# Guam Agricultural Experiment Station Annual Report 1982

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## 1982 ANNUAL REPORT GUAM AGRICULTURAL EXPERIMENT STATION

In 1982 the efforts of the Guam Agricultural Experiment Station to bring the USDA Soil Conservation Service to Guam materialized. In fact, the Soil Conservation Service placed two persons on Guam in collaboration with the station.

Programs in soils, vegetables, ornamentals, entomology, plant pathology, agricultural engineering, animal science, aquaculture and agricultural marketing continued to progress.

The station was able to recruit a Pomologist after a lapse of three years. For the first time two scientists from Guam were selected by the International Science and Education Council of USDA to set up collaborative programs in the Philippines. Four new projects were initiated with support from Section 406 Tropical Agriculture Funds. There was continuing emphasis on information and personnel exchanges with other territories and nations in the Pacific Basin.

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# Soil Science

Jefren Demeterio

**Fate of Added Pesticide on Guam**

Pesticide degradation studies in 1982 saw the conclusion of the malathion study. Preliminary testing of methods including recovery studies were conducted for diazinon.

Final studies with malathion involved spraying of tomato plants growing in the experimental field in Inarajan. Fruits and leaf samples were taken at timed intervals after spraying. The fruits were assayed for malathion fresh from the field and also after washing under running tap water. The washed fruits were patted dry with paper towels before chopping in a waring blender.

The same extracting procedure used in the citrus and okra leaves study reported in Annual Report 1981 was followed. Sampling amounts were 10-25 g for leaves and 20-50 g for fruits.

The results are shown in Table 1. Unwashed fruits showed 2.35 ppm malathion 1 hr. after spraying. This is below the 3 ppm tolerance level of tomato fruits suggested by the FAO-WHO (1973). Washing the fruit prior to analysis showed a decrease of more than 50% of added malathion. Malathion showed to be present by as much as 1.76 ppm in the leaves 7 days after spraying. This level may still adequately protect the leaves from insect pests. A weekly malathion (from a stock containing 2.27 kg malathion/3.781 liters) spraying of 30ml/3 gallons water could prevent insect pest damage and still be within tolerance limits at the time of spraying.

The disappearance of malathion in the spray mixture was traced. The mixture inside a Solo back pack was allowed to stand at room temperature. Fifty ml samples were taken at intervals for analyses.

One hundred ml acetonitrile was added and the solution was blended for 3 minutes in a waring blender at low speed. It was concentrated in a rotary evaporator and then extracted with 100 ml methylene chloride. Fifty grams $Na_2SO_4$ was added to the methylene chloride, the solution was swirled vigorously and allowed to stand for 10 minutes. It was filtered through glass wool. The methylene chloride was evaporated, taken up in ethyl acetate and injected into the gas chromatograph.

The results are shown in Table 2. The data show that roughly 20% of the active malathion ingredient is still left in the spray mixture after 10 days. Malathion should not be allowed to stand in the sprayer. Spray mixtures need to be used as soon as possible, and the sprayers cleaned after use.

**Peanut Studies**

1. Effect of Plant Population Density on Seed and Bio-mass yield of Peanuts.

The use of peanuts *(Arachis hypogea)* as an intercrop and as a mono-crop has been studied in Guam (Annual Report, 1976-81). As an intercrop, peanuts have shown depressed yields of both peanut and the companion crop. However, the beneficial residual effects of incorporated peanut biomass (leaves, stems, and roots) on the succeeding crop has been amply established.

This study was conducted to determine effects of plant population density on peanut seed and biomass yield.

A 5 treatment, 4 replication, randomized complete block experimental design was carried out on a fine, gibbsitic, isohyperthermic, *Lithic Ustropepts* at the Experiment Station in Inarajan. Each treatment plot consisted of 4 rows which were 5 meters in length and 1 meter apart. The experimental blocks (replications) were 1 meter apart. Spacings between plant hills within the row were 10, 15, 20, 25, and 30 centimeters. Three seeds were planted to the hill which was later thinned to one plant. The spacings resulted in the following population density - 100,000; 66,667; 50,000; 40,000; and 33,300 peanut

Table 1. Recovery of added malathion in tomato fruit and leaves as affected by time and washing.

| Time after spraying | Fruits: Washed | Fruits: Unwashed | Leaves | Rainfall in inches |
|---|---|---|---|---|
| | ppm malathion* | | | |
| 1 hr | 1.19 | 2.35 | 237.6 | 1th day - 0 |
| 1 day | 0.57 | .62 | 32.0 | 3rd day - .11 |
| 2 days | 0.45 | .25 | 4.05 | 9th day - .15 |
| 3 days | 0.09 | .08 | 1.51 | 14th day - .09 |
| 7 days | 0.007 | .007 | 1.76 | 17th day - .14 |
| 21 days | | | .07 | 22nd day - .20 |
| 27 days | | | .06 | 24th day - .41 |
| | | | | 27th day - .33 |

* Values are the mean of 3 replications

plants per hectare. No fertilizer or pesticide applications were made in the course of the experiment.

The field used in this study was previously planted to peanuts. The field was plowed in late December, 1981 and planted in February, 1982. The plants were watered using a sprinkler system and grew to maturity.

For yield data, the middle two rows were harvested. The peanut pods were removed by hand, air-dried, and the seeds removed by hand cracking the pods. For biomass assay, the plant roots were rinsed with tap water, the plants were air-dried and weighed. The root system was cut and weighed separately. The weight of leaves and stems was calculated.

The fresh peanut seed yield ranged from 2.18 to 3.63 tons/ha (Table 3). Yield difference was statistically significant at the 1% probability level. Highest yield obtained was at the 20 centimeter spacing between hills in rows which were 1 meter apart. This spacing is equivalent to a population density of 50,000 peanut plants per hectare.

The chemical content of the peanut plant biomass is shown in Table 4. These values were used to calculate total nutrient content of the peanut biomass (Table 5, 6, and 7). The tonnage of leaves and stems adjusted to 70°C ranged from 14.07 to 19.15 tons per hectare. Although the trend was similar to the seed weights where the 50,000 plants per hectare had the highest yield, statistical analysis of the data showed it to be not significant. This trend was likewise observed in the root yields and the chemical analysis.

It is of interest to note that the peanut biomass contained 260-418 kgm N, 48-53 $P_2O$, and 154-215 kgm $K_2O$ per hectare. If these nutrients could be utilized for successive crops, the use and dependence on commercial inorganic fertilizers will be minimized.

2. Effects of Commercial Nitrogen Fertilizer Application on Yield of Corn Grown on a Field Previously Planted to Peanuts.

The preceding peanut population density study has shown that peanut biomass does indeed turn over significant amounts of plant nutrients (N, P, and K) to the soil. This study was conducted to determine the effects of adding varying levels of inorganic nitrogen fertilizer on yield of corn grown on a field previously planted to peanuts.

The plant biomass in the population density study was spread evenly on the 20 x 20 meter field and rotatilled into the soil. A randomized complete block experiment with 5 treatments and 4 replications was setup. The individual treatment plots were 4 x 4 meters. The rows were 4 meters long and were 1 meter apart. A 1 meter pathway separated the blocks.

Native white field corn seeds were planted 20 cm apart within the row. The corn plants were thinned to 1 per hill within 2 weeks after germination.

To insure non-interference of phosphorus and potassium, a blanket application of 100 kgm $P_2O_5$ and 100 kgm $K_2O$/ha was made using treble superphosphate and sulfate of potash. Nitrogen (from ammonium sulfate) rates were 0, 25, 50, 100, and 200 kgm N/ha. One nitrogen application with P and K was done, banded in furrows, and hilled up prior to planting.

The experimental field was seeded in July 8 and harvested on Oct. 22. Normal preventive pesticide spraying was observed.

The corn ears were husked in the field and allowed to air-dry in the shade. The kernels were removed by hand and allowed to air-dry for a week in a drying cabinet. The seeds were weighed and the data gathered is presented in Table 8.

Although the control plots had generally lower seed yields than the "treated" plots, the differences were not statistically significant. This non-response to added N on soils previously planted to a legume, in this case peanuts, strongly supports the contention that legume effects are beneficial on the succeeding crop.

**Assessing Alternate Sources for Fertilizer Nitrogen**

The peanut intercrop treatment wherein peanut plants were grown side by side with the main crop has consistently shown depressed yield in the main crop. This treatment was dropped in favor of sewage sludge from the Agana treatment facility. At this point, sludge is considered as a source of nitrogen fertilizer with no regards to its heavy metal content or the uptake of such metals by the plant.

The same fertilizer applications were made adjusting for the PK content of the source to allow a blanket treatment of 300 kgm $P_2O_5$ and $K_2O$ per hectare. The sludge, chicken manure, and *Leucaena* leaves were allowed 4 to 6 weeks to decompose in place (within the farrow) prior to transplanting of bellpepper seedlings. Okra was once again planted between bellpepper plants to allow for a

Table 2. Potency of a spray mixture* allowed to stand at room temperature as affected by time.

| Days after Mixing | malathion in ppm |
|---|---|
| 0 | 667.4 |
| 1 | 263.2 |
| 3 | 133.5 |
| 10 | 123.0 |

* 30 ml (commercial grade malathion)/3 gallons water.

smooth transition for the residual study. Thus, plot integrity was maintained and tillage operations avoided. Normal weeding, watering, and pesticide application were made during the growing season of both bellpepper and okra.

Vegetable yield results are shown on Table 9. Bellpepper yield ranged from 5.33 tons/ha to 20.95 tons/ha. The *Leucaena* hedge intercrop (rows of *Leucaena* 1 meter apart) again yielded lower than the control. This suggests that the *Leucaena* intercrop is competing with the native soil nitrogen, severely depressing the yield of bellpepper.

The sludge treatment showed higher yields than the control but no higher than the rest of the treatments. The sludge used contained 2.58% N, .18% $P_2O_5$, and .06% $K_2O$. Highest yield was observed in the 20 ton chicken manure treatment with *Leucaena* leaves second at 17.75 tons/ha.

The residual study done during the rainy season showed the *Leucaena* intercrop yields to be as good as the 20 ton chicken manure treatment. This is quite significant since this *Leucaena* intercrop treatment has received no fertilizer nitrogen since the inception of this project in 1978. The *Leucaena* leaves of the intercrop were trimmed every week during the growth of the bellpepper and allowed to grow during the rainy season. It should be noted here that okra yield in the sludge treatment is considerably lower than all treatments.

The 1982 data showed that:

1. The use of sludge as a source of nitrogen needs further study. The sludge residual treatment depressed yield.
2. The use of fresh *Leucaena* leaves (Tangan-tangan) results in significantly higher yield.
3. Yield from the *Leucaena* intercrop was again statistically significant during the rainy season.

**Nitrogen Fertilization Studies**

1. Effect of Rate and Timing of N Fertilization on the Yield of Cherry Tomatoes.

Nitrogen is highly mobile in Guam soils. Unless N is bound in the organic matter fraction all available nitrogen is subject to leaching losses, utilization by the soil micro-organism, denitrification and being taken up by growing plants. To insure that most applied fertilizer nitrogen is available for plant uptake - the timing of nitrogen application is critical.

This experiment is a follow-up on an earlier (Annual Report 1981) timing study. The objective is to find out how much N to add and when.

A field experiment was conducted in Inarajan during the dry season (January to May). There were 7 treatments which were replicated 3 times in a completely randomized block design. Normal weeding, watering, and spraying were carried out during the course of the experiment.

The yield of cherry tomatoes as influenced by rate and timing of fertilizer nitrogen applications is shown on Table 10. The highest yield of 38.57 tons was observed where only one nitrogen application at 50 kgm N per hectare was made. The same response was noted in the 1981 study. It appears that on this particular soil a single application for tomatoes is desirable.

2. The effect of Varying Rates of Applied Nitrogen Fertilizer on the Yield of Chinese Cabbage (Wong Bok)

The need for nitrogen is greater in leafy vegetable as compared to fruiting vegetables like tomatoes, bellpepper, etc. This study was conducted to find the optimal rate for adding nitrogen on chinese cabbage. Phosphorus and potassium were blanket applied at 100 kgm $P_2O_5$ and 100 kgm $K_2O$ per hectare. The nitrogen levels were 0, 20, 40, 60, 80, 120, and 240 kgm N/ha from ammonium sulfate. All fertilizer applications were done once, banded within the furrow and hilled-up prior to transplanting of seedlings. The seedlings were spaced 20 cm apart in 3 meter rows. There were 4 rows in a given plot with the 2 middle rows used for yield data. There were 3

Table 3. Fresh peanut seed yield in tons/ha as affected by plant population density.

| Spacing Between Hills cm | Population plant/ha | Replications I | II | III | IV | Mean |
|---|---|---|---|---|---|---|
| 10 | 100,000 | 2.487 | 2.468 | 2.280 | 2.878 | 2.528 |
| 15 | 66,667 | 3.334 | 2.820 | 2.612 | 3.308 | 3.0185 |
| 20 | 50,000 | 3.903 | 3.326 | 4.182 | 3.103 | 3.629 |
| 25 | 40,000 | 1.885 | 3.022 | 1.976 | 2.941 | 2.456 |
| 30 | 33,333 | 2.591 | 2.008 | 1.864 | 2.258 | 2.180 |
| | | | | | LSD .01 | .9745 |

replications in a randamized complete block design. Normal weeding, watering, and pesticide applications were made during the course of the experiment. Harvesting was done intermittently based on physical appearance. The yield of chinese cabbage is presented in Table 11.

Chinese cabbage yields range from 3.57 tons to 6.62 tons per hectare. Highest yield was at the 240 kgm N/ha treatments. This yield return was calculated to gross $8,019.47 in income. The no-nitrogen plot was calculated to return $4,324.69 per hectare. No attempt was made to calculate labor and maintenance (i.e., pesticide spraying, weeding). It was assumed that the market would absorb all the produce.

Table 4. Chemical analysis peanut plant biomass as affected by population density.* [1]

| plants/ha | N** | P | K | Ca | Mg | Zn*** | Fe | Mn | Cu |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Leaves and Stems | | | | | |
| 100,000 | 1.44 | .10 | .88 | 3.85 | .37 | 34 | 142 | 105 | 5.5 |
| 66,667 | 1.86 | .11 | .79 | 3.50 | .45 | 27 | 135 | 125 | 5.5 |
| 50,000 | 1.71 | .10 | .89 | 3.59 | .40 | 25 | 138 | 151 | 5.5 |
| 40,000 | 1.50 | .11 | .87 | 3.15 | .42 | 19 | 158 | 148 | 5.5 |
| 33,333 | 1.53 | .12 | .86 | 3.40 | .46 | 30 | 179 | 128 | 5.5 |
| | | | | Roots | | | | | |
| 100,000 | 1.94 | .10 | .25 | 1.45 | .18 | 15 | 560 | 65 | 5.5 |
| 66,667 | 2.21 | .10 | .25 | 1.28 | .22 | 13 | 521 | 54 | 5.5 |
| 50,000 | 1.55 | .09 | .27 | 1.38 | .22 | 14 | 541 | 53 | 5.5 |
| 40,000 | 1.97 | .10 | .27 | 1.25 | .22 | 13 | 552 | 61 | 5.5 |
| 33,333 | 1.85 | .10 | .29 | 1.35 | .22 | 12 | 491 | 59 | 5.5 |

* All values are the mean of 4 replications.

** N, P, K, Ca and Mg are in percentages.

*** Zn, Fe, Mn, and Cu are in ppm.

Table 5. Nutrient content and yield of peanut leaves and stems as affected by population density.

| Population plants/ha | Leaves and Stems* tons/ha | N kg/ha | $P_2O_5$ kg/ha | $K_2O$ kg/ha |
|---|---|---|---|---|
| 100,000 | 18.29 | 263.3 | 40.9 | 195.1 |
| 66,667 | 18.58 | 345.5 | 45.6 | 176.9 |
| 50,000 | 19.15 | 327.4 | 44.9 | 204.2 |
| 40,000 | 17.24 | 258.6 | 44.2 | 180.7 |
| 33,333 | 14.07 | 215.2 | 39.4 | 145.4 |

* Dry matter yield adjusted for moisture content at 70°C.

Table 6. Nutrient content and yield of peanut roots as affected by population density.

| Population plants/ha | Roots* tons/ha | N kg/ha | $P_2O_5$ kg/ha | $K_2O$ kg/ha |
|---|---|---|---|---|
| 100,000 | 3.25 | 63.0 | 7.1 | 9.8 |
| 66,667 | 3.28 | 72.4 | 7.1 | 9.8 |
| 50,000 | 3.47 | 53.7 | 7.3 | 11.1 |
| 40,000 | 2.86 | 56.3 | 6.2 | 9.2 |
| 33,333 | 2.43 | 44.9 | 5.5 | 8.7 |

* Dry matter yield adjusted for moisture content at 70°C.

Table 7. Total nutrient content and biomass of peanuts as affected by population density.

| Population plants/ha | Biomass* tons/ha | N kg/ha | $P_2O_5$ kg/ha | $K_2O$ kg/ha |
|---|---|---|---|---|
| 100,000 | 21.54 | 326.3 | 48.0 | 204.9 |
| 66,667 | 21.86 | 417.9 | 52.7 | 186.8 |
| 50,000 | 22.62 | 381.1 | 52.2 | 215.3 |
| 40,000 | 20.10 | 314.9 | 50.4 | 189.9 |
| 33,333 | 16.50 | 260.1 | 44.9 | 154.0 |

* Dry matter yield adjusted for moisture content at 70°C.

Table 8. Corn seed yield in tons/ha as affected by nitrogen fertilization on a field previously grown to peanuts.

| Treatment kg N/ha | Replication I | II | III | IV | Mean |
|---|---|---|---|---|---|
| 0 | 2.32 | 3.31 | 2.56 | 2.44 | 2.53 |
| 25 | 3.55 | 3.76 | 2.42 | 3.19 | 3.23 |
| 50 | 3.54 | 3.29 | 3.83 | 2.52 | 3.30 |
| 100 | 3.12 | 4.30 | 3.49 | 2.74 | 3.41 |
| 200 | 3.70 | 2.91 | 3.90 | 2.95 | 3.37 |

Table 9. Vegetable yield in tons per hectare from the long term nitrogen source studies in 1982.

| Treatment | | Bellpepper | Okra |
|---|---|---|---|
| 1. No nitrogen | | 7.31 | 7.17 |
| 2. Leucaena leucocephala Intercrop | | 5.33 | 14.05 |
| 3. Sewage sludge (Agana), 11.3 tons* | | 11.89 | 2.81 |
| 4. Chicken manure, 10.2* tons | | 16.65 | 4.84 |
| 5. 100 kgm N, 21-0-0 | | 16.22 | 6.91 |
| 6. 100 kgm N, 21-0-0 plus 5.1 tons chickens manure* | | 13.87 | 3.59 |
| 7. *Leucaena luecocephala* leaves* 12 tons fresh weight | | 17.75 | 8.03 |
| 8. Chicken manure, 20.4 tons* | | 20.95 | 14.32 |
| | LSD .01 | 6.25 | 7.57 |

*Moisture content - sludge 41.75%, chicken manure 25.13, *Leucaena* 50.85%

Table 10. Yield of marketable Cherry tomatoes in tons per hectare as influenced by rate and timing of fertilizer nitrogen application.

| Treatment | I | II | III | Mean |
|---|---|---|---|---|
| 0 | 22.81 | 21.79 | 25.02 | 23.21 |
| 50 | 36.49 | 44.39 | 34.84 | 38.57 |
| 25/25** | 32.64 | 37.31 | 33.38 | 34.44 |
| 100 | 26.42 | 25.96 | 33.94 | 28.78 |
| 50/50** | 29.07 | 22.87 | 34.06 | 28.67 |
| 25/25/25/25/** | 26.72 | 23.43 | 34.94 | 28.37 |
| 100/100** | 39.08 | 40.37 | 27.54 | 35.66 |
| | | | LSD .05 | 9.40 |

* All values are in kg N/ha using 21-0-0. All initial nitrogen applications and a blanket treatment of 300 kgm $P_2O_5$ and 100 kgm $K_2O$/ha were banded within the furrow prior to transplanting of tomato seedlings.

** Figures denote splitting of N. The 2nd fertilizer application was during flowering. Subsequent applications in the 25/25/25/25 treatment was every 2 weeks after on-set of flowers.

Table 11. Yield and projected income from chinese cabbage as influenced by nitrogen fertilization.

| Treatment kgm N / ha | Yield tons / ha | N fertilizer | Gross Income* |
|---|---|---|---|
| 0 | 3.57 | 0 | 4,324.69 |
| 20 | 4.64 | 44.60 | 5,620.89 |
| 40 | 5.21 | 89.20 | 6,311.39 |
| 60 | 4.82 | 133.80 | 5,838.95 |
| 80 | 5.21 | 178.40 | 6,311.39 |
| 120 | 5.32 | 267.60 | 6,444.65 |
| 240 | 6.62 | 535.20 | 8,019.47 |
| | $LSD_{.05}$ 1.20 | | |

* Calculations based on a wholesale price of 55 cents per pound or $1.21 per kilogram

# Horticulture-Vegetable Crops

Dr. Chin-Tian Lee

The horticulture research work in (vegetable crops) 1982 continued to concentrate on screening and determining the adaptability of major vegetable varieties which have economical potential and suitability for growth under the environmental conditions of Guam. The vegetable varieties studied in 1982 were cucumber, bush bean and winged bean. The responses of bellpepper to trickle irrigation and irrigation frequency in a shadehouse was studied in cooperation with agricultural engineering personnel.

## Varietal Performance Studies on Cucumber

**Material and Methods:**

This experiment was conducted during the dry season. The objective was to evaluate environmental factors on varietal performance. The eight varieties of cucumber included in this experiment were Commander, Market King, Burpless, Sweet Slice, Dasher, Poinsett 76, Marketmore 70, and Slice Master.

