Guam Agricultural Experiment Station

University of Guam
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1985

FROM THE DIRECTOR

In 1985, a Beneficial Insects Introduction Quarantine Facility was set up in the Agricultural Station which has been approved and recognized by the USDA. Collaborative research programs with the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) and the International Potato Center (CIP) were initiated.

A regional Plant Quarantine training program for the islands of Micronesia was conducted in Guam in collaboration with the United Nations Development Program (UNDP) and the APHIS, USDA.

Two of our faculty members participated in international research activities supported by the Food and Agriculture Organizations of the the United Nations.

The insect, *Pareuchaetes pseudoinsulata* has been established in Guam for biological control of the weed, *Chromolaena pseudoinsulata.*

A grant has been received from the Office of International Cooperation and Development (OICD) of USDA for survey, collection, screening and shipment of natural enemies of mango tip moth from India to Guam.

WILFRED P. LEON GUERRERO
DEAN/DIRECTOR

The cover designed by Perry A. Perez features a photograph of winged beans, Psophocarpus tetragonobus, *a crop that is being developed as a supplemental source of protein for Pacific Basin and less developed countries. Photograph by Chin-Tian Lee.*

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CONTENTS

SOIL SCIENCE

J.L. Demeterio & J.T. Cope

Soil Fertility

Four NPK response studies were conducted in 1985, three in Guam and one in Yap. Of the Guam studies, two were conducted at the Guam Agricultural Experiment Station in Inarajan using Pioneer X3056 yellow field corn, and one in Yigo using tomato N-65 variety in cooperation with Extension Agent Jose A. Cruz. The Yap studies were conducted in cooperation with Clayton Anderson, then Chief of Agriculture, Yap State, Federated States of Micronesia, using the same corn variety. Soil test levels of the various experiment sites in Guam and in Yap prior to experimentation are shown in Table 1.

The soils at the first two sites at the Guam Agricultural Experiment Station have been identified as Saipan-fine, oxidic, isopyperthermic Oxic Paleustalfs. The soils at the Yigo farm were identified as Guam Cobbly clay-gibbsitic, nonacid, isopyperthermic Lithic Ustorthents. Guam clay used to be Lithic Ustrpepts (Park, 1979).

The serpentine Yap soils were of the Weloy-Ramung complex with the following description:

Weloy - clayey, skeletal, mixed, isohperthemic Typic Argiudolls

Ramung - clayey, skeletal, mixed, isohyperthermic Lithic Tropudalfs.

Response of Maize to NPK Fertilization and Timing of Nitrogen Application

Yield response of corn to varied NPK levels and the timing of N application was conducted in a split-plot design at the AES Soils Field #1 in Inarajan during the onset of the dry season in late December, 1984. The fertilizer levels are shown in Table 2. Fertilizer materials used were urea, treble superphosphate, and nuriate of potash. Fertilizers were applied within the furrow which was subsequently hilled up. Seeds were planted 1-2" deep on top of the ridge. A 3-4 soil boundary between fertilizer band and seeds was maintained.

NPK levels were the main plots while timing of nitrogen applications were the subplots. The first nitrogen applications were applied all at planting and the second were applied in splits, half at planting with the other half side-dressed at tasselling. The main plot size was 10x4 m with 5x4 m subplots. The treatments were replicated four times. The distance between hills was 33 cm with plants thinned to one per hill two weeks after planting. Normal pest control and water management using drip irrigation were done up to crop maturity.

Yield response to NPK fertilization is shown in Table 2. The response to nitrogen addition ranged from 72.3% to 127.80%. The yield differences are highly significant. Nitrogen recommendations in Guam are based on organic matter content and the nitrogen needs of the particular crop. Organic matter controls nitrogen transformations in the soil. Suggested adjustments in nitrogen requirements of non-legume crops based on organic matter are as follows:

Adjustments	
%o.m.	kgm N/hectare
0-2	+20
2-4	-20
6	-30

The soil organic matter content of this particular field was 3.12%, so it is not surprising that a 100% increase in yield due to nitrogen addition is possible. The optimal nitrogen level appears to be below 200 kgm N per hectare. A subsequent study to pinpoint an exact level is planned for next year.

A 24.48% and 7.47% increase in field is noted for phosphorus and potassium respectively. The yield differences are not significant. The initial soil test levels of P and K are 23 ppm and 99 ppm respectively. An Olsen reading 23 ppm P is considered two and for corn the general recommendation calls for a 60 kgm P/ha application. The potassium level is

Table 1. Soil test * levels of the various experimental sites in Guam and in Yap prior to experimentation.

	pH	o.m.(%)	P(ppm)	K(ppm)
1. AES Soils Field 1	7.85	3.12	23.0	99
2. AES Soils Field 2	7.76	4.90	26.0	149
3. Yigo Farm	7.30	9.70	85.0	80
4. Yap Experiment Sta.	6.86	2.38	3.4	22

*pH 1:1 waterpaste, Walkly-Black method for o.m., Olsen P, and normal NH4Ac at pH 7 for K.

medium where a 120 kgm K/hectare is recommended. The results complement the recommendation in the AES Bulletin on Fertilizing Crops on Guam.

The effects of nitrogen timing is shown in Table 3. There is no statistical difference on timing of nitrogen application. The traditional method of nitrogen application is splitting, half at planting and half at flowering. The implication of the results of the study is that in Guam clay soils, a single application of nitrogen at planting is enough.

Other data from this study (i.e. biomass yield at different stages of the phenological growth), taken from the border rows were sent to IBSNAT in Hawaii to test a Maize model.

Long Term Fertility Experiment

An attempt to establish a long-term fertility experiment was made in 1985 by using AES Soils Field #2. This particular field was the site of a long term study using legume rotation and *Leucaena leucocephala* hedges as alternate sources of fertilizer nitrogen. The established hedges were destroyed to accommodate the proposed long-term assessment of crop response to NPK fertilization.

A total of eight treatments (2N, 4P, 4K) replicated three times were tested in the field in a completely randomized design. Agronomic practices similar to the one used in the adjacent soils of AES Soils Field #1 were observed. The treatments and subsequent yield are shown in Table 4.

There was no statistically significant difference between treatment means. The results can be expected considering the high soil test levels of the field prior to experimentation. The initial soil organic matter content was 4.90%. A response to nitrogen addition may have been present had the dosage levels been higher than the 150 kgm N/hectare used. Normally, the laboratory recommends no phosphorus addition when Olsen P soil test levels are beyond 25 ppm. The yields due to potassium addition show a slight increase. Yields could indeed be expected to increase at a higher fertilizer level. However, such yield return may not be economically feasible.

N, P, K Response of Tomatoes in a Farmer's Field

This study was conducted at a farm in Yigo. Initial soil test results indicate a very high level of phosphorus (85 ppm), a medium rating for potassium (80 ppm) and high level organic matter (9.7%). With this data, the soils normally would not be expected to respond to fertilizer addition. A randomized complete block experimental design testing 12 treatments, replicated four times, was laid out and monitored by Cooperative Extension Agents.

The treatments, yield and yield response are shown in Table 5. The yields (mean of 4.721 tons per hectare) are generally low for this type of soil (Guam clay). The low yield may be due to poor crop stand which was affected by fertilizer burn at earlier growth stages. The yield ranged from 3.088 to 5.650 tons of marketable tomatoes per hectare. The differences in yield were not statistically significant. Yield response over control treatment, i.e. 0-120-120, 120-0-120, and 120-120-0 for nitrogen, phosphorus, and potassium, respectively, are shown only to demonstrate objectives of the study.

Table 2. Shelled corn yield in tons per hectare as effected by varied N, P, and K fertilization

Treatments		Yield**	% Yield Response N	P	K
0-60-60		3.009			
100-60-60		5.363	72.23		
200-60-60		6.795	125.83	24.48	7.466
300-60-60		6.857	127.88		
200-0-60		5.459			
200-60-0		6.381			
	LSD(.01)	2.316			
	LSD(.05)	1.675			

c.v. = 24.37%
**Significant at 1% probability

Response of Maize to NPK Fertilization in Yap State, Federated States of Micronesia

A 10 treatment (replicated four times) field experiment in a randomized complete block design was conducted at the Yap State Experiment Station in Kolonia, Yap. Initial soil test results indicate that the soils would respond well to any NPK fertilization.

The treatments, variables studied, yield, and yield response are shown in Table 6. Corn responded well to nitrogen and phosphorus fertilization. A 298% yield increase is noted at the 150 kgm N per hectare treatment. Yield increase to phosphorus, although not as dramatic as the nitrogen response, resulted in a 79.69% increase at 150 kgm P.

Although initial soil tests for potassium (22 ppm K and a total K content of 767 ppm by NaCO3 fusion) were very low, there was only a negligible response (3.15 to 9.59%) to potassium fertilization. This non-response to added K may indicate that a sufficient amount of K was supplied perhaps by native K.

Table 3. Shelled corn yield in tons per hectare as effected by varied N, P, and K fertilization and the timing of N application.

Treatment	Full N fertilization 1	Split N fertilization 2
0-60-60	3.023	2.994
100-60-60	5.231	5.495
200-60-60	7.075	6.516
300-60-60	6.608	7.106
200-0-60	5.520	5.397
200-60-0	6.061	6.701
	mean 5.586	5.702

1 All applied at planting
2 Half applied at planting and half at tasseling

Table 4. Shelled corn yield in tons per hectare as affected by varied NPK applications.

Treatment	Yield 1	N	P	K
0-60-60	6.984			
150-60-60	6.798	-2.66		
150-0-60	6.336			
150-30-60	5.839		-7.84	
150-60-60	6.798		-7.29	
150-120-60	6.564		3.60	
150-60-0	6.315			
150-60-30	6.488			2.74
150-60-60	6.798			7.65
150-60-120	6.612			4.70

c.v. = 10.5%
1 No statistically significant difference.

Table 5. Yield in tons per hectare of marketable tomatoes as affected by varying levels of N, P, and K.

			% Response Over Control		
	Treatment[1]	Yield	N	P	K
1.	0-120-120	3.793			
2.	60-120-120	5.065	33.54		
3.	120-120-120 [2]	4.529	19.40	21.06	18.62
4.	180-120-120	5.650	48.96		
5.	120-0-120	3.741			
6.	120-60-120	4.785		27.91	
7.	120-180-120	5.829		55.81	
8.	120-120-0	3.818			
9.	120-120-120	4.938			29.33
10.	120-120-180	5.091			33.34
11.	120-120-120 [2]	5.218	37.37	39.48	36.67
12.	120-120-120 [2]	4.200	10.73	12.27	10.01

c.v. = 24.01

1. Treatment 3, 5, 6, 7, 8, 9, 10 and 12 had split applications of nitrogen, half at planting and half at flowering. Treatment 2 and 11 single application of nitrogen at planting. Treatment 4 had 1/3 nitrogen at planting and 1 2/3 at flowering.

2. Treatments 3, 11, and 12 had the same NPK levels varying in nitrogen application, treatments 3 and 12 were split applied in addition to splitting K in 12. Treatment 11 had N in a single application

Table 6. Shelled corn yield in tons per hectare as affected by variable NPK fertilierzation in Yap State, FSM.

				% Yield Response		
	Treatment**	Variable	Yield	N	P	K
1.	100-150-50	50K 20	2.942			5.30
2.	0-150--100	N Control	1.012			
3.	100-150-100	Standard	3.063	202.67	79.75	9.59
4.	100-75-100	75 P205	2.986		75.23	
5.	50-150-100	50N	1.878	85.57		
6.	100-300-100	300P205	3.203		87.97	
7.	150-150-100	150N	4.030	298.22		
8.	100-0-100	P Control	1.704			
9.	100-150-0	K Control	2.794			

HORTICULTURE - VEGETABLE CROPS

C.T. Lee

Horticultural research work on vegetable crops continued in 1985. A new project to study the effect of exogenous growth regulators on growth, yield and quality of solanaceous and cucurbit crops. The project to study the potential of winged bean as a crop for Guam was continued. Several experiments were conduced to meet some objectives for the two projects.

I. Effect of Exogenous Growth Regulators on Growth, Yield and Quality of Solanaceous and Cucurbit Crops.

Most of the research work on the use of synthetic growth regulators to promote the growth and development of vegetable crops has been conducted at the low temperature and low humidity situations of temperate areas. Very little work has been reported regarding the application of growth regulators for the increase in production of solanaceous and cucurbit crops under humid tropical environmental conditions.

The objectives of this project are: (a) to assess the possibility of increasing the yield of solanaceous and cucurbit crops by increasing fruit size, number of fruit set and improving the fruit quality with the application of growth regulators; (b) to evaluate the growth regulators on fruit ripening to enable earlier harvest and increasing the number of solanaceous and cucurbit crops per year; and (c) to study the possible interactive effects of the application of mixtures of growth regulators on fruit production and quality of solanaceous and cucurbit crops.

The following two experiments were conducted in 1985:

IA. The effect of the 4-Chlorophenoxy Acetic Acid on Tomatoes

This experiment was to study the effect of 4-chlorophenoxy acetic acid on the growth and production of tomatoes during both dry and wet seasons.

Materials and Method

The tomato hybrid 'N-65' was used in this experiment. Seeds were sown in Jiffy-7 pellets and one-month old seedlings were transplanted to the field. Treatments consisted of six concentrations (0, 15, 30, 45, 60, 70ppm) of 4-chlorophenoxy acetic applied to tomato flowers at a ten-day interval. The experimental design used was a randomized complete block with four replications. Each experimental plot consisted of three rows, 5.03 meters long. A spacing of 1.22 meters between rows and 0.46 meters within rows was adopted.

Fertilizer (10-20-20) at the rate of 448 kg/ha was broadcast and incorporated into the soil before transplanting. Side-dressing with the same fertilizer at the same rate was done four weeks after transplanting. A preventive spraying schedule was followed twice weekly to control possible insect and disease damage by using Malathion 50, Diazinon Ag 500 EC, Lannate 1.8 L, Kelthane, Dithane M-45, and Tribasic Coppers. Sprinklers were used for irrigation whenever watering was needed. A rotary tiller and garden hoe were used to control weeds. Tomato plants were pruned to single items and tied to stakes.

Results and Discussion

a. During Dry Season:

The results of the effect of 4-chlorophenoxy acetic on

Table 1. The effect of 4-chlorophenoxy acetic acid some horticultural characteristics and production of tomatoes during the dry seasons.

Treatment	Fruit weight (g)	Total Number of fruit/ plant	Total soluble solid (%)	Unmarketable fruit yield (MT/ha)	Marketable fruit yield (MT/ha)	Total fruit yield (MT/ha)
0 ppm	142	8.50	5.1	4.82	17.94	22.76
15 ppm	153	9.60	5.2	5.76	20.31	26.07
30 ppm	178	9.90	5.5	5.99	20.74	26.73
45 ppm	185	9.72	5.5	5.81	21.23	27.04
60 ppm	180	9.36	5.5	5.65	20.90	26.55
75 ppm	176	9.40	5.6	5.78	20.47	26.35
LSD 0.05	24	1.27	0.4	1.42	2.77	3.34

some horticultural characteristics and production of tomatoes during the dry season are presented in Table 1. Treatments of 30, 45, 60 and 75 ppm significantly increased fruit weight and total soluble solid. There was a significant increase in the number of fruit from the application of growth regulators. However, there was no significant difference in un-marketable fruit yield between treated and untreated plants. The only treated plant showed a significant difference was at 45 ppm. Total fruit yield is associated with fruit weight and the number of fruit per plant. The treated plants (15 ppm through 75 ppm) produced a higher fruit yield in comparison to untreated ones

b. During the Wet Season:

The results of the effect of 4-chlorophenoxy acetic on some horticultural characteristics and production of tomatoes are shown in Table 2. Fruit weight and un-marketable yield and significantly increased with treatments of 30, 45, 60 and 75 ppm. All the treated plants (15 ppm through 75 ppm) resulted in the increases of the number of fruit per plant, marketable fruit and total fruit yield. Total soluble solid was significantly higher at 30, 45, and 75 ppm than untreated and 60 ppm one.

Conclusions

The experiment was to study the effect of 4-chlorophenoxy acetic acid (growth regulator) on some horticultural characters and production of tomatoes during both dry and wet seasons. Application of growth regulator could increase the total fruit yield due to the increase of fruit weight and the number of fruit per plant. However, it was found that this growth regulator seemed to cause a wilting problem of foliage if applied to the whole plant.

IB. The Effect of the Beta-Naphthoxy Acetic Acid on Tomatoes:

This experiment was designed to study the effect of beta-naphthoxy acid on the growth and production of tomatoes during the dry and wet seasons. The tomato cultivar, planting method, pest and weed control, irrigation system and experimental design were the same as in experiment IA except for the treatments. Treatments for this experiment consisted of five concentrations (0, 250, 500, 750, and 1,000 ppm) of beta-naphthoxy acetic acid applied to tomato flowers at a ten-day interval.

Results and Discussion

a. During the Dry Season:

The results of the effect of beta-naphthoxy acetic acid on some horticultural characteristics and production of tomatoes during the dry season are given in Table 3. Treatments of 750 and 1,000 ppm significantly increased fruit weight. All plants treated with the growth regulator gave a higher concentration of total soluble solid than the control. However, there was no significant difference in the number of fruit per plant and un-marketable or marketable fruit yield among the treated and control plants. The only significant increase in total fruit yield was at 750 ppm.

b. During the Wet Season:

Table 4 shows the results of the effect of beta-naphthoxy acetic acid on some horticultural characteristics during the wet season. Treatments of 750 and 1,000 ppm significantly increased fruit weight in comparison with the untreated ones. However, there was no significant difference in total soluble solid, un-marketable, marketable or total fruit yield.

Table 2. The Effect of 4-Chlorophenoxy Acetic Acid on Some Horticultural Characteristics and Production of Tomatoes during the Wet Season

Treatment	Fruit weight (g)	Total number of fruit/plant	Total soluble solid (%)	Unmarketable fruit yield (MT/ha)	Marketable fruit yield (MT/ha)	Total fruit yield (Mt/ha)
0 ppm	87	1.47	5.1	1.64	1.68	3.22
15 ppm	99	2.40	5.1	2.42	3.36	5.78
30 ppm	112	2.34	5.4	2.78	3.08	5.79
45 ppm	125	2.62	5.4	3.30	3.32	6.35
60 ppm	130	2.42	5.3	2.94	2.65	5.59
75 ppm	122	2.30	5.4	2.56	2.96	5.52
LSD 0.05	22	0.60	0.3	0.81	0.41	5.52

Table 3. The Effect of Beta-Naphthoxy Acetic Acid on Some Horticultural Characteristics and Production of Tomatoes during the Dry Season.

Treatment	Fruit weight (g)	Total number of fruit/plant	Total soluble solid (%)	Unmarketable fruit yield (MT/ha)	Marketable fruit yield (MT/ha)	Total fruit yield (MT/ha)
0 ppm	150	8.00	5.1	4.46	16.97	21.43
250 ppm	160	8.31	5.4	4.51	17.85	22.36
500 ppm	164	8.95	5.5	4.89	19.17	22.74
750 ppm	178	9.00	5.4	5.09	19.08	24.17
1,000 ppm	175	8.65	5.4	4.78	18.47	23.25
LSD 0.05	15	0.98	0.3	0.85	2.39	2.74

Table 4. The Effect of Beta-Naphthoxy Acetic Acid on Some Horticultural Characteristics and Production of Tomatoes During Wet Season

Treatment	Fruit weight (g)	Total number of fruit/plant	Total soluble solid (%)	Unmarketable fruit yield (MT/ha)	Marketable fruit yield (MT/ha)	Total fruit yield (MT/ha)
0 ppm	84	1.53	5.0	2.04	1.35	3.79
250 ppm	93	2.93	5.3	4.13	2.60	6.73
500 ppm	95	2.86	5.5	3.74	3.00	6.74
750 ppm	101	2.90	5.4	3.77	3.20	6.97
1000 ppm	102	2.80	5.3	3.79	2.76	6.55
LSD 0.05	13	0.41	0.3	1.40	0.80	0.75

Conclusion

The experiment was to study the effect of beta-naphthoxy acetic acid on some horticultural characteristics and production during both the dry and wet seasons. In general, responses were significant between wet and dry seasons. In the dry season there was no significant increase in the number of fruit per plant, un-marketable fruit yield, marketable fruit yield and total yield through the application of growth regulators except for fruit weight at 750 ppm. Significant increases were found in the number of fruit per plant, total soluble solid, un-marketable fruit yield, marketable fruit yield and total fruit yield through the application of the growth regulator.

II. Effect of Seed Size and Phosphorus Fertilization on the Growth and Production of Winged Bean

It appears that winged bean seeds are varied in size within the same cultivar. Also, phosphorous seems to be the main limiting macro-nutrient in all Guam soils, with soil test data consistently below 10 ppm, the lowest acceptable limit for growing crops in Guam. Therefore, this experiment was designed to have a better understanding of the seed size and phosphorus levels on the growth and production of winged bean.

Materials and Methods

This experiment was conducted at the Guam Agricultural Experiment Station during the dry season of 1985. The experimental design was a split-plot design with six treatments replicated three times. The three phosphorus levels (0, 50, and 100 kg/ha) were the main treatments. Two seed size of winged bean cultivar Chimbu (small seed = 25.9gg/100 seeds; large seed = 40.0 g/100 seeds) was the subtreatment. 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 given in three rows spaced 1.44m apart and 0.45m within rows. Before planting the winged bean seeds were immersed in concentrated sulfuric acid (sp. gr. 1.84) at 25C for five 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 two to three weeks from planting. The seeds were not treated with any inoculum.

All the phosphorus dosages were applied at planting. The plants were supported with leuceaena posts and cucumber plastic nets. Days to reach first flower stage were recorded. Data on the pod weight, number and yield of green pods were taken at each harvest (once a week).

Results and Discussion

Plant emergence was very fast with an average of five days. Perhaps scarification of hard-coated seeds of winged bean with sulfuric acid treatment speeded up the germination. No major disease was evident during the experiment 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 5 shows the effect of phosphorus level and seed size on the time to reach first flower from planting. Appearance of first flowers ranged from 62 to 70 days. Application of phosphorus at the rates of 50 and 100 kg/ha significantly

Table 5. The Effect of Phosphorus Level and Seed Size on Days to First Flower of Winged Bean

Main treatment (P Level)	Sub-treatment (Seed Size) Small Seed	Large Seed	Main Treatment mean
0 kg/ha	67.0	62.0	64.5
50 kg/ha	70.0	68.0	69.0
100 kg/ha	67.0	67.0	68.0
Sub-treatment mean	68.7	65.7	

LSD 0.05 Between main treatment---------- 2.4
LSD 0.05 Between sub- treatment---------- 2.3
LSD 0.05 Between sub-treatment for the same main treatment---------- 2.6
LSD 0.05 Between sub-treatment for the different main treatment---------- 3.7

delayed first flowers for about four days. The large seed reached the first flower significantly earlier than the small seed at the rate of 0 kg/ha of P compared with 50 and 100 kg/ha.

Green Pod Weight:

Green pod weight ranging from 12.1 to 24.0 g is presented in Table 6. The application of phosphorus significantly increased the green pod weight. Planting the large seeds at the same rate of phosphorus did not increase pod weight.

Total Number of Green Pod:

The effect of phosphorus level and seed size on the total number of green pod per plant is shown in Table 7. There was no difference in the number of green pods per plant between the large seed and small seed plants. The number of green pods per plant was decreased by the application of phosphorus rates at 50 and 100 kg/ha.

