# EFFECT OF GROWTH REGULATORS ON THE GROWTH AND FLOWERING OF ANTHURIUM
## (*Anthurium andreanum* Linden)

BY

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THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE
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2000

*Dedicated*

*To*

*Achan and Amma*

# DECLARATION

I hereby declare that this thesis entitled "**Effect of growth regulators on the growth and flowering of anthurium (*Anthurium andreanum* Linden)**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,

22-9 -2000

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## CERTIFICATE

Certified that this thesis entitled **"Effect of growth regulators on the growth and flowering of anthurium (*Anthurium andreanum* Linden)"** is a record of research work done independently by Ms. Beena R. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Beena, R.

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| | |
|---|---|
| @ | at the rate of |
| $^0C$ | Degree Celsius |
| Fig. | Figure |
| g | gram |
| $ha^{-1}$ | per hectare |
| LAI | Leaf area index |
| m | meter |
| cm | centimeter |
| mm | millimeter |
| % | per cent |
| ppm | parts per million |
| GA | Gibberellic Acid |
| K | Kinetin |
| TIBA | Tri Iodo Benzoic Acid |
| L.R. | Liver Red |
| K.O. | Kalympong Orange |
| C.R. | Ceylon Red |
| 3MAS | 3 months after first spray |
| 6MAS | 6 months after first spray |
| 9MAS | 9 months after first spray |

# INTRODUCTION

# 1. INTRODUCTION

*Anthurium* is one among the important cut-flower crops in the international flower trade. It is a tropical plant of great beauty, grown for it's colourful long lasting flowers and handsome foliage. Anthurium is now gaining popularity as one of the most important commercial crops of the modern world.

*Anthurium* constitutes the largest genus of the family Araceae, consisting of more than 700 species (Sheffer and Croat, 1983). This family is the most morphologically diverse and taxonomically complex one (Croat, 1980). The name *Anthurium* means tail flower in Greek ('Anthos' = flower and 'aura' = tail). Two species of the genus with commercial importance are *Anthurium andreanum* Linden ('oil with flower', tail flower' or palette flower) and *A. scherzerianum* ('flamingo flower' or 'flame plant'), both of which have magnificent flowers and attractive foliage.

*Anthurium andreanum* Linden is a native of South West Columbia (Singh, 1987). Anthuriums are semi terrestrial and perennial epiphytic plants with creeping arborscent stem. The anthurium "flower" consists of a colourful, shiny, heart shaped modified leaf (spathe) surrounding a straight or slightly curved inflorescence "candle" (spadix). The greatest advantage of anthurium is that it produces flowers all the year round. They can be easily fitted into the agro-climatic and socio-economic situation of Kerala. The regular demand in Kerala for anthurium was estimated at around 10000 flowers/week. However, at present demand is only growing at the rate of 3000 flowers/annum(Flower Tech,2000)

*Anthurium* requires a warm greenhouse ($18^0 - 28^0$ C) with shading (75 per cent) and a humid (75 per cent) condition. Bright, but filtered light is essential for abundant flowering. It is a very slow growing plant with a long juvenile phase taking about 2½ - 3 years to reach first flowering and the floral characters stabilize only after one more year. The annual flower production ranges from 5-6 spadices per year. Mature plants also produce vegetative suckers, one or two per plant per year. The income from anthurium crop depends on the number of suckers and the flowers that are produced by a plant annually. If the frequency of their production can be increased, income also can be increased.

In India, its cultivation is restricted to southern parts especially Kerala and parts of Karnataka and Tamil Nadu. Kerala is identified as one of the best places for growing anthurium because of the congenial climatic conditions. However, management practices adopted during cultivation are varying and not scientific. So standardization of agrotechniques in anthurium for commercial cultivation in our state is a felt need of the present situation. The present work is taken up with a view to find the effect of foliar application of growth regulators on the growth and flowering characteristics of *Anthurium andreanum* Linden.

# REVIEW OF LITERATURE

# 2. REVIEW OF LITERATURE

Anthurium is currently being promoted as an export oriented cutflower crop suitable for commercial cultivation in Kerala. Anthurium is valued for the number of suckers and flowers that are produced by a plant annually. If the frequency of their production can be enhanced, the income also can be increased. In recent years, plant growth regulators are being increasingly used to manipulate the size and number of flowers in cutflower crops. But reports on the response of anthurium to plant growth regulators is relatively scanty. A detailed analysis of the plant's morphological, floral, physiological and biochemical aspects, help to indicate the effect of plant growth regulators. Literature pertaining to these aspects is reviewed in this chapter.

## 2.1 Plant height

Plant growth can be expressed in terms of plant height (Tisdale *et al.*, 1985).

Salvi (1997) observed that plant height was significantly superior under 70 per cent shade and 750 ppm BA in *A. andreanum* cv. 'Hawaiian Red'. In the same variety, Abdussammed (1999) reported that growth regulators had significant effect on plant height. Combined application of BA and GA at 250 ppm resulted in the highest values for height.

Effect on height of *A. andreanum* plants grown on 14 different substrates was studied by Hetman *et al.* (1981), Higaki and Imamura (1988). They found that height of plants decreased with increasing pH upto eight.

Bindu and Mercy (1994) observed that based on observations taken on 5 variables of anthurium, normally plant height varies with varieties ranging from 45 cm in the var. Lady Jane to 85 cm in the var. Pink. Sindhu (1995) recorded the height of six other varieties with a range from 43 cm to 70 cm. Renu (1999) recorded the height of ten varieties of anthurium, in which Liver Red with 65.34 cm and CR with 50.56 cm.

## 2.2 Plant spread

In *Anthurium* cv. Hawaiian Red', Salvi (1997) found that higher shade intensity and application of BA at 750 and 1500 ppm had significantly improved the plant spread in East - West and North - South directions. Abdussammed (1999) observed that BA at 500 and 1000 ppm strength had significant effect on plant spread in both directions.

## 2.3 Number of leaves/spadices per year

### 2.3.1 Anthurium

According to Higaki and Rasmussen (1979), anthuriums are slow growing, producing only six to eight new leaves and vegetative buds on a stem axis per year. They reported that the growth in preflowering stage and later, flower production can be enhanced by using growth regulators like BA (1000 ppm) and GA (500 ppm). Salvi (1997) found that plants in 80 per cent shade receiving 750 ppm BA produced the highest number of leaves. Abdussammed (1979) reported that in *Anthurium* Hawaiian Red, maximum number of leaves/plant in ground planting was recorded by BA 100 ppm. But in pot culture this effect is showed by BA + GA (250 ppm each).

In contrast to the above reports, according to Leffering (1975), in plants that received 45 per cent of the available light, productivity increased from 5 to 12 flowers per plant per year. Gajek and Schwarz (1980) reported that there is a close correlation between the number of leaves and the number of flowers. Mercy and Dale (1994) observed that anthurium produced only five to eight new leaves on a stem axis per year and that with each new leaf, a new root also emerged. They also reported that on an average a plant can produce 5-8 spadices per year .Sindhu (1995) found that the number of spadices produced annually by an anthurium plant varied from four to eight. According to Renu (1999) number of leaves / spadices produced per year by Liver Red was 6.8 and Ceylon Red was 6.4.

Henny and Hamilton (1992) found that the use of $GA_3$ stimulated spadix production in *Anthurium scherzerianum*. Application of $GA_3$ at 0, 125, 250, 375, or 500 mg/ l as a foliar spray to potted plants of *A. scherzerianum* cv. Amazone, resulted in a small but significant increase in flower production per plant but there were no difference between treatments.

The effect of BA and GA at 500,1000 and 1500 ppm, each on growth, flowering and quality of flowers of *Anthurium* cv, 'Agnihotri', was examined by Valsalakumari *et al.* (1998). GA-1000 ppm resulted in maximum number of inflorescence produced per year.

Abdussammed (1999) reported that in ground planting the number of flowers per plant did not differ significantly among all the treatments involving BA and GA. Application of BA + GA 250 ppm each, produced the highest number of flowers per plant on pot planting also, there were no significant differences in the number of flowers per plant. Plants receiving 500 ppm BA, 1000 ppm GA and BA + GA -500 ppm each produced the highest number of flowers per plant.

### 2.3.2 Ornamental Aroids

Henny and Rasmussen (1980) reported that a single foliar spray of 250 ppm $GA_3$ stimulated uniform flowering of several dieffenbachia cultivars. Henny and Fooshe (1983) observed that $GA_3$ induced flowering in *Aglaonema*. Lateral bud break on *Dieffenbachia maculata* was increased significantly with a single foliar application of BAP at 500, 1000 or 2000 ppm, but ethephon applied at the same rate was ineffective (Wilson and Nell, 1983). In *Spathyphyllum*, $GA_3$ at 1250 ppm was found to induce flowering, (Blacquiere and De, 1990). Henny and Norman(1999) reported that a single GA spray at 250-2000ppm can induce flowering in *Syngonium podophyllum*

## 2.4 Rate of leaf / spadix production

Salvi (1997) and Abdussammed (1999) reported that growth regulators had no significant effect on the number of days taken for the successive leaves/ spadices to appear on the same plant.Henny and Norman (1999) reported that a single GA spray at 250-2000 ppm can induce floweing in Syngonium podophyllum

## 2.5 Suckering ability

### 2.5.1 Anthurium

In anthurium, conventional methods of propagation involve sprouting of vegetative buds positioned opposite to each leaf, at alternate nodes, (Higaki, 1976). Higaki and Rasmussen (1979) reported that treatment of anthurium plants with BA and ethephon can induce adventitious buds. Maximum sucker formation was observed with BA at 100 ppm (3.6 shoots per plant). Imamura and Higaki (1988) pointed out that with increasing concentration of GA and BA form 0-100 ppm, increased number of lateral shoots also appeared.

Hata *et al.* (1994) found that immersing of *A. andreanum* cuttings in hot water ($49^0$ C for 10 minutes) followed by a basal application of 0.87 per cent IBA increased the number of suckers/ cutting. Mercy and Dale (1994) reported that propagation of anthurium through suckers was a very slow and undependable process because most of the good commercial and hybrid varieties were very shy of suckering or did not sucker at all *A. andreanum* variety Pink is a profusely suckering variety but the variety is not valuable commercially. They found that, in general foliar spraying with GA or BA at 500-1000 ppm increased sucker production.

Anu (1997) reported that in *A. andreanum* $GA_3$-750 ppm produced maximum (4.67) lateral suckers in topped plants whereas BA-250 ppm was more effective on intact plants. Salvi (1997) pointed out that in *A. andreanum* cv. 'Hawaiian Red', $GA_3$-750 mg/l produced the maximum number of suckers. In the same variety, Abdussammed (1999) observed that 1000 ppm GA produced the maximum number of suckers (3) in ground planting which was on par with 1000 ppm BA in pot planting, the same treatments gave the maximum number of suckers (3.5).

### 2.5.2 Ornamental aroids

Henny and Fooshee (1985) found that application of 500 or 1000 ppm BAP as a soil drench to *Spathyphyllum* was shown to be more effective in increasing basal shoot production than as a foliar spray.

Foliar sprays of BAP were used successfully to increase lateral shoot production on a non-branching *Dieffenbachia* hybrid,(Henny , 1986). In this study three foliar sprays of 250 ppm BA each applied on consecutive days were more effective than 1 or 2 sprays; 3 sprays at 500 or 750 ppm BAP yielded more shoots than the lower dose or 250 ppm. In a related study, Henny and Fooshee (1986) reported that BAP treatment significantly increased basal shoot production on *Spathyphyllum* 'Bennet' whereas other cytokinins did not.

Wang and Boogher (1987) pointed out that foliar sprays of BAP on *Syngonium podophyllum* at 3 and 5 leaf stages induce earlier bud development of lateral shoots at increasing concentrations. Foliar application of 500 to 1000 ppm BAP induced axillary bud elongation of *Epipremnum aureum*.

## 2.6 Length and type of axis of spadix

Valsalakumari *et al.* (1998) reported that growth regulators especially GA increased the length of stalk of anthurium inflorescence. However, Abdussammed (1999) stated that the length of stalk of inflorescences were not influenced by growth regulators.

**2.7 Spathe size**

Criely (1989)recorded the spathe size was derived as a measurement of length x width (cm).

Salvi (1997) reported that growth regulators had effect on the size of anthurium spadices. Valsalakumari *et al.* (1998) observed that in *Anthurium* cv. 'Agnihotri', GA-1000 ppm resulted in the maximum size of spathe. However, Abdussammed (1999) observed that the length and breadth of spathe are not influenced by growth regulators.

Higaki and Poole (1978) noticed that the spadix size increased with the age of the plant. Anthurium spadices are usually graded based on the average width of spathe as miniature (under 8 cm), small (8-10 cm), medium (10-13 cm), large (13-15 cm) and extra large (15 cm). Henny *et al.* (1988) recorded that the miniature *Anthurium* cv. 'Southern Blush' had an average spathe length of seven cm and width of five cm.

Bindu and Mercy (1994) studied the spathe size of five varieties of *A. andreanum*. Among them Pink recorded the largest spathe size (10.4 x 9.7 cm) and smallest for Lady Jane (6.5 x 3.5 cm). Sindhu (1995) recorded that Pink and Kalympong Red produced super large flowers and variety white produced the smallest flowers. Henny (1999) recorded that the new variety Red Hot had six to seven cm long and four to five cm wide spathes.

## 2.8 Spathe colour

The presence of 3 - cyanidin glycoside and 1-pelargonidin glycoside in the spathe of *A. andreanum* was reported by Forsyth and Simmonds (1954). Birdsey (1956) recorded that the *A. andreanum* plants offered in the trade have a complete colour range from white to dark red. According to Lowry (1972) spathe of all the cultivars of *A. andreanum* had the presence of both pelargonidin and cyanidin rutinoside.

The anthocyanins in the spathes of *A. andreanum* cvs. were studied by Iwata *et al.* (1979) and they were identified to be cyanidin 3- rhamnosyl glucoside and pelargonidin 3- rhamnosyl glucoside. They also analysed the genetics of spathe colour and found that both the pigments were present in the red cultivars Ozaki, Kaumaina, Kozohara, Kansaka No. 1 and Nakazarva and in Pink cultivar Marian Seefurth. The orange and coral coloured contained only pelargonidin 3-rhamnosyl glucoside. In white varieties either pelargonidin pigment or both cyanidin and pelargonidin pigments are absent.

Iwata *et al.* (1985) inferred that the spathe colour in anthurium was determined by the relative concentrations of anthocyanins : a predominance of cyanidin 3-rhamosyl glucoside resulted in pink to dark red colours, whereas a predominance of pelargonidin 3 - rhamnosyl glucoside resulted in coral to orange. Another pigment flavour present in large and variable amounts was characterized but not demonstrated to have a modifying effect on cyanic shades.

Henny *et al.* (1988) observed that the anthurium hybrid 'Southern Blush' produced through interspecific hybridisation had a medium pink spathe with a slight lavender lint.

Criley (1989) classified the colours of the important cultivars and new introductions in Hawaii according to the Royal Horticultural Society colour chart.

Mercy and Dale (1994) reported that the colour of spathe fades gradually as flowers get older. Sindhu (1995) observed that the dark and brightly coloured flowers, which are commercially important were produced by the varieties Honeymoon Red, Chilli Red and Kalympong Red.

### 2.9 Spathe texture

Birdsey (1956) described the spathe texture of *A. andreanum* based on its degrees of smoothness and blistering. Arndt (1991) observed the spathe of *A. scherzerianum* variety 'Arabella' as broad with free lobes and a shallow sinus. According to Mercy and Dale (1994) the spathe in floral anthurium may be smooth, thick and glossy without prominent veins or it may be thinner, deeply veined and blistered.

Sindhu (1995) studied the spathe texture of different varieties of anthurium. According to her the variety Honeymoon Red had smooth, thick and glossy spathes without prominent veins while Pink and White had smooth, thin and lightly veined spathes. Kalympong Red, Kalympong Orange and Chilli Red showed intermediate spathe texture and deep to shallow blisters.

**2.10 Longevity of spadix**

According to Salvi (1997) among different growth regulators, BA-1500 ppm recorded to cause the maximum longevity of spadix (152.81 days) of variety 'Hawaiian Red'.

In *Anthurium andreanum* cv. 'Agnihotri', the longevity of spadix was maximum with 1000 ppm GA which was on par with 1500 ppm GA (Valsalakumari *et al.*, 1998). Abdussammed (1999) reported that combined application of BA + GA - 250 ppm each recorded the highest longevity of spadix.

Paull (1982) pointed out the visible changes accompanying the senescence of anthurium flowers as spathe-gloss loss, necrosis of spadix and greening of spathe and spadix. These changes were non-reversible process leading to death of spadix.

Mercy and Dale (1994) found out that the life of an unfertilized spadix was about two months while that of a fertilized inflorescence was about 4-7 months. Senescence was marked by yellowing of peduncle followed by withering of spathe and candle.

Sindhu (1995) reported that the life of unfertilized spadix ranged from 1½ months in kalyampong Orange to 3½ months in Honeymoon Red. For fertilized spadices, this period ranged from 4½ - 8 months.

## 2.11 Inclination of candle

Arndt (1991) described the *A. scherzerianum* hybrid 'Arabella' as having red spathe with a recurring spadix. Anu (1997) reported that both BAP and GA increased the angle between the spathe and candle.

According to Mercy and Dale (1994) in good commercial varieties of *A. andreanum*, the flower bearing candle was attached to the base of the spathe at an angle of $25^0$ to $40^0$. They also recommended that ideal anthurium varieties should have a short candle, curving towards the tip of the spathe and held at an angle less than $45^0$.

Sindhu (1995) studied the inclination of candle of different anthurium varieties. She observed the maximum angle of $75^0$ between the base of candle to the plane of spathe in the var. Honeymoon Red, which was not desirable. The ideal anthurium spadix with an angle less than $45^0$ was found in varieties Chilli Red, Kalympong Orange, Kalympong Red etc.

