EFFECTS OF FERTILIZER, LATE WEEDING, AND DESUCKERING ON YIELD AND PEST POPULATIONS OF TARO

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Abstract

The effects of fertilization, late weeding, and sucker removal on taro pest populations and yield were compared at two sites with different soils. The first experiment was in an area with shall calcareous soil. Fertilizer increased plant size and yield in this soil. However, in the plots with the lowest levels of iron in the soil, iron deficiency stopped growth of the taro even when fertilizer was applied. All plots showed some symptoms of iron deficiency. Taro planthoppers were more abundant on fertilized plants, but aphids and taro hornworm eggs were not affected by any treatment. The second experiment was planted in a deep clay soil with a more neutral Ph. Fertilizer applications showed no effect on yield in this experiment, in part because of leaching caused by heavy rainfall early in the season. Yield was higher in weeded plots. Pigs consumed significantly more taro in weeded plots than unweeded ones. Insect populations were not affected by the treatments. In both experiments, there was a significant positive association between the number of aphids and taro planthoppers per sample and the size of the plant sampled. The higher numbers of planthoppers on fertilized plants observed in the first experiment was probably due to size differences of plants in fertilized and unfertilized plots.

Introduction

In Guam, taro is a minor crop, but it is culturally important and relatively profitable for farmers to grow. Despite its profitability, local production is too low to meet market demand. In 1989, a Rapid Rural Appraisal (RRA) performed on taro farmers in Guam indicated that two of the major constraints to increased taro production were the amount of labor needed to weed the crop and yield losses to pests, primarily pigs (Manner 1990). The study also showed that agronomic practices varied considerably from farm to farm. At least two of the practices that varied (the amount of fertilizer applied and desuckering) potentially can affect damage by weeds and other pests. The amount of fertilizer applied varied from none to amounts higher than the recommended levels (Manner 1990). Nitrogen fertilizer is often associated with increased populations of certain pests such as aphids (Klinglauf 1987) , but no information is available on its effects on taro pests. Sucker removal was practiced by some farmers, but not others. Those who did so felt it was necessary to assure big corms, but other farmers felt that the suckers did not affect yield and that they were valuable as planting stock and in suppressing weeds by creating a dense canopy. Little research has been done on how sucker removal affects yield. Certain practices such as deep or dense planting tend to suppress suckers and increase total yield (although not necessarily yield of big corms) (Sivan 1984, Villanueva and Abenoja 1984), but other practices show an opposite effect. Fertilization with nitrogen promotes suckering and increases yield (Sivan 1984).

Most farmers on Guam keep their fields free of weeds, particularly early in the crop cycle. Early weed infestations are highly detrimental to yield (Sivan 1984, Cable and Asghar 1984), but the impact of late infestation on yield is less clear. The weeding itself requires substantial hand labor. Although no information about the relationship between weeds and pests of taro is available, in other crops, the presence of weeds has been associated with increased populations of predators and parasites and lower pest populations (Altieri et al. 1985, Kloen and Altieri 1990). Changes in plant density are also known to affect many crop pest species.

Given the lack of information on the effects of fertilization, late weeding, and desuckering, the current study was initiated to examine how these factors affect yield. Since the literature on weeds in taro is unanimous in showing that weeds early in the crop are extremely detrimental to yield, only the effect of weeding late in the crop was studied. In addition, since weediness is known to affect insect populations on various crops, populations of taro insects and selected natural enemies were also monitored. Several species of insects attack taro in the Pacific, and some of them are capable of causing severe damage (Mitchell and Maddison 1983). The biology and natural enemies of taro insect pests have been reviewed by Waterhouse and Norris (1987). These reviews indicate that little information is available as to how different agronomic practices affect the insect pests on taro, and this is the reason that the current investigation also included insect monitoring. Because all the factors (fertilization, late weeding, and desuckering) examined may interact, the field was designed to test all factors in all combinations.

Materials and Methods

Two experiments were conducted using the same design on different soils. The first taro field was planted July 9, 1990, using the common local variety, *sunin agaga* (Chamorro for red taro). The experiment consisted of fertilizing or not fertilizing, late weeding or not late weeding, and removing suckers or not removing suckers in all possible combinations. A randomized block design replicated four times was used. Plots were four rows wide and 5.5 m long. Rows were 90 cm apart, and plants were spaced 60 cm apart within the rows. The first field was planted at the Yigo Experiment Station in Yigo soil. This is thin clay soil over limestone. Soil depth varied in the field, with numerous limestone cobbles present in some plots and few in others. Fertilizer was applied twice (at planting and at six weeks after planting) at the rate of 20 ml 16-16-16 NPK per plant each time, for a total of 300 kg/ha each time. All plots were weeded on August 1, 1990. Weeded treatments were weeded two more times, in September and again in October. Suckers were removed on October 4 and on November 1. A typhoon hit the island on December 20 and stripped most of the leaves off the plants. The plants were harvested on January 15, 1991. Only the central two rows were weighed.