Green Pod Yield:

The results of the effect of phosphorus level and seed size on green pod yield are given in Table 8. Application of phosphorus at 50 and 100 kg/ha produced higher green pod yield than the control. However, there is no difference in yield between the large and small seed at the same rate of phosphorus.

III. Field Test for Inoculation Response on Winged Bean

The importance of nitrogen in food production is well recognized. There are, however, problems in supplying this element in the form of fertilizer at a reasonable cost and further problems in utilizing it efficiently, especially in tropical agriculture situations. Nitrogen fixation by legumes could provide a cheap form of readily available nitrogen which, in some cases, also benefits non-legume companion species and succeeding crops via N-rich plant residues.

Materials and Methods

This experiment was conducted at the Guam Agricultural Experiment Station with a Chimbu cultivar. A randomized complete block design with three basic treatments at two fertility levels replicated four times were used for the experiment. The basic treatments were: (1) plants inoculated with Rhizobium, (2) plants not inoculated, and (3) plants not inoculated but fertilized with 100 kg/ha of N. The two fertility levels were: (1) farm fertility (fertilized with 150 kg/ha of P_2O_5 and 150 kg/ha of K_2O) and (2) maximal fertility (fertilized with 300 kg/ha of P_2O_5 and 300 kg/ha of K_2O). Therefore, a total of six treatments used were as follows:

F-1: farm fertility, no nitrogen, no inoculation
F-2: farm fertility, add nitrogen, no inoculation
F-3: farm fertility, no nitrogen, add inoculation
M-1: maximal fertility, no nitrogen, no inoculation
M-2: maximal fertility, add nitrogen, no inoculation
M-3: maximal fertility, no nitrogen, add inoculation

Each experiment plot consisted of 3 rows, 7.5 meters long. The spacing adopted was 1.22 meters between rows. The plus N control plots received 100 kg/ha of N but in two doses. At planting, 25 kg/ha of N was applied, and 75 kg/ha of N was added four to five weeks after planting. While all the P and K were applied and tilled in at the planting. The determination of the number of nodules per plant total, fresh weight of nodules and total dry weight per plant was carried out at eight weeks after planting by sampling ten plants from the end of the central row of each plot. Data on the pod weight, number and yield of fresh pods were taken at each harvest (once a week).

Table 6. The Effect of Phosphorus Level and Seed Size on Pod Weight (g) of Winged Bean

Main treatment (P Level)	Sub-treatment (Seed size) Small seed	Large Seed	Main treatment mean
0 kg/ha	12.1	13.0	12.6
50 kg/ha	21.5	22.3	21.9
100 kg/ha	22.3	24.0	23.1
Sub-treatment mean	18.6	19.8	

LSD.0.05 Between main treatment ---------- 1.6
LSD 0.05 Between sub-treatment---------- 1.8
LSD 0.05 Between sub-treatment for the same main treatment---------- 3.2
LSD 0.05 Between sub-treatment for the different main treatment---------- 2.8

Table 7. The Effect of Phosphorus Level and Seed Size on Total Number of Green Pods per Plant of Winged Bean

Main treatment (P Level)	Sub-treatment (Seed Size) Small Seed	Large Seed	Main treatment mean
0 kg/ha	113.7	119.2	116.5
50 kg/ha	83.1	79.2	81.2
100 kg/ha	74.5	73.2	73.9
Sub-treatment mean	98.4	90.5	

LSD 0.05 Between main treatment--- 6.8
LSD 0.05 Between sub-treatment-- 8.3
LSD 0.05 Between sub-treatment for the same main treatment -- 14.4
LSD 0.05 Between sub-treatment for the different main treatment------------------------------------ 12.2

Table 8. The Effect of Phosphorus Level and Seed Size on Yield (Mt/ha) of Green Pods of Winged Bean.

Main treatment (P Level)	Sub-treatment (Seed Size) Small Seed	Large Seed	Main treatment mean
0 kg/ha	22.45	25.28	23.87
50 kg/ha	28.85	28.44	28.65
100 kg/ha	28.54	28.67	28.61
Sub-treatment mean	26.61	27.46	

LSD 0.05 Between main treatment--- 1.9
LSD 0.05 Between sub-treatment-- 3.1
LSD 0.05 Between sub-treatment for the same main treatment--- 5.3
LSD 0.05 Between sub-treatment for the different main treatment------------------------------------- 4.2

Results and Discussions:

The effect of nitrogen and inoculation on some horticultural characteristics of winged bean at first flower stage is presented in Table 9. The number of nodules per plant ranged from 47.0 to 71.3. Inoculation both at farm and maximal fertility levels significantly increased the number of nodules per plant. There was no significant difference in the number of nodule per plant among the treatments F-1, F-2, M-1, and M-2.

The total fresh weight of nodules per plant was higher with inoculation both at farm and maximal fertility levels than the rest of the treatments. No significant difference in total fresh weight of nodules per plant was found among the treatments F-1, F-2, M-1 and M-2.

It was also found that inoculation both at farm and maximal fertility levels significantly increased the total dry weight per plant. However, no significant difference was found among the treatments F-1, F-2, M-1 and M-2.

Application of nitrogen or inoculation treatment at maximal fertility levels produced higher fresh pod yield than the control (F-1). However, there was no significant difference in fresh pod yield between treatments M-2 and M-3, also among treatments F-1, F-2, F-3 and M-1.

Conclusions:

Fields inoculated with selected *Rhizobium* strains might be able to increase the total number of nodules, total fresh weight of nodules, total dry weight, and fresh pod yield of winged bean without application of nitrogen at maximal fertility levels of P and K.

Table 9. The Effect of Nitrogen and Inoculation on Some Horticultural Characteristics of Winged Bean at First Flower Stage

Treatment	Total number of nodules/plant	Total fresh weight of nodules/plant	Total dry weight/plant
F-1 (farm fertility, no nitrogen, no inoculation)	51.0	4.125	3.75
F-2 (farm fertility, no nitrogen, no inoculation)	47.0	3.675	3.41
F-3 (farm fertility, no nitrogen, add inoculation)	68.2	5.102	5.12
M-1 (maximal fertility, no nitrogen, no inoculatio)	54.3	4.923	5.33
M-2 (maximal fertility, no nitrogen, no inoculation)	49.5	4.562	4.84
M-3 (maximal fertility, no nitrogen, add inoculation)	71.3	6.216	6.21
LSD 0.05	16.0	0.980	1.03

Table 10. The Effect of Nitrogen and Inoculation on Fresh Pod Yield of Winged Bean.

Treatment	Fresh Pod Yield (MT/ha)
F-1 (farm fertility , no nitrogen, no inoculation)	23.29
F-2 (farm fertility, add nitrogen, no inoculation)	24.67
F-3 (farm fertility, no nitrogen, add inoculation)	25.67
M-1 (maximal fertility, no nitrogen, no inoculation)	25.03
M-2 (maximal fertility, add nitrogen, no inoculation)	26.06
M-3 (maximal fertility, no nitrogen, add inoculation)	28.07
LSD 0.05	2.97

HORTICULTURE - VEGETABLE CROPS

M. Marutani & J. A. Cruz

Potatoes

Introduction

Two experiments were conducted in 1985. During the dry season, three cultivars (Kennebec, Sequoia and LT-2) were evaluated for their field performance. In this experiment, two locations with different soil types were selected.

After harvesting tubers from the variety trial, a study on storage methods was initiated to investigate the possibility of storing locally grown potatoes as seed tubers for next planting.

I. Evaluation of Three Cultivars (Kennebec, Sequoia, and LT-2) at Two Locations on Guam During the 1984-85 Dry Season.

Varietal selection is the most important objective in the potato project. Variety trials need to be repeated each year in order to identify suitable cultivars for Guam. During the 1984-1985 dry season, three cultivars obtained from Australia were evaluated.

Materials and Methods

Three cultivars, Kennebec, Sequoia and LT-2 were evaluated at two locations, Barrigada and Mangilao. The randomized complete block design with four replications and 30 tubers/cultivar/replication was used. Planting spacings were 75 cm between rows and 30 cm between plants. The length of row was 10 m. Sequoia was planted in border rows.

A complete fertilizer (10-30-10; 375g/10 m) was applied prior to planting and was incorporated into the soil. At the Barrigada site, drip irrigation was used and a 16-16-16 fertilizer was side-dressed at 30 DAP (days after planting). Chemical spraying for disease control was carried out when necessary. Table 1 shows details of the growing conditions at the two locations.

The percentage of plants emerged, the percentage of plants harvested, number of stems/hill, number of tubers/hill, total yield/plant, average tuber weight were recorded and mean separations were done within each location using Duncan's multiple range test at 0.05 significance level. Tubers were classified into sizes <30mm, 30-50mm, and >50mm in diameter, and data on size distribution were also obtained and analyzed as above.

Results

Total Yield: Yields were low for all three cultivars at both locations (Table 2). At Barrigada, Sequoia produced a yield of 225g/plant which was significantly higher than Kennebec (160g/plant) and LT-2 (145g/plant). At Mangilao, however, there was no significant difference in total yield among cultivars. Yields at Mangilao were 201, 214, and 218g/plant for Sequoia, Kennebec, and LT-2, respectively The results of low yield for this season could be due to insufficient irrigation and fertilizers, and failure on insect control. Leafminers and thrips were serious problems, especially at Barrigada where a complete defoliation occurred at about 60 DAP.

Emergence Percentage: The emergence percentage of three cultivars at Barrigada ranged from 79% (LT-2) to 94% (Kennebec). Sequoia was recorded to have 88% of emergence.

Harvest Percentage: At Barrigada, about 80% of hills were harvested for all three cultivars. At Mangilao, Sequoia showed a significantly low harvest percentage (49%) while Kennebec and LT-2 had 82% and 75% of hills harvested, respectively.

Number of Stem/Hill: This data was taken at Barrigada. An average of 2.2 stems per hill was recorded for Sequoia and 3.6 stems per hill for both Kennebec and LT-2.

Number of Tuber/Hill and Average Tuber Weight: At both locations, LT-2 produced more tubers than Kennebec and Sequoia. However, the average tuber weight of LT-2 was significantly less than that of Kennebec and Sequoia indicating that LT-2 produced a number of small tubers. The average tuber weight of Sequoia was the greatest of all measuring 50g at Barrigada and 45g at Mangilao.

Size Distribution: At both locations Sequoia had a larger proportion of tubers with greater than 50mm in diameter. In turn the percentage of small tubers (less than 30mm in

Table 1. Growing conditions at Barrigada and Mangilao during the dry season of 1984-1985.

	Barrigada	Mangilao
Soil type and classification	Pulantat-Kagman clay very fine, kaolinitic, isohyperthermic	Guam Variant clayey, oxidic, isohyperthemic (reddish, clay soil)
Soil analysis before planting	pH=6.1; P-29.7ppm; K-255 ppm; Ca-3700 ppm; Mg-250 ppm; % Organic Matter-4.1.	
Length of sprout at planting	1/8 inch	1/4 inch
Growing period	12/24/84 - 2/21/85	1/3/85 - 3/21/85
Date of Harvest	3/19/85 for Rep III and IV 3/20/85 for Rep I and II	3/21/85
Rainfall	6.82 inch (1/7/85-2/21/85)	6.86 inch (1/3/85-2/26/85)
Pests and diseases:		
Insects	cutworms leaf miner thrips	Philippine lady beetles leaf miner
Fungi	Stem rot	

diameter) in Sequoia was the least of three.

Discussion

Total yields of three cultivars at two locations were low compared to other tropical areas such as the Philippines. Major problems encountered in this varietal test were infestation of leaf miners and thrips. In addition, insufficient irrigation and lower fertilizer applications could be major causes of low yield. Nevertheless, responses of three cultivars at two locations were somewhat different from each other. At Mangilao three cultivars produced about an equal total yield whereas at Barrigada Sequoia produced a significantly higher yield than LT-2 and Kennebec. In spite of a shorter growing period, performance of Sequoia was good at Barrigada. It was also noticed that Sequoia showed some degree of "resistance" to those insect problems than LT-2 and Kennebec.

Overall performance of Sequoia was superior, producing tubers with heavier average weight and larger proportion of large tubers. The average tuber weight of Kennebec was less than Sequoia but significantly higher than LT-2. LT-2 yielded many small tubers. Sequoia and Kennebec seem to have potential for growing in Guam. The soil type found in Mangilao could be more suitable for cultivation of potatoes due to better drainage. The comparisons of two soil types should be carried out when more detailed soil analyses are available.

II. Evaluation of Seed Potato Storage Methods

Storage of locally grown seed tubers becomes essential if a farmer wants to reduce the cost of seed-tuber imports and if he wants to obtain planting materials whenever his field is ready. Diffuse light storage is an inexpensive way to store seed tubers at the planting field and a farmer is benefited with less problems in transporting seed tubers. Cold storage and storing tubers in an air-conditioned room are other possible storage methods. This experiment was initiated to investigate possibilities of three storage methods in Guam.

Materials and Methods

Tubers of 30-50 mm in diameter were selected from three cultivars (Kennebec, Sequoia, and LT-2) in a variety trial which was conducted at two locations, Barrigada and Mangilao during the1984-85 dry season. At Barrigada, potatoes were grown from December 24, 1984 to February 21, 1985. This short growing period was due to complete senescence of canapy by heavy leaf miner infestation. Tubers were kept under ground until harvest times which were March 19, for Rep III and IV, and March 20, for Rep I and II. At Mangilao, potatoes were planted on January 3, 1985 and were harvested on March 21, 1985.

Fifteen tubers of each cultivar from each location were placed in dark cold storage (CS), an air-conditioned room (AC) with flourescent light (12- foot candles), and diffuse light storage (DLS) with ambient temperature. The temperature of cold storage was between 4°C and 6°C with high humidity. In the air-conditioned room, the temperature and humidity ranged from 22-24°C and 53-65 %, respectively. For the diffuse light storage, tubers were placed at a corner of a room in a concrete house with open windows. Ambient relative humidity in diffuse light strorage varied from 70% to 90% and air

Table 2. Results from a cultivar trial conducted at Barrigada and Mangilao during the dry season of 1984-1985.

Cultivar	Emergence (%)	Plants harvested (%)	Total yield g/plant	Total yield t/h	Stems/ hill (#)	Tubers/ hill (#)	Average tuber wt. (g)	Size distribution by number <30mm (%)	Size distribution by number 30-50mm (%)	Size distribution by number >50mm (%)
Barrigada										
LT-2	79 a	79 a	148 b*	5.9 b	3.6 a	7.6 a	19 c	41.3 a	58.4 a	0.3 b
Kennebec	94 a	78 a	160 b	6.4 b	3.6 a	4.6 b	35 b	34.4 ab	63.3 a	2.3 b
Sequoia	88 a	78 a	225 a	8.9 a	2.2 b	4.6 b	50 a	16.8 b	52.0 a	31.2 a
CV (%)	10.6	11.3	13.6	13.4	7.1	17.3	13.0	15.1	8.7	30.5
Mangilao										
LT-2		75 a	218 a	8.9 a		9.4 a	23 c	38.5 a	57.9 a	3.6 b
Kennebec		82 a	214 a	8.7 a		5.5 b	39 b	41.8 a	53.2 a	5.0 b
Sequoia		49 b	201 a	8.1 a		4.5 b	45 a	20.9 b	53.4 a	25.7 a
CV (%)		13.0	32.0	33.0		20.6	16.8	18.6	7.1	25.2

*Mean separation in columns within each location by Duncan's multiple range test, p=0.05. Means with the same letter are not significantly different.

temperature was between 22°C and 30°C.

The experiment began on March 30, 1985. The percentage of tuber retained, the percentage of tuber sprouted, and the average tuber weight were recorded at about a two-week interval. Date of sprouting was recorded when sprouts were visible for 50% of tubers.

The percentage of tuber retained, the percentage of weight loss and the length of the longest sprout were analyzed after a seven-month storing period. Color of sprouts was also recorded. Every treatment was repeated three times. All data were subjected to analysis of variance by using randomized complete block design with two factors. Treatment means were separated by Duncan's multiple range test at a five percent significance level.

Results

Storability: All tubers were retained in cold storage after a seven-month storing period (Table 3; Figs 1 and 2). The air-conditioned room was as good as cold storage for Kennebec and Sequioa (96%-100%), whereas LT-2 showed lower percentage of tuber retained (36% and 53%). In diffuse light storage, all cultivars lost some tubers with different percentages. The percentage of tubers retained in DLS ranged from 36% to 93%. Overall, Kennebec and Sequoia showed higher degrees of storability than LT-2. Figures 1 and 2 show the changes in percentage of tuber retained during the storage period. Although tubers harvested from Barrigada and Mangilao could be physiologically different due to different growing periods and harvest at different plant stages, responses of three cultivars from two locations in three storage methods seem identical.

Tuber weight loss: Storage methods greatly affected tuber weight loss. In cold storage, there were virtually no weight losses while in the air-conditioned room and in diffuse light storage, the tuber weight loss ranged from 33.2% to 44.5% and 28.9% to 43.8%, respectively. Various responses among cultivars appeared in both air-conditioned room and diffuse light storage. In the two storage methods, Kennebec had significantly less tuber weight loss than other two cultivars.

Sprouting: Sprouting started about one month after harvest and most commonly occurred around two months after harvest. After a seven-month storing period, the length of sprout was 3.0 cm to 3.8 cm in an air-conditioned room, 2.2 cm to 2.5 cm in diffuse light storage and 0.2 cm to 2.3 cm in cold storage. Colors of sprouts in three storages were white in cold storage, yellow-green in diffuse light storage, and green Kkennebec and Sequoia) and green-purple (LT-2) in the air-conditioned room.

Discussion

Cold storage was found to be the best method to store

Table 3. An evaluation of storage methods for three cultivars harvested from two locations.

Storage method	Cultivar	Tuber retained (%)	Weight loss (%)	Date of sprouting	Length of sprout (cm)	Color of Sprout	Other observation
Cold storage	LT-2 Barr	100 a	2.8 f	4/16/85	1.64 ef	White	
	LT-2 Man	100 a	3.2 f	5/30/85	0.40 g	White	
	Kennebec Barr	100 a	2.3 f	6/28/85	0.37 g	White	
	Kennebec Man	100 a	2.3 f	5/30/85	0.24 g	White	
	Sequoia Barr	100 a	2.3 f	7/15/85	2.28 cde	White	Root formation
	Sequoia Man	100 a	2.7 f	8/15/85	1.09 fg	White	Root formation
Air-conditioned room	LT-2 Barr	62 de	44.5 a	4/16/85	3.51 a *	Green-purple	
	LT-2 Man	42 fg	43.9 a	4/30/85	3.01 abcd	Green-purple	
	Kennebec Barr	100 a	33.2 de	5/15/85	3.71 a	Green	
	Kennebec Man	100 a	35.2 cd	5/30/85	3.79 a	Green	
	Sequoia Barr	98 a	37.1 bc	5/30/85	3.30 ab	Green	
	Sequoia Man	96 ab	40.7 ab	5/30/85	3.17 abc	Green	
Diffuse light storage	LT-2 Barr	53 ef	43.8 a	4/16/85	2.34 cde	Yellow-green	Mealy bugs
	LT-2 Man	36 g	34.6 cd	4/30/85	2.48 bcde	Yellow-green	Mealy bugs
	Kennebec Barr	84 bc	31.0 de	5/15/85	2.47 bcde	Yellow-green	
	Kennebec Man	67 d	28.9 e	5/15/85	2.19 de	Yellow-green	Mealy bugs
	Sequoia Barr	93 abc	38.2 bc	4/30/85	2.26 cde	Yellow-green	Mealy bugs
	Sequoia Man	82 c	38.3 bc	5/15/85	2.20 de	Yellow-green	Mealy bugs
	CV (%)	8.8	9.7		21.3		

* Mean separation in columns by Duncan's multilpe range test, p=0.05. Means with the same letter are not significantly different.

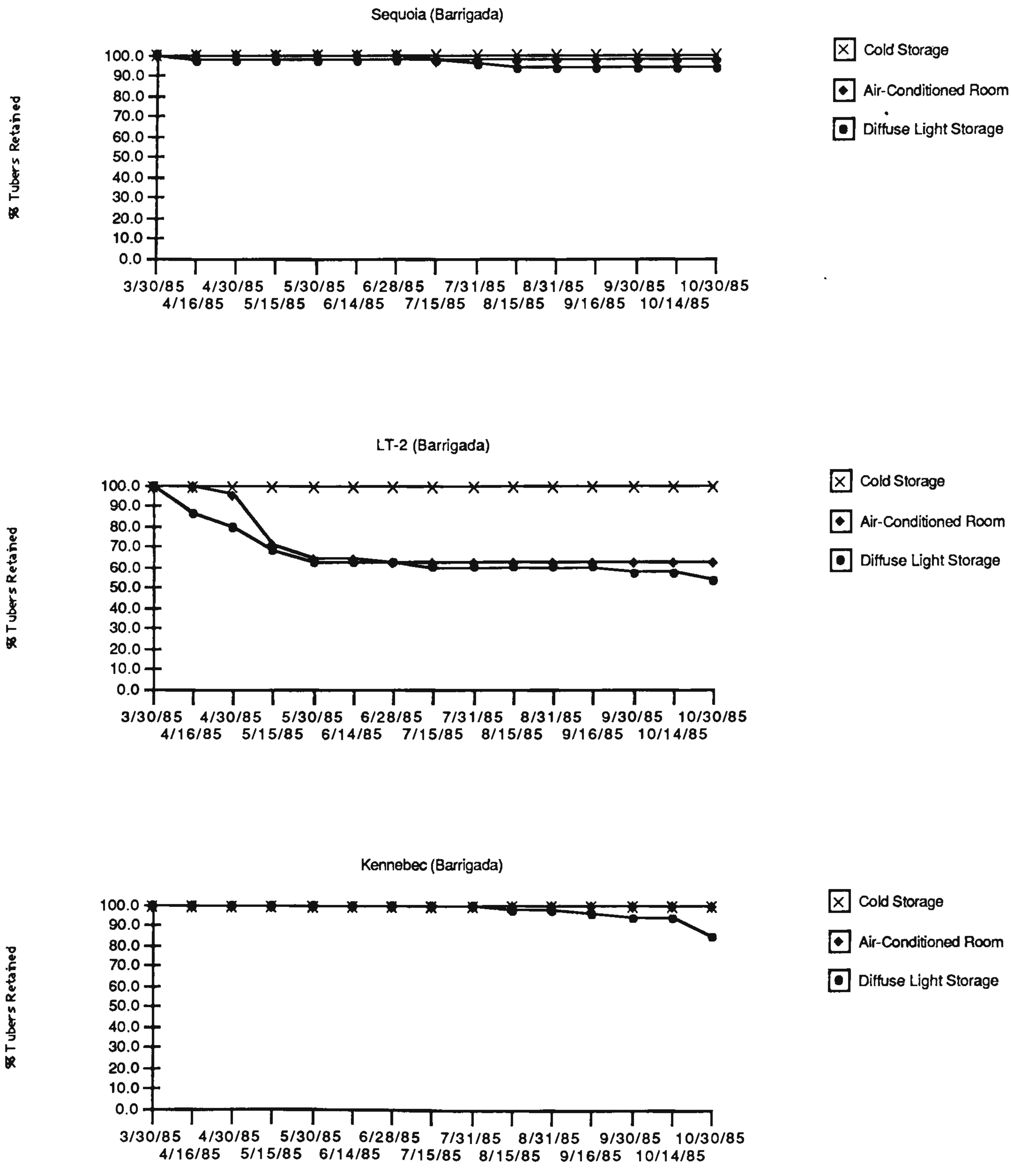


Figure 1. The percent tubers retained of three cultivars harvested from Barrigada in three storage methods.

