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ANTHURIUM CULTURE

With Emphasis on the Effects of Some Induced Environments on Growth and Flowering

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INTRODUCTION

Efficiency in growth and flowering of the anthurium plant depends upon a number of factors, of which growing medium and sunlight level may be considered the two most important factors. Media tests conducted some years ago (2) indicated that anthuriums may be grown successfully in a number of materials, when properly used. The factor of availability is a determinant for large-scale use of the materials tested, and since woodshavings and/or bagasse are readily available on all the major islands of Hawaii, these media were singled out for further testing. Results of the tests involving woodshavings in various mixtures have already been published *(3)*.

This paper gives the results of testing bagasse as a medium for growing anthuriums. Also included in this paper are results from experiments showing the effects of various levels of sunlight intensity, a factor equally as important as the growing medium.

In order to develop a broad understanding of the nature of the anthurium plant, especially with respect to the cultural aspects, several other factors which might affect growth and flowering were also investigated and the results are presented herein.

MATERIALS AND METHODS

Because of the independent nature of several experiments discussed in this paper, materials and methods will be presented together with the results for each experiment, except for methods or materials which are common to all experiments.

In all experiments, plants were set into the experimental plots and grown for several months before data were accumulated. Data consisted of measurements of length of flower stem, spathe size, and flower production. Length of flower stem was measured in inches from the base of the stem to the point of attachment to the spathe. Spathe size is presented as the product of the length and the width, and flower production was measured by recording the date of spathe unfurling. The number of flowers per plant per year was calculated by dividing the mean number of weeks between flowering into 52 weeks. Anthurium flower, as used in this paper, refers to the spathe and spadix complex and not to the true botanical flower, which is very small and found in large quantities on the spadix.

Fertilizer used in all experiments was the Orchid Organic Fertilizer (6-14-7.5 with 8.7 CaO), formerly known as the Anthurium Fertilizer.

Completed data were summarized and subjected to the conventional variance analysis method and where more than two treatment means were compared, Duncan's (*1*) multiple range and F test was used to delimit differences between means.

EXPERIMENTAL RESULTS

Effects of Bagasse as a Cultural Medium

It was mentioned earlier that bagasse was found to be a good medium for growing anthuriums and it is available in quantity wherever sugar cane factories are located. Since the bagasse utilized in the previous test was well decomposed, the question arose whether fresh bagasse would be equally as satisfactory for growing these plants, and the experiment reported herein was designed to test the effects of bagasse in different stages of decomposition.

Since fresh bagasse was obtainable at almost any time from the local sugar plantations, treatments consisting of four stages of decomposition (fresh, 5, 9, and 13 months old) were selected and combined with three fertilizer levels; namely, no fertilizer, 1 teaspoon Orchid Organic Fertilizer per plant per month, and the same amount per plant per 2 months. For controls, the standard woodshavings-manure mixture (5:1) was used with the same fertilizer variables as imposed upon the bagasse. Woodshavings used here were well decomposed. The various medium-fertilizer combinations are listed in table 1, for convenient reference, with their assigned symbols and treatment means for the three criteria measured.

Ten single-plant replicates of the variety *Kaumana* were completely randomized. As the media became depleted in the course of the experiment, each pot was replenished with medium at the appropriate stage of decomposition.

Table 1. Summary of 15 media treatments, with treatment means for stem length, spathe size, and flower production for variety *Kaumana*

TREATMENT SYMBOL	TREATMENT	TREATMENT MEANS* Stem Length (inches)	Spathe Size L × W (inches)	Number of Flowers/Plant/Year
A0	Fresh bagasse, no fertilizer	15.2	8.2	3.5
A1	Fresh bagasse, 1 tsp. fert./month	21.6	14.5	5.4
A2	Fresh bagasse, 1 tsp. fert./2 months	19.1	10.7	5.2
B0	5-month-old bagasse, no fertilizer	16.1	9.6	3.6
B1	5-month-old bagasse, 1 tsp. fert./month	20.3	13.0	5.2
B2	5-month-old bagasse, 1 tsp. fert./2 months	18.5	10.7	5.0
C0	9-month-old bagasse, no fertilizer	19.3	9.7	4.0
C1	9-month-old bagasse, 1 tsp. fert./month	22.8	15.9	5.7
C2	9-month-old bagasse, 1 tsp. fert./2 months	22.2	14.1	5.3
D0	13-month-old bagasse, no fertilizer	19.8	12.0	4.5
D1	13-month-old bagasse, 1 tsp. fert./month	21.6	15.1	5.4
D2	13-month-old bagasse, 1 tsp. fert./2 months	19.1	12.3	5.1
E0	Control: woodshavings-manure 5:1, no fertilizer	23.2	14.2	5.5
E1	Control: woodshavings-manure 5:1, 1 tsp. fert./month	23.7	15.8	5.9
E2	Control: woodshavings-manure 5:1, tsp. fert./2 months	24.0	15.9	6.1