## 2.12 Candle size (length + girth)

There are no previous report on the evaluation of candle size based on length + girth.

Bindhu and Mercy (1994) recorded that the candle length of five varieties of *A. andreanum* ranged from 4.0 to 9.5 cm. The candle was long and fleshy in ordinary varieties like Pink, Red and White, while it was shorter and more slender in highly bred hybrids and exotics (Mercy and Dale, 1994).

## 2.13 Leaf area

The size of a canopy structure or the total leaf area (LA) is an important determinant of its growth. Measurement of LA is essential for studying growth and yield analysis of crop plants. (Nedunzhiyan and Ray,1996) Salvi (1997) and Abdussammed (1999) reported that growth regulators had no effect on leaf area of *A. andreanum* cv. 'Hawaiian Red'.

## 2.14 Leaf area index

The same workers i.e., Salvi (1997) and Abdussammed (1999) have reported that growth regulators had no effect on leaf area index of *A. andreanum* cv. 'Hawaiian Red'.

## 2.15 Chlorophyll content

According to Salvi (1997) highest chlorophyll content (0.88 mg/g fresh weight) in *A. andreanum* was recorded in treatments with the growth regulator 750 ppm ethephon.

Abdussammed (1999) found out that chlorophyll content of anthurium leaves significantly differed among different growth regulator treatments. In ground planting, the highest content (22 mg/g) was in the case of GA-500 ppm at monthly interval and in pot planting, it was 2.127 mg/g for the combined application of BA and GA, each at 250 ppm.

## 2.16 Carotenoids and other pigments

There are no previous reports on the carotenoid content in the spathe of *A. andreanum* varieties.

Salvi (1997) found that anthocyanin content of spathe was not influenced by any of the growth regulator treatments or their combinations. But Abdussammed (1999) observed that anthocyanin content of *Anthurium* cv. 'Hawaiian Red' was significantly altered under different levels of growth regulator. The highest values for anthocyanin content in ground planting and in pot were 67.88 mg/g and 84.18 mg/g respectively by the application of GA + BA 500 ppm each.

## 2.17 Protein content and total phenolics

Malick and Singh (1980) reported that phenolics are aromatic compounds with hydroxyl groups. They occur in all parts of plants. They are said to offer resistance to diseases and pests in plants.

Mai and Radhakrishnaiah (1993) studied the phenolic constituents of different anthurium species. They found that the phenolic constituents present in *A. bookeri* were caffeic acid, Ferulic acid, p-OH-Benzoic acid and protocatechuic acid. But p-OH Benzoic acid and proteocatechuic acid were present only in *A. ornatum*, *A. scherzerianum* and *A. terrestre*.

## 2.19 Response to pests and diseases

According to Mecry and Dale (1994) important pests reported in anthurium were snails, slugs, termites, ants, leaf feeding caterpillars and grass hoppers. Important diseases were anthracnose caused by *Colletotrichum glorosporioides, and* bacterial blight by *Xanthomonas axonopodis* pv. differabachia.

# MATERIALS AND METHODS

# 3. MATERIALS AND METHODS

An investigation was carried out with a view to study the effect of growth regulators on growth and flowering of anthurium. The experiment was conducted during 1998-2000 at the Department of Plant Physiology, College of Agriculture, Vellayani, under the Kerala Agricultural University.

## 3.1 Material

Mature plants of *Anthurium andreanum* Linden formed the material.

### 3.1.1 Varieties - 3

1. Liver Red - $V_1$

2. Ceylon Red - $V_2$

3. Kalympong Orange - $V_3$

### 3.1.2 Growth regulators- 3, Controls - 2

1. Gibberellic acid (GA) - $G_1$

2. Tri Iodo Benzoic Acid (TIBA) - $G_2$

3. Kinetin (K) - $G_3$

4. Control (Distilled water spray) - $C_1$

5. Control (No spray) - $C_2$

### 3.1.3 Concentrations - 3

1. 100 ppm - $c_1$

2. 300 ppm - $c_2$

3. 500 ppm - $c_3$

The growth regulator G A was selected because there are many reports that it increases cell division (Saches *et al.*, 1959) and cell elongation (Haber and Luippoid,1960) and this can contribute an increase in flower and sucker production. Kinetin is reported to induce cell division and also to have a major role in chlorophyll retention, incorporation of amino acids and protein retention in leaves. The antiauxin TIBA was selected because of proven reports that it causes retardation of growth to bring about a compact nature in plant type (Galston, 1947) which is a desirable character in anthurium.

### 3.2 Methods

A total of 165 plants of uniform size belonging to three varieties were raised in pot culture for the experiment. The bottom one-third of each pot was filled with broken bricks and the middle one third portion was filled with a mixture of coarse sand, broken bricks, dried coconut husk pieces and charcoal mixed in 7 : 1 : 1 : 1 ratio respectively. Plants were placed over this and then anchored with more potting mixture. Coarse sand was used as filler. The potting materials used and the method of planting ensured good drainage.

Artificial shading of 75 per cent was provided with black polypropylene agro-shade netting. Mist irrigation was provided two or more times each day depending on the atmospheric temperature. When temperature was above $28^0$C misting was provided during the day time over and above the normal morning and evening.

Regular applications of fertilizers were given at weekly intervals. NPK mixture 17 : 17 : 17 was applied at a strength of 5 g/l as aqueous solution once a week. Once in a month additional nutrients like diluted cow dung water and fermented and diluted groundnut - neemcake mixture were also given. For this, 1 kg neemcake and 1 kg groundnut cake were fermented in 5 l water for two days. The mixture was then diluted by adding 45 l very dilute cow dung water. Half a litre of clear supernatant solution was then applied to each pot.

## HORMONE TREATMENT

### Preparation of spraying solution

Spraying solutions of 100, 300, 500 ppm of GA, TIBA and K were prepared by dissolving 100 mg, 300 mg, 500 mg of growth regulators in 5 ml. of 50 per cent ethanol and made up the volume to 1000 ml with water. Few drops of lanolin was added to the prepared solution to serve as wetting agent. Distilled water treatment and no spray were taken as control.

**Treatments**

| Sl. No. | Treatment code | Mode of treatment |
|---|---|---|
| 1 | $V_1 G_1 c_1$ | L.R. - GA - 100 ppm |
| 2 | $V_1 G_1 c_2$ | L.R. - GA - 300 ppm |
| 3 | $V_1 G_1 c_3$ | L.R. - GA - 500 ppm |
| 4 | $V_1 G_2 c_1$ | L.R. - TIBA - 100 ppm |
| 5 | $V_1 G_2 c_2$ | L.R. - TIBA - 300 ppm |
| 6 | $V_1 G_2 c_3$ | L.R. - TIBA - 500 ppm |
| 7 | $V_1 G_3 c_1$ | L.R. – K - 100 ppm |
| 8 | $V_1 G_3 c_2$ | L.R. – K - 300 ppm |
| 9 | $V_1 G_3 c_3$ | L.R. – K - 500 ppm |
| 10 | $V_1 C_1$ | Distilled water spray |
| 11 | $V_1 C_2$ | No spray |
| 12 | $V_2 G_1 c_1$ | C.R. – GA - 100 ppm |
| 13 | $V_2 G_1 c_2$ | C.R. – GA - 300 ppm |
| 14 | $V_2 G_1 c_3$ | C.R. – GA - 500 ppm |
| 15 | $V_2 G_2 c_1$ | C.R. - TIBA - 100 ppm |
| 16 | $V_2 G_2 c_2$ | C.R. - TIBA - 300 ppm |
| 17 | $V_2 G_2 c_3$ | C.R. - TIBA - 500 ppm |
| 18 | $V_2 G_3 c_1$ | C.R. - K - 100 ppm |
| 19 | $V_2 G_3 c_2$ | C.R. - K - 300 ppm |
| 20 | $V_2 G_3 c_3$ | C.R. - K - 500 ppm |
| 21 | $V_2 C_1$ | Distilled water spray |
| 22 | $V_2 C_2$ | No spray |
| 23 | $V_3 G_1 c_1$ | K.O. – GA - 100 ppm |
| 24 | $V_3 G_1 c_2$ | K.O. – GA - 300 ppm |
| 25 | $V_3 G_1 c_3$ | K.O. – GA - 500 ppm |
| 26 | $V_3 G_2 c_1$ | K.O. - TIBA - 100 ppm |
| 27 | $V_3 G_2 c_2$ | K.O. - TIBA - 300 ppm |
| 28 | $V_3 G_2 c_3$ | K.O. - TIBA - 500 ppm |
| 29 | $V_3 G_3 c_1$ | K.O. - K - 100 ppm |
| 30 | $V_3 G_3 c_2$ | K.O. - K - 300 ppm |
| 31 | $V_3 G_3 c_3$ | K.O. - K - 500 ppm |
| 32 | $V_3 G_1$ | Distilled water spray |
| 33 | $V_3 C_2$ | No spray |

| Name | Price | Brand |
|---|---|---|
| Kinetin | Rs. 1018.24 / g | SRL |
| 2, 3, 5-Tri Iodo Benzoic Acid | Rs. 184.71 / g | SRL |
| Gibberellic Acid | Rs. 152.22 / g | SRL |

Labour cost for each growth regulator application was worked out to be Rs. 0.50 per plant and a total of Rs. 1.50 was spent for the treatments for each plant.

**Experimental design**

The experiment was laid out in a completely randomised design, involving eleven treatments for three varieties.

Treatments - 27 + 3 + 3 (controls) = 33 (3 varieties, 3 growth regulators, 3 concentrations and 3 + 3 controls)

Replications - 5 (single plant)

Each concentration of the growth regulators was sprayed thrice at one month intervals. One set of control plants were sprayed with distilled water and other set was kept without any spray.

**Observations recorded**

Observations were taken on the morphological, floral, physiological and bio-chemical aspects three months after the first spray and then at three months intervals and their mean values were recorded.

**1. Plant height**

Plant height in centimeters was measured from the base of the plant to the top of the top most leaf.

**2. Plant spread**

Plant spreads in centimeters were taken on both directions - EW, NS

**3. Number of leaves/spadices per year**

The number of leaves/spadices produced during the one year period of the experiment were noted and recorded.

**4. Rate of leaf/spadix production**

Interval between the formation of leaf/spadix was noted and recorded.

**5. Suckering ability**

The ability of the plant to produce suckers from the base of the plant was observed and recorded .

**6. Length and type of axis of spadix**

Length was recorded as either tall (6" and more) above the leaf canopy, medium (upto 6" above the leaf canopy) or short (below leaf canopy). Type of axis of spadix was recorded as either straight, semi-curving or curving.

**7. Spathe size : Length x Width**

The product of width and length of the spathe was recorded as spathe size.

**8. Spathe colour**

The spathe colour of each plant was recorded after visual observation.

**9. Spathe texture**

The degree of blistering, thickness of spathe, presence of veins and glossiness of spathe were recorded.

**10. Longevity of spadix**

The period between the first day of emergence of inflorescence upto the time of its yellowing, withering of spathe and shrivelling of candle was recorded as the longevity of spadix.

**11. Inclination of candle**

The angle between the base of the candle and the plane of the subtending spathe was taken and recorded.

**12. Candle size (length + girth)**

Length and girth of candle in centimeter were added and recorded as candle size.

**14. Leaf area**

Leaf area was taken using leaf area meter.

**15. Leaf area index**

Total leaf area / land area (spacing) (Williams, 1946) was calculated and recorded.

### 3.5.15 Chlorophyll content

Chlorophyll was estimated by the method described by Arnon (1949). One gram of leaf sample from each treatment was finely cut and ground in a mortar with 20 ml of 80 per cent acetone. The homogenate was centrifuged at 5000 rpm for five minutes and the supernatant was transferred to a 100 ml volumetric flask. The above procedure was repeated till the residue became colourless. The final volume in volumetric flask was made upto 100 ml. Absorbance of the solution of 645 and 663 nm was read in a spectrophotometer against the solvent (80 per cent acetone) as blank. The chlorophyll content was calculated using the following equations and expressed as milligrams chlorophyll per gram tissue.

$$\text{Total chlorophyll} = 20.2\,(A645) + 8.02\,(A663) \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll a} = 12.7\,(A663) - 2.69\,(A645) \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll b} = 22.9\,(A645) - 4.68\,(A663) \times \frac{V}{1000 \times W}$$

where A = Absorbance at specific wave lengths,

V = Final volume of chlorophyll extract in 80 per cent acetone

W = Fresh weight of tissue extracted in 80 per cent acetone

### 3.5.16 Estimation of carotenoids

Carotenoids present in spathe was extracted using acetone and its optical density (OD) was measured at 450 nm.

**Procedure** : 200 mg of fresh spathe of each treatment was cut into small pieces and homogenised in a blender. The homogenate was transferred into a volumetric flask and made upto 100 ml and kept overnight in dark. The OD was measured at 450 nm (Jensen, 1978). The carotenoids present in extract was calculated using the formula.

$$C = \frac{D \times V \times f \times 10}{2500}$$

C = Total amount of carotenoids in mg

D = Absorbance of 450 nm

V = Volume of original extract in ml

f = Dilution factor

2500 = Average extension coefficient of the pigments.

**b. Estimation of anthocyanin**

Estimation of anthocyanin was done as per the method described by Ranganna (1977). The initial step was alcoholic extraction of the plant material (spathe). One gram of the spathe sample from each treatment was extracted with ethanolic HCl, filtered through a Buchner funnel using Whatman No. : 1 filter paper and filtrate was then diluted with ethanolic HCl to 50 ml to yield the optical density measurements within the optimum range of the spectrophotometer (535 nm). The anthocyanin content was then calculated using the following relationship and quantity was expressed as mg per 100 g of the sample.

in 10 ml of 80 per cent ethanol. The homogenate was centrifuged at 10000 rpm for 20 minutes, supernatant was saved and residue was extracted five times with 80 per cent ethanol and centrifuged. The supernatant was saved and evaporated to dryness. The residue was dissolved in 5 ml distilled water. An aliquot of 0.3 ml was pipetted out and made upto three ml with distilled water. Folin-Ciocalteau reagent (0.5 ml) was added and two ml of 20 per cent sodium carbonate solution was added to each tube after three minutes. This was mixed thoroughly and kept in boiling water for one minute. This was cooled and absorbance was measured at 650 nm against reagent blank. Standard curve was prepared using different concentrations of catechol and expressed in catechol equivalents as microgram per gram leaf tissue on fresh weight basis.

### 3.5.19 Response to pests and diseases

Response to pests and diseases were recorded without the application of insecticides and fungicides.

### Statistical analysis

The mean values for the different parameters were calculated and the data were analysed using the analysis of variance technique for completely randomised designs.

# RESULTS

# 4. RESULTS

## 4.1 Effect of growth regulators on plant characters

### 4.1.1 Plant height

The effect of growth regulators on plant height, taken at three months after the first spray and then two times more at three months interval is given on Table 1.

Statistical analysis of the data revealed that growth regulators had significant effect on plant height. In the 3rd, 6th and 9th month after the first spray, the variety K.O. treated with G.A. at 500 ppm recorded the maximum height (64.68 cm, 68.72 cm, 69.82 cm respectively). In all the three periods of observations, this maximum height of K.O. was on par with K.O. treated with kinetin at 500 ppm (61.0 cm, 64.08 cm, 66.34 cm respectively) and C.R. treated, with kinetin at 500 ppm (52.52 cm, 55.98 cm, 57.66 cm respectively).

Lowest value for height recorded during the 3rd, 6th and 9th month after the first spray is for the variety C.R. treated with TIBA at 500 ppm (24.14 cm, 26.10 cm, 28.20 cm respectively). In all the three observation periods this lowest value for height of C.R. (TIBA 500 ppm) was on par with the height of L.R. - no spray (25.50 cm, 28.56 cm, 29.88 cm respectively), C.R. - no spray (24.94 cm, 27.86 cm, 29.42 cm respectively) and L.R. treated with 100 ppm TIBA (24.80 cm, 26.88 cm, 28.34 cm respectively) and L.R. treated with TIBA at 300 ppm (25.08 cm, 26.88 cm, 28.12 cm respectively).

