm work is considered to be of low social prestige and farmers looking for employees find little response from a labor force aspiring to white-collar work.

In 1982, there were 107 paid farm workers on Guam; only 52 of them worked more than five months. However, there were 3,128 unpaid farm workers, mostly family members and relatives. Approximately 1,900 of them worked more than five months. Practically all farms on Guam use unpaid labor, especially for harvesting. Therefore, the availability of family workers pretty much determines, to a certain extent, the size of farm.

The unavailability of farm labor may discourage large scale comercial farm operations on Guam. Since 1980, the U.S. Department of Labor has not certified any foreign farm workers to come to Guam while continuing to allow alien construction workers to come in. Since the Reagan administration has transfered the responsibility of alien labor certification to the Government of Guam, the importation of foreign farm workers to develop the agricultural industry on the island should be seriously considered and persued. However, the U.S. Immigration Office still maintains final decisions on the importation of H-2 workers certified by the Guam Department of Labor.

Production and Marketing

Guam imports a large quantity of fruits and vegetables and local farmers have difficulties in marketing because their supplies are inconsistent, irregular, and wide fluctuations are experienced from year to year.

In the foreseeable future, import substitution appears to be the most viable strategy and the most obtainable goat for agricultural development on Guam. However, imort substitution cannot take place unless the local supply becomes more dependable. Ways to alleviate the problem of inconsistency of supply include the estimation of market supply and demand for the major crops grown on Guam, timely market information dissemination, production specialization and contractual marketing, improved storage facilities and handling methods, and alternative production systems.

The lack of production specialization can cause wide fluctuations in supply and prices. The existence of a few large specialized farmers with contractual marketing agreements with farmers cooperatives or major buyers could alleviate the problem of inconsistency of supply. These specialized farmers are expected to have a lower average cost of production than other farmers due to their specialized knowledge, experience, and economies of scale. One good example on Guam is the production and marketing of pineapple.

Using a screen or lath house to produce high valued vegetable crops during the wet season and ornamental plants was suggested. If this production system is proven feasible, it will certainly reduce the seasonal fluctuation of supply, increase production, and may encourage exportation of some ornamental products.

Another alternative production system was discussed in a recent analysis by the Bureau of Planning. It suggested that hydroponics may have special applicability on Guam where labor is in short supply, soils are generally poor, and land values are high. Prior to Typhoon Pamela, six hydroponic farms were in operation. One reportedly experimented with flower production and found the in-

itial results encouraging. The analysis also recognized some constraints. The availability, adequacy, and purity of water are crucial factors in hydroponic operations. Other serious constraints are high investment costs and technical expertise required for hydroponic farming.

Storage, refrigeration and handling facilities are inadequate even for the present volume of production. The lack of these facilities has prevented farmers from efficiently marketing their products. Improved storage and refrigeration facilities, and handling and packaging methods will allow the marketing firms to control the flow of produce into the market in an orderly fashion, prolong shelf-life, maintain quality, and reduce spoilage. Spoilage and shrinkage from improper packing and careless handling have been one of the causes of high prices for local vegetables. Improvements in these areas will strengthen the competitive postion of island grown produce, and investment in these facilities should be given top priority.

Standardization and grading systems will not only improve the competitiveness of locally grown produce compared to the quality of imports, but they will also compensate and provide incentives to farmers who supply high quality produce in terms of price differentials. Without these systems, incentives are absent. One possible way to stimulate more agricultural production on Guam is to increase the local market shares of island grown produce through quality control. Government-industry cooperation is needed in the development and enforcement of quality standards. As far as future export markets are concerned, quality control is a necessary requirement because competition is more severe in the international market than in the local market.

II. AGRICULTURAL MARKETING

The publication of Agricultural and Related Statistics in 1984 was in response to the needs of those who are interested and involved in agricultural activities on Guam. Farmers and prospective investors often ask for information about Guam production, imports and prices of produce. Administrators, planners and policy makers in various public agencies frequently inquire about agricultural statistics for planning and policy formulation purposes. The availability of these statistics will also facilitate efficient marketing.