*See table 2 for statistical significance of difference between treatment means.

Plants were set into the various media in July, 1956, and data taking was initiated in September, 1957, and terminated in June, 1958.

Data on mean flower stem length, spathe size, and number of flowers per plant per year for 15 treatments are presented in ranked order in table 2.

Mean stem length—Considering the treatment means for stem length only, it is clearly shown that relatively fresh bagasse without fertilizer induced poor stem elongation. Five months of decomposition of the bagasse appear also to be inadequate for providing good stem elongation. However, there seems to be some improvement in the elongation of stem length with further decomposition, even without fertilizer, as indicated by the mean stem length for treatment C0 (9 months, no fertilizer) and D0 (13 months, no fertilizer).

Fresh bagasse with fertilizer appears to be as good as the decomposed material, as shown by treatment means for A1 (fresh bagasse, 1 tsp. per month). C1 and C2 (9 months, 1 tsp. per month; and 9 months, 1 tsp. per 2 months, respectively) gave the best results among the bagasse series, although statistically there was no difference even between A1 (fresh bagasse with 1 tsp. fertilizer per month) and D1 (13 months, 1 tsp. fertilizer per month).

The woodshavings-manure control series gave the best performance whether additional fertilizer was added or not. However, there was no statistical difference between the woodshavings-manure series and the best of the bagasse series.

Mean spathe size—For mean spathe size, fresh bagasse without fertilizer was again the poorest medium, followed by 5-month-old bagasse without fertilizer. In fact, bagasse at all stages of decomposition without fertilizer gave poor results, although statistically they did not differ from B2 and D2 (5- and 13-month-old bagasse with 1 tsp. fertilizer per 2 months).

As with stem length, 9-month-old bagasse, fertilized monthly, gave results as satisfactory as with the woodshavings-manure control series. The bagasse series, regardless of decomposition, when fertilized monthly, induced a significant increase in spathe size over those fertilized once every 2 months. The difference between lowest and highest treatment means was almost 2 times, which indicates that spathe size is highly responsive to fertilizer application.

Flower production—Flower production was poorest for unfertilized bagasse at all stages of decomposition, followed by those fertilized once every 2 months. Again, with monthly application of fertilizer, even fresh bagasse gave satisfactory results, indicating the importance of regular fertilizer applications. The woodshavings-manure series gave the best results, although not statistically different from bagasse treatments with monthly fertilizer application.

TABLE 2. Results of bagasse-fertilizer experiment, showing treatment means in ranked order for stem length, spathe size, and number of flowers per plant per year (variety *Kaumana*)

TREATMENTS*	A0	B0	B2	D2	A2	C0	D0	B1	D1	A1	C2	C1	E0	E1	E2
Mean stem length	15.2	16.1	18.5	19.1	19.1	19.3	19.8	20.3	21.6	21.6	22.2	22.8	23.2	23.7	24.0

NOTE: Means not underscored by the same line are significantly different at the 1 percent level.

TREATMENTS	A0	B0	C0	A2	B2	D0	D2	B1	C2	E0	A1	D1	E1	C1	E2
Mean spathe size (L × W)	8.2	9.6	9.7	10.7	10.7	12.0	12.3	13.0	14.1	14.2	14.5	15.1	15.8	15.9	15.9

NOTE: Significance level same as above.

TREATMENTS	A0	B0	C0	D0	B2	D2	B1	A2	C2	A1	D1	E0	C1	E1	E2
Mean number of flowers	3.5	3.6	4.0	4.5	5.0	5.1	5.2	5.2	5.3	5.4	5.4	5.5	5.7	5.9	6.1

NOTE: Significance level same as above.