Biweekly insect samples were taken beginning six weeks after planting when there were three leaves per plant available for the sample. Ten plants from the center of the plots were used for each insect sample. The third oldest leaf from the center one was used as the standard sample leaf for taro planthoppers and aphids. The total number of taro planthoppers on the petiole and lamina of this leaf were recorded. Aphids were counted in the triangular area behind the attachment of the petiole. This area is defined by two large side veins and the leaf edge. Caterpillar eggs and larvae, aphid predators, and various other natural enemies were counted on all three innermost leaves.

Data were analyzed by averaging individual plant counts of each insect to produce a plot mean, and these plot means were then averaged to produce a seasonal mean. A three-way analysis of variance (PROC GLM, SAS Institute 1985) was performed on this seasonal mean for each insect and on the plot mean on the date when the insect population reached its peak. There were severe iron deficiency symptoms in some of the plants in the first experiment, so observations were made on each sample date as to the color of the leaves and the size of the sampled plants. Multiple regressions between numbers of selected insects and plant size and color were run to determine whether these influenced insect numbers (MGLH procedure, Wilkinson 1986).

A soil sample was taken from all plots in November. Five standard samples per plot were taken from the areas in between the rows, combined, and analyzed by the University of Guam soils laboratory. Yield was taken from the center two rows of each plot. All plants were harvested and the tops cut off. Corms were measured by passing them through a hole with a 5 cm diameter. Corms too large to pass through were considered marketable unless they were damaged or rotten, and they were assigned to a separate category. Data were analyzed by a three-way analysis of variance (PROC GLM, SAS Institute 1985).

The experiment was repeated in 1991 in Barrigada, Guam in a deep clay soil. The *sunin agaga* was planted in late July. The same treatments were repeated, but the plots were somewhat smaller, being only 4.25 m long (7 taro plants per row rather than 9). The plants in the fertilized blocks were fertilized at planting at the same rate as in the previous planting. The experimental design called for split fertilizer applications with the second half applied six weeks after planting, but the second fertilizer application was not made. Plots were weeded in the first week of September and again in October. The third weeding was done in the first week of December. Suckers were removed in October and December. Pigs entered the field in late December and consumed numerous plants. To estimate yields, all tops left lying in the plots were collected and the width of the plant at the base of the stem was measured. After harvest, a sample of 50 plants of various sizes were randomly selected from all plots. The corm was cut off and weighed, and the width of the base of the stem was measured. A regression was performed to provide a formula for estimating corm weight from the width of the base of the stems and used to estimate yields of plants eaten by pigs. Plants were harvested on January 13, 1992. Insects were sampled using the same methods as in 1990.

Results and Discussion

Yield

Yield for both experiments was relatively low. This was due in part because a six-month growing season was used and because small corms were used for planting material. The growing season is typical for unirrigated taro in the Marianas. In the first experiment on the shallow calcareous soil, all plants showed symptoms of iron deficiency. In two plots where limestone cobbles covered the surface, the plants were entirely white and eventually died. In other parts of the field, the plants were green with the yellow mottling that is typical of iron deficiency in taro. Marketable yield per plot ranged from 0 to 7,175 kg/ha. Multiple regression of marketable weight versus various soil constituents showed that only iron content was close to significantly correlate with yield (Table 1).

Table 1. Multiple correlation of marketable weight of taro versus soil constituents in 1990.

Parameter	Coefficient	*t*	*p*
Intercept	-6.041	-0.501	0.6
pH	0.917	0.596	0.6
Organic matter	-0.117	-0.590	0.6
Sodium	-0.052	-0.868	0.4
Potassium	0.025	0.894	0.4
Calcium	-0.000	-0.736	0.5
Magnesium	0.013	1.237	0.2
Phosphorus	0.263	0.263	0.3
Zinc	-0.003	-0.074	0.9
Iron	0.177	1.945	0.065
Manganese	-0.002	-0.289	0.8

Analysis of variance showed that marketable weight was significantly greater in fertilized plots than in unfertilized ones, but that desuckering the plants and the two late weedings had no influence on yield (Table 2).