Seeds of cucumber were sown directly in the field. A randomized complete block design with three replications were used. Each experimental plot consisted of one single row 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 the same fertilizer at the same rate was done three to four weeks after sowing the seed. A preventive spraying program was followed twice weekly to reduce possible insect and disease damage by using Dibrom 8E, Malathion 50, Lannate 1.8 L, Dithane M-45 and Tribasic Coppers. A rotary tiller and garden hoe were used to control weeds. Sprinklers were used for irrigation. Cucumber vines and fruits were trained onto a plastic net to reduce the problem of fruit rot.

**2. Results and Discussion:**

All entries are monoecious, producing both male and female flowers separately on the same plant. All of these tested varieties are best suited for slicing purposes. 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.

*a. Fruit weight:*

The fruit weight ranged from 0.240 to 0.327 kg. Market King with 0.327 kg was significantly heavier than the rest of the six varieties except for Burpless. There was no signifcant difference in fruit weight among Marketmore 70, Slice Master, Poinsett 76, and Dasher. The weights ranged from 0.240 to 0.255 kg (Table 1).

*b. Number of fruit per plant:*

Fruit number on cucumber is affected by pollination and fertilization. Poor pollination and fertilization will result in lower fruit number. Dasher, Burpless, and Slice Master produced the highest number of fruit per plant, and Marketmore 70 the lowest.

Table I
Performance of Selected Cucumber Varieties
During the Dry Season of 1982 in Guam

| Variety | Fruit Weight (kg) | Number of Fruit per Plant | Marketable Fruit Yield (MT/ha) | Unmarketable Fruit Yield (MT/ha) |
|---|---|---|---|---|
| Commander | 0.281 | 2.89 | 18.27 | 0.37 |
| Market King | 0.327 | 3.87 | 31.89 | 0.36 |
| Burpless | 0.305 | 4.41 | 33.90 | 0.39 |
| Sweet Slice | 0.290 | 2.55 | 18.57 | 0.38 |
| Dasher | 0.255 | 4.31 | 27.76 | 0.42 |
| Poinsett 76 | 0.251 | 4.02 | 25.45 | 0.34 |
| Marketmore 70 | 0.240 | 1.69 | 10.32 | 0.36 |
| Slice Master | 0.245 | 4.30 | 26.57 | 0.35 |
| LSD 0.05 | 0.026 | 0.37 | 2.60 | 0.07 |

*c. Marketable fruit yield:*

Marketable fruit yield was based on the fruit which was firm and crisp while the seeds were still quite immature, and free of pest damage. Burpless and Market King, with an average of 32.90 MT/ha., significantly outyielded the rest of the six varieties. There was no significant differences in marketable fruit yield among Poinsett 76, Slice Master, and Dasher. The weights ranged from 25.45 to 27.76 MT/ha. Marketmore 70 with 10.32 MT/ha was the lowest. There was no significant difference in marketable fruit production among Dasher, Poinsett 76, and Slice Master.

*d. Unmarketable fruit yield:*

The unmarketable fruit was attributed to insect and disease damage. Unmarketable fruit yield ranged from 0.34 MT/ha for Poinsett 76 to 0.42 MT/ha for Dasher. There was no significant difference in unmarketable fruit yield among Commander, Market King, Burpless, Sweet Slice, Dasher, Marketmore 70 and Slice Master.

*3. Conclusions:*

Based on appearance, size and production, Market King and Burpless were the most promising varieties from the results of the experiment conducted during the dry season of 1982.

II

## Varietal Performance Studies on Bush Beans

**1. Material and Methods:**

This bush bean experiment was conducted during the dry season of 1982. The objective was to evaluate the climatic factors on varietal performance. Ten varieties of bush beans were included in this experiment. They were: Contender, Gator Green, Green Perfection Bountiful, Triumph, Blue Lake, Del Rey, Top Crop, Green Pak and Green Genes.

Seeds of bush beans were sown directly in the field. A randomized complete block design with three replications was used. Each experimental plot consisted of one single row of 3.66 meters. A spacing of 1.22 meters between rows and 0.15 meters within rows was adopted. A 10-20-20 fertilizer was broadcast at the rate of 435 kg/ha., and incorporated into the soil before sowing the seed. Side-dressing with the same fertilizer at the same rate was done right after the first harvest.

A preventive pest control program was followed twice weekly to reduce the possible insect, mite, and disease damage. Lannate 1.8 L, Cygon E.C. Diazinon Ag 500, Malathion E.C., Dithane M-45 and Tribasic Coppers were used. A rotary tiller and garden hoe were used for weed control. Sprinklers were used for irrigation.

**2. Results and discussion:**

The cost of materials and labor for growing bush beans lower than the pole beans, because bush beans do not require any means of support with staking or trellising. Bush beans were harvested when the pods reached full size and while the seeds were still small. They were picked by hand at the time of harvest.

When beans are harvested late, they become fiberous and stringy.

**a. Pod weight:**

The average pod weight of each of the ten varieties ranged from 2.31 to 3.26 gm (Table II). The pod weight of Top Crop with 3.26 gm was significantly heavier than the rest of the nine varieties. There was no significant difference in fruit weight among Contender, Gator Green, Bountiful, Triumph, Del Rey, Green Park and Green Genes. All of the varieties had an average of 2.40 gm.

**b. Number of pods per plant:**

Bountiful, with 83.52 pods per plant produced the highest number of pod and Contender was the next highest with 63.75 pods. Triumph and Blue Lake produced the lowest number of pod per plant. There was no significant difference in pod number among Gator Green, Green Perfection, and Green Pak (Table II).

**c. Marketable pod yield:**

Bountiful with a marketable pod production of 10.12 MT/ha significantly outyielded the rest of the nine varieties, Contender and Top Crop, with an average of 7.73 MT/ha were the next highest. Triumph and Blue Lake, which showed approximately 2.82 MT/ha., were the lowest pod producers. Green Pak, Del Rey, Green Genes, Gator Green, and Green Perfection produced 2.85 to 6.35 MT/ha.

**d. Unmarketable pod yield:**

The unmarketable pods were attributed to insect and disease damage, especially from the pod borer. Bountiful, Contender and Top Crop, with an average of 0.19 MT/ha., produced the highest number of unmarketable pod. There was no significant difference in unmarketable pod yield among Del Rey, Top Crop, Greek Pak, Blue Lake, and Triumph which ranged from 0.06 to 0.10 MT/ha.

**3. Conclusions:**

Based on appearance, size and production, Bountiful, Top Crop and Contender were the most promising varieties from the results of the experiment conducted during the dry season of 1982.

III

## Studies on the Potential of Winged Beans As A Crop for Guam

The winged bean (*Psophocarpus tetragonolobus*) has received considerable attention in the recent past. It's value as a multi-purpose crop and a source of protein has been recognized. The winged bean is a tropical crop commonly grown in backyards on Guam. They produce pods only during the short day-length months of December-January. Winged bean, therefore is commonly considered a seasonal crop. The following experiment was conducted during the long day-length period during the summer to determine if some varieties are insensitive to the photoperiod.

**I. Materials and Methods:**

Seeds of twenty-four varieties were collected from Puerto Rico, Hawaii, Indonesia, the Philippines and Guam. The twenty-four varieties were Mariposa, Mixed, Lunita, Chimbu, Ribbon, Siempre, Tinge, Dual, Toano, Bogor, C 1, C 3, C 5, Guam Long 01, Guam Short 02, Guam Medium 03, Guam Long 04, Guam Short 05, UP Accession 42, Up Accession 44, Up Accession 45, Up Asseccion 46, UP Accession 47, and Hawaii. Seeds of winged beans were directly sown in the field on May 25, 1982, to evaluate the effect of the long day-length in terms of time to flower, seed yield, pod length, seed size, seed coat color, and harvesting period. A randomized complete block design with three replications was used. Each experimental plot was a single row of 4.57 meters long. The spacing adopted was 1.22 meters between rows and 0.46 meters within rows. Side-dressing with a 10-20-20 fertilizer at the rate of 387 kg/ha., was done four weeks after sowing the seed. A preventive spraying program was followed once weekly to reduce possible insect damage. Kelthan and Malathion 50 were used. A rotary tiller and garden hoe were used to control weeds. Sprinklers were used for needed to irrigation.

The plant was supported with a trellis constructed of tangantangan stakes and plastic nets. The mature pods were allowed to stay on the plants in the field until they were dry. The seeds were then collected. All the seeds were kept for use in the next planting.

**II. Results and Discussion:**

*a. Days to first flower:*

Great diversity in the first flowering dates among the twenty-four varieties was revealed (Table III). The number of days from sowing to first flower ranged from 74 to 166 days. Chimbu, Tinge, and Dual were the early flowering varieties, while Guam Medium 03, Guam Short 05, Guam Long 01, C3, and Guam Long 04 were the late flowering ones.

*b. Days to mature pod:*

There was significant difference among the twenty-four varieties ranging from 95 to 190 days in reaching maturity. Chimbu, Tinge, Dual and Toano were the early maturing varieties, while Guam Medium 03, Guam Short 05, Guam Long 01, C3, and Guam Long 04 were the last maturing varieties.

Table II
Performance of Selected Bush Beans Varieties
During the Dry Season of 1982 in Guam

| Variety | Pod Weight (gm) | Number of Pod per Plant | Marketable Pod Yield (MT/ha) | Unmarketable Pod Yield (MT/ha) |
|---|---|---|---|---|
| Contender | 2.31 | 63.75 | 7.60 | 0.19 |
| Gator Green | 2.36 | 44.75 | 5.44 | 0.12 |
| Green Perfection | 2.68 | 45.96 | 6.35 | 0.14 |
| Bountiful | 2.35 | 83.52 | 10.12 | 0.21 |
| Triumph | 2.55 | 21.21 | 2.79 | 0.06 |
| Blue Lake | 2.64 | 20.94 | 2.85 | 0.07 |
| Del Rey | 2.45 | 30.86 | 3.90 | 0.10 |
| Top Crop | 3.26 | 46.74 | 7.85 | 0.17 |
| Green Pak | 2.42 | 30.83 | 3.85 | 0.08 |
| Green Genes | 2.33 | 36.49 | 4.38 | 0.10 |
| LSD 0.05 | 0.24 | 4.60 | 0.67 | 0.04 |

*c. Yield component:*

Different varieties had significant differences yields of dry pods and dry seeds, and number of dry pods per plant (Table IV and V). Ten out of the twenty-four varieties were ready for harvest dry pods in November, 1982. The ten varieties were Mariposa, Mixed, Lunita, Chimbu, Ribbon, Siempre, Tinge, Dual, Toano, and Bogor. In December 1982, fifteen varieties were producing pods in contrast to ten during the rest of the year. The five varieties were UP Accession 42, UP Accession 44, UP Accession 46, UP Accession 47 and Hawaii. Tinge and Dual produced the highest number of pods per plant, while Ribbon produced the lowest. Dual produced the highest dry pod, while Mariposa and Ribbon produced the lowest. Chimbu, Tinge and Dual had the highest dry seed production and Ribbon was the lowest (Table Ivand V). There was no tendency of dry pod shatter at maturity among the tested varieties.

*3. Conclusions:*

Problems of photoperiod-sensitity and maturity are the central issues of this study. Tropical summer environmental conditions are suitable for screening for the day-length insensitive varieties. Chimbu, Tinge and Dual showed a great degree of day-length neutrality based on the results of the experiment conducted during the summer of 1982.

Table III
Effect of Long Day-Length on Days to First Flower and Days to Mature Green Pods in Winged Beans

| Variety | Days to First Flower | Days to Mature Green Pod |
|---|---|---|
| MITA 1018-Mariposa | 120 | 145 |
| MITA 969-Mixed | 113 | 136 |
| MITA 960-Lunita | 117 | 139 |
| MITA 943-Chimbu | 74 | 95 |
| MITA 951-Ribbon | 123 | 147 |
| MITA 953-Siempre | 115 | 138 |
| MITA 964-Tinge | 74 | 101 |
| MITA 958-Dual | 82 | 104 |
| MITA 961-Toano | 87 | 108 |
| MITA 942-Bogor | 125 | 146 |
| C 1 | 150 | 171 |
| C 3 | 165 | 187 |
| C 5 | 142 | 164 |
| Guam Long 01 | 163 | 188 |
| Guam Short 02 | 151 | 172 |
| Guam Medium 03 | 156 | 178 |
| Guam Long 04 | 166 | 190 |
| Guam Short 05 | 157 | 179 |
| UP Accession 42 | 124 | 147 |
| UP Accession 44 | 123 | 146 |
| UP Accession 45 | 143 | 166 |
| UP Accession 46 | 124 | 147 |
| UP Accession 47 | 123 | 146 |
| Hawaii | 125 | 149 |
| LSD 0.05 | 12 | 13 |

Table IV
Effect of Long Day-Length on Yield
Components of Winged Bean
Planting Date: May 25, 1982 Harvesting Date: November, 1982

| Variety | Number of Dry Pod/Plant | Yield of Dry Pods (kg/ha) | Yield of Dry Feeds (kg/ha) |
|---|---|---|---|
| MITA 1018-Mariposa | 1.78 | 201.3 | 90.5 |
| MITA 969-Mixed | 9.66 | 788.5 | 343.9 |
| MITA 960-Lunita | 4.77 | 444.0 | 188.3 |
| MITA 943-Chimbu | 5.96 | 899.7 | 412.1 |
| MITA 951-Ribbon | 2.23 | 265.3 | 104.3 |
| MITA 953-Siempre | 2.97 | 342.1 | 153.3 |
| MITA 964-Tinge | 12.76 | 1,215.0 | 409.5 |
| MITA 958-Dual | 10.75 | 1,215.0 | 409.5 |
| MITA 961-Toano | 9.59 | 872.4 | 350.7 |
| MITA 942-Bogor | 3.89 | 483.3 | 221.7 |
| C 1 | 0 | 0 | 0 |
| C 3 | 0 | 0 | 0 |
| C 5 | 0 | 0 | 0 |
| Guam Long 01 | 0 | 0 | 0 |
| Guam Short 02 | 0 | 0 | 0 |
| Guam Medium 03 | 0 | 0 | 0 |
| Guam Long 04 | 0 | 0 | 0 |
| Guam Short 05 | 0 | 0 | 0 |
| UP Accession 42 | 0 | 0 | 0 |
| UP Accession 44 | 0 | 0 | 0 |
| UP Accession 45 | 0 | 0 | 0 |
| UP Accession 46 | 0 | 0 | 0 |
| UP Accession 47 | 0 | 0 | 0 |
| Hawaii | 0 | 0 | 0 |
| LSD | | | |
| 0.05 | 0.75 | 68.6 | 28.0 |

Table V
Effect of Long Day-Length on Yield
Components of Winged Bean
Planting Date: May 25, 1982 Harvesting Date: December, 1982

| Variety | Number of Dry Pod/Plant | Yield of Dry Pods (kg/ha) | Yield of Dry Feeds (kg/ha) |
|---|---|---|---|
| MITA 1018-Mariposa | 2.93 | 345.8 | 155.6 |
| MITA 969-Mixed | 12.63 | 1,030.3 | 449.2 |
| MITA 960-Lunita | 7.89 | 733.4 | 310.9 |
| MITA 943-Chimbu | 8.04 | 1,213.6 | 555.8 |
| MITA 951-Ribbon | 1.73 | 206.3 | 81.1 |
| MITA 953-Siempre | 6.33 | 728.9 | 326.6 |
| MITA 964-Tinge | 12.63 | 1,060.8 | 456.1 |
| MITA 958-Dual | 14.25 | 1,609.9 | 542.5 |
| MITA 961-Toano | 9.85 | 896.0 | 360.2 |
| MITA 942-Bogor | 5.00 | 619.6 | 271.4 |
| C 1 | 0 | 0 | 0 |
| C 3 | 0 | 0 | 0 |
| C 5 | 0 | 0 | 0 |
| Guam Long 01 | 0 | 0 | 0 |
| Guam Short 02 | 0 | 0 | 0 |
| Guam Medium 03 | 0 | 0 | 0 |
| Guam Long 04 | 0 | 0 | 0 |
| Guam Short 05 | 0 | 0 | 0 |
| UP Accession 42 | 2.57 | 31.0 | 147.1 |
| UP Accession 44 | 2.90 | 394.2 | 173.4 |
| UP Accession 45 | 0 | 0 | 0 |
| UP Accession 46 | 3.04 | 397.8 | 171.1 |
| UP Accession 47 | 2.11 | 275.9 | 132.2 |
| Hawaii | 4.19 | 582.9 | 280.0 |
| LSD | | | |
| 0.05 | 0.70 | 71.1 | 29.2 |

# Ornamental Horticulture

Syamal K. Sengupta

This project was initiated in 1980 to study various cultural practices on some ornamental plants. Treatments with growth retardants and the black cloth method for flowering were the two studies conducted during this year. Plants utilized were Poinsettia, Chrysanthemums, and Kalanchoe.

### Poinsettia

Apex cuttings of cultivars GV-10 (Amy), GV-14 (Glory), C-1 Red (Eckespoint), Annett Hegg Hot Pink, Dark Red and White were directly planted in plastic pots on March 15, 1982. Medium for the pots was a mixture of top soil, Hortipearl and Peat Moss (1:1:2 v/v). The medium was ammended with "Perk" (micronutrient) and pastuerized before planting. The cuttings, in the pots were drenched with Captan and Terraclor. Root initiation took place in three weeks. Fertilization was given at intervals of one week alternating between ammonium sulfate and soluble 20-20-20.

Drenching with Cycocel at 1500, 2500, 3000 and 3500 p.p.m. was done on July 17, and August 10, 1982 to reduce the growth of the Poinsettia. Black cloth treatment was started on September 6, 1982.

GV-10 (Amy) and C-1 Red showed color bract on October 26, and November 22, 1982 respectively.

Other varieties did not show the color bracts until December 15, 1982. Drenching with cycocel caused "Toning" of the plants by darkening the color of the leaves.

GV-10 and C-1 Red are the two promising varieties for growing in Guam.

### Potted Chrysanthemum

Six cultivars: Intrepid White, Intrepid Gold, Loyalty, Wild Honey, Royal Trophy and Dramatic were donated by Yoder Brothers of Ohio to study their performances on Guam. Fifty rooted cuttings of each variety were planted on August 25, 1982 in plastic pots. Composition of the medium consisted of top soil, Hortipearl and Peatmoss (1:1:2 v/v). The medium was amended with "Perk" (micronutrient) and pasteurized before planting. The pots were drenched by Captan and Terraclor. The plants were pinched on September 8, 1982. The Short Day treatment was started on September 17, 1982. Flower buds were initiated ten days after treatment in all the varieties.

Treatments used were control and B-9 at 2500 p.p.m. and 5000 p.p.m.

The effect of B-9 on Loyalty and Intrepid Gold was quite remarkable in reducing the growth and was less effective on Wild Honey and Intrepid White. (Table 1.)

### Kalanchoe

Sonata (Orange), Sensation (Deep Pink), Serenade (Red), Nugget (Orange) and Firefly (Yellow) were the varieties treated with B-9 at 2500 ppm and 5000 ppm with a control and replicated six times.

The height of plants responding to different treatments are shown in Table 2.

Photoperiodic control by covering with black cloth at 4:30 p.m. and uncovering at 8:00 a.m. started on July 26, 1982 and terminated on October 19, 1982 for inducement of flowering.

The above mentioned varieties planted outside the greenhouse flowered in November when the day length was about 12 hours per day.

### Tuberose

Tuberose plants were sprayed with B-9 at 2500 ppm and 5000 ppm with a Control and was replicated six times. The average spike length in Control, 2500 ppm B-9 and 5000 ppm B-9 were 85.7 cm, respectively. This clearly proved that B-9 did not have any effect on tuberose spike length.

Table 1

Effect of B - 9 on Chrysanthemum plants

| | Height of Plants in cm | | | Difference in growth in cm | |
|---|---|---|---|---|---|
| | Control | 2500 ppm | 5000 ppm | 2500 ppm | 5000 ppm |
| Wild Honey (Golden yellow) | 43.5 | 43.5 | 40.5 | 0 | 3.00 |
| Royal Trophy (Dark pink) | 34.4 | 32.0 | 30.4 | 2.40 | 4.40 |
| Dramatic (Yellow) | 34.75 | 31.75 | 30.0 | 3.00 | 4.74 |
| Loyalty (Dark pink) | 35.0 | 30.5 | 26.0 | 4.50 | 9.00 |
| Intrepid Gold (Dark yellow) | 31.6 | 24.8 | 21.6 | 6.80 | 10.00 |
| Intrepid White (White) | 25.75 | 24.0 | 22.25 | 1.75 | 3.50 |
| mean | 34.08 | 30.89 | 28.04 | | |

Table 2

Height of Kalanchoe Plants In Response to treatment

| | Control | B-9 2500 p.p.m. | B-9 5000 p.p.m. |
|---|---|---|---|
| Sonata | 22.1 | 15.7 | 14.0 |
| Sensation | 17.1 | 15.8 | 14.3 |
| Serenade | 26.5 | 24.9 | 23.8 |
| Firefly | 30.6 | 26.3 | 22.8 |
| Nugget | 31.9 | 26.2 | 25.0 |

# Entomology-Pest Management

Ilse H. Schreiner and
Donald M. Nafus

**Beans**

A program to develop a pest management system for beans, particularly emphasising control of the leaf miner *Liriomyza trifolii* was continued.

**I.**

A survey was taken of 13 bean farmers to determine their inputs into producing beans, and to determine which insecticides were being used. The average inputs for each farm are summarized in Table 1. The average size of the bean field grown was 0.4 acres, and the average yield reported by farmers was 10,320 lbs. per acre. The greatest labor inputs were for weeding and harvesting. Most farmers (8 out of 12 reporting) used a backpack sprayer. Some people were hand watering, which greatly increased labor inputs for irrigation.

The pesticide use data is summarized in Table 2. Most farmers sprayed against pod borers (*Maruca testulalis*), leaf miners, and mites (presumed to be broad mites). Beanflies (*Ophiomyza phaseoli*), garden semiloopers (*Chrysodeixes chalcites*) and aphids are only occasionally a problem. Only two farmers reported spraying against downy mildew, which causes the bean planting to die prematurely. Cygon, Diazinan, and Dibrom were most frequently used against leaf miners.

