1988 Annual Report

# Guam

# AGRICULTURAL EXPERIMENT STATION

College of Agriculture and Life Sciences

University of Guam

Research in 1988 continued to be applied in nature. An Animal Nutritionist, Dr. F. Abawi, joined the staff in late 1988.

The Guam Agricultural Experiment Station with Dr. R. Muniappan coordinating, successfully conducted in February, the first International Workshop on *Chromolaena odorata* in Thailand. Worldwide collaboration to conduct this noxious weed is on-going.

The Agricultural Development of the American Pacific involving Guam, Hawaii, the Federated States of Micronesia, Northern Marianas and the American Samoa was launched. AES scientists are involved with Data Base Management, Staff Development, Crop Protection, Communications and Administration.

The Experiment Station in Barrigada occupying a 30 acre lot leased from the United States Navy was started. Development of a 47.5 area lot in Northern Guam was initiated. Hopefully this facility will be operational in late 1989.

The first and only Director of the Guam AES, Dr. W.P. Leon Guerrero was appointed President of the University of Guam in March.

Jose T. Barcinas
Acting Dean/Director

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# Horticulture–Vegetable Crops (Winged Bean, Cucumber and Muskmelon)

C.T. Lee

## I. The Effectiveness of Growth Regulators on the Growth and Production of Winged Bean

### Materials and Methods

Two experiments were conducted to evaluate the effectiveness of plant growth regulators alone and in combination on the growth and production of winged bean. Winged bean cultivar 'Chimbu' was planted in February and August to represent the dry and wet season. A randomized complete block design with three replications was used. Growth regulators for these two experiments were 2, 3, 5-triidobenzoic acid (60 ppm), (B-naphthoxy) acetic acid (100 pm), (2-chloroethyl) trimethyl ammonium chloride (100 ppm) and Spray-N-Grow (3,000 ppm) applied alone or in combination. These chemicals were applied to the entire foliage at 4 to 5 trifoliate stage.

Each experimental plot was three rows of 4.57 meters long. The spacing adopted was 1.22 meters between rows and 0.46 meters within rows. Before planting, all the winged bean seeds were immersed in a concentrated sulfuric acid (sp.gr.1.18) at 25° C for 5 minutes follow by a 10-minute rinse under running tap water. Seeds were directed sown in the field. The whole field received a blanket application of 387 kg/ha of 10-20-20 fertilizer prior to planting. Side-dressing with the same fertilizer at the same rate was done four weeks after planting. A preventive spraying program was followed once weekly by applying Kelthane and Malathion 50 to reduce possible insect damage. A rotary tiller and garden hoe were used to control weeds. Drip system was used as needed for irrigation. The plants were supported with a trellis constructed by leucaena (*Leucaena leucocephala* (L. )DC) stakes and plastic nets.

All the data were collected from the central row of each plot. The data collected were plant height, pod weight, number of pods per plant, marketable fresh pod yield and unmarketable fresh pod yield.

### Results and Discussion

The results of the effect of growth regulators on plant height are presented in Table 1 and 3. The plant height was significantly reduced up to about 8 weeks after planting by the application of 2,3,5-triiodobenzoic acid, (B-naphthoxy) acetic acid, or (2-chloroethyl) trimethyl ammonium chloride alone or any combination of two chemicals from these three chemicals and Spray-N-Grow.

The effect of growth regulators on some horticultural characteristics and production of winged bean are shown in Table 2 and 4. All chemical treatments significantly increased the number of pods per plant and yield of marketable fresh pods. However, fresh pod weight with an average of 21.2g and yield of unmarketable fresh pods were not affected by the application of these growth regulators. It was noticed that the number of pods per plant and yield for marketable fresh pods grown in August were much higher than those grown in February.

## II. The Effect of Different Rates of Gibberellic Acid on Growth and Production of Cucumber

### Introduction

The sex-expression in cucurbits is governed by genetical as well as environmental factors and can be effectively modified by exogenous application of various chemicals. A series of earlier reports from the several research workers have conclusively demonstrated such effect on cucumber. Most of the research work on the use of synthetic growth regulators to promote the growth and development of cucurbits have been conducted at low temperature and low humidity situations of the temperate areas. Very little work has been reported on the application of growth regulators for the increase in production of cucurbits under humid tropical environmental conditions. Therefore, it was interesting to observe that the effect of growth regulators on growth and production of cucumber on Guam.

### Materials and Methods

This experiment was conducted during the dry season. The objective was to evaluate how the different rates of gibberellic acid affected the growth and production of cucumber cultivar 'Market King' planted for the experiment. Gibberellic acid at 0, 25, 50, 75, and 100 ppm were applied as one spray at the three to four-leaf stage. A randomized complete block design with three replications was used. Each experimental plot consisted of three rows of 4.87 meters. A spacing of 1.22 meters between

rows and 0.31 meters within rows was adopted. A 10-20-20 fertilizer was broadcast at the rate of 580 kg/ha and incorporated into the soil before sowing the seed. Side-dressing with potassium nitrate at 200 kg/ha through the drip irrigation system was accomplished three to four weeks after sowing the seed. A preventive spraying program was followed twice weekly to reduce possible insect and disease damage by applying Lannate 1.8L, Malathion 50, Dithane M-45 and Tribasic Coppers. The plastic mulch and garden hoe were used for irrigation when needed. Drip system was used for irrigation when needed. Cucumber vines and fruits were trained onto a plastic net to reduce the problem of fruit rot.

The tested cultivar was suited for slicing purpose. The data were collected from the central row of each plot. The fruits of cucumbers were harvested as soon as they had reached marketable size. They were picked by hand, care being taken to avoid injuring the vine.

## Results and Discussion

1) Node number for the Appearance of First Male and Female Flowers: The data in Table revealed the gibberellic acid treatments (25,50,75, or 100 ppm) significantly reduced the node number for the production of first pistillate flower. But gibberellic acid treatments failed to affect the formation of first male flower in terms of node number.

2) Number of Male, Female, Total Flowers and Sex Ratio: As shown in Table 6 gibberellic acid treatments at all rates increased the number of male flowers but induced higher number of female flowers especially at higher rates of 50,75, or 100 ppm. Total number of flowers was reduced at the rate of 25 ppm but was increased at the higher rates of 50, 75, or 100 ppm. It is also evident from Table 6 that all gibberellic acid treatments reduced the sex ratio (M/F).

Table 1. The Effect of Different Growth Regulators on Plant Height of Winged Bean (planted in February 1988).

| | Plant Height (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatment * | 4 weeks after Planting | 5 weeks after Planting | 6 weeks after Planting | 7 weeks after Planting | 8 weeks after Planting | 9 weeks after Planting | 10 weeks after Planting |
| 1 | 27.0c** | 35.2c | 50.7d | 62.8c | 73.1d | 85.1a | 102.5a |
| 2 | 21.0a | 29.0a | 38.1b | 54.0b | 68.2cd | 83.7a | 101.2a |
| 3 | 20.7a | 26.8a | 33.9a | 47.8a | 56.0a | 77.2a | 98.0a |
| 4 | 23.0b | 31.0b | 41.2c | 54.3b | 63.2bc | 76.9a | 94.5a |
| 5 | 33.6d | 40.1d | 52.7d | 63.1c | 73.7d | 87.2a | 103.7a |
| 6 | 20.0a | 28.9a | 38.9b | 52.9b | 66.7c | 81.9a | 101.0a |
| 7 | 20.2a | 28.2a | 37.0ab | 53.0b | 67.0c | 84.3a | 104.2a |
| 8 | 29.7c | 30.0c | 49.6d | 60.0c | 71.5d | 84.7a | 101.3a |
| 9 | 20.8a | 21.0a | 36.9ab | 52.8b | 68.7cd | 83.6a | 100.7a |
| 10 | 29.9c | 37.8c | 50.0d | 61.0c | 72.8d | 84.9a | 104.8a |
| 11 | 30.0c | 37.9c | 50.1d | 61.8c | 72.3d | 85.3a | 103.4a |

* 1) Control
2) 2,3,5-triiodobenzoic acid
3) (B-naphthoxy) acetic acid)
4) (2-chloroethyl) trimethyl ammonium chloride
5) Spray-N-Grow
6) 2,3,5-triiodobenzoic acid + (B-naphthoxy) acetic acid)
7) 2,3,5-triiodobenzoic acid + (2-chloroethyl) trimethyl ammonium chloride
8) 2,3,5-triiodobenzoic acid + Spray-N-Grow
9) (B-naphthoxy) acetic acid + (2-chloroethyl) ammonium chloride
10) (B-naphthoxy) acetic acid + Spray-N-Grow
11) (2-chloroethyl) trimethl ammonium chloride + Spray-N-Grow

**Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

3) Marketable yield: Number of female flowers is one of the important factors in the determination of yield in cucumber. Gibberellic acid treatments at higher rates of 50, 75, or 100 ppm significantly increased the marketable yield probably due to the increase of number of female flowers at these rates.

## Conclusion

Based on this experiment gibberellic acid treatments at all rates significantly reduced node number of first female flower but did not affect the appearance of node number of first male flower.

Gibberellic acid treatments at higher rates of 50, 75 or 100 ppm increased number of male flowers, total number of flowers and marketable yield but reduced number of female flowers and sex-ratio.

### III. The Effect of Different Rates of Naphtheneacetic Acid on Growth and Production of Muskmelon

#### Material and Method

This study was conducted at the Guam Agricultural Experiment Station in Inarajan during the dry season to study the effect of naphthene acetic acid on growth and production of muskmelon cultivar 'New Century'. The treatments used in this study were naphtheneacetic acid at 0, 50, 100, 150 and 200 ppm. The chemicals were applied as one spray at three to four-leaf stage. The field plan was designed according to randomized complete block design with three replications. The seeds were directly planted in the field. Each experimental plot consisted of three rows, 5.03 meters long. The spacing adopted was 1.83 meters between rows and 0.61 meters within rows. Localized application of 10-20-20 fertilizer at the rate of 800 kg/ha was applied to a planting hole 15 cm deep and 30 cm wide, then covered with 10 cm of soil over the fertilizer before sowing the seeds. This method of application was to avoid the burning effect on the seeds or young seedlings. Side-dressing with potassium nitrate at 300 kg/ha through drip irrigation system was accomplished four to five weeks after sowing seeds.

A preventive program followed twice weekly to reduce possible insect and disage by using Lannate 1.8L, Malathion 50, Diazinon Ag500 EC, Dithane M-45 and Tribasic Coppers. The plastic mulch and garden hoe were used to control weeds. Drip system was used for irrigation when needed. The data were collected from the central row of each plot. Number of staminate and pistillate flowers were counted from the first two weeks of flowering.

Table 2. The Effect of Different Growth Regulators on Plant Height of Winged Bean (Planted in February 1988)

| Treatment* | Fresh Pod Weight (g) | Number of Pods/ Plants | Unmarketable Fresh Pod Yield (MT/ha) | Marketable Fresh Pod Yield (MT/ha) |
|---|---|---|---|---|
| 1 | 20.7a** | 30.1a | 0.46a | 10.5a |
| 2 | 21.2a | 34.2b | 0.40a | 12.6b |
| 3 | 20.8a | 35.6b | 0.42a | 12.9b |
| 4 | 21.3a | 34.9b | 0.50a | 12.7b |
| 5 | 20.0a | 36.2b | 0.47a | 13.1b |
| 6 | 20.1a | 34.7b | 0.41a | 12.8b |
| 7 | 21.3a | 35.1b | 0.42a | 12.7b |
| 8 | 21.2a | 34.6b | 0.50a | 13.0b |
| 9 | 20.8a | 35.0b | 0.43a | 12.3b |
| 10 | 22.1a | 33.2b | 0.43a | 13.0b |
| 11 | 22.0a | 33.7b | 0.48a | 13.2b |

* 1) Control
2) 2,3,5-triiodobenzoic acid
3) (B-naphthoxy) acetic acid)
4) (2-chloroethyl) trimethyl ammonium chloride
5) Spray-N-Grow
6) 2,3,5-triiodobenzoic acid + (B-naphthoxy) acetic acid)
7) 2,3,5-triiodobenzoic acid + (2-chloroethyl) trimethyl ammonium chloride
8) 2,3,5-triiodobenzoic acid + Spray-N-Grow
9) (B-naphthoxy) acetic acid + (2-chloroethyl) ammonium chloride
10) (B-naphthoxy) acetic acid + Spray-N-Grow
11) (2-chloroethyl) trimethl ammonium chloride + Spray-N-Grow

**Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

#### Results and Discussion

Plant Height: The plant height was reduced in all treatments by the application of naphtheneacetic acid (Table 7). Naphteneacetic acid at a concentration of 200 ppm gave the lowest in plant height.

Sex Expression: As shown on Table 7 all the treatments increased the number of pistillate flowers per plant from 0.2 to 1.0. The number of staminate flowers per plant was suppressed by naptheneacetic acid at 150 and 200 ppm but had no effect at 50 and 100 ppm. It also indicated application of the growth regulator reduced the sex-ration (S/P).

Yield: Spraying the plants at the three to four-leaf stage with naphtheneacetic acid from 50 to 200 ppm delayed maturity by the increase in number of fruits per hectare of weekly harvesting (Table 8). Treatment from 50 to 200 ppm significantly reduced early marketable fruit yield but did not reduce the total yield except increasing total yield at the rate of 100 ppm.

## Conclusion

The findings concluded that all treatments of naphtheneacetic acid reduced plant height, modified sex expression toward femaleness (increasing number of pistillate flowers). Treatment with naphtheneacetic acid delayed maturity, especially at 200 ppm. Treatment at 100 ppm was the only one that increased total yield.

**Table 3. The Effect of Different Growth Regulators on Plant Height of Winged Bean (planted in August 1988).**

| | Plant Height (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatment * | 4 weeks after Planting | 5 weeks after Planting | 6 weeks after Planting | 7 weeks after Planting | 8 weeks after Planting | 9 weeks after Planting | 10 weeks after Planting |
| 1 | 28.5c** | 36.1c | 51.2d | 64.8c | 74.7de | 88.8a | 104.1a |
| 2 | 20.0a | 28.6a | 38.9b | 56.1b | 70.7cd | 86.5a | 103.0a |
| 3 | 20.1a | 27.0a | 34.9a | 49.8a | 58.7a | 79.8a | 97.7a |
| 4 | 24.0b | 32.2b | 42.8c | 56.4b | 65.7bc | 79.2a | 96.0a |
| 5 | 34.8d | 40.1d | 53.8d | 65.9c | 76.8e | 90.0a | 106.7a |
| 6 | 20.5a | 29.7a | 39.7b | 55.7b | 69.3cd | 85.6a | 102.8a |
| 7 | 20.1a | 28.9a | 37.8ab | 55.6b | 69.3d | 87.5a | 105.0a |
| 8 | 30.2c | 38.5c | 50.1d | 62.9c | 73.4de | 87.1a | 103.8a |
| 9 | 21.2a | 26.2a | 37.6ab | 55.4b | 70.1cd | 85.9a | 102.1a |
| 10 | 30.8c | 38.1c | 50.2d | 63.7c | 75.2de | 88.1a | 106.1a |
| 11 | 31.2c | 38.9c | 52.3d | 65.0c | 75.9e | 89.1a | 106.8a |

* 1) Control
2) 2,3,5-triiodobenzoic acid
3) (B-naphthoxy) acetic acid)
4) (2-chloroethyl) trimethyl ammonium chloride
5) Spray-N-Grow
6) 2,3,5-triiodobenzoic acid + (B-naphthoxy) acetic acid)
7) 2,3,5-triiodobenzoic acid + (2-chloroethyl) trimethyl ammonium chloride
8) 2,3,5-triiodobenzoic acid + Spray-N-Grow
9) (B-naphthoxy) acetic acid + (2-chloroethyl) ammonium chloride
10) (B-naphthoxy) acetic acid + Spray-N-Grow
11) (2-chloroethyl) trimethl ammonium chloride + Spray-N-Grow

**Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

**Table 4. The Effect of Different Growth Regulators on Plant Height of Winged Bean (Planted in August 1988)**

| Treatment* | Fresh Pod Weight (g) | Number of Pods/ Plants | Unmarketable Fresh Pod Yield (MT/ha) | Marketable Fresh Pod Yield (MT/ha) |
|---|---|---|---|---|
| 1 | 21.3a** | 62.7a | 1.07a | 20.82a |
| 2 | 21.0a | 73.8b | 1.01a | 23.93b |
| 3 | 20.9a | 75.1b | 1.12a | 24.87b |
| 4 | 20.8a | 75.8b | 1.09a | 25.07b |
| 5 | 21.2a | 76.3b | 1.12a | 25.88b |
| 6 | 22.3a | 73.7b | 1.01a | 24.72b |
| 7 | 21.0a | 75.2b | 1.02a | 25.21b |
| 8 | 23.0a | 25.9b | 1.11a | 26.01b |
| 9 | 22.1a | 74.7b | 1.13a | 25.37b |
| 10 | 20.1a | 75.7b | 1.07a | 24.97b |
| 11 | 22.2a | 73.8b | 1.11a | 24.85b |

* 1) Control
2) 2,3,5-triiodobenzoic acid
3) (B-naphthoxy) acetic acid)
4) (2-chloroethyl) trimethyl ammonium chloride
5) Spray-N-Grow
6) 2,3,5-triiodobenzoic acid + (B-naphthoxy) acetic acid)
7) 2,3,5-triiodobenzoic acid + (2-chloroethyl) trimethyl ammonium chloride
8) 2,3,5-triiodobenzoic acid + Spray-N-Grow
9) (B-naphthoxy) acetic acid + (2-chloroethyl) ammonium chloride
10) (B-naphthoxy) acetic acid + Spray-N-Grow
11) (2-chloroethyl) trimethl ammonium chloride + Spray-N-Grow

**Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

**Table 5. The Effect of Different Rates of Gibberellic Acid on Node Number of First Male and Female Flower Appearance in Cucumber**

| Treatment | Node Number of First Male Flower | Node Number of First Female Flower |
|---|---|---|
| 0 ppm | 2.9a* | 8.3d |
| 25 ppm | 3.0a | 7.4c |
| 50 ppm | 3.1a | 6.0c |
| 75 ppm | 2.9a | 5.4a |
| 100 ppm | 3.3a | 5.3a |

*Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

**Table 6. The Effect of Different Rates of Gibberellic Acid on Some Horticultural Characteristics and Production of Cucumber.**

| Treatment | Number of Male Flowers | Number of Female Flowers | Total Number of Flowers | Sex-Ratio (M/F) | Marketable Yield (MT/ha) |
|---|---|---|---|---|---|
| 0 ppm | 18.3b* | 4.7a | 23.0b | 3.9 | 23.4a |
| 25 ppm | 16.4a | 5.0a | 21.4a | 3.3 | 24.5a |
| 50 ppm | 20.7c | 6.3b | 27.0c | 3.3 | 26.8b |
| 75 ppm | 21.2c | 6.5b | 27.5c | 3.3 | 27.1b |
| 100 ppm | 20.9c | 6.1b | 27.0c | 3.4 | 26.0b |

*Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

**Table 7. The Effect of Different Rates of Naphtheneacetic Acid on Some Horticultural Characteristics of Muskmelon.**

| Treatment | Plant Height cm | Number of Flowers/Plant | | Sex Ratio Staminate/Pistillate |
|---|---|---|---|---|
| | | Pistillate | Staminate | |
| 0 | 100d* | 0.2a | 6.1b | 30.5 |
| 50 | 92c | 0.8b | 6.2b | 7.8 |
| 100 | 87c | 0.9b | 6.2b | 6.9 |
| 150 | 75b | 1.0b | 4.1a | 4.1 |
| 200 | 67a | 0.9b | 4.3a | 4.8 |

*Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

**Table 8. The Effect of Different Rates of Naphtheneacetic Acid on Production of Muskmelon.**

| | Number of Fruits/ha | | | | | |
|---|---|---|---|---|---|---|
| | Weeks of Harvest | | | | Marketable Fruit Yield (Mt/ha) | |
| Treatment | First | Second | Third | Total | Early (First Week) | Total |
| 0 ppm | 495d* | 1,696c | 3,025a | 5,216a | 2.0d | 21.3a |
| 50 ppm | 400c | 1,304d | 3,505b | 5,209a | 1.7c | 21.6ab |
| 100 ppm | 294b | 1,179c | 3,744b | 5,511a | 1.2b | 23.1b |
| 150 ppm | 391c | 1,096b | 3,878b | 5,345a | 1.6c | 22.2ab |
| 200 ppm | 0a | 127a | 5,001c | 5,125a | .0a | 21.0a |

*Means followed by the same letter within same measurement in a column do not differ significantly at the 5% probability level using Ducan's Multiple Test.