*For actual treatments represented by the treatment symbols, see table 1.

Effects of Leaf Pruning

A general practice of anthurium growers is to include three or four leaves with each dozen flowers delivered to the florist or consumer. Excessive pruning of the leaves for this purpose may be detrimental to the plant in subsequent growth and flowering. For this reason it was considered important to determine the least number of leaves necessary for a plant to perform satisfactorily.

A leaf-pruning experiment consisting of retaining two, three, four, five, and six leaves per plant, and an unpruned plant, was designed and initiated in January, 1957, on the Manoa campus. Five plants each per plot of two commercial varieties, *Kaumana* and *Nitta*, were planted in cement pots in July, 1956, and set randomly on the benches in the lathhouse. Plants were grown in woodshavings-manure mixture (5:1) and fertilized with Orchid Organic Fertilizer at the rate of 1 tablespoon per plant per 2 months.

Actual leaf pruning was initiated approximately 6 months after planting date, and initial recording of data began 3 months after leaf pruning was initiated. The required number of leaves per plant was maintained throughout the experimental period by pruning the oldest leaves on the dates set aside for recording new flowers.

In tables 3 and 4 are presented the treatment means in ranked order for mean flower stem length, spathe size, and flower production of *Kaumana* and *Nitta* varieties.

Mean stem length—According to the data on stem length in tables 3 and 4, both varieties were affected in a similar manner. In both varieties, retention of only two or three leaves per plant significantly reduced the length of the stem. Unpruned plants produced the longest flower stems, but statistically the difference in stem length for plants with four, five, and six leaves per plant was not significant.

Mean spathe size—The data for spathe size for both varieties again showed similar trends. Size of the spathe was significantly reduced in plants having only two or three leaves. Unpruned plants gave larger flowers, although not differing statistically from plants having five and six leaves. The data for both varieties indicate that optimum size of flowers may be obtained with a minimum of five leaves.

Flower production—Flower production appears to be less sensitive to effects of different number of leaves retained on the plant. In the case of variety *Nitta*, although there was no statistical difference between any of the treatments imposed, plants with two leaves produced the least number of flowers. For the variety *Kaumana*, the mean number of flowers, 4.7 flowers per plant per year, for plants with two leaves, was significantly less

TABLE 3. Effects of different number of leaves retained on anthurium plants upon stem length, spathe size, and flower production (variety *Kaumana*)

	Number of leaves left on plant					
PRUNING TREATMENTS	2	3	4	5	6	Unpruned
Mean flower stem length in inches	20.3	21.8	23.9	24.7	25.4	25.9

NOTE: Means not underscored by the same line are significantly different at the 5 percent level.

	Number of leaves left on plant					
PRUNING TREATMENTS	2	3	4	5	6	Unpruned
Mean spathe size (L × W)	11.8	13.3	15.4	16.2	16.8	17.7

NOTE: Statistical treatment same as above.

	Number of leaves left on plant					
PRUNING TREATMENTS	2	4	6	5	3	Unpruned
Mean number of flowers per plant per year	4.7	5.5	5.7	5.8	5.8	5.9

NOTE: Statistical treatment same as above.

than the means for other treatments. There were no statistical differences among all other treatments.

Effects of Different Shade Levels

It is a well-established fact that anthurium plants do not thrive well under high light intensity and that some shade must be provided for satisfactory growth and flowering. Since experimental evidence relative to the degree of shade necessary for optimum performance is lacking, an experiment was designed to determine the relative degree of shade best suited for growth and flowering of the anthurium.

For this purpose, a saran clothhouse (see fig. 1) providing four shade levels (75, 63, 47, and 30 percent actual shade) and a lathhouse with two shade levels (75 and 65 percent shade at midday) were used. The shade levels in the saran clothhouse were induced by different-meshed saran cloth which provided the same relative shade at each level throughout the day.

TABLE 4. Effects of different number of leaves retained on anthurium plants upon stem length, spathe size, and flower production (variety *Nitta*)

PRUNING TREATMENTS	NUMBER OF LEAVES LEFT ON PLANT					
	2	3	6	4	5	Unpruned
Mean flower stem length in inches	23.0	24.0	25.4	25.8	26.0	26.8

NOTE: Means not underscored by the same line are significantly different at the 5 percent level.