**Table 1 Effect of growth regulators on plant height of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Plant height (cm) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 9th Month |
| 1 | $V_1G_1c_1$ | 31.48 | 34.34 | 35.56 |
| 2 | $V_1G_1c_2$ | 44.08 | 47.44 | 48.76 |
| 3 | $V_1G_1c_3$ | 48.12 | 51.28 | 52.60 |
| 4 | $V_1G_2c_1$ | 24.80 | 26.88 | 28.34 |
| 5 | $V_1G_2c_2$ | 25.08 | 26.88 | 28.12 |
| 6 | $V_1G_2c_3$ | 26.90 | 29.48 | 30.92 |
| 7 | $V_1G_3c_1$ | 32.32 | 35.24 | 36.74 |
| 8 | $V_1G_3c_2$ | 35.94 | 39.56 | 40.98 |
| 9 | $V_1G_3c_3$ | 38.18 | 41.76 | 43.38 |
| 10 | $V_1C_1$ | 31.52 | 34.58 | 36.30 |
| 11 | $V_1C_2$ | 25.50 | 28.56 | 29.88 |
| 12 | $V_2G_1c_1$ | 40.96 | 43.86 | 45.34 |
| 13 | $V_2G_1c_2$ | 45.08 | 50.80 | 52.26 |
| 14 | $V_2G_1c_3$ | 56.66 | 60.18 | 62.04 |
| 15 | $V_2G_2c_1$ | 35.36 | 38.46 | 40.16 |
| 16 | $V_2G_2c_2$ | 34.20 | 37.16 | 39.28 |
| 17 | $V_2G_2c_3$ | 24.14 | 26.10 | 28.20 |
| 18 | $V_2G_3c_1$ | 49.26 | 52.76 | 54.56 |
| 19 | $V_2G_3c_2$ | 56.34 | 59.50 | 61.06 |
| 20 | $V_2G_3c_3$ | 52.52 | 55.98 | 57.66 |
| 21 | $V_2C_1$ | 31.54 | 35.48 | 37.36 |
| 22 | $V_2C_2$ | 24.94 | 27.86 | 29.42 |
| 23 | $V_3G_1c_1$ | 53.30 | 56.04 | 57.56 |
| 24 | $V_3G_1c_2$ | 57.24 | 60.42 | 62.18 |
| 25 | $V_3G_1c_3$ | 64.68 | 68.72 | 69.82 |
| 26 | $V_3G_2c_1$ | 55.52 | 53.32 | 54.76 |
| 27 | $V_3G_2c_2$ | 44.64 | 48.40 | 50.02 |
| 28 | $V_3G_2c_3$ | 45.56 | 48.46 | 50.72 |
| 29 | $V_3G_3c_1$ | 45.68 | 49.62 | 51.20 |
| 30 | $V_3G_3c_2$ | 55.12 | 58.54 | 60.62 |
| 31 | $V_3G_3c_3$ | 61.00 | 64.08 | 66.34 |
| 32 | $V_3C_1$ | 49.12 | 52.30 | 54.02 |
| 33 | $V_3C_2$ | 43.62 | 44.72 | 45.42 |
| CD (0.05) | | 9.15 | 9.76 | 9.83 |

**Plate 1 Effect of gibberellic acid on plant height of *Anthurium andreanum* cv. Liver Red**

**Plate 2 Effect of gibberellic acid on plant height of *Anthurium andreanum* cv. Ceylon Red**

**Plate 3 Effect of gibberellic acid on plant height of *Anthurium andreanum* cv. Kalympong Orange**


**Plate 1**


**Plate 2**


**Plate 3**

**Plate 4** **Effect of kinetin on plant height of *Anthurium andreanum* cv. Liver Red**

**Plate 5** **Effect of kinetin on plant height of *Anthurium andreanum* cv. Ceylon Red**

**Plate 6** **Effect of kinetin on plant height of *Anthurium andreanum* cv. Kalympong Orange**


Plate 4


Plate 5


Plate 6

**Plate 7 Effect of TIBA on plant height of *Anthurium andreanum* cv. Liver Red**

**Plate 8 Effect of TIBA on plant height of *Anthurium andreanum* cv. Ceylon Red**

**Plate 9 Effect of TIBA on plant height of *Anthurium andreanum* cv. Kalympong Orange**

Plate 7

Plate 8

Plate 9

**Fig. 1 Effect of growth regulators on plant height of *Anthurium andreanum* cv. Liver Red**

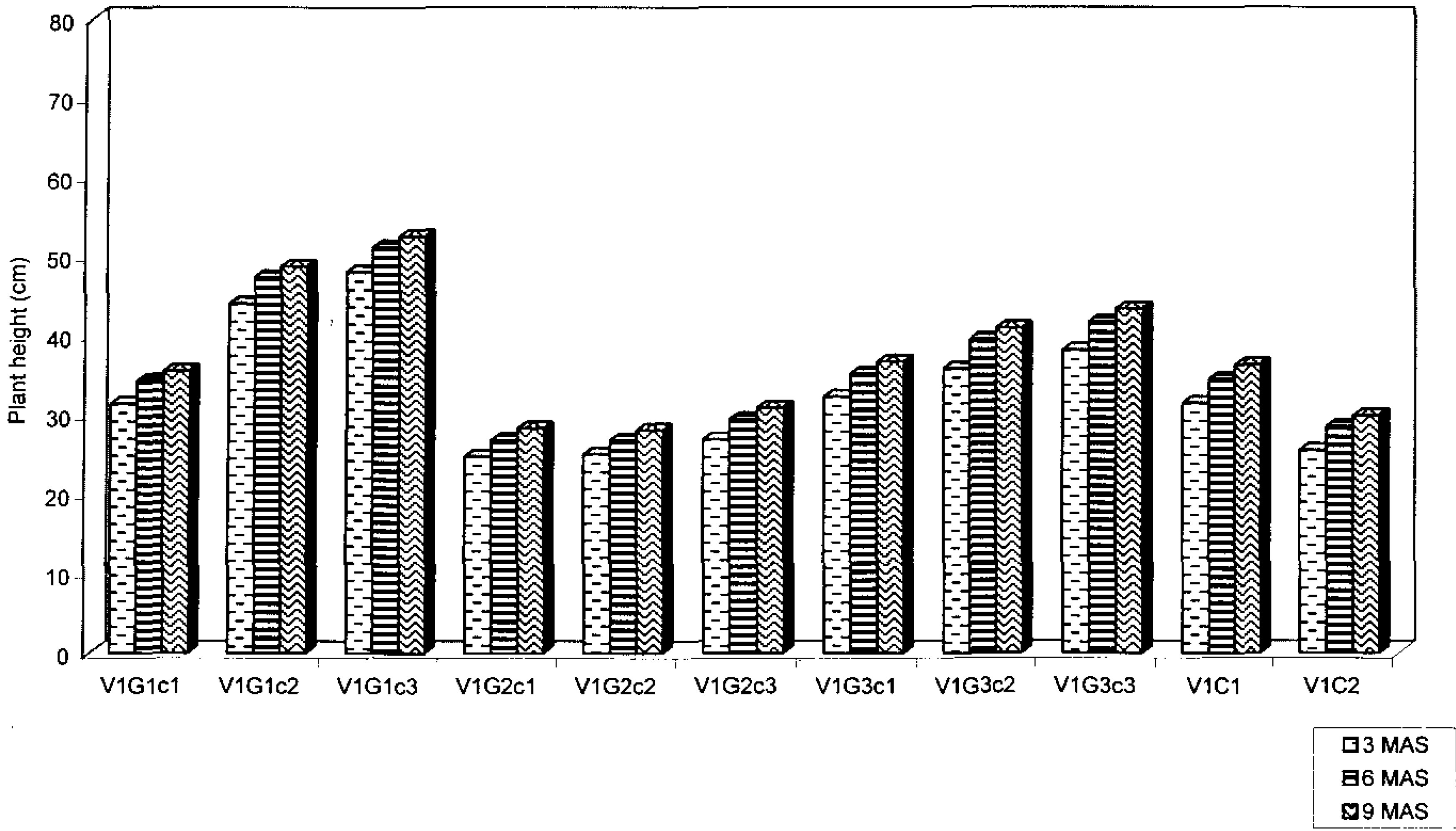


**Fig. 2 Effect of growth regulators on plant height of *Anthurium andreanum* cv. Ceylon Red**

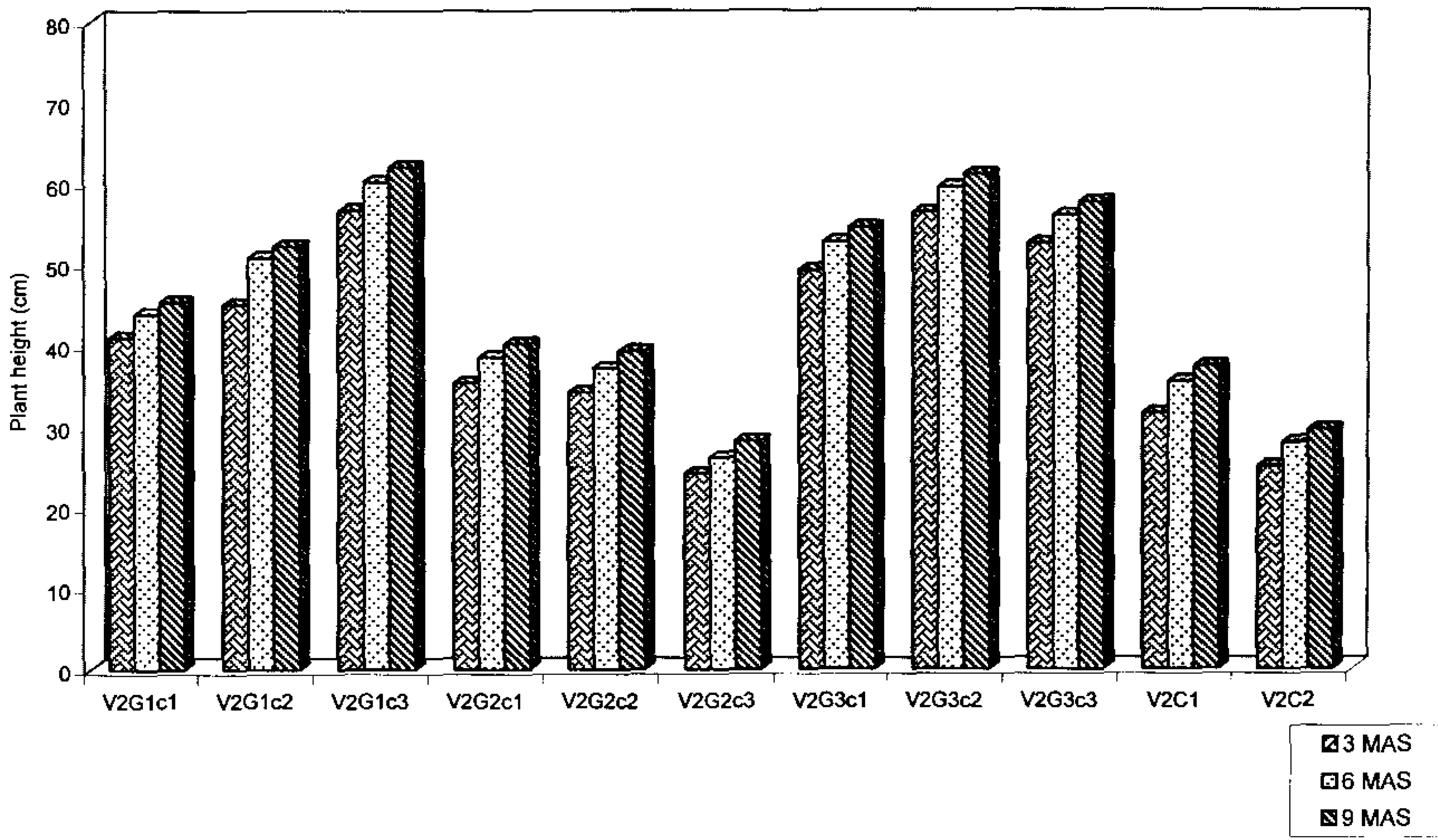
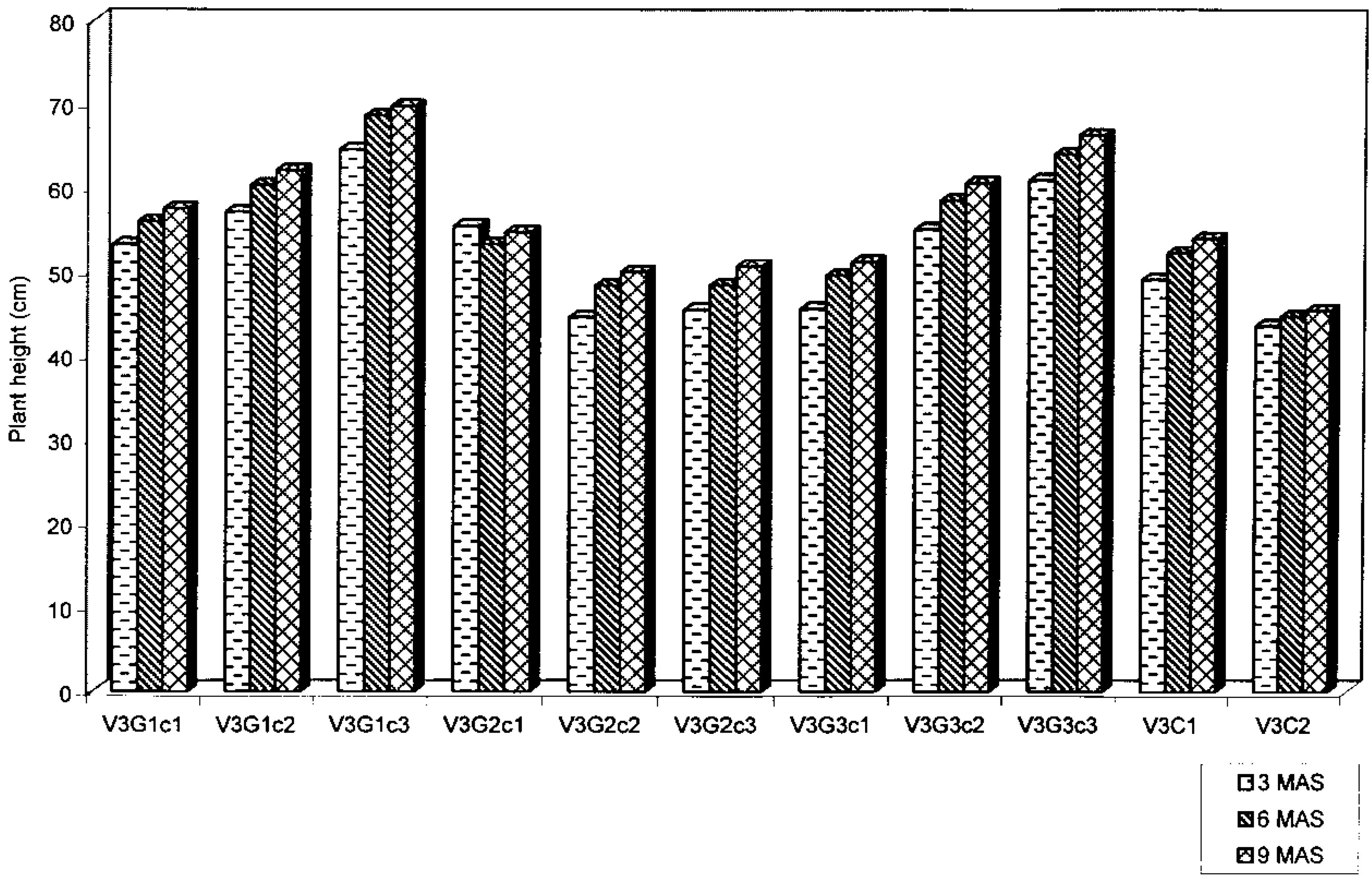


**Fig. 3 Effect of growth regulators on plant height of *Anthurium andreanum* cv. Kalympong orange**



### 4.1.2 Plant spread [East West (EW)]

Growth regulators had significant effect on plant spread (EW) in the 3rd, 6th and 9th month after spraying (Table 2).

Statistical analysis of the data revealed that 3rd month after spraying C.R.variety treated with kinetin at 500 ppm recorded the maximum plant spread (EW) (67.74 cm) which was on par with C.R. treated with G.A. at 500 ppm (62.28 cm) and C.R.treated with kinetin at 300 ppm.(58.22)The lowest plant spread (EW) is showed by C.R. - no spray (29.96 cm). This treatment was on par with L.R. - no spray (30.18 cm), L.R. treated with distilled water (32.82 cm), C.R. treated with TIBA at 100 ppm (35.48 cm), K.O. treated with kinetin at 100 ppm (36.22 cm), C.R. treated with distilled water spray (36.60 cm), L.R. treated with kinetin at 100 ppm (37.82 cm), K.O. treated with distilled water spray (38.08 cm) and L.R. treated with G.A. at 100 ppm (38.50 cm).

Six months after spraying the variety C.R. treated with kinetin at 500 ppm recorded the maximum plant spread (EW) (68.18 cm) which was on par with C.R. treated with G.A. at 500 ppm (61.80 cm), K.O. treated with G.A.at 500 ppm (60.12 cm), C.R. treated with kinetin at 300 ppm(59.54 cm) and K.O. treated with G.A. at 100 ppm (56.30 cm). The lowest plant spread - EW was recorded by L.R. - no spray (29.68 cm) which was on par with C.R. treated with distilled water spray (30.52 cm), K.O. treated with GA at 300 ppm (31.12 cm), K.O. treated with TIBA at 500 ppm (35.9 cm), C.R. treated with TIBA at 100 ppm (36.48 cm), K.O. treated with kinetin at 500 ppm (36.64 cm), K.O. treated with no spray (37.96 cm), C.R. treated with TIBA at

**Table 2 Effect of growth regulators on plant spread (EW) of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Plant spread (EW) (cm) | | |
|---|---|---|---|---|
| | | $3^{rd}$ Month | $6^{th}$ Month | $9^{th}$ Month |
| 1 | $V_1G_1c_1$ | 38.50 | 39.14 | 38.76 |
| 2 | $V_1G_1c_2$ | 47.16 | 47.62 | 46.12 |
| 3 | $V_1G_1c_3$ | 33.74 | 33.56 | 34.36 |
| 4 | $V_1G_2c_1$ | 37.88 | 38.34 | 38.20 |
| 5 | $V_1G_2c_2$ | 50.80 | 51.50 | 52.68 |
| 6 | $V_1G_2c_3$ | 50.66 | 52.30 | 52.68 |
| 7 | $V_1G_3c_1$ | 37.82 | 39.02 | 39.34 |
| 8 | $V_1G_3c_2$ | 40.94 | 42.24 | 56.00 |
| 9 | $V_1G_3c_3$ | 53.36 | 54.86 | 55.20 |
| 10 | $V_1C_1$ | 32.82 | 33.14 | 33.32 |
| 11 | $V_1C_2$ | 30.18 | 29.68 | 29.86 |
| 12 | $V_2G_1c_1$ | 55.54 | 54.20 | 56.00 |
| 13 | $V_2G_1c_2$ | 46.76 | 47.28 | 48.80 |
| 14 | $V_2G_1c_3$ | 62.28 | 61.80 | 62.70 |
| 15 | $V_2G_2c_1$ | 35.48 | 36.48 | 36.66 |
| 16 | $V_2G_2c_2$ | 45.84 | 45.42 | 45.38 |
| 17 | $V_2G_2c_3$ | 50.54 | 50.22 | 50.24 |
| 18 | $V_2G_3c_1$ | 54.10 | 54.92 | 54.30 |
| 19 | $V_2G_3c_2$ | 58.22 | 59.54 | 63.26 |
| 20 | $V_2G_3c_3$ | 67.74 | 68.18 | 66.28 |
| 21 | $V_2C_1$ | 36.60 | 30.52 | 29.36 |
| 22 | $V_2C_2$ | 29.96 | 51.24 | 48.50 |
| 23 | $V_3G_1c_1$ | 49.24 | 56.30 | 52.06 |
| 24 | $V_3G_1c_2$ | 56.16 | 31.12 | 31.24 |
| 25 | $V_3G_1c_3$ | 59.10 | 60.12 | 58.08 |
| 26 | $V_3G_2c_1$ | 44.38 | 44.50 | 28.44 |
| 27 | $V_3G_2c_2$ | 44.92 | 49.74 | 49.30 |
| 28 | $V_3G_2c_3$ | 48.94 | 35.90 | 34.50 |
| 29 | $V_3G_3c_1$ | 36.22 | 43.30 | 43.82 |
| 30 | $V_3G_3c_2$ | 41.30 | 57.22 | 56.66 |
| 31 | $V_3G_3c_3$ | 49.66 | 36.64 | 32.18 |
| 32 | $V_3C_1$ | 38.08 | 50.22 | 47.14 |
| 33 | $V_3C_2$ | 33.14 | 37.96 | 39.60 |
| CD (0.05) | | 10.90 | 12.47 | 12.19 |

100 ppm (36.48 cm), K.O. treated with kinetin at 500 ppm (36.64 cm), K.O. treated with no spray (37.96 cm), L.R. treated with TIBA at 100 ppm (38.34 cm) and L.R. treated with G.A. at 100 ppm (39.14 cm).