Ilse

**II.**

An experiment was set up during the dry season to test the effectiveness of the three chemicals most often used against the leaf miner, and to assess their impact on parasite populations.

**Materials and Methods**

*Phaseolus* pole beans (var. Takii Flat Pod Kentucky Wonder) were planted March 3, 1982. Each plot consisted of 3 rows which were 15 feet long, and 4 feet apart. A barrier of sweet corn was planted between the plots to reduce insecticide drift. All plots were sprayed with Dipel once flowering began, to reduce pod borer damage to the beans. Plots were either sprayed with diazinon, dimethoate (Cygon) or naled (Dibrom) at 3 or at 10 day intervals or left unsprayed as a check. To estimate the number of mines per plot, a height was chosen that had many mature leaves with mines. Then 33 leaves per plot were chosen randomly from leaves at this height. The number of mines was counted weekly. Every other week, 15 leaves from each plot were taken, using the same method. These leaves were examined through a backlit binocular microscope and the number of miner larvae, pupae and parasites were counted. The parasite pupae were held for emergence and then identified and counted.

Don

**Results**

The results are summarized in Table 3. Cygon sprayed at 3 day intervals slightly reduced the number mines per leaf (significant at the 0.05 level). However, the number of live miner larvae found was the same in all plots. There was no difference in yields. Thus, none of the chemicals provided economical control. All three chemicals when sprayed at 3 day intervals significantly reduced the total number of parasites present. Only 2 species of parasites were found. There were identified as *Hemiptarsenus semialbiclavus* and *Chrysonotomyia formosa*. Counts of emerged parasites show tha *C. formosa* was adversely affected by the insecticide sprays, but that *H. semialbiclavus* was not. Dibrom at 3 day intervals provided substantial additional control of the pod borer compared to Dipel alone.

**III.**

Ilse

The survey of bean farmers indicated that most farmers were using over 150 lbs. of nitrogen fertilizer per acre. Current recommendations are that 80 lbs. per acre should be used. An experiment was run to determine whether varying nitrogen fertilizer levels have an effect on leaf miner populations.

**Materials and Methods**

Yard long beans (var. green pod kaohsiung) were planted August 23, 1982. Plots consisted of 3 rows, 12 feet long and 4 feet apart. Treatments were replicated 4 times. Nitrogen was applied at the rate of 0, 40, 80, 120, or 160 pounds per acre. The nitrogen application was split. Half was applied when the first true leaf appeared (16 days after planting), and half when the plants began flowering (50 days after planting). Once flowering began, naled was applied twice weekly to control pod borers. The number of mines and miners was sampled to determine nitrogen content. Fifty-five leaflets (10g dry weight) were picked randomly, rinsed in distilled water and dried at 70°C overnight. Nitrogen content was then analyzed.

**Results**

The nitrogen fertilizer had no effect on the number of mines in the leaves, the number of live miners or of parasites (Table 4). The treatments also had no effect on yield. Analysis of the nitrogen content is not complete at this time. It may be that the high rainfall during this period (over 50 inches) leached out most of the nitrogen.

**IV**

As part of a program to determine economic injury levels, a test was initiated to determine at which age yard-long bean leaves are attacked by the leafminer. Individual bean and leaves were tagged, and every two days they were checked for new mines. Leaves had an average lifespan of 28 ± 12 days. The leaves took 9 ± 2 days to reach full size and the first mines became apparent 4 ± 5 days after the bean leaves had stopped expanding. Apparently the leafminer begins laying its eggs as soon as the leaf is fully expanded.

**Corn**

**I.** Don

Corn lines were screened for resistance to *Ostrinia furnacalis*. 140 inbred and hybrid lines were obtained from the corn breeding programs in Iowa, Hawaii and New York. The corn was planted January 22, 1982. Each row was 21 feet long and received 20 seeds. Rows were 3 feet apart.

Fertilizer was applied at the rate of 1000 lbs. 10-30-10 per acre (2 lbs. per row), and sidedressed with ammonium sulphate at 6 weeks. On week 4, all plants were checked for the presence of corn borer egg masses. All plants not naturally infested received 1 egg mass at that time. At week 6, plants were rated using a modified Guthrie leaf rating scale. Once the ears were mature, plants were measured. The number of borer cavities in the stalk and the amount of the stalk tunneled were recorded.

The data are summarized in Table 5. Variation was seen in the leaf resistance, and stalk damage with some lines appearing quite promising. However, no conclusions can be drawn until the trial is repeated.

II. DON

The experiment attempting to augment *Trichogramma* parasitism of *O. furnacalis* eggs by intercropping corn and sweet potatoes was continued. Two more trials were run. In the first trial, sweet potatoes were planted 1 month before the corn. In the second trial, the corn and sweet potatoes were planted at the same time. Other methods were the same as last year's experiment, except in Trial II, 3 replicates of each treatment were run instead of 2 and the sweet potato monoculture was not run.

In both experiments, corn borers began oviposition earlier than the 1980 experiment. Rates of oviposition and parasitism of eggs of corn borers and hornworms are reported in Tables 6 and 7.

Rates of parasitism of eggs with corn borer egg masses were similar between treatments (Table 8) and approximately 33% of the eggs were parasitized. Marking and following the development of egg masses showed that the rate of parasitism obtained by counting the number of parasitized and unparasitized egg masses underestimates the true parasitism rate by a factor of 2 (Table 9).

No differences were found between any of the treatments, possibly due to early invasion of high numbers of *O. furnacalis*. Intercropping corn and sweet potatoes probably does not help raise *Trichrogramma* numbers consistently enough to warrant use in an IPM program.

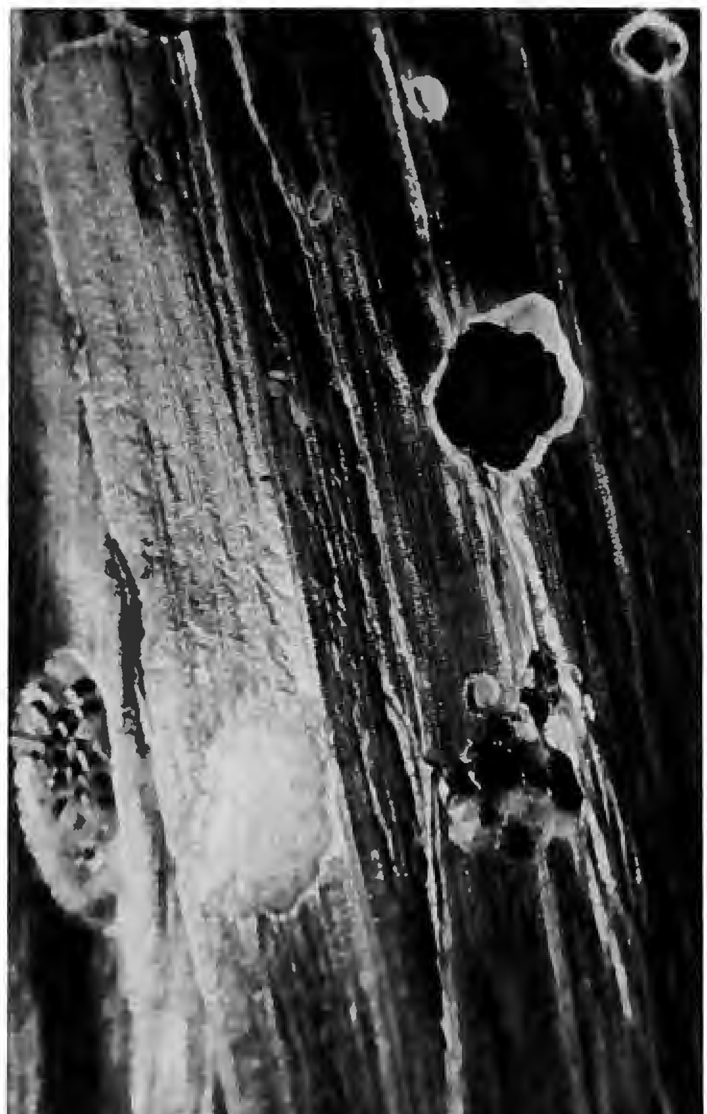


Table 1

## Inputs Per Acre For Guam Bean Farmers

**Bean Farmers**

**Average inputs per acre**

| | |
|---|---|
| Plow | 21 hours |
| Disc | 25 hours |
| Rototill | 7 hours |
| Hoe | 228 hours |
| Put up stakes and nets | 75 hours |
| Harvest | 473 hours |
| Spray pesticide | 130 hours |
| Stakes | 850 stakes |
| Nets | 140 sixty ft. nets |
| Fertilizer | |
| Nitrogen | 200 lbs |
| Phosphorus | 260 lbs |
| Potassium | 290 lbs |
| Water | $147.00 |
| Pesticides | $210.00 |

Table 2

## Survey of Pesticides Used by Guam Bean Farmers

**Farmers Using Chemicals Against**

| **Chemical** | **Insects** | | | | | **Mites** | **Diseases** | |
|---|---|---|---|---|---|---|---|---|
| | **Leafminer** | **Pod Borer** | **Beanfly** | **Semi looper** | **Aphids** | | **Leaf spot** | **Downy mildew** |
| Insecticide | | | | | | | | |
| Malathion | 1 | | 1 | | 4 | 2 | | |
| Sevin | | 3 | | 1 | | | | |
| Orthene | | 2 | | | | | | |
| Cygon | 3 | | | | | | | |
| Lannate | | 2 | | | | | | |
| Diazinon | 2 | 2 | 1 | | | 1 | | |
| Dibrom | 3 | 3 | | | | | | |
| Acaricide | | | | | | | | |
| Kelthane | | | | | | 3 | | |
| Ethion | | | | | | 1 | | |
| Fungicide | | | | | | | | |
| Copper sulfate | | | | | | | 1 | |
| Dithane | | | | | | | | 2 |
| Total | 9 | 12 | 2 | 1 | 4 | 7 | 1 | 2 |

Table 3

## Effects of Pesticides Against Leaf Miners and Their Parasites

| | | **Seasonal mean number** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Insecticide, lbs A.I. / Acre** | **Spray Interval (days)** | **Mines/leaflet** | **Miner larvae/ per 5 leaflets** | **Parasites/ 5 leaflets** | ***C. formosa*/ 5 leaflets/** | ***H. semialbiclavus*/ 5 leaflets** | **Yield (kg.)** | **% borer damaged** |
| diazinon, 0.2 | 3 | 15.9 b | 8.0 a | 10.6 a | 1.2 a | 2.1 a | 6.4 a | 21.5 ab |
| diazinon, 0.2 | 10 | 16.3 b | 8.0 a | 22.8 bc | 4.1 bcd | 3.6 a | 8.0 a | 26.5 bc |
| dimethoate, 0.25 | 3 | 12.9 a | 7.0 a | 12.0 a | 1.8 ab | 2.5 a | 5.7 a | 26.6 b |
| dimethoate, 0.25 | 10 | 14.4 ab | 7.6 a | 23.2 bc | 5.1 cd | 5.6 a | 9.3 a | 28.6 c |
| naled, 0.95 | 3 | 15.1 b | 8.3 a | 19.4 ab | 3.7 abc | 4.9 a | 10.8 a | 15.4 a |
| naled, 0.95 | 10 | 15.2 b | 8.8 a | 26.2 c | 6.4 d | 4.2 a | 6.7 a | 22.9 bc |
| check | - | 16.2 b | 8.7 a | 26.4 c | 6.7 d | 3.2 a | 6.9 a | 26.5 bc |

Numbers followed by the same letter within each column are not significantly different at 0.05 level by Duncan multiple range test.

Table 4

Effects of Nitrogen Fertilizer on Leaf Miner Populations

| | Seasonal mean number | | | |
|---|---|---|---|---|
| lbs. Nitrogen per acre | mines/leaflet | miner larvae/ 5 leaflets | parasites/ 5 leaflets | Yield (kg.) |
| 0 | 5.4 | 18.6 | 3.9 | 14.8 |
| 40 | 6.0 | 20.6 | 3.8 | 15.0 |
| 80 | 6.0 | 17.1 | 4.6 | 14.6 |
| 120 | 5.6 | 17.1 | 5.6 | 15.5 |
| 160 | 5.2 | 13.3 | 6.5 | 16.5 |

Table 5. Corn ratings for resistance to feeding by *O. furnacalis*.

A. Germplasm from University of Hawaii

| Breeding Line | Number of Plants | Leaf rating (Guthrie's Scale) x ± s | Number of Cavities/ Stalk | Length (cm) of Stalk Tunnelled | Percent of Stalk Tunnelled |
|---|---|---|---|---|---|
| Hi31 | 4 | 2.5 ± 1.3 | 4.7 | 19 ± 11 | 27 |
| H 610 | 6 | 3.8 ± 1.0 | 7.4 | 51 ± 32 | 38 |
| H 763 | 17 | 7.7 ± 0.5 | 6.9 | 39 ± 18 | 36 |
| H 767 | 16 | 7.3 ± 0.7 | 5.7 | 31 ± 17 | 28 |
| H 824 | 17 | 5.6 ± 1.2 | 5.8 | 28 ± 13 | 23 |
| H 929 | 13 | 6.2 ± 1.4 | 6.9 | 37 ± 12 | 31 |
| H 945 | 19 | 8.3 ± 0.5 | 6.5 | 44 ± 11 | 49 |
| H 946 | 16 | 8.6 ± 1.5 | 7.2 | 43 ± 17 | 46 |
| H 948 | 16 | 8.1 ± 0.5 | 7.5 | 50 ± 19 | 51 |
| H 949 | 14 | 6.9 ± 1.6 | 7.9 | 32 ± 16 | 34 |
| H 950 | 17 | 5.8 ± 1.6 | 6.7 | 32 ± 17 | 24 |
| Ha 34-2 | 4 | 3.0 ± 1.8 | 6.0 | 50 ± 25 | 48 |
| X 304-C | 19 | 4.8 ± 1.5 | 4.6 | 22 ± 13 | 20 |

B. Misc. Germplasm

| | | | | | |
|---|---|---|---|---|---|
| Com 9E74 EWR | 10 | 4.6 ± 1.8 | 4.5 | 47 ± 24 | 56 |
| MPSWC B4 | 19 | 1.6 ± 0.9 | 5.4 | 26 ± 11 | 18 |

C. Germplasm from Cornell

| Breeding Line | Number of Plants | Leaf rating (Guthrie's Scale) x ± s | Number of Cavities/ Stalk | Length (cm) of Stalk Tunnelled | Percent of Stalk Tunnelled |
|---|---|---|---|---|---|
| ECB F1 | 16 | 2.5 ± 1.4 | 3.1 | 13 ± 13 | 11 |
| ECB F2 | 9 | 3.7 ± 2.4 | 5.2 | 40 ± 21 | 47 |
| ECB F3 | 19 | 4.0 ± 1.7 | 6.4 | NC | NC |
| ECB F4 | 17 | 3.5 ± 2.3 | 6.9 | 53 ± 19 | 44 |
| ECB F5 | 19 | 3.9 ± 2.1 | 4.2 | NC | NC |
| ECB F6 | 16 | 3.9 ± 1.7 | 4.1 | 24 ± 19 | 21 |
| ECB F7 | 17 | 4.5 ± 2.0 | 6.4 | NC | NC |
| ECB F8 | 18 | 3.2 ± 1.5 | 3.2 | 17 ± 11 | 17 |
| ECB F9 | 14 | 3.2 ± 1.1 | 7.4 | 47 ± 21 | 39 |
| ECB F10 | 10 | 2.8 ± 1.6 | 5.4 | 42 ± 20 | 37 |
| ECB F11 | 16 | 3.2 ± 1.6 | 6.4 | 49 ± 22 | 37 |
| ECB F12 | 15 | 4.3 ± 1.7 | 8.1 | 57 ± 15 | 54 |
| ECB F13 | 15 | 3.9 ± 1.4 | 6.0 | 40 ± 14 | 35 |
| ECB F14 | 16 | 4.8 ± 1.3 | 4.8 | 27 ± 12 | 23 |
| ECB F15 | 17 | 4.5 ± 1.0 | 6.5 | 46 ± 16 | 43 |
| ECB F16 | 18 | 3.4 ± 1.0 | 2.4 | 12 ± 11 | NC |
| ECB F17 | 18 | 4.1 ± 1.5 | 9.9 | 75 ± 16 | 52 |
| ECB F18 | 19 | 3.5 ± 1.3 | 5.7 | 37 ± 13 | 30 |
| ECB F19 | 20 | 5.9 ± 1.3 | 8.6 | 69 ± 20 | 53 |
| ECB F20 | 18 | 2.7 ± 1.3 | 6.4 | 56 ± 21 | 53 |

(Table 5 Continue)
**D. USDA Germplasm (W.D. Guthrie).**

| Breeding Line | Number of Plants | Leaf rating (Guthrie's Scale) x ± s | Number of Cavities / Stalk | Length (cm) of Stalk Tunnelled | Percent of Stalk Tunnelled |
|---|---|---|---|---|---|
| A239 | 12 | 7.6 ± 1.0 | 5.2 | 24 ± 18 | 37 |
| A257 | 13 | 4.1 ± 2.1 | 3.6 | 22 ± 9 | 32 |
| A495 | 19 | 3.0 ± 0.9 | 5.4 | 39 ± 19 | 40 |
| A509 | 10 | 4.0 ± 1.3 | 5.5 | 33 ± 10 | 51 |
| A554 | 12 | 4.5 ± 1.8 | 2.1 | NC | NC |
| A619 | 11 | 2.4 ± 0.7 | 8.1 | 51 ± 19 | 50 |
| A634 | 6 | 3.7 ± 0.6 | 7.0 | 26 ± 13 | 31 |
| A632 | 10 | 3.1 ± 1.1 | 5.5 | 28 ± 16 | 31 |
| A635 | 17 | 4.8 ± 1.8 | 3.8 | 17 ± 10 | 19 |
| A636 | 10 | 6.7 ± 1.4 | 6.0 | 23 ± 9 | 27 |
| A638 | 4 | 5.5 ± 2.7 | 5.5 | 40 ± 23 | 47 |
| A641 | 17 | 5.5 ± 1.8 | 3.5 | 17 ± 11 | 23 |
| A654 | 12 | 2.3 ± 1.1 | 4.9 | 31 ± 15 | 33 |
| B14A | 18 | 6.4 ± 1.2 | 8.2 | 29 ± 14 | 29 |
| B49 | 15 | 3.1 ± 2.4 | 3.9 | 19 ± 11 | 25 |
| B52 | 16 | 5.9 ± 1.8 | 4.2 | 19 ± 10 | 26 |
| B57 | 10 | 5.4 ± 1.6 | 5.2 | 20 ± 6 | 22 |
| B64 | 17 | 4.8 ± 1.3 | 6.2 | 25 ± 14 | 30 |
| B68 | 19 | 4.0 ± 1.0 | 4.8 | 19 ± 8 | 16 |
| B73 | 17 | 5.1 ± 1.1 | 0.9 | 6 ± 7 | 5 |
| B75 | 14 | 4.6 ± 1.1 | 5.1 | 29 ± 16 | 27 |
| B85 | 18 | 4.4 ± 1.3 | 3.5 | 13 ± 10 | 13 |
| B86 | 6 | 7.2 ± 0.7 | 3.7 | 27 ± 10 | 45 |

(Table 5 Continue)

| Breeding Line | Number of Plants | Leaf rating (Guthrie's Scale) x ± s | Number of Cavities/ Stalk | Length (cm) of Stalk Tunnelled | Percent of Stalk Tunnelled |
|---|---|---|---|---|---|
| C103 | 9 | 5.7 ± 1.2 | 7.0 | 52 ± 19 | 47 |
| C103D | 18 | 3.4 ± 2.1 | 1.9 | NC | NC |
| C123 | 13 | 6.3 ± 1.4 | 6.5 | 39 ± 21 | 38 |
| C131A | 15 | 4.3 ± 1.0 | 5.1 | 24 ± 14 | 26 |
| C144 | 10 | 3.3 ± 1.1 | 5.7 | 19 ± 12 | 20 |
| C164 | 8 | 2.4 ± 0.5 | 4.0 | 20 ± 12 | 28 |
| C166 | 13 | 4.1 ± 1.2 | 3.2 | 9 ± 4 | 12 |
| CI21E | 19 | 6.7 ± 2.1 | 5.8 | 22 ± 10 | 33 |
| CH593-9 | 10 | 2.7 ± 2.0 | 7.0 | 34 ± 11 | 39 |
| CO106 | 3 | 2.3 ± 0.9 | 3.0 | 15 ± 8 | 29 |
| FR4A | 16 | 7.4 ± 1.7 | 6.4 | 34 ± 14 | 35 |
| GT112 | 10 | 4.2 ± 1.4 | 6.3 | 47 ± 20 | 56 |
| H21 | 9 | 4.6 ± 1.3 | 6.4 | 29 ± 13 | 40 |
| H49 | 11 | 4.8 ± 2.4 | 7.2 | 42 ± 12 | 52 |
| H55 | 15 | 6.2 ± 1.6 | 3.6 | 41 ± 16 | 46 |
| H60 | 16 | 3.5 ± 1.6 | 2.6 | 12 ± 10 | 11 |
| H84 | 11 | 4.1 ± 1.2 | 2.4 | 11 ± 8 | 10 |
| H91 | 8 | 4.3 ± 1.3 | 7.6 | 38 ± 14 | 41 |
| H93 | 15 | 4.9 ± 1.4 | 7.5 | 42 ± 21 | 40 |
| H95 | 8 | 3.2 ± 1.6 | 2.4 | NC | NC |
| H96 | 16 | 4.3 ± 1.7 | 6.4 | 43 ± 9 | 49 |
| H99 | 17 | 2.8 ± 1.5 | 5.1 | 22 ± 12 | 29 |