Table 2. Marketable yield of taro in 1990.

Treatment	Marketable yield (kg)[a] Fertilized	Unfertilized
Suckers removed - weeded	2.7 ± 3.1	0.7 ± 0.5
Suckers not removed- weeded	1.8 ± 0.5	0.2 ± 0.3
Suckers removed- not weeded	3.2 ± 3.1	0.3 ± 0.6
Suckers not removed- not weeded	1.8 ± 1.3	0.9 ± 0.6
ANOVA	F	*p*
Fertilizer	9.71	0.005
Weeding	0.06	0.8
Suckers	0.82	0.4
Fertilizer x weeding	0.01	0.9
Fertilizer x suckers	1.09	0.3
Weeding x suckers	0.06	0.8

[a] Multiply by 996 to obtain kg/ha

Fig. 1 suggests that fertilizer had little effect on yield when soil iron levels were less than ca. 15-17 ppm, but above that level it more than doubled yield. According to the Guam Extension Service (F. Cruz, pers. comm.), farmers deal with this condition in their fields by failing to side-dress those plants which show these severe deficiency symptoms, thus acknowledging that they are never going to produce a yield.

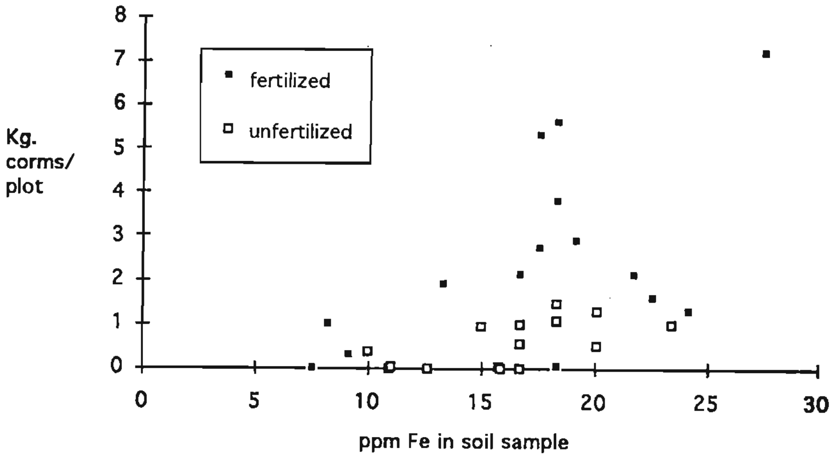

Fig. 1. Relationship between soil iron content and yield of fertilized and non-fertilized taro.

Table 3. Marketable yield, pig damage, and yield corrected for pig consumption of taro for 1991 experiment.

Treatment	Marketable yield (kg)[a] Fertilized	Marketable yield (kg)[a] Unfertilized	No. corms eaten by pigs Fertilized	No. corms eaten by pigs Unfertilized	Estimated yield (kg)[a] Fertilized	Estimated yield (kg)[a] Unfertilized
Suckers removed - weeded	1.3 ± 0.6	1.4 ± 1.1	4.8 ± 1.5	4.5 ± 3.3	2.5 ± 0.3	2.1 ± 1.2
Suckers not removed - weeded	2.3 ± 0.4	2.2 ± 0.7	2.5 ± 5.0	0.5 ± 1.0	2.9 ± 1.4	2.3 ± 0.6
Suckers removed - not weeded	2.3 ± 0.9	1.6 ± 0.7	0.0 ± 0.0	0.5 ± 1.0	2.3 ± 0.9	1.7 ± 0.6
Suckers not removed - not weeded	1.7 ± 0.7	1.4 ± 0.6	0.2 ± 0.5	0.0 ± 0.0	1.6 ± 0.7	1.5 ± 0.6
ANOVA	F	*p*	F	*p*	F	*p*
Fertilizer	0.83	0.4	0.40	0.5	2.20	0.15
Weeding	0.02	0.8	13.06	0.001	4.69	0.04
Suckers	0.83	0.4	14.19	0.052	0.03	0.9
Fertilizer x weeding	0.92	0.3	0.62	0.4	0.01	0.9
Fertilizer x suckers	0.15	0.7	0.62	0.4	0.05	0.8
Weeding x suckers	6.24	0.01	3.56	0.07	1.80	0.2

[a] Multiply by 1281 to obtain kg yield per hectare.