Nine months after first spraying the variety C.R. treated with kinetin at 500 ppm recorded the maximum plant spread (WE) (66.28 cm), which was on par with C.R. treated with kinetin at 300 ppm (63.26 cm), C.R. treated with G.A. at 500 ppm (62.7 cm), K.O. treated with G.A. at 500 ppm (58.08 cm), K.O. treated with kinetin at 300 ppm (56.66 cm), C.R. treated with K. at 100 ppm (54.3 cm).

The lowest plant spread (EW) at nine months was recorded by K.O. treated with TIBA at 100 ppm (28.44 cm). This was on par with C.R. treated with distilled water spray (29.36 cm), L.R. - no spray (29.86 cm), K.O. treated with G.A. at 300 ppm (31.24 cm), K.O. treated with kinetin at 500 ppm (32.18 cm), L.R. treated with distilled water spray (33.32 cm), L.R. treated with G.A. at 500 ppm (34.36 cm), L.R. treated with TIBA at 100 ppm (38.2 cm), L.R. treated with G.A. at 100 ppm (38.76 cm), L.R. treated with kinetin at 100 ppm (39.37 cm) and K.O. - no spray (39.6 cm).

### 4.1.3 Plant spread - [North South (NS)]

Growth regulators had significant effect on plant spread - NS in the 3$^{rd}$, 6$^{th}$ and 9$^{th}$ month after spraying (Table 3).

Statistical analysis of the data revealed that 3$^{rd}$ month after the first spray the variety C.R. treated with kinetin at 500 ppm recorded the maximum plant spread - NS (65.44 cm), which was on par with C.R. treated with kinetin at 100 ppm (58.58 cm) and L.R. treated with kinetin at 500 ppm (55.06 cm).

The lowest value for plant spread (NS) is recorded by K.O. - no spray (31.86 cm) which was on par with C.R. treated with no spray (32.9 cm), L.R. treated with G.A. at 100 ppm (34.56 cm), K.O. treated with TIBA at 500 ppm (34.78 cm), C.R. treated with TIBA at 500 ppm (35.1 cm), C.R. treated with distilled water spray (35.48 cm), K.O. treated with kinetin at 500 ppm (31.86 cm), K.O. - no spray (36.5 cm), C.R. treated with TIBA at 300 ppm (36.78 cm), L.R. treated with TIBA 100 ppm (38.1 cm), K.O. treated with G.A. at 100 ppm (40.58 cm), C.R. treated with TIBA at 100 ppm (39.92 cm) and K.O. treated with G.A. at 100 ppm (40.58 cm).

Six months after first spraying the variety C.R. treated with kinetin at 500 ppm recorded the maximum plant spread - NS (66.92 cm). This treatment was on par with C.R. treated with kinetin at 100 ppm (59.24 cm), L.R. treated with kinetin at 500 ppm (56.84 cm) and C.R. treated with G.A. at 100 ppm (55.74 cm). The lowest value for plant spread - NS is recorded by K.O. treated with kinetin at 500 ppm (29.74 cm), which was on par with C.R. - no spray (31.9 cm), K.O. treated with kinetin at 300 ppm (34.74 cm), K.O. treated with TIBA at 500 ppm (35.58 cm), C.R. treated with distilled water spray (37.08 cm), L.R. treated with G.A. at 300 ppm (39.12 cm), L.R. treated with TIBA at 300 ppm (35.74 cm), L.R. treated with TIBA at 100 ppm (39.12 cm), L.R. treated with G.A. at 500 ppm (39.12 cm) and K.O. treated with G.A. at 500 ppm (40.09 cm).

Nine months after first spraying, the variety C.R. treated with kinetin at 300 ppm recorded the maximum plant spread - NS (69.74 cm), which was on par with C.R. treated with kinetin at 500 ppm (65.16 cm). The lowest value

**Table 3 Effect of growth regulators on plant spread (NS) of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Plant spread (EW) (cm) | | |
|---|---|---|---|---|
| | | $3^{rd}$ Month | $6^{th}$ Month | $9^{th}$ Month |
| 1 | $V_1G_1c_1$ | 34.56 | 44.56 | 42.32 |
| 2 | $V_1G_1c_2$ | 37.10 | 37.64 | 36.90 |
| 3 | $V_1G_1c_3$ | 38.78 | 39.12 | 38.74 |
| 4 | $V_1G_2c_1$ | 38.10 | 39.00 | 37.78 |
| 5 | $V_1G_2c_2$ | 46.06 | 45.70 | 43.86 |
| 6 | $V_1G_2c_3$ | 43.08 | 38.26 | 38.00 |
| 7 | $V_1G_3c_1$ | 43.30 | 44.90 | 46.30 |
| 8 | $V_1G_3c_2$ | 47.18 | 48.50 | 49.42 |
| 9 | $V_1G_3c_3$ | 55.06 | 56.84 | 55.02 |
| 10 | $V_1C_1$ | 46.02 | 43.28 | 39.32 |
| 11 | $V_1C_2$ | 41.28 | 40.72 | 37.32 |
| 12 | $V_2G_1c_1$ | 54.22 | 55.74 | 58.80 |
| 13 | $V_2G_1c_2$ | 54.48 | 53.04 | 52.40 |
| 14 | $V_2G_1c_3$ | 43.42 | 45.26 | 43.92 |
| 15 | $V_2G_2c_1$ | 39.92 | 41.00 | 39.32 |
| 16 | $V_2G_2c_2$ | 36.78 | 38.34 | 45.54 |
| 17 | $V_2G_2c_3$ | 35.10 | 35.84 | 38.54 |
| 18 | $V_2G_3c_1$ | 58.58 | 59.24 | 56.34 |
| 19 | $V_2G_3c_2$ | 47.94 | 50.14 | 69.74 |
| 20 | $V_2G_3c_3$ | 65.44 | 66.92 | 65.16 |
| 21 | $V_2C_1$ | 35.48 | 35.72 | 36.26 |
| 22 | $V_2C_2$ | 32.90 | 31.90 | 28.36 |
| 23 | $V_3G_1c_1$ | 40.58 | 38.76 | 47.62 |
| 24 | $V_3G_1c_2$ | 49.10 | 49.88 | 59.08 |
| 25 | $V_3G_1c_3$ | 39.46 | 40.08 | 45.14 |
| 26 | $V_3G_2c_1$ | 43.64 | 45.36 | 49.28 |
| 27 | $V_3G_2c_2$ | 43.14 | 43.20 | 43.22 |
| 28 | $V_3G_2c_3$ | 34.78 | 35.58 | 35.26 |
| 29 | $V_3G_3c_1$ | 46.84 | 44.44 | 45.18 |
| 30 | $V_3G_3c_2$ | 36.00 | 34.74 | 35.32 |
| 31 | $V_3G_3c_3$ | 31.86 | 29.74 | 28.02 |
| 32 | $V_3C_1$ | 38.32 | 37.08 | 40.40 |
| 33 | $V_3C_2$ | 36.50 | 36.48 | 34.92 |
| CD (0.05) | | 9.29 | 11.77 | 10.21 |

for plant spread - NS is recorded by K.O. - no spray (28.02 cm), which was on par with C.R. - no spray (28.36 cm), K.O. treated with TIBA at 500 ppm (35.26 cm), K.O. treated with kinetin at 300 ppm (35.32 cm), C.R. treated with distilled water spray (36.26 cm), L.R. treated with G.A. at 300 ppm (36.9 cm), L.R. - no spray (37.32 cm) and L.R. treated with TIBA at 100 ppm (37.78 cm).

#### 4.1.4 Number of leaves/spadices per year

Statistical analysis of the data revealed that growth regulators had significant effect on the number of leaves/spadices produced by the plant per year. (Table No. 4)

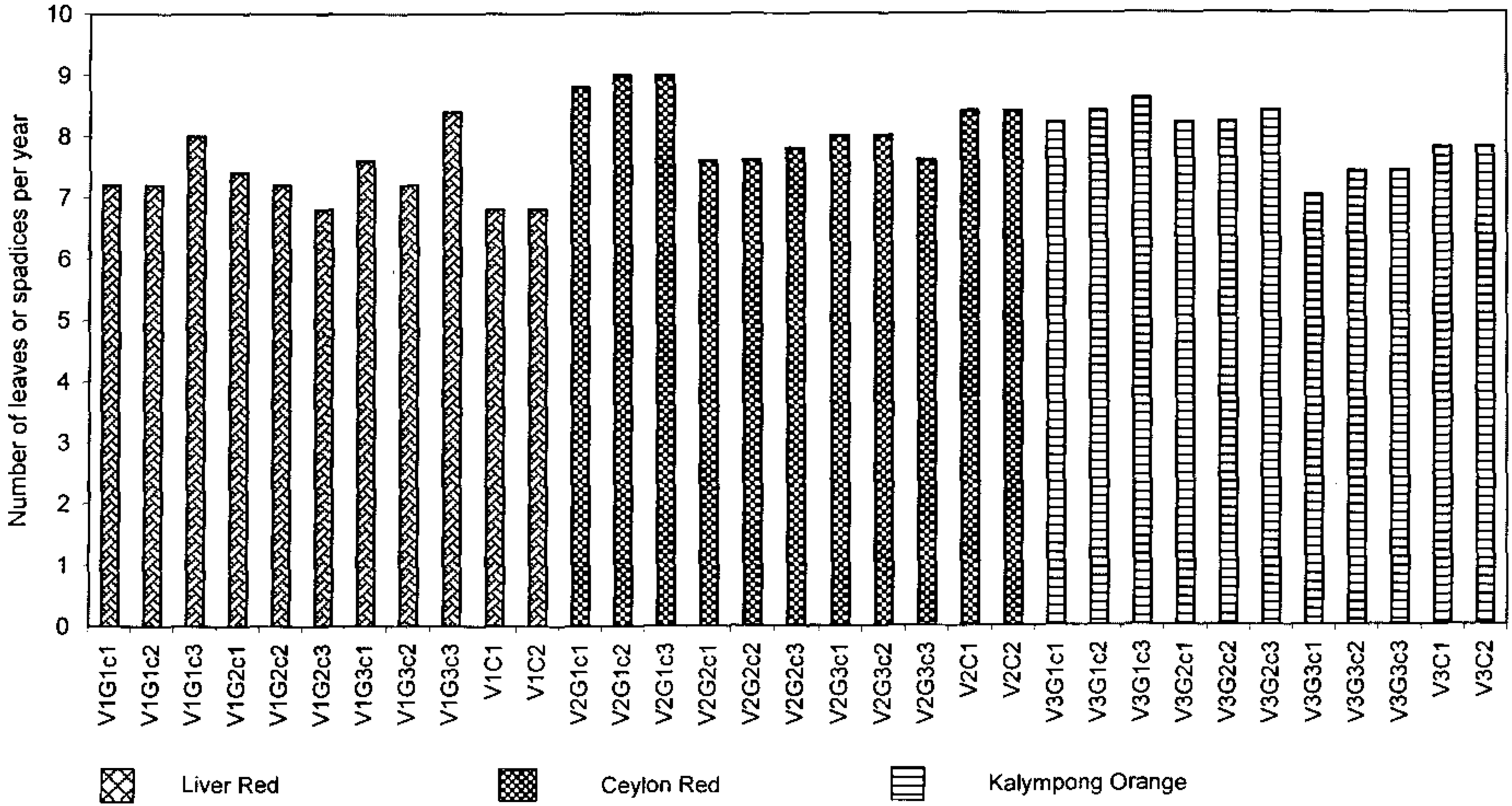
The maximum number of leaves/spadices (9.0) was recorded by the variety C.R. treated with GA at 300 and 500 ppm which was on par with C.R. with GA 100 ppm (8.8), K.O. with GA 500 ppm (8.6), L.R. treated with kinetin 500 ppm (8.4), C.R. treated with distilled water spray (8.4), CR - no spray (8.4), K.O. treated with TIBA at 500 ppm (8.4) and K.O. treated with GA at 300 ppm (8.4).

The variety L.R. - no spray (6.8), L.R. treated with distilled water spray (6.8) and TIBA at 500 ppm (6.8) recorded the minimum number of leaves/spadices per year. This was on par with K.O. treated with kinetin at 100 ppm (7.0), L.R. treated with G.A. at 100 and 300 ppm (7.2), L.R. treated with TIBA at 300 ppm (7.2), L.R. treated with kinetin at 300 ppm (7.2), L.R. treated with TIBA 100 ppm (7.4), K.O. treated with kinetin at 300 ppm (7.4), L.R. treated with kinetin at 100 ppm (7.6), C.R. treated with kinetin 500 ppm (7.6), C.R. treated with TIBA at 100 and 300 ppm (7.6).

**Table 4 Effect of growth regulators on number of leaves or spadices per year**

| Sl. No. | Treatment | Number of leaves or spadices per year |
|---|---|---|
| 1 | $V_1G_1c_1$ | 7.20 |
| 2 | $V_1G_1c_2$ | 7.20 |
| 3 | $V_1G_1c_3$ | 8.00 |
| 4 | $V_1G_2c_1$ | 7.40 |
| 5 | $V_1G_2c_2$ | 7.20 |
| 6 | $V_1G_2c_3$ | 6.80 |
| 7 | $V_1G_3c_1$ | 7.60 |
| 8 | $V_1G_3c_2$ | 7.20 |
| 9 | $V_1G_3c_3$ | 8.40 |
| 10 | $V_1C_1$ | 6.80 |
| 11 | $V_1C_2$ | 6.80 |
| 12 | $V_2G_1c_1$ | 8.80 |
| 13 | $V_2G_1c_2$ | 9.00 |
| 14 | $V_2G_1c_3$ | 9.00 |
| 15 | $V_2G_2c_1$ | 7.60 |
| 16 | $V_2G_2c_2$ | 7.60 |
| 17 | $V_2G_2c_3$ | 7.80 |
| 18 | $V_2G_3c_1$ | 8.00 |
| 19 | $V_2G_3c_2$ | 8.00 |
| 20 | $V_2G_3c_3$ | 7.60 |
| 21 | $V_2C_1$ | 8.40 |
| 22 | $V_2C_2$ | 8.40 |
| 23 | $V_3G_1c_1$ | 8.20 |
| 24 | $V_3G_1c_2$ | 8.40 |
| 25 | $V_3G_1c_3$ | 8.60 |
| 26 | $V_3G_2c_1$ | 8.20 |
| 27 | $V_3G_2c_2$ | 8.20 |
| 28 | $V_3G_2c_3$ | 8.40 |
| 29 | $V_3G_3c_1$ | 7.00 |
| 30 | $V_3G_3c_2$ | 7.40 |
| 31 | $V_3G_3c_3$ | 7.40 |
| 32 | $V_3C_1$ | 7.80 |
| 33 | $V_3C_2$ | 7.80 |
| CD (0.05) | | 0.98 |

**Fig. 4 Effect of growth regulators on number of leaves or spadices per year of *Anthurium andreanum* cv. Liver Red, Ceylon Red and Kalympong Orange**



### 4.1.5 Rate of leaf/spadix production

Data pertaining to the rate of leaf/spadix production (interval in days) is given on Table No. 5 .

Statistical analysis of the data revealed that growth regulators had significant effect on rate of leaf/spadix production. C.R. treated with GA at 500 ppm and 300 ppm recorded the minimum number of days taken for successive leaf production (40.60). This was on par with C.R. treated with GA at 100 ppm (41.6), TIBA at 500 ppm (41.6) and K.O. treated with GA at 100 ppm (42.6).

The variety L.R. treated with TIBA at 500 ppm recorded the maximum number of days taken for successive leaf production (53.6). This was on par with L.R. - no spray and distilled water spray (53.4), K.O. treated with Kinetin at 100 ppm (52).

### 4.1.6 Suckering ability

Statistical analysis of the data revealed that growth regulators had significant effect among treatments regarding suckering ability (Table 6).