PRUNING TREATMENTS	NUMBER OF LEAVES LEFT ON PLANT					
	2	3	4	6	5	Unpruned
Mean spathe size (L × W)	14.1	15.7	18.7	19.5	19.9	20.0

NOTE: Means not underscored by the same line are significantly different at the 1 percent level.

PRUNING TREATMENTS	NUMBER OF LEAVES LEFT ON PLANT					
	2	6	4	3	Unpruned	5
Mean number of flowers per plant per year	5.1	5.4	5.4	5.6	5.6	5.8

NOTE: Means underscored by the same line are not significantly different.

The lathhouse shade percentages were taken at midday and shade was provided by calculated spacing of 1 × 3 laths.

Ten plants per treatment of the variety *Kaumana* were planted individually in cement pots and randomized on benches under each of the shade levels. All plants were grown in woodshavings-manure mixture (5:1) and fertilized with Orchid Organic Fertilizer at the rate of 1 tablespoon per plant every 2 months. Recording of data was initiated approximately 6 months after planting and was continued for 1 complete year.

Mean flower stem length—In table 5 are presented the six treatment means in ranked order for the three categories measured. Flower stem length was positively associated with the degree of shade. Shortest stems were found in the lightest shade, and with an increase in shade, there was a corresponding increase in length. Figure 2 shows flower stem length

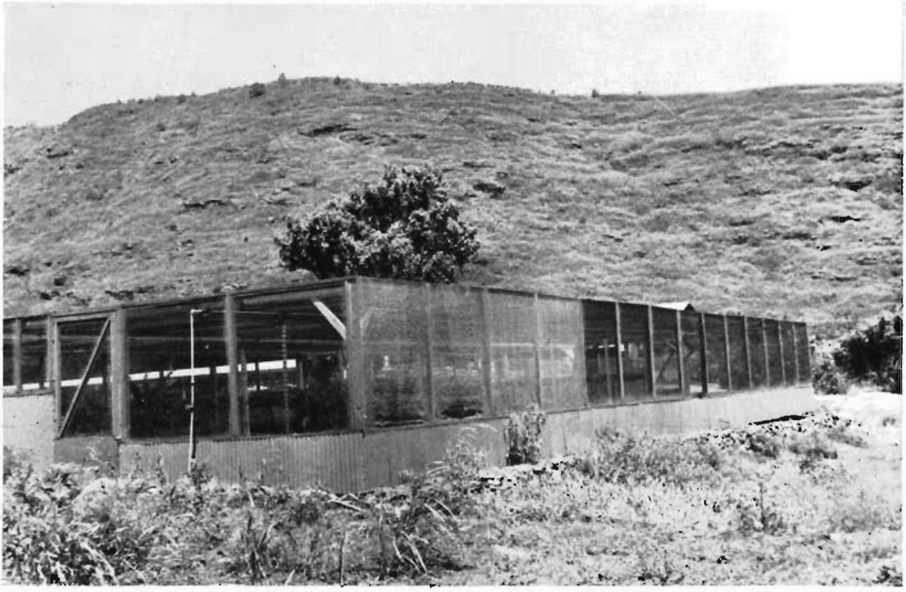

FIGURE 1. Saran clothhouse with four shade levels: 30, 47, 63, and 75 percent shade.

under four shade levels in the saran clothhouse. The treatment mean for the 30 percent shade was the only one significantly different from the others. However, in practical terms, the range of shade level provided by 63 to 75 percent appears to be desirable for stem elongation.

The stem length for the 75 percent shade (lathhouse) was slightly longer than for the same shade level in the saran clothhouse. This may be explained on the basis that the lathhouse shade was 75 percent only at midday and slightly shadier at other times of the day. However, this difference was not statistically significant.

Mean spathe size—Data for mean spathe size presented in table 5 indicate significant difference only between the two extremes, 30 and 75 percent shade levels. Practically, this difference of 2.4 is rather small. Spathe size does not appear to be influenced greatly by the light intensities imposed upon this variety in this experiment.