This publication is by no means comprehensive but it is hoped that the dissemination of information contained in the publication will assist many people who are involved in and concerned with agricultural development on Guam. Since statistical data provide an important basis for decision making and evaluating agricultural activities over a period of time, their availability should lead to better planning, improved decision making processes, effective policy formulation, and increased marketing efficiency and competition.

Pomology Fruit Crops

R. Rajendran

I. Fruit Crop Survey

The survey of fruit crops of Guam was continued in 1984. Seedlings and vegetatively propagated materials from identified single plants were planted at the Guam Agricultural Experiment station as per the list given below.

Anacardium accidentale	Cashew nut
Ananas comosus	Pineapple
Artocarpus heterophylla	Jack fruit
Artocarpus integenfolia	Jack fruit
Artocarpus integer	Champeden
Carica papaya	Papaya
Chrysophyllum cainito	Star apple
Citrus aurantifolia	Lime
Citrus paradisi	Grapefruit
Cocos nucifera	dwarf coconut
Diospyros discolor (D. Mololo)	Butterfruit
Diospyros kaki	Persimmon
Eugenia uniflora	Surinam Cherry
Hibuscus sabdanffa	Raselle
Macadamia integrifolia	Macadamia nut
Mangifera indica	Mango
Moringa pterygosperma (M. Olifera)	Horse radish
Musa acuminata .f. nana	Dwarf Banana
Musa paradisiaca	Plantain
Persea americanan	Avocado
Psidium guajava	Guava
Tamarindus indica	Tamarind

Sixty-six each of mango and Guava seedlings were planted at the Ija, Inarajan station for an N, P, K and Lime response experiment.

The objectives were:

1) To compare the effect of 0, 50, 100, 150 and 200 lbs/acre of Nitrogen from ammonium sulphate on rate of growth and leaf production.
2) To compare 0, 75, 150 and 300 lbs/acre of P_2O_5 from concentrated superphosphate.
3) To compare rates of 0, 75 and 150 lbs/acre of K_2O from murate of potash.
4) To measure response to lime from crushed coral on seedlings planted in spacings of 15'x20'.

II. Papaya

After completing the initial performance in the experimental field at Inarajan, low and early bearing papaya was taken to two farmer's field, one in Northern and the other in Southern Guam.

The plants were observed to be early bearing and uniform. The experiment is in progress.

Mulberry

Dwarf, purple fruited table mulberry introduced to the Guam Agricultural Experiment Station in 1980 was observed to be productive and is recommended for home gardens and in school and public gardens.

Banana

A dwarf multiple bunch producing banana has been located and added to the experimental collection. This clone produced two bunches on a plant maturing normally in 1982 and 1983. In 1984 one of the suckers produced seven flowers and seven bunches producing 429 fruits in total (Table 1). A normal plant of this variety produces 80 to 90 fruits in a single bunch under the normal conditions of Guam. The sucker is being maintained at the experimental lab for further observation.

Mango

Initial trials were conducted on indirect flowering of mango by using KNO_3 at the rate of 10 to 20 grams per liter and a combination of KNO_3 and $NaNO_3$ at the rate of 10 gms

each/litre. The effect on the seedlings of ''Carabao'' mango (*Mangimera indica L.*) was dramatic. The fruit set was high and fruit drop was well over 60% of the set fruits in the trees that dropped. In some of the trees both vegetative and floral shoots developed simultaniously. The experiment will be repeated in 1985 to see the effect on lower concentrations. Even the fertilizer grade KNO_3 induced flowering. The first week there was 38% flowering which increased to 100% by the third week. In the Hayden variety, the spraying was repeated after 2 weeks. The tree flowered after the third spraying.

In 1984 a grafting experiment on seedlings was more successful when the scion wood was dipped in 0.5g Benlate in 1 litre of water. It was necessary to spray the plants with 1.7gm per litre of Sevin to control borers.

Fruit Count in Multiple Flower Stock Producing Clone of Cavandish

No. of bunch	I	II	III	IV	V	VI	VII
Total No. of Hands	8	7	6	6	7	8	6

Flowering In Normal Plant	Nodes on the Exposed Pseudo Stem	Number of fingers on the bunches I	II	III	IV	V	VI	VII
0	1	0	0	0	0	0	0	0
14	2	10	8	0	0	0	14	6
14	3	9	8	0	0	10	10	7
13	4	10	8	10	11	11	12	6
12	5	8	9	10	14	9	9	9
11	6	7	10	10	13	8	9	3
10	7	8	8	9	10	10	12	1
9	8	8	3+4*	12	9	9	8	0
6+3*	9	7+3*	0	12+3*	9	10	6+4*	0
89+3* Total	9	67+3*	54+4*	63+3*	66	67	80+4*	32
Total								=429 fruits

*Underdeveloped fruits which are small.