In the second experiment yields varied from 640 to 6,278 kg/ha among individual plots. Analysis of variance of the raw data showed no difference in yield among any of the treatments (Table 3). Heavy rainfall in August caused extensive sheet erosion in the plot and probably washed out all the fertilizer applied. A typhoon occurred in late November 1991, although it did not completely strip the plants as the storm in 1990 did. Pigs invaded the field about three weeks before harvest and consumed many corms. Pigs consumed significantly more corms in weeded plots than unweeded ones (Table 3) and apparently preferred desuckered plots to ones in which the suckers were left. The latter difference was marginally significant.

Corm base width and weight are significantly correlated, so this relationship was used to estimate the potential yield of plants eaten by the pigs. For the corrected data, yield was significantly higher for the weeded plots than the unweeded plots (Table 3). Fertilizer had no effect on yield in this experiment.

Effects of Cultural Practices on Insect Populations

Melon aphids (*Aphis gossypii*), taro planthoppers (*Tarophagus colocasiae,*) and taro hornworms (*Hippotion celerio*) were reasonably common, although populations were not high enough to be damaging to the plants. Cluster caterpillars (*Spodoptera litura*) were too rare to show any effects of treatment and are not further considered.

Taro hornworm

Damage by the taro hornworm was highest in the youngest plants and decreased as the plants became larger (Figs. 2 and 3). Overall damage by the taro hornworm never exceeded more than five percent of leaf tissue in a plot, although individual plants occasionally had heavy damage. The number of eggs per sample peaked about three months after planting in the 1990 trial. In 1991, populations were highest earlier when the plants were small. Later, the eggs were heavily parasitized (mostly by *Trichogramma* sp., presumed to be *T. chilonis*) and a few caterpillars were seen. None of the treatments had any significant effect on the number of eggs found per plant (Tables 4 and 5). In 1990 in the October 1 sample, eggs were most abundant on green plants (0.59 ± 0.78 eggs per sample), intermediate on yellow-green plants (0.19 ± 0.46), and least abundant on yellow plants (0.17 ± 0.41). The difference was significant $F = 14.81$, $df = 2, 291$ $p = 0.001$). No record of plant size was kept until October 15, so it cannot be determined whether this was a response to plant color or to plant size. The correlation between hornworm eggs and plant size was reexamined on October 29, and no association between plant size or plant color and the number of eggs present was found. In 1991, no significant correlation between the index of plant size and the number of eggs present on the plants was observed. In 1991, all plants were uniformly green and did not show any symptoms of iron deficiency.

Melon Aphids

In 1990, aphid numbers were very low and peaked on October 15, about three months after the taro was planted (Fig. 4). Ladybeetle larvae, primarily *Menochilus sexmaculatus*, and syrphid larvae, *Ischiodon scutellaris*, were present and probably kept aphid numbers low. There

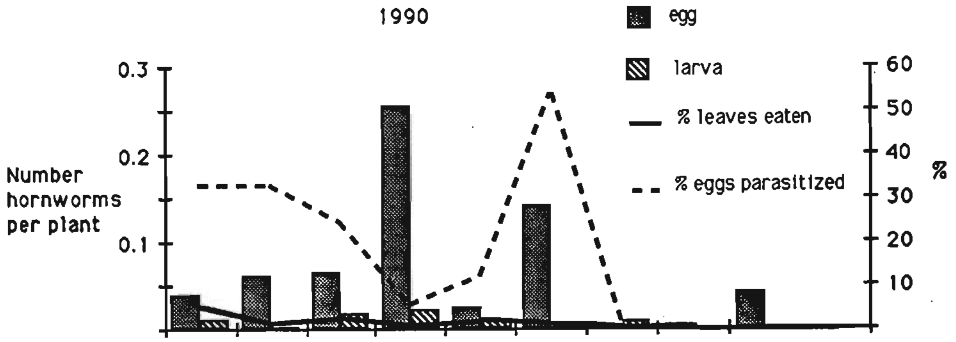

Fig. 2. Population trend of taro hornworm eggs and larvae (bars), proportion of hornworm eggs parasitized, and percent of taro foliage consumed by chewing insects in 1990 (lines).