Mean flower production—The treatment means for mean number of flowers per plant per year, given in table 5, show a reversed trend. In general, there was a reduction in flower production with increase in shade. The mean number of 4.7 flowers per plant per year under 75 percent shade (lathhouse) is significantly less than the mean numbers for 75, 30, and 47

TABLE 5. Treatment means in ranked order for stem length, spathe size, and interval between flowering for plants exposed to different sunlight intensities (variety *Kaumana*)

	SHADE LEVELS IN PERCENT					
SHADE TREATMENTS	30	47	63	65*	75	75*
Flower stem length (inches)	16.8	19.2	21.4	22.2	22.8	23.1

NOTE: Means not underscored by the same line are significantly different at the 1 percent level.

	SHADE LEVELS IN PERCENT					
SHADE TREATMENTS	30	65*	75*	63	47	75
Mean spathe size (L × W)	19.3	20.0	20.0	20.7	20.8	21.7

NOTE: Significance level same as above.

	SHADE LEVELS IN PERCENT					
SHADE TREATMENTS	75*	65*	63	75	30	47
Mean number of flowers per plant per year	4.7	4.9	5.4	5.8	5.8	6.0

NOTE: Means not underscored by the same line are significant at the 5 percent level.

*Shade levels in lathhouse.

percent shade levels in the saran clothhouse. Sixty-five percent shade in the lathhouse also gave poor results. The fact that the same variety grown in the same kind of medium and in the same shade level in the lathhouse for the media test (see table 1, treatment E2, flower production) produced an average of six flowers per plant per year indicates that some unknown factor or factors affected the growth of the plants adversely in the lathhouse-grown plants for the light intensity study.

Considering the flower production for the shade levels in the saran clothhouse only, there appears to be an increase in production with increase in light intensity. However, the quality of the plants and flowers is affected adversely. Under 30 and 47 percent shade, plants appeared stunted with yellow and occasionally burnt leaves. This is clearly shown in figure 3.