Crop Modeling

Chuh Tek Tseng

Rainfall Probabilities and Wet-Dry Periods on Guam

1. Introduction

In tropical areas the timing and amount of rainfall are the major factors that affect agricultural production. Rainfall is directly related to soil water content, soil erosion and nutrient leaching. Short-term farm management such as scheduling for planting and harvesting application of fertilizers, and designing irrigation systems depends heavily on rainfall distributions. In recent years forecasts of precipitations from meteorological or climatological data have been used in many farming decisions. However, uncorrelated rainfall distribution based on the past weather data are still considered to be a good indicator for practical farm management.

The objectives of this study are two fold. The first is to complete the needed minimum data set of weather components for the IBSNAT (International Benchmark Sites Network for Agrotechnology Transfer) project for crop modeling of corn, cassava and potato. The second is to provide a preliminary survey of Guam's weather data collected by the US weather bureau over the past 30 years for the preparation of an Agroclimatic Atlas of Guam.

Two types of rainfall distribution were considered in this study. The first was the annual distribution of average weekly-rainfall and the cumulative rainfall probabilities. The second was the weekly rainfall distributions in both wet and dry periods. Comparisons of distributions between these two types yielded distinct patterns of rainfall on Guam.

II. Procedures and Methodologies

Daily rainfall data from 1958 to 1983 were obtained in magnetic tapes from the Natinal Weather Service in Ashvelle, North Carolina. The data in general were of reasonable values. Missing and miscoded data, typhoons and obvious outliners were excluded from the analysis. The commercial SAS (Statistical Analysis System) package of the SAS Institute, North Carolina, was used for computing descriptive statistics, performing nonparametric tests of normalcy of distributions, and constructing frequency tables. In-house Fortran programs were written to adjust the frequency tables and to normalize the distributions.

In constructing smooth distributiosn from field data, many authors prefer to assume mathematical models such as exponential, gamma, kappa, log and transformed normal distributions. However, the physical basis of these models appear not to have been firmly established. In this study the usual histogram approach was used. To be more flexible the bin widths of the histograms were not assumed to be equally spaced. Cubic splines were passed through the upper edges of the bins at their midwidth to approximate rainfall distributions. The equation of spline for the i-th bin between points (x_i, x_{i+1}) is given by

$$y = y_i + y_i' x + c_i x^2 + d_i x^3$$

where

$$c_i = 3(y_i + y_{i+1})/(Dx_i)^2 - (2f_i' + y_{i+1}')/(Dx_i)$$

$$d_i = (y_i' + y_{i+1}')/(Dx_i)^2 - 2(y_i - y_{i+1})/(Dx_i)^3$$

$$Dx_i = x_{i+1} - x_i$$

The derivatives y_j' $(j=1,2,....N)$ of all splines for the histogram in turn satisfy

$$(Dx_k)y_{k-1}' + 2(Dx_{k-1}+Dx_k)y_k' + (Dx_{k-1})y_{k+1}' = 3(y_k - y_{k-1})(x_{k+1}-x_k)/(x_k - x_{k-1}) + 3(y_{k+1}-y_k)(x_k - x_{k-1})/(x_{k+1}-x_k)$$

$(k=2,3,...N-1)$

These (N-2) equations, together with the boundary conditions (y'_1 y'_N) at the end points, complete the construction of histograms.

The end-point derivatives were computed from cubic curves that pass the first and the last four points of the histogram, respectively. The distribution was normalized with the scaling factor over the range of the rain fall $(0, R_{total})$

$$P(x) = y(x)/S$$

$$S = (R_{total})/\int_0^{R_{total}} y(x)dx$$

To avoid leap-year complications, the first climatological week was choosen to start on March 1. Julian days were used to compute the weeks thereafter. The one or two days over the last 52nd week at the end of February were absorbed into the 52nd week to compute the average. The results were not expected to significantly affect the estimation of distribution. For convenience of agricultural applications, the weeks were renumbered, starting at the beginning of the year.