# Agricultural Engineering

C.A. Saruwatari & C.T. Lee

## I. Irrigation Water Requirement Based on Potential Evapotranspiration

As reported previously, a general agreement between the various methods used to determine the daily maximum crop consumptive use for Guam during the "dry" season (when potential evapotranspiration exceeds rainfall) yielded a value of 5,000 gallons per acre per day as a rough approximation. This represents a conservative design maximum water requirement since this amount of water is needed only one month per year. The value presently being considered as a yearly average value is 3,750 gallons per acre per day based on discussions with the Bureau of Reclamation and the Soil Conservation Service.

## II. Water Requirement of Vegetable Crops on Guam

Research continued in agricultural engineering with vegetable horticulture to study the application of micro-irrigation for the major row crops grown on Guam during the dry season. The objectives are to determine the optimum quantity and frequency of irrigation and to determine the effects of various irrigation water application rates on the root development of the radish. Results of the experiments are not yet available.

1) The water application rate will range from rainfall only (no additional irrigation) to a maximum total of 0.40 inches (10-millimeter) per day. A continuous function design with five water treatments (0.0, 0.10, 0.20, 0.30 and 0.40 inches per day) with three replications will be used for the trials to be conducted at the Barrigada station. Initial trials will be on bellpepper (Probell). The discharge rate of the RIS Biwall (Hardie Irrigation) is approximately one gallon per minute (224 liter per hour) per 100-foot (30-meters) lateral with a 18-inch (46-centimeter) spacing. Rainfall will be measured on site. Domestic water will be used. Fertilizer applications preplant of 10 pounds per 100 feet (4.54 kilograms per 30 meters of 10-10-10 fertilizer) and a side dress of one pound per 100 feet (0.45 kilograms per 30 meters) of 21-0-0 fertilizers and 10 pounds per 100 feet (4.54 kilograms per 30 meters of 16-16-16 fertilizer) and pesticide spraying will follow existing guidelines. Soil water status will be measured at appropriate intervals by means of tensiometers. The effect on yield and market quality will be studied. Data to be collected will include marketable yield, unmarketable yield, total water applied and other pertinent information.

2) The experiment will be conducted in a screenhouse at the Agricultural Experiment Station. Radish seedlings (Daikon: Raphanus sativa L., variety: Minowase Summer Cross No. 3) will be transplanted into 12-inch (30 centimeters) pots containing a mixture of 33% peat moss and 67% soil with one ounce (30 grams) of 10-20-10 fertilizer. Foliar 60 fertilizer will be applied as a side dress. The micro-irrigation emitter (Submatic button emitter) will be placed 2-inches (5-centimeters) away from the plant with one emitter per plant. The experiment will have four water application rates replicated four times. A complete randomized block design will be used. The water application rate will range from 0.6 to 1.2 ET (0.6, 0.8, 1.0 and 1.2 estimated potential evapotranspiration) of approximately 0.25 inches (6-millimeter) per day or 0.088, 0.119, 0.147 and 0.175 gallons (0.34, 0.46, 0.57 and 0.68 liters) per hour. Insects problem and plant diseases will be noted and treated accordingly as part of the general spraying program. Data to be collected will include root size and quality, top growth, any problems such as bolting, marketable and unmarketable yield, and the total water applied.

# Yield Response of Pole Bean Plant to Varying Nitrogen Levels

J.A. Cruz

Although pole bean plants are legume, a well designed fertilizer management program may be needed to furnish a continuous supply of available nitrogen for producing high quality fresh bean pod yields. At the Agricultural Experiment Station, a study was conducted to investigate the yield of fresh bean pods of pole bean plants as affected by different nitrogen rates.

## Materials and Methods

Experiment was conducted on a field heavily fertilized with N,P, K at the Agricultural Experiment Station at Inarajan. The soil was classified as Guam-Saipan Complex (Clayey, gibbsitic, nonacid isohyperthermic Lithic Ustortherns). Soil sample was taken and chemically analyzed for P, K, Ca, Mg, and organic matter. The soil analysis results were: ph, 6.60; available P, 12.18 ppm; exchangeable K, 82.50 ppm; exchangeable Ca 1763 ppm; exchangeable Mg, 195 ppm; and organic matter, 6.14%.

The pole bean cultivar "Dade" was direct seeded on each plot at 46cm between plants. Each plot 5.50m long, consisted of 2 rows 1.20m apart on a level bed. Plants were thinned out to two plants per hill. The six nitrogen fertilizer treatments were replicated four times in a randomized complete block design. Nitrogen as urea was placed in the furrows and covered with soil during planting at the rates of 0, 25, 50, 75, 100, and 125 Kg ha-1 in a single application. A blanket application of treble super phosphate and potassium chloride were also placed in the furrows in all plots at 200kg ha-1 P205 and 200 Kg ha-1 K20 at planting.

Fresh bean pods were harvested from the two central rows per plot and weighed on a gram balance every 3-4 days for eight harvest.

## Results

Fresh bean yield increased was significant with increasing rates of N up to 125 Kg ha-1 (Table 1). The results showed a favorable influence on the yield at the 125 Kg ha-1 of N treatment rate.

**Table 1. Yield of Fresh Bean Pods of Pole Bean Plants at**

| Treatment | Yield (Kg/plot) | | | | |
|---|---|---|---|---|---|
| | Treatment | | | | |
| Kg ha-1 | RI | RII | RIII | RIV | Mean |
| 0 | 1.53 | 3.44 | 2.81 | 2.05 | 2.46b |
| 25 | 3.31 | 2.04 | 1.16 | 3.28 | 2.45b |
| 50 | 3.12 | 4.18 | 3.25 | 3.94 | 3.62ab |
| 75 | 3.50 | 6.14 | 3.11 | 2.74 | 3.87ab |
| 100 | 3.00 | 3.65 | 6.50 | 4.40 | 4.39a |
| 125 | 3.97 | 4.65 | 4.90 | 4.87 | 4.60a |

*Means followed by different letters down columns are significantly different by Duncan's Multiple range test at the 0.05 level.

# Plant Pathology

G.C. Wall

## A Study of the Diseases of Beans on Guam, their Importance and Control

A study of lab records during the past five years showed that the most frequently reported diseases on beans are : a virus disease, root rot, powdery mildew, rook knot, and various other minor problems. With the exception of the virus disease, all of these pests are known to cause yield loss, and therefore to be of economic importance. During 1988, virus-infected and healthy bean plants were compared in pairs, for plant height and pod production. As expected, diseased plants produced less than healthy plants. Yield loss studies on this disease will continue next year.

Seed collected in a grower's field with 99% virus incidence on local yardlong bean were germinated in the greenhouse to test for seed transmission of this virus disease. No symptoms were observed, although plants were grown to maturity.

In other greenhouse tests, the virus disease was transmitted mechanically from infected to healthy yardlong bean plants. Infected leaves were crushed, and healthy plants were rubbed with infected sap after sprinkling leaves with carborundum. Symptoms appeared in 10 days as a mosaic.

Aphids (*Aphis craccivora*) collected on yardlong bean plants were transferred to healthy seedlings and allowed to multiply for several weeks. Individuals were then picked up with a sterile camel-hair brush, transferred on to wet filter paper in a petri dish and forced to fast for 30 min. They were then allowed to feed for 10-30 min. on virus-infected plants. After this time, they were transferred to healthy seedlings. They were eliminated the next day with malathion. Ten days later, systemic symptoms developed in 10% of the plants. Control plants, which received aphids not exposed to infected plants, developed no symptoms.

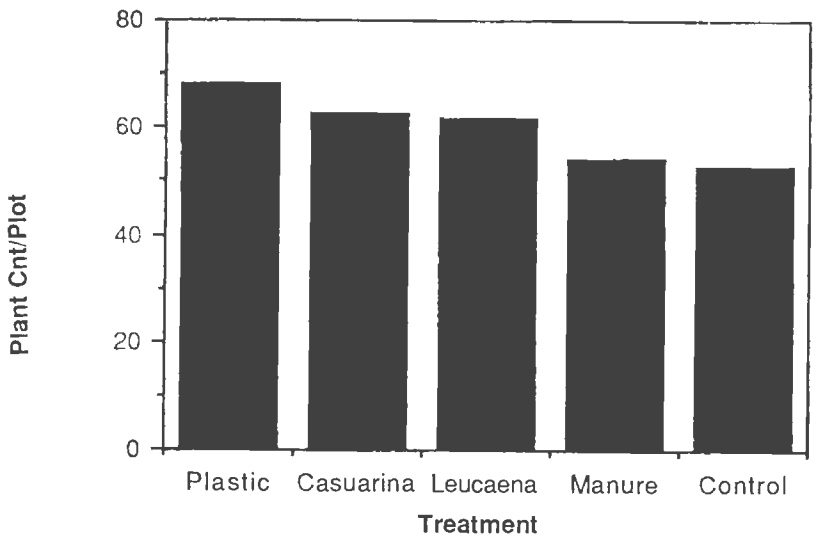
Five antisera for *Vigna* viruses occurring in the U.S. were obtained from Dr. Kuhn in Georgia. Ring-interface tests with these antisera had no positive reaction with the virus on yardlong bean occurring here.

## Effect of cultural practices on soilborne diseases of bell peppers

In field experiments carried out at Barrigada various cultural practices were tested for controlling soilborne pathogens on bell pepper, primarily *Sclerotium rolfsii*. There were five treatments , as follows: 1. Plastic mulch 2. Soil amended with shredded foliage and twigs from *Leucaena sp.* 3. Soil amended with *Casuarina* needles 4. Soil amended with chicken manure 5. Control with no mulch or amendments. Plastic mulch plots had the highest yields. A multiple regression model explaining 99.9% of the variation in yield was based on fruit weight per plant and plant count. The data (Figures 1&2) show that plastic mulch resulted in significantly higher amounts of both of these, meaning that not only does plastic mulch reduce the soilborne disease incidence (expressed in the plant count), but additionally (and primarily) increases fruit weight per plant through other effects on crop development (less weed competition, more soil moisture, lower soil temperature, etc.).

In a greenhouse test, the addition of organic matter (chicken manure) to potted soil resulted in higher incidence of southern blight on bell peppers when subjected to drought stress (Figures 3&4). This means that, if manure is to be used as fertilizer, drought stress must be avoided to prevent an increase in the infection of plants by *Sclerotium rolfsii*.

Figure 1



### Effect of cultural practices on two bacterial diseases of bell peppers

In a field experiment planted at Mangilao, various cultural practices were tested to see their effect on bacterial leaf spot and bacterial wilt of bell peppers. In this experiment, raised beds (Figures 5-7) reduced the incidence of bacterial wilt (but not in later experiments). Raised beds also showed a tendency to reduce bacterial leaf spot severity.

The effect of plastic mulch was to reduce wilt incidence (Figures 5-7); however, plastic mulch showed a tendency to increase bacterial leaf spot severity.

Overhead polyethylene cover (Figs. 8-11) reduced bacterial leaf spot severity, increased fruit weight per plant, and reduced the number of unmarketable fruit, which in turn resulted in higher yields. This was in spite of a slightly higher bacterial wilt incidence.

The best overall yields in this experiment were obtained in raised beds with black plastic mulch and overhead polyethylene cover. The use of overhead cover reduces, although it may not eliminate, the need for spraying pesticides to control bacterial leaf spot. Used together with plastic mulch, it can compensate for the tendency of the latter to increase leaf spot severity, and still have the advantages of plastic mulch mentioned before. Combining these practices with raising the planting beds reduces leaf spot severity even further.

Figure 2

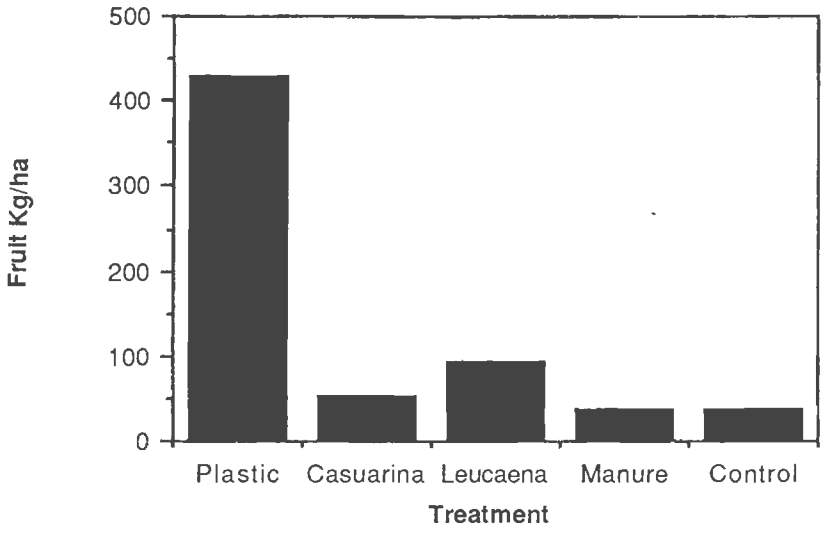



Figure 3

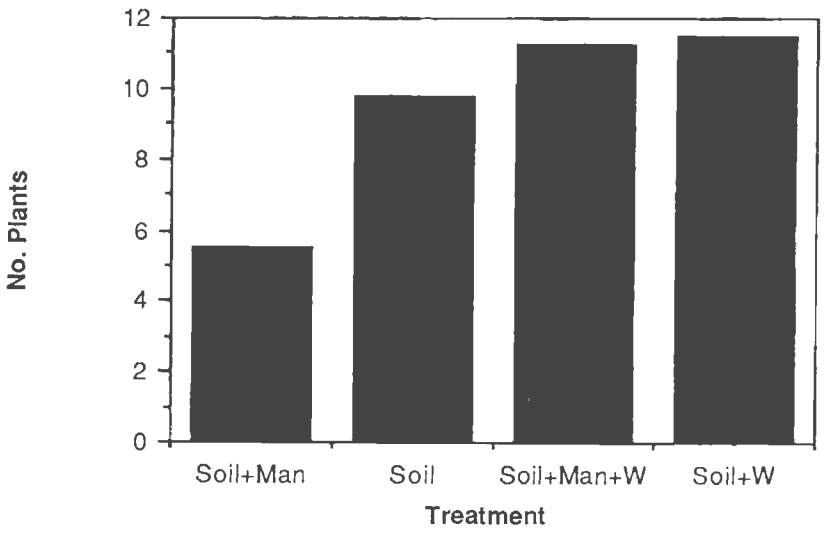
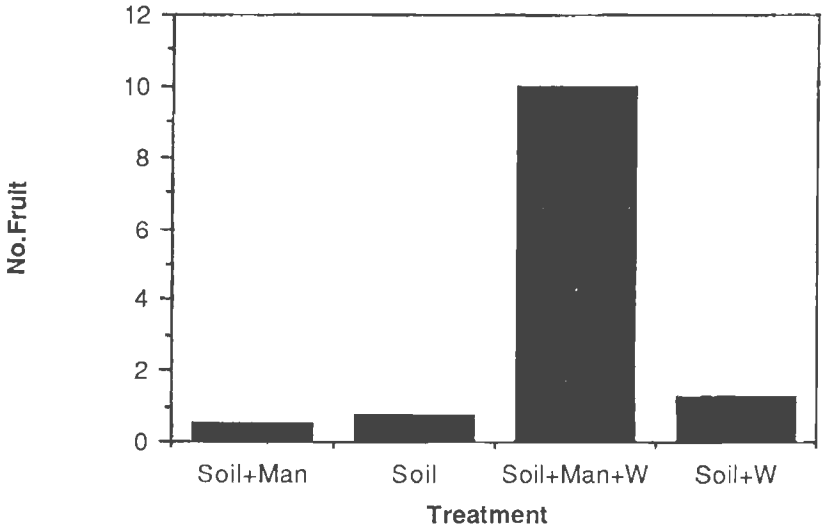



Figure 4



### Determination of plant diseases on Guam.

A list of diseases and their causal agents identified on Guam as of May, 1985 was published by Russo et al. under the title Plant pathogens and associates hosts on Guam (Technical Report, AES Publication No. 46). In it, there are 123 plant diseases and 80 genera of plant pathogens reported occurring on Guam. The following is a series of information produced or gathered in the process of accomplishing this project's objective after 1985. An additional 50 plant diseases not appearing in the previous publication are listed (Table 1).

Three plant disease databases have been prepared and are currently in the Apple Macintosh computer system at the AES office, College of Agriculture & Life Sciences. These are intended as reference material for faculty and students. Full descriptions of each are given later in this report. In addition to these, other teaching aids obtained with this project's funds include three slide sets and many slides of local diseases.

Four publications have resulted from work in this project, another one is in press at this time, and two more are being prepared.

### New reports of plant diseases on Guam as of 1986.

The following list of pathogens, hosts, diseases, and locations on pages 18-20 is comprised of reports not listed in Technical Report AES Publication No. 46, 1985. The information is taken from the plant disease logbook, where all samples handled in the plant pathology lab are recorded. This list of pathogens is intended to complement AES Publication No. 46, and update the latter. A new Technical Report composed of all of the above is planned for the near future. Pathogens have been keyed out to genus, and when possible, to species. Species appearing in parenthesis are not certain, but likely.

### References, Teaching aids.

In addition, three slide sets on plant diseases of various crops have been purchased as reference material. These slide sets, together with over 100 slides prepared from plant disease specimens on Guam, now form part of the slide collection kept at the plant pathology lab. The collection is often is used as teaching material for class presentations, and in presentations of their kinds, such as workshops, etc. The are available to faculty and students.