(Table 5 Continue)

| Breeding Line | Number of Plants | Leaf rating (Guthrie's Scale) x ± s | Number of Cavities / Stalk | Length (cm) of Stalk Tunnelled | Percent of Stalk Tunnelled |
|---|---|---|---|---|---|
| K55 | 14 | 5.4 ± 2.6 | 5.5 | 24 ± 14 | 35 |
| K64 | 16 | 6.0 ± 1.6 | 5.4 | 18 ± 9 | 25 |
| KY201 | 11 | 4.8 ± 1.8 | 3.4 | 16 ± 5 | 37 |
| KY228 | 13 | 4.2 ± 1.5 | 6.4 | 54 ± 23 | 55 |
| M05 | 15 | 6.6 ± 1.5 | 5.6 | 22 ± 13 | 37 |
| M013 | 20 | 3.1 ± 1.4 | 1.2 | 4 ± 4 | 4 |
| M014W | 12 | 4.7 ± 1.8 | 5.2 | 24 ± 13 | 25 |
| M017 | 14 | 4.4 ± 1.8 | 5.4 | 20 ± 10 | 23 |
| M021R | 11 | 7.0 ± 0.7 | 6.1 | 31 ± 14 | 45 |
| N6 | 14 | 5.8 ± 0.9 | 7.0 | 35 ± 18 | 46 |
| N7A | 9 | 4.4 ± 0.8 | 2.6 | 14 ± 15 | 14 |
| N28 | 15 | 5.4 ± 1.9 | 3.0 | NC | NC |
| ND203 | 17 | 4.5 ± 1.3 | 5.6 | 31 ± 13 | 39 |
| NY821 | 18 | 3.4 ± 1.0 | 3.1 | 16 ± 11 | 22 |
| OH07B | 18 | 6.6 ± 1.8 | 5.3 | 22 ± 16 | 24 |
| OH43 | 13 | 3.9 ± 1.3 | 5.4 | 48 ± 9 | 47 |
| OH51A | 15 | 4.6 ± 2.5 | 4.6 | 28 ± 14 | 44 |
| OH514 | 14 | 5.4 ± 2.5 | 6.4 | 52 ± 13 | 70 |

(Table 5 Continue)

| Breeding Line | Number of Plants | Leaf rating (Guthries Scale) x ± s | Number of Cavities/ Stalk | Length (cm) of Stalk Tunnelled | Percent of Stalk Tunnelled |
|---|---|---|---|---|---|
| OH551 | 16 | 2.0 ± 0.5 | 1.2 | NC | NC |
| PA762 | 9 | 3.9 ± 1.7 | 3.5 | 19 ± 15 | 19 |
| PA884P | 15 | 4.0 ± 1.4 | 4.6 | 34 ± 10 | 31 |
| R177 | 12 | 6.6 ± 1.0 | 5.7 | 25 ± 9 | 28 |
| SC213 | 17 | 5.2 ± 1.3 | 4.4 | 13 ± 7 | 15 |
| SC213R | 15 | 7.0 ± 1.2 | 4.1 | 21 ± 8 | 21 |
| SD5 | 8 | 5.3 ± 1.0 | 7.3 | 46 ± 17 | 57 |
| SD15 | 18 | 4.7 ± 1.9 | 5.9 | 45 ± 22 | 40 |
| T8 | 16 | 6.1 ± 0.8 | 6.8 | 28 ± 18 | 26 |
| T101 | 3 | 6.3 ± 1.2 | 6.0 | 34 ± 14 | 46 |
| T111 | 8 | 2.5 ± 0.7 | 2.2 | 8 ± 6 | 10 |
| T115 | 9 | 3.0 ± 1.5 | 6.8 | 26 ± 8 | 27 |
| T220 | 13 | 7.4 ± 1.4 | 6.6 | 27 ± 9 | 46 |
| T222 | 18 | 5.9 ± 2.2 | 2.4 | 10 ± 10 | 11 |
| T224 | 16 | 6.9 ± 1.7 | 8.7 | 40 ± 16 | 60 |
| T226 | 14 | 3.9 ± 2.2 | 6.5 | 40 ± 23 | 54 |
| T232 | 9 | 5.8 ± 1.9 | 3.2 | 16 ± 10 | 12 |
| TX61M | 17 | 6.2 ± 0.9 | 4.2 | 20 ± 8 | 23 |
| TX325 | 2 | 6.5 ± 1.5 | 5.0 | 34 ± 23 | 38 |
| TX441 | 15 | 6.5 ± 1.4 | 8.3 | 30 ± 14 | 29 |

(Table 5 Continue)

| Breeding Line | Number of Plants | Leaf rating (Guthries Scale) x ± s | Number of Cavities/ Stalk | Length (cm) of Stalk Tunnelled | Percent of Stalk Tunnelled |
|---|---|---|---|---|---|
| TX508 | 17 | 6.1 ± 3.1 | 4.4 | 16 ± 6 | 18 |
| TX585 | 13 | 3.6 ± 1.6 | 1.2 | 7 ± 8 | 6 |
| W59E | 14 | 2.9 ± 0.9 | 6.7 | 36 ± 10 | 50 |
| W64A | 18 | 5.8 ± 1.1 | 9.1 | 40 ± 11 | 54 |
| W64B | 14 | 2.6 ± 1.4 | 3.3 | NC | NC |
| W73A | 13 | 4.1 ± 1.8 | 4.5 | 26 ± 19 | 32 |
| W117 | 16 | 4.1 ± 1.8 | 2.1 | 10 ± 5 | 10 |
| W153R | 14 | 5.4 ± 1.4 | 7.7 | 47 ± 13 | 58 |
| W182B | 19 | 3.5 ± 2.1 | 3.7 | 36 ± 18 | 42 |
| W182E | 6 | 6.5 ± 1.3 | 10.2 | 59 ± 21 | 51 |
| W401 | 19 | 2.3 ± 1.2 | 1.1 | NC | NC |
| W629A | 14 | 3.9 ± 2.4 | 4.4 | 24 ± 12 | 31 |
| WF9 | 14 | 5.4 ± 1.0 | 7.1 | 41 ± 19 | 46 |
| WR3 | 14 | 2.8 ± 0.9 | 6.4 | 73 ± 23 | 59 |
| VA26 | 13 | 6.1 ± 0.9 | 4.4 | 19 ± 11 | 19 |
| VA35 | 8 | 3.0 ± 1.7 | 1.5 | NC | NC |
| 33-16 | 18 | 4.6 ± 1.6 | 2.9 | 15 ± 9 | 15 |

Table 6. Parasitism of Sweet Potato Hornworm Eggs by *T. chilonis*.

a. Trial 1. June - August 1982

Sweet Potato Monoculture

| Date | Mean Number Eggs/100 Leaves | Mean No. Parasitized Eggs/100 Leaves | Percent Parasitism Field | Percent Parasitism Held in Lab |
|---|---|---|---|---|
| 6/17/82 | 1.5 | 0.3 | 20 | 52 |
| 6/25/82 | 0.0 | 0.0 | 23 | 87 |
| 7/ 1/82 | 0.4 | 0.2 | 48 | 100 |
| 7/ 9/82 | 0.7 | 0.3 | 40 | 95 |
| 7/16/82 | 1.5 | 0.6 | 38 | 85 |
| 7/22/82 | 1.1 | 0.3 | 30 | 100 |
| 7/28/82 | 2.2 | 0.5 | 22 | 88 |
| 8/ 5/82 | 3.3 | 1.7 | 50 | |
| 8/12/82 | 1.7 | 0.6 | 35 | 80 |
| 8/19/82 | 4.6 | 1.8 | 40 | |
| 8/26/82 | 0.8 | 0.4 | 50 | |
| 9/ 2/82 | 2.5 | 0.7 | 29 | 85 |
| 9/ 9/82 | 1.7 | 0.7 | 40 | |

Table 6 Continue

**Sweet Potato-Maize Intercrop, 3 Row**

| Date | Mean Number Eggs/100 Leaves | Mean Number Parasitized Eggs/100 Leaves | Percent Parasitism Field | Percent Parasitism Held in Lab |
|---|---|---|---|---|
| 6/17/82 | 2.6 | 0.4 | 17 | 7 |
| 6/25/82 | 0.4 | 0.0 | 0 | 50 |
| 7/ 1/82 | 0.0 | 0.0 | | |
| 7/ 9/82 | 0.7 | 0.4 | 50 | 100 |
| 7/16/82 | 1.1 | 0.2 | 15 | 90 |
| 7/22/82 | 1.1 | 0.4 | 35 | 89 |
| 7/28/82 | 2.2 | 0.6 | 28 | 95 |
| 8/ 5/82 | 2.9 | 0.9 | 32 | |
| 8/12/82 | 0.0 | 0.0 | 24 | 72 |
| 8/19/82 | 2.9 | 1.0 | 33 | |
| 8/26/82 | 1.7 | 0.3 | 17 | |
| 9/ 2/82 | 1.7 | 0.4 | 25 | 90 |
| 9/ 9/82 | 3.4 | 1.1 | 31 | |

Table 6 Continue

Sweet Potato-Maize Intercrop, 7 Row

| Date | Mean Number Eggs/100 Leaves | Mean Number Parasitized Eggs/100 Leaves | Percent Parasitism Field | Percent Parasitism Held in Lab |
|---|---|---|---|---|
| 6/17/82 | 0.4 | 0.0 | 0 | 50 |
| 6/25/82 | 3.7 | 0.2 | 5 | 55 |
| 7/ 1/82 | 2.2 | 1.9 | 86 | 100 |
| 7/ 9/82 | 3.6 | 0.7 | 20 | 80 |
| 7/16/82 | 0.0 | 0.0 | 30 | 100 |
| 7/22/82 | 2.3 | 1.1 | 49 | 100 |
| 7/28/82 | 2.3 | 0.3 | 11 | 87 |
| 8/ 5/82 | 4.2 | 2.5 | 60 | |
| 8/12/82 | 3.4 | 1.1 | 33 | 75 |
| 8/19/82 | 2.1 | 1.3 | 64 | |
| 8/26/82 | 0.8 | 0.8 | 100 | |
| 9/ 2/82 | 0.8 | 0.3 | 35 | 94 |
| 9/ 9/82 | 0.8 | 0.2 | 28 | |

Table 7. Parasitism of *O. furnacalis* egg masses by *T. chilonis* in the corn sweet potato intercrop.

| | Monoculture | | | Intercrop, 7 Row | | | Intercrop, 3 Row | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Number Masses/ Plant | Number Parasitized Masses/Plant | Percent Parasitized Masses | Number Masses/ Plant | Number Parasitized Masses | Percent Parasitized Masses | Number Masses/ Plant | Number Parasitized Masses/Plant | Percent Parasitized Masses |
| Trial 1, June - August, 1982 | | | | | | | | | |
| 8/3 | 0.6 | 0.0 | 3 | 0.2 | 0.0 | 6 | 0.0 | 0.0 | — |
| 8/12 | 1.7 | 0.1 | 6 | 0.8 | 0.0 | 7 | 0.3 | 0.0 | 6 |
| 8/17 | 1.8 | 0.1 | 4 | 1.8 | 0.1 | 7 | 0.7 | 0.1 | 3 |
| 8/24 | 1.7 | 0.5 | 38 | 2.0 | 0.3 | 15 | 2.1 | 0.6 | 25 |
| 8/31 | 1.7 | 0.4 | 25 | 1.2 | 0.3 | 24 | 0.8 | 0.4 | 46 |
| 9/9 | 0.1 | 0.1 | 83 | 0.0 | 0.0 | 100 | 0.3 | 0.2 | 55 |
| Seasonal Average | | | 27 | | | 27 | | | 23 |
| Trial 2, November - December, 1982 | | | | | | | | | |
| 11/24 | 0.9 | 0.0 | 3 | 1.0 | 0.0 | 3 | 0.8 | 0.0 | 1 |
| 11/30 | 1.9 | 0.3 | 14 | 2.3 | 0.1 | 7 | 1.7 | 0.2 | 13 |
| 12/9 | 5.2 | 0.7 | 17 | 5.1 | 0.7 | 14 | 5.6 | 1.0 | 19 |
| 12/16 | 4.1 | 1.3 | 30 | 3.7 | 1.1 | 24 | 3.1 | 0.9 | 26 |
| 12/22 | 7.1 | 2.8 | 41 | 4.5 | 1.7 | 41 | 4.4 | 1.7 | 53 |
| Seasonal Average | | | 21 | | | 18 | | | 22 |

Table 8. Rate of Parasitism of Corn Borer Eggs Within Individual Egg Masses, Trial II.

| | Monoculture | | | | Intercrop, 7 Row | | | | Intercrop, 3 Row | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Number Masses/ sampled | Mean No. Eggs/Mass | Mean No. Parasitized Eggs/Mass | Mean Percent Parasitism | Number Masses Sampled | Mean No. Eggs/Mass | Mean No. Parasitized Eggs/Mass | Mean Percent Parasitized | Number Masses Sampled | Mean No. Eggs/Mass | Number Parasitized Eggs/Mass | Mean Percent Parasitism |
| 12/10/82 | 15 | 36.5 | 14.8 | 41 | 15 | 38.8 | 17.7 | 54 | 20 | 29.8 | 11.2 | 43 |
| 12/15/82 | 33 | 30.9 | 10.5 | 36 | 28 | 30.6 | 7.6 | 33 | 31 | 31.7 | 8.9 | 29 |
| 12/22/82 | 29 | 32.3 | 10.9 | 31 | 30 | 27.1 | 8.4 | 37 | 30 | 31.5 | 11.7 | 35 |
| Seasonal Mean | | 33.2 | 12.1 | 36 | | 32.2 | 11.2 | 42 | | 31.0 | 10.6 | 36 |

Table 9. Rate of Parasitism of Newly Laid Egg Masses Marked and Re-examined five (5) Days Later.

| | Monoculture | | | Intercrop, 7 Row | | | Intercrop, 3 Row | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Number Eggs Masses Found on Recheck | Number Egg Masses Parasitized | Percent Parasitism | Number Egg Masses Found on Recheck | Number Egg Masses Parasitized | Percent Parasitism | Number Egg Masses Found on Recheck | Number Egg Masses Parasitized | Percent Parasitism |
| 12/9 | 29 | 8 | 27 | | | | | | |
| 12/13 | 29 | 13 | 44 | 28 | 11 | 39 | 28 | 7 | 24 |
| 12/17 | 29 | 15 | 51 | 29 | 13 | 44 | 29 | 11 | 40 |
| 12/23 | 29 | 13 | 45 | 30 | 13 | 43 | 29 | 14 | 49 |
| | | | | 28 | 9 | 33 | 30 | 11 | 37 |
| Seasonal | 29.0 | 12.3 | 42 | 28.8 | 11.5 | 40 | 28.8 | 10.8 | 38 |

# Entomology

## Biological Control

James R. Nechols

The research in biological control continued to focus on an evaluation of the natural enemies of the spherical mealybug. In addition, a sampling program was initiated to monitor populations of the spiraling whitefly and its imported natural enemies.

## Spherical Mealybug

### I. Host Selection

Host selection studies of the spherical mealybug, *Nipaecoccus vastator* (Mask.), by its gregarious parasitoid, *Anagyrus indicus* Shaffee et al., were expanded to determine: (1) which mealybug stages are acceptable for oviposition by *Anagyrus* females; (2) which host stages are preferred by female parasitoids; and (3) which host stages are the most suitable for growth, development and survival of immature parasitoids.

### Methods and Materials

*N. vastator* was cultured in a parasitoid-free laboratory rearing room on potted *Jatropha integerrima* (Rutaceae). The parasitoid, *A. indicus*, was reared from a culture of spherical mealybugs that was held outdoors in screened, frame cages.

To test which of *N. vastator's* stages are susceptible to oviposition by *A. indicus*, unparasitized 1st, 2nd, or 3rd instar nymphs, or the newly molted adult female mealybug, were placed on excised *Jatropha* leaves in dixie cages that were provisioned with water vials and honey. Subsequently, the mealybugs were exposed to a mated, fed, female parasitoid (30 h old) for 24 hours and then dissected for parasitoid eggs. In the no-choice experiment, groups of 12 individuals of each mealybug stage were exposed separately to parasitoids. In the choice (= preference) experiment, 3 individuals from each of the 4 mealybug stages were confined together in cages and then exposed to parasitoids. Both experiments were run in an incubator at 27 ± 2°C., and ca. 60% relative humidity (L:D = 14:10).

In the suitability experiment, groups of 12 individuals from each mealybug stage were confined separately in 3-inch diameter dialysis cages that were fitted over leaves of potted *Jatropha* plants in a rearing room (temp. = 28 ± 2°C.; R.H. = 60%; L:D = 14:10). One pair of honey-fed *Anagyrus* adults (female and male) were released into each cage. After a 24 hour exposure period, parasitoids were removed and the hosts were counted. Cages were checked daily for parasitoid emergence and the sex and emergence date of each parasitoid was recorded. After all emergence had stopped, cages were removed and hosts were examined for parasitism.

Each of the above experiments were replicated a minimum of 12 times. To test mean differences between life stages, standard t-tests or Welch's approximate t-solution of the Behrens-Fisher method for multiple pair comparisons (hereafter, mod. t-test), were used.

### Results

## Effect of host stage on parasitoid ovipositon

#### No-choice experiment

The results (Table 1) show that each *N. vastator* stage was susceptible to ovipositon by *A. indicus*. However, significantly (mod. t-test, $P < 0.05$) more parasitoid eggs were deposited in 3rd nymphal and adult females mealybugs than in 1st and 2nd instar nymphal columns B and C). The frequency of hosts parasitized also increased with increasing host age. Significantly ($P < 0.05$) fewer 1st instar nymphs were parasitized than were later mealybug stages (column A).

#### Choice experiment

In contrast to the no-choice tests, when parasitoid females were offered a choice of host stages, oviposition occured in the 3rd nymphal and adult female mealybug stages only (Table 2). Furthermore, whereas *N. vastator's* 3rd nymphal and adult female stages were parasitized approximately equally when exposed individually (see Table 1), in the choice tests, female parasitoids deposited significantly more eggs in a significantly greater number of adult female mealybugs than in the 3rd nymphal host stage (mod. t-test, P 0.05) (Table 2).

## Effect of host stage on parasitoid emergence and development

Table 3 shows that, although *Anagyrus* progeny developed successfully and emerged after exposure to each of the 4 *N. vastator* stages, very few parasitoids emerged after parasitism of the 1st nymph mealybug stage. Emergence increased progessively with increased host age (stage) and was significantly ($P < 0.05$) greater in 3rd nymph and adult female mealybugs than in the earlier stages (columns A and C). Moreover, the mean number of hosts producing parasitoids generally increased as host age increased. Third stage nymphs produced the most parasitized hosts (column B).

The mean total development time (egg to adult) for *A. indicus* was the shortest (ca. 18 days) in adult female mealybugs and the longest (ca. 25 days) in 1st instar mealybugs. Differences in development times between all host stages were significant ($P < 0.05$) except for 2nd and 3rd nymphs (Table 4).

The sex ratio of parasitoids shifted from male to female as the host stage advanced. First and 2nd instar nymphs produced mostly males; whereas 3rd nymphal and adult female mealybugs produced 2.5 parasitoid females for every male (Table 4).

### Discussion

Host selection efficiency is an important attribute of parasitoids in biological control programs because both parasitoid production and host (pest) mortality usually occur at high levels. The results show that parasitoid females not only prefer to oviposit in the spherical mealybug's 3rd nymphal and adult female host stages, but that selection of these larger stages results in the highest production of parasitoids in the shortest period of time. On the other hand, field studies support our laboratory experiments which show that *A. indicus* is capable of successfully parasitizing smaller mealybug stages when the preferred, more suitable, larger host stages are unavailable. This adaptation is especially useful when pests are scarce and may explain the high rates of parasitism in the field where mealybugs are rare.

Because *A. indicus* is a gregarious parasitoid, it is capable of controlling the distribution of its progeny in host mealybugs in two ways: 1) by varying the frequency of hosts parasitized;

and 2) by varying the number of eggs laid in each parasitized host. Such a mechanism, in combination with a good searching ability, could allow *A. indicus* to maintain *N. vastator* populations at the very low levels observed in our field samples (see below).

The above findings document the value of *A. indicus* as a biological control agent of the spherical mealybug. Moreover, they provide information useful for the efficient culture of this parasitoid. For example, because the 3rd nymphal and adult female mealybugs yielded the highest number of parasitoid females in the least time, either of these host stages would be highly suitable for mass-rearing *A. indicus*. However, although more preferred, the adult stage of *N. vastator* was relatively less efficient for producing parasitoids than was the 3rd nymphal stage (Table 3, column C). Thus maximum rearing efficiency of *A. indicus* could be attained by exposing hosts in the 3rd nymphal stage. Also, because newly-emerged adult female mealybugs are probably more suitable than older adult hosts, exposing 3rd nymphs should extend the period during which *N. vastator* adult females could be parasitized, thereby reducing problems of synchronization.

## II. Distribution and relative abundance

Extensive and intensive samples of the spherical mealybug were continued in 1982 to determine the seasonal distribution and relative abundance of the pest and its natural enemies.

## A. Extensive samples:

### Methods and Materials

Surveys were made along roadsides at 56 sites in Guam at 2-mile intervals at 30 and 26 sites in Saipan and Tinian, respectively. At each site, all the vegetation on 10 adjacent trees (height = 3-4 m.) of the woody legume, *Leucaena leucocephala* (Lam.), was examined for adult female mealybugs which were collected and counted. At sites where mealybugs were abundant, estimates of adult female densities were made by randomly sampling representative clusters. Each mealybug was inspected in the laboratory and categorized as "alive", "dead", "mummified-unemerged", or "mummified-emerged". Densities were calculated only from mealybugs that were either alive or mummified-unemerged.

Ovisacs of field-collected mealybug females were also examined, and the kind and number of predators found were recorded. Predator pupae and parasitized mealybug mummies were held for emergence, identified whenever possible, and then preserved in 70% alcohol.