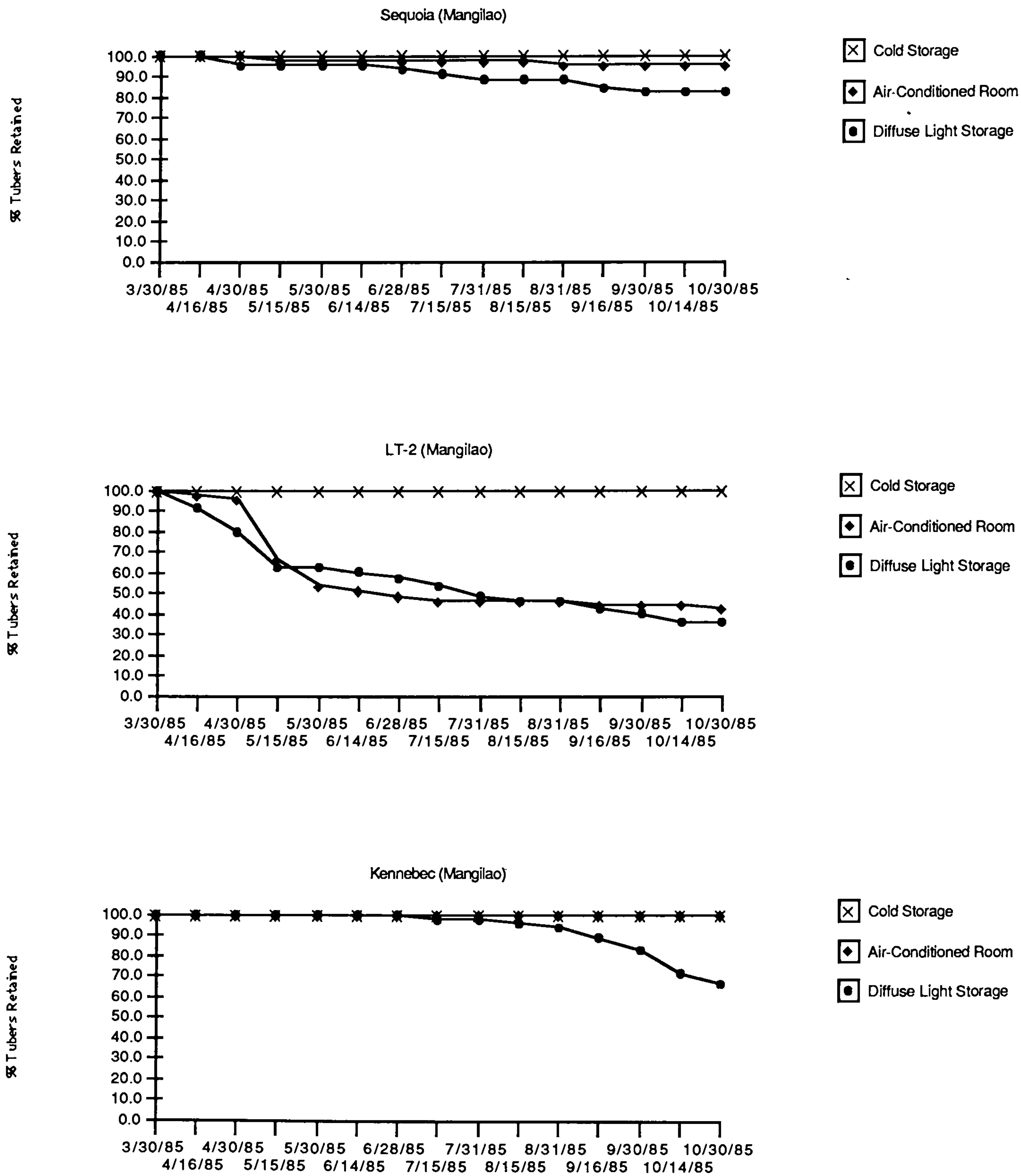


Figure 2. The percent tubers retained of three cultivars harvested from Mangilao in three storage methods.

locally grown seed tubers for over seven months. No tubers were lost for all three cultivars during storing period and weight loss was minimal. In air-conditioned room and diffuse light storage, a rapid tuber loss of LT-2 occurred at about two to three months of storing period (Figs 1 and 2). A declining for Kennebec and Sequoia started much later and in a smaller quantity than LT-2. Both Kennebec and Sequoia showed higher storability than LT-2.

The higher degree of tuber rot in diffuse light storage was partially due to infestation by mealy bugs. Mealy bugs which fed on potato sprouts enhanced the incidence of tuber rot. Although cold storage was the recommended storing method in Guam, diffuse light storage which is the lowest cost storage still have potentials to store some cultivars with higher storability such as Kennebec and Sequoia. Use of pesticides and combination of storing methods could also help reducing tuber rot.

Color of sprouts indicated the amount of light intensity provided in the three types of storage. Continuous light was provided in an air-conditioned room to have sprouts green in color. Diffuse light storage with ambient temperature also produced healthy sprouts.

Studies on seed tuber storage will be continued to evaluate modified diffuse storage methods and to confirm the result of this experiment.

HORTICULTURE-ORNAMENTAL CROPS

J. McConnell

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

This project was established to evaluate various ornamentals for use in commercial operations in Guam and to determine the cultural methods for optimum production of selected ornamentals. The emphasis of current research is the evaluation of plants for commercial cut flower production in Guam. Three species have been selected for advance testing: vandas, dendrobiums, and anthuriums. Cultivars of three other species are being evaluated: bird of paradise, heliconias and gingers. Finally local ferns are being collected and evaluated for use as cut foliage.

Vanda Media-Fertilizer Study

Vanda Miss Joaquim is a good choice for beginning commercial production in Guam. It is a low investment crop. Miss Joaquim is easily propagated from cuttings, which are available locally. The cuttings are grown in full sun and so there is no investment in a structure. The first experiment was designed to evaluate crushed coral and coconut husk for use as growing media and to obtain basic information on fertilizing. Coconut husk is commonly used as a growing medium in Guam but decomposes quickly. Also coconut husk is not readily available in large quantities. The advantages of coral over coconut are that coral is available in abundant quantities and does not need replacement as coconut husk requires. Two fertilizing methods were compared with no fertilizing. A slow release fertilizer applied at three month intervals was compared with a liquid fertilizer applied at weekly intervals. The fertilizer treatments were a starting point for future experiments.

Material and Methods

The plants were established in a randomized complete block design consisting of two media treatments, three fertilizer treatments and three replications. The plants were grown in either coconut husk or one inch coral aggregate. Fertilizer treatments included Foliar 60 (applied weekly), Osmocote (applied at 3 month intervals), or the control (no fertilizer).

Data was recorded from February 1985 through February 1986. Characters recorded were number of flowers (over the

Table 1. Mean values of vegetative characteristics and flower production of *Vanda* Miss Joaquim grown in media-fertilizer experiment.

Treatments: Media	Treatments: Fertilizer	Stem Fresh Weight	Stem Dry Weight	Number of Leaves	Number of Nodes	Number of Roots	Stem Length	Number of Flowers
Coconut	No Fertilizer	60.9a[z]	12.8a	20.8a	23.9a	21.0a	34.9a	4.3
	Foliar 60	63.4a	12.5a	20.4a	24.0a	19.7a	36.4a	3.7
	Osmocote	64.5a	12.8a	20.9a	23.6a	19.8a	36.4a	0.0
Coral	No Fertilizer	21.0b	6.0b	10.9b	15.3c	13.7b	20.7c	8.3
	Foliar 60	30.6b	8.1b	14.6b	18.6b	14.2b	25.0bc	4.7
	Osmocote	33.1b	7.9b	14.3b	18.1bc	15.2b	25.3b	6.7

[z]Mean separation in columns by Baye's least significant difference test, p=0.05. Means with same letter are not significantly different.

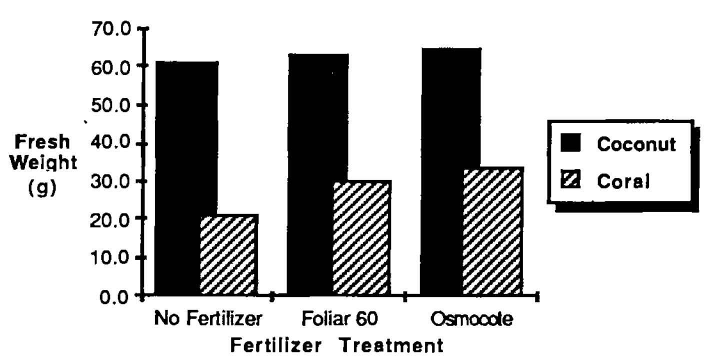


Figure 1. Mean fresh weights of *Vanda* Miss Joaquim after one year of growth in coral or coconut husk media and three fertilizer treatments.

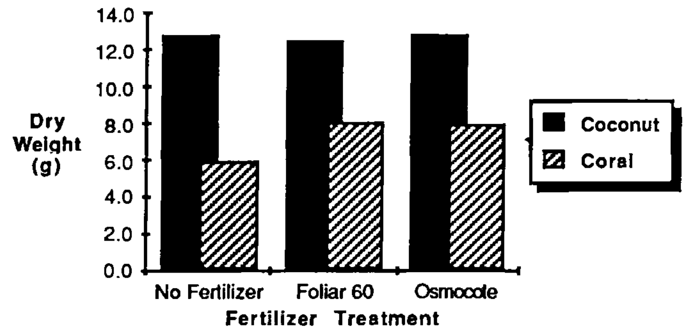


Figure 2. Mean dry weights of *Vanda* Miss Joaquim after one year of growth in coral or coconut husk media and three fertilizer treatments.

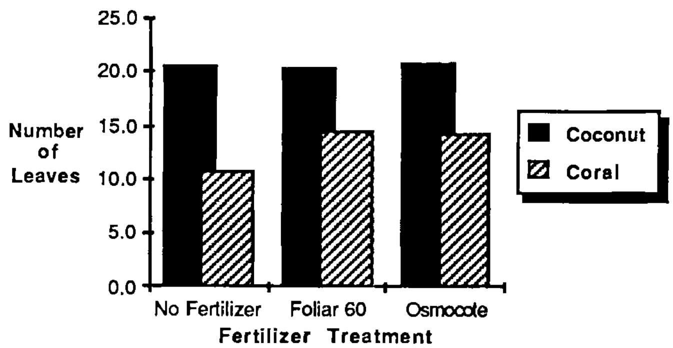


Figure 3. Mean number of leaves of *Vanda* Miss Joaquim after one year of growth in coral or coconut husk media and three fertilizer treatments.

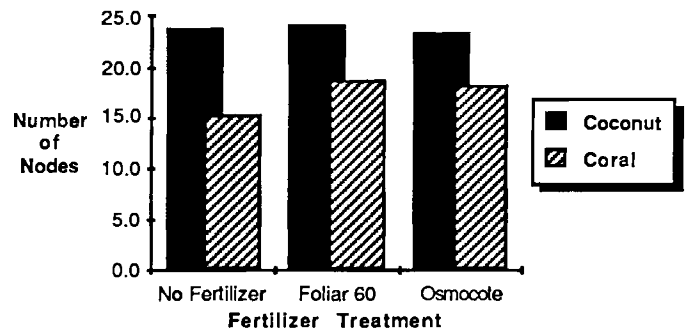


Figure 4. Mean number of nodes of *Vanda* Miss Joaquim after one year of growth in coral or coconut husk media and three fertilizer treatments.

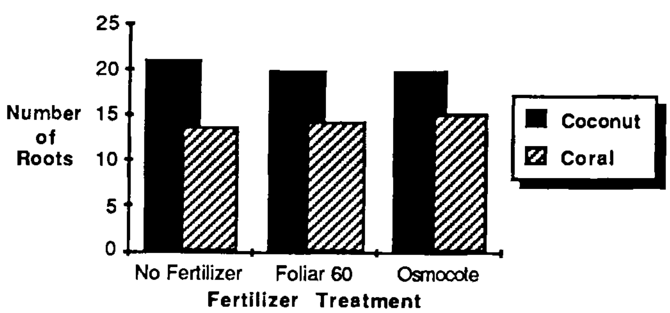


Figure 5. Mean number of roots of *Vanda* Miss Joaquim after one year of growth in coral or coconut husk media and three fertilizer treatments.

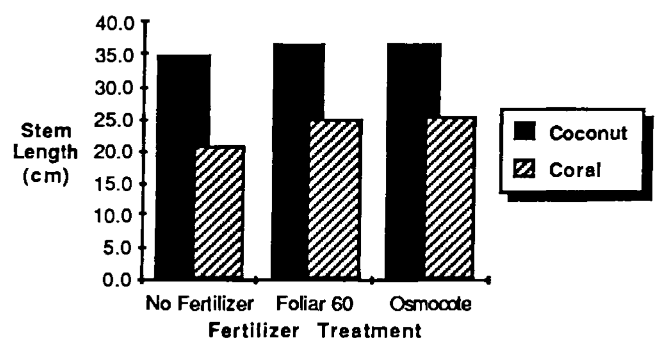


Figure 6. Mean stem lengths of *Vanda* Miss Joaquim after one year of growth in coral or coconut husk media and three fertilizer treatments.

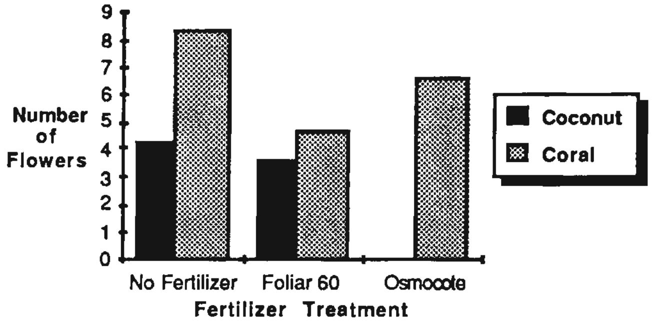


Figure 7. Mean numbers of flowers of *Vanda* Miss Joaquim after one year of growth in coral or coconut husk media and three fertilizer treatments.

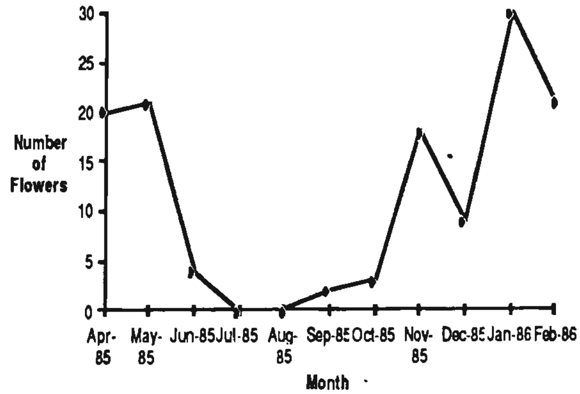


Figure 8. Flower production of 200*Vanda* Miss Joaquim from April, 1985 to February, 1986.

duration of the experiment), stem length, number of leaves, number of nodes, number of roots, fresh weight, and dry weight were recorded at the termination of the experiment. Mean separations were done using Baye's least significant difference test at the 0.05 significance level (K=100).

Results and Discussion

The plants grown in coconut husk were larger and had greater values for all vegetative characters measured (Table 1; Figures 1-6). Vandas grown in coral were much smaller and had lower values for all vegetative characters measured. Vandas grown in coconut husk showed no response to the fertilizer rates used. Vandas grown in coral showed some response (Table 1; Figures 1-7). When grown in crushed coral vandas appear to require more fertilizer than when grown in coconut husk. Slow release fertilization appears as effective as liquid fertilization with the advantage of less frequent application. Tissues are currently being analyzed to compare nutrient uptake among the treatments. Future experiments will compare different application rates. Flower production was low among all treatments. Environmental factors are suspected in reducing yield because the plants became shaded during afternoons. Also, seasonal flowering was observed with the lowest production of flowers occurring during the months of July and August (Figure 8).

A series of new plantings are being established at a new location to continue evaluating growing media. Soil has been included in addition to coconut husk and crushed coral aggregate. An expanded fertilizer study to determine application rates of slow release fertilizer and evaluate the use of combinations of different fertilizers. Experiments for evaluating spacing and the use of supports are also underway.

CULTIVAR EVALUATION

Additional vanda cultivars have been collected for evaluation. Vanda Miss Joaquim 'Atherton' was identified as a superior cultivar with larger flowers and greater production of flowers. Flower production in preliminary studies indicates different seasonal flowering than Vanda Miss Joaquim.

Dendrobium

Dendrobium cultivars have been collected from Hawaii and Thailand. The cultivars will be evaluated for total number of flowers produced, size of flowers, and how long the cut flowers last. Media and fertilizer trials have begun using several cut flower cultivars developed at the University of Hawaii. Three cultivars are included in the media and fertilizer study: *Dendrobium* Jaquelyn Thomas 'Uniwai Pearl', *Dendrobium* Jaquelyn Thomas 'Uniwai Blush', and *Dendrobium* Jaquelyn Thomas 'Uniwai Supreme'.

Anthurium

Anthurium cultivars were collected in Hawaii to evaluate for use in Guam as commercial cut flowers. Size of spathe, length of spadix, shape of spathe, color, and number of flowers produced will be recorded. Propagation by stem node cuttings is under evaluation as a method of propagating the anthuriums. This form of plant material is readily available in Hawaii, ships well, and are inexpensive. First flowering occurred three months after planting the cuttings. Further experiments will evaluate various media, fertilizers, and shading requirements.

HORTICULTURE-FRUIT CROPS

R. Rajendran

Survey and Accession

The survey of fruit crops on Guam and the accession of new cultivars was continued during 1985.

A tree of 'spondias' (*Spondias dulcis* Forst.) belonging to the mango (*Anacardiaceae*) family was located in Maina village. The acidic edible compound leaf in this plant was 12 inches long. Leaves were clustered at the end of branches, and leaflets were narrow, oval and slightly toothed in four to 12 pairs with an extra one at the end. The leaves fall in December and new ones appear only in April. Tiny, white, five-petaled flowers also appear in April. The ovoid orange fruit is a drupe, one to three inches long, surrounded by a five-ridged core, with five seeds. Seedlings have been introduced into the Guam Agricultural Experiment Station germplasm collection.

A new type of breadfruit was observed in the Santa Rita village area. The leaves in this cultivar are not lobed and are free of clefts. The fruits are larger than the local cultivar and are seedless. Root suckers have been planted in the fruit crop germplasm collection area of the experiment station.

Two cultivars of fig (*Ficus carica* L., family Moraceae) were observed in Agana Heights. These plants shed leaves in November. The dormant cuttings taken at this time rooted easily and have been planted in the experiment station.

One cultivar of Longan, (*Euphoria longon* (Lour) family Sipendiaceae) an ornamental plant with edible fruits and four cultivars of papaya (*Carica papaya* L.) were introduced from the USDA Subtropical Horticultural Research Station in Miami, Florida.

Tomatillo (*Physalis ixocarpa* Brot., family Solanaceae) was introduced for trial. This plant is a native of Mexico and is said to grow well in tropical climate. The fruits are used as vegetables.

Fertilizer Experiment

Fertilizer experiments on mango and guava are in progress at the Ija, Agricultural Experiment Station. Wind damage was observed, and wind breaks have been planted. Arrangements are being made for an irrigation system.

Papaya Experiments

A high density trial was conducted to assess the sex ratio and to eliminate the undesirable types in the Low Bearing Gyno-Hermaphrodite cultivar. The line was observed to be uniform in height, early and low bearing. Female to hermaphrodite ratio was observed to be 1:2, and the appearance of four male plants in a population of 460 plants was considered insignificant. Due to selection pressure the total soluble solids increased from an average of 8.2 to 12.7. Further improvement is being attempted by increasing selection pressure and hybridization with other low bearing cultivars.

In the farmers' field trials this line maintained its uniformity, early yield, low bearing habit. Dwarfness in this cultivar is an advantage in terms of resistance to damage due to storms.

Total Soluble Solids Assessment

The testing for total soluble solids (TSS, an indicator of sugar percentage), in papaya fruit was done at the stem end, mid portion and the blossom end of the fruit at three different depths--closer to the skin, middle area and the portion closer to the cavity. The juice was extracted and a TSS reading was taken using a refractometer.

The total soluble solid contents in the Low Bearing Hermaphrodite cultivar had insignificant variation with a range of 13.2 to 14.0 (Line Chart 1). Whereas in the cultivar Solo (Line Chart 2) the portion closer to the skin was less sweet and the range was 12.7 to 14.5. The Truk cultivar (Line Chart 3) had a range of 10.8 and 15.0. The edible portion closer to the skin was less sweet. The Local Tall cultivar (Line Chart 4) exhibited highest deviation in the TSS in different parts of the fruit.

It was observed that the stem end of papaya was less sweet as compared to the middle and the blossom end and the portion close to the skin was also less sweet as compared to the middle and the cavity portions. The total soluble solid content in the edible portions of the fruit in the Low Bearing Hermaphrodite Cultivar exhibited uniform distribution of sugar as compared to Solo, the Cultivar from Truk and the Local Tall Cultivar.

Minerals in the Edible Portion of Ripe Papaya

The mineral content of the juice of seven different cultivars of papaya was analyzed. The seven types include, the Low Bearing Hermaphrodite, Solo, Local Tall, Coorg Honey Dew, Low Bearing Female, Tall Hermaphrodite and the cultivar from Truk. This work was done in association with the Soils Research and Testing Laboratory of AES using a Perkin Elmer 305B, Atomic Absorption Spectro Photo Meter.