Figure 5

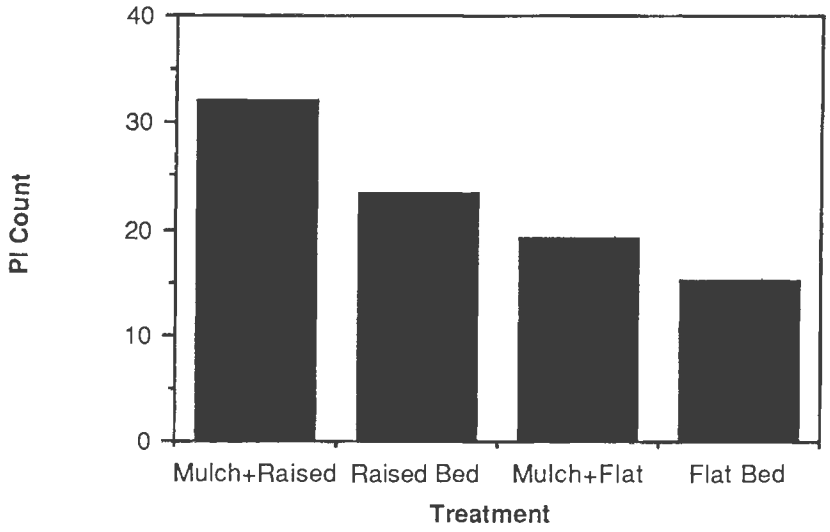



Figure 6

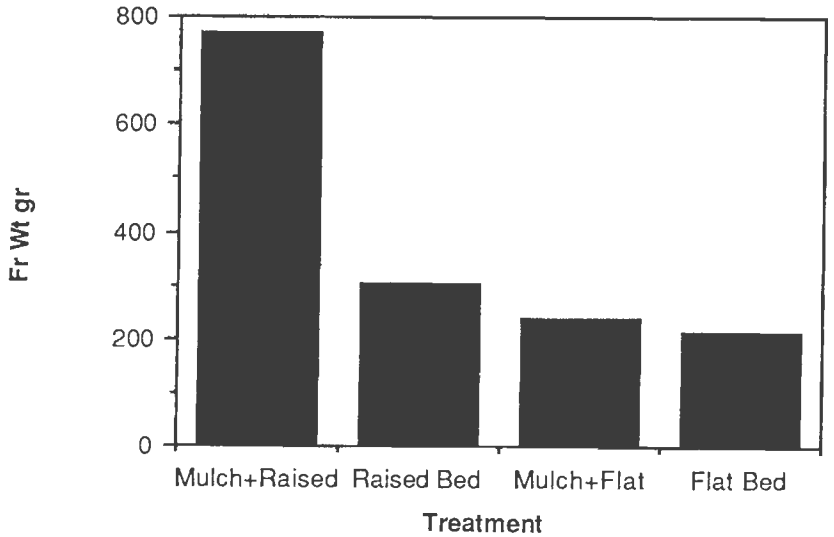


Figure 7

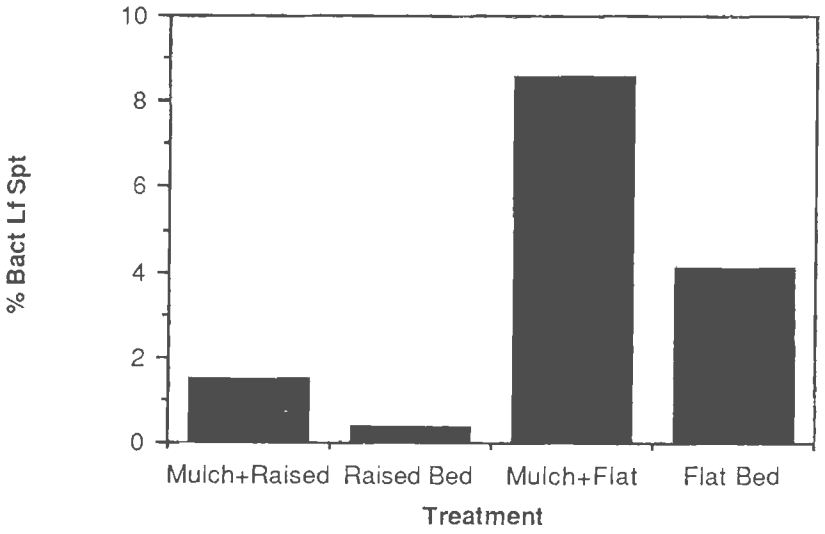



Figure 8

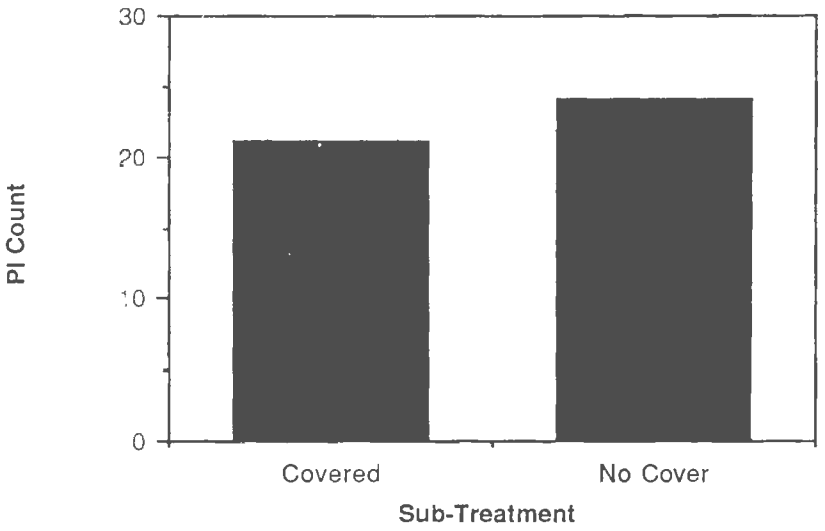



Figure 9

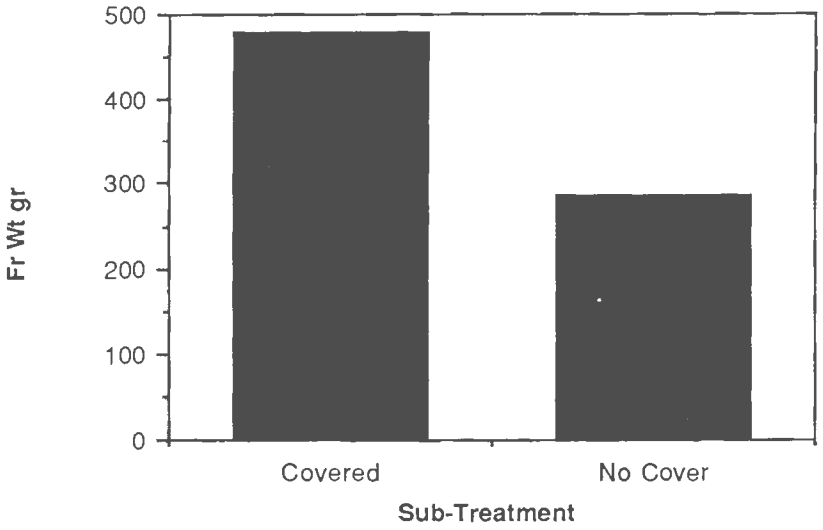


Figure 10

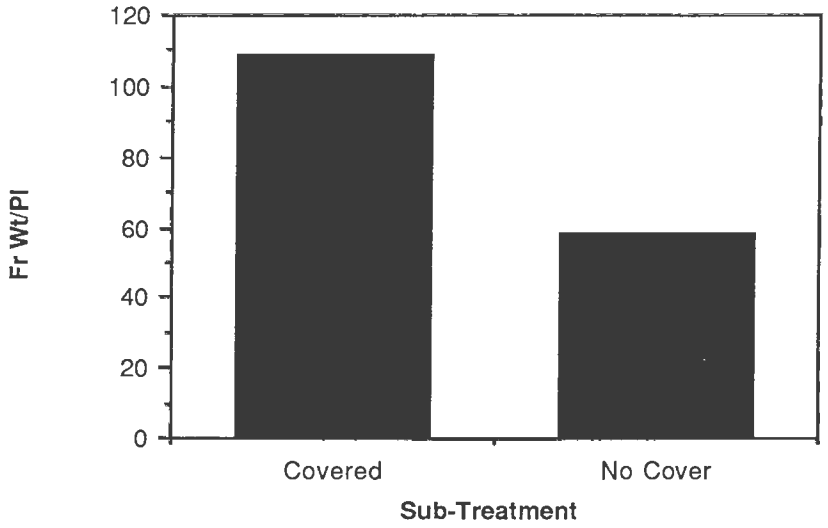



Figure 11

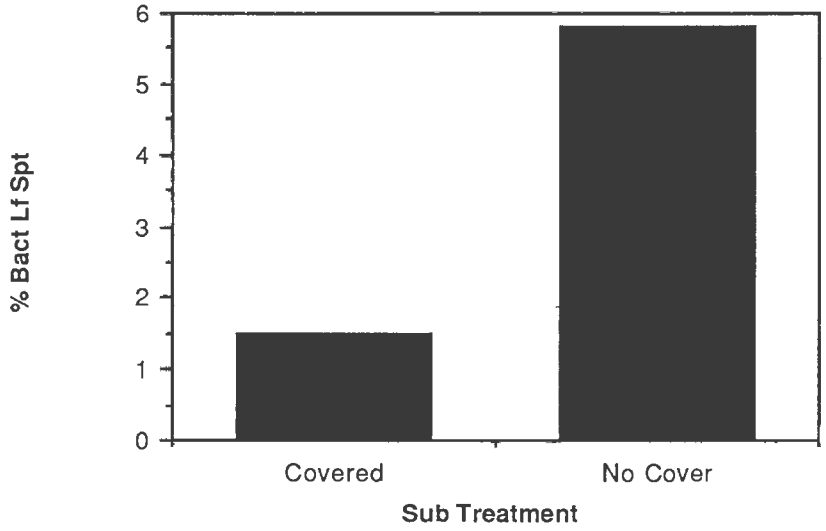


**Table 1. New reports of plant diseases on Guam.**

| Pathogen | Host | Disease | Location |
|---|---|---|---|
| *Agrobacterium tumefaciens* | Rose | Crown Gall | Yona |
| *Aphelenchoides* sp (?) | *Lansium domesticum* | Stem galls | Sinajana |
| *Ascochyta* sp | Bittermelon | Leaf spot | Barrigada |
| *Botryodiplodia theobromae* | *Annona squamosa* | Diplodia rot | Barrigada |
| *Capnodium (citri)* | Citrus | Sooty mold | Inarajan |
| *Cassytha filiformis* | Citrus | Dodder | Mangilao |
| *Cassytha filiformis* | False verbena | Dodder | Inarajan |
| *Cercospora (ipomeae)* | *Ipomoea triloba* | Leaf spot | Inarajan |
| *Cercospora* sp | Yd long bean | Leaf spot | Inarajan |
| *Cercospora (citrullina)* | *Cucumis melo* | Leaf spot | Barrigada |
| *Colletotrichum gloeosporioides* | Papaya | Fruit rot | Inarajan |
| Cucumber Mosaic Virus | Tomato | Distortion | Yigo |
| Cucumber Mosaic Virus | Banana | Mosaic | Mangilao |
| *Curvularia* sp | Taro | Leaf spot | Inarajan |
| *Diaporthe citri* | Citrus | Melanose | Barrigada |
| *Erwinia (carotovora)* | Watermelon | Soft rot | Dandan |
| *Erwinia (carotovora)* | Broccoli | Soft rot | Inarajan |
| *Erwinia (carotovora)* | Tomato | Soft rot | Talofofo |
| *Fusarium* sp | Papaya | Fruit rot | Inarajan |
| *Fusarium* sp | Watermelon | Wilt | Barrigada |

| | | | |
|---|---|---|---|
| *Glomerella cingulata* | Bell pepper | Anthracnose | Pago Bay |
| *Gloeosporium* sp | *Davillia* sp | Tip blight | Mangilao |
| *Macrophoma* sp | Bell pepper | Stem rot | Barrigada |
| *Macrophomina phaseolina* | KW Bean | Ashy stem blight | Inarajan |
| *Meloidogyne* sp | Banana | Root knot | Yona |
| *Meloidogyne* sp | Bell pepper | Root knot | Mangilao |
| *Meloidogyne* sp | Tomato | Root knot | Yigo |
| *Meloidogyne* sp | Yd long bean | Root knot | Inarajan |
| Mosaic Virus | Wild bittermelon | Mosaic | Piti |
| *Mycosphaerella (fijiensis)* | Banana | Black leaf streak | Merizo |
| *Oidium* sp | False verbena | Powdery mildew | Barrigada |
| *Phomopsis citri* | Calamansi | Scab | Inarajan |
| *Phomopsis citri* | Lemon | Scab | Inarajan |
| *Phyllosticta* sp | Banana | Freckle | Inarajan |
| *Phytllosticta* sp | Taro | Leaf spot | Inarajan |
| *Phytophthora* sp | Mango | Root rot, Gummosis | Yona |
| *Phytophthora (citrophthora)* | Tangerine | Fruit rot, Gummosis | Ipan |
| *Pseudomonas (solanacearum)* | False verbena | Bacterial wilt | Mangilao |
| *Pseudomonas pseudoalcaligenes subsp. citrulli* | Watermelon | Fruit Blotch | Dandan |
| *Pythium (aphanidermatum)* | Cucumber | Cottony leak | Merizo |

| | | | |
|---|---|---|---|
| *Rhizoctonia (solani)* | Tomato | Fruit rot | Yona |
| *Rhizoctonia* sp | Bermuda grass | Dollar spot | Dededo |
| *Rhizoctonia* sp | Melon | Root rot | Inarajan |
| *Rhizoctonia (solani)* | Potato | Black scurf | Yigo |
| *Rhizoctonia* sp | Yam | Root rot | Inarajan |
| *Trichoderma* sp | Betel nut | Fruit spot | Santa Rita |
| *Ulocladium* sp | Bell pepper | Fruit spot | Barrigada |
| Woody Gall Virus | Mango | Woody gall | Mangilao |
| *Xanthomonas campestris pv manihotis* | Cassava | Bacterial blight | Inarajan |
| *Xanthomonas (campestris)* | Cabbage | Leaf scald | Yigo |
| *Xanthomonas campestris pv citri* | Citrus (lemon) | Canker | Mangilao |

# Entomology

R. Muniappan, M. Marutani & G.R.W. Denton

## Biological Control of Chromolaena odorata

The Siam weed, *Chromolaena odorata* is neotropical in origin. It has become a serious problem in the humid tropical regions of Asia, Africa and Micronesia. A project for biological control of *C. odorata* was initiated in 1984. Since this project was successful in the Mariana Islands, an attempt was made to assist other countries in control of this weed.

An International Workshop on *Chromolaena odorata* was organized in Bangkok, Thailand, during Feb.-March 1988. About 20 participants from different countries attended and as an outcome of this workshop, proceedings and two newsletters were produced during the year of 1988. Shipments of *Pareuchaetes pseudoinsulata*, a natural enemy of *Chromolaena odorata*, were sent to Yap, Thailand and South Africa.

## Publications and Reports

1) Muniappan, R., Marutani, N. and Denton, G.R.W. Biological Control of *Chromolaena odorata* in the Western Caroline Islands. J. Biological Control (In Press).
2) Muniappan, R. 1988. *Chromolaena odorata* Newsletter #1. Guam Agricultural Experiment Station. 15p.
3) Muniappan, R. 1988. *Chromolaena odorata* Newsletter #2. Guam Cooperative Extension Service 23p.
4) Muniappan, R., Marutani, M. and McConnell, J. 1988. A bibliography of *Chromolaena odorata*. *Chromolaena odorata* Newsletter 1:3-15.
5) Muniappan, R. and Marutani, M. 1988. Biological control and insect induced yellowing of leaves of *Chromolaena odorata* (L.)K and R. (Asteraceae). Proc. 18th International Congress of Entomology, Vancouver, B.C., Canada (Abstract):371.
6) Muniappan, R. 1988. Proceedings of the first international workshop on biological control of *Chromolaena odorata*. Guam Agricultural Experiment Station. 85p.
7) Muniappan, R., Sundaramurthy, V.T. and Viraktamath, C.A. Distribution of *Chromolaena odorata* (Asteraceae) and bionomics and consumption and utilization of food by *Pareuchaetes pseudoinsulata* in India. Proc. VII. Int. Symp. Biol. Contr. Weeds. (In Press).
8) Muniappan, R. and Seibert, T.F. 1987. Biological control of *Chromolaena odorata* in Thailand: A study team report. Guam Agricultural Experiment Station. 9p.
9) Seibert, T.F. 1988. Biological control of the weed, *Chromolaena odorata* (Asteraceae) by *Pareuchaetes pseudoinsulata* (Lepidoptera: Arctiidae) on Guam and the Northern Mariana Islands. Entomophaga (In Press).

## Biological Control of the Red Coconut Scale

The red coconut scale, *Furcaspis oceanica*, is an endemic species to Caroline Islands. It became a serious pest in Saipan at the end of World War II. Introduction of the parasite, *Adelencyrtus oceanicus* from Ulithi to Saipan in 1948 has resulted in successful control of the red coconut scale. In recent years, *F. oceanica* has been accidentally introduced and established on Guam. Currently, it is a problem only in the central part of Guam. In 1987, a project was initiated for biological control of red coconut scale on Guam. Efforts to study the biology of the red coconut scale in the laboratory were continued using butternut squash and banana squash. The parasite, *A. oceanicus*, collected from Ulithi Atoll and Peleliu island in Palau were brought to Guam and field released on May and November 1988, respectively. Even though one male parasite was recovered from the field, further surveys did not reveal the establishment of *A. oceanicus* in the field. Further releasings of the parasite from the Caroline Islands are planned.

## Publications and Reports

1) Marutani, M. and R. Muniappan. 1988. Incidence of the red coconut scale, *Furcaspis oceanica* and its parasites in Micronesia. J. Plant Protection in the Tropics. (Submitted for publication)
2) Muniappan, R. 1987. Status of red coconut scale in Micronesia. 5th Regional Tech. Meeting on Plant Protection. South Pacific Commission, New Caledonia, 5p.

## Management of Cruciferous Crop Pests

Major pests that affected cruciferous crops on Guam during 1988 were: imported cabbage webworm (*Hellula undalis*), fire ant (*Solenopsis geminata*), cutworm (*Spodoptera litura*), corn earworm (*Helicoverpa armigera*) and diamond back moth (*Plutella xylostella*). *H. undalis* was a problem primarily in

the seedling stage of the crop. Application of Naled provided effective control. *S. geminata* girdled transplanted seedlings in the fields during the hot dry season. Diazinon and Dursban proved to be effective in controlling *S. geminata*. Diamond back moth was found to be resistant to carbamates, organophosphates, synthetic pyrethrins and Dipel on Guam.

Further studies on varietal preference, varietal resistance, and natural enemies are being continued.

### Publications and Reports

1) Yalemar, J., Muniappan, R. and Marutani, M. 1988. Control of fire ant on cabbage. Insecticide and Acaricide Tests. (Submitted for publication).
2) Marutani, M. and Muniappan, R. 1988. Imported cabbage webworm control. Insecticide and Acaricide Tests. (Submitted for publication)
3) Yalemar, J., Marutani, M. and Muniappan, R. 1988. Cabbage insect control. Insecticide and Acaricide Tests. (Submitted for publication).

### Biological Control of Lantana camara

A survey of the natural enemies of *Lantana camara* on major islands in Micronesia was carried out. There were two or more taxa of *L. camara* present in Micronesia. The reaction of natural enemies on these two taxa seemed to vary.

*L. camara* is not present in the island of Rota. Hence, steps being taken to introduce a legislation to prevent future introduction of *L. camara* to Rota.

Seasonal fluctuation of populations of natural enemies of *L. camara* on Guam is being studied.

### Publications and Reports

1) Muniappan, R. 1988. Biological control of *Lantana camara* L. in Yap. Proc. Hawaiian Entomol. Soc. (In Press).
2) Muniappan, R. 1988. Biological control of the weed, *Lantana camara* in Guam. J. Plant Protection in the Tropics 5(2):99-101.

### Biological Control of Fruit Piercing Moth, Othreis fullonia

The fruit piercing moth, *Othreis fullonia* is distributed in the tropical Oceania, Asia and Africa. The larva feeds on *Erythrina spp.* in the Pacific Islands, but in the continental land areas it feeds on plants in the family Minispermaceae. Adult moths are strong fliers and live up to 30 to 40 days. Adult pierce the fruits and suck the sap.

*O. fullonia* is observed to cause serious damage to fruits in the Commonwealth of the Northern Marianas, Guam, Kosrae and American Samoa. It is present in Palau and Pohnpei and its economic impact needs to be evaluated.

Six different species of egg parasites have been collected on Guam two of which play a major role in controlling numbers of this species. The distribution of egg parasites and their efficacy in Micronesia are being evaluated.

### Publications and Reports

1) Denton, G.R.W., Muniappan, R., Marutani, M., McConnell, J., Lali, T.S. & Afaisan, D. 1989 Biology and natural enemies of the fruit piercing moth, *Othreis fullonia* (Noctuidae). In proceedings of the ADAP Crop Protection Conference, May 18-19, 1989, University of Hawaii, Honolulu, Hawaii (in press).
2) Wall, P. and R. Muniappan. 1988. Food preference of fruit piercing moth, *Othreis fullonia*. South Pacific Commission Biological Control Workshop, Tonga. 3p.