Three months after first spraying, the variety, K.O. treated with G.A. at 500 ppm recorded the more number of suckers/plant (3.4). This was on par with K.O. treated with kinetin at 500 ppm (3.2) and L.R. treated with G.A. at 500 ppm (2.6). Both controls in L.R. and C.R. recorded the lowest number of suckers/plant (0.6).

**Table 5 Effect of growth regulators on rate of leaf or spadix production**

| Sl. No. | Treatment | Number of leaves or spadices per year |
|---|---|---|
| 1 | $V_1G_1c_1$ | 50.60 |
| 2 | $V_1G_1c_2$ | 50.60 |
| 3 | $V_1G_1c_3$ | 46.00 |
| 4 | $V_1G_2c_1$ | 49.40 |
| 5 | $V_1G_2c_2$ | 50.60 |
| 6 | $V_1G_2c_3$ | 53.60 |
| 7 | $V_1G_3c_1$ | 48.00 |
| 8 | $V_1G_3c_2$ | 50.80 |
| 9 | $V_1G_3c_3$ | 43.60 |
| 10 | $V_1C_1$ | 53.40 |
| 11 | $V_1C_2$ | 53.40 |
| 12 | $V_2G_1c_1$ | 41.60 |
| 13 | $V_2G_1c_2$ | 40.60 |
| 14 | $V_2G_1c_3$ | 40.60 |
| 15 | $V_2G_2c_1$ | 48.00 |
| 16 | $V_2G_2c_2$ | 48.00 |
| 17 | $V_2G_2c_3$ | 41.60 |
| 18 | $V_2G_3c_1$ | 45.60 |
| 19 | $V_2G_3c_2$ | 45.60 |
| 20 | $V_2G_3c_3$ | 48.00 |
| 21 | $V_2C_1$ | 43.40 |
| 22 | $V_2C_2$ | 43.40 |
| 23 | $V_3G_1c_1$ | 42.60 |
| 24 | $V_3G_1c_2$ | 43.60 |
| 25 | $V_3G_1c_3$ | 44.40 |
| 26 | $V_3G_2c_1$ | 44.60 |
| 27 | $V_3G_2c_2$ | 44.60 |
| 28 | $V_3G_2c_3$ | 43.60 |
| 29 | $V_3G_3c_1$ | 52.00 |
| 30 | $V_3G_3c_2$ | 49.20 |
| 31 | $V_3G_3c_3$ | 49.20 |
| 32 | $V_3C_1$ | 46.80 |
| 33 | $V_3C_2$ | 46.80 |
| CD (0.05) | | 2.18 |

Six months after first spraying, maximum number of suckers/plant (4.2) was produced by the varieties K.O. and L.R. treated with G.A. at 500 ppm. This was on par with L.R. treated with TIBA at 100 ppm (3.75). C.R. treated with kinetin at 300 ppm recorded the lowest number (1.4) of suckers/plant. This was on par with C.R. treated with TIBA at 100 (1.6) and 300 ppm (1.8) and kinetin at 500 ppm (1.8).

Nine months after first spraying the variety K.O. treated with G.A. at 500 ppm recorded the maximum number of suckers/plant (4.6). This treatment was on par with L.R. treated with G.A. 500 ppm (4.4). C.R. treated with kinetin at 100 ppm recorded the lowest number of suckers/plant (1.6). This was on par with C.R. treated with TIBA at 100 and 300 ppm (2.2) and kinetin at 300 ppm (2.2).

### 4.1.7 Length of spadix

Statistical analysis of the data revealed that growth regulators had significant effect on length of spadix (Table 7).

In the third month after first spraying, the variety L.R. treated with G.A. at 500 ppm recorded the highest length (38.0 cm) of spadix. This treatment was on par with L.R. treated with G.A. at 100 ppm (34.88 cm) and 300 ppm (35.50 cm), TIBA at 100 ppm (37.96 cm) and 300 ppm (35.38 cm), kinetin at 500 ppm (35.30 cm), C.R. treated with G.A. at 300 ppm (35.48 cm) and 500 ppm (35.56 cm) distilled water spray (36.02 cm) and TIBA at 100 ppm (34.86 cm). The lowest length of spadix is recorded by the variety L.R.-no spray (19.98 cm). This treatment was on par with K.O. - no spray (21.66 cm), kinetin at 100 ppm (21.78 cm) and C.R. with G.A. at 100 ppm (22.80 cm).

**Table 6 Effect of growth regulators on suckering ability**

| Sl. No. | Treatment | Sucker production | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 9th Month |
| 1 | $V_1G_1c_1$ | 1.20 | 2.20 | 2.80 |
| 2 | $V_1G_1c_2$ | 1.20 | 2.80 | 3.40 |
| 3 | $V_1G_1c_3$ | 2.60 | 4.20 | 4.40 |
| 4 | $V_1G_2c_1$ | 1.20 | 3.75 | 3.60 |
| 5 | $V_1G_2c_2$ | 1.20 | 2.20 | 3.00 |
| 6 | $V_1G_2c_3$ | 1.20 | 2.00 | 2.80 |
| 7 | $V_1G_3c_1$ | 1.20 | 2.40 | 2.80 |
| 8 | $V_1G_3c_2$ | 1.00 | 2.20 | 2.80 |
| 9 | $V_1G_3c_3$ | 1.20 | 2.20 | 3.40 |
| 10 | $V_1C_1$ | 0.60 | 2.00 | 2.60 |
| 11 | $V_1C_2$ | 0.60 | 2.00 | 2.60 |
| 12 | $V_2G_1c_1$ | 1.20 | 2.40 | 2.60 |
| 13 | $V_2G_1c_2$ | 1.20 | 2.40 | 2.60 |
| 14 | $V_2G_1c_3$ | 2.40 | 3.20 | 3.40 |
| 15 | $V_2G_2c_1$ | 1.20 | 1.60 | 2.20 |
| 16 | $V_2G_2c_2$ | 1.20 | 1.80 | 2.20 |
| 17 | $V_2G_2c_3$ | 1.00 | 2.00 | 2.60 |
| 18 | $V_2G_3c_1$ | 1.20 | 1.40 | 1.60 |
| 19 | $V_2G_3c_2$ | 1.00 | 2.00 | 2.20 |
| 20 | $V_2G_3c_3$ | 1.20 | 1.80 | 2.60 |
| 21 | $V_2C_1$ | 0.60 | 2.20 | 2.40 |
| 22 | $V_2C_2$ | 0.60 | 2.60 | 2.40 |
| 23 | $V_3G_1c_1$ | 1.20 | 2.60 | 3.40 |
| 24 | $V_3G_1c_2$ | 1.20 | 3.00 | 3.40 |
| 25 | $V_3G_1c_3$ | 3.40 | 4.20 | 4.60 |
| 26 | $V_3G_2c_1$ | 1.00 | 2.60 | 3.00 |
| 27 | $V_3G_2c_2$ | 1.00 | 2.00 | 3.40 |
| 28 | $V_3G_2c_3$ | 1.20 | 2.20 | 3.40 |
| 29 | $V_3G_3c_1$ | 2.00 | 2.40 | 3.40 |
| 30 | $V_3G_3c_2$ | 1.20 | 2.60 | 3.60 |
| 31 | $V_3G_3c_3$ | 3.20 | 3.00 | 3.60 |
| 32 | $V_3C_1$ | 2.20 | 3.20 | 3.40 |
| 33 | $V_3C_2$ | 2.00 | 3.00 | 3.40 |
| CD (0.05) | | 0.86 | 0.86 | 0.67 |

**Plate 10 Multiple sucker production in *Anthurium andreanum* cv. Liver Red with GA at 500 ppm**

Plate 10

**Plate 11 Multiple sucker production in *Anthurium andreanum* cv. Ceylon Red with GA at 500 ppm**

Plate 11

**Plate 12 Multiple sucker production in *Anthurium andreanum* cv. Kalympong Orange with GA at 500 ppm**


Plate 12

Fig. 5 Effect of growth regulators on sucker production of *Anthurium andreanum* cv. Liver Red

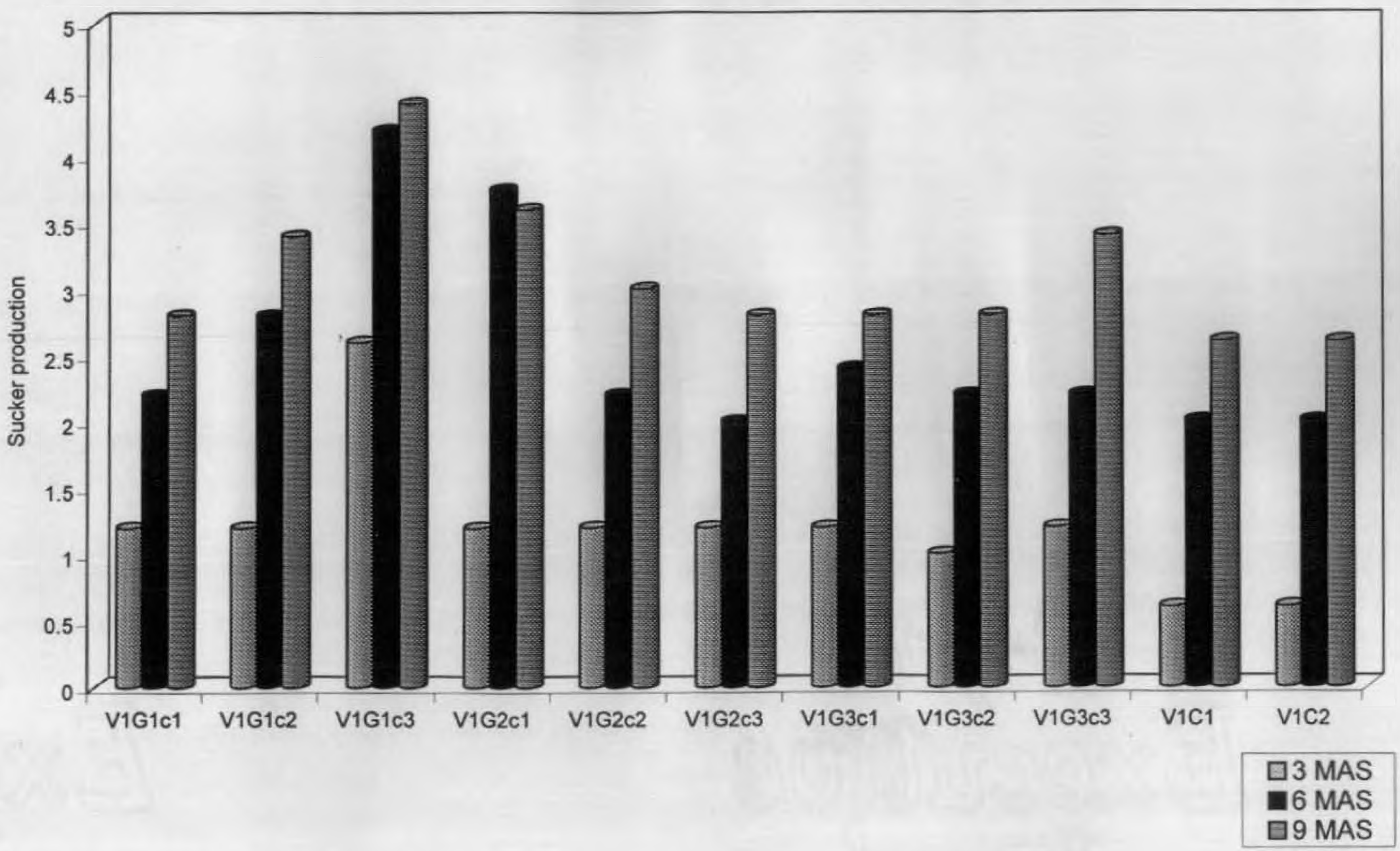


**Fig. 6 Effect of growth regulators on sucker production of *Anthurium andreanum* cv. Ceylon Red**

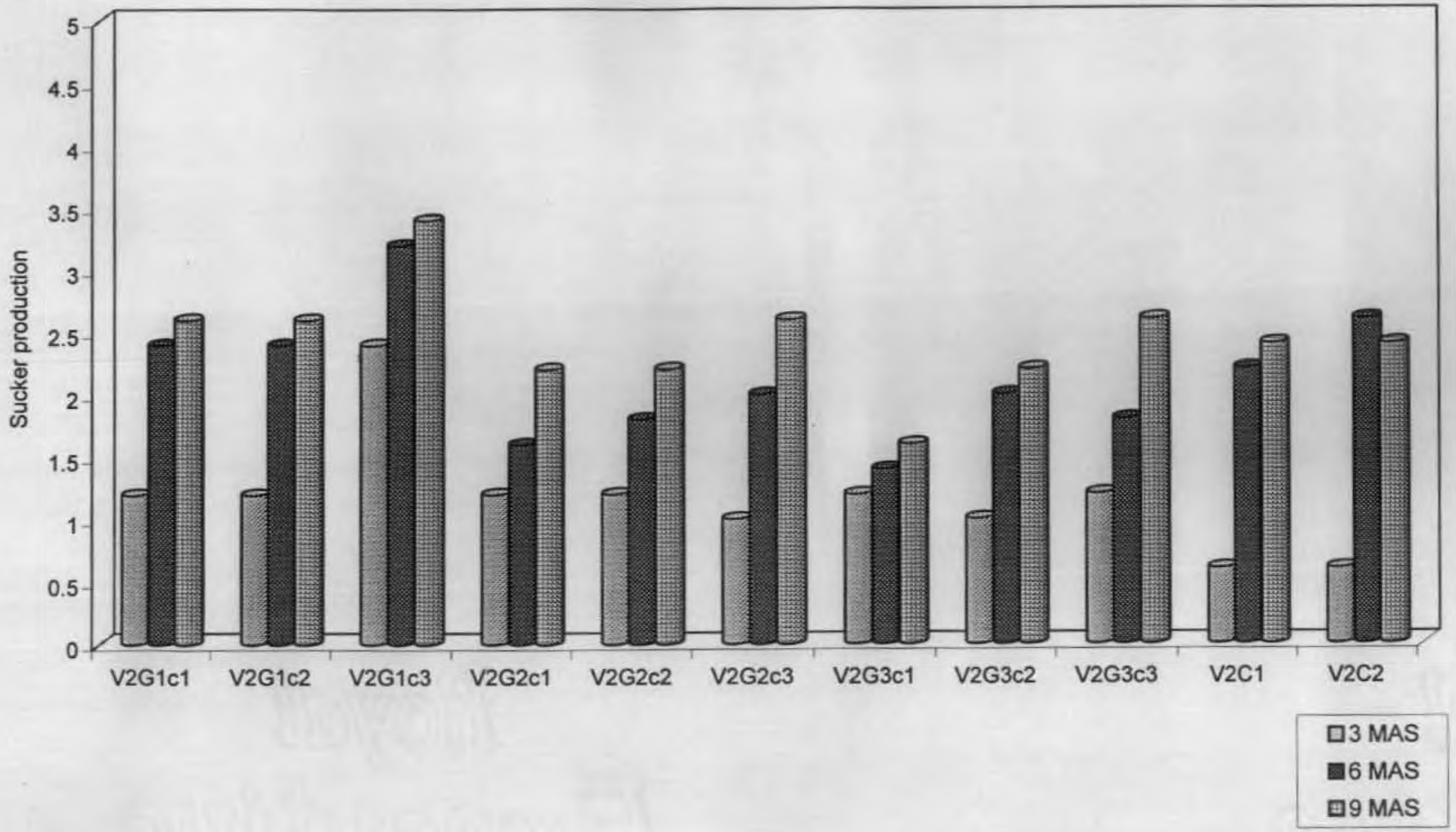
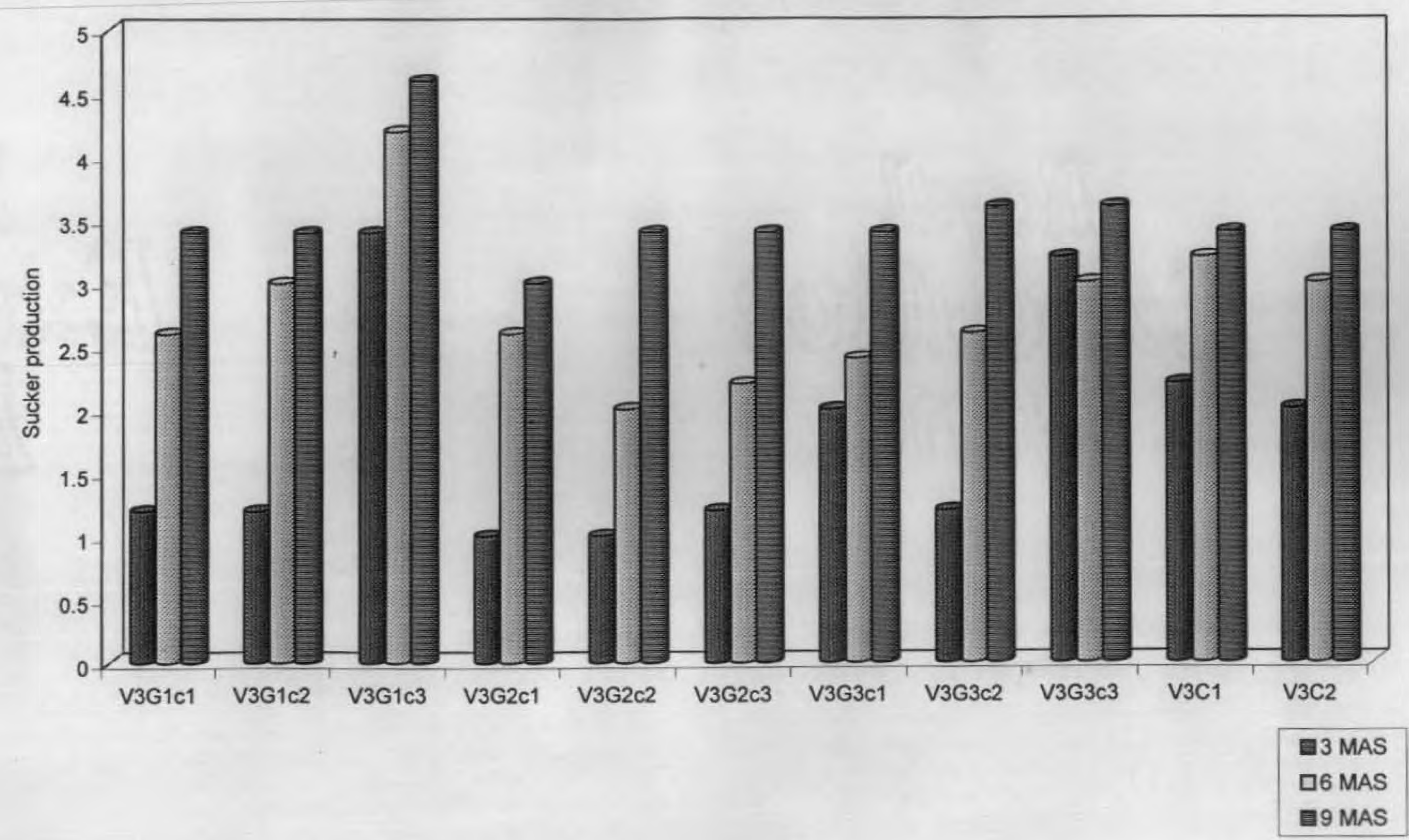


**Fig. 7 Effect of growth regulators on sucker production of *Anthurium andreanum* cv. Kalympong Orange**



Six months after first spraying, the highest length of spadix is produced by L.R. treated with G.A. at 500 ppm (43.52 cm). L.R. treated with distilled water spray produced the lowest length of spadix (20.20 cm). This was on par with treatments like L.R. - no spray (20.28 cm), C.R. treated with distilled water spray (22.70 cm), K.O. - no spray (22.50 cm), TIBA at 300 ppm (22.58 cm) and 500 ppm (22.24 cm).