Each sample was made 4 times in Guam: once during the wet season (August-September); once during the dry season (March-April); and once during each transitional period (June and December). Extensive samples of Saipan were made twice--once during each wet and dry season. Tinian was sampled in September only.

Because the mealybug's distribution was highly skewed, the data were ranked-ordered and expressed as the 50th, 75th, 95th, and 100th percentile values. The densities between islands and among sample dates were compared using either the Kruskal-Wallis test or the Mann-Whitney U-test. The percentage parasitism data between sample dates were arcsine transformed and then analyzed using Welch's modified t-test (hereafter, mod. t-test) for multiple comparisons.

Table 1. Relationship between *Nipaecoccus vastator* stage and oviposition by its parasitoid, *Anagyrus indicus*, in no-choice tests. Exposure period = 24 hours. Temperature = 27 ± 2°C., L:D = 14:10. [1,2]

| Mealybug stage | (A) Number of hosts parasitized/replicate (x ± s.d., N) | (B) Number of eggs/ parasitized host (x ± s.e., N) | (C) Total number of eggs/replicate (x ± s.d., N) |
|---|---|---|---|
| 1st nymphal | 1.0 ± 1.2 a (22) | 1.2 ± 0.4 a (12) | 2.2 ± 1.2 a (12) |
| 2nd nymphal | 1.8 ± 2.3 ab (24) | 1.25 ± 0.38 a (13) | 4.3 ± 3.2 b (13) |
| 3rd nymphal | 3.4 ± 2.6 b (14) | 2.14 ± 0.84 b (12) | 8.25 ± 4.5 c (12) |
| Adult female | 3.2 ± 2.4 b (19) | 2.8 ± 1.1 b (15) | 10.9 ± 6.7 c (15) |

1 Each host stage was exposed separately to adult female parasitoids
2 Each replicate contained 12 hosts
3 Pairs of means within columns followed by a different letter are significantly different at the 5% level (mod. t-test).

## Results

Table 5 shows that the percentage of Guam sites infested by *N. vastator* was the highest in June (50%) and the lowest (37.5%) in December. However, on all sample dates at least 75% of the sites were either uninfested or had very low densities (i.e., 1 to 3 adult females). The peak mealybug density for individual sites ranged from c. 1,000 adult females in June to 44 in December. Also, seven sites had densities of 20 or more mealybug adults in June compared with 6 sites in August and 4 sites in March and December. However, there were no significant differences in mealybug distributions among sample dates (Kruskal-Wallis test, P 0.02). Both the percentage of infested Saipan sites and the mealybug densities were slightly, but insignificantly, higher in March than in September. In Tinian, the density of *N. vastator* was very low; only 1 mealybug adult was found at one site (Table 5).

In Guam, the mean percentage parsitism of *N. vastator* ranged from 42 to 88 percent, and was significantly (mod. t-test, P 0.005) greater than that n August (Table 5). In Saipan, a similarly high percentage of the adult female mealybugs were parasitized in March (84%) and in September (80%). In Tinian, the one adult female found was parasitized (Table 5).

Table 6 shows that the gregarious parasitiod, *A. indicus*, was the most dominant natural enemy of *N. vastator*. It comprised 87 and 97 percent of all insects recorded from the spherical mealybug in Guam, and it was the only natural enemy recovered in the Saipan and Tinian samples. The coccinellid, *Nephus roepki* was the dominant predator in Guam on all sample dates. Its relative abundance varied from 1.5 percent of all beneficial species in June to over 10 percent in December. The drosophilid, *?Gitonides* sp. accounted for nearly 2 percent of all natural enemies in August but was rare, or absent, in the order samples. The cecidomyiid, *Kalodiplosis* sp. was present in very low numbers in the December sample. A second encyrtid species, which resembled the hyperparasitoid genus, *Acrysopophagous*, comprised over 2 percent of the June sample, but appeared only sporadically in March and December.

Table 7 shows that *A. indicus* was also the most constant beneficial species associated with adult *N. vastator* females. It was present at 75 to 86 percent of the infested sites in Guam and at 80 to 100 percent of the infested Saipan sites. In Guam, this parasitoid was distributed most widely in December.

The lady beetle, *N. roepki*, was the most consistent predator found in Guam; it occurred at 11 to 22 percent of the mealybug-infested sites. In contrast, *Kalodiplosis* sp. was present at only 1 site in the December sample. The fly, *?Gitonides* sp. occurred sporadically and was never present at more than 3 sites in Guam. No predators were recovered from any of the samples in Saipan or in Tinian (Table 7).

Table 2. Relationship between *Nipaecoccus vastator* stage and oviposition by *Anagyrus indicus* when adult female parasitoids were allowed to choose among 3 individuals of each host stage indicated.
Temp. = 27 ± 2°C.; L:D = 14:10. [1,2]

| **Mealybug Stage** | **(A) Mean (± s.d.) number of hosts parasitized/ replicate** | **(B) Mean (± s.e.) number of parasitoid eggs/exposed host** |
|---|---|---|
| 1st nymphal | 0 (16) | ------ |
| 2nd nymphal | 0 (16) | ------ |
| 3rd nymphal | 0.63 ± 0.88 a (16) | 0.63 ± 1.14 a (16) |
| Adult female | 2.06 ± 0.57 b (16) | 3.0 ± 1.75 b (16) |

1 Means within colums followed by a different letter are significantly different at the 5% level (t-test)

2 (N) = number of replicates

Discussion

## Distribution and relative abundance of *N. vastator*

With the exception of a small proportion of sites, *N. vastator* occurred at very low (endemic) levels in Guam and in the Northern Mariana Islands in 1982. Infestations tended to be widely scattered on all islands.

In Guam, the frequency of spherical mealybug infestations was greatest in the transitional period following the dry season (June). Peak densities also occurred in this period. This trend may be related to active growth (and, hence, associated increased nutritional quality) of its host plant, *Leucaena*. Or, it may be the result of reduced weather-related mortality during the dry season.

The incidence of *N. vastator* was the smallest in the transitional period following the rainy season (December). Peak densities were also the lowest in December. Because very high relative humidity is known to suppress egg hatching in *N. vastator*, sustained high humidity conditions--characteristic of the rainy season--could have limited the establishment of new mealybug infestations by preventing hatching and dispersal by 1st instar nymphs ("crawlers"). Heavy rainfall and wind may also have caused direct mortality to *N. vastator*, thereby reducing existing populations.

The seasonal abundance patterns for *N. vastator* and *A. indicus* differed between Guam and Saipan. For example, local mealybug populations were much more common, and occurred at higher densities, in Guam than in Saipan. Also, whereas high rates of parasitism occurred both in the dry and rainy seasons in Saipan, the percentage parasitism followed a seasonal trend in Guam (Table 5).

Two lines of evidence suggest that these differences may be associated with the presence of ants. First, recent studies in our laboratory indicate that at least one species of ant interferes with *N. vastator's* natural enemies; this results in higher mealybug survivorship. Second, surveys show that these ants are commonly associated with high densities of *N. vastator* at sites near limestone forest vegetation which is more prevalent in Guam than in Saipan.

## Distribution and relative abundance of natural enemies.

*A. indicus* continued to be the most dominant and the most consistent natural enemy of spherical mealybug on all islands, and on all sample dates. This parasitoid was efficient in finding mealybugs at extremely low densities, but it was also capable of attacking 95 to 100 percent of its hosts at higher densities.

In contrast, species of predators were rare and sparsely distributed. These findings may reflect the very low mealybug densities at most sites since mealybug clusters appear to serve as feeding sites for immature predators. Also adult coccinellids,

Table 3. Relationship between *Nipaecoccus vastator* stage and emergence of its parasitoid, *Anagyrus indicus*. Exposure period = 24 hrs. Temp. = 28 ± 2°C.; L:D = 14:10. Each replicate contained 12 hosts. [1]

| **Mealybug stage** | **Mean ± s.d. (N)[2], Range:** | | |
|---|---|---|---|
| | **Number of parasitoid emergences / host (A)** | **Number of hosts per replicate yielding parasitoid adults (B)** | **Total number of parasitoid emergences per replicate (C)** |
| 1st nymphal | 1.0 ± 0.0 a<br>(4)<br>------ | 0.24 ± 0.6 a<br>(25)<br>0 - 2 | 1.5 ± 0.58 a<br>(4)<br>1 - 2 |
| 2nd nymphal | 1.1 ± 0.35 a<br>(15)<br>1 - 2 | 1.25 ± 1.5 b<br>(24)<br>0 - 5 | 3.1 ± 1.9 b<br>(15)<br>1 - 7 |
| 3rd nymphal | 2.7 ± 1.26 b<br>(27)<br>1 - 5 | 2.40 ± 1.7 b<br>(12)<br>0 - 5 | 7.9 ± 5.0 c<br>(10)<br>2 - 19 |
| Adult female | 3.55 ± 1.82 b<br>(18)<br>1 - 7 | 1.50 ± 1.3 b<br>(14)<br>0 - 4 | 7.0 ± 4.8 c<br>(10)<br>1 - 15 |

1 Pairs of means within columns followed by different letter are significantly different at the 5% level (Welch's modified t-test).

2 (N) = number of replicates

which feed on the spherical mealybug's early life stages, were not sampled. Hence, predators may be more important than the results suggest.

Although the relative abundance of *A. indicus*, and the high level of mealybug mortality attributable to this parasitoid, suggest its importance as a biological control agent of *N. vastator*, experimental evidence is needed. Presently, exclusion experiments are in progress to establish the regulatory roles of *A. indicus* and predacious species.

## B. Intensive samples

### Methods and Materials

To investigate the relationship between mealybug density and level of parasitism, host and parasitoid populations were monitored at 2 infested sites in Guam. At each site, 25 to 30 *Leucaena* trees were tagged from which 10 were randomly chosen for the samples.

Mealybugs were sampled monthly and parasitoids were sampled ca. every two weeks. To sample mealybugs, ten 25cm. branch tips were randomly selected from each sample tree at each site. The number of adult female mealybugs per branch tip were counted without removal. The total number of branch tips was also counted, and estimates of density were expressed as the number of mealybug adult females per tree.

To obtain estimates of the percentage parasitism of *N. vastator*, 50 adult mealybugs were collected (where available) from nonsample trees at each site. Live mealybug adults were dissected in the laboratory and mummified mealybugs were held for parasitoid emergence.

### Results

Figures 1 and 2 show the population fluctuations of the spherical mealybug and its parasitoid, *A. indicus*, at the Yigo and Santa Rita sites, respectively. On the average, mealybug densities were higher and the percentage parasitism lower in Yigo than in Santa Rita.

In Yigo, the mealybug populations peaked in January ($\bar{x}$ = 153 adult females/ tree) and then declined rapidly (Fig. 1). In general, both the magnitude of the fluctuations and the density of the mealybug decreased throughout the year. The density was very low in December.

The relative activity of parasitoids was assessed by the percentage parasitism. In general, parasitoids responded to fluctuations in mealybug numbers both at high and at low host densities (Fig. 1, cf. January to March, and October to December data). However, the rate of parasitism never exceeded 62 percent and, on average, was much lower ($\bar{x}$ = 15%; range: 0-62%).

In Santa Rita, *N. vastator* populations remained at low levels throughout 1982. Mealybug densities were relatively higher in January and in October ($\bar{x}$ = 15 and 21 adult females/ tree, respectively) than in the other months. Very low densities occurred from February to April and in August and September (Fig. 2).

The monthly rate of parasitism varied greatly from 3 percent in August to 80 percent in November (annual mean = 36%). Although the parasitoid appeared to respond to increases in *N. vastator* density, high rates of parasitism were observed over the range of mealybug densities (Fig. 2).

Table 4. Mean (± s.d.) number of days for total development and sex frequency of the parasitoid, *Anagyrus indicus*, in each indicated stage of its host, *Nipaecoccus vastator*. Temp. = 28 ± 2°C.; L:D = 14:10. [1,2]

| Mealybug stage | Number of days for parasitoid development (egg to adult) | | | Sex frequency |
|---|---|---|---|---|
| | Female | Male | Combined | No. females: No. males |
| 1st nymphal | ------ | 25.4 ± 3.6 a (5) | 25.4 ± 3.6 a (5) | 0 : 6 |
| 2nd nymphal | 23.2 ± 3.3 a (13) | 19.3 ± 2.3 b (22) | 20.8 ± 3.3 b (35) | 13 : 22 |
| 3rd nymphal | 20.7 ± 3.8 b (49) | 20.7 ± 2.9 b (31) | 20.7 ± 3.5 b (80) | 49 : 31 |
| Adult female | 17.6 ± 1.4 c (49) | 18.1 ± 1.0 c (28) | 17.7 ± 1.3 c (77) | 49 : 28 |

1 Pairs of means within columns followed by different letter are significantly different at the 5% level (Mod. t-test).

2 (N) = Number of individuals

**Discussion**

The results (Figs. 1 and 2) showed that *A. indicus* did not respond to mealybug population fluctuations in a typically density-dependent manner. However, the parasitoid attacked a large proportion of its hosts, both at high and low densities. The absence of a clear density-dependent response may have been the result of ant interference. For example, the surveys showed that ants were present more abundantly at the experimental sites than elsewhere. These sites also had mealybug densities that were approximately 10 times greater than at other localities. Moreover, ants appeared to be relatively more common in Yigo than in Santa Rita (cf. Figs. 1 and 2), a finding that agrees with the lower average mealybug densities, higher rates of parasitism, and better parasitoid response in Santa Rita.

**III. Summary**

The spherical mealybug is currently under natural control in Guam. Population regulation of the pest appears to be quite stable with the exception of a very few isolated localities in Guam. Natural enemies are important sources of mortality and appear capable of maintaining mealybug populations at observed low densities.

The gregarious parasitoid, *Anagyrus indicus*, possesses many useful attributes including a good host finding ability, a response to very low host densities, apparent host specificity, the ability to utilize many of its host's life stages, relatively fast development, and an ability to regulate oviposition for efficient host utilization and increased fitness. These characteristics indicate its intrinsic value as a biological control agent but, also, make this parasitoid quite suitable for culturing (e.g., mass-rearing).

Predators appear to be less abundant and less persistent than the parasitoid, *A. indicus*, and, thus, are probably incapable of regulating *N. vastator* alone. However, they may play a more important role than indicated by the present study because: a) individual feeding rates of predators are unknown; b) the adult stage of coccinellid species (whose adults are predacious) was not sampled; and c) the mealybug's nymphal stages--which serve as prey for some of the predators--were not sampled.

Ants appear to interfere with parasitoids at certain localities. However, their effect is not complete and the relatively high mealybug densities are confined to relatively small areas. Hence, the widespread outbreaks of *N. vastator* in Guam and in the Northern Mariana Islands from 1977 to 1980 are probably not related to the action of ants.

## SPIRALING WHITEFLY

The distribution range of the spiraling whitefly, *Aleurodicus dispersus* Russell, continued to increase in Guam during 1982. However, populations at most localities declined from outbreak densities to very low levels following the release of two introduced natural enemies: the predatory lady beetle, *Nephaspis amnicola* Wingo (Coccinellidae), and the parasitic wasp, *Encarsia haitiensis* Dozier (Aphelinidae) (see 1981 Guam Agri. Exp. Sta. Ann. Report). Because the post-release documentation of introduced natural enemies is an important, but often neglected, phase of biological control programs, we monitored populations periodically: (1) to determine whether the exotic beneficial species had become established; (2) to check the distribution and relative abundance of both introduced and native natural enemies in relation to that of the sprialing whitefly; and (3) to make a preliminary assessment of the role of imported biological agents in the control of *A. dispersus*.

**Methods and Materials**

Whitefly populations were censused ca. bimonthly from July to November on trees of *Plumeria obtusa* at natural enemy release sites. On each sample date and at each location, 5 fully-expanded leaves were selected randomly from each of two trees and the number of 4th instar nymphal whiteflies per leaf was counted. Intact 4th instar whiteflies were inspected for parasitism and then held in the laboratory for parasitoid emergence. Adult predators were surveyed during early morning hours at tow localities by examining 20 to 30 leaves from each of 9 to 11 trees.

To determine the distribution and relative abundance of the spiraling whitefly and its natural enemies, 9 leaves from plumeria and other host trees at 11 localities were sampled from July to October. On each leaf, the empty whitefly "pupal" cases were counted and visually categorized as parasitized or unparasitized. Also, nine to 12 additional leaves per tree were examined for the larval or pupal stages of the lady beetle, *N. amnicola*. Predators and parasitoids that emerged in the laboratory were preserved for later identification.

**Results**

Figure 3 compares the 1981 and 1982 population data for *A. dispersus* in Barrigada-Mongmong. In 1982, the density of spiraling whitefly declined from a mean of 6.8 4th instar nymphs per leaf in the July-August samples to less than 1 nymph per leaf in November. This contrasts markedly with the 1981 samples which showed a progressive increase in mean whitefly density from 48 to 91 4th instar nymphs per leaf. Decreasing *A. dispersus* densities in 1982 were generally associated with an increase in the mean percentage parasitism (Fig. 3).

The relationship between whitefly density and percentage parasitism at various sites on successive sample dates is shown in Figure 4. With the exception of the Tumon Bay and Santa Rita sites (Fig. 4, C and J, respectively), there was a good correlation between increasing rates of parasitism and decreasing densities of spiraling whitefly. Mean whitefly densities declined to less than 2 emergences per leaf at all localities by the October-November sample dates; corresponding parasitism rates in October-November ranged from 58 to 100 percent ($\bar{x}$ = 84%). On the average, *Encarsia* populations increased 8 fold between July and September.

Table 8 shows that the imported natural enemy, *E. haitiensis*, comprised 86 percent of all parasitoid emergence. A second parasitoid, which resembled an *Encarsia* species, was less common but occurred at all sites except for Agat and Santa Rita. This species was not most abundant in Mongmong where it accounted for 38 percent of the total parasitoids collected.

The lady beetle, *N. amnicola*, was rarely found near release sites in Barrigada and Mangilao, and it was present only sporadically at the other localities from July to September. This predator was not observed in the October-November samples (Table

9). Two other predaceous coccinellids--*Nephus roepki* Fluiter and an unidentified black species--and a green lacewing (Chrysopidae) were also observed frequently. However, predation on *A. dispersus* was not observed.

**Discussion**

The results presented above suggest that parasitoids may have had a relatively greater impact on the suppression of *A. dispersus* populations than did predators. For example, sharp declines in whitefly densities were correlated with increasing rates of parasitism and rapid population growth of parasitoids. Whereas, predators were observed infrequently in our samples.

The imported parasitoid, *E. haitiensis*, appears to be an effective, well-adapted natural enemy of the spiraling whitefly in Guam. Within 9 months of its initial release, this beneficial species had extended its range to include all areas affected by *A. dispersus*. Moreover, high rates of parasitism by *E. haitiensis* occurred over a wide range of whitefly densities including many cases in which the host had become rare (Fig. 4). A second, non-introduced, parasitoid species was also present at many of the sites. In Mongmong, this species accounted for almost 40 percent of the total parasitism. Because other whitefly species occur in Guam, this parasitoid may have already been present before *A. dispersus* was introduced.

Although the ladybeetle, *N. amnicola*, was present at many localities, its role in the control of the spriraling whitefly is uncertain because densities of both the beetle's larval and adult stages were very low and nonpersistent in 1982. However, these results differ from those in 1981 when *Nephaspis* adults were observed frequently on whitefly-infested trees adjacent to release sites. Thus, the scarcity of this predator may be related to the very low average densities of whiteflies at most sites in 1982.

Predators other than *N. amnicola* were also observed on whitefly-infested leaves. However, because this pest co-occurs with at least 6 other homopterans on plumeria, further studies are needed to test whether these native predators prey on *A. dispersus*.

Difference in whitefly population curves and rates of parasitism among localities (Fig. 4) may be related to variability in the dates of whitefly infestation, dates of parasitoid immigration, initial parasitoid: host ratios or competition among natural enemies.