# Entomology

D. Nafus & I. Schreiner

## CORN
### Augmentation of predators

Several species of general predators including various spiders, nabids, anthocorids, mantids, and ants are present on corn plants. Many of these species feed on various life stages of the corn borer. In 1988 we continued to examine the question of whether the plants surrounding the corn have a significant impact on predator populations. To test this question, corn was grown in a monoculture or intercropped with sweet potatoes. The numbers and species of predators on the corn and the number of corn borers were counted for comparison. Sweet potatoes were grown around the corn. In the monoculture the corn was planted in hills of 3 plants spaced at 3 hills per meter. Rows were 1 meter apart. In the intercrop, two hills of corn were replaced by sweet potatoes plant in each meter yielding a density of 1 corn hill per meter. Each treatment was replicated 4 times.

The density of the orb weaver *Neoscana* sp. was found to be significantly increased in the intercrop situation. *Neoscana* densities were nearly twice as high in the intercrops as in the monocultures (Table 1). Densities of other species of orb weavers did not show a difference between the two treatments.

The number of hunting spiders was higher in 1988 than in 1987 and, like *Neoscana* , there were significantly more on the intercrop plants than on the monoculture corn. This was particularly true later in the season when there were nearly 4 times as many hunting spiders on the inter-

### INSECTS ESTABLISHED IN MICRONESIA WHICH WERE FIRST IDENTIFIED IN 1988

| Insect *Genus species* Order: family | Host | Status | Comments |
|---|---|---|---|
| Guam | | | |
| *Phytoseiulus macropilis* (Banks) Acari: Phytoseiidae | spidermites | New record | Probably on Guam for many years Predator on spidermites |
| *Amblyseius longispinosus* (Evans) Acari: Phytoseiidae | spidermites | New record | Probably on Guam for many years Predator on spidermites |
| *Melormenis basalis* (Walker) Homoptera: Flatidae | guava, etc. | New record | First collected in 1985. A Neotropical sp. new to Hawaii in 1967 |
| *Liris aurentulus* F. Hymenoptera: Sphecidae | crickets | New record | First collected in 1987. |
| *Lindingaspis tingi* McKenzie Homoptera: Diaspididae | star apple cycads? | New record | First collected 1988, on leaves Source: Philippines |
| *Pseudaonidia trilobitiformis* (Green) Homoptera: Diaspididae | pomello tangerine star apple | New record | First collected 1988, on leaves fruit Widely distrib: Philippines, Japan, China, etc. |
| *Keiferophyes guamensis* Mohanasundaram & Muniappan Acari: Eriophyidae | mango | New record | Probably on Guam for some time feeds on new buds. |
| *Helicoperva assaulta* (Guenee) Lepidoptera:Noctuidae | corn tomato etc. | New record | First collected in 1987. Widely distributed in old world. Feeds on fruit. |
| Saipan | | | |
| *Curinus coeruleus* Mulsant Coleoptera: Coccinellidae | scales psyllids | Biocontrol establishment | Released 1986 for control of *Heteropsylla cubana*: Recovered Dec 31, 1988 |
| *Delta pyriforme* (F.) Hymenoptera: Eumenidae | caterpillars | New record | Collected 1988, probably present for some time, as was collected in Tinian 1985. |

crop plants. Other groups of spiders were too rare to show trends.

Among the other predators on corn, only the minute pirate bugs showed any significant differences between the intercrop and the monoculture. Initially the number of anthocorids was similar in both treatments but numbers in the monoculture dropped as the corn aged. In the intercrop the number remained approximately the same, leading to nearly a 5-fold difference in the final sample. The minute pirate bugs were observed feeding on both eggs and first instar corn borers. Unlike 1987, *Solenopsis* was not abundant and no siginificant differences were found in the number present in the two treatments. The other species of ants showed a similar response (Table 2).

The number of corn borers was very high this year and the level of general predation was not high enough to prevent complete yield loss. An average of about 300 borers per plant was found in both treatments (Table 3). The monoculture plants were destroyed earlier than the intercrop plants. At the time of the third sample, 21% of the intercrop plants were dead compared to 51% of the monoculture plants.

## MANGO

### Biology of the Mango Shoot Caterpillar

Mango shoot caterpillar eggs and first instar larvae were collected in the field and reared on mango flowers and foliage of various ages to determine what stage of leaves constitutes a suitable host for this caterpillar. Larvae were individually reared in 1 ounce plastic creamer containers. Food of a suitable stage was provided daily, and the container was kept humid with a piece of moistened filter paper on the bottom. Leaves and flowers were collected in the field as needed. The various types of food tested were as follows: Flowers in the bud stage or just opened; newly emerged leaves 1-2 inches long; larger leaves about 5-6 inches long; full-sized leaves longer than 8 inches but still tender and red in color; or full-sized leaves beginning to become mature.

The larvae developed most quickly on the youngest leaves, a little more slowly on the older ones as long as they were still immature, and most slowly on the flowers (Table 4).

**Table 1.** Difference in damage to corn plants and in the numbers of spiders found on 75 corn plants when the corn is grown intercropped with sweet potatoes or in a monoculture. Damage is indicated by the number of tips killed by the corn borers. Plants with dead tips either failed to produce a tassel or the tassel was destroyed before it reached the pollen-shedding stage.

| Date | Crop type | Dead tips | | Orb weavers: *Neoscana* | | Orb weavers: other | | Hunting spiders | | Other spiders | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mean | std | mean | std | mean | std | mean | std | mean | std |
| 8/15/88 | Intercrop | 0.8 | 1.5 | 178.5 | 13.9 | 8.5 | 2.6 | 2.8 | 2.2 | 0.8 | 1.0 |
| | Monoculture | 2.5 | 2.1 | 87.0 | 8.0 | 5.8 | 2.1 | 2.3 | 2.1 | 0.5 | 0.6 |
| 8/22/88 | Intercrop | 6.5 | 7.0 | 177.5 | 30.0 | 9.8 | 4.0 | 5.0 | 2.6 | 0.5 | 0.6 |
| | Monoculture | 18.5 | 12.9 | 98.3 | 37.2 | 9.0 | 6.2 | 1.5 | 1.9 | 0.0 | 0.0 |
| 8/30/88 | Intercrop | 21.8 | 12.0 | 214.5 | 49.0 | 8.3 | 4.7 | 19.0 | 9.6 | 0.3 | 0.5 |
| | Monoculture | 51.0 | 12.4 | 92.5 | 48.3 | 10.8 | 8.1 | 4.8 | 2.2 | 0.0 | 0.0 |
| F-value/probability of F | | 7.8 / 0.03 | | 23.4 / 0.03 | | 0.02 / 0.9 | | 8.2 / 0.033 | | 1.0 / 0.4 | |

However pupal weight, which is likely to be correlated with fecundity, showed the reverse trend. The greatest pupal weights were found for larvae which were fed flowers, and the smallest pupae were those of the larvae fed on young leaves. A different picture was seen for leaves which had begun to mature. On those leaves all but one of the first instar larvae died within the first day or two. Only one out of 20 tested survived and this one took 21 days to reach the pupal stage, more than twice as long as the larvae took on any other type of foliage. Another set of larvae was reared on young leaves until they molted to the third instar. Then they were switched to old leaves. These older larvae survived and completed their development, but took 3-4 days longer than larvae fed on younger leaves. The pupal weight was only 60-75% of that of larvae fed on young leaves for the entire period.

**Table 2.** Difference in the numbers of predators other than spiders on 75 corn plants when the corn is grown intercropped with sweet potatoes or in a monoculture.

| Date | Crop type | Anthocorids | | *Tapinoma* | | *Technomyrmex* | | *Solenopsis* | | Other predators | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mean | std | mean | std | mean | std | mean | std | mean | std |
| 8/15/88 | Intercrop | 59.3 | 11.4 | 3.8 | 2.5 | 7.8 | 4.6 | 0.8 | 0.5 | 0.5 | 0.6 |
| | Monoculture | 41.0 | 13.1 | 1.5 | 2.4 | 3.3 | 3.6 | 2.3 | 2.9 | 0.5 | 0.6 |
| 8/22/88 | Intercrop | 50.3 | 13.0 | 2.3 | 2.2 | 17.0 | 6.5 | 3.3 | 4.7 | 1.5 | 1.3 |
| | Monoculture | 10.0 | 5.4 | 1.8 | 2.4 | 7.8 | 6.3 | 5.5 | 6.5 | 2.0 | 1.8 |
| 8/30/88 | Intercrop | 49.5 | 33.7 | 3.0 | 3.5 | 11.3 | 7.5 | 12.8 | 9.4 | 4.5 | 2.4 |
| | Monoculture | 10.0 | 5.0 | 0.5 | 0.6 | 4.0 | 3.7 | 3.0 | 3.2 | 1.0 | 1.4 |
| F-value/probability of F | | 18.5/0.005 | | 2.3/0.2 | | 4.4/0.07 | | 0.5/0.5 | | 2.1/0.2 | |

**Table 3.** Number of eggs of Asian corn borer laid on corn plants on Aug 17 and number of corn borers found on the corn plants on Aug 31.

| | Number of egg masses per plant | Number of larvae per plant | | |
|---|---|---|---|---|
| | | first | older than first | total, all instars |
| Intercrop | 4.0 | 67 | 225 | 292 |
| Monoculture | 4.3 | 72 | 234 | 306 |

**Table 4.** Growth rate and pupal weights of mango shoot caterpillars fed on foliage of various ages

| Type of food | Total time to pupate | Time from 3rd instar to pupation | Pupal weight (g) |
|---|---|---|---|
| Flowers | 10.4 ± 0.7 | 8.4 ± 0.9 | .171 ± .021 |
| Leaves 1-2" long | 9.3 ± 0.6 | 7.8 ± 0.8 | .126 ± .023 |
| Leaves 5-6" long | 9.8 ± 0.8 | 8.3 ± 0.9 | .134 ± .030 |
| Full-sized leaves, still tender | 9.5 ± 0.7 | 7.4 ± 0.7 | .158 ± .022 |
| Instars 1-2 on new leaves 3-5 on maturing leaves | NA | 11.3 ± 1.0 | .097 ± .017 |
| Analysis of variance: F (probability) | 4.75 (<.006) | 31.86 ( <0.001) | 17.82 (<0.001) |

# Pest Management

I. Schreiner

## MANGO

### Biology of the blotch miner

Blotch miner (*Procontarinia* sp. n.) populations were surveyed monthly over a period of 2 1/2 years. The mean number of mines per leaf was quite low, averaging less than 10 per leaf every month except for two (Figure 1). Populations were low during the 1988 dry season, but not in the 1987 dry season. Two population peaks, where the number of mines per leaf exceeded 15, occurred in Nov. 1986 and Aug. 1987. Both followed one month after a relatively large proportion of mango trees produced new flush. Individual trees during the sampling period suffered much heavier damage on occasion. Counts of more than 200 mines in a leaf were recorded and averages of over 90 per leaf were found on some trees in some months.

## CUCUMBERS

### Injury levels of various pests

Cucumbers (var.Slice Master) were planted November 30, 1987 at Inarajan, Guam. The plants were grown on trellises. Four different mulch treatments were used: black, silver or white plastic or coconut leaves. Each 18 m (60 ft) mulch row was split into three foliar treatments: dimethoate (2.67EC 0.7 kg A. I./ha), carbaryl (Sevin 50%WP 2 kg A. I./ha) + malathion (2 EC 0.75 kg A. I./ha) or no treatment. All treatments were replicated 4 times. The foliar treatments in all three trials were applied weekly with a Solo backpack sprayer, and approximately 1400 l of water were sprayed per hectare.

Thrips were artificially introduced to the field about one month, weeks after planting by placing infested leaves around the edges of the field.

*Diaphania indica* (Asian melon worm) numbers were estimated by counting the number of caterpillars per leaf on each of 20 mature leaves per subplot. All yield was picked and weighed, and the incidence of melon fly damage was recorded. Numbers of melon thrips (*Thrips palmi* ) were estimated by picking 10 mature leaves per subplot and placing them in bags, and bringing them to the laboratory, where thrips numbers were counted with the aid of a binocular microscope.

### Results

The number of orange pumpkin beetles was low, about 3-6 per row, and no damage due to them could be observed. Melon fly numbers were also quite low, as less than 10% of the fruit were damaged. There were no differences among treatments in the number of fruits damaged by melon flies.

The number of *D. indica* caterpillars was significantly reduced in the subplots being sprayed with insecticides, with the malathion +carbaryl combination being more effective than dimethoate. The number of *D. indica* per leaf was significantly lower in the coconut mulch treatments than in the other mulch treatments. Both yield and the number of cucumbers was significantly higher in the insecticide treated plots (Table 1). The cucumbers grown on coconut mulch had a significantly lower total yield. The coconut mulch allowed a large number of weeds to penetrate, and it is probable that this factor reduced yield.

There was a significant difference in the number of melon thrips present among the different replicates. The number of melon thrips per leaf was not affected by the mulch or the insecticide treatments (Table 1). Differences among replicates were probably due to initial differences in the number of thrips successfully introduced to the field. No relationship between thrips numbers and the number of cucumbers per plot could be observed (Figure 2a). Melon thrips also damage the cucumber fruit directly causing scarring. However, no significant correlation between thrips numbers and numbers of scarred fruit could be observed (Figure 2b).

A regression was calculated for each trial with the average number of *D. indica* per leaf as the independent axis and the number of cucumbers per plot as the dependent axis. The mean number of *D. indica* per leaf in a plot ranged from 0 to 0.9 caterpillars per leaf. The regression based on all the data points showed no relationship between caterpillar numbers and yield of cucumbers. However, the coconut mulch treatments had low numbers of caterpillars but also low yield, and so differed from the other treatments. Therefore the regression between *D. indica* numbers and number of fruits was recalculated without the data from the coconut mulch plots. The slope approached significance in this circumstance ( $P < 0.1$, Figure 3). As the the number of caterpillars per leaf increased towards one, the

number of cucumbers per plot decreased 13%. Although the slope of the regression was not significant, the comparison between treated and non-treated plots discussed above indicated a significant decrease in the number of cucumbers in the untreated plots, with the untreated plots yielding about 11% fewer fruit.

## BEANS

### Injury level of various pests

A trial was run to compare several spray regimes for the leafminer, and control of other pests with untreated beans. Beans were planted Jan 22, 1988. Plots consisted of two 6 m rows, 1.2 m apart. The rows were separated by rows of sweet corn to minimize insecticide drift. Treatments were aranged in a randomized complete block design. The treatments consisted of:

1. spraying once a week with fenvalerate (Pydrin )for the whole growing season,
2. spraying Pydrin weekly until the beans flowered (ca. Mar. 9), then Dipel weekly thereafter,
3. spraying dimethoate weekly for the whole growing season,
4. no treatment.

The number of leafminers per plot was estimated by counting the number of mines on 40 mature leaves in each plot. Samples were taken on Mar.1 and Apr.5. Another 40 leaflets per plot were picked and kept in sealed paper bags until parasites and adult flies had emerged and died. Beanflies were sampled by examining 60 seedlings per plot on Feb. 12 and determining whether they were infested, and by examining 60 petioles of leaves on Apr. 12. Yield was the total yield for both rows. A subsample of 50 beans per plot was taken from each harvest, and the number that were infested with aphids and with pod borers was counted.

### Results

The insecticide treatments had a significant effect on most variables (Table 2). All the leafminers which emerged from the reared samples were *Liriomyza trifolii*. The number of mines per leaf was significantly lower in the insecticide treated plots on the first sample date. Cygon was more effective than Pydrin. This contradicts results from earlier years and suggests that resistance to Pydrin may have appeared in the Guam. On the second sample date, the leafminer population had become low even in the untreated plots. The reared samples showed a high level of parasitization by the recently established wasp *Ganaspidium hunter*. In this experiment it was clearly unnecessary to continue spraying insecticides for the control of leafminers after flowering, as the parasites were controlling them just as well as the insecticides. This is the first bean experiment, out of 8 performed on Guam up until this date, where we have noted that the number of mines was reduced during the course of the season, a factor which might be attributable to the new parasite species.

Beanflies (*Ophiomyia phaseoli)* were significantly reduced in the insecticide treatments on both dates. Pydrin and Cygon were both effective, but the Pydrin stopped at flowering was less effective that the Pydrin sprayed all season. This result is not surprising for the second sample which was taken one month after the last Pydrin spray. However, at the time of the first sample the two treatments were exactly the same, and the fact that there are significant differences even there suggested that the infestation level was different for reasons not connected with the insecticide.

The proportion of beans with pod borers (*Maruca testulalis* ) was reduced compared to the control in the Pydrin and Dipel plots, but higher than the control in the Cygon plots. The proportion of beans with aphids (*Aphis craccivora)* on them also varied significantly among plots. They were low in the Cygon and Dipel treatments, and higher in the control and Pydrin treatments.

Single regressions of the various insect populations against yield showed that there was a signficant association only with the first leafminer sample. Multiple regression was performed using yield as the dependant variable and the various insect populations as the independant variables. Only the first leafminer sample and the first beanfly sample were close to significantly correlated with yield (Table 3). However there was a high degree of collinearity between variables. In particular, the first leafminer count could be used to significantly predict both beanfly counts and aphids infestation. Because of this it cannot be determined what to what degree the beanfly and aphid populations affected yield. Only the proportion of pods damaged by borers was not

significantly correlated with the leafminer counts, but there was no relationship between the proportion of beans attacked by borers and total yield. Pod borers damage flowers as well as the more mature beans, but at this level of attack (ca 10% of pods in the untreated plots), apparently the beans can compensate for the injury.

## EGGPLANT
### Resistance to leafhoppers

Eggplants were transplanted June 28, 1988. The plants were spaced 2 ft apart, in rows 5ft apart. Alternate row of two varieties were planted: a recently imported purple variety (Northrup-King Oriental eggplant), and a green local variety, probably originally from the Philippines. Each row was divided into two parts, receiving different foliar insecticide treatments, either wettable sulfur (8 lbs A.I/ 100 gal water) or no treatment. Treatments were begun on August 15. Leafhopper (*Amrasca biguttula*) numbers were estimated by counting the number of leafhoppers/ 20 leaves per plot, and the number of the small insects was counted by picking 10 leaves per plot, bringing them to the laboratory and counting the number under a microscope. For melon thrips (*Thrips palmi*), melon aphids (*Aphis gossypii*), and spider mites *Tetranychus* sp., mature leaves were used. Since the leaves of the green variety were larger than those of the purple variety, the green variety leaves were cut in half to make the size more comparable. Yield was collected for each plant individually since a number of plants died due to root disease. A leafhopper burn damage rating was done by examining 30 leaves per subplot and assigning them to one of 4 categories. These were:

1. No visible damage,
2. Leaves yellow in few spots around the edge,
3. Most of edge of leaf yellow, with at most only 1-2 small dead areas,
4. Most of leaf yellow, several large dead areas.

### Results

Leafhoppers were counted on three dates (once each in August, September and October). On none of these occasions was there any significant difference in the number of leafhoppers between the green and the purple varieties of eggplants, although the number of leafhoppers was always slightly higher on the purple variety (Table 4). This contrasts with the results from the previous year when the purple variety (in that case Ichiban) had significantly more leafhoppers on the leaves. The reason for the difference is likely due to the number of spines on the plants. Ichiban has significantly fewer spines per unit area of leaf than does the green variety but the purple variety tested in 1988 has the same number, or slightly more per unit area as does the green. Hairiness has been shown to induce resistance to this species of leafhopper in both okra and cotton, and it is likely that the same factor applies in eggplants. There was a difference amongst the two varieties tested in 1988. Whereas the two varieties had similar numbers of leafhoppers, the amount of hopperburn visible on the plants at the end of the growing season was significantly less in the green variety. The green variety appears to be resistant to leafhoppers both because it is hairy, but also because it is less susceptible to the symptoms of hopperburn, which are caused by toxins in the saliva of the leafhoppers.