Nine months after first spraying, the variety C.R. treated with G.A. at 500 ppm recorded the highest length of spadix (38.78 cm). This was on par with L.R. treated with G.A. at 500 ppm (37.22 cm) and 300 ppm (35.60 cm) kinetin at 100 ppm (35.32 cm), C.R. treated with G.A. at 100 ppm (37.04 cm) and 300 ppm (36.90 cm) kinetin at 100 ppm (35.52 cm) and 500 ppm (36.70 cm), K.O. treated with kinetin at 300 ppm (34.98 cm) and 500 ppm (35.14 cm). The lowest length of spadix is recorded by the variety K.O. - no spray (26.9). This was on par with K.O. treated with kinetin at 100 ppm (26.94 cm), G.A. at 100 ppm (29.12 cm) and TIBA at 500 ppm (31.00 cm), C.R. treated with TIBA at 100 ppm (33.80 cm) and 500 ppm 30.86 cm), L.R. treated with distilled water spray (30.42 cm) and no spray (32.26 cm).

### 4.1.8 Spathe size

Data pertaining to the effect of growth regulators on spathe size is given in Table 8. The data revealed that growth regulators had significant effect on spathe size.

**Table 7 Effect of growth regulators on length of spadix**

| Sl. No. | Treatment | Length of spadix (cm) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 9th Month |
| 1 | $V_1G_1c_1$ | 34.88 | 35.68 | 33.64 |
| 2 | $V_1G_1c_2$ | 35.50 | 35.22 | 35.60 |
| 3 | $V_1G_1c_3$ | 38.00 | 43.52 | 37.22 |
| 4 | $V_1G_2c_1$ | 37.96 | 34.40 | 34.50 |
| 5 | $V_1G_2c_2$ | 35.38 | 30.00 | 33.38 |
| 6 | $V_1G_2c_3$ | 32.24 | 31.32 | 31.92 |
| 7 | $V_1G_3c_1$ | 31.56 | 26.60 | 35.32 |
| 8 | $V_1G_3c_2$ | 32.94 | 28.98 | 34.50 |
| 9 | $V_1G_3c_3$ | 35.30 | 34.00 | 35.40 |
| 10 | $V_1C_1$ | 34.18 | 23.22 | 30.42 |
| 11 | $V_1C_2$ | 19.98 | 20.28 | 32.26 |
| 12 | $V_2G_1c_1$ | 22.80 | 38.64 | 37.04 |
| 13 | $V_2G_1c_2$ | 35.48 | 35.98 | 36.90 |
| 14 | $V_2G_1c_3$ | 35.56 | 39.30 | 38.78 |
| 15 | $V_2G_2c_1$ | 34.86 | 34.06 | 33.80 |
| 16 | $V_2G_2c_2$ | 33.90 | 26.18 | 32.42 |
| 17 | $V_2G_2c_3$ | 25.44 | 27.78 | 30.86 |
| 18 | $V_2G_3c_1$ | 27.68 | 28.96 | 35.52 |
| 19 | $V_2G_3c_2$ | 33.28 | 34.96 | 34.26 |
| 20 | $V_2G_3c_3$ | 33.68 | 38.04 | 36.70 |
| 21 | $V_2C_1$ | 36.02 | 22.70 | 32.32 |
| 22 | $V_2C_2$ | 24.56 | 28.52 | 36.06 |
| 23 | $V_3G_1c_1$ | 27.12 | 25.56 | 29.12 |
| 24 | $V_3G_1c_2$ | 30.94 | 24.10 | 34.24 |
| 25 | $V_3G_1c_3$ | 32.18 | 27.84 | 35.48 |
| 26 | $V_3G_2c_1$ | 33.70 | 24.64 | 29.14 |
| 27 | $V_3G_2c_2$ | 29.12 | 22.58 | 33.46 |
| 28 | $V_3G_2c_3$ | 26.14 | 22.24 | 31.00 |
| 29 | $V_3G_3c_1$ | 21.78 | 23.42 | 26.94 |
| 30 | $V_3G_3c_2$ | 25.32 | 28.10 | 34.98 |
| 31 | $V_3G_3c_3$ | 25.46 | 24.86 | 35.14 |
| 32 | $V_3C_1$ | 23.72 | 25.34 | 32.68 |
| 33 | $V_3C_2$ | 21.600 | 22.50 | 26.90 |
| CD (0.05) | | 3.70 | 3.32 | 4.13 |

In the third month after first spraying, the variety K.O. treated with G.A. at 500 ppm recorded the largest spathe (95.4 $cm^2$). The smallest spathe is obtained with variety C.R. treated with TIBA at 300 ppm (22.80 $cm^2$), which was on par with L.R. treated with TIBA of 300 ppm (25.2 cm).

Six months after first spraying K.O. treated with G.A. at 500 ppm (92.94 $cm^2$) recorded the largest spathe. C.R treated with TIBA at 500 ppm recorded the smallest spathe (17.71 $cm^2$). This was on par with L.R. treated with distilled water spray (21.08 $cm^2$) and C.R. treated with TIBA at 300 ppm (22.71 $cm^2$).

Nine months after first spraying, K.O. treated with G.A. at 500 ppm (87.6 $cm^2$) recorded the largest spathe. The smallest spathe was recorded by C.R. treated with TIBA at 300 ppm (22.2 $cm^2$) which was on par with L.R. treated with TIBA at 300 (24.6 $cm^2$) and 500 ppm (22.8 $cm^2$), G.A. at 100 ppm (23.2 $cm^2$).

### 4.1.9 Longevity of spadix

Statistical analysis of the data revealed that growth regulators had significant effect with respect to longevity of spadix (Table 9), recorded in days.

The variety L.R. treated with kinetin at 500 ppm recorded the highest longevity of spadix (103 days). This treatment was on par with L.R. treated with G.A. at 500 ppm (102.4). The lowest longevity of spadix is recorded by the variety K.O. treated with TIBA at 100 ppm (66.8).

**Table 8 Effect of growth regulators on spathe size**

| Sl. No. | Treatment | Spathe size ($cm^2$) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 9th Month |
| 1 | $V_1G_1c_1$ | 31.96 | 27.00 | 23.20 |
| 2 | $V_1G_1c_2$ | 45.40 | 47.60 | 41.80 |
| 3 | $V_1G_1c_3$ | 74.40 | 71.34 | 63.20 |
| 4 | $V_1G_2c_1$ | 37.40 | 38.90 | 30.60 |
| 5 | $V_1G_2c_2$ | 25.20 | 28.36 | 24.60 |
| 6 | $V_1G_2c_3$ | 28.00 | 27.52 | 22.80 |
| 7 | $V_1G_3c_1$ | 38.20 | 37.54 | 32.80 |
| 8 | $V_1G_3c_2$ | 43.40 | 44.88 | 42.40 |
| 9 | $V_1G_3c_3$ | 64.60 | 63.19 | 59.60 |
| 10 | $V_1C_1$ | 31.40 | 21.08 | 28.60 |
| 11 | $V_1C_2$ | 33.40 | 34.66 | 33.00 |
| 12 | $V_2G_1c_1$ | 53.60 | 61.74 | 52.00 |
| 13 | $V_2G_1c_2$ | 64.60 | 58.10 | 66.00 |
| 14 | $V_2G_1c_3$ | 42.20 | 78.81 | 42.60 |
| 15 | $V_2G_2c_1$ | 30.80 | 43.19 | 26.40 |
| 16 | $V_2G_2c_2$ | 22.80 | 22.71 | 22.20 |
| 17 | $V_2G_2c_3$ | 51.40 | 17.71 | 55.20 |
| 18 | $V_2G_3c_1$ | 59.60 | 54.11 | 59.00 |
| 19 | $V_2G_3c_2$ | 69.00 | 59.71 | 54.60 |
| 20 | $V_2G_3c_3$ | 30.00 | 70.80 | 33.20 |
| 21 | $V_2C_1$ | 35.80 | 25.80 | 33.60 |
| 22 | $V_2C_2$ | 54.60 | 40.89 | 52.00 |
| 23 | $V_3G_1c_1$ | 59.60 | 56.65 | 53.40 |
| 24 | $V_3G_1c_2$ | 82.80 | 85.92 | 77.60 |
| 25 | $V_3G_1c_3$ | 95.40 | 92.94 | 87.60 |
| 26 | $V_3G_2c_1$ | 63.40 | 62.54 | 62.60 |
| 27 | $V_3G_2c_2$ | 71.80 | 61.54 | 69.20 |
| 28 | $V_3G_2c_3$ | 72.80 | 47.18 | 71.00 |
| 29 | $V_3G_3c_1$ | 76.00 | 67.37 | 75.40 |
| 30 | $V_3G_3c_2$ | 63.20 | 83.35 | 66.00 |
| 31 | $V_3G_3c_3$ | 63.60 | 83.36 | 64.00 |
| 32 | $V_3C_1$ | 54.00 | 71.96 | 52.60 |
| 33 | $V_3C_2$ | 55.20 | 80.12 | 45.20 |
| CD (0.05) | | 4.99 | 6.92 | 2.49 |

Plate 13 Effect of gibberellic acid on spathe size of *Anthurium andreanum* cv. Liver Red

Plate 14 Effect of gibberellic acid on spathe size of *Anthurium andreanum* cv. Ceylon Red

Plate 15 Effect of gibberellic acid on spathe size of *Anthurium andreanum* cv. Kalympong Orange