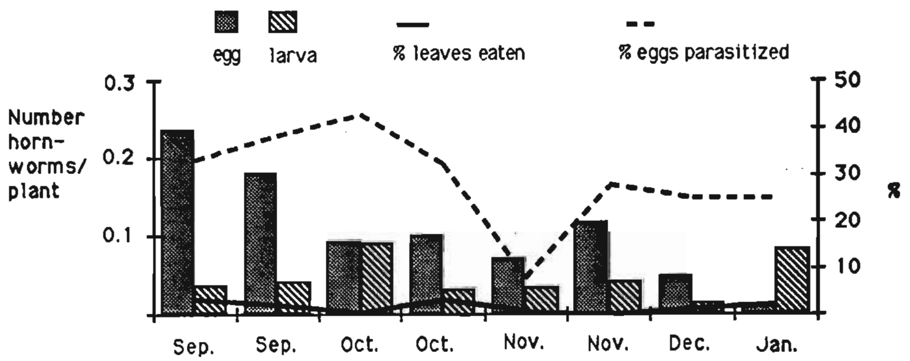

Fig. 3. Population trend of taro hornworm eggs and larvae (bars), proportion of hornworm eggs parasitized, and percent of taro foliage consumed by chewing insects in 1991 (lines).

Table 4. Number of hornworm eggs per plant in 1990.

	Number hornworm eggs per plant			
	Peak population		Seasonal mean	
Treatment	Fertilized	Unfertilized	Fertilized	Unfertilized
Suckers removed - weeded	0.25 ± 0.30	0.15 ± 0.13	0.12 ± 0.08	0.07 ± 0.01
Suckers not removed - weeded	0.25 ± 0.10	0.15 ± 0.10	0.11 ± 0.12	0.04 ± 0.03
Suckers removed - not weeded	0.20 ± 0.16	0.02 ± 0.05	0.09 ± 0.06	0.09 ± 0.04
Suckers not removed - not weeded	0.45 ± 0.24	0.55 ± 0.37	0.13 ± 0.05	0.14 ± 0.10

Table 5. Number of hornworm eggs per plant in 1991.

	Number hornworm eggs per plant			
	Peak population		Seasonal mean	
Treatment	Fertilized	Unfertilized	Fertilized	Unfertilized
Suckers removed - weeded	0.20 ± 0.08	0.05 ± 0.06	0.12 ± 0.02	0.12 ± 0.06
Suckers not removed - weeded	0.10 ± 0.08	1.08 ± 0.09	0.10 ± 0.04	0.13 ± 0.02
Suckers removed - not weeded	0.32 ± 0.21	0.40 ± 0.34	0.11 ± 0.04	0.13 ± 0.05
Suckers not removed - not weeded	0.12 ± 0.09	0.07 ± 0.09	0.16 ± 0.06	0.12 ± 0.06

were no significant treatment effects on aphid populations (Table 6). No association between plant size or plant color was seen in the October 15 sample, but in the October 29 sample aphid numbers were highest on the largest plants. Plant color had no effect. Ladybeetle and syrphid numbers were too low to perform statistical analysis. Aphids were more abundant in 1991 than in the previous year. They peaked at slightly over 20 aphids in the sample area on September 17 (Fig. 5). At this time, aphid predators were also most abundant. Two weeks later, aphid populations crashed and remained low for the remainder of the experiment. The cause of the crash was probably an epizootic of fungal disease rather than the action of predators. If the entire season is considered, aphids were more abundant in fertilized plots. However, at the time of the peak population, there was no significant differences between treatments (Table 7). For the two dates analyzed, there was a significant positive correlation between number of aphids present and the index of plant size. The meaning of this is unclear, however, since the area of the leaves and the sample area also increase with plant size and the increase in the population of aphids was proportional to the increased area. This suggests that larger leaves have more aphids, but not more aphids per unit area. On the date when aphid predators were most abundant, no treatment effects were found (Table 8).

Table 6. Mean number of aphids per sample and analysis of variance in 1990.

	Number aphids per plant			
	Peak population		Seasonal mean	
Treatment	Fertilized	Unfertilized	Fertilized	Unfertilized
Suckers removed - weeded	0.3 ± 0.6	0.2 ± 0.4	0.1 ± 0.1	0.1 ± 0.1
Suckers not removed - weeded	0.6 ± 1.0	1.3 ± 0.8	1.1 ± 1.8	1.2 ± 1.6
Suckers removed - not weeded	3.5 ± 4.1	6.1 ± 10.2	0.4 ± 0.4	0.2 ± 0.3
Suckers not removed - not weeded	0.6 ± 1.1	0.8 ± 1.0	1.7 ± 1.6	0.6 ± 0.4
ANOVA	F	*p*	F	*p*
Fertilizer	0.37	0.5	0.66	0.4
Weeding	2.44	0.13	0.03	0.9
Suckers	1.56	0.2	6.66	0.02
Fertilizer x weeding	0.14	0.7	0.84	0.38
Fertilizer x suckers	0.08	0.3	0.37	0.5.
Weeding x suckers	2.97	0.1	0.14	0.7

Table 7. Number of aphids per sample and analysis of variance for 1991.