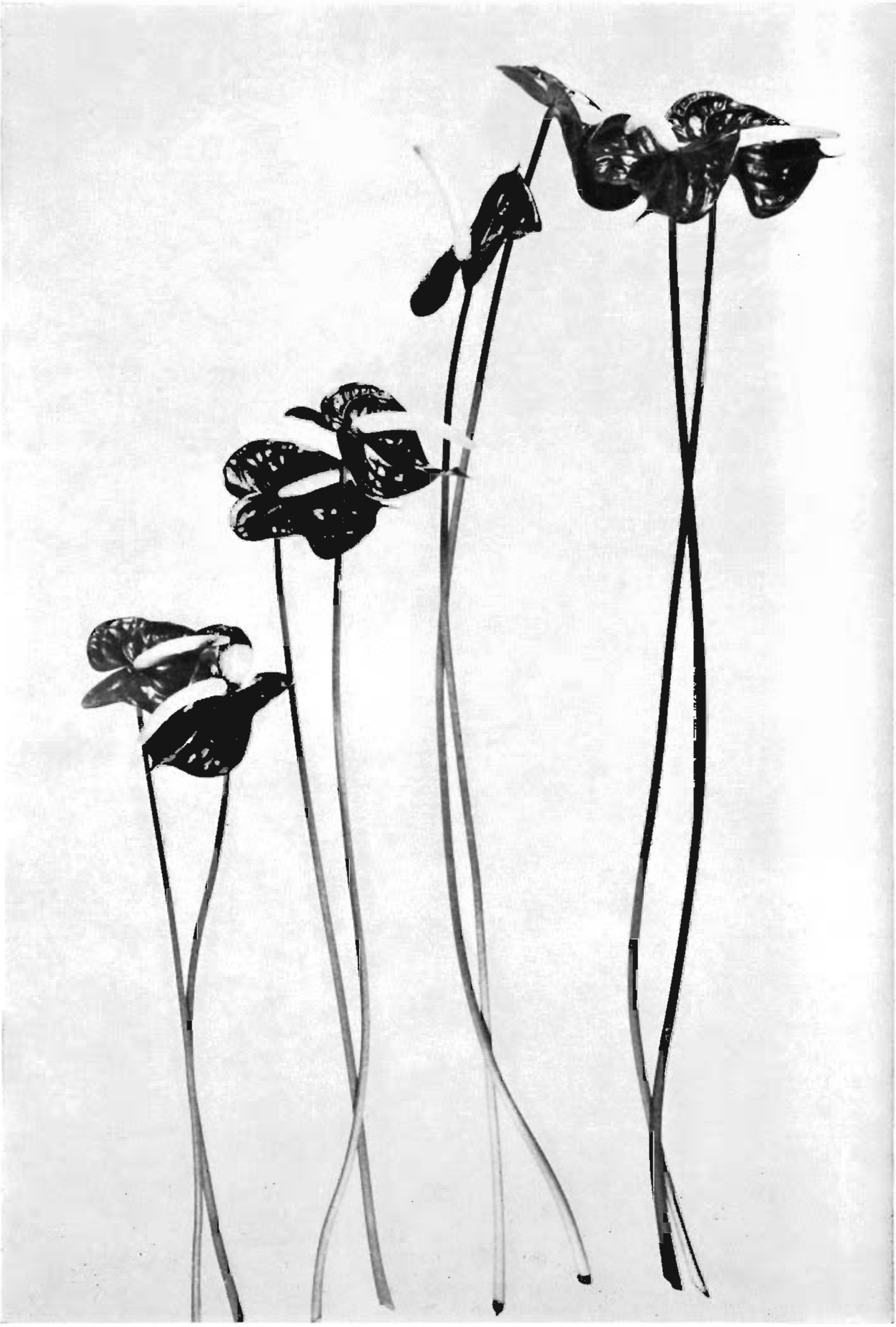

FIGURE 2. Differences in flower stem length induced by the four shade levels in the saran clothhouse. *Left to right:* 30, 47, 63, and 75 percent shade, respectively.

This photograph was taken during the winter months when less burning occurs. The older leaves of plants in the 30 and 47 percent shade show burnt effects. Although not shown in the photograph, spathe color was somewhat affected with loss of gloss, especially in the 30 percent shade.

Effects of Gibberellic Acid on Growth and Flowering

Gibberellic acid has been shown to stimulate growth and flowering of many plants. Based on the premise that if anthurium plants could be stimulated to grow more rapidly in terms of leaf production, then flower production would also be increased.

To determine the actual effects of gibberellic acid on anthurium, an experiment consisting of four concentrations and two frequencies of application was initiated. Concentrations of 10, 25, 50, and 100 ppm were applied once and four times at monthly intervals. Each treatment consisted of ten relatively uniform plants grown individually in cement pots randomized on benches in the lathhouse under 67 percent shade. These plants were grown in woodshavings-manure mixture (5:1) for several months before application of treatments.

Data accumulated over a period of 5 months are summarized and presented in table 6. Variance analysis showed no real differences between treatment means for the three characters measured.

TABLE 6. Treatment means for stem length, spathe size, and flower production of plants treated with gibberellic acid (variety *Kaumana*)

	ONE APPLICATION					MONTHLY			
	Concentration (ppm)								
	Check	10	25	50	100	10	25	50	100
Stem length (in.)	25.8	25.4	26.1	26.5	26.3	26.5	26.9	26.9	25.8
Spathe size (sq. in.)	19.6	20.1	20.5	21.3	20.1	19.9	19.0	21.6	21.2
Flower production (Per plant per year)	5.2	5.2	4.9	5.5	5.0	5.0	5.1	4.8	5.3

NOTE: No significant difference between means for all categories.

Average stem length of the check plants was no different from the mean length of any treatment. Plants sprayed four times showed no increase in elongation over plants sprayed only once.

Gibberellic acid at the concentrations and frequencies used in this experiment did not increase the size of the spathes. Flower production was also unaffected by any of the treatments imposed under the conditions of this experiment.