The sulfur treatment applied for the control of broad mites significantly reduced the number of leafhoppers by about 65% or more. However this difference was not enough to affect the hopperburn damage rating, and there was no difference among treated and untreated plants in this rating. There was no difference in yield between treated and untreated plots. Broad mite damage was not observed. The damage due to the leafhoppers is apparently mainly due to the hopperburn, so that the lack of difference in damage ratings is reflected in the lack of difference in yield. The green eggplants yielded significantly more than the purple ones, but it is cannot be determined whether this was due to the leafhoppers, or simply a varietal difference.

Aphids, thrips, spider mites and their predators were not significantly affected by the variety of eggplant, nor did the sulfur treatment have any consistent effect on the numbers of these insects. At the time of the first sample, the number of melon thrips per leaf averaged about 6 per leaf. Predatory anthocorid bugs (*Orius niobe*) and predatory mites were present at densities of about 1 for every 2-10 leaves. These were apparently sufficient to control the thrips population was the thrips were

almost gone by the second sample one month later. Spider mite numbers also decreased between the first and the second sample.

## POINCIANA
### Insecticide trial

Poinciana loopers are a recurring problem on poincianas, defoliating the trees several times a year in most years and disrupting flowering. Foliar applications of insecticide need to be done too frequently to be practical. Therefore insecticide pellets which could be implanted into trees to release their toxicant systemically were tested. Five trees were were drilled as per the manufacturer's instructions and Acecaps were places in the holes. Five trees adjacent to the treated trees were marked to serve as controls. This was done in Sept. 1987 at the time when the first outbreak of loopers in 1987 was detected. Every two weeks thereafter the total number of caterpillars was counted on 10 branch tips on each tree. Beginning in February 1988, twenty branch tips were inspected biweekly and the number which had flowers was recorded.

### Results

Poinciana looper numbers were very low in 1987 as compared with 1988. We believe that 1988 is the more normal population level. In the month following the application the number of caterpillars was somewhat lower on the treated trees, but the difference was not significant due to high variability between trees (Figure 3). By February 1988 there was no indication of differences among treers, and there were only small differences between treated and untreated trees during the large outbreaks in 1988. The pattern and abundance of flowers on treated and untreated trees was similar (Fig.3).

**Table 1. Effect of soil and foliar insecticides on numbers of melonworms and melon thrips and cucumber yield.**

| Foliar Treatment | Mulch Treatment | Number per leaf *D. indica* | *T. palmi* | Number cucumbers per plot | Number scarred fruit per plot | Yield (kg) per hectare |
|---|---|---|---|---|---|---|
| Dimethoate | Black | 0.18 | 37.8 | 195 | 38 | 13333 |
| | Coconut | 0.0 | 19.1 | 172 | 31 | 11926 |
| | Silver | 0.14 | 23.6 | 187 | 39 | 13333 |
| | White | 0.12 | 32.3 | 196 | 30 | 13333 |
| Malathion + | Black | 0.08 | 38.3 | 195 | 39 | 14167 |
| Carbaryl | Coconut | 0.0 | 36.2 | 183 | 31 | 12407 |
| | Silver | 0.05 | 15.9 | 185 | 34 | 13056 |
| | White | 0.06 | 34 | 190 | 40 | 13963 |
| Control | Black | 0.25 | 17.7 | 155 | 34 | 11296 |
| | Coconut | 0.21 | 27.6 | 163 | 31 | 10741 |
| | Silver | 0.65 | 42.2 | 173 | 30 | 12778 |
| | White | 0.36 | 11.8 | 179 | 38 | 12778 |
| Analysis of Variance | | | | | | |
| Mulch treatment | | | | | | |
| F | | 4.27 | 0.43 | 3.50 | 3.53 | 4.08 |
| probability | | 0.04 | 0.7 | 0.06 | 0.06 | 0.04 |
| Foliar treatment | | | | | | |
| F | | 21.92 | 0.31 | 7.15 | 0.59 | 4.05 |
| probability | | 0.0001 | 0.7 | 0.004 | 0.6 | 0.03 |
| Soil X Foliar Treatment | | | | | | |
| F | | 2.28 | 1.32 | 0.93 | 0.28 | 0.53 |
| probability | | 0.07 | 0.3 | 0.5 | 0.9 | 0.8 |

**Table 2. Effectiveness of insecticide treatments on bean pests**

| Treatment | Number leaminers/ leaf Mar.1 | Number leafminers/ leaf Apr.5 | No. bean-flies/sample Feb. 12 | No. bean-flies/sample Apr.12 | % beans with aphids | % beans with borers | Yield/ plot (kg) |
|---|---|---|---|---|---|---|---|
| Cygon | 4.4a | 4.5a | 7a | 2a | 5a | 12d | 33b |
| Pydrin | 5.0b | 4.7a | 10a | 4a | 13c | 8c | 38c |
| Pydrin/Dipel | 6.8c | 4.6a | 14b | 8b | 4a | 2a | 30b |
| No treatment | 10.4d | 4.7a | 21c | 19c | 10b | 5b | 23a |

*Numbers followed by the same letter do not differ significantly at the 0.05 probability level.

**Table 3.Multiple regression of insect population levels versus yield of beans**

| Variable | Parameter estimate | Standard error | *t* | Probability |
|---|---|---|---|---|
| Intercept | 44.63 | 13.61 | 3.278 | 0.0096 |
| Leafminers Mar.1 | -2.07 | 1.16 | -1.775 | 0.1097 |
| Leafminers Apr.5 | -0.41 | 1.59 | -0.258 | 0.8019 |
| Beanfly Feb.12 | 0.76 | 0.42 | 1.803 | 0.1049 |

**Table 4. Yield and insect numbers on eggplant**

| Variety and Treatment | Number Eggplants | Seasonal mean number per leaf *S. biguttula* | *A. gossypii* | *T. palmi* | *Tetranychus* | Damage rating |
|---|---|---|---|---|---|---|
| Green local | | | | | | |
| Sulfur | 28.4 | 1.1 | 3.3 | 2.3 | 1.0 | 1.9 |
| None | 26.0 | 3.6 | 18.1 | 3.2 | 2.8 | 1.9 |
| Purple | | | | | | |
| Sulfur | 14.8 | 1.6 | 0.9 | 1.6 | 2.3 | 2.8 |
| None | 10.9 | 4.2 | 12.6 | 4.1 | 24.8 | 3.1 |
| Analysis of variance | | | | | | |
| Variety | | | | | | |
| F | 19.33 | 1.07 | 0.65 | 0.01 | 3.70 | 32.38 |
| Significance level | 0.001 | 0.3 | 0.4 | 0.9 | 0.08 | 0.0002 |
| Foliar treatment | | | | | | |
| F | 3.82 | 35.04 | 7.39 | 2.24 | 3.31 | 0.49 |
| Significance level | 0.08 | 0.0002 | 0.02 | 0.2 | 0.1 | 0.5 |
| Variety X Foliar treatment | | | | | | |
| F | 0.39 | 0.02 | 0.12 | 0.25 | 2.27 | 1.20 |
| Significance level | 0.5 | 0.8 | 0.7 | 0.6 | 0.2 | 0.3 |

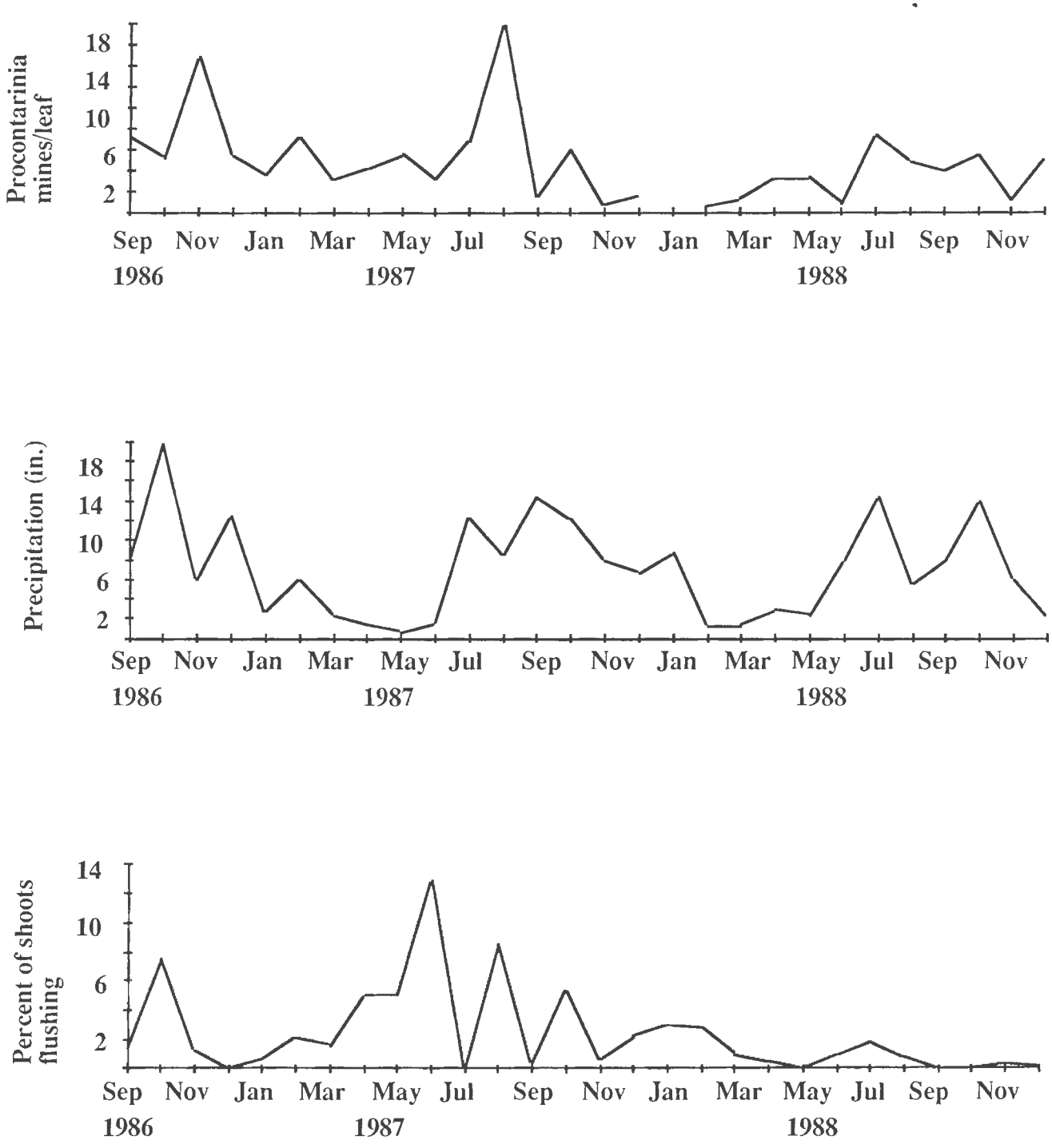



**Figure 1. Average number of *Procontarinia* mines per leaf between 1986-1988 in relation to total monthly precipitation and percent of mango branches with new leaves on 16 marked trees.**

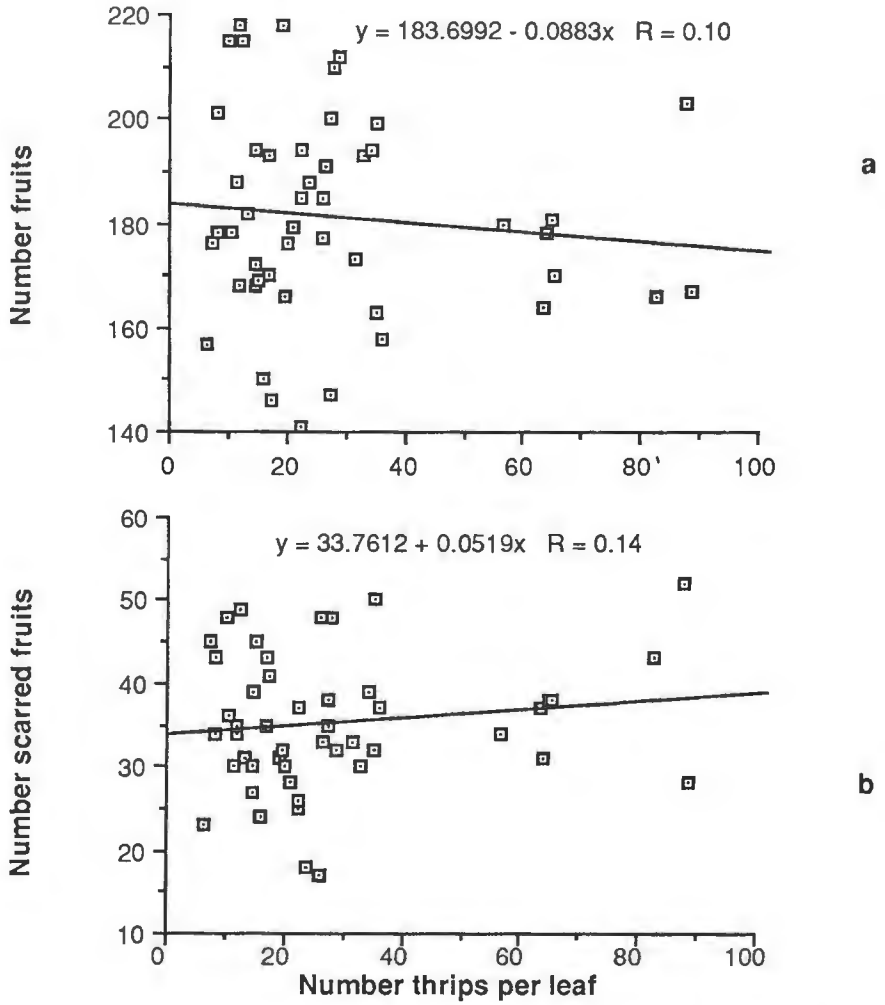



**Figure 2. Relationship between mean number of thrips per cucumber leaf and number of cucumbers per plot (a) or number of damaged cucumbers per plot (b).**

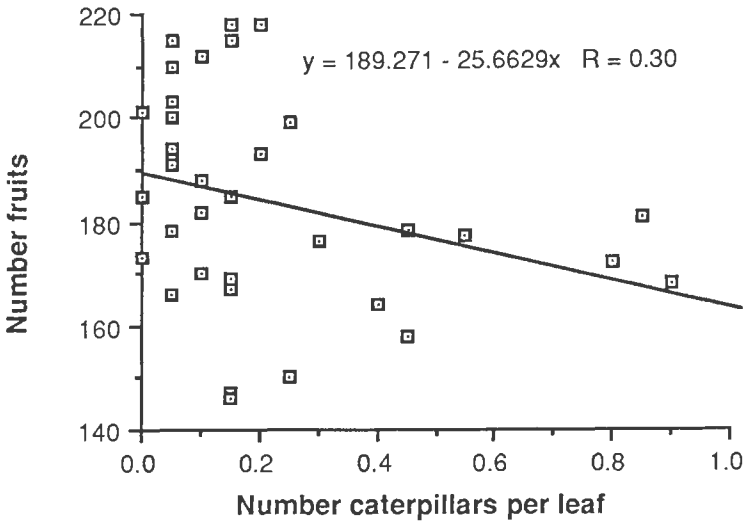



**Figure 3. Relationship between mean number of Asian melonworms per leaf and number of cucumbers produced per plot.**

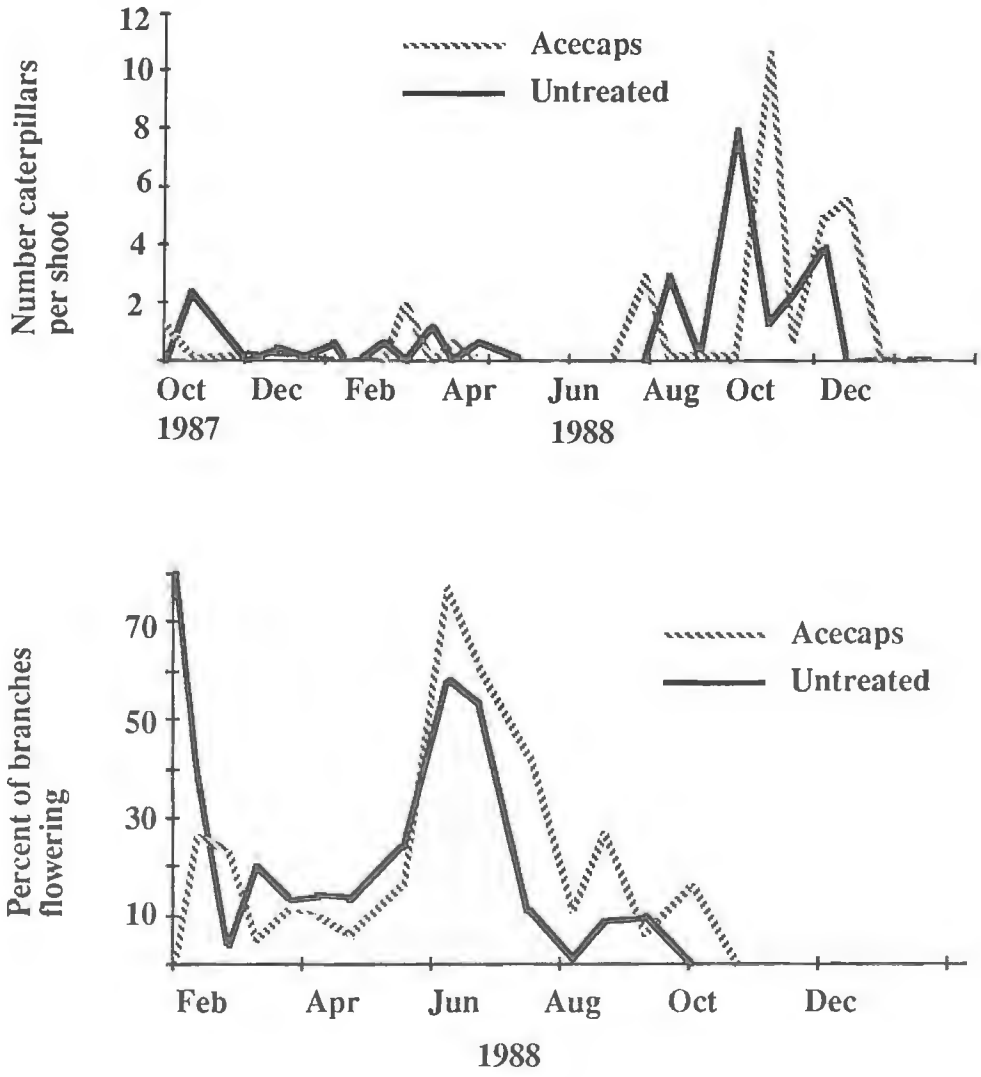



Figure 4. Effect of inplanted insecticide pellets on mean number of poinciana loopers per branch and proportion of poinciana branches flowering.

# Biological Control

D. Nafus

**Biological control of the mango shoot caterpillar, *Penicillaria jocosatrix.***

In 1986/87, four parasitoid species, the wasps*Trichogramma platneri, Aleiodes* sp. near *circumscriptus* , and *Euplectrus* sp., and the tachinid *Blepharella lateralis*, were released to control *P. jocosatrix*. Caterpillar populations have declined markedly from 1986 through 1988, and were very low in 1988 except for brief outbreaks in February and August (Fig 1). Heavy damage to the trees was observed up prior to July-August,1987. Since then little damage, except to isolated trees, has been found.