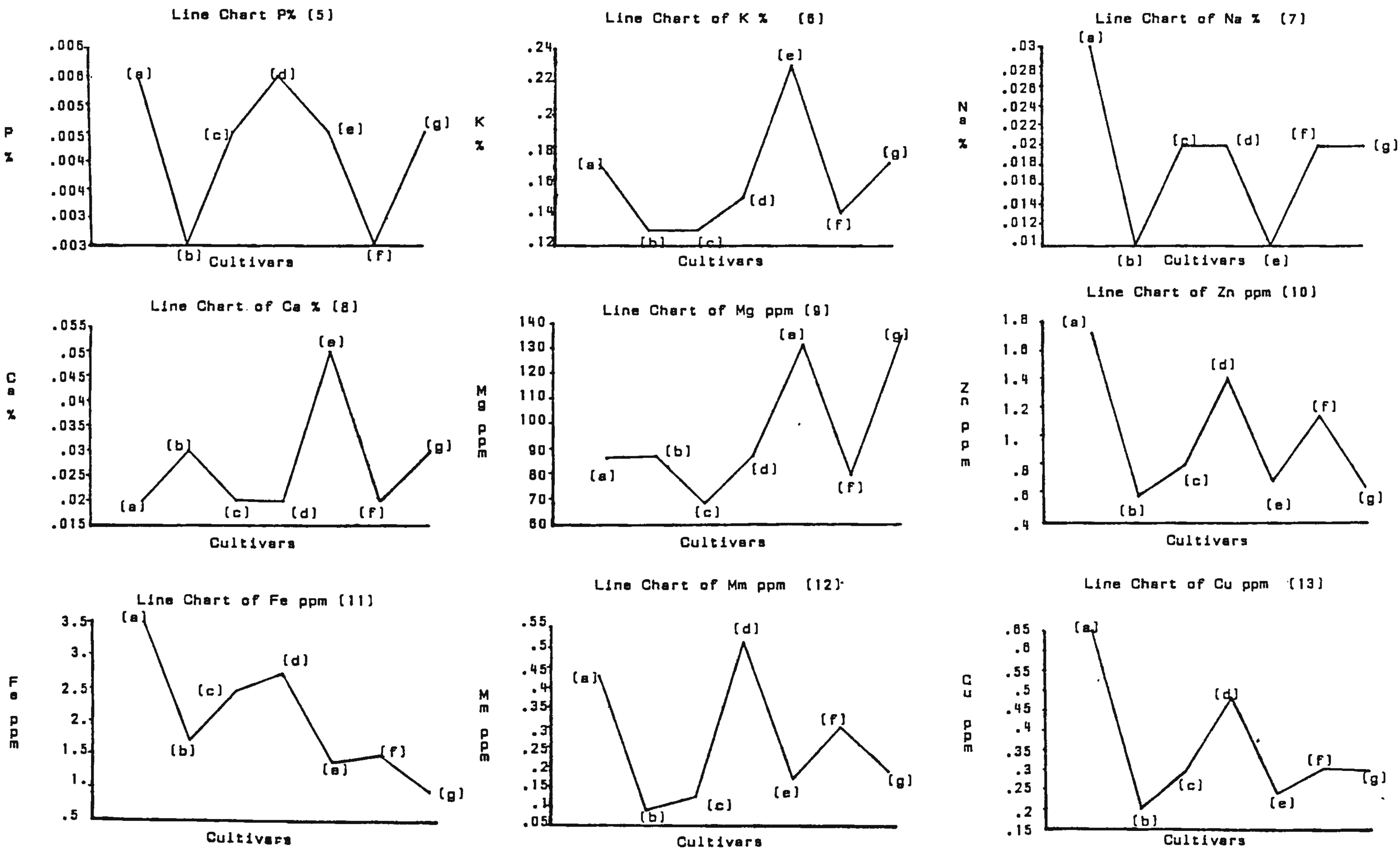
Cultivars Low Bearing Hermaphrodite and Coorg Honey Dew were rich in phosphorus whereas Local Tall Low Bearing Female, and the accession from Truk were medium and Solo and Tall Hermaphrodite were low in phosphorous (Line Chart 5).

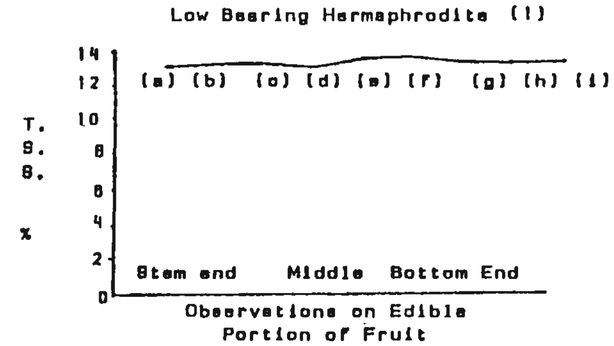
The Low Bearing Female was rich in potassium. The Low Bearing as well as the Tall Hermaphrodite were medium in potassium content. All the other lines were low in potassium (Line Chart 6).

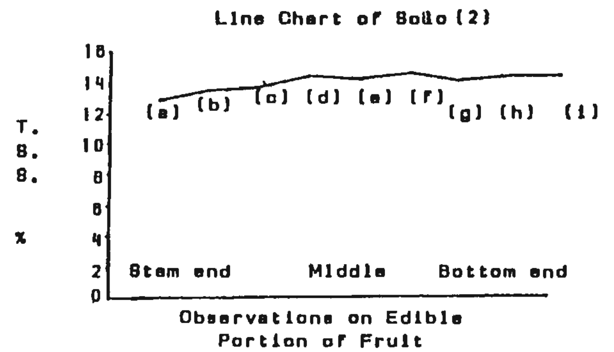
The Low Bearing Hermaphrodite was rich in sodium. The Local Tall, Coorg Honey Dew, Low Bearing Female as well as the Tall Hermaphrodite had medium sodium. (Line Chart 7).

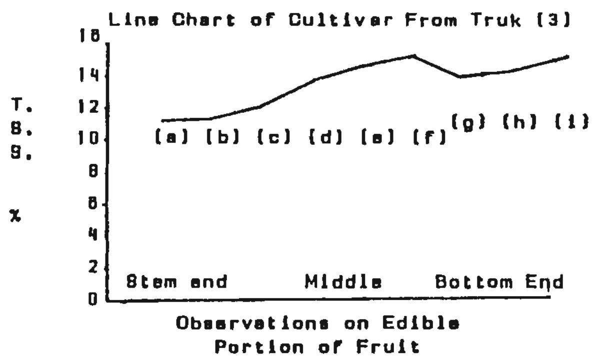
The Low Bearing Female was rich in calcium. The Solo and the Truk cultivars were medium in calcium. The Low Bearing Hermaphrodite, Local Tall and Coorg Honey Dew

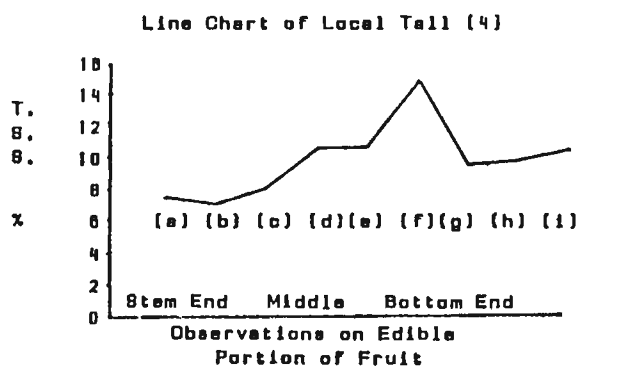
Mineral Composition of the edible portion of ripe papaya cultivars
(a) Low bearing Hermaphrodite. (b) Solo. (c) Local Tall.
(d) Coorg Honey Dew (e) Low Bearing Female (f) Tall Hermaphrodite
(g) Cultivar from Truk











Line charts of total soluble solids (sweetness) measured in different parts of Papaya fruit of (1) Low Bearing Hermaphrodite, (2) Solo, (3) Cultivar from Truk, and (4) Local Tall Selection: (a) stem end flesh close to the skin, (b) stem end, middle portion of the flesh, (c) stem end edible portion close to cavity, (d) middle portion of the fruit edible portion close to skin, (e) middle portion of fruit, middle of the flesh (f) middle portion of the fruit, cavity end flesh, (g) blossom end of fruit, skin end of flesh, (h) blossom end of fruit, middle portion of flesh, (i) Blossom end of fruit, cavity end of flesh.

were low in calcium (Line Chart 8).

The Truk cultivar and the Low Bearing female had a higher magnesium content than all other cultivars (Line Chart 9).

The Low Bearing Hermaphrodite had a high zinc content with Coorg Honey Dew and Tall Hermaphrodite following it. All the other lines were low in zinc (Chart Line 10).

The Low Bearing Hermaphrodite and Coorg Honey Dew were rich in iron content. All the other lines were low in iron (Line Chart 11).

Coorg Honey Dew had high manganese content, followed by Low Bearing and the Tall Hermaphrodites. All others were low in manganese (Line Chart 12).

Low Bearing Hermaphrodite was high in copper followed by Coorg Honey Dew. All the other lines were low in copper (Line Chart 13).

The results indicate that Low Bearing Hermaphrodite is rich in phosphorous, potash, sodium, zinc, iron, manganese and copper contents as compared to other cultivars examined.

Banana

Leaf analysis of the cultivars Williams Hybrid, Lacatan and Valery were done and the results are presented in Table 1. Third leaf from the top was used for anaylsis.

There is a marked difference in nitrogen, phosphorus, and the mineral contents in the leaf samples. This suggests that the varieties require different amounts of nutrients.

Mango

In 1984 initial trials were conducted on flower induction in mango. The effect was dramatic on the cultivar "Carabao." During 1985, ten terminal shoots with mature leaves (about eight months old) were labeled on selected mango trees of different varieties in the farmers' field and were sprayed with reagent grade potassium nitrate at ten grams in a liter of distilled water. In treatments where no flowering was observed, spraying was repeated at fifteen-day intervals. The results are shown in Table 2.

It was observed that the trees that were fertilized and irrigated responded better to the potassium nitrate application. Further studies will be taken up to confirm the requirements of different varieties for flower induction.

ANIMAL SCIENCES

A.L. Palafox

I. Continuing studies are being conducted on the use of local and available feedstuffs for animals. A pair of purebred Duroc male and female pigs were obtained for the purpose of maintaining the breed and crossing with existing breeds for the production of hybrids for nutritional experiments.

Experiment S116.1
The effect of 16, 17 and 18 percent protein starter diets on performance of 15-kg pigs.

Introduction

The dependence of Guam on imported feeds to meet the needs of the swine industry continues to be an important problem. Protein supplements are expensive. It is important to find means by which this ingredient may be used at a lower concentration than recommended levels by the Nutritional Research Council. An experiment was therefore designed to determine the feasibility of feeding 15-kg pigs with lower protein levels than the 18 percent which is used for this weight class of swine.

Materials and Methods

Experiment S116.1 was conducted with approximately 15-kg pigs which were distributed at random into their respective pens. A "Latin Square Changeover" experimental designed was used. There were three treatments (diets) and three 14-day periods. All the animals received the same corn-soybean diets, one in each period. There were three pens of animals with similar weights in each of 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 as treatments in each of the three 14-day periods. The pigs were distributed at random by weight into nine pens, one pig in each pen. Body weight and feed consumption were obtained. Feed and water were provided add libitum.

Results and Discussion

Data on the effect of 16, 17 and 18 percent protein starter diets on final weight and weight gain of 15-kg pigs are shown in Table 1. The data show that average initial body weight ranged from 14.53 to 17.41 kg. It can be seen also that during the first period, final body weight and weight gain were similar for all pigs fed the 16, 17 and 18 percent protein starter diets.

Table 1 also shows that during the second period, initial weights were similar and the final weights were also similar among treatments. Weight gain ranged from 6.35 to 9.15 kg among pigs fed the 16, 17 and 18 percent protein diets. Weight gain increased with protein level in the diet. During the third period, final body weight ranged from 37.83 to 46.16 kg. There were significant differences in weight during the third period. Pigs fed the 17 percent protein diet gained significantly more than those fed 16 percent protein.

Table 2 shows the effect of dietary protein level on feed consumption, weight gain and feed conversion. During the first period there were no significant differences on feed/period, feed/day, gain/day and feed conversion. This was also true during the second period. However, it was noted that gain/day increased in the dietary protein level. Feed conversion decreased with the increase of dietary protein in the starter diet.

The data also show that during the third period, feed per period, gain per day and feed conversion were significantly affected by the dietary protein level. Feed/period was

Table 1. Effect of 16, 17 and 18 percent starter diets on performance of 15-kg pigs (S116.1).1.2

Period	Protein %	Initial Weight Kg	Final Weight Kg	Weight Gain Kg
1	16	17.41	26.79	9.88
1	17	14.53	22.39	7.86
1	18	15.74	23.91	8.17
2	16	24.02	30.87	6.35
2	17	26.03	33.90	7.87
2	18	26.79	35.94	9.15
3	16	36.47	41.16	
3	17	38.29	46.16	4.69b
3	18	32.99	37.83	7.87a

1. Average of 3 values from individual fed pigs
2. Means with different letters in a vertical within each period are significantly different (P<0.05).

significantly more for pigs fed 17 percent protein than those fed 18 percent protein. Gain per day was signficantly more for swine fed 17 percent protein than those fed 16 percent. The data also showed that feed conversion of pigs fed the 17 percent ration was significantly superior to that of pigs fed 16 percent protein.

Conclusion

Under the conditions of the present experiment, 15-kg pigs may be fed a 17 percent protein starter diet instead of the 18 percent recommended by the Nutritional Research Council for optimum feed efficiency.

II. Continuing studies were conducted on the "Potential of Cassava as a crop for Guam and Micronesia", Research Grant P.L. 89-808, Section 406.

Experiment M209.1 Comparative Measurement of Tuber and Plant Parts of Nine *M. esulenta* Accessions.

Introduction

In previous studies it was noted that there were significant differences in the tuber yield of cassava accessions. Less known is the relationship of different measurements of the aerial parts of the plant and certain other measurements pertaining to the size of the tubers. The present study determines the relationship of the different parameters among accessions.

Materials and Methods

Nine accessions of *M. esculenta* were planted at the Kagman Agricultural Station (KAS), Saipan, Commonwealth of the Northern Marianas Islands. Seed pieces with at least five nodes were planted diagonally in rows one meter apart. The seed pieces were planted one meter apart. There were nine treatments with four replicate lots of six plants each. A randomized block experimental design was used. Standard practices were used in watering and weeding whenever they were needed. The duration of the experiment was 32 weeks. At harvest time, data were obtained on the total weight of the plant above ground, branch weight of the different parts of the plants, circumference of the different stems and branches, total root weight and weight of the unmarketable small roots. Measurements of individual roots were also obtained.

Results and Discussion

Table 3 shows that there were significant differences in the average weights of the aerial part of the plant due to accessions. The range was 6.51 to 13.63 kg. Accession 34 showed the heaviest aerial part (shoot), whereas accession 34 was lightest. Significant differences were also noted in branch weight and base weight of the branch. Circumference of the stem ranged from 9.83 to 11.67 cm. There were significant differences in the circumference of the stem among accessions. The base circumference did not significantly differ among accessions.

In Table 4 are shown the data obtained on plant weight, small unmarketable roots and total root weight. There were significant differences in plant weight due to accessions. Plant weight of accession 34 was heaviest, whereas accession 37 was the lightest. The weight of small unmarketable roots were significantly different among accessions. The range in weight averaged from 0.11 to 0.38 kg. Accession 33 showed the lightest weight, whereas six was the heaviest. The weight of all roots per plant ranged from 0.54 to 2.46 kg. There were significant differences among accessions. Accession nine showed the heaviest roots. The data obtained on individual roots are shown in Table 5. The average root weight significantly differed among accessions. The range was 0.17 to 0.32 kg. Accession six roots were heaviest, whereas roots of accession 39 were lightest. Root length ranged from 20.84 to 26.53 cm. Likewise there were also significant differences in root length among accessions. Root circumference

Table 2. Effect of 16, 17 and 18% protein starter diets on performance of 15-kg pigs (S116.1) 1,2

Period	Protein	Feed/Period	Feed/Day	Gain/Day	Feed/Gain
1	16	14.17	1.29	0.85	1.53
1	17	13.83	1.26	0.71	1.77
1	18	13.23	1.21	0.74	1.64
2	16	20.83	1.89	0.58	3.39
2	17	21.00	1.91	0.71	2.69
2	28	20.83	1.89	0.83	2.47
3	16	23.17a.b.	2.11	0.42b	4.99a
3	17	23.67a	2.13	0.72a	3.18b
3	18	22,33b	2.10	0.45ab	4.74ab

1. Average of three values.
2. Means with different letters in a vertical line in each period are significantly different (P<0.05).

Table 3. Comparative weight and circumference data obtained from nine cassava accessions in experiment M209.1. 1,2

Accession	Aerial Weight Kg	Branch Weight Kg	Base Weight Kg	Branch Circumferenc cm	Base Circumference cm
33	7.41b	5.58b	1.84c	10.75ab	15.58
34	13.63	10.66a	2.97ab	12.50a	20.33
35	10.07ab	6.91b	3.15a	10.00b	20.17
36	8.42b	6.05b	2.36abc	10.00b	15.67
37	6.51b	4.60b	1.90bc	11.67ab	18.50
38	10.51ab	7.95ab	2.56abc	9.83b	18.00
39	7.78b	5.75b	2.03bc	10.33ab	14.92
6	9.46b	7.54ab	1.93bc	10.92ab	17.83
9	8.12b	5.87b	2.24abc	10.17b	16.0

1. Means within the same category bearing different letters are significantly different (P< 0.05)
2. Conducted at the KAS, Saipan, CNMI

Table 4. Comparative weight data obtained from nine cassava accessions in experiment M209.1. 1, 2, 3.

Accession	Plant Weight kg	Small Root Weight kg	Root Weight (Total) kg
33	10.39b	0.11c	2.46a
34	16.18a	0.31ab	2.28ab
35	11.13ab	0.14abc	0.92cd
36	10.62b	0.24abc	1.96ab
37	8.05b	0.18abc	1.36bcd
38	11.28ab	0.22abc	0.54d
39	8.93b	0.14abc	1.01cd
6	11.64ab	0.38a	2.18ab
9	10.51b	0.19b	2.40a

1. Means within the same category bearing different letters are significantly different (P < 0.05).
2. Conducted at the KAS, Saipan, CNMI

Table 5. Comparative root data obtained from nine cassava accessions in experiment M209.1. 1,2

Accession	Root Weight (Individual) Kg	Root Length cm	Root Circumference cm	Root Diameter cm
33	0.27a	23.73bcd	14.04ab	4.75a
34	0.28a	26.81ab	14.73a	4.80a
35	0.20b	23.32cd	11.50d	3.89b
36	0.28a	75.51a	13.30bc	4.6aa
37	0.30a	27.52a	13.27bc	4.53a
38	0.18b	20.84d	10.84d	3.67b
39	0.17b	22.97d	12.94c	4.01b
6	0.32a	26.53abc	14.44a	4.78ab
9	0.29a	26.32abc	14.02ab	4.69ab

1. Means within the same category bearing different betters are significantly different ($P<0.05$).
2. Conducted at the KAS, Saipan, CNMI

Table 6. Nutrient composition of nine cassava accessions in experiment M209.2. 1, 2, 3.

Accession Number	Dry Matter %	Ash %	Crude Fat %	P %	K %	Na %
33	90.02	3.16	0.67	0.16	1.17	0.07
34	89.88	3.30	1.04	0.20	0.78	0.13
35	88.85	3.63	0.85	0.19	0.97	0.07
36	89.24	3.45	0.71	0.18	1.09	0.06
37	89.61	3.68	0.87	0.16	1.16	0.06
38	89.42	3.30	0.80	0.18	1.12	0.06
39	89.62	3.00	1.06	0.14	1.10	0.05
6	88.02	3.05	0.83	0.16	0.98	0.06
9	89.22	2.77	0.78	0.14	0.94	0.05

1. Average of two or more plants with two or more samples per plant.
2. Dry matter of air dried cassava chips
3. Nutrient composition expressed on a dry matter basis.

significantly differed among accessions. The range was 10.84 to 14.73 cm. Root diameters also were significantly different among accessions. The range averaged from 3.89 to 4.80 cm. Root diameters of accessions 33, 34, 36, and 37 were similar. Their root diameters were superior to those of accessions 35, 38 and 39.

Conclusion

There were significant differences in aerial parts of the plant, branch weight above the first one foot of stem above ground, branch beyond the first one foot of the stem, circumference of the stem, total root weight and weight of small unmarketable roots. Individual root parameters including average root weight, root length, root circumference and root diameter differed significantly among accessions. The preceding data suggest that the different parameters used in this study may be effectivly used in differentiating accessions as to their usefulness as determinants of acceptable accessions for propagating purposes.

Experiment M209.1
Comparative leaf petiole composition of Nine *M. esculenta* accessions.

Introduction

No data are available on the nutrient composition of *M. esculenta* leaf petioles. The paucity of information on the comparative composition of leaf petioles from different cassava accessions is very much in evidence in literature reviews. The object of the study was to determine the comparative nutrient composition of cassava from the Northern Marianas Islands.

Materials and Methods

During harvest time at 32 weeks of nine accessions used for tuber yield determination, leaf petioles from each replicate plot were gathered for nutrient analysis. The samples were obtained from plants grown at Kagman Agricultural Station, Station, Saipan, CNMI. Analysis was conducted at the Guam Agricultural Experiment Station at Inarajan. Dry matter of air dried samples were obtained by drying in an oven calibrated at 70 degrees centigrade until the sample reached a constant weight. Ash was obtained with the use of a muffle furnace set at 450 degrees centigrade and crude fat was obtained with the use of a Goldfish Fat Extractor. Mineral composition was obtained with the use of a Perkin Elmer Atomic Absorption Spectrophometer.

Results and Discussion

Table 7 shows the dry matter, ash, crude, fat, P, K, and Na composition of cassava petioles. Air dried samples showed dry matter (DM) contents of 85.88 to 89.20 percent. Ash content averaged 9.75 to 12.63 percent, whereas crude fat showed averages ranging from 0.93 to 1.78 percent was fairly uniform among accessions. Potassium content of petioles averaged 2.06 to 2.96 percent. Sodium content also was fairly uniform among accessions, 0.05 to 0.91 percent.

The Ca, Mg, Mn, Fe, Cu and Zn content of cassava leaf petioles are shown in Table 8. Ca content ranged from 1.13 to 2.71 percent and Mg content ranged from 0.035 to 0.63 percent whereas Mn content ranged from 68 to 255 parts permillion. The Fe content averaged 31-66 ppm . Copper content averaged 9.3 - 12.9 ppm. Zinc content of cassava leaf petioles ranged 42-98 parts per million.

Table 7. Nutrient composition of nine cassava accessions used in experiment M209.2. 1, 2, 3.

Accession Number	Dry Matter %	Ash %	Crude Fat %	P %	K %	Na %
33	88.60	11.60	1.78	0.52	2.32	0.91
34	88.18	12.63	1.29	0.38	2.92	0.06
35	85.88	10.70	1.32	0.31	2.42	0.05
36	89.20	12.27	1.50	0.62	2.63	0.05
37	88.47	10.73	1.60	0.36	2.88	0.07
38	87.85	12.20	0.93	0.41	2.96	0.05
39	89.12	9.75	1.44	0.32	2.50	0.07
6	87.00	11.65	1.64	0.51	2.32	0.07
9	87.28	10.18	1.58	0.46	2.06	0.06

1. Average of two or more plants with two or more samples per plant.
2. Dry matter of air dried cassava chips.
3. Nutrient composition expressed on a dry matter basis.

Conclusion

The dry matter of air dry cassava leaf petioles was analyzed for ash, crude fat, P, K, Na, Mg, Mn, Fe, Cu and Zn. The data suggest there are apparent differences in the nutrient content of leaf petioles but significant differences due to accessions were not indicated. Mg, Cu and Zn composition of petioles were fairly uniform.

Table 8. Nutrient composition of nine cassava accessions used in experiment M209.2. 1,2.

Accession Number	Ca %	My %	Mn ppm	Fe ppm	Cu ppm	Zn ppm
33	2.38	0.58	225	38	11.1	60
34	2.71	0.48	127	31	11.1	50
35	1.13	9.63	101	66	9.3	42
36	2.19	0.52	140	33	11.1	98
37	1.60	0.45	68	344	11.1	43
38	2.61	0.53	102	36	12.9	60
39	2.00	0.35	93	38	11.1	54
6	2.10	0.48	153	509	11.1	84
9	1.96	0.45	110	40	11.1	74

1. Average of two or more plants with 2 or more samples per plant.
2. Nutrient composition expressed on a dry matter basis.