	Number aphids per plant			
	Peak population		Seasonal mean	
Treatment	Fertilized	Unfertilized	Fertilized	Unfertilized
Suckers removed - weeded	22 ± 18	25 ± 14	0.6 ± 0.4	0.3 ± 0.2
Suckers not removed - weeded	25 ± 14	11 ± 4	0.6 ± 0.4	0.3 ± 0.2
Suckers removed - not weeded	13 ± 9	26 ± 18	1.1 ± 1.5	0.2 ± 0.3
Suckers not removed - not weeded	24 ± 20	26 ± 12	0.6 ± 0.5	0.5 ± 0.3
ANOVA	F	*p*	F	*p*
Fertilizer	0.03	0.9	4.43	0.04
Weeding	0.10	0.8	0.02	0.9
Suckers	0.00	0.9	0.02	0.9
Fertilizer x weeding	2.51	0.2	0.08	0.8
Fertilizer x suckers	1.96	0.2	0.00	1.0
Weeding x suckers	1.12	0.7	0.66	1.4

Table 8. Number of aphid predators per ten plants on the date when predator numbers were highest.

	Coccinellidae		Syrphidae	
Treatment	Fertilized	Unfertilized	Fertilized	Unfertilized
Suckers removed - weeded	0.7 ± 0.5	2.0 ± 3.3	5.7 ± 4.6	5.0 ± 1.6
Suckers not removed - weeded	1.2 ± 1.2	1.2 ± 1.5	5.5 ± 1.3	3.0 ± 3.1
Suckers removed - not weeded	1.5 ± 1.0	3.0 ± 4.7	3.0 ± 4.8	3.2 ± 2.7
Suckers not removed - not weeded	0.7 ± 0.9	3.5 ± 5.1	5.2 ± 5.0	2.5 ± 2.4

Taro planthoppers

Taro planthoppers were the most common insects. Although data for nymphs and adults were recorded separately, no consistent differences between them were noted, so they were combined for analysis. In 1991, populations reached seven per sample by October 15 and remained at that level (Fig. 6). Over the crop season in 1991, taro planthopper numbers were generally lower than in 1990 (Fig. 7), although they reached a higher peak (12 per leaf) than in the previous year. In 1991, planthoppers were significantly more abundant on fertilized plants at the peak population and for the entire season (Table 9). The presence of weeds and the density of plants as altered by the number of suckers present had no effect on taro planthopper numbers. The greater number of planthoppers on fertilized taro plants was primarily due to the larger size of the fertilized plants. Multiple regression

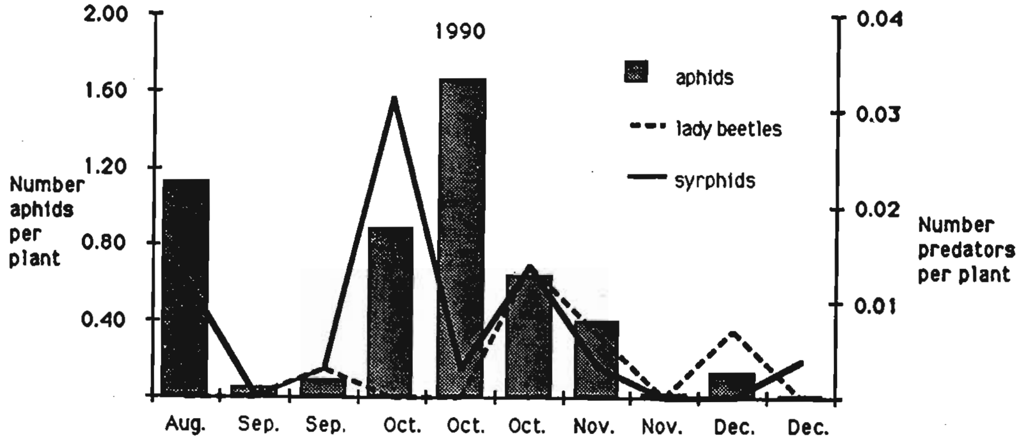

Fig. 4. Population trends of aphids (bars) and aphid predators (lines) in 1990.