In July, 1987, mortality of the caterpillars from all parasitoids was 16.2%. By December, the mortality had increased to 39.8%. In August, 1988, the mortality was approximately the same, 36.3%. *Euplectrus* sp. and *B. lateralis* were the dominant parasitoids. In December most of the mortality was due to *Euplectrus* but in August, 1988, *B. lateralis* was the dominant parasite.

*Euplectrus* sp. was found parasitizing all instars. However, third and fourth instars were the most frequently parasitized. Second instars were also commonly parasitized. Parasitization of first and fifth instars was rare.

*Aleiodes* sp. near *circumscriptus* failed to establish permanently. No recoveries were made after July, 1987.*Trichogramma platneri* does not appear to have established either.

In 1988, there has been noticeably higher mango fruit production and many trees which have never borne fruit produced. In March through May,1986, an average of 0.11 fruits per branch were produced on monitored trees in Barrigada and Agat. In 1987, an average of only 0.03 fruits per branch were produced. In 1988, a dramatic increase in fruit production was observed. Fruit production averaged of 2.3 fruits per branch in March: a 20 to 80 fold increase over previous years.

**Biological control of the leucaena psyllid, *Heteropsylla cubana.***

The coccinellid beetle *Curinus coeruleus,* released in 1985, is still within one kilometer of the initial release site.

Populations of the psyllid tend to be highest in the wet season and lowest in the dry season. (Fig. 2a) In part this is due to a lack of foliage at some of the sites during the dry season. At most sites, psyllid populations remained below 100 nymphs and 50 adults per gram of tip leaves (dry weight). Populations showed moderate fluctuations at most sites (Figs 2b-i). The largest fluctuations were found at Mangilao, which is the site where *C. coeruleus* has established (Fig 2j). Large fluctuations followed by periods of low psyllid numbers were observed at that site. The coccinellid may be enhancing the amount of fluctuation of the psyllids. Beetle populations track the psyllid populations, but the degree of response in beetle abundance is not well correlated with psyllid abundances. The value of *C. coeruleus* as a biocontrol agent for *H. cubana* is questionable.

To study the impact of the psyllid and introduced biological control agents, permanent transects have been set up at all sites. Herbs, shrubs and trees are being monitored. Growth of selected leucaena plants is being monitored.

**Biological control of the wooly whitefly, *Aleurothrixus floccosus* (Maskell)**

Population surveys were continued on the wooly whitefly and the parasitoid *Eretmocerus* sp. in 1988 (Fig. 3). Population levels of the wooly whitefly were low throughout 1988 except for minor outbreaks in Feb-Mar and May-June. Parasitization levels by *Eretmocerus* sp.were relatively low. Weather conditions may have affected populations of both species as 1988 was an el nino year and severe dry conditions prevailed in late 1987 through June.

**Biological control of leafminers, *Liriomyza sp.***

*Ganaspidium utilis* was reported established in 1984. Since then it has increased to become the dominant parasite on beans, cucumber, certain weeds and ornamentals (Table 1). On beans (*Vigna sp.*) parasitization rates between 50 and 80 percent were found in 1986 and 1987 (Table 2). In late 1987 and early 1988 leafminer populations fell to extremely low levels. Parasitoid numbers also declined to very low levels in 1988 and only began to recover in August. In pole beans *G.*

*utilis* has complemented existing parasites and added significantly to leafminer control. Early surveys on unsprayed long beans (*Vigna)* showed strong increases in leafminer populations in October and November at the end of the wet season. In the dry season leafminer populations were high, around 10-12 leafminers per trifoliate leaflet, and either remained about the same level or declined slightly Fig.4a-d). In 1988, leafminer populations started about the same level but then declined from over 10 leafminers per leaflet to about 4 per leaflet (Fig 4e). This is a substantially higher drop than was found prior to the release of *G. utilis*. *G. utilis* was the most abundant parasitoid in 1988.

In other crops including cucumber, Brassica sp., tomato, and watermelon, in addition to the larval ectoparasites H*emiptarsenus semialbiclavus* and *Chrysonotomyia formosa*, two species of larval/pupal parasites, *Disorygma pacifica*, and *G. micromorpha* are abundant. In these crops leafminers have only rarely been a problem and insecticide controls specifically for leafminers has not been practiced. In beans only the ectoparasites *H. semialbiclavus* and *C. formosa* were common. Although internal parasites were present, they were rare. Beans have had a history of problems with leafminers since *L. trifolii* was accidentally introduced into Guam about 1978. *G. utilis* has become an important parasite and has significantly reduced leafminer problems on beans.

**Table 1. Relative abundance of parasites attacking *Liriomyza sativae* and *L. trifolii* on beans.**

| Date | Number per 25 leaves | | Percent emerging | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Liriomyza sativae* | *trifolii* | *Liriomyza sativae* | *trifolli* | *Ganaspidium utilis* | *Hemiptarsenus semiabiclavus* | *Chrysonotomyia formosa* | *Disorgama pacifica* | *Grotonoma guamensis* | *G. micromorpha* |
| Oct-85 | 3.3 | 4.3 | 31.8 | 41.0 | 3.8 | 7.7 | 6.0 | 5.8 | 4 | 0 |
| Nov-85 | 5.1 | 21.4 | 18.7 | 78.0 | 1.5 | 0.0 | 1.0 | 0 | 1 | 0 |
| Dec-85 | 3.7 | 48.3 | 7.0 | 91.0 | 0.4 | 0.0 | 1.0 | 0 | 0 | 0 |
| Jan-86 | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 | 25.0 | 25.0 | 0 | 25 | 0 |
| Feb-86 | 6.5 | 51.0 | 11.1 | 88.0 | 0.0 | 0.3 | 0.0 | 0 | 0 | 0.0 |
| Mar-86 | 35.1 | 36.9 | 37.0 | 39.0 | 23.0 | 0.2 | 1.0 | 0 | 0 | 0.2 |
| Apr-86 | 0.3 | 5.2 | 1.2 | 18.0 | 78.0 | 0.7 | 1.0 | 0 | 0 | 0.7 |
| May-86 | 0.4 | 9.6 | 0.8 | 19.0 | 65.0 | 13.0 | 1.0 | 0 | 0 | 0.4 |
| Jun-86 | 0.2 | 21.4 | 0.4 | 35.0 | 53.0 | 10.0 | 1.0 | 0 | 0 | 0.3 |
| Sep-86 | 2.2 | 3.7 | 4.2 | 7.0 | 64.0 | 17.0 | 1.0 | 0 | 4 | 2.7 |
| Oct-86 | 0.3 | 6.5 | 1.0 | 22.0 | 38.0 | 30.0 | 0.0 | 0 | 6 | 4.0 |
| Nov-86 | 1.7 | 0.3 | 7.0 | 1.0 | 44.0 | 35.0 | 0.0 | 0 | 7 | 4.8 |
| Dec-86 | 0.0 | 0.0 | 0.0 | 0.0 | 34.0 | 30.0 | 0.0 | 0 | 23 | 14.0 |
| Jan-87 | 0.0 | 1.0 | 0.0 | 10.0 | 30.0 | 26.0 | 2.0 | 0 | 20 | 12.0 |
| Feb-87 | 0.1 | 0.4 | 2.3 | 11.0 | 59.0 | 5.4 | 11.0 | 0 | 11 | 0.0 |
| Mar-87 | 20.6 | 99.8 | 16.6 | 81.0 | 1.8 | 0.2 | 0.0 | 0 | 0 | 0.0 |
| Jun-87 | 0.0 | 0.5 | 0.0 | 12.0 | 63.0 | 4.9 | 10.0 | 0 | 10 | 0.0 |
| Aug-87 | 1.2 | 8.8 | 11.0 | 78.0 | 3.6 | 1.8 | 4.0 | 0 | 2 | 0.0 |
| Oct-87 | 1.5 | 0.5 | 46.9 | 16.0 | 13.0 | 13.0 | 6.0 | 0 | 6 | 0.0 |
| Dec-87 | 0.7 | 2.8 | 16.3 | 69.0 | 9.8 | 4.9 | 0.0 | 0 | 0 | 0.0 |
| Jan-88 | 0.0 | 2.0 | 0.0 | 77.0 | 15.0 | 7.7 | 0.0 | 0 | 0 | 0.0 |
| Feb-88 | 0.0 | 2.7 | 1.1 | 72.0 | 0.0 | 16.0 | 11.0 | 0 | 0 | 0.0 |
| Mar-88 | 0.0 | 10.5 | 0.0 | 87.0 | 0.0 | 9.9 | 3.0 | 0 | 0 | 0.0 |
| Apr-88 | 0.0 | 16.0 | 0.0 | 92.0 | 0.0 | 5.7 | 2.0 | 0 | 0 | 0.0 |
| Aug-88 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 71.0 | 29.0 | 0 | 0 | 0.0 |

**Table 2. Rates of parasitization of Liriomyza sp. by various species of parasites on various crop plants. Data is summarized from the years 1985 through 1988.**

| Plant species | common name | Percent found of *Liriomyza* | | | Percent parasitized | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *brassicae* | *sativae* | *trifolii* | by all species | *G. utilis* | *H. semialbiclavus* | *C. formosa* | *D. pacifica* | *G. guamensis* | *G. micromorpha* | all *Eucol. exc. utilis* |
| *Vigna* sp. | long beans | | 16.5 | 83.4 | 28.0 | 20.0 | 4.7 | 1.1 | 0.5 | 1.0 | 0.5 | 2.1 |
| *Bidens pilosa* | bidens | | 54.8 | 45.2 | 48.4 | 7.3 | 24.7 | 11.0 | 0.9 | 4.6 | 0.5 | 5.9 |
| *Brassica chinensis* | chinese cabbage | 9.3 | 5.3 | 85.4 | 25.6 | 9.9 | 6.5 | 1.7 | 0.5 | 3.6 | 3.4 | 7.5 |
| *Cucumis sativus* | cucumber | | 4.2 | 95.8 | 33.9 | 26.0 | 3.2 | 0.8 | 0.0 | 3.1 | 0.8 | 3.9 |
| *Luffa* sp. | luffa | | 50.4 | 49.6 | 27.7 | 2.4 | 5.9 | 4.0 | 2.7 | 6.6 | 6.1 | 15.0 |
| *Lycopersicon lycopersicum* | tomato | | 38.7 | 61.3 | 30.1 | 2.6 | 19.4 | 3.0 | 1.8 | 1.2 | 2.2 | 5.1 |
| *Brassica* sp. | mustard | 53.8 | 20.4 | 25.8 | 41.4 | 6.9 | 11.2 | 6.0 | 0.4 | 13.0 | 3.4 | 17.0 |
| *Mikania micrantha* | mikania | | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Tagetes* sp. | marigold | | 27.0 | 73.0 | 14.3 | 2.2 | 6.6 | 3.3 | 0.0 | 2.2 | 0.0 | 2.2 |

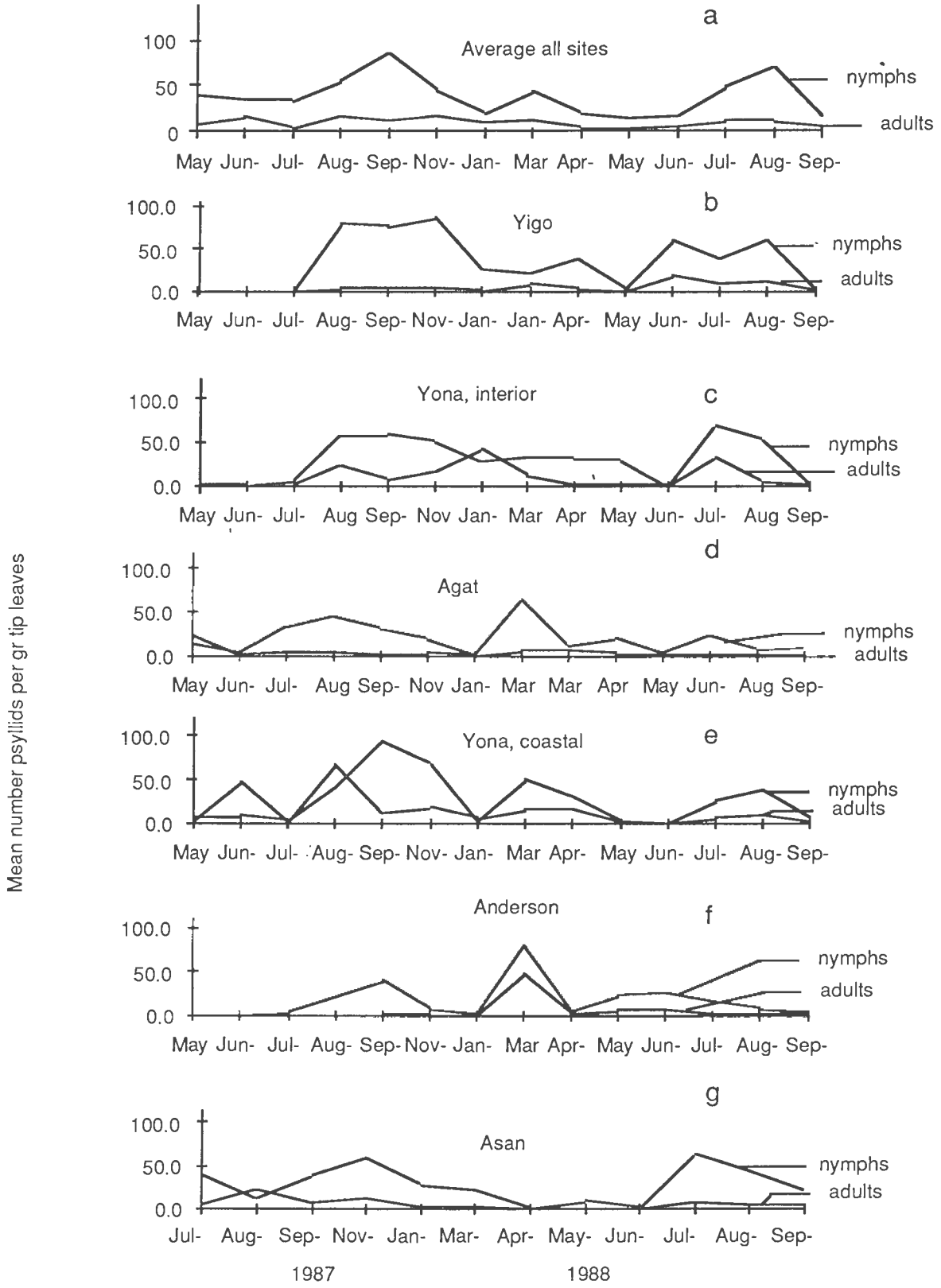



**Figure 2. Fluctuations of psyllids at various sample sites on Guam. Only the Mangilao site has *C. Coeruleus* present.**