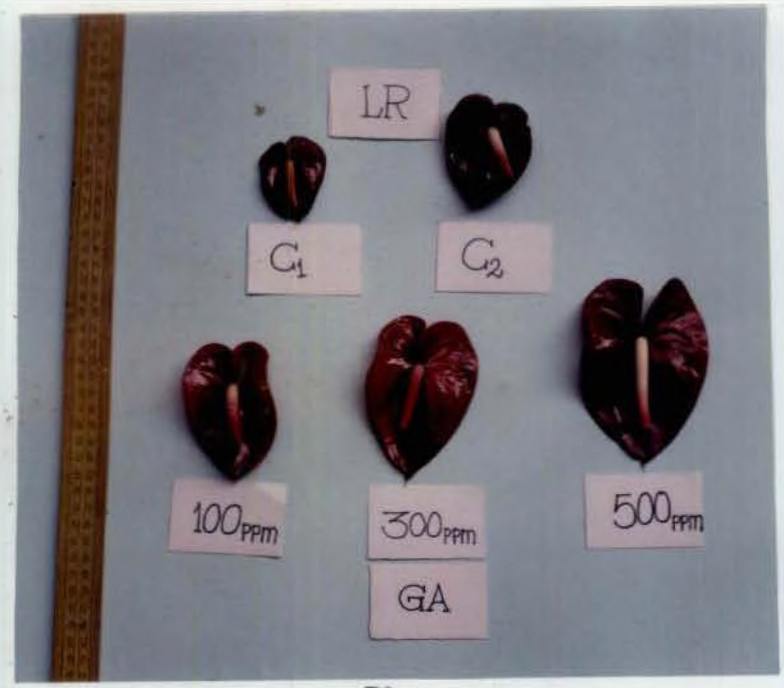


Plate 13

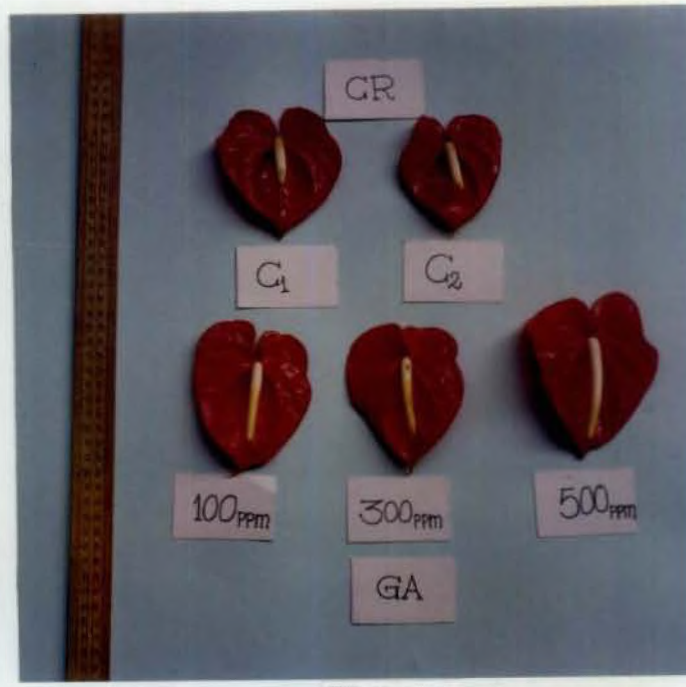


Plate 14

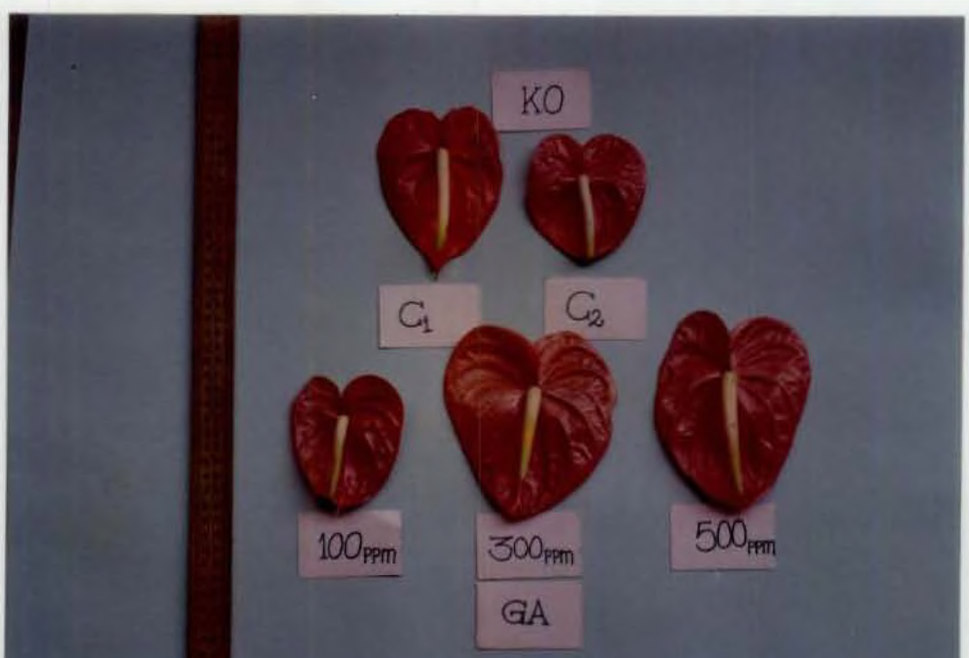


Plate 15

**Plate 16 Effect of kinetin on spathe size of *Anthurium andreanum* cv. Liver Red**

**Plate 17 Effect of kinetin on spathe size of *Anthurium andreanum* cv. Ceylon Red**

**Plate 18 Effect of kinetin on spathe size of *Anthurium andreanum* cv. Kalympong Orange**

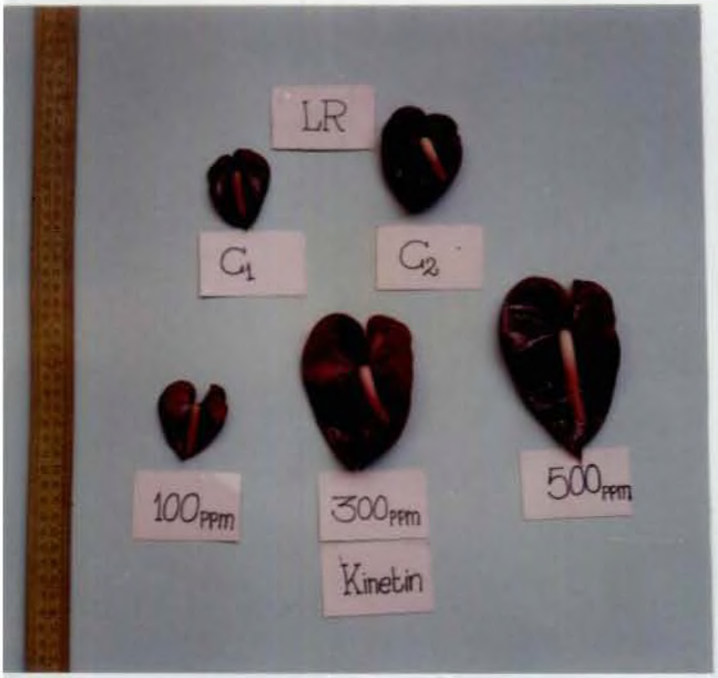



Plate 16

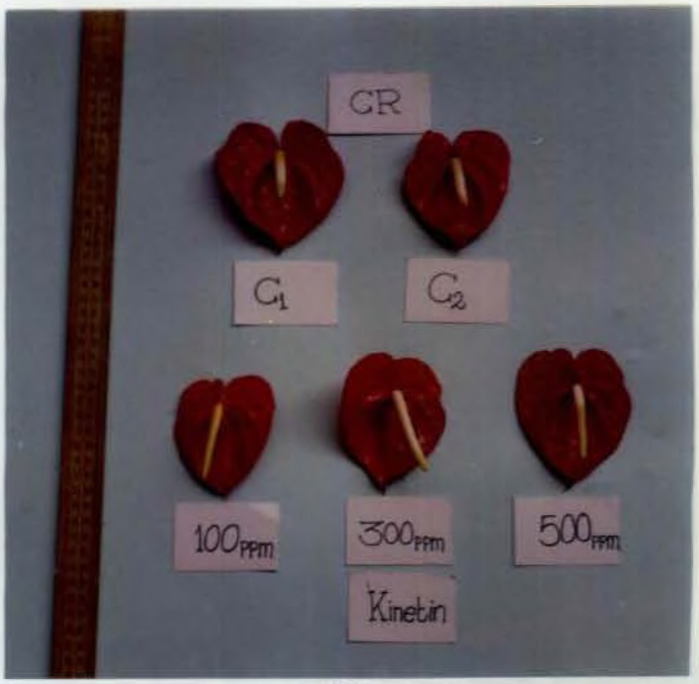



Plate 17

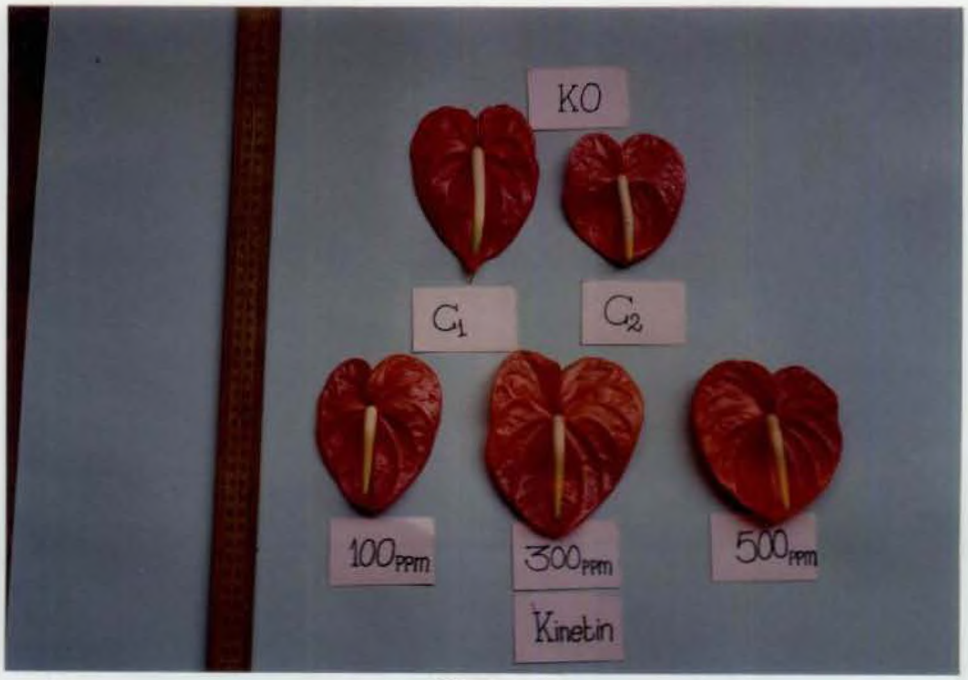



Plate 18

**Plate 19 Effect of TIBA on spathe size of *Anthurium andreanum* cv. Liver Red**

**Plate 20 Effect of TIBA on spathe size of *Anthurium andreanum* cv. Ceylon Red**

**Plate 21 Effect of TIBA on spathe size of *Anthurium andreanum* cv. Kalympong Orange**

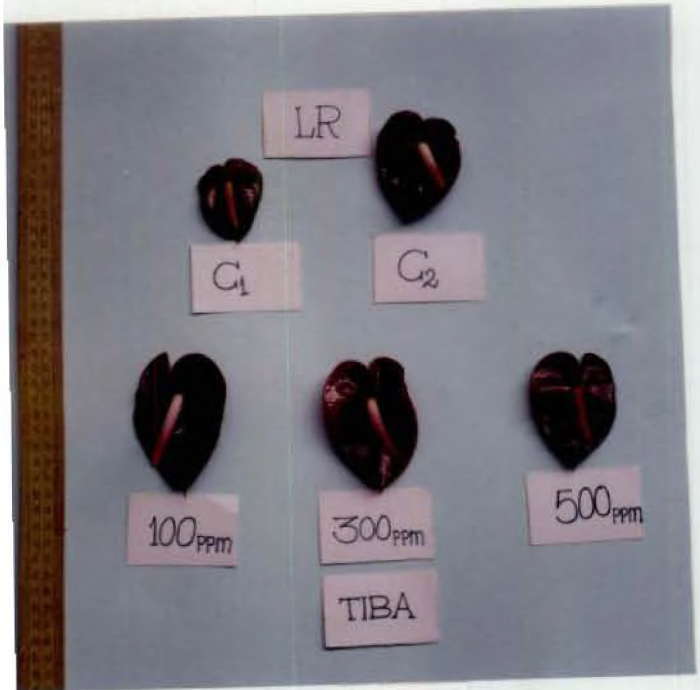



Plate 19

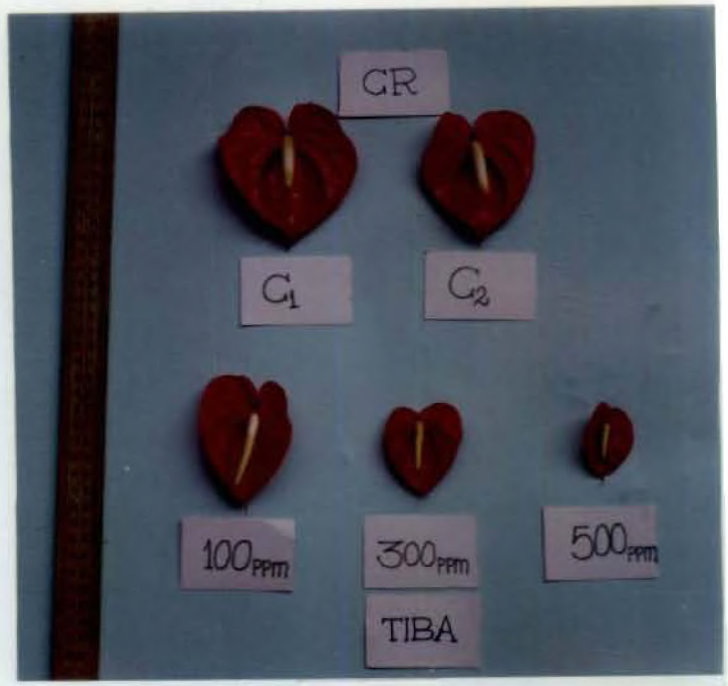



Plate 20

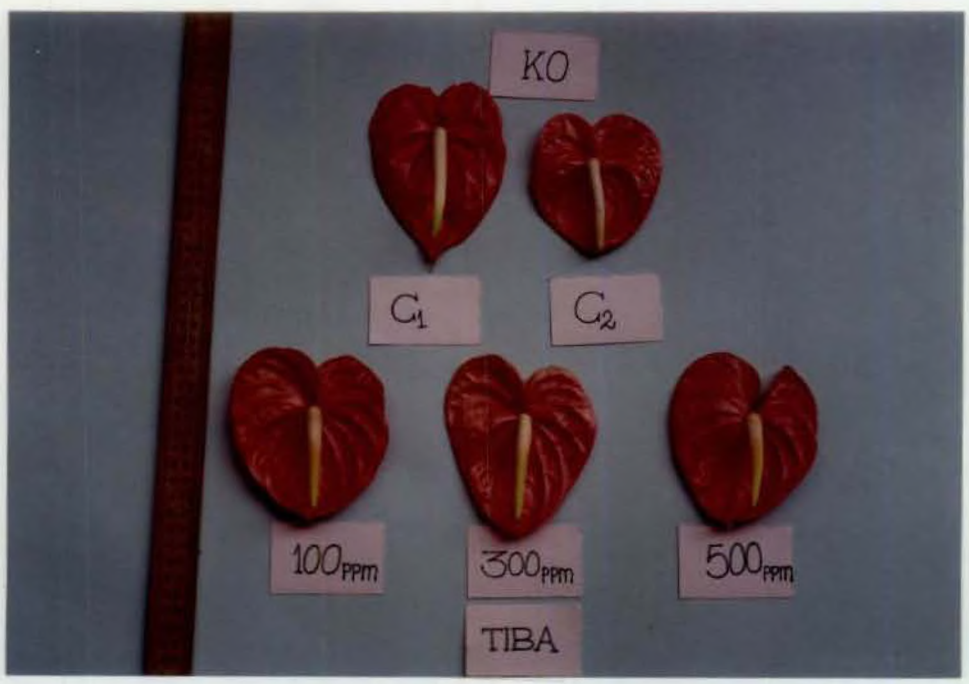
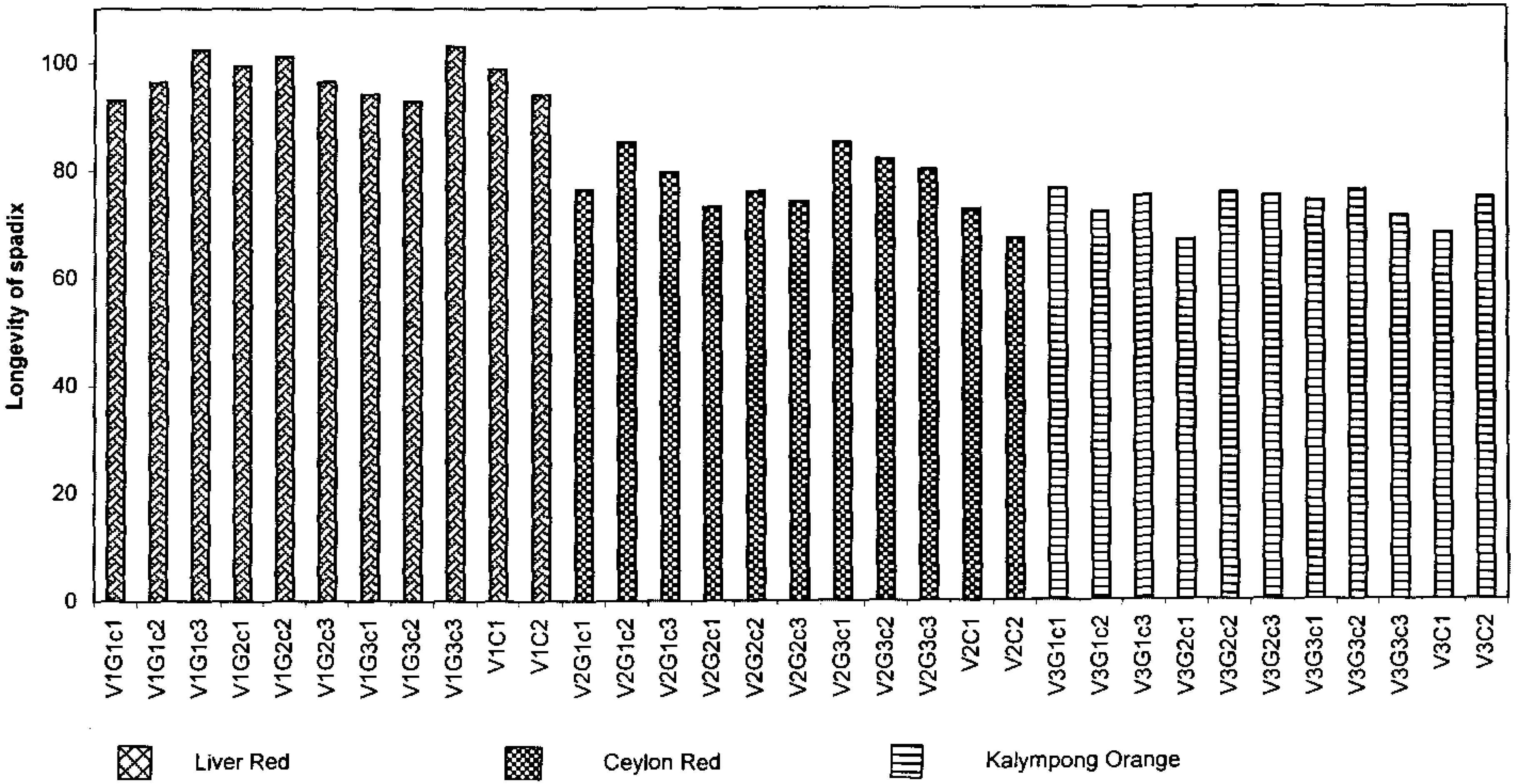



Plate 21

**Table 9 Effect of growth regulators on longevity of spadix**

| Sl. No. | Treatment | Longevity of spadix (in days) |
|---|---|---|
| 1 | $V_1G_1c_1$ | 93.0 |
| 2 | $V_1G_1c_2$ | 96.4 |
| 3 | $V_1G_1c_3$ | 102.4 |
| 4 | $V_1G_2c_1$ | 99.4 |
| 5 | $V_1G_2c_2$ | 101.0 |
| 6 | $V_1G_2c_3$ | 96.4 |
| 7 | $V_1G_3c_1$ | 94.2 |
| 8 | $V_1G_3c_2$ | 92.8 |
| 9 | $V_1G_3c_3$ | 103.0 |
| 10 | $V_1C_1$ | 98.8 |
| 11 | $V_1C_2$ | 94.0 |
| 12 | $V_2G_1c_1$ | 76.4 |
| 13 | $V_2G_1c_2$ | 85.2 |
| 14 | $V_2G_1c_3$ | 79.6 |
| 15 | $V_2G_2c_1$ | 73.2 |
| 16 | $V_2G_2c_2$ | 76.0 |
| 17 | $V_2G_2c_3$ | 74.2 |
| 18 | $V_2G_3c_1$ | 85.2 |
| 19 | $V_2G_3c_2$ | 82.0 |
| 20 | $V_2G_3c_3$ | 80.0 |
| 21 | $V_2C_1$ | 72.6 |
| 22 | $V_2C_2$ | 67.2 |
| 23 | $V_3G_1c_1$ | 76.4 |
| 24 | $V_3G_1c_2$ | 72.0 |
| 25 | $V_3G_1c_3$ | 75.0 |
| 26 | $V_3G_2c_1$ | 66.8 |
| 27 | $V_3G_2c_2$ | 75.6 |
| 28 | $V_3G_2c_3$ | 75.0 |
| 29 | $V_3G_3c_1$ | 74.0 |
| 30 | $V_3G_3c_2$ | 76.0 |
| 31 | $V_3G_3c_3$ | 71.2 |
| 32 | $V_3C_1$ | 68.0 |
| 33 | $V_3C_2$ | 74.6 |
| CD (0.05) | | 1.83 |

**Fig. 8 Effect of growth regulators on longevity of spadix of *Anthurium andreanum* cv. Liver Red, Ceylon Red and Kalympong Orange**



### 4.1.10 Candle size

Application of growth regulators had significant effect on candle size (Table 10).

Analysis of data revealed that three months after first spraying, K.O. treated with G.A. at 500 ppm recorded the largest candle (10.76 cm). The smallest candle is recorded by L.R. treated with G.A. at 100 ppm (5.00 cm). This was on par with L.R. treated with TIBA at 100 ppm (5.24 cm) and C.R. - no spray (5.46 cm).

Six months after first spraying, K.O. treated with G.A. at 500 ppm recorded the largest candle (11.22 cm). L.R. treated with TIBA at 100 ppm recorded the smallest candle (5.48 cm). This was on par with C.R. treated with distilled water spray (6.14 cm) and no spray (5.64 cm), L.R. with distilled water spray (6.12 cm) and TIBA at 300 ppm (6.50 cm).

In the ninth month of observation period, K.O. treated with TIBA at 100 ppm recorded the largest candle (9.78 cm). The smallest candle is recorded by C.R. treated with TIBA at 500 ppm (4.1 cm).