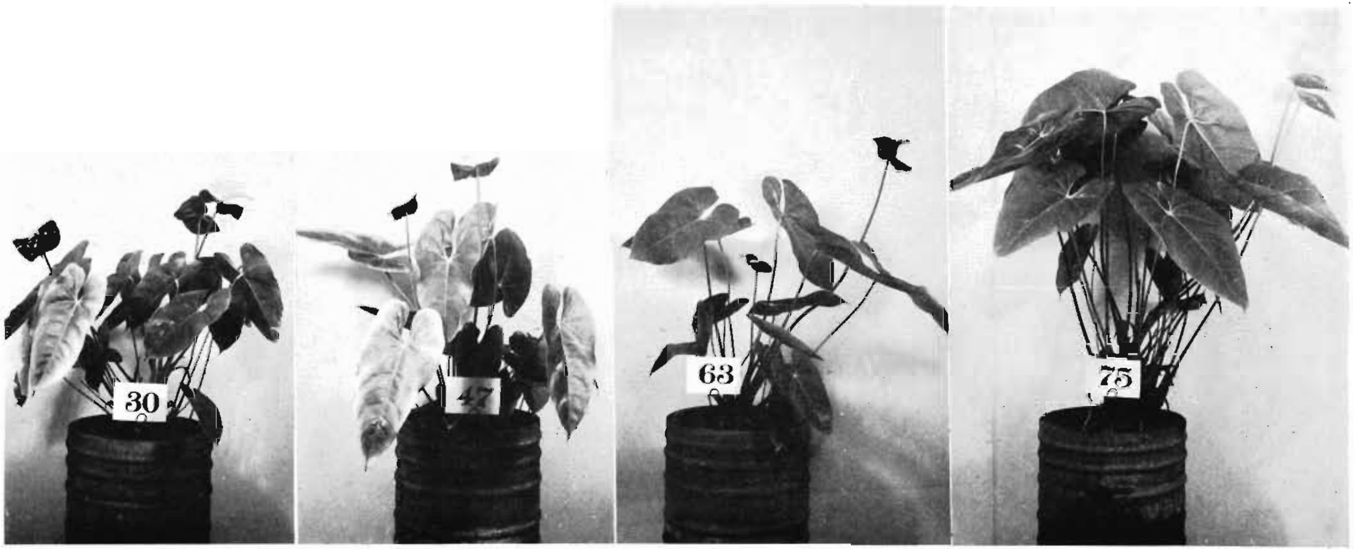

FIGURE 3. Photograph of plants representing each of the shade levels in the saran clothhouse. Note the burnt leaves of plants in the 30 and 47 percent shade and also the luxuriant growth of the plant in the 75 percent shade.

Effects of Containers on Flowering

A minor experiment involving the culture of plants in cement pots and in cans was conducted to determine whether there were any growth differences resulting from the use of these two types of containers. The cement pots were approximately 10 inches in diameter and 11 inches deep, while the cans were approximately 10 inches in diameter and 13 inches deep. Each container was planted with one plant, using coarse tree-fern fibers as the growing medium. Each plant received 1 tablespoon of Orchid Organic Fertilizer once every 2 months. Nine plants per treatment of the variety *Asakura Pink* were paired on the basis of plant size and flowering cycle and grown under 75 percent shade in the lathhouse. Data were analyzed by the paired comparison method using the *t* test, and the summarized results are presented in table 7. Although the difference in flower production between cement pot- and can-cultured plants was statistically significant at the 5 percent level, the difference of 0.17 flower per plant per year is too small to be of practical value.

TABLE 7. Number of flowers per plant per year for plants grown in cement pots and in cans (variety *Asakura Pink*)

CONTAINER	NUMBER OF FLOWERS PER PLANT PER YEAR
Cement pot	4.89
Can	5.06

NOTE: Difference is significant at the 5 percent level.

For practical purposes, although cans are favored statistically, the choice of container should be based upon factors such as availability and cost.

DISCUSSION AND CONCLUSIONS

A previous media test (*2*) showed that bagasse was a good material for growing anthuriums. The results of further tests involving the effects of bagasse at different stages of decomposition reported herein confirm previous conclusions. It was found that fresh bagasse may be used satisfactorily as a medium for anthurium culture, provided additional fertilizer is applied. The ranked order of treatment means given in table 1 for the three categories measured shows that, in general, fresh bagasse without fertilizer was the poorest, followed by bagasse at any stage of decomposition but fertilized only once per 2 months. It may be concluded from these results that for optimum growth and flowering, bagasse is a good medium wherever this material is available in large quantities at low cost, provided a monthly fertilizer schedule is followed. In areas where bagasse is not readily available, tree fern or woodshavings may be used with equal satisfaction, provided a well-defined fertilizer schedule is practiced.