Results

The means, standard deviations, maxima and minima, and frequency tables of weekly rainfall were computed from the weather data. The variations of means and standard deviationsin dry and wet periods were quite large. For example, in the 14th week and the 34th week the daily means and standard deviations were (0.172, 0.286) and (0.656, 1.050) inch respectively, yet their coefficients of variation were very close; 1.662 and 1.600 respectively. This suggested that the patterns of precipitation in the wet and dry periods on Guam over the past 30 years were very similar, although the amount of weekly rainfall between periods may differ up to 400% within a year.

Nonparametric Kolmogorov-Smirnov tests of normalcy were applied to the weekly distribution. It was found that at a 5% level of significance none of the weekly rainfalls were normally distributed.

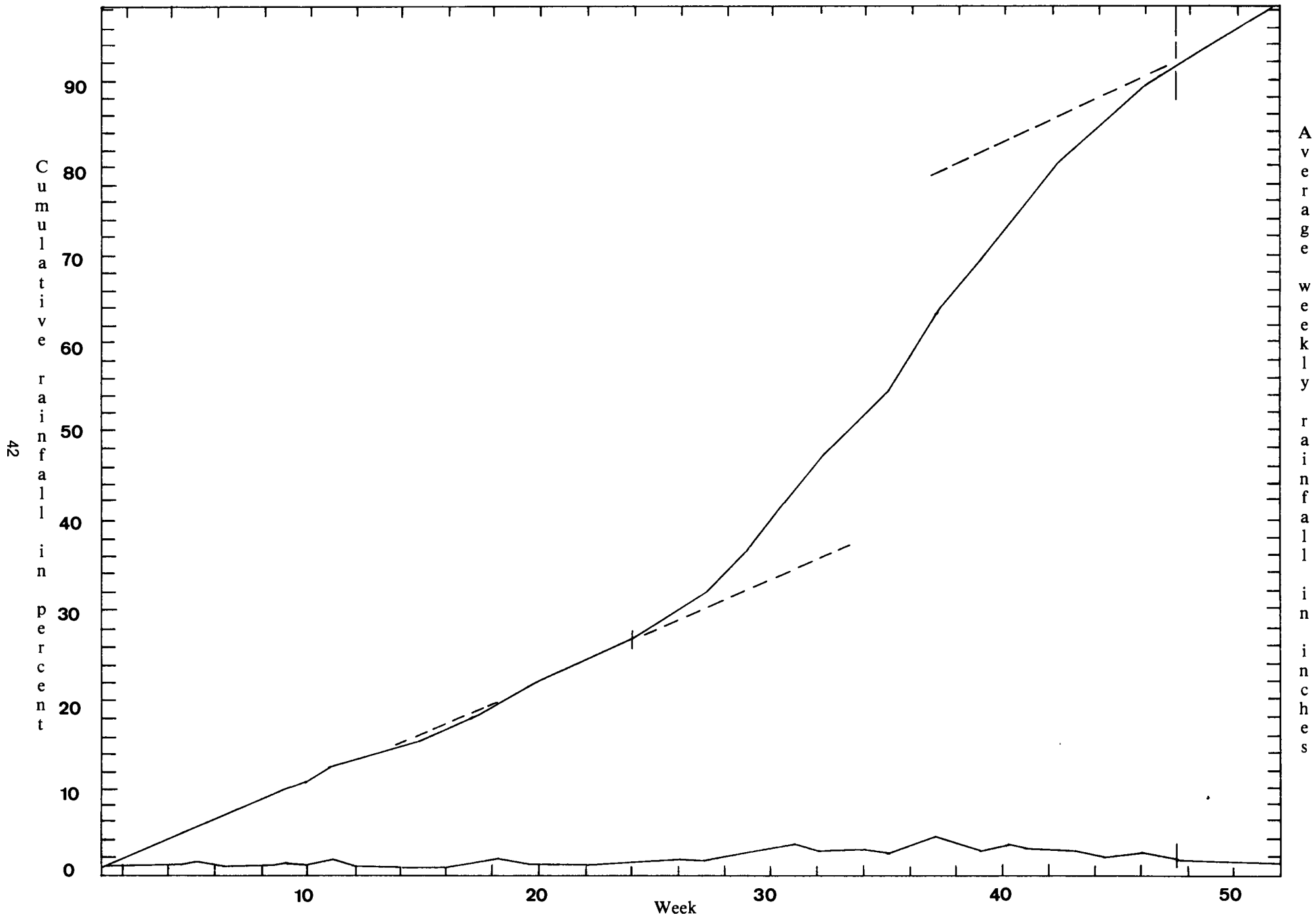
The lack of a well-defined mathematical distribution for rainfall on Guam cals for sets of splines-fitted curves for practical applications. These curves shall be published Atlas of the Guam Agricultural Experiment Station.