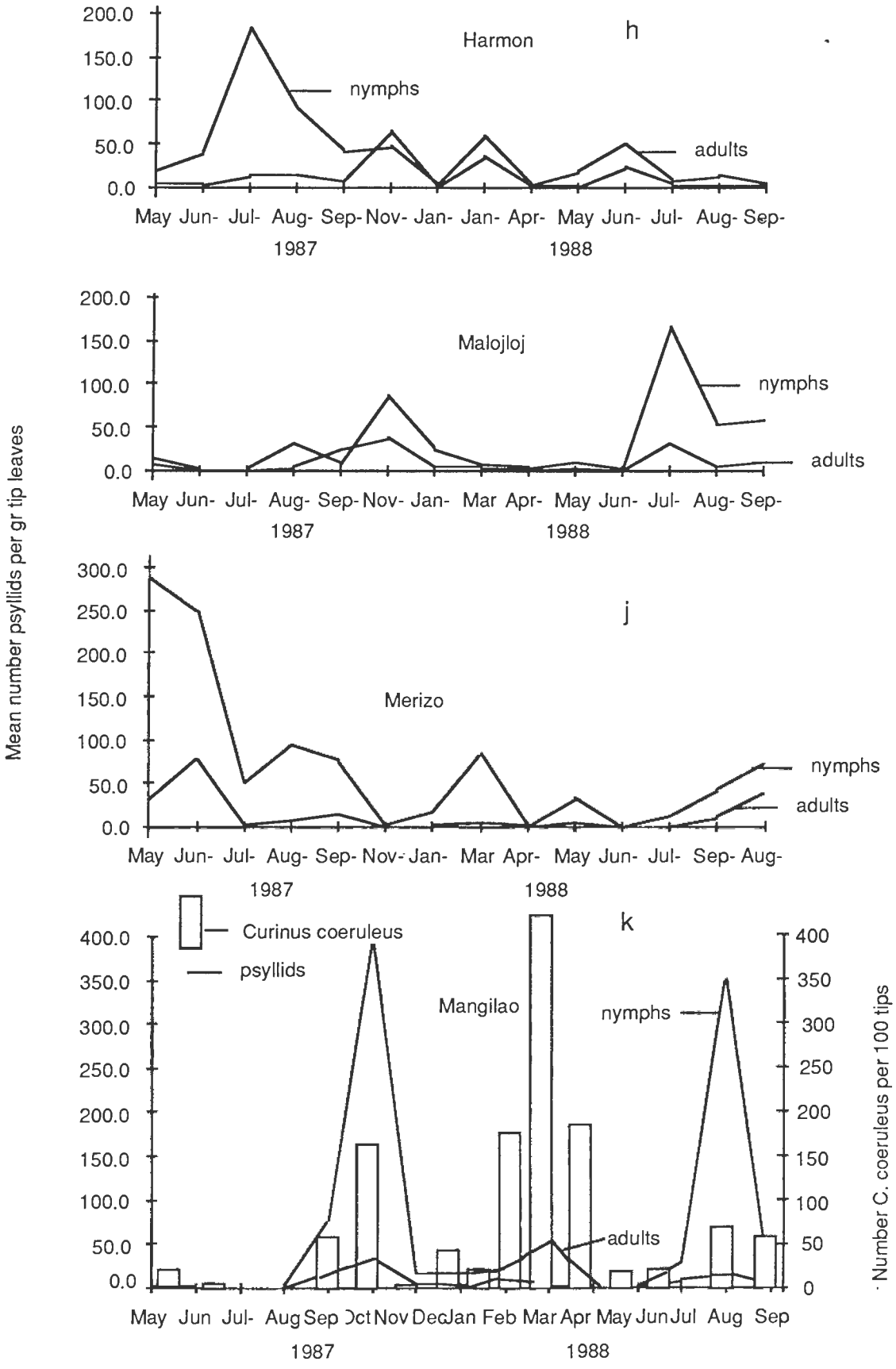



**Figure 2, Cont.**

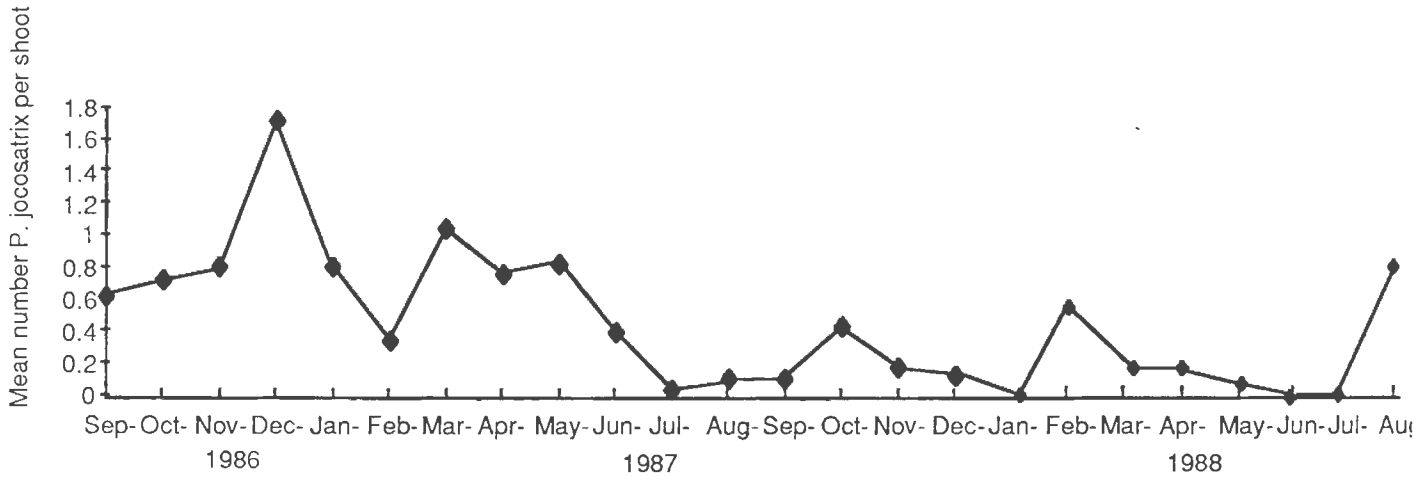



**Figure 1. Population levels of *P. jocosatrix* per shoot from 1986 to 1988.**

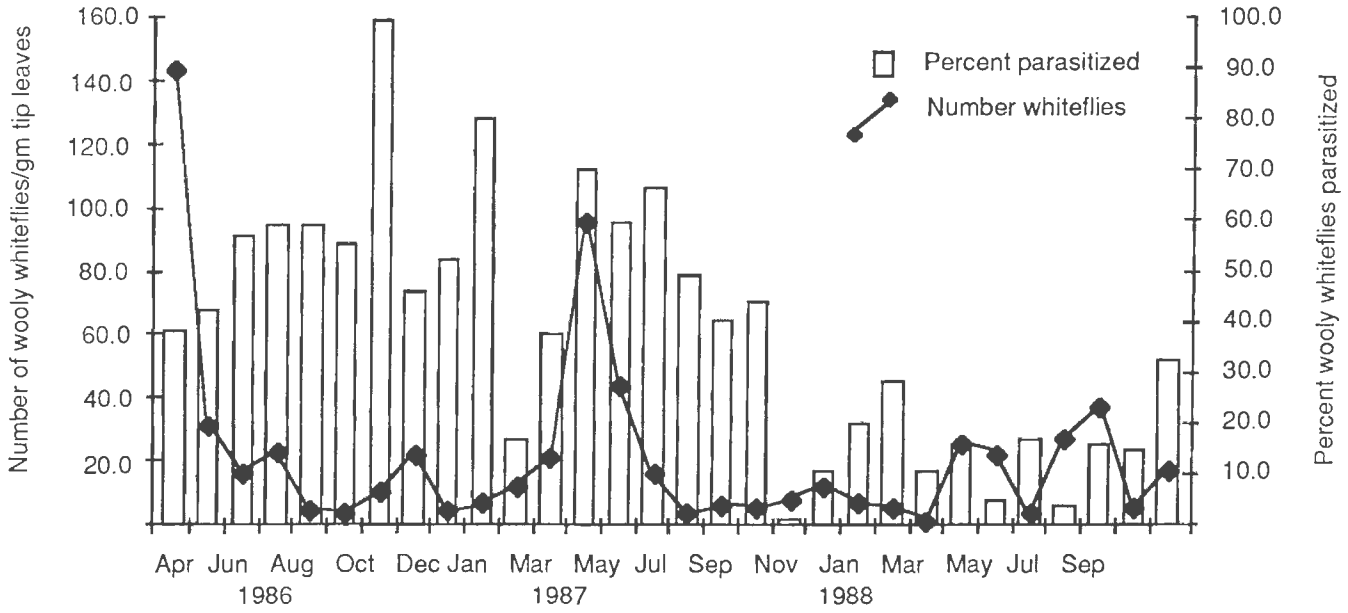



**Figure 3. Population levels of the wooly whitefly on citrus and the percent whiteflies parasitized by *Eretmocerus* sp.**

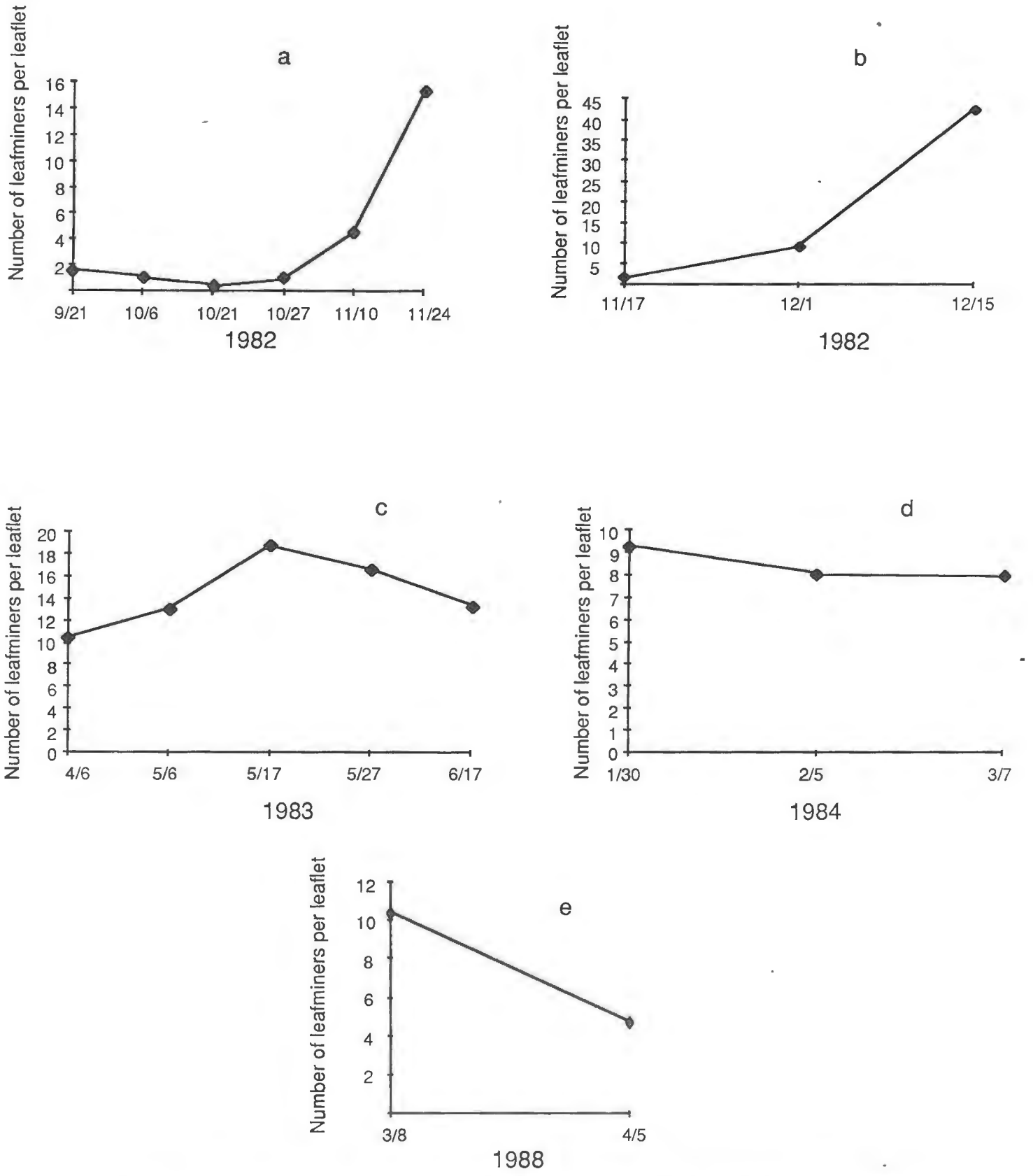



**Figure 4. Trends in leafminer populations in plantings of unsprayed long beans before the release of *G. utilis* (1982-4) and after the release (1988).**

# Ornamental Horticulture

J. McConnell

The emphasis of the program has been to evaluate and select specific ornamental plants for their potential development as commercial crops in Guam and to determine the cultural methods for optimum production in the tropics. Current research has concentrated on commercial cut flower production. The production aspects have been broken into two areas: cultivar evaluation and crop management. Several cultivars of orchid genera have been chosen for advance testing. Cultivars of other species that have been collected for further evaluation are heliconias, gingers, plumerias and various foliage plants (for use as cut foliage).

## Cultivar Evaluation

Flowering plants are being collected and screened for their cut flower qualities. These include several cultivars of gingers, heliconias, and over two hundred orchid cultivars. Some of the characteristics evaluated include attractiveness, color, size of flower, number of flowers, cut vase life or keeping quality. The ornamentals program is in process of propagating selected plant material.

## Fiberglass House

A fiberglass-covered house was also designed and built to allow more control of irrigation. Control of water is very important in growing seedlings that have just been transplanted from tissue culture flasks. This structure was built to withstand high winds without dismantling. The structure is 10' high (Figure 1) to lesson heat buildup at the height that the plants are grown. The light intensity is controlled by attaching shade cloth to the bottom of the beams and to the sides of the house.

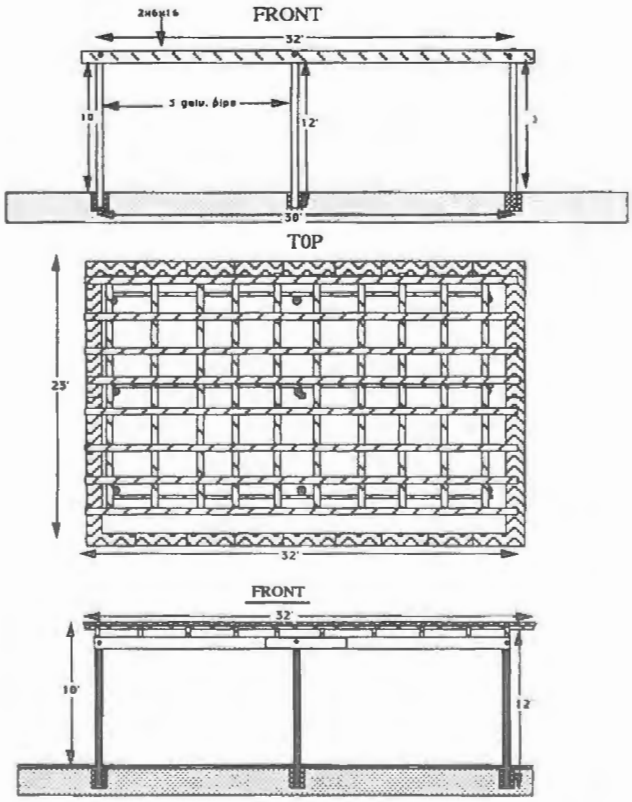



Figure 1. Layout of fiberglass-covered house.

### Shade House Development

Over the past three years various shade house designs have been evaluated. The objective of this study was to identify various designs and develop a structure that will withstand lower speed winds is and is easy to disassemble and reassemble if a major storm approaches. The structure was built with 1 1/4' x 12' galvanized pipes connected together with pipe fittings (Figure 2). The structure is reinforced and the shade cloth is supported by woven nylon fishing rope (220 lb). The design is modular. The pipe fittings allow for expansion in any direction. The resulting structure is 10 feet high. This is to lessen heat build;dup at the height at which the plants are grown. The dimensions are flexible to allow for selection of various shaped shade cloth.

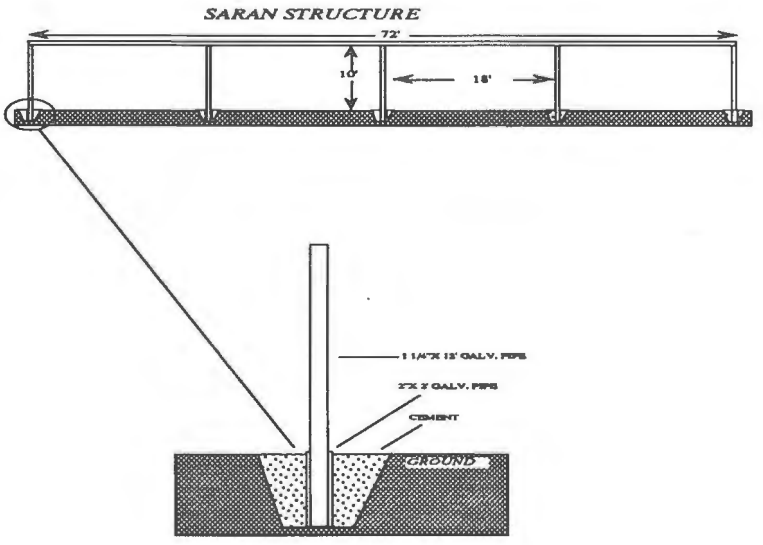



**Figure 2. Pipe layout of shade house. (side view)**

### Irrigation
### Semi-automatic Hydraulic timer system

To maintain a constant water supply while saving labor costs, various timing systems have been evaluated. Frequently there will not be sufficient water pressure to irrigate the entire nursery at one time. Even if and irrigation system is installed, and individual will have to wait to turn the water on at each station. This is where automatic timers come into play. A relatively inexpensive system was found that uses hydraulic timers and solenoids. The system does not require electricity and is semi-automatic. It is operated by the water flow through the meter. Once the system is installed (Figure 3), one needs to set each valve (timer) for the number of gallons required at each station. The first station will release the set volume of water and shut off. when the first station shuts off, the next station turns on. The stations operate in sequential order supplying water after the previous station turns off. An entire nursery can be irrigated with the only labor being to set all of the valves. This will only take a few minutes per day.

### Environmental Factors Affecting Flowering in Some *Vanda* and *Dendrobium* hybrids in the Tropics.

Flower production in orchids varies from season to season in the subtropics and tropics. This variation is not consistent year to year due to an interaction between the plants and the environment. The primary environment factors affecting have not been clearly identified. The

objective of this project is to determine the environmental factors affecting flowering in vandas and dendrobiums.

The flowering behavior of several orchid hybrids is being monitored concurrently with recording the weather data at several locations in Guam. Phenological data is being recorded for vandas and dendrobiums of different stages of development. Dates of raceme initiation and raceme harvest are recorded daily for *Dendrobium* X Jaquelyn Thomas 'Uniwai Supreme' and D. X Jaq-Hawaii 'Uniwai Pearl'. date of raceme initiation, flower harvest, and raceme removal are being recorded daily for *Vanda* X Miss Joaquim and V, X Miss Joaquim 'Atherton'. Date of shoot initiation and shoot maturation are being recorded weekly for D. X Jaquelyn Thomas 'Uniwai Supreme' and D.X Jaq-Hawaii 'Uniwai Pearl'. Seedling dendrobiums were transplanted and are now located in beds. date of first flowering is being recorded.

The weather factors recorded by the loggers are: solar radiation, rainfall, air temperature (high, low, and mean). the data is logged at 15 minute intervals and as daily reports. the data is uploaded and stored on a personal computer.

Preliminary data indicates that solar radiation has a significant effect on the timing of flower initiation. There appears to be a lag response of about 45 days. High temperature was found to affect time flower harvest. The cultivars vary among themselves in their response indicating that there is genetic variation. This allows for selection of cultivars for flowering under different environmental conditions. Dendrobiums growing in 30% shade have been found to initiate flowering approximately one month before dendrobiums growing in full sun. The greatest flower production has occurred in the months of January and February. Some of the data is presented in Figures 4-8.

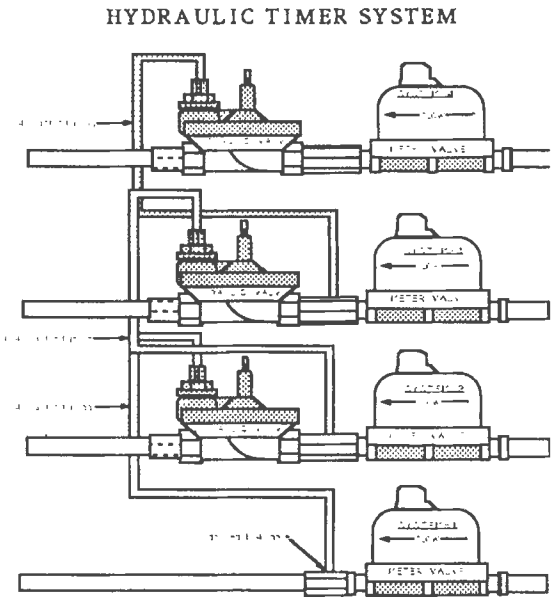



Figure 3: Three hydraulic timers in sequential order.

Information on flowering behavior is useful in developing new cultivars for commercial production. By understanding what factors induce flowering, breeders can grow the orchids under simulated conditions ans screen plants in a much shorter time frame. This will help in developing collections of cultivars to allow flower production throughout the year.

It is important for growers to have flowers when there is a demand. While is it currently not possible to accurately induce or time flowering in most orchids, it is possible to generate short term predictions on when flowers will be available. Also by utilizing it is possible to adjust the flowering period of a specific cultivar. This technique will allow growers to supply flowers of a given cultivar over a longer period of the year.

**Publications and Presentations:**

McConnell, J. 1988. Computer data management system for agricultural research. HortScience. 23(3):735. (Abstr,)

Poster presentation at ASHS National Meeting-988 Title: Computer data management system for agricultural research.

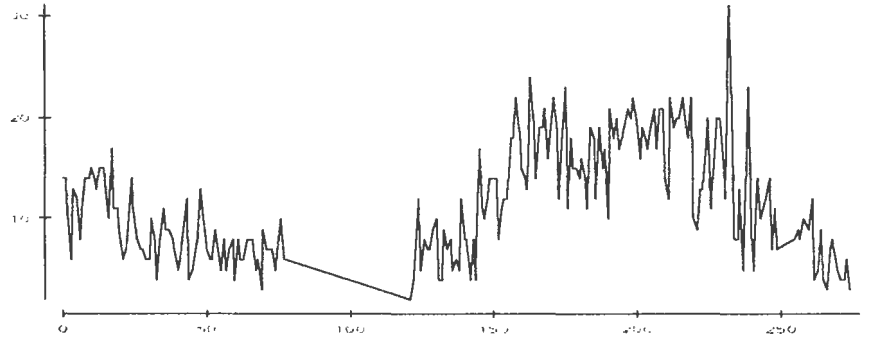


Figure 4. Vanda Yield by Day

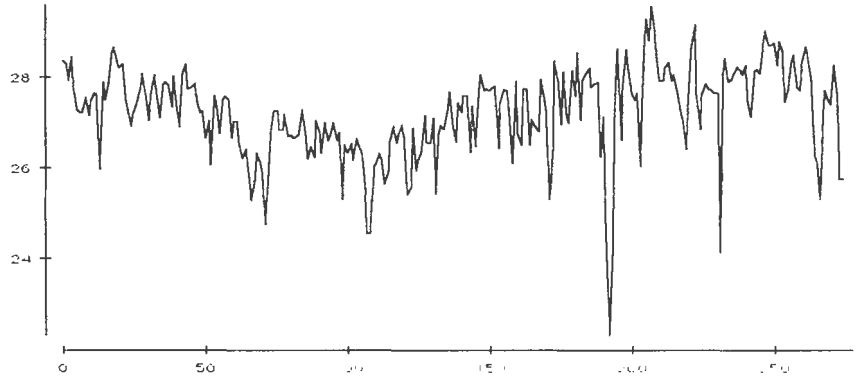



Figure 5. Maximum daily air temperature.