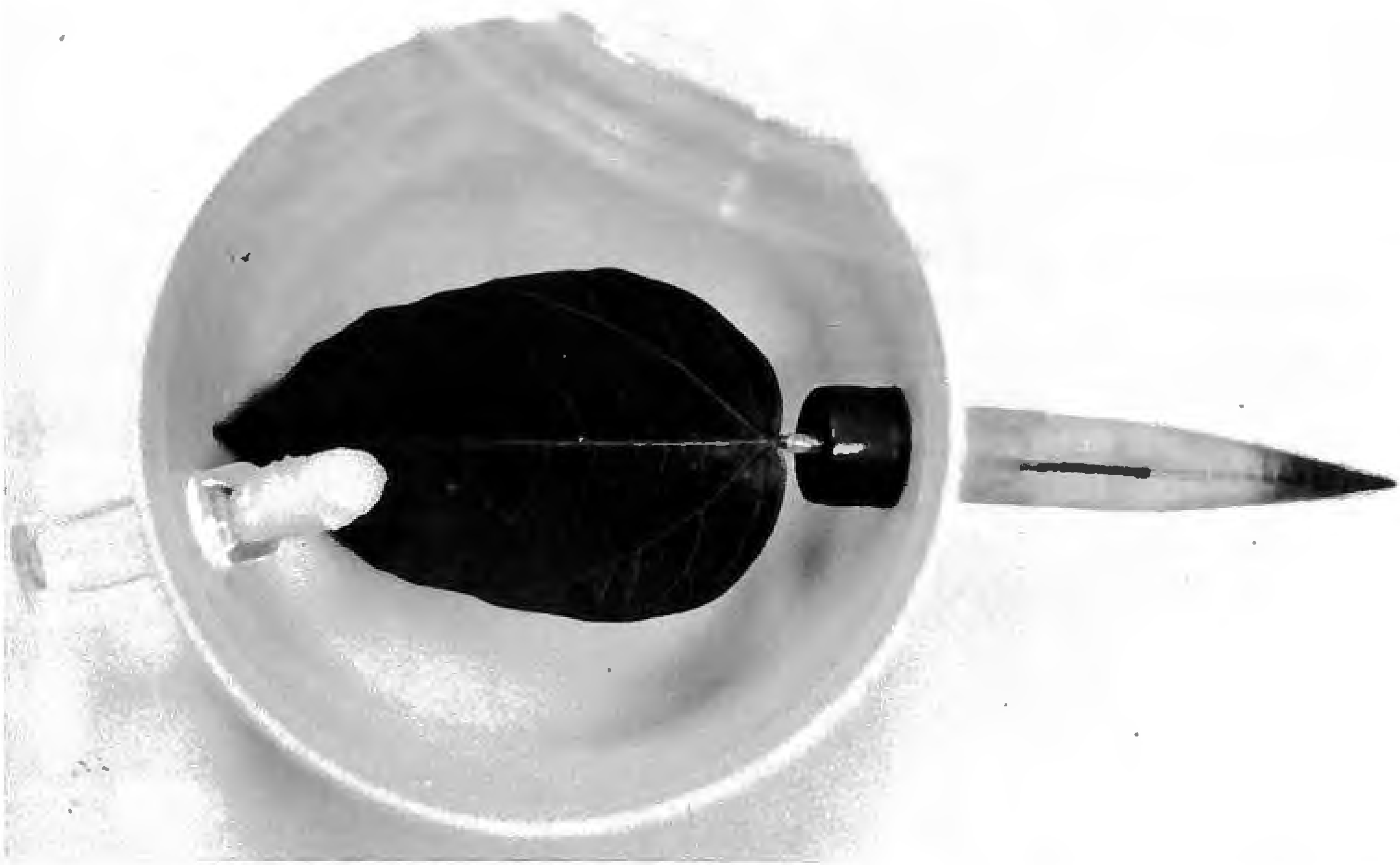


Table 5. Relationship between the relative abundance of the spherical mealybug, *Nipaecoccus vastator*, and the percentage parasitism by *Anagyrus indicus* in Guam, Saipan, and Tinian on the indicated sample dates, 1982.

| Location / sample date | Percentage of mealybug-infested sites | Number of adult female mealybugs per site in each percentile: 50th | 75th | 95th | 100th | Mean (± S.D.) percentage parasitism[2] |
|---|---|---|---|---|---|---|
| Guam | | | | | | |
| March 5 | 43<br>(24/56)[1] | 0 | 3 | 32 | 102 | 87.9 ± 23.9 a<br>(23)<br>0 - 100 |
| June 2 | 50<br>(28/56) | 0 | 3 | 70 | 1,000 | 55.4 ± 40.9 bc<br>(28)<br>0 - 100 |
| August 30 + | 41<br>(23/56) | 0 | 2 | 50.5 | 57 | 42.0 ± 39.3 b<br>(23)<br>0 - 100 |
| December 29 | 37.5<br>(21/56) | 0 | 2 | 24.5 | 44 | 76.2 ± 32.2 ac<br>(21)<br>0 - 100 |
| Saipan | | | | | | |
| March 10 | 23.3<br>(7/30) | 0 | 0 | 36 | 63 | 83.9 ± 31.1<br>(7)<br>14.3 - 100 |
| September 11 + | 16.7<br>(5/30) | 0 | 0 | 1 | 1 | 80.0 ± 44.7<br>(5)<br>0 - 100 |
| Tinian | | | | | | |
| September 11 | 3.8<br>(1/26) | 0 | 0 | 0 | 1 | 100<br>(1) |

1 (n/N) = Number of mealybug-infested sites/total number of sites sampled.

2 Values followed by a different letter are significantly different ($P < 0.005$ or $0.0001$); modified t-test. All percentages were arcsine transformed.

+ Spherical mealybug distributions are significantly different (Mann-Whitney U-test, $P < 0.02$).

Table 6. Relationship between sample date and the percentage occurence of natural enemy species at sites infested by *Nipaecoccus vastator* in Guam, Saipan, and Tinian, 1982.

| | Initial sample date | Percentage of mealybug-infested sites occupied by each of the indicated species: | | | | |
|---|---|---|---|---|---|---|
| | | *Anagyrus indicus* | other encyrtid spp. | *Kalodiplosis* sp. | ?*Gitonides* sp. | *Nephus roepki* |
| Guam | | | | | | |
| | Mar. 5 | 82.6 (19/23)[1] | 13.0 (3/23) | 0 (0/23) | 4.3 (1/23) | 21.7 (5/23) |
| | June 2 | 75 (21/28) | 14.3 (4/28) | 0 (0/28) | 7.1 (2/28) | 10.7 (3/28) |
| | Aug. 30 | 78.3 (18/23) | 0 (0/23) | 0 (0/23) | 13.0 (3/23) | 13.0 (3/23) |
| | Dec. 29 | 85.7 (18/21) | 9.5 (2/21) | 4.8 (1/21) | 0 (0/21) | 19.0 (4/21) |
| Saipan | | | | | | |
| | Mar. 10 | 100 (7/7) | 0 (0/7) | 0 (0/7) | 0 (0/7) | 0 (0/7) |
| | Sept. 11 | 80.0 (4/5) | 0 (0/5) | 0 (0/5) | 0 (0/5) | 0 (0/5) |
| Tinian | | | | | | |
| | Sept. 11 | 100 (1/1) | 0 (0/1) | 0 (0/1) | 0 (0/1) | 0 (0/1) |

1 (n/N) = Number of sites occupied by natural enemy/total number of mealybug-infested sites.

Table 7. Relationship between sample date and the relative abundance of various natural enemy species of *Nipaecoccus vastator* in Guam, Saipan, and Tinian, 1982.

| | Initial sample date | N | Mean (± S.D.) percentage of the total number of natural enemies represented by each of the indicated species: | | | | |
|---|---|---|---|---|---|---|---|
| | | | *Anagyrus indicus* | Other encyrtid sp. | *Kalodiplosis* sp. | *?Gitonides* sp. | *Nephus roepki* |
| Guam | | | | | | | |
| | Mar. 5 | 19 | 96.9 ± 6.0 | 0.8 ± 2.4 | 0 | 0.2 ± 1.0 | 2.1 ± 4.1 |
| | June 2 | 21 | 95.4 ± 10.3 | 2.5 ± 6.8 | 0 | 0.6 ± 2.4 | 1.5 ± 4.3 |
| | Aug. 30 | 19 | 91.8 ± 23.0 | 0 | 0 | 1.9 ± 5.3 | 6.3 ± 22.9 |
| | Dec. 29 | 20 | 87.0 ± 30.5 | 0.4 ± 1.3 | 0.3 ± 1.3 | 0 | 10.6 ± 30.6 |
| Saipan | | | | | | | |
| | Mar. 10 | 7 | 100 | 0 | 0 | 0 | 0 |
| | Sept. 11 | 5 | 100 | 0 | 0 | 0 | 0 |
| Tinian | | | | | | | |
| | Sept. 11 | 1 | 100 | 0 | 0 | 0 | 0 |

Table 8. Relative abundance of spiraling whitefly parasitoids at various localities in Guam, 1982.

| Village | Host Plant | *E. haitiensis* No. | (%) | *?Encarsia* sp. No. | (%) | Total No. |
|---|---|---|---|---|---|---|
| *Barrigada | *Plumeria obtusa* | 15 | (88) | 2 | (12) | 17 |
| *Mangilao | *P. obtusa* | 26 | (96) | 1 | (4) | 27 |
| | Guava | 13 | (100) | 0 | (0) | 13 |
| | Papaya | 3 | (100) | 0 | (0) | 3 |
| | Total | 42 | (98) | 1 | (2) | 43 |
| *Mongmong | *P. obtusa* | 16 | (73) | 6 | (27) | 22 |
| | Guava | 2 | (100) | 0 | (0) | 2 |
| | Lemon | 0 | ( 0) | 5 | (100) | 5 |
| | Total | 18 | (62) | 11 | (38) | 29 |
| Tumon | *P. obtusa* | 32 | (91) | 3 | (9) | 35 |
| | *P. rubra* | 2 | (100) | 0 | (0) | 2 |
| | *Plumeria* hybrid | 5 | (100) | 0 | (0) | 5 |
| | Coconut | 4 | (100) | 1 | (0) | 4 |
| | Unidentified | 1 | (50) | 1 | (50) | 2 |
| | Total | 44 | (92) | 4 | (8) | 48 |
| *Dededo | *P. obtusa* | 15 | (75) | 5 | (25) | 20 |
| Agat | *P. obtusa* | 5 | (100) | 0 | (0) | 5 |
| Santa Rita | *P. obtusa* | 1 | (100) | 0 | (0) | 1 |
| Overall total | | 140 | (86) | 23 | (14) | 163 |

* Data combined for two sites in each village.

Table 9. Relative abundance of *Nephaspis amnicola* on *Plumeria obtusa* leaves in Guam on the indicated sample dates.

| Site | July / August | September | October / November |
|---|---|---|---|
| (A) combined number of larvae and pupae per 10 leaves[1] | | | |
| Barrigada #1 | 2.2 | 1.1 | 0 |
| Barrigada #2 | 1.2 | 0 | 0 |
| Mangilao #1 | 0 | 0 | 0 |
| Mangilao #2 | 0 | 0 | 0 |
| Mongmong | 0 | 0 | 0 |
| Dededo #1 | 0 | 0 | 0 |
| Dededo #2 | 0 | 0 | 0 |
| Tumon | 1.2 | 0 | 0 |
| Agat | 2 | 2.4 | 0 |
| Santa Rita | — | 0 | 0 |
| (B) Combined number of adults per 250 leaves[3] | | | |
| Barrigada | 15.9 | 0 | — |
| Mangilao | — | 2.8 | — |

1 Numbers adjusted. Actual number of leaves examined was 9 or 11 per site.

2 No sample taken

3 Numbers adjusted. Actual number of leaves examined ranged from 220 to 270 per site.

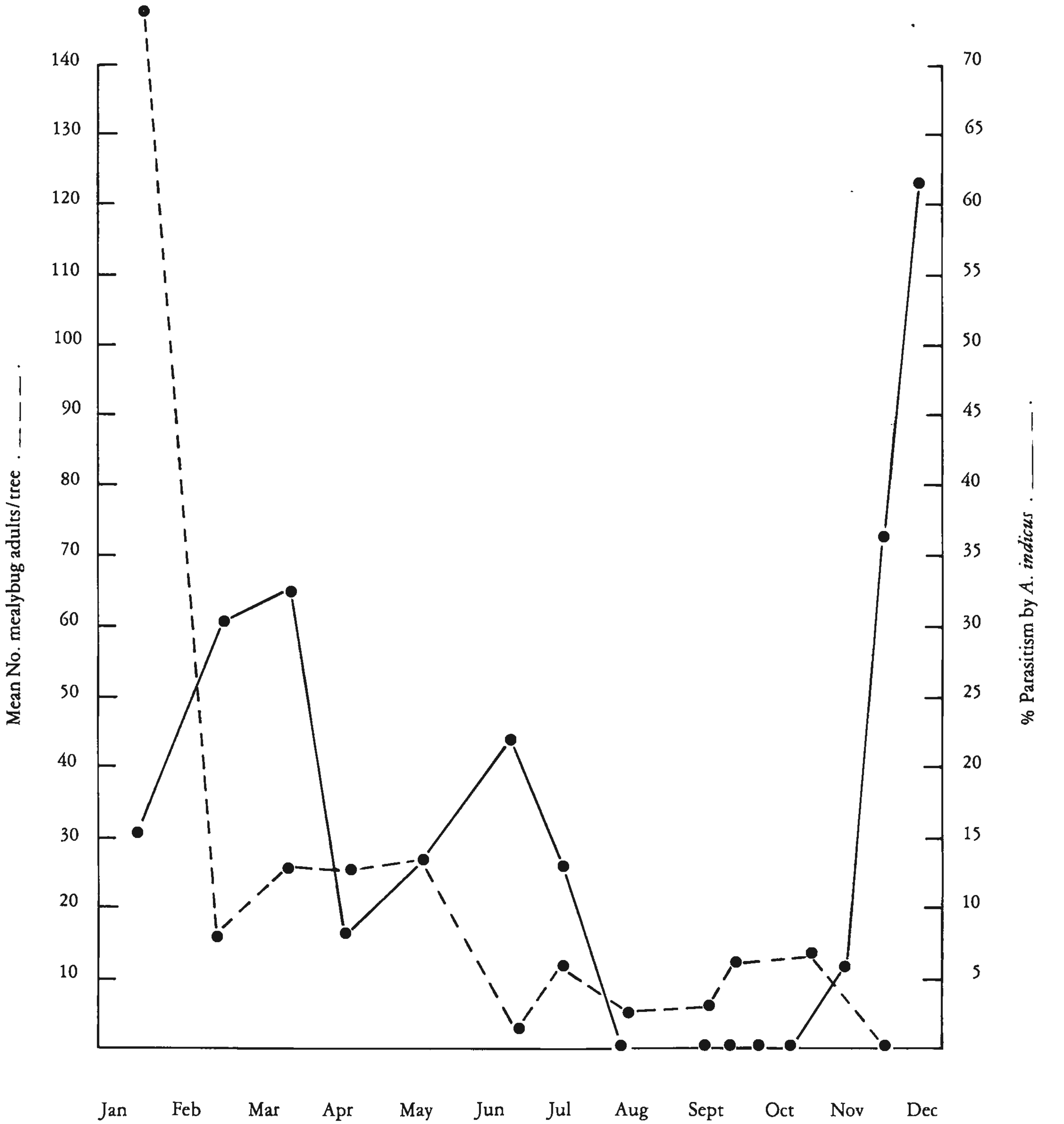



Fig. 1 Relationship between density of the spherical mealybug, *Nipaecoccus vastator*, and percentage parasitism by *Anagyrus indicus* in Yigo, Guam. 1982

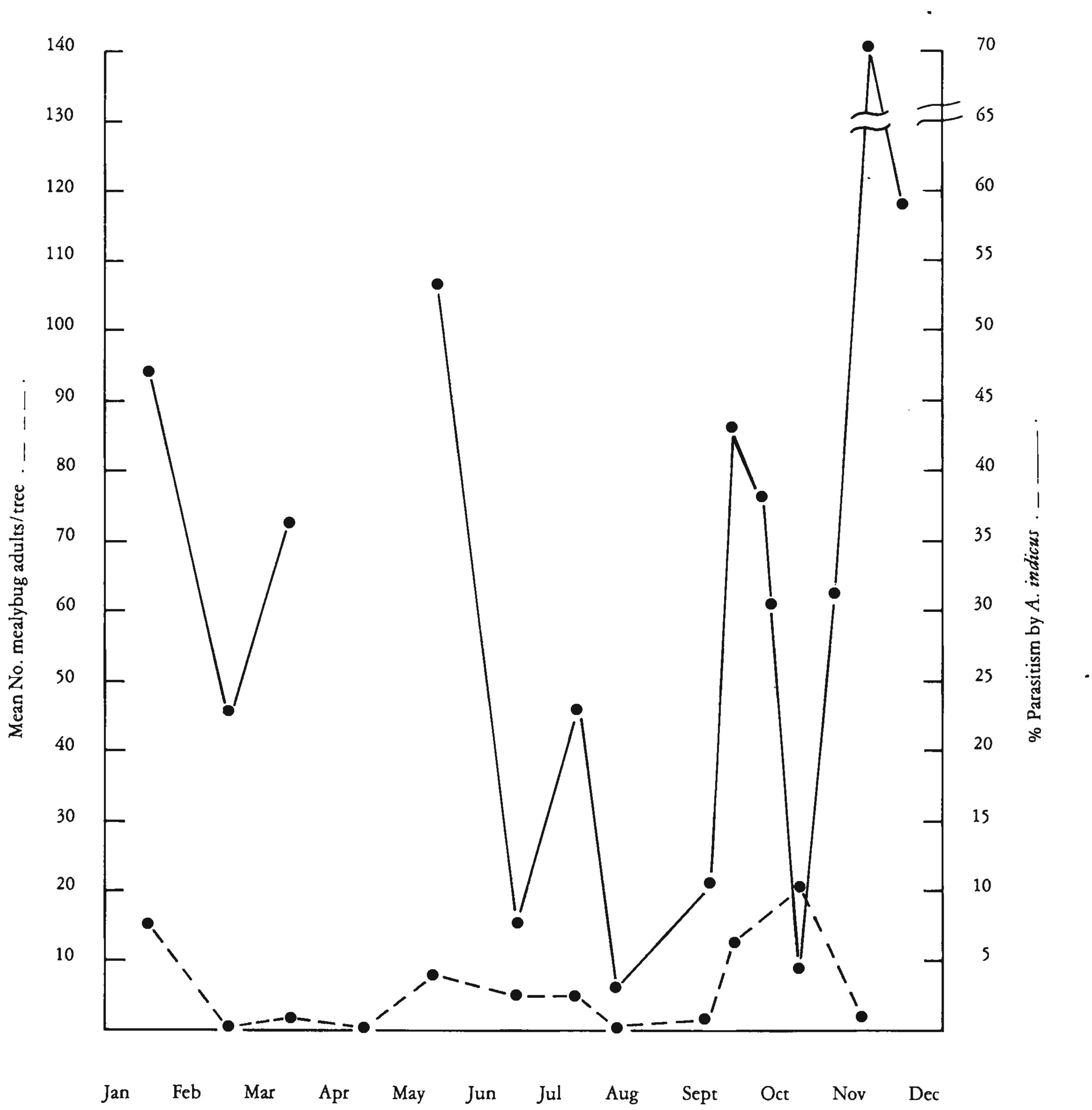



Fig. 2 Relationship between density of the spherical mealybug, *Nipaecoccus vastator*, and percentage parasitism by *Anagyrus indicus* in Santa Rita, Guam. 1982

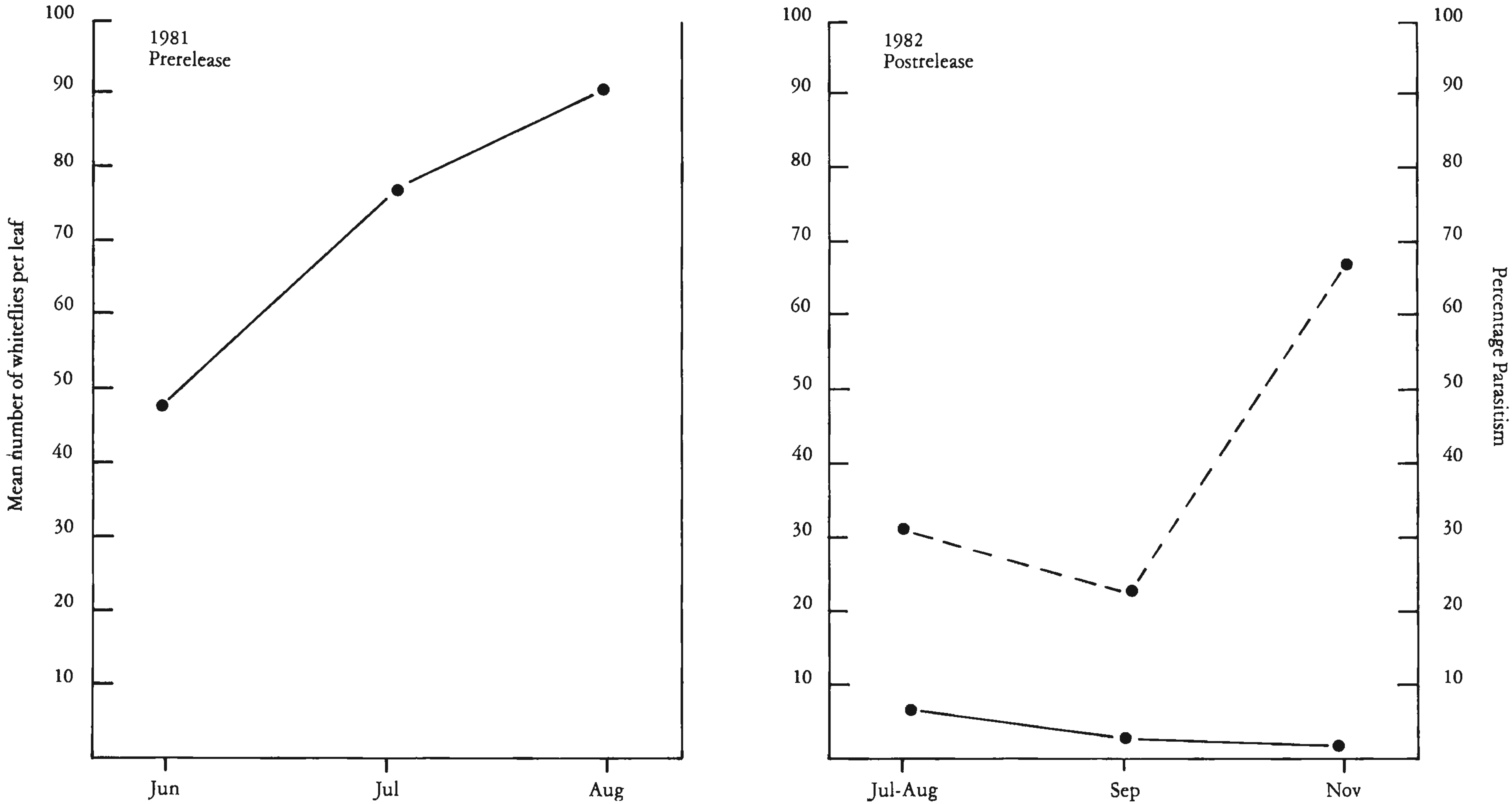
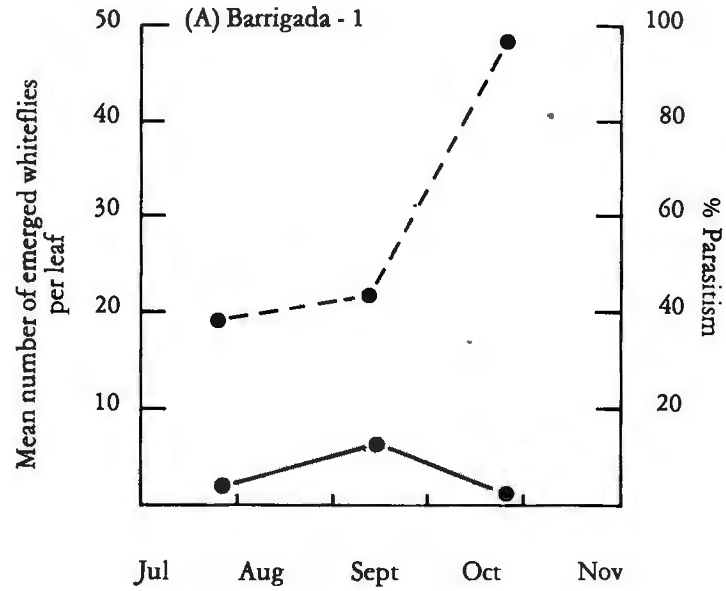



Fig. 3 Spiraling whitefly densities before and after natural enemy releases, and percentage parasitism in Mongmong-Barrigada, Guam on the indicated sample dates, 1981-1982.

whitefly . ———— .
parasities . — — — —. .