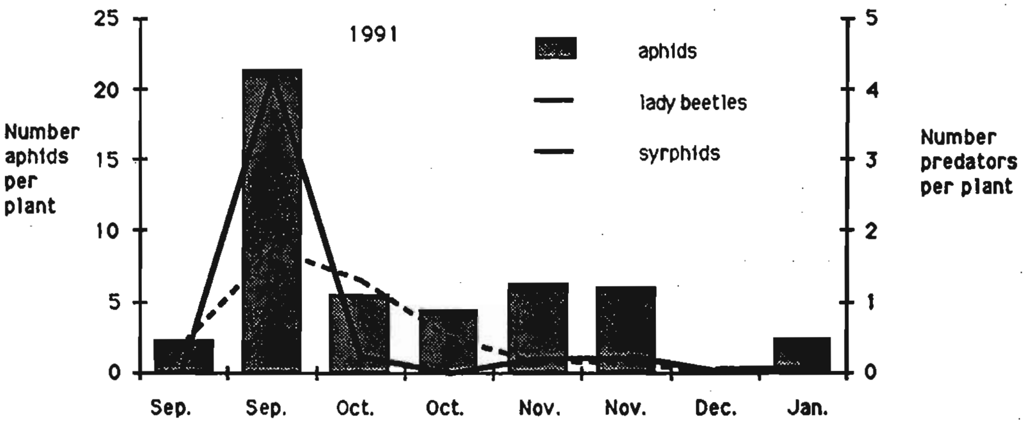

Fig. 5. Population trends of aphids (bars) and aphid predators (lines) in 1991.

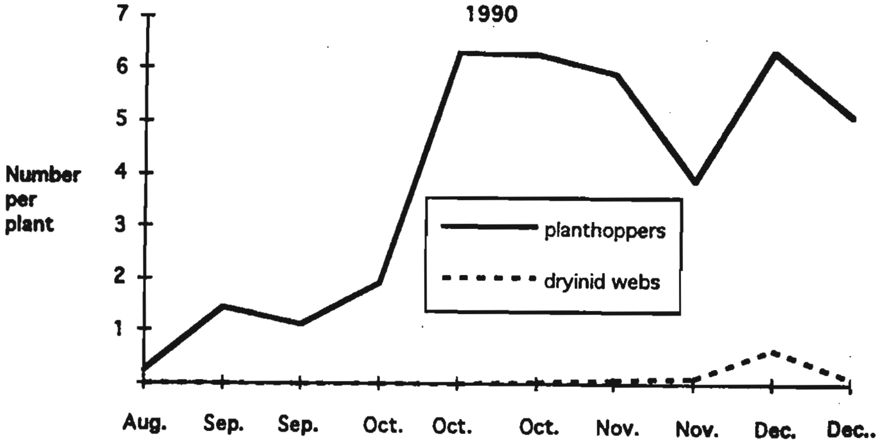

Fig. 6. Population trends of taro planthoppers and their parasites in 1990.

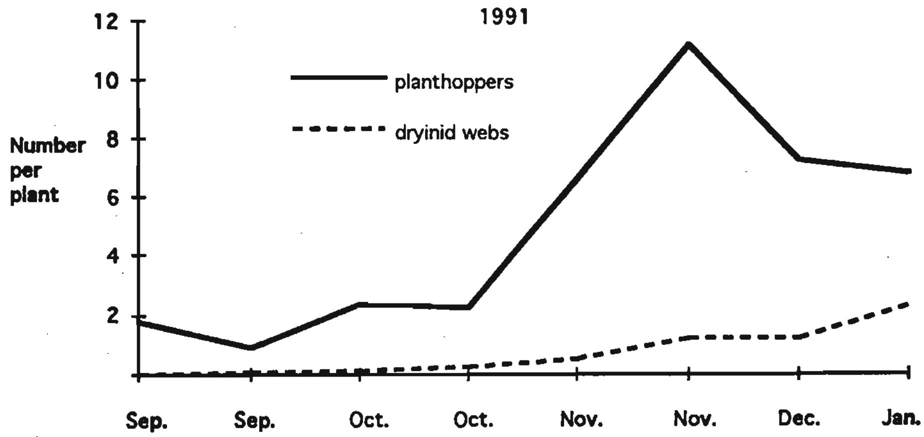

Fig. 7. Population trends of taro planthoppers and their parasites in 1991.

of number of planthoppers versus plant size, plant color, and whether or not the plant had been fertilized showed that in general and showed that only plant size was significantly associated with population size of taro planthoppers. On one date, October 15, 1991, plant color and fertilizer status was significantly associated with planthopper population size, but on the other dates no association was found suggesting that the effect was not really meaningful. In 1991, none of the treatments affected planthopper numbers (Table 10). On the three 1991 dates analyzed, there was a significant correlation between plant size and the number of planthoppers present. The only parasites or predators of taro planthoppers observed were dryinids. The number of webs on leaves, an index of their abundance, showed that they became more abundant later in the season (Figs. 6 and 7). Only a small fraction of the webs were reared, but these showed that 80 percent or more of the dryinids were hyperparasitized.