AGRICULTURAL ENGINEERING

C.A. Saruwatari and C.T. Lee
with J.A. Cruz

Introduction

Research continued in agricultural engineering to study the applications of trickle irrigation to vegetable crops. Field trials were carried out to determine the water requirement under trickle irrigation for tomato and cabbage on a private farm field. For all trials domestic water was used.

Description of Experiments

Experiment 1: Tomato

A continuous function design with five water treatments and three replications was initiated on tomato (Walter) in March, 1985. Treatments 1 to 5 were set at 1.0 hours, 1.5 hours, 2.0 hours, 2.5 hours, and 3 hours per day, respectively. The discharge rate of the RIS Biwall was approximately one gallon per minute (224 liters per hour) per 100-foot (30-meters) lateral with a 18-inch (46-centimeter) spacing. Rainfall was measured on site and totaled approximately 13-inches (40-centimeters). Preplant fertilizer was applied at a rate of 10 pounds per 100 feet (22 kg per 30 meters) of 10-30-10 and a side dress was applied at the same rate of 21-0-0. Insects such as the tomato fruit worm and plant diseases (primarily the bacterial leaf spot) were noted and treated with Dibrom, Tribasic Copper Sulfate, Sevin, and Dithane M-22 as part of the spraying program.

Experiment 2: Cabbage

A continuous function design with five water treatments and three replications was initiated on a cabbage (KK-cross) in April, 1985. Treatments 1 to 5 were set at 1.0 hours, 1.5 hours, 2.0 hours, 2.5 hours, and 3 hours per day, respectively. The discharge rate of the RIS Biwall was approximately one gallon per minute (224 liters per hour) per 100-foot (30-meters) lateral with a 18-inch (46-centimeter) spacing. Rainfall was measured on site and totaled approximately 12-inches (30-centimeters). Preplant fertilizer was applied at a rate of 10 pounds per 100 feet (22 kilograms per 30 meters) of 10-30-10 and a side dress was applied at the same rate of 21-0-0. Insects, primarily the cabbage worm, was noted and treated with Sevin as part of the spraying program.

Results and Discussion

Experiment 1: Tomato

Due to the heavy rains during a tropical storm, lodging of the plants occurred. An attempt to save the crop was unsuccessful. However, a count was made to determine if there was any difference in the number of fruits formed per treatment due to the different water application rates. Analysis of the data collected showed no significant difference in the number of fruits formed between the treatments. The experiment was discontinued after a second tropical storm damaged the crop.

Experiment 2: Cabbage

Visual assessment of the cabbage during its early stages of growth indicated no visible differences in the rate of growth. Due to problems in the continuance of the spraying program to control the cabbage worm and the heavy rainfall, there was poor development of the cabbage heads. The experiment was discontinued.

ENTOMOLOGY - Pest Management and Biological Control of Arthropod Pests

D. Nafus and I. Schreiner

Work was concentrated on cantaloupe, corn, mango and parasites of the leafminer *Liriomyza trifolii*, a serious pest of beans and other vegetable crops. Results of a survey of citrus and vegetable pests in Kosrae, conducted in November 1984, and analyzed in 1985, are also reported.

Biological Control of *Liriomyza trifolii*

I. Status of establishment of released natural enemies of *Liriomyza trifolii.*

Ganaspidium hunteri was imported from Hawaii to aid in the control of the agromyzid leafminer *Liriomyza trifolii*.

Methods

G. hunteri was released at 6 locations beginning in February. Releases of 100 wasps per site were made. To monitor for establishment, periodic samples of leafminers and associated parasitoids were collected from a variety of crops (principally tomato, cucumber, and beans), weeds (*Bidens*), and ornamentals (marigold) near the release areas. Samples consisted of 25 randomly chosen leaves from each plant species. The leaves were placed in paper sacks which were taped shut and held until all parasitoids and leafminers emerged.

Results

The first recoveries of *Ganaspidium* were made in Northern Guam on marigolds in August. Parasitoids were reared from samples collected about one mile from the release site.

II. Natural enemies of the leafminer already on Guam.

Native parasitoids reared from leafminers were *Eucoilidea micromorpha* Perkins, *E. guamensis* Yoshimoto, *Cothonaspis pacifica* Yoshimoto, *Hemiptarsenus semialbiclavus* (Girault), and *Chrysonotomyia formosa* (Girault). *C. pacifica* and *E. micromorpha* are new records for Guam.

Biological control of citrus spiny whitefly

In 1982 Kosrae requested help from the University of Guam in controlling a severe infestation of the Citrus spiny whitefly, *Aleurocanthus spiniferus*. Arrangements were made to send a parasite, *Encarsia smithii*, to Kosrae for release. The parasites were released on tangerines at five sites, Tafunsak, Lelu Island, Agricultural Station at Lelu, Malem, and Uttwa. Prior to 1984, surveys did not demonstrate establishment of the parasite. In November 1984, a survey was conducted by the university to determine if *E. smithii* had established.

Methods

In each of the release areas, and at selected sites between release sites, tangerine or orange trees were sampled for spiny whiteflies and for *E. smithii*. The number of trees sampled at each site varied and is indicated in Table 1. On each tree, 20 shoots were randomly selected from those shoots which had recently produced new growth but had mature leaves. These leaves were selected for sampling because they were the site of the most active spiny whitefly infestations. All suitably-aged leaves on each shoot were examined for presence of spiny whiteflies and the number of shoots with or without them was recorded. On each tree a random sample of 10 leaves from shoots with spiny whiteflies was collected and taken to the laboratory. At the Agricultural Station in Lelu, the sampling procedure was modified by collecting all infested leaves on the sample shoots and enough additional leaves so that a minimum of 35 leaves was collected from each tree. On each of the sample leaves, the number of spiny whiteflies was counted and the leaves were placed in 0.5 liter white plastic cups to incubate any spiny whiteflies or wasps. On leaves with more than 30 spiny whiteflies, 30 whiteflies were marked and rechecked later to determine the ratio of emerged parasites to spiny whiteflies. On leaves with less than 30, all whiteflies were incubated. All samples were checked daily for wasp or whitefly emergence and any emerged specimens were removed and identified. At the conclusion of the holding period, 10-14 days after collection, the number of wasp and whitefly exit holes were counted.

Results

E. smithii successfully established on Kosrae. The infestation of spiny whitefly had been severe but populations were declining in all areas visited. Older leaves had been heavily encrusted with sooty mold, which was in the process of peeling off, and were completely covered underneath with enclosed spiny whiteflies. New leaves were largely free of spiny whitefly infestation. On a small sample of older leaves on which most of old, dead whiteflies were attached and in good condition, counts ranged from 189-700 whiteflies per leaf and averaged about 400. On new leaves with active infestations, counts were substantially lower, ranging from 0 to 51 per leaf. Spiny whitefly nymphs and pupae averaged less than 10 per leaf and many new leaves were uninfested. Parasitization ratios ranged from 1 to 93 percent, typically being between 50 to 90 percent (Table 1). In the case where only one percent of the spiny whiteflies were parasitized, whiteflies were extremely rare in that orchard and had never been abundant. Overall *E. smithii* was successfully controlling the spiny whiteflies.

Corn

I. Resistance screening

Screening for resistance to the corn borer at the leaf stage and at the tassel stage continued for both sweet corn and field corn. Both tropical and temperate zone germplasm were tested.

A. Sweet Corn: Thirty-nine sweet corn breeding lines obtained from a commercial company and 17 named varieties of sweet corn were evaluated for leaf and tassel resistance to the Asian corn borer.

Methods

The corn was planted Nov. 2, 1984, at Harmon, Guam. All varieties were planted in rows of 15 plants at a density of 1 plant/23 cm. Rows were planted 90 cm apart. All varieties were randomized within a block. Three replicates were run. The breeding lines and the named varieties were planted in separate blocks adjacent to one-another. Because a natural infestation was used, ratings were done only on plants with evidence of borer infestation. Guthrie's modified leaf rating scale was used to rate leaf resistance. The rating was done at the late whorl stage. For resistance in silk-stage and older corn, the tassel rating scale developed in 1984 was used.

Results

Considerable variance was observed in the mean leaf-ratings among the various replicates. The coefficient of variance was 37.1% for the leaf-ratings. Overall there were no significant differences among the breeding lines or varieties tested (F test). However the mean damage rating for the leaves of the breeding lines varied from 5.3 for line 5417-2 to 1.8 for line 5367-2 and Duncan's analysis showed the differences were significant (Table 2). For the named varieties, Duncan's analysis did not show any significant differences (Table 3). The leaf ratings of the named varieties varied from 6.1 for Hawaiian Supersweet # 10 to 3.2 for Golden Cross Bantam and NK51036.

Among the breeding lines the mean tassel ratings varied from a high of 3.9 for 5417-2 to a low of 1.5 for 5366-1 (Table 2). The tassel rating for the named varieties varied from 4.5 in Quicksilver and Stylepak down to 3.1 in Golden Cross Bantam and Supersweet #10 (Table 3). The named varieties appeared more susceptible to the borer than the breeding lines. There was a highly significant correlation ($p < 0.0001$) between the leaf rating and the tassel rating for the corn breeding lines, but not for the named varieties. There was no correlation between the tassel ratings recorded for the named varieties in this year's trial with same varieties tested last year ($r=-0.68$, $p=.78$), suggesting either no resistance is present or the tassel rating scale is not reliable. In either case the tassel rating scale needs further testing under more controlled

Table 1. Parasitism of *A. spiniferus* by *P. smithii* at different localities on Kosrae.

Area	Km from Release Point	Number of: Leaves Sampled per tree	Whiteflies Nymphs or Pupae	Wasp Exit Holes	Whitefly Exit Holes	Whitefly Infected With Fungus	Percent Whiteflies Parasitized by wasps
Lelu Is A	0	10	14.6	6.5	1.0	0.7	0.90
Lelu Is B	0	10	204.8	6.8	2.3	0.0	0.74
Lelu Main	1	10	2.5	0.9	0.1	0.0	0.88
Malem A	0	10	9.3	1.8	1.3	0.5	0.50
Malem B	0	10	7.4	1.1	0.9	0.4	0.54
Malem C	?	10	8.4	0.1	7.5	0.0	0.25
Malem D	?	10	24.6	4.3	3.2	0.0	0.50
Tafunsak	0	10	42.1	12.3	0.9	0.2	0.87
Uttwa A	?	10	19.7	9.9	1.5	0.0	0.85
Uttwa B	?	10	7.3	3.2	0.6	0.0	0.72
Uttwa C	?	10	22.1	4.8	3.1	0.0	0.53
Lelu Stn A	0	35	2.3	1.0	0.2	1.0	0.81
Lelu Stn B	0	24	2.7	0.7	0.2	2.3	0.77
Lelu Stn C	0	10	2.1	0.2	0.3	1.0	0.67
Lelu Stn D	0	31	4.0	1.2	0.5	2.9	0.72
Lelu Stn E	0	26	3.3	0.8	0.4	2.0	0.79
Lelu Stn F	0	32	4.3	1.2	0.2	1.9	0.86

conditions. The leaf ratings could not be compared because a late infestation the previous year had resulted in essentially undamaged leaves.

The tassel rating scale was easier to use than the leaf rating scale. The tassel rating's major disadvantage is that it has to be performed on tassels that are spread and shedding for the most reliable results. Since not all varieties flower at the same time, ratings must be done over a period of time.

B. Field Corn: Further testing of field corn inbreds for resistance to corn borers was continued. Two trials were run. In the first trial, 17 high-performance U.S. inbreds, selected on the basis of their performance in previous tests at the Experiment Station, were retested. The inbreds selected were the ones which had had the best leaf ratings in the previous trials. In the second trial, 114 inbreds which perform well in the tropics were tested.

Methods

Methods are as described for the sweet corn. For both trials the number of replicates was increased to 4 . Leaf ratings and tassel ratings were performed only on plants with evidence of infestation. The first trial was planted on Oct. 29, 1984, at Harmon. The second trial was planted on June 10, 1985. In the first trial only leaf ratings were done. In the second trial both leaf ratings and tassel ratings were done. Because the infestation level was low, undamaged plants were not rated as it was assumed they were missed by the moths. In the analysis, plots which had less than four plants rated were

Table 2. Mean leaf and tassel damage ratings for resistance to the Asian corn borer of some commercial, sweet-corn breeding lines.

Breeding Line	Mean leaf rating	Mean tassel rating
5417-2	5.3a	3.9a
5453-3	5.1ab	3.8ab
5447-2	5.0ab	3.3ab
5453-1	4.7abc	3.1abc
5418-1	4.2abcd	3.8ab
5387-2	4.1abcd	3.4ab
5387-1	4.1abcd	3.4ab
5417-1	4.1abcd	3.1abc
5381-1	4.1abcd	2.9abc
5386-2	4.0abcd	3.0abc
5454-3	4.0abcd	3.0abc
5448-1	3.9abcd	2.6abc
5418-2	3.7abcd	3.5ab
5447-1	3.7abcd	3.0abc
5436-3	3.5abcd	2.7abc
5367-1	3.4abcd	3.0abc
5381-2	3.4abcd	3.0abc
5394-1	3.4abcd	2.7abc
5394-3	3.3abcd	3.4ab
5388-2	3.3abcd	2.5abc
5394-4	3.3abcd	3.0abc
5366-2	3.0abcd	2.7abc
5436-2	3.0abcd	2.1bc
5388-3	3.0abcd	3.3abc
5388-1	2.9abcd	3.0abc
5448-2	2.8abcd	2.8abc
5367-4	2.7abcd	2.2abc
5367-5	2.7abcd	2.3abc
5387-3	2.5abcd	3.0abc
5453-2	2.5bcd	2.1bc
5394-2	2.4bcd	2.9abc
5367-3	2.1cd	2.1bc
5366-1	2.0cd	1.5c
5436-1	1.9d	2.7abc
5367-2	1.9d	2.6abc

Numbers within a column followed by the same letter are not significantly different at the 0.05 level (Duncan's DMRT) dropped from the analysis. Twenty-three varieties were chosen which had tassel ratings were distinctly in the low, medium or high range. Ten plants were examined in each replicate, and ear and stalk damage was measured. Ear damage was measured on a 1-4 scale: where 0 was no damage; 1 was only the unpollinated tip damaged; 2 was 1-50% of the ear surface damaged and 3 was 51-100% of the ear damaged. Stalk damage was assessed by measuring the length of the stalk, cutting the stalk open, and measuring the total length of stalk tunnelled, and calculating the percent of the stalk tunnelled. Stalk damage was mathematically transformed before analysis to arcsin $\sqrt{p}$ where p was the proportion of the stalk damaged.

Results

In the first trial significant differences were seen between varieties (Table 4). The leaf ratings varied from 2.1 in Mp496 to 6.2 for N7A. Overall the Mp inbreds suffered the least damage from the Asian corn borer. The variety K55 did not germinate.

In the second trial there were also significant differences between varieties. The 10 varieties with the lowest leaf ratings were A619, Hi40, H60, ANTC5S5, HIX4231, CYMMIT 11ES, CI66, INV138, Mp496, HI31 (Table 5). The 10 varieties with the lowest tassel rating were ICAL29, ICAL25, Mp68:616, HI34, HIX4267, Fl 2BT 106, PhilDMR S5, Hi41, H95, NC246 (Table 5). There was a small but significant correlation between the leaf ratings and the tassel ratings (r=0.21 p=0.02). There was no correlation between leaf rating and stalk damage (r=0.37 p=0.09). There was a significant correlation between tassel rating and stalk damage (r=0.45 p=0.04). All the varieties examined had heavily damaged ears (Table 6) and there was no correlation between ear damage and leaf rating (r=.34 p=0.12) or tassel rating (r=0.32 p=0.15).

II. Insecticide trials and cultural controls:

Materials and Methods

Sweet corn (Var. Hawaiian Supersweet #9) was planted on Jan. 2, 1985 at Harmon. Seeds were planted 23cm apart in rows 90cm apart. The field was fertilized preplant at the rate of 1000 lbs 10-30-10 per acre. Each plot consisted of seven rows 2.7m long. The four treatments were: Dipel sprayed weekly all season; Dipel sprayed weekly until silking and Pydrin sprayed weekly thereafter; Dipel sprayed weekly all season and the plants detasselled at the time of tassel emergence; and an untreated check. Each treatment was replicated four times in a randomized-block design. The Dipel was applied at the rate of 2 Tablespoons/gallon of water and the Pydrin was applied at the rate of 1/4 teaspoon/gallon of water. The corn was planted at the beginning of the dry season. No irrigation water was available.

Table 3. Mean leaf and tassel damage ratings for resistance to the Asian corn borer of some commercial sweet-corn varieties.

Variety	Mean leaf rating	Mean tassel rating
Supersweet #10	6.1a	3.1d
Stylepak	5.8ab	4.5ab
HXP2340Y	5.2abc	4.0abcd
Florida Staysweet	5.1abc	4.3ab
Midway	5.1abc	3.8abcd
Resistall	5.0abc	3.4bcd
GuardianH	4.9abc	4.2abc
Paramount	4.8abc	3.9abcd
Jubilee	4.5abc	3.7abcde
Bonanza	4.2abc	2.7e
Quicksilver	4.0abc	4.5ab
Terrific	4.0bc	4.1abcd
Cr8028	4.0bc	3.5bcde
Goldwinner	3.9bc	3.2cde
Crisp&Sweet	3.6c	4.0abcd
Golden Cross Bantam	3.2c	3.1de
Nk5106	3.2c	4.0abcd

Numbers within a column followed by the same letter are not significantly different at the 0.05 level (Duncan's DMRT)

Results

The Dipel+detasselling averaged twice as many undamaged ears as the control (Table 7). The Dipel+Pydrin and the Dipel alone produced about 1.5 times as many undamaged ears as the control. Because of a large variance between plots due to uneven infestations and drought-stressed plants, some of the differences were significant.

III. Alternate Hosts:

To determine where Asian corn borer are breeding in the absence of corn, various species of grasses were tested for suitablility as alternate hosts.

Methods

Grasses were planted in 6.2 m3 cages. Three species of grass were planted in each cage in a latin square design. Rows were 1.8 m long and each row contained 1 plant of each species. First instar *O.furnacalis* larvae were placed on each of the plants to determine whether they could feed and develop on the plant. *Echinochloa colonum, Eleusine indica, Miscanthus floridulus, Panicum maximum, P. muticum, Paspalum paniculatum, Pennisetum pupureum, P. polystachyon*, and *Phragmites carca* were tested.

Results

Corn borers fed on *Phragmites carca, Panicum maximum, P. muticum, Eleusine indica, Pennisetum pupureum, P. polystachyon*, and *Paspalum paniculatum. Echinochloa colonum* was eaten by young larvae but older larvae left the plant. *Miscanthus floridulus*, an extremely common grass on Guam, was not a suitable host. These results indicate that the Asian corn borer feeds on a wide variety of common grasses which are weeds in fields or in border areas adjacent to fields. Its numbers are low in these grasses, but since the grasses are common, a large number of borers are available to infest corn fields even in the absence of previous plantings of corn.

IV. Parasite survey:

Corn borer larvae were collected from Harmon and reared on corn cobs in 16 oz. plastic cups. Larvae were checked daily for emergence of parasites. No parasites emerged from 1100 larvae. Larval parasites are evidently not present on Guam.

Cantaloupes

Two experiments were run to test methods of controlling *Thrips palmi*. One experiment examined the effect of mulching on thrips numbers and the other was a screening trial of standard insecticides used on Guam sprayed at the maximum allowable rates.

I. Mulching trial:

Materials and Methods

A trial to test the effects of black plastic mulch on insects attacking cantaloupes was planted May 28, 1985, at Inarajan. Cantaloupe seeds (Var. Planter's Jumbo) were planted at a density of 3 plants every 30 cm. Rows were 13.7 m long and 1.5 m apart. Fertilizer was applied at a rate of 0.7kg of 10-30-10 per row. Treatments were black plastic mulch placed before planting or no mulch. Plants were sprayed with benomyl (1 Tb/gal) to control downy mildew. Insects were

Table 4. Leaf ratings for U. S. field corn inbreds with previously shown potential for corn borer resistance.

Inbred	Leaf rating
N7A	6.2a
CH593	6.0a
A619	6.0a
Mo13	6.0a
B68	5.6ab
Ms1334	5.4abc
Pa762	5.4abc
H60	4.4abcd
CI31A	4.4abcd
CI66	3.9abcd
H99	3.3bcd
A638	3.2bcd
Mp702	3.1bcd
W117	3.1cd
Mp704	2.8cd
Mp496	2.2d

Numbers within a column followed by the same letter are not significantly different at the 0.05 level (DMRT).

Table 5. Continued.

Inbred	No. Reps.	Mean Leaf Rating	
CM117	3	5.2	EBDAGCF
CM207	3	5.2	EBDAGCF
CM103	2	5.1	EBDAGCF
ICAL221	3	5.1	EBDAGCF
SC12	3	5.1	EBDAGCF
FLA2AT114	3	5.0	EBDAGCF
SR52F	1	5.0	EBDAGCF
INV534	4	4.9	EBDAGCF
B84	1	4.8	EBDAGCF
HI29	4	4.8	EBDAGCF
ICAL224	4	4.6	EBDAGCF
FLA2BT106	2	4.6	EBDAGCF
F44	3	4.6	EBDAGCF
FLA2AT115	2	4.5	EBDAGCF
PA762	2	4.5	EBDAGCF
HI34	2	4.4	EBDAGCF
FLA2BT54	4	4.3	EBDAGCF
H55	2	4.2	EBDAGCF
INV36	3	4.0	EBDAGCF
HI39	3	3.9	EBDAGCF
ICAL36	1	3.6	EBDAGCF
FLA2AT113	1	3.6	EBDAGCF
HI30	1	3.6	EBDAGCF
FLA2BT73	1	3.6	EBDAGCF
H632F	2	3.5	EBDAGCF
MP68:616	1	3.5	EBDAGCF
N6G	2	3.2	EBDGCF
HIX4267	1	3.2	EBDGCF
HI31	1	2.5	EDGCF
MP496	1	2.4	EDGCF
INV138	2	2.3	EDGCF
CI66	1	2.3	EDGCF
CIM.T11ES	1	1.8	EDGF
HIX4231	1	1.7	EGF
ANTC5S5	1	1.7	EGF
H60	1	1.6	FG
HI40	1	1.4	G

Inbred	No. Reps.	Mean Tassel Rating	
INV575	4	3.4	EBDACF
CM117	3	3.4	EBDACF
T220	2	3.4	EBDACF
HAWAIIAN SS10	4	3.4	EBDCF
TX601	3	3.4	EBDCF
TX29A	3	3.3	EBDCF
HIX4283	2	3.3	EBDCF
A619	1	3.3	EBDCF
T258	1	3.2	EBDCF
CM103	1	3.1	EBDCF
N139	3	3.1	EBDCF
INV534	2	3.1	EBDCF
IITA1368	3	3.1	EBDCF
HI26	2	3.1	EBDCF
CIM.A-21	3	3.1	EBDCF
ICAL210	3	3.1	EBDCF
H632G	3	3.1	EBDCF
PA762	3	3.1	EBDCF
NC248	1	3.0	EBDCF
FLA2AT114	1	3.0	EBDCF
TUXPENO-S5	1	3.0	EBDCF
OH43	2	3.0	EBDCF
ANT C5S5	2	3.0	EBDCF
N28	2	3.0	EBDCF
SC55	3	3.0	EBDCF
ARG F298	3	2.9	EBDCF
INV138	2	2.9	EBDCF
AR258	2	2.9	EDCF
HI31	2	2.9	EDCF
FLA2AT113	1	2.9	EDCF
ICAL223	2	2.8	EDCF
NC246	1	2.8	EDCF
H95	3	2.8	EDF
HI41	1	2.8	EDF
PHIL DMR6-S5	3	2.7	EDF
FLA2BT106	3	2.7	EDF
HIX4267	3	2.7	EDF
HI34	2	2.6	EDF
MP68:616	2	2.5	EDF
ICAL25	1	2.5	EF
ICAL29	1	2.0	F

[1] Numbers within a column followed by the same letter are not significantly different at the 0.05 level (DMRT).