Fig. 4 Relationship between spiraling whitefly density and percentage parasitism at various sites, and on the indicated sample dates. Guam 1982.

Whitefly . ———— .
Parasite . — — — .



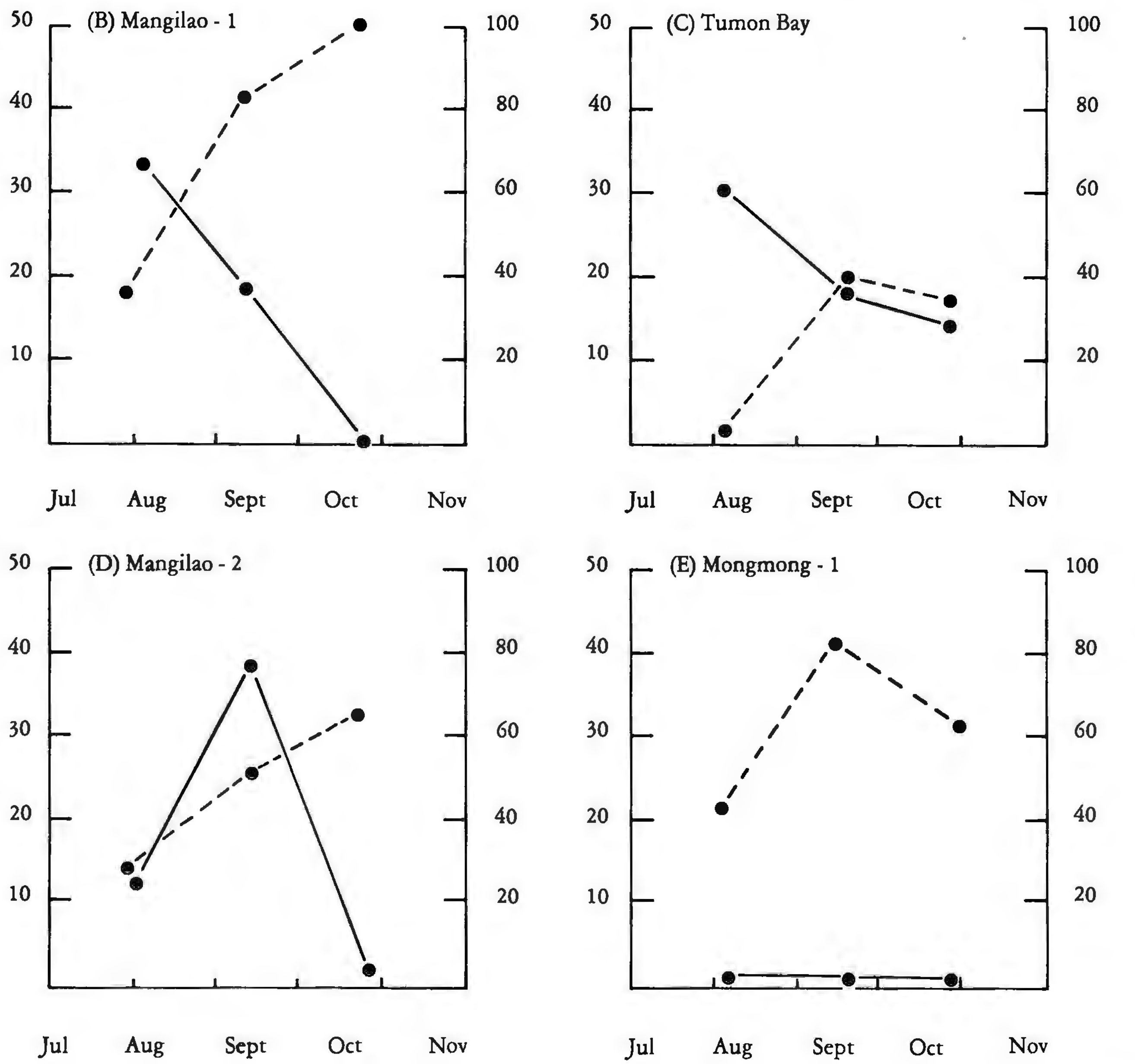
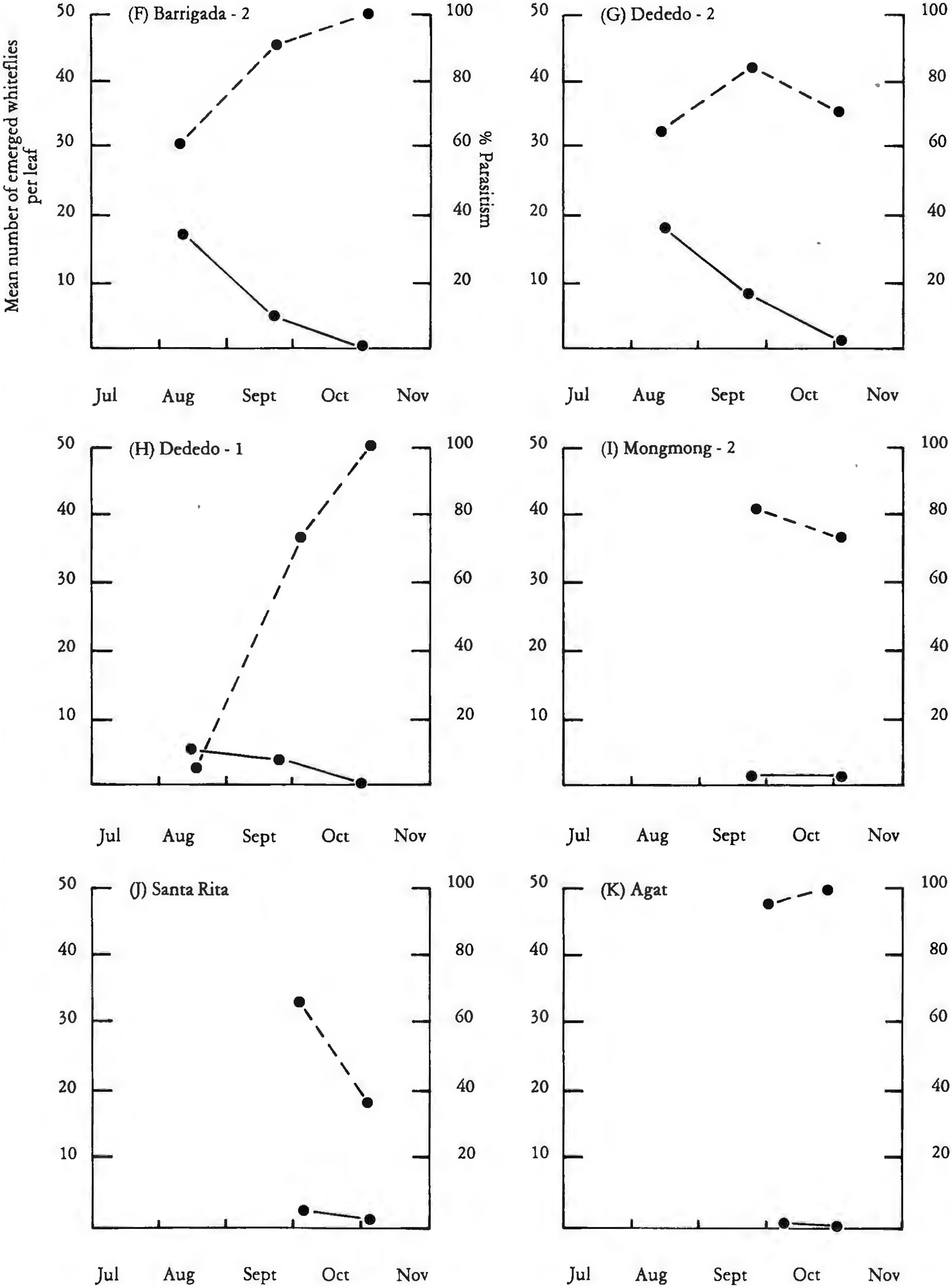



Fig. 4 (continued)



# Plant Pathology

Vincent M. Russo

### I. Identification of Plant Diseases

The identification of micro-organisms associated with disease symptoms has continued. As in the previous year, the search included ornamental, grass, and weed hosts, in addition to regularly cultivated fruit and vegetable crops. New reports of suspected organisms are shown in Table 1.

### II. Panama Wilt in Banana

Panama wilt, caused by *Fusarium oxysporum*, is continuing to spread slowly on Guam. During the past year, one new location for the disease was identified in Asan.

### III. Control of Soilborne Pant Pathogens

Earlier examination of soils in Guam indicated that suppressive activity to diseases incited by *Fusarium* and *Rhizoctonia* existed. A study is now underway to determine if levels of inorganic nutrients, ions of macro nutrients, affect the development of *Fusarium* and *Rhizoctonia*. The study is not conclusive at this time.

Table 1. Reported associated agents of symptoms on various hosts. New reports are indicated by an *.

**FRUITS**

| HOST | | ASSOCIATED AGENT |
|---|---|---|
| Banana (*Musa paradisica*) subsp. *sapientum*) | 1. Corm rot | *Phoma* sp.* |
| | 2. Leaf spot | *Colletorichum musae** |
| Breadfruit-sterile (*Artocarpus altilis*) | 1. Anthracnose | *Colletotrichum arthocarpi** |
| Guava (*Psidium guajava*) | 1. Leaf spot | *Colletotrichum gloeosporioides* |
| | 2. Leaf spot | *Curvularia* sp.* |
| | 3. Leaf spot | *Pestalotia* sp.* |
| Mango (*Mangifera indica*) | 1. Algal leaf spot | *Cephalovorus virescens** |
| | 2. Leaf spot | *Pestalotia* sp.* |
| | 3. Leaf spot | *Colletotrichum* sp.* |
| Papaya (*Carica papaya*) | 1. Mosaic | Virus |
| | 2. Leaf spot | *Helminthosporium papayae* |
| Pineapple (*Ananas comosus*) | 1. Fruit mold (secondary) | *Trichoderma viride** |
| | 2. Fruit rot | *Fusarium* sp* |
| | 3. Post Harvest Decay | *Chalara paradoxa** |
| Tangerine (*Citrus nobilis* var. *deliciosa*) | 1. Canker | *Xanthomonas citri* |

## ORNAMENTALS AND TURF

HOST

Boneset (*Euphtorium odoratum*)

1. Leaf spot
2. Leaf spot

Bouvardia (*Bouvardia* sp.)

1. Leaf spot

Chain of Love (*Antigonon leptopos*)

1. Leaf spot
2. Leaf spot

Coral-tree (*Erythrinia variegata var orientalis*)

1. *Leaf spot*
2. *Leaf spot*

*Diffenbachia (Diffenbachia* sp.)

1. Decline

Gardenia (*Gardenia* sp.)

1. Sooty Mold

Guam Daisy (*Bidens pilosa*)

1. Leaf spot

Morning Glory (*Ipomoea indica*)

1. White Rust

Orchid-tree (*Bauhinia variegata*)

1. Leaf spot

Pink Tecoma (*Tabebaui pallida*)

1. Leaf spot

Plumeria (*Plumeria* sp.)

1. Leaf spot

Tangantangan (*Leucaena leucocephala*)

1. Leaf spot

ASSOCIATED AGENT

*Curvularia* sp.*
*Pestalotia* sp.*

*Pestalotia* sp.*

*Colletotrichum* sp.*
*Pestalotia* sp.*

*Colletotrichum gloeosporioides**
*Phoma musae**

Physiological (non-infectious)
Unidentified fungus

*Colletotrichum* sp.*

*Albugo impomoea-pandurante*

*Colletotrichum* sp.*

*Colletotrichum* sp.*

*Colletotrichum* sp.*

*Pestalotia* sp.*

## ROOT CROP

HOST

Cassava (*Manihot esculenta*)

1. Tuber Rot

Ginger (*Zingiber officinale*)

1. Leaf spot
2. Leaf spot

Taro (*Colocasia esculenta*)

1. Blight

ASSOCIATED AGENT

*Fusarium solani**

*Colletotrichum* sp.*
*Phoma* sp.*

*Phytophtora* sp.

## VEGETABLES

Cabbage (*Brassica oleracea var capitata*)

1. Leaf spot
2. Leaf spot

Cantaloupe (*Cucumis melo*)

1. Southern Blight

Corn (Zea mays)

1. Rust

Eggplant (*Solanum melongena*)

1. Fruit Rot

K.W. Beans (*Phaseolus vulgaris*)

1. Marginal Necrosis
2. Stem Rot
3. Leaf spot
4. Southern Blight

Onion (*Allium cepa*)

1. Tip Blight

Pepper (*Capsicum annum*)

1. Anthracnose

Potato-Irish (*Lycopersicon esculatum*)

1. Southern Blight

Tomato (*Lycopersicon esculentum*)

1. Leaf spot
2. Leaf spot

Yam (*Dioscorea alata*)

1. Rust

Yardlong Bean (*Vigna unguiculata var sesquipedalis*)

1. Anthracnose
2. Mosaic

*Alternaria brassicae*
*Pseudomonas maculicola*

*Sclerotium rolfsii**

*Puccinia sorghi*

*Phomopsis* sp.

Physiological (non-infectious)
*Rhizoctonia solani*
*Colletotrichum* sp.*
*Sclerotium rolfsii**

*Colletotrichum circinans**

*Colletotrichum capsici**

*Sclerotium rolfsii**

*Curvularia* sp.*
*Stemphyllium* sp.*

*Goplana dioscoreae*

*Colletotrichum* sp.*
Virus

**OTHER PLANTS**

HOST

Fern (*Phymatodes scolopendria*)

1. Leaf spot
2. Leaf spot

ASSOCIATED AGENT

*Colletotrichum* sp.*
*Phom* sp.*

# Agricultural Engineering

Chin-Tian Lee

Calvin A. Saruwatari

Research in agricultural engineering continued in cooperation with horticulture to study trickle irrigation of vegetable crops. An experiment, conducted to determine the response of bell pepper to trickle irrigation in the screenhouse to explore the possibility of year round production, was initiated in February, 1982.

### Description of Experiment

The experiment was conducted in a screenhouse located at the Agricultural Experiment Station. Four and a half week old bell pepper seedlings (Ruby King) were transplanted into 30 cm (19 liter) pots which contained a mixture of 67% soil and 33% peat moss, with 30 g of 10-20-20 fertilizer. The drip line was placed about 5 cm away from the plant with one emitter per plant. A completely randomized design with three replications was used. Each replication consisted of seven plants. Four trickle irrigation treatments (94.63, 79.49, 64.35 and 47.31 liters per treatment) (4.54, 3.78, 3.03, and 2.27 liters per plant) were used for the experiment. The irrigation frequency was once every three days. Domestic water was used for irrigation. Foliar fertilizer was applied once every two weeks (Foliar 60).

Insects (mites, scales, mealybugs, ants) and diseases (Southern blight, bacterial leaf spot, *Fusarium* wilt) were noted on all plants. Cygon, Kelthane, Malathion, Dithane, and Tribasic Copper Sulfate were used to control the insects and diseases.

Evaporation from a Class A evaporation pan was measured and recorded on each day that the irrigation system was turned on to estimate the evapotranspiration in the screenhouse. Temperature measurements of the outside and inside the screenhouse were taken. Tensiometer readings (one per replication) were taken prior to the irrigation application.

### Data and Discussion

No signigicant difference was found in the total number of marketable fruits between the treatments. Also, no significant difference was found in the total marketable yield between treatments. However, it was found that the average weight of the marketable fruits was higher for the highest water treatment.

The average daily evaporation rate from the Class A evaporation pan was found to be 0.32 cm per day and was relatively constant for the duration of the experiment. The effect of wind-driven rain into the screenhouse on the evaporation measurement was not determined. It was assumed that there was no effect because the evaporation pan was in the screenhouse.

Temperatures measurements outside and inside the screenhouse showed that the average temperature difference was 2.8°C higher in the screenhouse. The average outside temperature was 30.0°C and the average inside the screenhouse temperature was 32.8°C. This showed that a well ventilated screenhouse can be used instead of a greenhouse which had temperature differences of up to 11°C higher.

Tensiometer readings were highly variable. If tensiometers are to be used in irrigation scheduling, the average reading of several tensiometers must be used.

### Conclusions

Although no significant difference was found between treatments, the highest water application rate produced the highest average weight of marketable fruit. However, since there is no significant differnce in the total number of fruits produced and the total yield between the treatments, irrigation water application at the lowest rate (2.27 liters per plant every three days) is sufficient.

Evaporation from a Class A pan was nearly constant during the entire period of this experiment. If a yearly average value or a value for each of the four seasons (wet, dry and two transitional) can be established, the same irrigation amount and frequency can be maintained during the entire growing season once the amont and frequency are established.

### Further Work

Research to determine the response of eggplant to trickle irrigation in the screenhouse was initiated in 1982. The project is still in progress.

| Irrigation Treatment (liters/treatment) (liters/plant) | Marketable Yield (kg/treatment) (Fruits/treatments) | Average Marketable Fruit Weight (g) | Unmarketable Yield (kg/treatment) (Fruits/treatment) | Tensiometer Readings (Means/S.D.) |
|---|---|---|---|---|
| 94.63<br>4.54 | 8.544<br>(252) | 33.78b | 0.440<br>(8) | 23.24/23.62 |
| 79.49<br>3.78 | 7.861<br>(268) | 27.35a | 0.494<br>(11) | 47.70/26.92 |
| 64.35<br>3.03 | 8.500<br>(298) | 28.75ab | 0.234<br>(9) | 52.29/25.89 |
| 47.31<br>2.27 | 7.153<br>(254) | 25.89a | 0.438<br>(9) | 58.90/29.88 |
| LSD*<br>0.05 | | 6.20/5.56 | | |

* Means flanked by the same letter are not significantly different at 0.05 level
a = 6.20 b = 5.56
Unequal sample size in a = 6.20 with one replication removed in Treatment 47.31

# Animal Sciences

A.L. Palafox

Studies were continued on the identification of organic and inorganic feed ingredients that are produced and available in Guam and Micronesia for the nutrition of animals.

I

*Manihot esculenta* (mandioca) is a hardy plant grown in Guam and Micronesia. Roots and succulent leaves are used as human food and animal feed. No data have been published locally on the nutrient composition of this important plant for human and animal consumption.

Clones of *M. esculenta* were grown at the Inarajan Agricultural Experiment Station. Leaves and petioles of the different clones were gathered at 25 weeks of age, dried, ground and then analyzed for nutrient content.

Table 1 shows the nutrient composition of *M. esculenta* leaves. Eight clones were obtained for propagation, but only seven grew to the end of the test period. Leaf ash showed an average of 7.23 percent. The ash content ranging from 6.35 to 7.94 percent suggests that leaves of *M. esculenta* are high in mineral content. Clone 1 leaves contained the highest ash (7.94%) among the seven clones tested. Leaf calcium content ranged from 1.60 to 2.40 percent with an average of 1.99 percent for the seven clones. Clone 7 contained the least calcium, whereas clone 1 contained the most. Leaf phosphorus was low. It ranged from 0.08 to 0.09 percent. Potasium content of the mandioca leaves averaged 1.21 percent. Sodium content ranged from 0.02 to 0.06 percent. The average sodium content of the seven clones was 0.04 percent. Magnesium content of the leaves of the seven clones was 0.68 percent, indicating a fairly high concentration of this mineral in the leaves.

Copper content of the leaves was highest for clones 1, 7, and 8 (11.1 ppm) and lowest for clone 6 (5.5 ppm). The average copper content for the seven clones was 8.33 ppm. Clone 6 showed the highest leaf iron content (191.6 ppm) and clones 1 and 8 showed the lowest (83.3 ppm). Manganese in the leaves averaged 106.93 ppm. The range was from 71.9 ppm for clone 6 to 125.0 ppm manganese from the leaves of clone 2. Leaves of *M. esculenta* averaged 70.43 ppm zinc. The zinc content ranged from 50.5 ppm to 85.0 ppm.

Petiole mineral content showed that petiole ash averaged 10.67 percent and the range was from 9.25 to 11.15 percent. All the clones showed relatively high concentrations of ash, indicating that *M. esculenta* petioles are good sources of minerals. Calcium content of petioles averaged 3.79 percent, ranging from 3.10 to 4.45 percent. Petiole phosphorus averaged 0.11 percent. The range was from 0.09 to 0.13 percent. Potassium content averaged 1.63 percent in *M. esculenta* petioles, with clone 4 showing the lowest (1.29%) and clone 2 showing the highest (1.69%) K concentration. Sodium content of petioles averaged 0.09 percent. Clones 2 and 7 showed the lowest K concentration (0.06%), whereas clone 8 showed the highest (0.22%).

Copper content of petioles did not vary much among the seven clones. The average was 5.60 ppm. Iron content of petioles ranged from 45.8 to 75.0 ppm with clone 6 showing the lowest and clone 8 the highest Mn content. Zinc content of petioles averaged 78.29 ppm. Clone 1 showed the lowest (50.0 ppm) and clone 6 the highest (150.0 ppm) concentration of Zn in their petioles.