Fig. I shows the annual distribution of average weekly rainfall in the past 30 years. The transitions between the dry and wet periods are remarkably sharp on the cumulative probability curve. The wet period obviously starts in the middle of June and ends in mid-November. The heaviest rainfall occurs around mid-September.

IV. Conclusions

The amount of annual rainfall on Guam over the past 30 years was fairly constant. The distribution of annual rainfall can be separated into a wet period and a dry period with sharp transitions. The wet period started in the middle of June and ended in mid-November. The heaviest rainfall usually occured around mid-September. The amount of weekly rainfall varied greatly between the wet and dry periods, and the distribution was not Gaussian. However the patterns of weekly rainfall distribution, apart from typhoons and severe storms were quite similar. In wet periods raintall usually occured in early morning and late afternoon. Highland and hilly areas received more rainfall than the coast and valleys. Because of the limited number of weather stations on Guam, detailed contour maps at present have not been available.

Fig. I Average (lower curve, in inches) and cumulative (upper curve, in %) of rainfall



Micronesian Area Tropical Agriculture Data Base Center

Kenneth L. Carriveau

The Micronesian Area Tropical Agriculture Data Base Center began operation in the fall of 1982 as a four-year USDA Section 406 project. The Center functions as a cooperative venture of the College of Agriculture and Life Sciences and the University's Robert F. Kennedy Memorial Library. It's overall objective is to gather into one location all available published and unpublished documents produced in Micronesia concerning tropical agriculture and related topics, and to provide bibliographic retrieval and information dissemination services.

The Center began acquiring materials through personal contacts, correspondence and site visits. To date, more than 1800 documents have been acquired and cataloged. Approximately 1000 additional documents have been identified for acquisition.Response from other enfities has been positive. Memoranda of Understanding have been signed by government officials in the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia (Pohnpei, Kosrae, Truk and Yap), the Republic of the Marshall Islands and the Republic of Belau to insure automatic deposits of research materials produced within the island territories. A registry of persons involved in agricultural research has been developed to help monitor research activity within the region.

Once a document is received, it is cataloged and abstracted. A modified version of the *CBE Style Manual* is used for bibliographic references. Each catalog entry is augmented by an abstract of key words. Each key word abstract is a composite of structured language subject headings taken from a "Thesaurus of Key Words" complied by the center's staff and natural language key words abstracted from the text of the document itself. The information is then entered into the data base and is immediately accessible to scientists, extension agents, government officials, farmers and anyone else who has a terminal connected to the University's mainframe computer. Bibliographic searching privileges and photocopying services have been extended to participants who do not have computer terminals. This includes those in Guam and other Pacific Island Communities.

Since SQL/DS is not a bibliographic data base *per se*, the products have certain limitations. Bibliographies appear unconventional in form, however, the flexibility of the interactive query language offsets any shortcomings.

A user can request for a bibliography of references by author, by title, by source or by subject. More sophisticated search requests can be formulated by using elementary Boolean logic. After the search request is entered, the computer displays all references which match the parameters of the request. If the user is not satisfied with the results, he can reformulate the search request until he is satisfied. A simple command instructs the computer to print out the bibliography thus generated.

The Interactive Structured Query Language is easy to use. However, not everyone is familiar with the language. Data base inquiry technique workshops are underway for all participants and the feasibility of electronic exchange of information with other centers is being studied. Theoretically, the Micronesian Area Tropical Agriculture Data Base Center could evolve into a regional hub for a Pacific nations network system.