Table 6. Damage caused by Asian corn borer to ears and stalks of selected inbreds of tropical corn.

Breeding Line	Mean Ear Rating	Number Replicates	Mean Stalk Damage %	Number Replicates
CM116	2.2	4	14.0	4
CM117	2.2	4	16.8	4
CM207	2.1	3	14.7	4
CI64	2.6	4	14.4	4
FLA2BT54	2.3	3	17.8	3
F44	2.0	4	11.6	4
HI29	2.3	3	12.9	4
HI35	2.6	3	21.9	3
H632F	2.5	4	17.6	4
ICAL221	2.4	3	13.1	4
ICAL223	2.3	3	8.5	4
INV302	2.4	3	19.4	3
INV36	2.5	4	12.8	4
INV575	2.1	4	13.2	4
KU1409	2.7	4	19.0	4
KU1414	2.8	4	27.4	4
MO5	2.5	2	7.0	3
MP68:616	2.1	3	15.7	3
N6G	2.4	3	11.0	4
PHIL DMR6-S5	2.8	4	14.9	4
TX5855	2.3	3	14.5	4
TX601	2.5	2	16.8	2

Table 7. Impact of detasselling silk-stage corn and insecticide treatments for control of the Asian corn borer.

Treatment	Mean number of undamaged ears
Dipel	42.5
Dipel+Pydrin	47.75
Dipel+detasselling	58.25
Untreated	27.75

Table 8. Evaluation of insecticides for control of *Thrips palmi* on cantaloupe.

Treatment	Lbs A.I./100 gal.	Number thrips/leaf	Yield (kg)
Dimethoate 2.67EC	0.5	29.9a[1]	23.60a
Dibrom 8EC	2.0	36.9a	20.60a
Lannate 1.8L	0.9	33.8a	25.05a
Malathion 5EC	1.3	40.5a	14.80a
Pydrin 2.4EC	0.1	48.7a	26.40a
Check		12.5a	20.95a
Coefficient of variation		.58	.45

[1]Numbers followed by the same letter within a column are not significantly different at the 0.05 level (DMRT)

Table 9. Evaluation of pesticides in increasing yields of flowering mangoes.

Treatment	Average flower damage rating	Total number fruit harvested	Number good fruit harvested
Dipel	0.50	16.0ab [1]	8.3ab
Captan	1.30	8.3a	3.7a
Dipel+Captan	0.35	36.3b	22.5b
None	1.25	9.2a	5.3a

[1]Numbers followed by the same letter within a column are not significantly different at the 0.05 level (DMRT)

sampled by randomly choosing tips and collecting the 8th leaf back from the tip. All insects within a 4.5 cm diameter circle were counted under a binocular microscope. Samples were taken on July 8, July 23, Aug. 8.

Results

In the first sample, aphids and spider mites were relatively abundant. Aphids averaged 1.4 individuals per leaf in the mulched rows and 9.2 per leaf in the unmulched rows. The difference was significant at the 0.05 level (Student's t-test). Spider mites were more abundant in the mulched rows, averaging 6.7 per leaf, compared to an average of 3.0 per leaf in the unmulched rows, although the difference was not significant. In subsequent samples, all insects were present at abundances of less than one per leaf and no differences between treatments were observed.

On all sample dates thrips were very rare, averaging less than one per leaf, and no differences between treatments were observed.

The benomyl treatments were too infrequent to adequately control downy mildew and no yield was obtained.

II. Evaluation of insecticides:

Materials and Methods

Cantaloupes (var Edisto 47) were planted on Dec. 18, 1984, at Inarajan. Plots consisted of two 9m rows, 1.2m apart. Plots were 2m apart. Six hills were planted in each row at even spacings. Each treatment was replicated four times using a randomized, complete-block design. Plots were sprayed to the drip point with insecticides with a backpack sprayer twice a week beginning Jan. 15. Once a week, all plots were sprayed with benomyl (1 tsp/gal) to prevent downy mildew. Sticker, Triton B-1956, was applied with all treatments. On Feb. 12, all plots were artificially infested with thrips by five heavily-infested cucumber leaves within the foliage. On March 19 thrips were sampled by randomly selecting 20 tips per plot, collecting the tenth leaf from the tip and counting the thrips. All yield was harvested.

Results

The number of thrips was lowest in the control plots, although the difference was not significant for any of the treatments. There was no difference in yield among treatments. None of the insecticides tested were useful for controlling *T. palmi* (Table 8).

Mango

I. Impact of the mango shoot moth, *Bombotelia jocosatrix* on leaf production

The study of the impact of *B. jocosatrix* on mango was continued into 1985.

Results

The treated trees averaged about 1/4 as many caterpillars as the untreated ones and had very few caterpillars except during the end of the monitoring period (Fig. 1). The total leaf area produced was 5.9 m2 per 25 shoots on the treated trees and 3.3 m2 in the untreated trees. Shoot growth averaged 20cm on treated trees compared to 11cm on untreated trees. Flowers were produced on 35% of the treated branches and 13% of the untreated ones. Trees with a leaf area of less than 4.5 m2/25 shoots did not produce flowers (Fig 2), suggesting the hypothesis that there is a relationship between leaf area and flowering. However, because of the low number of trees (8) included in the study, the results could be spurious. Further work on this possible relationship is needed. All but one of the untreated trees had less than 4.5 m2 of leaf area/ 25 shoots. Fruit production was not measured because of heavy damage to the flowers by *B. jocosatrix*. In summary, *B. jocosatrix* had a significant impact on the mango both in reducing the amount of foliage and in destroying flowers.

II. Evaluation of pesticides on mango flowers for fruit production

In an attempt to control the mango shoot moth and diseases on flowers, an experiment was designed to test the effectiveness of Dipel and Captan. The treatments were the insecticide *Bacillus thuringiensis* (Dipel®), the fungicide captan(50% WP), both pesticides together, or no treatment.

Methods

The experiment was conducted in a mango orchard in Agat. Individual trees were induced to flower by spraying a 1:1 mixture of KNO_3 and $NaNO_3$ at the rate of 100g of each chemical per 100 gallons of water. Trees were treated with the mixture two times; on Jan. 16 and 23. As soon as flower buds were observed, the treatments were started. Each treatment was applied to half a tree, and replicated six times in a randomized block design. The pesticides were applied at the rate of 2 lbs per 100 gallons water. On Feb. 15, 10 flowers per treatment were chosen randomly, and rated. If the flower was undamaged, it was rated 0, if it was partly consumed it was rated 1, and if it was completely consumed it was rated 2. Fruit was harvested as it was beginning to ripen, sorted into damaged and undamaged groups, and counted. Fruit was harvested on May 23 and May 30.

Results

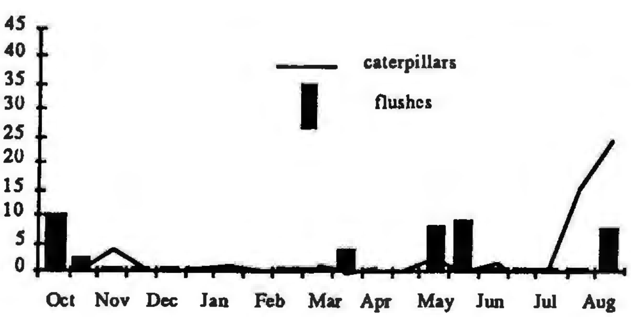
Observation of the trees after flowering indicated that large numbers of mango shoot moths were present on the new flowers. The Dipel treatments significantly decreased the amount of damage sustained by the flowers(Table 9; Kruskal-Wallis test. Corrected H=8.74. probability < 0.05). Untreated trees or trees treated only with fungicide had 47% of their flower stalks completely consumed and 24% partly consumed. In contrast, in the two treatments using Dipel, 11% of the flowers were completely consumed, 21% partly consumed and 68% were not damaged. However, one tree in the Dipel alone treatment had most of its flowers consumed, indicating that careful monitoring or more frequent spraying may be necessary to reliably prevent significant damage by the mango shoot moth.

The total number of fruits harvested was nearly three time as high in the Dipel+ Captan treatments than in the treatments using only Dipel and nearly 6 times as many as the other treatments (Table 9). The Dipel-alone treatments had almost twice as many fruit as the other two treatments. The captan treatments produced slightly more fruit than the untreated trees. The proportion of good fruit was 62% in the Dipel+Captan treatments, 52% in the Dipel treatments, 48% in the untreated treatments and 42% in the captan treatments. Captan appeared to help increase the fruit set, but was not effective at improving the quality of the fruit. Much of the damage to the fruit observed at harvest appeared to be due to mango scab.

Survey of crop pests in Kosrae

Citrus, head cabbage, Chinese cabbage, watermelon, cucumbers, corn and sweet potatoes were surveyed for pests in Kosrae. Most of the citrus survey work concentrated on tangerine, although orange and lime were also examined.

Citrus : A list of insects found on citrus is given in Table 10. The most abundant insects were scales, spiny whiteflies, various hoppers and aphids. Fruit flies, *Dacus frauenfeldi*, were reared from tangerines, but were only found in a few localities.



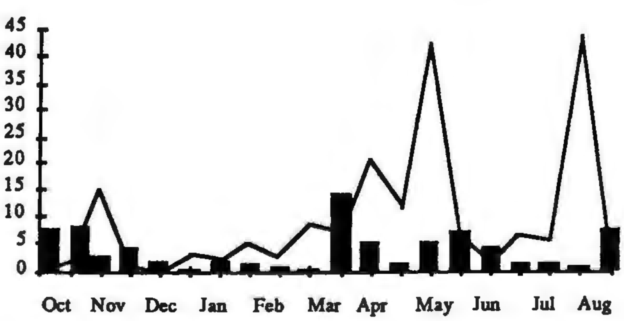


Fig. 1. Changes in the numbers of *Bombotelia jocosatrix* in relation to the number of tips flushing.

Vinsonia stellifera (Westwood)and *Coccus viridis* (Green) are new records for Kosrae. A scale, *Abgrallaspis palmae*, was the most abundant scale but was heavily parasitized by an entomophagous fungus and an unknown wasp. The other scales were uncommon. Most of the hoppers, including *Lamenia caliginea*, *Phaciocephalus phaedra*, and *Uguops kinbergi* were not abundant. Adults of *Armacia clara* were present in large numbers on occasion, but did not seem particularly damaging. A Derbid, *Flaccia dione* Fennah, was found in large numbers at several sites and was damaging some plants. No juveniles of any hopper species were found on citrus. Damage characteristic of the Fruit Piercing Moth, *Othreis* sp. was also found on some fruit. A tortricid moth, *Adoxophyes fasciculana*, was webbing the tips of new growth together, feeding on the young leaves and boring into the shoot tip. Isolated pockets of *Aphis gossypii* were found, but were typically not present in damaging numbers.

Vegetable Crops: A list of insects found on vegetables is given in Table 11.

Brassica (Chinese cabbage and head cabbage): These crops were remarkably free of insect damage. *H. tibialis* was the only insect pest of significance and in almost all cases, it was not abundant enough to cause serious damage. Adults of the delphacid *Sardia pluto* were found on cabbage in very low numbers. A single larvae of *Heliothis* sp. was found in a head of cabbage.

Cucurbits (cucumber, watermelon): On both crops, aphids, principally *A. gossypii*, were abundant and were highly damaging. *Empoasca* sp., *H. tibialis*, and *Lygus kusaiensis* were also problems in certain fields. Adults of the cerambicid beetle, *S. latior*, were present in low numbers and were feeding on the leaves of cucumber.

Solanum melongena (eggplant): *Empoasca* sp., *A. gossypii*, *L. kusaiensis, and Phaciocephalus phaedra* were common on eggplant.

Taro: The hopper *Lallemandana phalerata* was sufficiently abundant to cause yellowing of the leaves. Immatures of the Ricaniid, *Armacia clara* were found on *Alocasia*.

New Insects Identifications: Beginning with 1985 all insect identified as being new on Guam or Micronesia will be included in the annual report to provide an informal record. All insects not previously reported in annual reports are included (Table 12).

Publications of Entomology Section, 1985

1985. Schreiner, I. and D. Nafus. Control of mango shoot moth, 1983. Insecticide and Acaricide Tests 10:39-40.

1985. Nafus, D. and I. Schreiner. Effectiveness of insecticides against Asian corn borer. Insecticide and Acaricide Tests 10:107.

Table 10. Insects found on Citrus on Kosrae

Scientific Name	Common Name	Distribution
	HOMOPTERA	
DELPHACIDAE		
Ugyops kinbergi kusaieana Fennah	sharp-nosed plant hopper	Kosrae
DERBIDAE		
Lamenia caliginea Fennah	purple planthopper	Pacific Islands
Phaciocephalus phaedra Fennah	striped planthopper	Marianas, Carolines
Flaccia dione Fennah	planthopper	
RICANIIDAE		
Armacia clara Fennah	Clear-winged plant hopper	Carolines
APHIDIDAE		
Aphis gossypii Glover	cotton or melon aphid	Cosmopolitan
Aphis craccivora Koch	cowpea aphid	Cosmopolitan
ALEYRODIDAE		
Aleurocanthus spiniferus (Quaintance)	orange spiny whitefly	Guam, Ponape, Kosrae, Asia
PSEUDOCOCCIDAE		
Planococcus citri (Risso)	citrus mealybug	Pan tropical
COCCIDAE		
Pulvinaria psidii Maskell	green shield scale	Widespread
Saissetia nigra (Nietner)	nigra scale	Widespread
DIASPIDIDAE		
Aonidiella inornata McKenzie	inornata scale	Widespread Hemiberlesia
palmae (Cockerell)	palm scale	Widespread
Parlatoria proteus (Curtis)	variable shaft scale	Widespread
	COLEOPTERA	
CHRYSOMELIDAE		
Rhyparida carolina Chujo	caroline mango leaf beetle	Micronesia
	LEPIDOPTERA	
SPINGIDAE		
Othrais sp.	orange piercing moth	Widespread
TORTRICIDAE		
Adoxophyes fasciculana (Walker)	citrus shoot moth	Pacific Islands

Table 11. Insects found on selected vegetable crops on Kosrae.

Brassica spp. ____________ Cabbages and related crops

Aphis gossypii Glover	cotton or melon aphid	Widespread
Halticus tibialis Reuter	black garden fleahopper	African, Oriental
Sardia pluto (Kirkaldy)	leafhopper	Western Pacific

Cucurbitaceous plants __________ cucumber, melons, etc.

Aphis gossypii Glover	cotton or melon aphid	Widespread
Aphis craccivora	cowpea aphid	Widespread
Halticus tibialis Reuter	black garden fleahopper	Caroline, Marianas Lygus
kusaiensis Carvalho	kosrae lygus bug	Kosrae
Lamenia caliginea Fennah	purple plant hopper	Pacific Islands
Sciadella latior (Blair)	spiny-winged long-horn beetle	Kosrae, Ponape

Solanum melongena __________ Eggplant

Aphis gossypii Glover	cotton or melon aphid	Widespread
Saissetia nigra (Nietner)	nigra scale	Widespread Phaciocephalus
phaedra Fennah	striped plant hopper	Marianas, Carolines
Empoasca sp.	leafhopper	
Lygus kusaiensis Carvalho	kosrae lygus bug	Kosrae, Ponape

Zea mays ____________ Maize or corn

Saissetia nigra (Nietner)	nigra scale	Widespread

Ipomea batatas _____ Sweet potato

Aphis craccivora	cowpea aphid	Widespread
Lygus kusaiensis Carvalho	kosrae lygus bug	Kosrae, Ponape
Halticus tibialis Reuter	black garden fleahopper	Carolines, Marianas Ugyops
kinbergi Fennah	sharp-nosed plant hopper	Carolines
Nysius pulchellus Stal	lygaeid bug	Carolines

Colocasia esculenta _____ Taro

Aphis gossypii Glover	cotton or melon aphid	Widespread
Ugyops kinbergi Fennah	sharp-nosed planthopper	Kosrae, Carolines
Lallemandana phalerata Metcalf	Yellow-striped froghopper	Carolines, Marianas
Tarophagus proserpina (Kirkaldy)	taro leafhopper	Widespread
Pseudococcus orchidicola Takahashi	orchid mealybug	Micronesia
Saissetia nigra (Nietner)	nigra scale	Widespread

Table 12. New insects reported on Guam, 1980-1985, not previously reported in the Annual Reports. All insects reported are established.

Species	Order	Year	Host	Comments
Maconellicoccus hirsutus	Homoptera	1983	hibiscus	present several years before ID
Ceroplastes ceriferus	Homoptera	1983	Ficus sp.	parasitized
Steatococcus samaraius	Homoptera	1985	monkeypod	
Aleurothrixus floccosus	Homoptera	1984	citrus,guava	
Heteropsylla sp. poss.*incisa*	Homoptera	1985	Leucaena	
Rhyparida sp.	Coleoptera	1985	unknown	
Popillia lewisii	Coleoptera	1985	many	eradication being attempted
Ganaspidium hunteri	Hymenoptera	1985	Liriomyza	released for biocontrol, recovered
Eucoilidea micromorpha	Hymenoptera	1985	Liriomyza	present several years before ID
Cothonaspis pacifica	Hymenoptera	1985	Liriomyza	present several years before ID
Pareuchaetes pseudoinsulata	Lepidoptera	1985	Chromolaena	released for biocontrol, recovered
Elasmus sp. near *atratus*	Hymenoptera	1985	?	poss. parasite betelnut caterpillar
Anisodes illepidaria	Lepidoptera	1985	mango	
Delta pyriforme	Hymenoptera	1985	predator	present since mid 70s
Other areas of Micronesia				
Aleurodicus dispersus	Homoptera	1985	Polyphagous	Belau
Coccus viridis	Homoptera	1984	Polyphagous	Kosrae
Vinsonia stellifera	Homoptera	1984	Polyphagous	Kosrae
Heteropsylla sp. poss.*incisa*	Homoptera	1985	Leucaena	Belau, CNMI

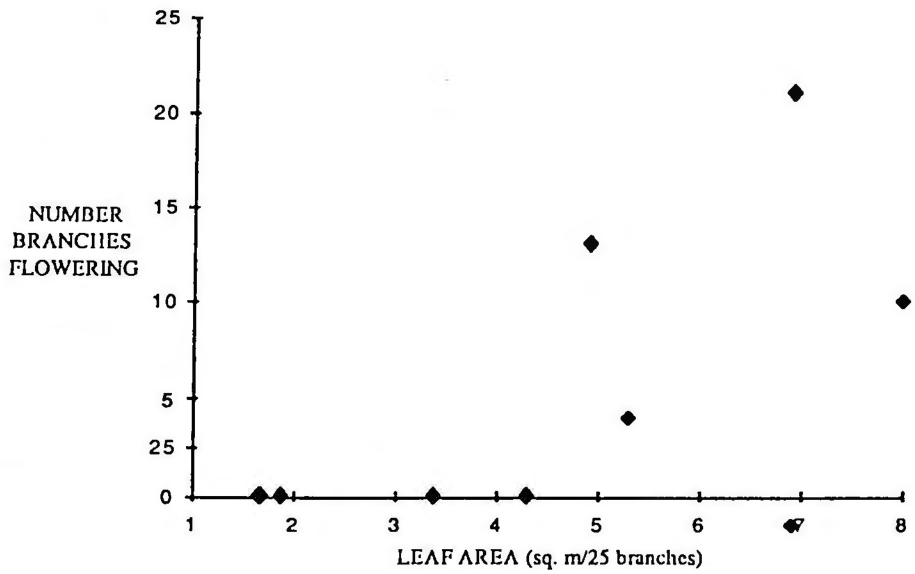


Fig. 2. Number of branches flowering as a function of leaf area

BIOLOGICAL CONTROL - continued

T. Seibert

I. Biological Control of *Chromolaena odorata*

The second year of the project to control *Chromolaena odorata* has been a successful one. One insect, *Pareuchaetes pseudoinsulata*, was established in the field after problems of large scale rearing and release were resolved. The documentation of the spread of the insect suggested hypotheses that may help explain the problems that have been faced worldwide in establishing this insect. Laboratory information obtained on the biology of *P. pseudoinsulata* will be of assistance in evaluating the condition of the field population in terms of host plant quality, and will allow one to follow changes that occur in various population characteristics over time. The mechanism of field maintenance of moth populations in areas where larvae have completely defoliated the host plant is under study as are other aspects of population growth and decline. Finally, characteristics of the host plants biology that are being affected by the defoliation pressure of the insect are being examined and will allow one to make an evaluation of the insects ability to control the plant in the long term.

Biology of *Pareuchaetes pseudoinsulata* - pupae and adults

Males typically emerge before females though this is of little significance in the field and merely reflects development times. Larvae that develop into either males or females may take from 5 to 6 instars. The development process appears to have shifted from 5 in the pre-release population to a combination of both 5 and 6 instars in the current field population. This shift has taken place over approximately 6 field generations. Follow-up laboratory rearing studies are in progress to determine whether this shift is environmentally or genetically determined.

Males typically live 3.65 days (s.d.=1.26) while females live 5.38 days (s.d.=1.56) under laboratory conditions. The females were never found to live longer than it was required of them to lay all of their eggs. Female fecundity varies with size and can be accurately predicted using the wing length of the female as a measure of adult size (fig. 1). Wing length is convenient for evaluating the fecundity of field-captured females, since body weight changes with the number of eggs laid and with the loss of body fluids due to excretion and evaporation. The same is true when considering the value of pupal weights as a predictor of fecundity. Laboratory measurements showed pupae typically losing 3.85 to 23.53% of their body weight from pupation to eclosion, making it a poor predictor of fecundity if weights are not taken at a uniform time following pupation. Wing length can also be used to accurately evaluate the condition of field populations because adult size is an indirect indicator of larval growing conditions.

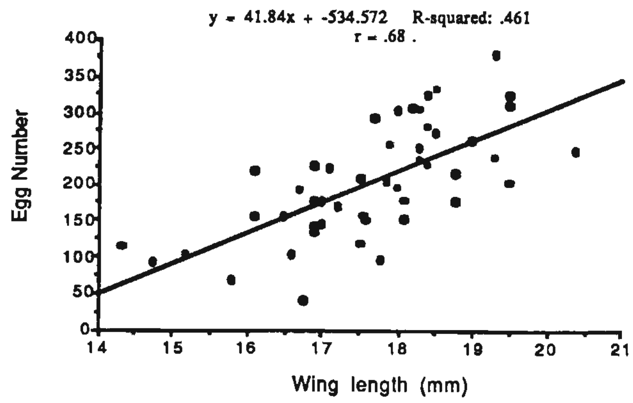


Figure 1. The correlation between the size of female *P. pseudoinsulata* (wing length) and the corresponding potential fecundity (egg number).