Leaves and petioles of seven clones were separately analyzed and the data showed that petioles contain a significantly higher concentration of ash than petioles. Petioles contained 10.67 ash compared with only 7.29 percent for the leaves. Petioles also contained a significantly higher concentration of calcium (3.79%) than leaves (1.99%). The phosphorus content of leaves (0.08%) and petioles (0.11%) are relatively low compared to their respective concentrations of calcium and potassium. Petioles P content was significantly higher than that of the leaves ($P < 0.05$). The sodium content of the petioles (0.10 ppm) was 2.5 times higher than that of the leaves (0.04 ppm).

It was also noted that the leaves were significantly higher in copper content than the petioles. The leaves contained 50 percent more copper that the petioles. The iron content of the leaves was 116.62 ppm compared with 55.93 ppm for the petioles. The difference was highly significant ($P < 0.01$). The manganese content of the leaves was 106.92 ppm compared with 134.15 ppm for the petioles. The difference was not significant. There was no significant difference in the zinc content (70.43 ppm) of the leaves and that of the petioles (78.29 ppm).

**Summary**

*M. esculenta* leaves contained relatively high concentration of minerals. Leaf ash averaged 7.29 percent for the seven clones. Different clones may significantly differ in leaf mineral content.

Petioles contain relatively high concentrations of minerals, specially calcium, potassium, manganese and zinc. Petioles of different clones may differ significantly in mineral content.

Leaves contained significantly less concentration of ash, calcium, potassium, phosphorus, sodium, and magnesium than those of the petioles. On the other hand, the leaves contained significantly higher concentrations of magnesium, copper and iron than those of the petioles. Leaves and petioles did not significantly differ in manganese and zinc content.

Potential of Cassava as a Crop, Food and Feed for the Marianas

(Supported by P.L. 89-808, Section 406)

Experiment M 1.1 was conducted to determine and differentiate the potential of cassava clones presently grown in Guam as a food and feed crop.

**Materials and Methods**

Six clones of *M. esculenta* were obtained from the villages of Mangilao (3), Yigo (1), Barrigada, (1), and Inarajan (1). Clones 1, 2 and 3 were from Mangilao, clone 4 from Yigo and clone 5 from Barrigada, and clone 6 from the Agricultural Experiment Station at Inarajan. Clone 3 was not included in the experiment because seed pieces produced weak shoots.

The study was conducted at the Inarajan Agricultural Experiment Station. Seed pieces were four to six nodes from five clones (1, 2, 4, 5, and 6) were planted horizontally one inch under the soil on ridged rows and 1 meter apart. The hills were also 1 meter apart. The experiment duration was 32 weeks, May 19 to December 29, 1982.

Observations were made on growth, color of stems, petioles, leaves, and roots. Data were also obtained on number of roots, root weight, diameter and circumference. Nutrient composition of roots was obtained.

## Results and Discussion

Table 4 shows the result of Experiment M 1.1 at the end of a 32 week period. Marketable roots averaged from 9.00 to 11.80. Clone 6 produced the least number of roots (9.00) compared with clone 4 (11.80). No significant difference in the number of roots were observed among clones. Root weight averaged from 2.94 to 5.59 kg per plant. Clone 1, produced the lightest root weight, whereas Clone 2 roots were heaviest. Root length ranged from 21.26 to 30.10 cm. Clone 2 roots measured the longest, whereas Clone 5 roots were the shortest.

Root circumference at the thickest part averaged from 11.86 to 15.55 cm. There was a significant difference ($P < 0.01$) in thickness of roots among the five clones. Root diameter averaged from 4.60 to 5.35 cm. Clone 5 roots showed 14.02 percent longer in diameter than that of clone 2.

The aerial parts of the cassava plant cut at ground level averaged 9.46 to 13.43 kg in weight. Clone 1 stems and leaves weighed the least, whereas those of clone 2 weighed the most. It was noteworthy that clones which produced the heavier roots tended to also produce heavier stems plus leaves.

Stem circumference at ground level averaged 19.31 to 21.64 cm. Clone 2 showed the heaviest roots. Clone 5 stems showed the least circumference, 19.31 cm. Stem circumference at 1 foot above ground level showed that clone 6 averaged the shortest (11.54 cm), whereas clone 5 averaged the longest (13.00 cm).

## CONCLUSION

Under the conditions of Experiment M 1.1, clone 2 produced the heaviest root per plant, 5.59 kg, compared with only 2.94 kg for clone 1 among the five clones tested. Clones which produced the heavier roots tended to also produce heavier stems plus leaves.

Table 1 Nutrient Composition of *M. esculenta* (cassava) leaves at 25 weeks of age.

| CLONE | | 1 | 2 | 4 | 5 | 6 | 7 | 8 | 1-8 |
|---|---|---|---|---|---|---|---|---|---|
| CULTIVARS | | PAL 1 | GAB 2 | PAL 4 | PAL 5 | PAL 6 | ALP 7 | YOL 8 | $\bar{x}$ |
| ASH | % | 7.94 | 7.60 | 7.35 | 7.84 | 6.94 | 7.00 | 6.35 | 7.23 |
| Ca | % | 2.40 | 1.85 | 1.80 | 2.05 | 1.90 | 1.60 | 2.30 | 1.99 |
| P | % | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.08 | 0.09 | 0.08 |
| K | % | 1.27 | 1.41 | 1.01 | 1.18 | 1.13 | 1.27 | 1.21 | 1.21 |
| Na | % | 0.03 | 0.02 | 0.06 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Mg | % | 0.62 | 0.65 | 0.80 | 0.80 | 0.67 | 0.80 | 0.42 | 0.68 |
| Cu | ppm | 11.1 | 5.6 | 8.3 | 5.6 | 5.5 | 11.1 | 11.1 | 8.33 |
| Fe | ppm | 83.3 | 120.8 | 125.0 | 95.8 | 191.6 | 116.6 | 83.3 | 116.63 |
| Mn | ppm | 115.6 | 125.0 | 115.6 | 109.4 | 71.9 | 101.6 | 109.4 | 106.93 |
| Zn | ppm | 53.5 | 69.0 | 50.5 | 77.5 | 85.0 | 76.5 | 81.0 | 70.43 |

Table 2 Nutrient Composition of *M. esculenta* (cassava) petioles at 25 weeks of age.

| CLONE | | 1 | 2 | 4 | 5 | 6 | 7 | 8 | 1-8 |
|---|---|---|---|---|---|---|---|---|---|
| CULTIVARS | | PAL 1 | GAB 2 | PAL 4 | PAL 5 | PAL 6 | ALP 7 | YOL 8 | $\bar{x}$ |
| ASH | % | 11.15 | 10.55 | 9.90 | 9.25 | 12.20 | 10.77 | 10.85 | 10.67 |
| Ca | % | 4.25 | 3.90 | 3.60 | 3.10 | 4.45 | 3.25 | 3.95 | 3.79 |
| P | % | 0.09 | 0.09 | 0.09 | 0.09 | 0.13 | 0.12 | 0.13 | 0.87 |
| K | % | 1.38 | 1.69 | 1.29 | 1.58 | 1.60 | 2.42 | 1.46 | 1.63 |
| Na | % | 0.11 | 0.06 | 0.08 | 0.09 | 0.05 | 0.06 | 0.22 | 0.10 |
| Mg | % | 0.46 | 0.44 | 0.66 | 0.56 | 0.60 | 0.50 | 0.50 | 0.53 |
| Cu | ppm | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 5.60 |
| Fe | ppm | 50.0 | 50.0 | 45.8 | 54.2 | 75.0 | 58.3 | 58.3 | 55.51 |
| Mn | ppm | 143.8 | 104.7 | 109.4 | 128.1 | 125.0 | 131.2 | 196.9 | 134.16 |
| Zn | ppm | 50.0 | 67.0 | 61.0 | 80.0 | 150.0 | 61.0 | 79.0 | 78.29 |

Table 3 Comparison of the nutrient content of *M. esculenta* leaves and petioles at 25 weeks of age.

| MINERAL | UNIT | LEAVES | PETIOLES | DIFFERENCE |
|---|---|---|---|---|
| Ash | % | 7.29 | 10.67 | ** |
| Calcium | % | 1.99 | 3.79 | ** |
| Potassium | % | 1.21 | 1.63 | * |
| Phosphorus | % | 0.08 | 0.11 | * |
| Sodium | % | 0.04 | 0.10 | * |
| Magnesium | ppm | 0.62 | 0.53 | * |
| Copper | ppm | 8.33 | 5.55 | * |
| Iron | ppm | 116.62 | 55.93 | ** |
| Manganese | ppm | 106.92 | 134.15 | N.S. |
| Zinc | ppm | 70.43 | 78.29 | N.S. |

1. **-P < 0.01, *-P < 0.05, N.S.- not significant.

2. Each value

Table 4 Summary of data obtained from five clones of *M. esculenta* grown in Guam.[5]

| | | CLONES | | | | | |
|---|---|---|---|---|---|---|---|
| Parametes | | 1 | 2 | 4 | 5 | 6 | F |
| Number of roots | | 9.40 | 9.55 | 11.80 | 9.25 | 9.00 | 0.20 |
| Root weight, | kg | 2.94 | 5.59 | 4.40 | 3.85 | 4.84 | 1.71 |
| Root length, | cm | 26.62 | 30.10 | 24.09 | 21.26 | 25.82 | 1.72 |
| Root circumference, | cm | 14.68 | 15.24 | 15.55 | 11.86 | 14.07 | 4.97[4] |
| Root diameter | cm | 4.92 | 5.35 | 4.70 | 4.60 | 4.88 | 0.62 |
| Plant weight,[1] | kg | 9.46 | 14.45 | 13.43 | 9.71 | 10.58 | 1.56 |
| Stem circumference,[2] | cm | 21.00 | 21.64 | 19.71 | 19.31 | 20.44 | 0.13 |
| Stem circumference,[3] | cm | 13.04 | 12.73 | 12.93 | 13.00 | 11.54 | 0.69 |

1. Aerial part
2. Circumference of stem at ground level
3. Circumference of stem one foot above ground level
4. P < 0.01.
5. Sampled at 25 weeks of age.

# Aquaculture:

## Stephen G. Nelson

This past year efforts were focused primarily on brackish water species. Included were studies on the development of larval rearing techniques for the Malaysian prawn *Macrobrachium rosenbergii*, genetic variations in the Guamanian prawn *Macrobrachium lar*, growth studies on two local mullets, *Liza vaigiensis* and *Chelon engeli*, and nitrogen nutrition of a red alga *Gracilaria edulis*.

**Prawn studies:**

An experimental, low-technology prawn hatchery was constructed and operated at the University Of Guam Marine Laboratory. Approximately 83,000 post-larval prawns from this hatchery were delivered to local farmers and a number of hatchery technicians were trained. Also, studies of the elctrophretic genetic variation of the Guamanian prawn *Macrobrachium lar* were completed and these results were presented in a Biology Masters thesis by Ms. Gretchen Grimm.

**Mullet Studies:**

Growth experiments were conducted with two local species of mullet to determine their potential for culture on Guam. The juvenile fish were collected by cast net from the shallow areas of the reef around the island. Results of some six-week growth trials are shown in Table 1. Thus far, the most promising species for culture appears to be *Liza vaigiensis*. It has proven to be hardy and quickly adapts to artificial feeds. In the growth trials locally available chicken feed was used at a feeding rate of 20% of the fish weight per day. Some of the groups of fish doubled their weight during the 6-week growth period. Studies are now in progress to estimate the efficiency of assimilation of various dietary components by individuals of these species.

**Algal Studies:**

Studies were made to determine the growth rates and nitrogen content of apical tips of the red alga *Gracilaria edulis* in response to nutrient enrichment with a variety of nitrogen sources including urea, ammonia, nitrate, nitrite, and phenylalanine, an amino acid. Results of these trials are shown in Table 2. In all cases, growth of the apical tips was stimulated by nitrogen enrichment, even at concentrations as low as 5 M. The results indicate that *Gracilaria* thalli exhibit luxury uptake of various nitrogen concentrations while growth rates peak at some optimum level. Phenylalanine, however, appears toxic at concentrations in excess of 20 M nitrogen.

Concurrent studies on nitrogen uptake kinetics indicated that ammonia uptake is best described by a diffusive uptake model while both nitrate and nitrite uptake appear to fit the Michaelis-Meten (saturation) model. Evidence was found that nitrate and nitrite uptake capacities are induced after approximately 30 minutes exposure to elevated nitrogen.

**Sources:**

Grimm, G. 1983. Genetic variation in *Macrabrachium lar* on Guam. M.S. Thesis in Biology, University of Guam. 45 p.

Table 1. Mean weight of fish cultured in flow-through circular tanks (28°C, 32%) and fed commercial poultry feed at 20% of their body weight per day.

| | TANK NUMBER | | | | | |
|---|---|---|---|---|---|---|
| **Week** | 1+ | 2+ | 3+ | 4+ | 5* | 6* |
| 0 | 8.9 | 8.2 | 24.6 | 10.7 | 1.2 | 1.8 |
| 1 | 9.8 | 8.7 | 26.0 | 12.4 | 1.7 | 2.0 |
| 2 | — | 9.3 | 28.4 | 14.3 | 1.8 | 2.2 |
| 3 | 10.8 | 9.7 | 30.3 | 14.8 | 1.9 | 2.2 |
| 4 | 11.3 | 9.8 | — | 17.1 | 2.3 | 2.2 |
| 5 | 11.9 | 9.8 | — | 19.1 | 2.8 | 2.3 |
| 6 | 12.4 | 10.5 | — | 20.1 | — | — |

\+ *Liza vaigiensis*
* *Chelon engeli*

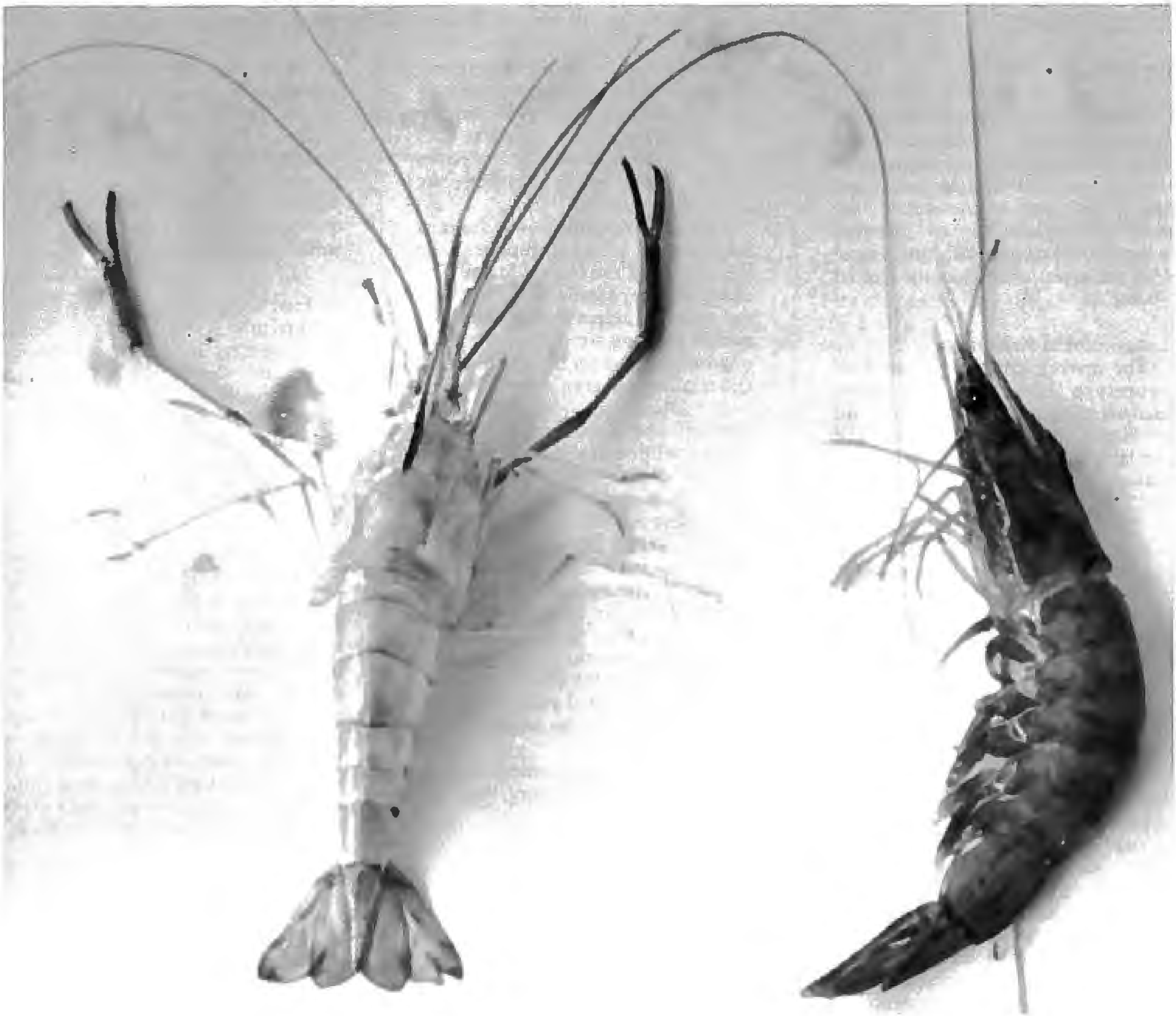


Table 2. Average relative growth rate (% per day) and nitrogen content of *Gracilaria* apical tips in relation to nitrogen enrichment.

| Nitrogen Concentrations ( M) | Urea | | Phenylalanine | | Ammonia | | Nitrate | | Nitrite | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Growth | %N | Growth | %N | Growth | %N | Growth | %N | Growth | %N |
| 0 | 0.04 | 1.2 | 0.04 | 0.9 | 0.05 | 1.0 | 0.05 | 2.5 | 0.04 | 1 |
| 5 | 0.06 | 1.8 | 0.05 | 1.0 | 0.05 | 1.5 | 0.06 | 1.4 | 0.06 | 2.2 |
| 10 | 0.06 | 2.1 | 0.06 | 1.0 | 0.06 | 1.2 | 0.06 | 1.3 | 0.06 | 2.6 |
| 20 | 0.05 | 2.5 | 0.06 | 1.4 | 0.05 | 1.4 | 0.06 | 1.4 | 0.06 | 1.4 |
| 40 | 0.06 | 2.4 | 0.04 | 1.9 | 0.06 | 2.4 | 0.06 | 2.4 | 0.05 | 2.3 |
| 80 | 0.06 | 2.1 | 0.03 | 2.4 | 0.05 | 3.2 | 0.05 | 2.5 | 0.06 | 2.0 |

# Agricultural Economics

Thao Khamoui

In 1982, two agricultural economics research projects were initiated. One project was to analyze the efficiency of agricultural marketing on Guam and the other was to determine the economic feasibility of growing selected field crops to substitute some feed grains imported from the United States.

**I. Agricultural Marketing**

The market structure of the food industry in Guam and a comparative analysis of market size on Guam and in Hawaii have been studied. The available information reveals that Hawaii had thirty two wholesalers in 1977, but it was estimated that twelve wholesalers could efficiently provide the required marketing services. In the same year, Guam had three agricultural marketing cooperatives, six major middlemen, and ten major retail food outlets.

Hawaii's population that patronized commercial food outlets increased from 820,000 in 1975 to 930,000 in 1980, while the total number of civilian population on Guam increased from 78,000 to 86,000 during the same period. Guam's population was approximately one tenth of Hawaii's population. Food market structures in both Guam and Hawaii have not changed significantly in the last few years. It is, therefore, reasonable to conclude that Guam has a relatively large number of food distributors given the limited market size.

While there is ample evidence to support the argument that major food retailers on Guam are vertically integrated into the importing and wholesaling, it is believed that the effects of the gross receipts tax on this development are minimal. A replacement of the gross receipts tax by other taxes does not assure greater competition or increased efficiency in wholesale and retail business. It is also very unlikely that vertical integration would be discouraged and barriers to entry would be lowered. Whether a replacement of the gross receipts tax by a sales tax would benefit consumers in terms of lower retail prices, or whether it would simply increase the profit margins of the integrated firms under the present market structure is questionable. The lost government revenue, however, must be made up by other taxes. It is quite possible, however, that retail food prices on Guam could have been higher without vertical integration in the food industry. The gross receipts tax would have been levied at each stage of the marketing activities before foods finally reached the ultimate consumers.

Guam is 6,000 miles away from its main source of food supplies, the West Coast of the United States. The desire of the distributors to reduce risk through better market coordination in securing steady supplies is an important reason for food wholesaling and retailing integration on Guam.

A distinction must be made between operational and price efficiences. Although the operational efficiency of the vertically integrated food firms can reduce marketing costs, there is no assurance that these cost savings will be passed on to the consumers in terms of retail price reduction. The operational efficiency of large scale marketing allows only a few efficient food firms to remain in the market where competition is weakened and price efficiency reduced. An operational-price efficiency dilemma exists in the market structure on Guam.

It is believed that vertical integration in the food industry may not necessarily affect the market structure on Guam undesirably. For example, a vertical integration of the once financially troubled feed mill and egg farm on Guam is a matter of survival and growth. A successful integration would not only improve the profitablility of the mill, but would also desirably change the market structure by encouraging competion in the egg industry, increasing feed and egg production, and improving self-sufficiency on Guam.

**II. Feed Crops**

Currently, experiments are being conducted by an animal scientist to determine the nutritive value of cassava for swine. Some varieties of cassava have been planted. Their economic value as animal feeds will be assessed when statistics on yields and cost of production become available.

Arrangements have been made to obtain the most recent available data on Thai cassava production and trade in terms of yield, production costs, export price, quantity, and types such as cassava chips and pellets. Thailand is the largest exporter of cassava to Europe for animal feeds. The aforementioned statistics are needed to determine whether Thai cassava can be used economically to substitute feed grains imported from the United States, and whether Guam has comparative advantages in growing cassava.

Cassava Root Harvest