Table 9. Mean number of taro planthoppers per sample and analysis of variance in 1990.

	Number taro planthoppers per plant			
	Peak population		Seasonal mean	
Treatment	Fertilized	Unfertilized	Fertilized	Unfertilized
Suckers removed - weeded	21 ± 15	0.2 ± 0.4	2.6 ± 2.9	1.1 ± 1.6
Suckers not removed - weeded	10 ± 7	3 ± 4	6.7 ± 7.6	2.8 ± 4.8
Suckers removed - not weeded	11 ± 8	4 ± 8	4.2 ± 3.1	1.1 ± 0.8
Suckers not removed - not weeded	7 ± 10	1 ± 1	8.9 ± 5.4	1.2 ± 1.2
ANOVA	F	*p*	F	*p*
Fertilizer	11.86	0.003	8.13	0.009
Weeding	0.65	0.5	0.15	0.7
Suckers	1.38	0.3	3.64	0.07
Fertilizer x weeding	1.78	0.2	0.93	0.4
Fertilizer x suckers	1.38	0.3	1.51	0.3
Weeding x suckers	0.01	0.9	0.03	0.9

Table 10. Number of taro planthoppers per sample and analysis of variance for 1991.

Treatment	Number taro planthoppers per plant: Peak population, Fertilized	Unfertilized	Seasonal mean, Fertilized	Unfertilized
Suckers removed - weeded	14 ± 26	11 ± 17	4.7 ± 3.0	3.6 ± 2.7
Suckers not removed - weeded	7 ± 10	5 ± 7	4.1 ± 4.0	4.3 ± 2.2
Suckers removed - not weeded	17 ± 17	6 ± 8	6.6 ± 4.9	5.6 ± 4.2
Suckers not removed - not weeded	9 ± 15	20 ± 37	4.6 ± 3.6	5.3 ± 4.6
ANOVA	F	*p*	F	*p*
Fertilizer	0.02	0.9	0.05	0.8
Weeding	0.28	0.6	1.08	0.3
Suckers	0.05	0.8	0.19	0.7
Fertilizer x weeding	0.02	0.9	0.01	0.9
Fertilizer x suckers	0.65	0.4	0.31	0.6
Weeding x suckers	0.47	0.5	0.24	0.7

Conclusions and Recommendations

Data were inconclusive on the usefulness of fertilizer with the variety *sunin agaga*. In the first experiment, fertilizer only increased yields when iron content of the soil (as measured by standard soil test) was greater than 15 to 17 ppm. In the second experiment, no fertilizer-induced increase in yield was seen, possibly because of heavy rains and leaching. This suggests that at least in the rainy season on Guam there is no point of applying fertilizer at planting when the suckers lack roots as the fertilizer will leach out of the soil by the time the plant is growing.

The only herbivores that were affected by the experimental factors were pigs. Pigs removed taro that was laid out in clean rows with no obstructing vegetation and avoided plots that were thick with weeds or suckers.

None of the cultural practices had any significant effects on the insects at the pest densities observed in these experiments. Most of the insects appeared to be under good control by natural enemies at least during the rainy season. Aphids can become very abundant on some plantings in the dry season when fungus epidemics are not prevalent. Taro planthoppers were not a problem in these plantings. The egg predator *Cyrtorhinus fulvus* of taro planthoppers does not appear to be present on Guam anymore. It had been introduced in the 1950s and became established (Pemberton 1954). It may have gone extinct because taro culture has become an occasional practice on Guam, and continuous cultures of plantings with planthoppers are not readily available to the predators. One area, the Agana swamp, now has a continuous taro field maintained by Palauan immigrants. Considerable damage due to planthoppers was observed in this field during the Guam RRA. Other farmers who have grown taro continuously in the last few years have also experienced severe planthopper problems. It may be worth reintroducing the egg predator to Guam in the Agana swamp.

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