Laboratory rearing of *Pareuchaetes pseudoinsulata*

Techniques that would allow the rearing of large numbers of adults in the laboratory had to be developed before field populations of the insect could be established. The following schedule has been successful.

Early instars are reared in 16 oz. cups. Approximately 30 newly hatched larvae are placed together on one or two leaves. The containers should be airtight. This makes it possible for the vegetation to remain succulent for 1-2 days or until the larvae consume it. The vegetation should be changed after two days even if it has not been consumed. More vegetation increases the humidity to unacceptable levels. After the first two instars the larvae are transferred to a container approximately four times the original size with 1/4 inch hardware cloth bent to keep the vegetation off the bottom. This allows frass to fall clear of the food and reduces mortality due to disease at a later time. Finally, as the insects enter their most active feeding stages as fourth, fifth and sixth instar larvae, approximately 50 individuals can be placed in 25 gallon trash cans closed at the top by fine nylon mesh cloth that is held in place by an rope around the trash container. Several whole stems of vegetation are placed in as food. This allows for easy cleaning and separation of the larvae every 2-3 days and it keeps them out of the frass on the bottom. New food should be added as needed, often daily. The pupae form in the bottom amongst the frass or in leaves. Quarter-inch hardware cloth can be used to sift the frass for pupae whenever a food change takes place. The pupae should be kept in a sealed container until emergence, as this is a stage vulnerable to predaceous larvae. Adults are mated in 1x1x1ft nylon-organdy covered cages. They readily lay their eggs on the cloth sides. Eggs are collected by gentle scraping and placed in 16 oz cups until emergence.

The establishment of *Pareuchaetes pseudoinsulata*

It appears that the major obstacle to establishment is overcoming the resistance due to natural enemies. Numerous release efforts ended in failure when after only a few days, no sign of the released larvae could be found in the field. A maximum of 800 late instar larvae were released at one time with no successful recoveries the following generation.

Finally, in an effort to maximize the number of *P. pseudoinsulata* individuals in one location, adult moths were released. By doing so, all of the realized fecundity of the females was deposited in the field, rather than losing females and their offspring in the laboratory due to handling and crowding. For best results, it was found that approximately 500 adults, if released in the same location without attempting to spread them out, would establish. This is desirable because the high resulting density of larvae are believed necessary to swamp predators and create an epidemic population. The larvae feed on relatively small amounts of food until the fourth instar and are highly mobile by this stage being able to search out their own food over considerable distances.

The first recoveries of field reared *P. pseudoinsulata* were made in June of 1985 in Northern Guam. Later populations were also established in another N. Guam location and in a Central Guam location. The map in figure 2 shows the release sites and the current distribution of the insects. Releases were made in Rota in November and December, however no information has yet been obtained as to whether or not these insects have been established.

The initial spread of the insect was very slow. It is believed that this initial slow expansion is due to the small number of dispersing adults from the core population. As the core became larger and the number of dispersing adults grew, the natural enemies of previously unoccupied land were

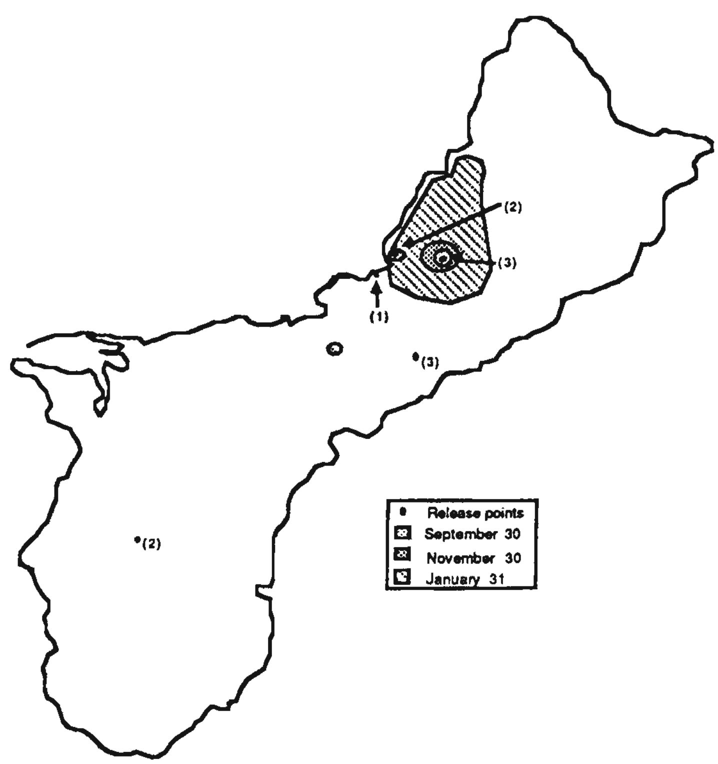


Figure 2. Map of Guam showing release sites and the spread of the insects over time. The number of releases are shown in parentheses. Marked releases occurred between May and August of 1985.

overwhelmed by the immigrating numbers of *P. pseudoinsulata* adults and the range expansion progressed in an exponential fashion. Further work to support or negate this proposed explanation of events is in progress. The evidence for natural enemy resistance is circumstantial at this point, however surveys beyond the center of defoliation showed no signs of any feeding damage by what would have been isolated colonization events. These early dispersal-colonization efforts are comparable to early attempts on Guam and elsewhere to colonize patches of *Chromolaena* with insufficient numbers of laboratory reared individuals.

The Pattern of Local Insect Population Growth and Decline

The local population at the initial release site went through a rapid expansion and then crashed following the 100% defoliation. The population was able to maintain itself in this area on very poor quality food (ie. stem tissue). Presumably, a part of the observed population was due to recruitment from the periphery of the expanding range and not natality in the local area. Gradually, new growth from the roots and an occasional bud that had not been destroyed provided some fresh food for this population.

Projecting ahead one can be optimistic and hope that the local *Pareuchaetes* populations can maintain themselves even on very limited food reserves and that their numbers will be great enough to stay ahead of suppression and/or local extinction by natural enemies. In so doing they should be able to maintain significant pressure on the *Chromolaena* and reduce its dominance in the plant community. On the pessimistic side, one can hypothesize that the local populations of *Pareuchaetes* will decline to levels below which they either go extinct or are too few to suppress *C. odorata* populations. Presumably local eruptions of *Pareuchaetes* may occur even if the latter scenario develops, and periodic widespread defoliation may occur. Erratic, widespread defoliation may still have a significant impact on the stature of *Chromolaena* in the community as current evidence suggests (see below). The timing of defoliation is important when considering the maintenance of the insect's population as the dry season advances. If the plants are defoliated while there is still time for them to produce new growth from either the roots or the stems, then the *P. pseudoinsulata* population may be able to maintain itself in an area and won't be necessary. However, if the insects destroy all of the lateral buds and the plants have no time to respond with new growth before the dry season, then there may be no palatable food until the onset of the transitional season and the local population may go extinct.

Pareuchaetes'* impact on *Chromolaena

The impact of *P. pseudoinsulata* on *C. odorata* is significant. As previously mentioned, 100% defoliation could be expected in an area. The shoot tips were severely chewed back and virtually all buds were also destroyed, leaving little or no source for regrowth from the stem. This is much more severe than a simple defoliation because the plant has no recourse other than to produce new shoots from the root cap. Plants defoliated in June had in many cases not yet produced new leaves or shoots. In the wetter areas, defoliated in August or September, regrowth from the root had commenced, however caterpillars of *P. pseudoinsulata* were found feeding at ground level and none of the emerging shoots examined could be seen without uprooting the plant. Additionally, in the area of initial defoliation there was considerable stem and individual mortality. Most of the plants died back to the ground level, but those in moist areas often were alive at the base.

The effect of defoliation on flowering was also considerable. As might be expected, those plants that were defoliated and had their growing tips and lateral buds destroyed prior to the onset of flowering in late November produced no flowers. An occasional bud was missed by feeding larvae, and in these rare instances regrowth from this bud would usually flower. Still, the contribution to seed set from this regrowth compared to control vegetation is insignificant.

Plants that were defoliated while they were in the early stages of flowering had seed contributions to the next generation reduced in one of three ways: 1. The caterpillars after defoliating the plant would feed on the capitula and its developing seeds, usually leaving the surrounding bracts intact but destroying all seed production from that head. (The flowers prior to opening were also untouched indicating the bracts must contain an unpalatable chemical). 2. By comparing the germination success of seeds that developed from plants that were simultaneously being defoliated with control seeds produced by undefoliated plants, it was found that germination was significantly reduced due to the defoliation ($n_{defoliated}$=571, $n_{control}$=484, Chi Square=43.26, p<.005). 3. Seeds of defoliated plants were also significantly lighter ($n_{control}$=104, $\bar{x}_{control}$=.152, $n_{defoliated}$=100, $\bar{x}_{defoliated}$=.125, t=3.188, .0005<p< .005) indicating much of the resources for seed development come from the leaves. Field survivorship of these reduced size seeds probably would be reflected in increased mortality as the weight reduction was undoubtedly in the form of endosperm for growth prior to photosynthesis, Without this early resource fewer embryos would be expected to attain an independent size.

II. The effect of the parasite, *Anagyrus indicus*, on the spherical mealybug

The Spherical Mealybug project was completed in early 1985. The final experiments had two goals: 1. An analysis of the pattern of parasitism by *Anagyrus indicus* within local populations of *Nipaecoccus vastator* and its influence, if any, on the observed cluster sizes of the mealybug; 2. The impact of parasitism by *A. indicus* on the fecundity of *N. vastator* when parasitism occurs in different mealybug instars. Additionally, in early 1985 the invasion by *Heteropsylla* sp. of the principal host plant on Guam of *N. vastator*, *Lucaena leucocephala*, prompted surveys for the mealybug and *A. indicus* to determine the impact of this Psyllid on their presence.

Parasitism by *A. indicus* and its influence on cluster sizes of *N. vastator.*

The data used for the evaluation of Spherical mealybug cluster size as influenced by *A. indicus* parasitism was from field experiments on the effect of ant attendance on parasitism by *N. vastator* (Nechols and Seibert 1985). Cluster size is based on the number of third and fourth instar individuals present. Only these instars were used because they are the preferred host stage for oviposition by A. indicus. Clusters are defined as distinct aggregations of *N. vastator* individuals.

The principal results are summarized as follows:

1. The probability of encounter by *A. indicus* of ant attended or unattended clusters as measured by the presence of any parasitized individual appears higher for larger-clusters than for smaller clusters. The relationship is nonlinear.
2. Percent parasitism by *Anagyrus indicus* is similar for different cluster sizes of *N. vastator* if encountered by parasites and not tended by ants. However, individuals in ant-tended clusters of *N. vastator* have a higher probability of surviving in larger clusters.
3. The cluster size predicted by the intersection of the change in rate of parasitism and the probability of encounter is close to the observed average cluster size in the field.

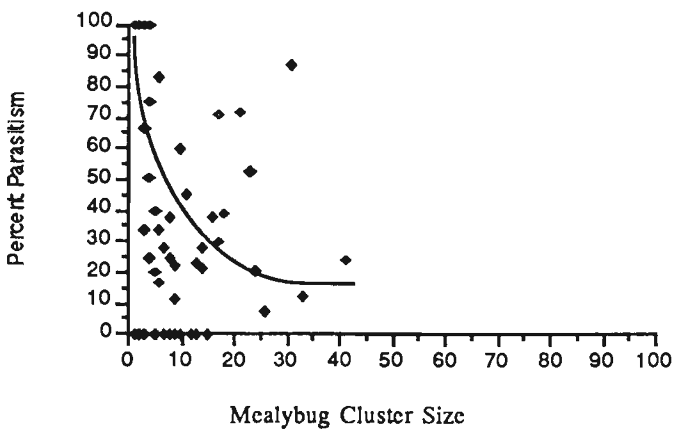


Figure 1a. The percent parasitism of *N. vastator* by *A. indicus* when ants are excluded by tanglefoot™. All clusters are included.

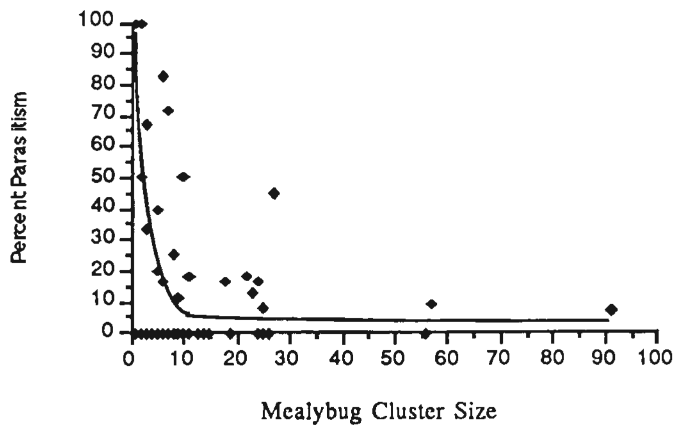


Figure 1b. The percent parasitism of *N. vastator* by *A. indicus* when ants are present. All clusters are included.

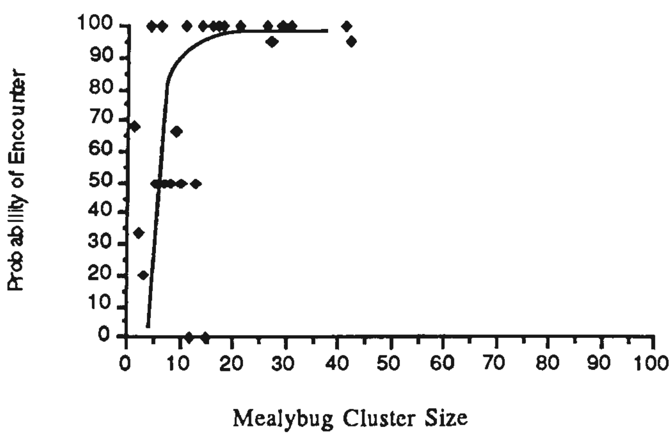


Figure 2a. The probability of *N. vastator* clusters being encountered by *A. indicus* parasites as a function of cluster size when ants are excluded. Probability of encounter is the proportion of clusters of a given size that have at least one parasitized individual. The assumption made is that if a female parasite encounters a cluster she will oviposit into at least one individual.

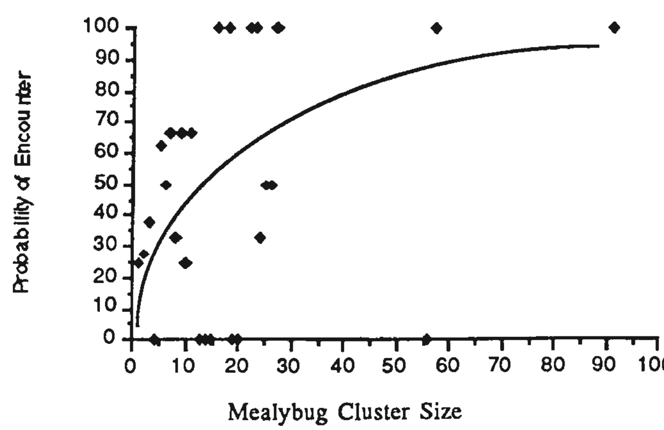


Figure 2b. The probability of *N. vastator* clusters being encountered by *A. indicus* parasites as a function of cluster size in the presence of ants. Probability of encounter is described in fig. 2a.

Though there appears to be no significant difference between the percent survivorship for clusters whether tended or not tended by ants (fig. 1 a,b), a pattern emerges when breaking the data into probability of encounter and percent parasitized once encountered. It is important to make this distinction because both determine the likelihood of being parasitized. The overall percent parasitism will vary with the quality of protection offered by ants, and the parasite/prey ratio, but how they vary will be determined by the probability of encounter and the number parasitized in a cluster once encountered. Larger cluster sizes are more likely to be encountered as determined by the presence of any parasitized individuals in a cluster (Figs. 2a,b). Without ants, larger encountered cluster sizes appear to provide little protection from parasitism by *A. indicus* (fig. 3). However, in the presence of ants, a distinct curvilinear pattern emerges. The point where the curve levels out may be the minimum cluster size necessary to maintain constant attention by ants due to honey-dew secretion. Larger clusters appear to be protected from *A. indicus* better than encountered clusters smaller than about 10 to 15 individuals (Fig. 4).

In trying to minimize parasitism and encounter by parasites, *N. vastator* cluster sizes that reduce overall encounter and parasitism may be hypothesized to be selected for. To test this hypothesis, the intersection of the curve tracing the percent *N. vastator* parasitized in given cluster sizes with the line approximating the probability of being encountered as a function of cluster size was predicted to be near the observed field cluster size if parasitism by *N. vastator* was important. Figures 5 and 6 show the intersection of these lines for

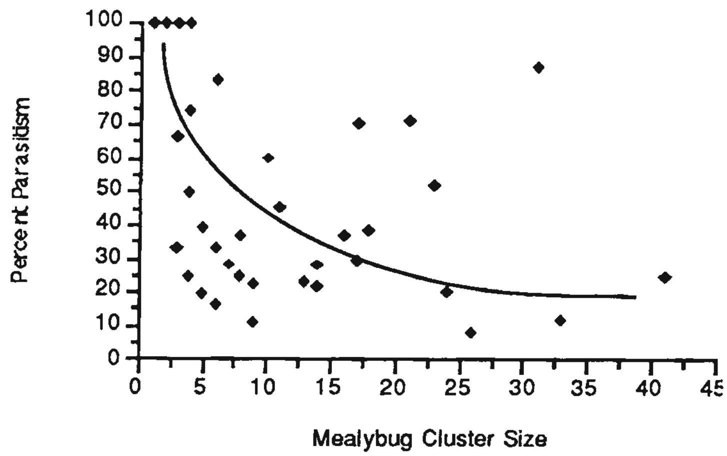


Figure 3. The percent parasitism of *N. vastator* clusters in the absence of ants. Clusters that were not encountered are excluded.

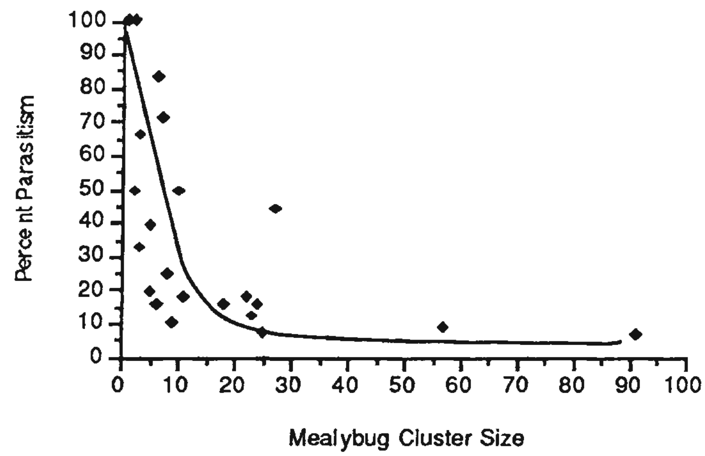


Figure 4. The percent parasitism of *N. vastator* clusters in the presence of ants. Only encountered clusters are included.

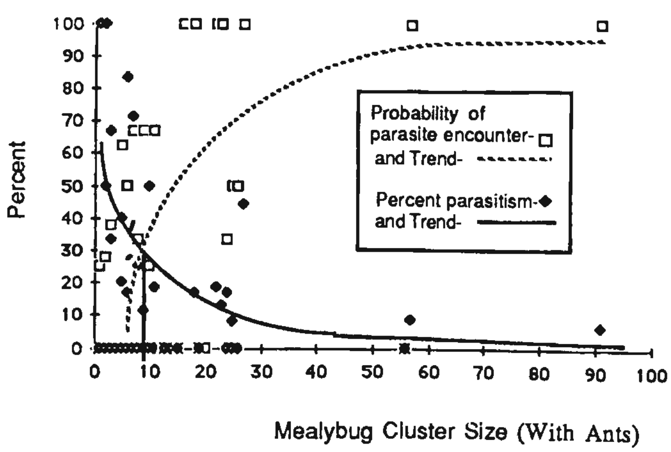


Figure 5. Nonlinear changes in percent parasitism and the probability of encounter as a function of cluster size (curves fit by eye). The intersection of these two selection pressures may represent a compromise size that minimizes parasitism by keeping the largest cluster size possible without significantly increasing the probability of encounter. The intersection occurs at a cluster size of 9. This is close to the observed average field cluster size with ants of $\bar{x} = 7.88 \pm 12.07$.

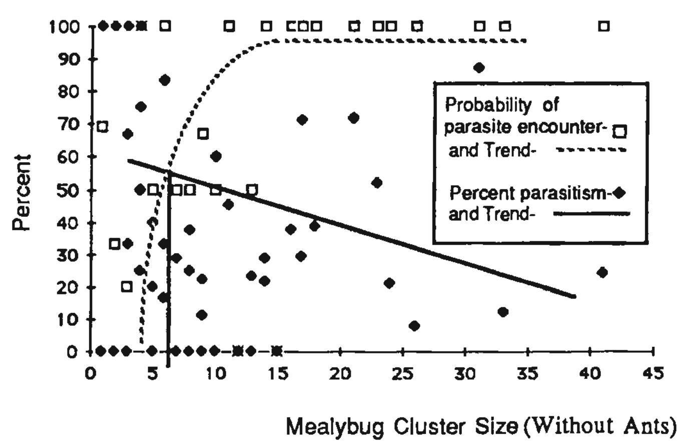


Figure 6. Changes in percent parasitism and the probability of encounter as a function of cluster size (curve fit by eye). The intersection occurs at a cluster size of 6.5. This is close to the observed average field cluster size without ants of $\bar{x} = 7.87 \pm 5.39$.

clusters with and without ants respectively. The value predicted for the unattended clusters was smaller than for the tended clusters. The average field cluster sizes for both ant-tended and unattended clusters were not significantly different though both were near the predicted values.

Considering the variability resulting from the local assemblage of clusters (i.e., the distance to the nearest neighboring cluster(s) and the variation in parasite and ant densities), the observed field cluster sizes indicated in this analysis could be explained by pressure to reduce parasitism. However, alternative hypotheses must be considered.

Another major selection pressure shaping cluster size in sap suckers that has been demonstrated in other systems is host plant quality.

To distinguish between the hypotheses that parasites or host plant quality select for *N. vastator* cluster sizes, further experimental evaluation is necessary. Differences within host plant species when host plant quality is locally increased by foliar fertilizer may produce larger local *N. vastator* aggregations on treatment branches if host plant quality is more important in shaping cluster size than is pressure from parasitism by *A. indicus*. A similar experiment for evaluating the role of available space in limiting cluster size may be approached by providing suitable host feeding sites of different sizes and predicting no ceiling to growth if parasites are unimportant.

The influence of age when parasitized on realized fecundity.

The purpose of this experiment was to evaluate 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. The extent of this contribution may profoundly effect the outcome of population models based on parasitism and appears to have been largely overlooked in the literature to date. To quantify the effect of parasitism, methods for evaluating total individual fecundity for females from third and fourth instars were developed. These methods follow. Unfortunately, the experiment was terminated before further refinement of the methods could be completed and the actual experiment begun. It is hoped that the the approach to the question of individual fecundity as influenced by age at parasitism can be continued by this or other workers at some point in the future and that these methods and recommendations will assist in the development of those projects.