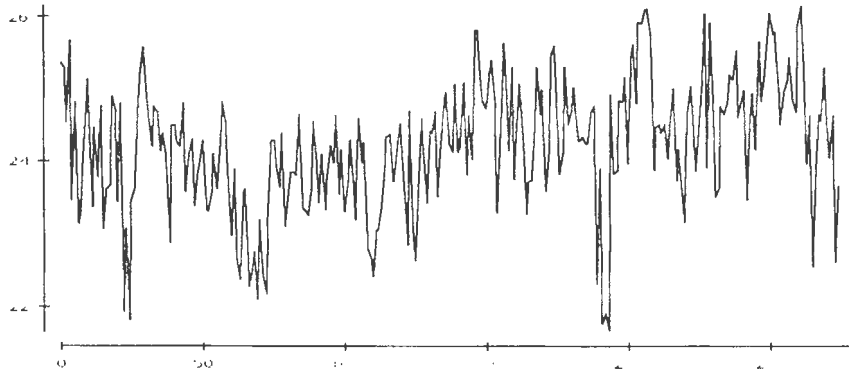



Figure 6. Minimum daily air temperature.

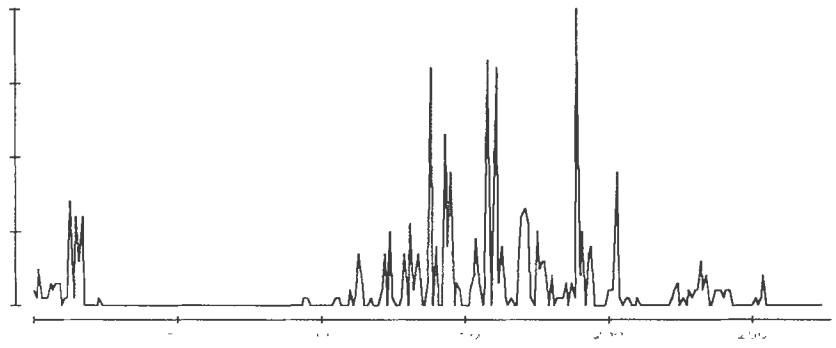


Figure 7. Daily total rainfall

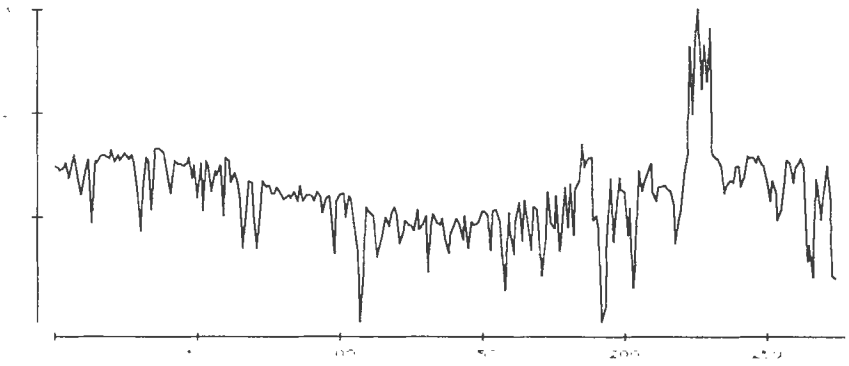


Figure 8. Total solar radiation per day

## Control of Scale By Sprinkler Irrigation on *Vanda* X Miss Joaquim

**J. McConnell & R. Muniappan**

Vanda orchid scale (*Genaparlatoria pseudaspidiotus* (Lindinger)) is a persistent pest on orchids. Preliminary observations indicated that certain types of irrigation could reduce populations of scale. An attempt was made to control scale populations solely by the use of irrigation. Thirty plants of *Vanda* X Miss Joaquim were established in beds of crushed limestone and were irrigated with either impact sprinklers or spinners. No pesticides were applied to the plants. Counts were made on the number of scales present on the leaves and stems 6 months after establishment. Significant reduction in scale populations were observed for both stems and leaves on plants grown under spinners. The mean numbers of scale for leaves were 13.1 (spinner) and 30.4 (impact) for stems were 11.5 (spinner) and 47.7 (impact).

# Aquaculture

S. Nelson

Major emphasis this past year has been on refining the techniques for the maintenance and production of food organisms needed in the culture of siganids and other small-mouthed marine fishes. It is particularly important to have suitable densities of appropriately sized food organisms available to the fish larvae at the time of first feeding. The controlled production of food organisms involved the coordination of culture systems for the production of phytoplankton, rotifers, copepods, and brine shrimp nauplii. We are maintaining monospecific cultures both of *Chaetoceros gracilis* and of a locally isolated *Chlorella*-type alga, phytoplankton species which are, in turn, used in the production of rotifers and copepods. Cultures of s-type marine rotifers *Branchionus plicatilis* are being maintained for use as an initial food for the larval fish. Cultures of calanoid copepods which were isolated from broodstock ponds are being maintained for use as food for the later larval stages.

## Phytoplankton Culture

Stock cultures of a locally isolated *Chlorella*-type alga are being maintained in the environmental chamber of the University of Guam Marine Laboratory. In order to effectively maintain stock cultures of phytoplankton used to sustain the rotifer cultures at the Guam Aquaculture Development and Training Center (GADTC), the growth dynamics of particular species under routine culture conditions must be determined. Since growth rates of the alga cultures is dependent of the nutrient concentration of the media, experiments were conducted to determine in the alga production in response to concentration of the media, experiments were conducted to compare alga production in response to concentrations of nutrient media in routine use at GADTC.

## Methods

These experiments were conducted in an environmental chamber set at 23° Celsius. The photoperiod was maintained with a timer to provide light and dark periods of 12 hours each. Salinity of the seawater medium was 33 ppt. Lighting was achieved by a combination of neon and incandescent bulbs.

The experimental units were 12 15-ml test tubes filled with 0.45-micron filtered seawater. The seawater-filled test tubes were enriched with Provasoli's F medium, prepared from commercial nutrient concentrates available from Fritz Aquaculture, at concentrations of either F/2, F/4 or F/8. Four test tubes were used at each nutrient concentration. The mean initial cell densities established in each tube ranged from 0.74 to 0.85 million cells per ml. Though the use of a haemocytometer, the cell densities were estimated daily in replicate samples from each tube.

The initial (I) and final (F) cell densities of each of three groups were used to calculate the specific growth rates and the doubling times of the cultures. The specific growth rates (K) were calculated as (ln I-ln F)/t, where t represents the culture period, 7 days in this case. The doubling time was calculated as (ln 2)/K. A one-way Analysis of Variance was then used to determine whether or not there were significant differences between the specific growth rates of the cultures in each treatment group. The analyses were carried out with the BMDP package of statistical software, available from the University of California at Los Angeles.

## Results

The mean cell densities of the four test tubes at each nutrient concentration are shown in Table 1. The highest cell densities were reached in the test tubes containing the highest nutrient concentration. Similarly, the highest instantaneous growth rates and the shortest doubling times were exhibited by the cultures grown in the highest nutrient concentrations as shown in Table 2. The cultures grown on F/8 medium grew from a mean density of 0.8 million cells per ml to 3.2 million cells per ml on the seventh day of culture.

These results show that, under our routine culture conditions, phytoplankton growth in the stock cultures is nutrient-limited at concentrations less than those provided by Provasoli's F/2. However, the cultures were actively growing even at the lowest nutrient level examined (F/8), and less frequent splitting of the batches would be necessary if the stock cultures were maintained at these lower levels. In addition, these data can be used to determine when batches should be split and to estimate when stock cultures should reach desirable cell densities for use in the inoculation of larger culture vessels.

### Rotifer Culture

Stock cultures of the marine rotifer *Branchionus plicatilis* are maintained at the University of Guam Marine Laboratory and at the Guam Aquaculture Development and Training Center (GADTC) to be used as feed for larval siganids. Information on the dynamics of growth of the rotifers under specific local environmental conditions is useful in providing for the efficient maintenance of stock cultures.

Presently, two phytoplankton species are being cultured in support of the programs at GADTC. The diatom *Chaetoceros gracilis* and a green alga, which is morphologically similar to *Chlorella* and which was isolated form local milkfish pond, is being produced for culturing rotifers. If one algal species was found to be suitable for both purposes, phytoplankton production at GADTC could be more efficient, and the probability of cross contamination would be reduced.

This study was designed to examine the effects of phytoplankton concentration on the specific growth rates and doubling times of laboratory populations of the rotifer *B. plicatilis* fed with either a locally isolated *Chlorella*-type alga or with the diatom *Chaetoceros gracilis*. Also, the growth rates of rotifer cultures fed with each of these algae at equal cell concentrations were compared.

### Methods

The rotifers used in the trials were an s-type (small) strain originally obtained from the Brackish Water Aquaculture Center at Phuket, Thailand. Stock cultures of these rotifers are currently being maintained both at GADTC and the UOG Marine Laboratory. For the trials, the rotifers were fed one of two phytoplankton species.

One of the phytoplankton species used was a locally isolated *Chlorella*-like algal strain (referred to as P-series at GADTC), and the other was *Chaetoceros gracilis*, cultures of which had been originally obtained from the Hawaii Institute of Marine Biology. Both phytoplankton cultures were maintained in the laboratory on Provasoli's F/2 media.

For trials with each of the two phytoplankton species, experimental cultures of 20 rotifers were established in eight 150-ml flasks each filled initially with 50 ml of 0.45-micron filtered, 33 ppt, seawater at phytoplankton densities of either 0.1, 0.5, 2.5 or 5.0 million cells per ml. Four flasks were used at each phytoplankton density for each species. The flasks were placed in a temperature-controlled environmental chamber at 23° Celsius and aerated through tygon and glass tubing. A photoperiod of 12 hours of light and 12 hours of darkness was maintained by a timer attached to the system lights. As a result of space limitations in the environmental chamber, we could not run trials of all of the experimental phytoplankton densities at the same time. Instead, trials with each phytoplankton species were run separately with two phytoplankton densities run per trial. For each species, the second set of trials was initiated within a few days after the completion of the first trials.

Daily counts of phytoplankton, expressed as number of cells per ml, were made for 2 relicate samples from each flask, and phytoplankton was added as needed to restore the cell densities to the initial levels. Phytoplankton densities were determined with a haemocytometer. At the end of four days of culture the rotifers were counted. These data were used to calculate the specific growth rates (K) and the doubling times for each group of rotifers. The specific growth rate is the number of rotifers produced per existing rotifer per day.

To compare the growth of rotifers cultured on *Chlorella*-type algae and *Chaetoceros*, four flasks of each species were established, each with a phytoplankton density of 1 million cells per ml. Each flask was stocked with 20 rotifers and placed in the environmental chamber. Environmental conditions in the chamber were the same as those described in the previous section. Phytoplankton densities were determined daily and adjusted to initial levels by adding additional phytoplankton. On the fourth and eighth days after trials began, a plankton counting wheel and a dissecting microscope were used to count the rotifers in each flask. We calculated the specific growth rate and the doubling time for each flask for both a 4-day and an 8-day growth interval. A two-sample Student's test (BMDP 3D) was used to compare the means of the specific growth rates and the doubling times, for each of the growth intervals, of the

rotifers grown on the two phytoplankton species.

### Results

Results of the trials comparing rotifer population growth rates at different cell concentrations of the *Chlorella*-type algae are shown in Table 3. The calculated specific growth rates and the doubling times are presented for each group. In general, the rotifers grew more rapidly with increased phytoplankton density within the range of cell densities examined. The cultures did not grow well at the lowest phytoplankton density of 100,000 cells per ml, and one of the flasks had fewer rotifers after 4 days than initially. Therefore, for routine maintenance of rotifer stock cultures at GADTC, phytoplankton at higher concentrations should be used.

Also, from Table 3, it can be seen that there was considerable variation in the population growth of rotifers within groups grown at equal phytoplankton densities. Some of this variation may have resulted from differences between flasks in the number of eggs per female stocked. The number of eggs per female rotifers in normal cultures ranges from 0 to 3. Also, it has been shown that rotifers change physiologically with age. In these trials the rotifers were chosen randomly for the initial stockings, and differences in the egg to female ratios undoubtedly existed between flasks.

Table 4 compares the growth rates and doubling times for rotifer cultures grown either on the *Chlorella*-type alga or on *Chaetoceros*. Results of the two-sample Student's t-test indicated that the mean specific growth rates over the eight-day interval for rotifer cultures grown on *Chlorella*-type alga were significantly higher than those for rotifer cultures grown on *Chaetoceros* (Pooled T=5.88; p=0.001). Although the results of indentical comparisons with data from the 4-day growth interval were similar, the difference in mean specific growth rate between groups was not statistically significant (Pooled T=2.10; p=0.080).

### Broodstock

Broodstock of *Siganus argenteus* reared from juveniles collected from the reef flats of Guam during the May-June recruitment episode of 1988 have reached reproductive maturity and have begun to spawn. Methods for collecting eggs released in spawning tanks have been developed. The eggs of *S. argenteus*, unlike those of other siganids, are not adhesive, and can be collected by routing the discharge water from the spawning tank through a 350-micron mesh bag. Eggs of *S. spinus*, which were collected as the same time and raised in the same pond, have not been collected yet since this fish did not grow as rapidly. Juveniles of *S. vermiculatus* have also been collected and are being reared to maturity.

**Table 1.** Daily mean cell densities of P-Series stock cultures maintained at three different dillutions of Provasoli's nutrient solution. The data presented are the mean counts of 4 per ml with the standard deviatiations provided in parentheses.

| | Nutrient Concentration | | |
|---|---|---|---|
| **Day** | **F/2** | **F/4** | **F/8** |
| 1 | 85.0(10.7) | 77.04(4.5) | 74.0(5.3) |
| 2 | 100.8(3.3) | 85.0(3.2) | 78.2(4.6) |
| 3 | 177.2(4.1) | 97.5(7.1) | 86.8(7.6) |
| 4 | 246.9(7.2) | 139.8(3.1) | 94.5(9.4) |
| 5 | 378.8(17.4) | 224.0(32.8) | 127.6(20.2) |
| 6 | 653.1(48.8) | 320.0(76.1) | 257.4(42.3) |
| 7 | 983.1(32.7) | 635.6(43.7) | 382.5(60.4) |
| 8 | 1100.0(76.7) | 958.8(33.6) | 493.1(108.2) |

**Table 2.** Instantaneous growth rates (K) and doubling times of P-Series algal stock cultures at three dilutions of Provasoli's F-growth media. The mean cell densities on day 1 and day 8 were used to calculate the K values and subsequently the doubling times.

| Nutrient Level | K | Doubling Time (Days) |
|---|---|---|
| F/2 | 0.368 | 1.88 |
| F/4 | 0.360 | 1.93 |
| F/8 | 0.271 | 2.56 |

**Table 3.** Growth of s-type *Branchionus plicatillis* in flasks with 4 concentraitons of a locally isolated, Chlorella-type, species of phytoplankton. Initial rotifer density was 20 per flask. The growth interval was 4 days. Temperature was maintained at 23 degrees Celsius.

| Flask | Phytoplankton density (cells per ml) | Final rotifer density (number per flask) | K | Doublings Time(days) |
|---|---|---|---|---|
| 1a | 100,000 | 37 | 0.154 | 4.51 |
| 2a | 100,000 | 18 | — | — |
| 3a | 100,000 | 24 | 0.045 | 15.40 |
| 4a | 100,000 | 22 | 0.024 | 29.12 |
| 1b | 500,000 | 78 | 0.340 | 2.04 |
| 2b | 500,000 | 72 | 0.320 | 2.17 |
| 3b | 500,000 | 65 | 0.295 | 2.35 |
| 4b | 500,000 | 50 | 0.229 | 3.03 |
| 1c | 2,500,000 | 100 | 0.402 | 1.72 |
| 2c | 2,500,000 | 85 | 0.362 | 1.92 |
| 3c | 2,500,000 | 97 | 0.395 | 1.76 |
| 4c | 2,500,000 | 68 | 0.306 | 2.27 |
| 1d | 2,500,000 | 75 | 0.331 | 2.10 |
| 2d | 2,500,000 | 150 | 0.504 | 1.38 |
| 3d | 2,500,000 | 70 | 0.313 | 2.13 |
| 4d | 2,500,000 | 160 | 0.520 | 1.33 |

**Table 4.** Comparison of specific growth rates *(K) and doubling times (DT) of cultures of the rotifer *Branchionus plicatilis* grown on a locally isolated *Chlorella*-type alga (A) with those of cultures grown on diatom on Chaetoceros gracilis (b), 20 rotifers were stocked in each flask, and counts were made after 4 and 8 days of culture. Phytoplankton densities were maintained at 1 million cells per ml. Temperature was mainted at 23 degrees Celsius.

| | Number of Rotifers | | K | | DT | |
|---|---|---|---|---|---|---|
| Algal Food | Day 4 | Day 8 | t=4 | t=8 | t=4 | t=8 |
| A | 65 | 315 | 0.295 | 0.345 | 2.35 | 2.01 |
| A | 87 | 330 | 0.367 | 0.350 | 1.89 | 1.98 |
| A | 71 | 360 | 0.317 | 0.361 | 2.19 | 1.92 |
| A | 91 | 421 | 0.379 | 0.381 | 1.83 | 1.82 |
| | | Mean: | 0.340 | 0.359 | | |
| | | (SEM): | (0.020) | (0.016) | | |
| B | 64 | 243 | 0.291 | 0.312 | 2.38 | 2.22 |
| B | 72 | 219 | 0.320 | 0.299 | 2.17 | 2.32 |
| B | 62 | 183 | 0.283 | 0.277 | 2.45 | 2.50 |
| B | 61 | 213 | 0.278 | 0.296 | 2.49 | 2.34 |
| | | Mean: | 0.293 | 0.296 | | |
| | | (SEM): | (0.019) | (0.014) | | |

### The Reproductive Biology of Three Commercially Valuable Sea Cucumber Species

The three commercially valuable sea cucumber species under study, *Actinopyga mauritiana*, *Holothuria (Microthele) nobilis*, and *Thelenota ananas* are all gonochoric (dioecious), and all spawned during the late spring and summer. Populations from our sampling stations exhibited reduced gonadal size during the winter months, consistent with a reproductive resting stage. Males of the first two species have had active sperm throughout the year, while the females have demonstrated a marked seasonality in gonadal development.

Fertilization experiments demonstrated that mixing gametes from excised gonads produced few viable embryos, while inducing spawning through temperature stress and mixing the released gametes was highly successful. Larvae of both *Actinopyga mauritiana* and *Holothuria (Microthele) nobilis* was raised through settlement and metamorphosis. The auricularia stage was reached within three days of fertilization, with metamorphosis to the doliolaria stage observed as early as six days. Larvae began to settle late in the second week following fertilization.

Experiments with Dithiothreitol (DTT) found this substance enables immature oocytes to be fertilized, with subsequent embryogenesis. Such treatment may allow for the production of larvae outside of the normal reproductive season.

Results of the first year's research were presented at the animal meeting of the American Society of Zoologists, where there were special sessions on larval biology. Graduate student Dave Hopper made the presentation to a group of approximately 85 larval biologists. Numerous suggestions were made how to increase recruitment success, a major concern at this point. Rather than raise the sea cucumber larvae on monocultures of phytoplankton, the use of polycultures was recommended. *Rhodomonas lens* was found to be particularly good for echinoderm larvae.

Electrophoretic examination of sea cucumber populations was started to determine the degree of genetic variability within populations. This data will be useful in understanding the process of reproduction as it relates to larvae recruitment.

A survey of dried-fish stores in San Francisco's Chinatown found dried *Holothuria spp.* was selling for $11 per pound dry weight. The product examined contained about 25% moisture with each individual sea cucumber weighing between 1 1/2 - 1 lb.

### Executive Summary of Year 1

1) Sea cucumbers have a distinct seasonality in their normal reproductive behavior, with one or several spawning events occurring during the summer months (June, July and August). From the present data available, harvesting would be best carried out during October, November and December.
2) During the cleaning process, immature eggs could be collected and treated with Dithiothreitol (STT), with the potential for raising larvae for reseeding reef areas.
3) Both gonadal index (weight of the gonad/weight of the drained animal) and oocyte (egg) diameter can be used to determine the time of spawning. Small hatcheries could be established on islands to raise larvae through settlement and enable reseeding of reef areas for future harvest.

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