Among the three characters studied, spathe size and flower production showed a high degree of sensitivity to the treatments. Monthly application of fertilizer, regardless of the stage of decomposition of the bagasse, greatly increased spathe size and flower production. The woodshavings-manure mixture (5:1) used as a control in this experiment has been found to be a highly satisfactory medium for anthurium culture.

A leaf-pruning experiment showed that flower production was least affected by the variations in the number of leaves retained on the plants. This indicates that growth in terms of flower production was not affected by the number of leaves on the plant. Regardless of the treatment, except for the two-leaved treatment on the variety *Kaumana,* the rate of leaf production and, hence, flower production was the same.

Flower stem length and spathe size were more sensitive to the effects of number of leaves retained on the plants. Considerable differences were noted in stem length and spathe size of plants with two leaves and those with more than four leaves. Efficiency of the plant is improved with four to six leaves per plant, but any further increase in the number of leaves does not seem to increase efficiency as shown by the performance of unpruned plants.

Shade level studies showed that in general there is an increase in stem length and spathe size with increasing shade. Significant differences were noted in stem length and spathe size between plants grown in 30 and 75 percent shade levels.

Flower production increased with greater light intensity, although there was no statistical difference in flower production of plants grown in 30 and 75 percent shade in the saran clothhouse. The low flower production of plants in the 65 and 75 percent shade in the lathhouse for the light intensity study conflicted with results obtained under the same light and medium conditions for the control series in the bagasse media studies. Production of six flowers per plant per year for treatment E2 in table 1 indicates that the 75 percent lathhouse shade did not affect flower production adversely. The low production shown in table 5 for the lathhouse shade levels appears to be affected by an unknown factor or factors other than light intensity itself. It has already been mentioned in presenting the results of the shade level study that, in spite of the trend towards increased flowering under higher light intensities, other adverse effects were noted. Plants became yellow and leaves were frequently burnt. Flowers lacked the natural gloss of those grown under 63 and 75 percent shade levels.

For optimum performance, as concluded from the data in table 5, the 75 percent shade level provided by saran cloth appeared to be best under the conditions of the experiment. For areas other than the vicinity of the University of Hawaii, Manoa campus, where this experiment was conducted, shade levels ranging between 60 and 75 percent would most likely be adaptable, but the selection of a specific shade level for optimum plant performance must necessarily be based upon trials within the various areas.

In the experiment involving the use of gibberellic acid to induce growth and flowering, no positive results were obtained with the concentrations and frequencies of application used. The lack of positive effects may be due to two reasons: (a) anthuriums are not sensitive to gibberellic acid stimulation, and (b) inadequate concentration and/or frequency of application. These points may easily be resolved by further trials using higher concentrations and/or increased frequencies of application.

In the case of the experiment involving cement pots and cans for growing anthuriums, the difference in mean number of flowers between treatments, although statistically significant at the 5 percent level, appears to be too small to influence the choice of containers. Economic factors such as durability, availability, and cost of containers would be of greater value than the small difference in flower production.

SUMMARY

1. Bagasse at any stage of decomposition used in this experiment was found to promote satisfactory growth and flowering of anthuriums, provided a monthly fertilizer schedule was maintained.

2. Size of spathe and number of flowers produced per plant per year were influenced considerably by fertilizer practices.

3. A minimum of four leaves per plant appeared to be necessary for optimum growth of anthuriums.

4. Among the three characters measured, flower production was least affected by the number of leaves retained by a plant.

5. In general, stems were longer and spathe size was increased with increasing shade, while flower production was increased somewhat with decrease in shade.

6. Under the conditions of this experiment, shade levels between 63 and 75 percent provided by saran cloth gave satisfactory results, taking into consideration the appearance of the plants and the quality of the flowers produced.

7. Gibberellic acid at concentrations of 10, 25, 50, and 100 ppm and applied once and four times at monthly intervals showed no visible effects upon the plants.

8. The difference in mean flower production per plant per year of plants grown in cement pots and in cans was statistically significant, favoring cans, but this difference appeared too small as a practical basis for selection of containers.

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