Methods for evaluating individual Fecundity

1. The last two instars are desirable for study as these are the preferred host stages of the *A. indicus* female for oviposition. Two weeks prior to the hatch of new crawlers, the ovisac of the female is removed and placed in 95% alchohol to dissolve the ovisac and facilitate counting of the eggs or young crawlers contained therein. The female is returned to the plant and the procedure repeated until the female dies.

When comparing this approach to caging, the eggs or early crawlers are still contained within the eggsac and no sophisticated apparatus is necessary to keep crawlers from leaving the plant intentionally or otherwise. Several caging designs were tried and none were as satisfactory as periodic eggsac removal.

2. Precautions:

a. Care must be taken not to damage the female when dislodging her from the host plant to remove the eggsac. The removal is easily accomplished with practice.

b. The host plant these trials were carried out on, *Jatropha integerima*, has short hairs that make it difficult for the female to reattach once dislodged. If *Jatropha* is used, the surface should be shaved to allow the mealeybug complete access to the central leaf vein.

c. The major problem with the approach is the variation in host plant quality between sites on a plant and between plants. This variation will affect both fecundity and longevity. Instead of *Jatropha*, it is recommended that a more uniform host resource for *N. vastator* be used such as potatoes or pumpkins to eliminate or reduce this intra-host variability.

Planned approach once methods of evaluating individual fecundity were satisfactory:

A. Female mealeybugs would be exposed to parasites as third and fourth instars for one day and then isolated and allowed to develop along with unexposed controls.

B. The methods outlined above for evaluating fecundity would be repeated for the exposed and control individuals until the females die.

C. Data collected should include age when egg sacs are fully developed, number of eggs produced per unit time, total number of eggs produced, female longevity and the number of parasites that develop.

Current status of *N. vastator* and *A. indicus* on Guam.

In early 1985 an irruption of *Heteropsylla* sp.(Homoptera: Psyllidae) occurred on *Lucaena leucocephala* on Guam. This is the principal host plant for *N. vastator* on the island. Widespread defolition occurred and a roadside census revealed less that 2% of the sites (n = 110 sites) had *N. vastator* present. No Anagyrus were recovered from the mealybugs collected for rearing and no exit holes were observed. A second similar census in late August and a third in late November of 1985 showed that *N. vastator* was not recovering.

AQUACULTURE

S. Nelson

The past year's efforts have dealt primarily with rabbitfishes. These are brackish-water herbivorous fishes of the genus *Siganus* which are commercially important throughout Micronesia and are currently being imported to Guam from the Philippines and Palau. These fishes have a high potential for aquaculture on Guam since they will readily accept pellet feeds as well as their natural diets of macrophytic algae. Observations by local fish farmers of the growth of rabbitfishes which have inadvertently entered their ponds indicate that these fishes will adapt well to pond culture on Guam, as has been demonstrated in other areas. Our preliminary trials at stocking one pond in Southern Guam with wild-caught juveniles confirmed this, even though the trial was terminated prematurely as a result of heavy mortalities following unusually heavy rains. There is considerable interest by local farmers in the cultivation of this species.

Our studies thus far have focused primarily on the feeding habits and digestive abilities of *Siganus argenteus* and *Siganus spinus*, the two most common rabbitfishes on Guam. These included an examnination of the natural diets of these species, determination of the assimilation efficiencies of wild-caught fish, laboratory determinations of assimilation efficiency of fish which were fed algal diets, and studies of their food preferences.

Our results indicate that the fish feed on a wide variety of benthic macroalgae. For example, Table 1 shows the percent occurence of algal species in the stomach contents of both species collected from a natural habitat at Sella Bay on the southern coast of Guam. Table 2 indicates the relative abundances of the algae which were found in the fish stomachs (The relative abundances were originally calculated as percentages but are expressed here as the means of the arcsine-transformed values in an attempt to normalize the data). Such a varied diet may be necessary to achieve good growth rates in algal-based, rabbitfish culture systems.

Assimilation trials with specific algal diets revealed that the efficiency of assimilation can be up to 54% of the total organics and up to 84% of dietary nitrogen for some algal diets. We noted with interest that rabbitfish could efficiently assimilate material from ingested thalli of *Gracilaria*, a commercially important red alga which also has potential for cultivation within the region. Work on the assimilation efficiencies of these fishes is continuing.

Table 1. The frequency (F) and the percent occurrence (%) of fish stomachs containg various alga taxa. The algal samples were obtained from the stomachs of rabbitfishes, *Siganus argenteus* (N=18) and *Siganus spinus* (N=8), collected from Sella Bay, Guam.

	Siganus argenteus		*Siganus spinus*	
Algal Taxa	%	F	%	F
Chlorophyta				
Boodlea	9	50	4	50
Chaetomorpha	2	11	0	0
Chlorodesmis	3	17	0	0
Cladophora	5	28	3	38
Cladophoropsis	11	61	1	13
Dictyosphaeria	0	0	1	13
Enteromorpha	12	66	22	25
Pseudochlorodesmis	3	17	0	0
Udotea	1	6	0	0
Ulva	1	6	0	0
Uniden. siphonous alga	6	33	0	0
Valonia	1	6	1	13
Chrysophyta				
Diatoms	17	94	1	13
Cyanophyta				
Oscillatoria	12	66	1	13
Unidentified alga	13	72	0	0
Phaeophyta				
Dictyotaceae	11	61	7	88
Ectocarpus	14	77	1	13
Padina	0	0	3	38
Sphacelaria	18	100	6	75
Rhodophyta				
Actinotrichia	2	11	0	0
Centrocerus	5	28	1	13
Ceramium	9	50	0	0
Champia	4	22	2	25
Gracilaria	18	100	8	100
Hypnea	0	0	1	13
Jania	0	0	7	88
Laurencia	7	39	0	0
Leviella	1	6	0	0
Mastophora	2	11	0	0
Polysiphonia	3	17	0	0
Spyridia	0	0	1	13
Uniden. coralline alga	2	11	0	0
Uniden. thalloid alga	4	22	3	38

Table 2. The mean arcsines of the percent relative abundances, the standard errors (S.E.) of the arcsines, and the mean percent relative abundances of alga taxa found in the stomachs of *Siganus argenteus* (N=18) and *Siganus spinus* (N=8) from Guam.

	Siganus argenteus			*Siganus spinus*		
Algal taxa	Arcsine	S.E.	Mean	Arcsine	S.E.	Mean
Chlorophyta						
Boodlea	8.07	3.07	1.9	6.65	1.35	4.9
Chaetomorpha	0.0	0.0	0.0	0.52	0.37	0.01
Chlorodesmis	0.0	0.0	0.0	1.34	0.80	0.10
Cladophora	2.52	1.23	0.2	2.43	1.06	0.17
Cladophoropsis	1.35	1.35	0.1	5.64	1.20	1.00
Dictyosphaeria	1.46	1.46	0.1	0.0	0.0	0.0
Enteromorpha	2.24	1.51	0.2	9.15	2.05	2.5
Pseudochlorodesmis	0.0	0.0	0.0	1.72	1.06	0.1
Udotea	0.0	0.0	0.69	0.69	0.01	
Ulva	0.0	0.0	0.0	0.69	0.69	0.01
Valonia	2.59	2.59	0.2	0.44	0.44	0.01
Unident. siphonous	0.0	0.0	0.0	3.24	1.20	0.3
Chrysophyta						
Diatoms	1.55	1.55	0.1	12.79	1.35	4.9
Cyanophyta						
Oscillatoria	1.31	4.51	0.1	4.07	0.81	0.5
Unidentified	0.0	0.0	0.0	10.02	1.81	3.0
Phaeophyta						
Dictyotacae	22.16	4.01	14.2	10.96	2.68	3.6
Ectocarpus	7.15	0.72	0.0	8.97	1.65	2.5
Padina	8.98	1.58	5.0	0.00	0.00	0.0
Sphacelaria	13.61	3.43	5.5	20.79	1.58	12.6
Rhodophyta						
Actinotrichia	0.0	0.0	0.0	1.22	0.84	0.1
Centrocerus	0.64	0.64	0.01	2.75	1.61	0.2
Ceramium	0.0	0.0	0.0	3.13	0.87	0.3
Champia	2.87	1.96	0.2	2.43	1.11	0.2
Gracilaria	41.83	4.69	44.4	28.67	1.29	23.0
Hypnea	2.97	2.97	0.3	0.0	0.0	0.0
Jania	12.35	2.31	4.6	21.64	1.92	13.6
Laurencia	0.0	0.0	0.0	5.71	2.14	1.0
Leviella	0.0	0.0	0.0	0.67	0.67	0.01
Mastophora	0.0	0.0	0.0	1.65	1.15	0.1
Polysiphonia	0.0	0.0	0.0	1.64	1.04	0.1
Spyridia	0.68	0.68	0.01	0.0	0.0	0.0
Unident. coralline alga	0.0	0.0	0.0	1.10	0.77	0.03
Unident. thalloid alga	7.55	4.03	1.7	5.42	2.74	0.9

CROP MODELS

C.T. Tseng

Introduction

Among the agroclimatic components, the daily sunshine hours, rainfall and temperature are the dominant factors that affect plant growth and crop yields. Below a certain base temperature a plant stops growing. Above the base temperature the development of plants depends on the effective temperature, which is the mean air temperature minus the base temperature, and the time duration of the plant growth. In the Eighteenth Century the French botanist Reaumur proposed to use the effective temperature-day (heat units) as an index to monitor plant development. It was assumed that aside from the sunshine hours which control the antithesis time of photoperiod sensitive plants, the physiological clock that sets the timing of phenological stages depends primarily on a single environmental temperature factor. This is in contrast with the growing rate, which depends on other environmental factors such as rainfall, solar radiations, nutrients, and insect stresses as well. Since the time of Reaumur's proposal, heat units (HU) or thermal time has been used to predict the onset of phenological stages and the maturity time of many crops. Crop models such as CEREAL and WHEAT developed in the USDA research centers have used the predicted phenological time to calculate the total amount of plant growth in all phenological stages to estimate crop yields.

Procedures and Results

There are several different mathematical formulations to estimate heat units. These formulations were developed for different field environments and different plot locations of the crops. On Guam and the Micronesian islands where the diurnal and seasonal temperature variations are not large, the heat units are given by:

$$HU = T, \text{ if } T \text{ is positive}$$
$$HU = O, \text{ if } T \text{ is negative or zero}$$

Where $T = (T_{max} + T_{min})/2 - T_{base}$,
and T_{max}, T_{min}, T_{base} are the daily maximum, daily minimum and base temperatures respectively.

For corn of the variety X304C grown in Texas, and rice grown in Arkansas, the T bases were estimated to be around 10C (50 F). However, there is evidence that the base temperature for some crops may not be constant throughout their growth. The base temperature may be the same for some development stages and different for other stages.

The thermal times for Guam with base temperatures 32, 40, 50, 60 F (0, 5, 10, 15 C) were calculated from the daily records of the US Weather Service. The records cover a period of thirty years, from 1955 to 1984. The temperature range 32 to 60 F encompasses most cash crops grown on Guam and the Western Pacific islands. Both the computer statistical package SAS and in-house developed Fortran programs were used to analyze the data. Records in the typhoon periods and the obvious outliners were excluded from the working data set. The standard errors of temperature over the weekly averages were found to be very small, only a few percent of the mean; and the thermal-time curves over the months were found surprisingly linear with practically no seasonal variation throughout the year. This is in sharp contrast with the thermal time in the US mainland, where large seasonal temperature variations render the curves highly nonlinear. Figures 1 and 2 show the unsmoothed curves of the thermal time in Fahrenheit-days. The average slopes of these curves are 45.5, 38.5, 28.5, 18.5 heat units per day respectively.

Field observations for corn X304C indicated that phenological stage-change from emergence to leaf tip appearance (Phylochron) occurs when thermal time reaches about 90 Fahrenheit-days; and from emergence to the end of juvenile phase occurs when thermal time reaches about 610 Fahrenheit-days. Crop maturity occurs when thermal time reaches about 1580 Fahrenheit-days. Assuming that the base temperature of corn X304C is 50 F and using Guam's thermal-time curve shown in Fig. 2, the time intervals between the mentioned stages were estimated to be 4, 22, 56 days respectively.

Discussion

The near perfect linearity of the thermal-time curves on Guam indicates that the phenological stages of many crops grown on the island should be reasonably predictable. The antithesis time of many photoperiod sensitive plants can be estimated with sunshine hours, which vary no more than two hours throughout the year. When the base temperatures of the cultivars are known, the time intervals between all growth stages should be predictable with good accuracy to within a few days. Moreover, if one accepts the asumption that thermal time predominately sets the physiological clock of a plant, then on Guam the usual practice of changing sowing time for favorable rainfall would not profoundly alter these intervals. The constancy of phenological intervals for many cash crops resulting from the linearity of thermal-time curves is an important feature of Guam's weather, and should be exploited to the fullest for farm management. This constancy facilitates farm scheduling. It offers a more flexible planting or sowing timetable, a more precise date for application of fertilizers, and a better estimation of harvest time.

The linearity of thermal time also makes the adaptation of different base temperatures to different phenological stages more mathematically tractable, which in turn allows better estimation of crop development. Crop models using linear thermal time simplify the calculations, and at the same time afford an easy way to incorporate different base temperatures to the phenological stages for a more realistic prediction of crop yields.

Figure 1

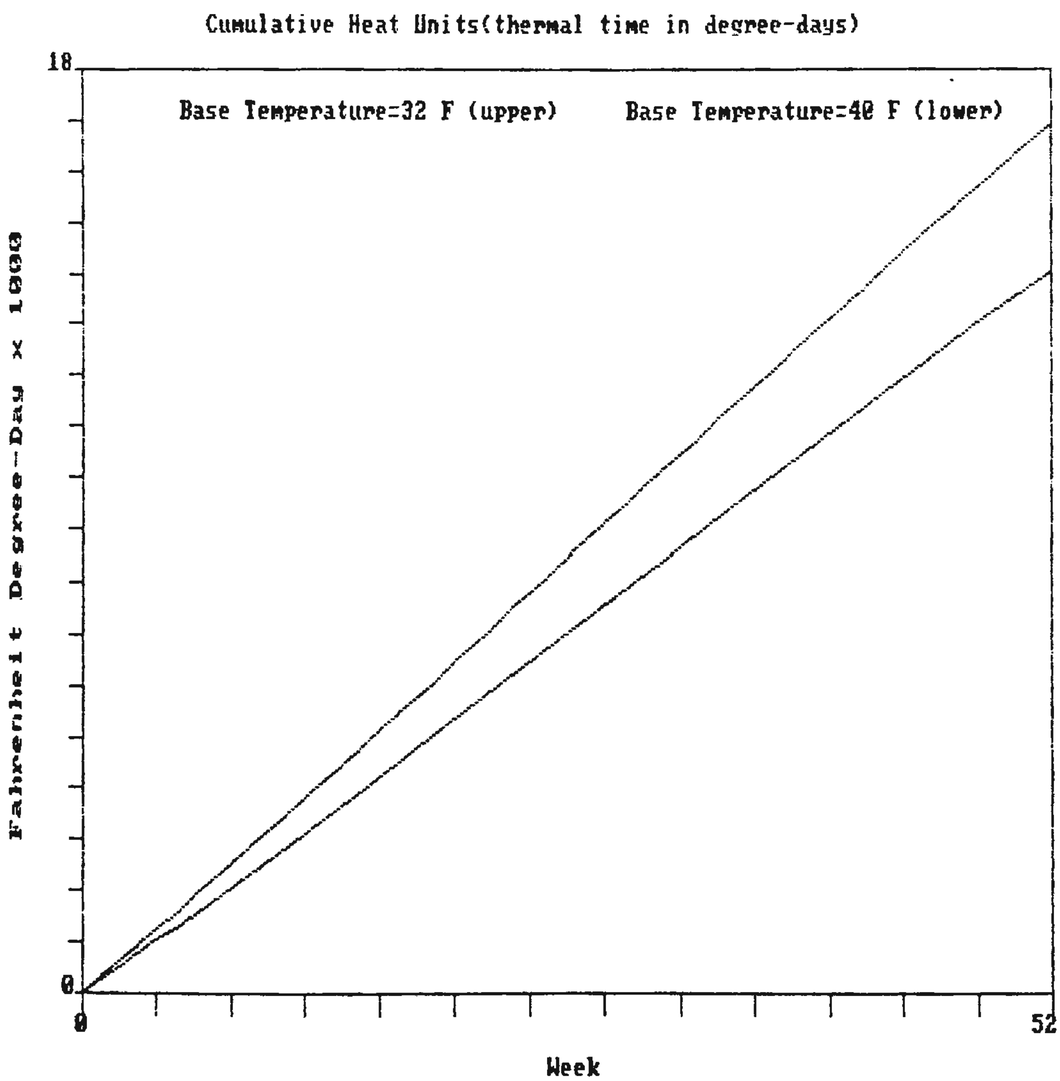
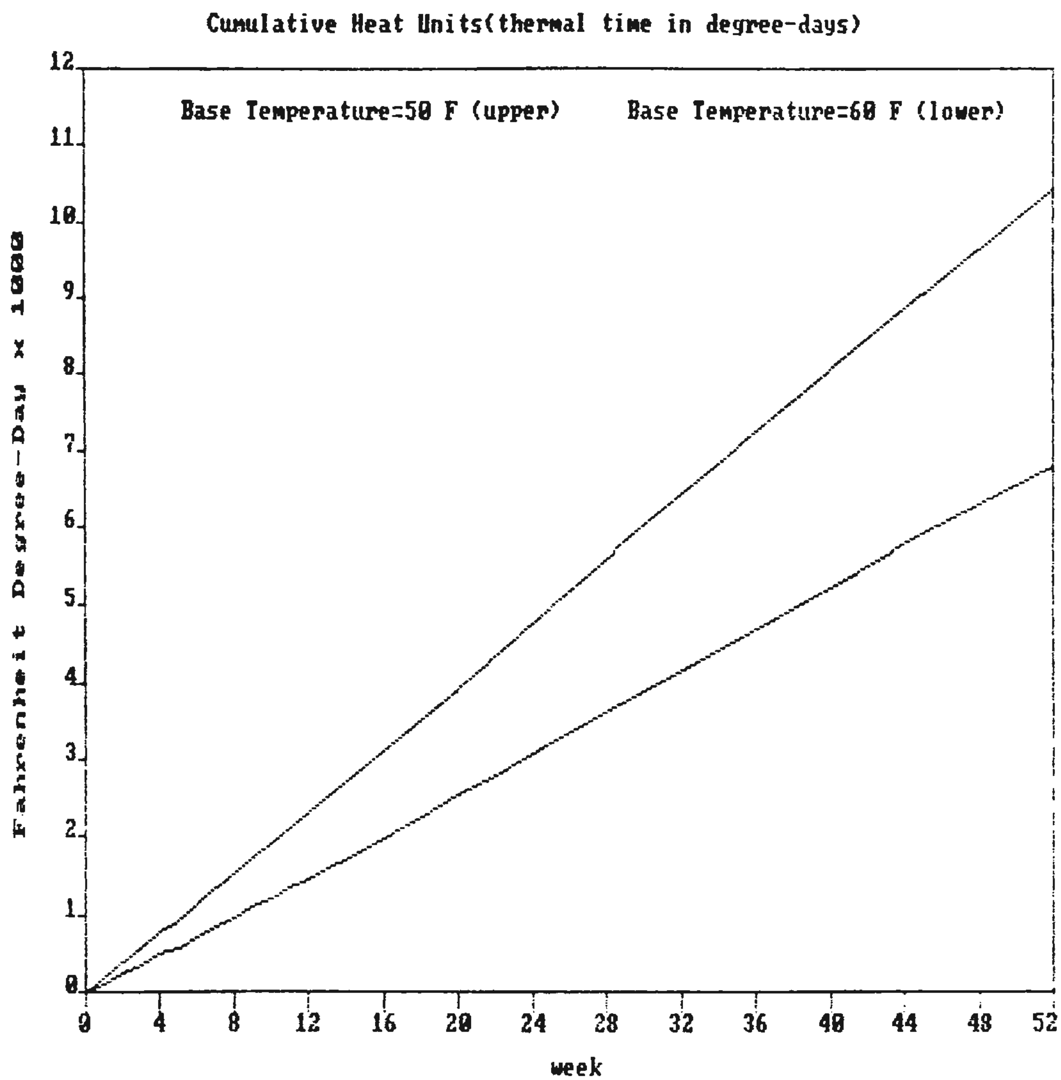

Cumulative Heat Units(thermal time in degree-days)
18
Base Temperature=32 F (upper)
Base Temperature=40 F (lower)
Fahrenheit Degree-Day x 1000
0
0
52
Week

Figure 2



Cumulative Heat Units(thermal time in degree-days)
Base Temperature=50 F (upper)
Base Temperature=60 F (lower)
Fahrenheit Degree-Day x 1000
12
11
10
9
8
7
6
5
4
3
2
1
0
0
4
8
12
16
20
24
28
32
36
40
44
48
52
week

DATABASE: Micronesian Area Tropical Agriculture Database (MATADB) and Agriculture Registry (AGREG) Projects

K.L. Carriveau

Introduction

The Micronesian Area Tropical Agriculture Database Center began in 1982 as a cooperative venture of the College of Agriculture and Life Sciences and the Robert F. Kennedy Memorial Libray.

In the Fall of 1985, the Micronesian Area Research Center was designated the new home of the bibliographic and registry databases.

One problem facing researchers in Micronesia is the lack of information about agricultural research. The major objective of these projects is to acquire all published and unpublished documents produced in or about Micronesia and to provide information retrieval and dissemination services.

Accomplishments

A bibliographic database (MATADB) has been developed and implemented to provide reference services similar to those provided by AGRICOLA. It s scope is designed to complement that of the national bibliographic database.

Memoranda of Understanding have been negotiated with the Commonwealth of the Northern Marianas Islands, the Federated States of Microneisa, and the Republic of the Marshall Islands for automatic deposit of agricultural materials in the Center's collection.

Over 4,000 documents have been indexed and abstracted for entry into MATADB. An additional 2,400 documents on some 400 rolls of microfilm have been acquired, but have not yet been indexed and abstracted. More than 2,000 additional documents available through commercial sources have been identified for purchase sometime in the future.

A computerized registry of scientists and other project participants has been developed. It's scope is similar to USDA's Current Research Information System (CRIS) and makes provision for the recording of the person's name, title, mailing address, interests and on-going projects. The database is updated annually.

Three mini-workshops were conducted in 1985 in order to advertise the Center's service capabilities. The first was presented to the College of Agriculture and Life Sciences' faculty; the second was part of a regional quarantine workshop; the third addressed on-line searching techniques for AES scientists.

The Center produced three publications during the past year (i.e., a Directory of Participants; Selective Dissemination of Information Services (SDI); and Thesaurus of Key Words, 2nd edition).

Prospects for the Future

Informal working relationships have been made with institutions outside the Micronesian region such as the University of Hawaii, the Pacific Basin Development Council, the Institute of Pacific Island Forestry, the University of the South Pacific, and the South Pacific Commission to share bibliographic data and/or publications. The Center is currently able to exchange bibliographic data with other centers either in tape or in hard copy. Letters of inquiry have been sent to various agricultural centers and ministries to investigate the feasibility of establishing a Pacific region bibliographic network.