### 4.1.11 Leaf area

Statistical analysis of the data revealed that growth regulators had significant effect on leaf area. In the 3rd, 6th and 9th month after spraying, the variety K.O. treated with G.A. at 500 ppm recorded the highest leaf area (1353.20 $cm^2$, 1264.68 $cm^2$, 1273.00 $cm^2$) respectively. In all the three periods of observation the smallest leaf area was recorded by C.R. with TIBA

**Table 10 Effect of growth regulators on candle size (Length +Girth)**

| Sl. No. | Treatment | Candle size ($cm^2$) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 9th Month |
| 1 | $V_1G_1c_1$ | 5.00 | 6.72 | 6.90 |
| 2 | $V_1G_1c_2$ | 6.54 | 7.88 | 6.74 |
| 3 | $V_1G_1c_3$ | 6.68 | 7.54 | 7.30 |
| 4 | $V_1G_2c_1$ | 5.24 | 5.48 | 4.86 |
| 5 | $V_1G_2c_2$ | 7.02 | 6.50 | 7.24 |
| 6 | $V_1G_2c_3$ | 6.92 | 6.60 | 7.32 |
| 7 | $V_1G_3c_1$ | 7.86 | 7.68 | 6.98 |
| 8 | $V_1G_3c_2$ | 7.80 | 7.86 | 6.98 |
| 9 | $V_1G_3c_3$ | 9.14 | 9.22 | 7.14 |
| 10 | $V_1C_1$ | 7.16 | 6.12 | 6.08 |
| 11 | $V_1C_2$ | 7.14 | 7.42 | 6.82 |
| 12 | $V_2G_1c_1$ | 9.46 | 9.00 | 9.22 |
| 13 | $V_2G_1c_2$ | 7.82 | 7.74 | 8.44 |
| 14 | $V_2G_1c_3$ | 8.60 | 8.48 | 7.30 |
| 15 | $V_2G_2c_1$ | 7.64 | 7.12 | 6.74 |
| 16 | $V_2G_2c_2$ | 7.78 | 7.16 | 7.22 |
| 17 | $V_2G_2c_3$ | 7.82 | 7.04 | 4.10 |
| 18 | $V_2G_3c_1$ | 7.52 | 7.04 | 7.38 |
| 19 | $V_2G_3c_2$ | 8.64 | 8.00 | 7.56 |
| 20 | $V_2G_3c_3$ | 9.22 | 9.38 | 8.30 |
| 21 | $V_2C_1$ | 6.24 | 6.14 | 5.44 |
| 22 | $V_2C_2$ | 5.46 | 5.64 | 6.98 |
| 23 | $V_3G_1c_1$ | 8.76 | 8.74 | 7.52 |
| 24 | $V_3G_1c_2$ | 9.16 | 9.76 | 8.36 |
| 25 | $V_3G_1c_3$ | 10.76 | 11.22 | 8.44 |
| 26 | $V_3G_2c_1$ | 8.74 | 8.66 | 9.78 |
| 27 | $V_3G_2c_2$ | 7.74 | 7.06 | 7.44 |
| 28 | $V_3G_2c_3$ | 8.18 | 7.52 | 6.42 |
| 29 | $V_3G_3c_1$ | 8.38 | 8.50 | 8.44 |
| 30 | $V_3G_3c_2$ | 9.28 | 9.78 | 8.40 |
| 31 | $V_3G_3c_3$ | 9.68 | 9.78 | 6.62 |
| 32 | $V_3C_1$ | 7.76 | 7.98 | 7.52 |
| 33 | $V_3C_2$ | 8.22 | 9.36 | 8.32 |
| CD (0.05) | | 0.82 | 1.02 | 0.52 |

**Table 11 Effect of growth regulators on leaf area of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Leaf area ($cm^2$) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 8th Month |
| 1 | $V_1G_1C_1$ | 826.80 | 814.05 | 818.80 |
| 2 | $V_1G_1C_2$ | 817.20 | 872.75 | 856.00 |
| 3 | $V_1G_1C_3$ | 1222.00 | 1192.28 | 1185.40 |
| 4 | $V_1G_2C_1$ | 698.60 | 751.48 | 756.60 |
| 5 | $V_1G_2C_2$ | 701.20 | 724.17 | 727.00 |
| 6 | $V_1G_2C_3$ | 500.40 | 571.29 | 569.40 |
| 7 | $V_1G_3C_1$ | 780.60 | 792.05 | 794.80 |
| 8 | $V_1G_3C_2$ | 859.60 | 858.74 | 859.40 |
| 9 | $V_1G_3C_3$ | 1065.20 | 1129.91 | 1136.60 |
| 10 | $V_1C_1$ | 577.00 | 583.08 | 586.40 |
| 11 | $V_1C_2$ | 648.20 | 647.43 | 652.40 |
| 12 | $V_2G_1C_1$ | 872.28 | 901.93 | 914.04 |
| 13 | $V_2G_1C_2$ | 934.56 | 936.33 | 940.20 |
| 14 | $V_2G_1C_3$ | 987.48 | 968.96 | 1001.16 |
| 15 | $V_2G_2C_1$ | 688.80 | 681.56 | 701.52 |
| 16 | $V_2G_2C_2$ | 521.76 | 520.37 | 514.32 |
| 17 | $V_2G_2C_3$ | 460.56 | 473.30 | 477.60 |
| 18 | $V_2G_3C_1$ | 707.16 | 720.20 | 818.04 |
| 19 | $V_2G_3C_2$ | 757.92 | 754.31 | 766.56 |
| 20 | $V_2G_3C_3$ | 749.04 | 759.40 | 760.68 |
| 21 | $V_2C_1$ | 670.32 | 665.29 | 675.24 |
| 22 | $V_2C_2$ | 689.40 | 684.73 | 678.72 |
| 23 | $V_3G_1C_1$ | 982.40 | 983.08 | 983.60 |
| 24 | $V_3G_1C_2$ | 1265.00 | 1253.50 | 1268.00 |
| 25 | $V_3G_1C_3$ | 1353.20 | 1264.68 | 1273.00 |
| 26 | $V_3G_2C_1$ | 853.80 | 808.82 | 829.60 |
| 27 | $V_3G_2C_2$ | 962.00 | 964.04 | 974.20 |
| 28 | $V_3G_2C_3$ | 982.40 | 674.16 | 654.20 |
| 29 | $V_3G_3C_1$ | 953.00 | 955.57 | 958.80 |
| 30 | $V_3G_3C_2$ | 963.80 | 981.08 | 1268.00 |
| 31 | $V_3G_3C_3$ | 1239.20 | 1209.74 | 1237.60 |
| 32 | $V_3C_1$ | 1152.60 | 1124.17 | 1137.20 |
| 33 | $V_3C_2$ | 1180.20 | 1175.46 | 1181.60 |
| CD (0.05) | | 45.39 | 43.57 | 44.55 |

at 500 ppm (460.56 $cm^2$, 473.30 $cm^2$, 477.60 $cm^2$) respectively. In the sixth month after spraying the highest leaf area (1264.68 $cm^2$ is on par with K.O. treated with G.A. at 300 ppm (1253.50 $cm^2$). In the ninth month of observation the highest leaf area (1273.00 $cm^2$) was on par with K.O. treated with kinetin at 300 and 500 ppm (1268.00 $cm^2$, 1267.60 $cm^2$ respectively).

### 4.1.12 Leaf area index

In the 3rd, 6th and 9th month after first spray the highest leaf area was recorded by the variety K.O. treated with G.A. at 500 ppm (0.67, 0.62, 0.63 respectively). In the 3rd, 6th and 9th month after the first spray the lowest leaf area was recorded by the variety C.R. treated with TIBA at 500 ppm (0.23, 0.23, 0.24 respectively). In the third month after the first spray the lowest leaf area (0.23) is on par with C.R. treated with TIBA at 300 ppm (0.26) and L.R. treated with TIBA at 500 ppm (0.25).

### 4.1.13 Chlorophyll content

Data pertaining to chlorophyll content of *A. andreanum* cv. L.R., C.R., K.O. are presented on Table 13.

Statistical analysis of the data revealed that there were significant differences among treatment in all the three periods of observation.

In the third month after the first spray, the variety L.R. treated with G.A. at 500 ppm recorded the highest content of chlorophyll (2.14 mg/g tissue). This was on par with K.O. treated with G.A. at 500 ppm (2.12 mg/g tissue). The lowest content of chlorophyll was recorded by C.R. treated with G.A. at 100 ppm (0.58 mg/g tissue).

**Table 12 Effect of growth regulators on leaf area index of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Leaf area index | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 8th Month |
| 1 | $V_1G_1C_1$ | 0.41 | 0.04 | 0.40 |
| 2 | $V_1G_1C_2$ | 0.40 | 0.43 | 0.42 |
| 3 | $V_1G_1C_3$ | 0.60 | 0.59 | 0.59 |
| 4 | $V_1G_2C_1$ | 0.35 | 0.37 | 0.37 |
| 5 | $V_1G_2C_2$ | 0.35 | 0.36 | 0.36 |
| 6 | $V_1G_2C_3$ | 0.25 | 0.28 | 0.28 |
| 7 | $V_1G_3C_1$ | 0.39 | 0.39 | 0.39 |
| 8 | $V_1G_3C_2$ | 0.42 | 0.42 | 0.42 |
| 9 | $V_1G_3C_3$ | 0.52 | 0.56 | 0.56 |
| 10 | $V_1C_1$ | 0.28 | 0.29 | 0.29 |
| 11 | $V_1C_2$ | 0.32 | 0.32 | 0.32 |
| 12 | $V_2G_1C_1$ | 0.43 | 0.44 | 0.45 |
| 13 | $V_2G_1C_2$ | 0.46 | 0.46 | 0.46 |
| 14 | $V_2G_1C_3$ | 0.49 | 0.48 | 0.49 |
| 15 | $V_2G_2C_1$ | 0.34 | 0.34 | 0.35 |
| 16 | $V_2G_2C_2$ | 0.26 | 0.26 | 0.25 |
| 17 | $V_2G_2C_3$ | 0.23 | 0.23 | 0.24 |
| 18 | $V_2G_3C_1$ | 0.35 | 0.35 | 0.40 |
| 19 | $V_2G_3C_2$ | 0.37 | 0.37 | 0.38 |
| 20 | $V_2G_3C_3$ | 0.37 | 0.37 | 0.38 |
| 21 | $V_2C_1$ | 0.33 | 0.33 | 0.33 |
| 22 | $V_2C_2$ | 0.34 | 0.34 | 0.34 |
| 23 | $V_3G_1C_1$ | 0.47 | 0.47 | 0.47 |
| 24 | $V_3G_1C_2$ | 0.48 | 0.48 | 0.61 |
| 25 | $V_3G_1C_3$ | 0.67 | 0.60 | 0.63 |
| 26 | $V_3G_2C_1$ | 0.42 | 0.62 | 0.41 |
| 27 | $V_3G_2C_2$ | 0.47 | 0.48 | 0.48 |
| 28 | $V_3G_2C_3$ | 0.34 | 0.33 | 0.32 |
| 29 | $V_3G_3C_1$ | 0.48 | 0.48 | 0.49 |
| 30 | $V_3G_3C_2$ | 0.63 | 0.62 | 0.63 |
| 31 | $V_3G_3C_3$ | 0.61 | 0.60 | 0.63 |
| 32 | $V_3C_1$ | 0.57 | 0.56 | 0.56 |
| 33 | $V_3C_2$ | 0.58 | 0.58 | 0.58 |
| CD (0.05) | | 0.03 | 0.01 | 0.02 |

**Table 13 Effect of growth regulators on chlorophyll content on *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Chlorophyll content (mg /g tissue) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 9th Month |
| 1 | $V_1G_1c_1$ | 1.17 | 1.14 | 1.16 |
| 2 | $V_1G_1c_2$ | 1.02 | 1.02 | 1.04 |
| 3 | $V_1G_1c_3$ | 2.14 | 2.00 | 2.04 |
| 4 | $V_1G_2c_1$ | 1.03 | 1.04 | 1.04 |
| 5 | $V_1G_2c_2$ | 1.43 | 1.42 | 1.44 |
| 6 | $V_1G_2c_3$ | 1.52 | 1.55 | 1.53 |
| 7 | $V_1G_3c_1$ | 1.62 | 1.61 | 1.63 |
| 8 | $V_1G_3c_2$ | 1.54 | 1.75 | 1.63 |
| 9 | $V_1G_3c_3$ | 1.34 | 1.33 | 1.33 |
| 10 | $V_1C_1$ | 1.05 | 1.22 | 1.02 |
| 11 | $V_1C_2$ | 1.53 | 1.56 | 1.53 |
| 12 | $V_2G_1c_1$ | 0.58 | 0.57 | 0.58 |
| 13 | $V_2G_1c_2$ | 1.02 | 1.02 | 1.03 |
| 14 | $V_2G_1c_3$ | 2.02 | 2.02 | 2.04 |
| 15 | $V_2G_2c_1$ | 1.25 | 1.26 | 1.26 |
| 16 | $V_2G_2c_2$ | 2.02 | 2.01 | 2.00 |
| 17 | $V_2G_2c_3$ | 1.78 | 1.82 | 1.76 |
| 18 | $V_2G_3c_1$ | 1.01 | 1.02 | 1.02 |
| 19 | $V_2G_3c_2$ | 1.12 | 1.11 | 1.15 |
| 20 | $V_2G_3c_3$ | 1.75 | 1.80 | 1.74 |
| 21 | $V_2C_1$ | 1.13 | 1.16 | 1.14 |
| 22 | $V_2C_2$ | 1.15 | 1.16 | 1.15 |
| 23 | $V_3G_1c_1$ | 0.88 | 0.86 | 0.88 |
| 24 | $V_3G_1c_2$ | 0.79 | 0.86 | 1.82 |
| 25 | $V_3G_1c_3$ | 2.12 | 2.05 | 2.16 |
| 26 | $V_3G_2c_1$ | 1.45 | 1.38 | 1.44 |
| 27 | $V_3G_2c_2$ | 1.07 | 1.32 | 1.08 |
| 28 | $V_3G_2c_3$ | 1.18 | 1.21 | 1.22 |
| 29 | $V_3G_3c_1$ | 1.84 | 1.84 | 1.86 |
| 30 | $V_3G_3c_2$ | 1.86 | 1.85 | 1.95 |
| 31 | $V_3G_3c_3$ | 1.94 | 1.29 | 1.76 |
| 32 | $V_3C_1$ | 1.18 | 1.17 | 1.24 |
| 33 | $V_3C_2$ | 1.18 | 1.14 | 1.21 |
| CD (0.05) | | 0.03 | 0.03 | 0.04 |

Six months after the first spray the highest chlorophyll content was recorded by K.O. treated with G.A. at 500 ppm (2.05 mg/g tissue), which was on par with C.R. treated with TIBA at 300 ppm (2.01 mg/g tissue), L.R. treated with G.A. at 500 ppm (2.00 mg/g tissue). The lowest chlorophyll content was recorded by C.R. treated with G.A. at 100 ppm (0.57 mg/g tissue).

Nine months after the first spray the variety K.O. treated with G.A. at 500 ppm (2.16 mg/g tissue) recorded the highest content of chlorophyll. C.R. treated with G.A. at 100 ppm recorded the lowest content of chlorophyll (0.58 mg/g tissue).



#### 4.1.14 Carotenoid content

Statistical analysis of the data revealed that growth regulators had significant effect on the carotenoid content of anthurium (Table No. 14)

In the third month after first spraying, L.R. treated with G.A. at 300 ppm recorded the highest content of carotenoid (10.38 mg/100g tissue). This was on par with L.R. treated with G.A. at 100 ppm (10.31 mg/100 g tissue) and 500 ppm (10.31 mg/100 g tissue). The lowest content of carotenoid (3.49 mg/100g tissue) is recorded in K.O. - no spray. This was on par with all treatments of TIBA and kinetin on K.O.

Six months after first spraying, L.R. treated with GA at 300 ppm recorded the highest content of carotenoid (10.41 mg/100g tissue). This was on par with L.R. treated with G.A. at 100 ppm (10.15 mg/100 g tissue) and 500 ppm(10.50 mg/100 g tissue). The lowest content of carotenoid was recorded on K.O. treated with distilled water spray (3.20 mg/100g tissue).

**Table 14 Effect of growth regulators on carotenoid content on *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Carotenoid content (mg / 100 g tissue) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 9th Month |
| 1 | $V_1G_1c_1$ | 10.31 | 10.15 | 10.03 |
| 2 | $V_1G_1c_2$ | 10.38 | 10.41 | 10.05 |
| 3 | $V_1G_1c_3$ | 10.31 | 10.50 | 10.07 |
| 4 | $V_1G_2c_1$ | 7.36 | 7.72 | 7.80 |
| 5 | $V_1G_2c_2$ | 7.37 | 7.54 | 7.38 |
| 6 | $V_1G_2c_3$ | 7.24 | 7.60 | 7.52 |
| 7 | $V_1G_3c_1$ | 9.38 | 9.68 | 9.54 |
| 8 | $V_1G_3c_2$ | 9.27 | 9.81 | 9.76 |
| 9 | $V_1G_3c_3$ | 9.30 | 9.76 | 7.40 |
| 10 | $V_1C_1$ | 7.52 | 7.38 | 7.76 |
| 11 | $V_1C_2$ | 7.35 | 7.56 | 6.32 |
| 12 | $V_2G_1c_1$ | 6.49 | 6.33 | 6.68 |
| 13 | $V_2G_1c_2$ | 6.45 | 6.54 | 6.70 |
| 14 | $V_2G_1c_3$ | 6.64 | 6.64 | 5.44 |
| 15 | $V_2G_2c_1$ | 5.66 | 5.65 | 5.72 |
| 16 | $V_2G_2c_2$ | 5.45 | 5.48 | 5.56 |
| 17 | $V_2G_2c_3$ | 5.31 | 5.52 | 5.74 |
| 18 | $V_2G_3c_1$ | 5.50 | 5.76 | 5.42 |
| 19 | $V_2G_3c_2$ | 5.51 | 5.71 | 5.74 |
| 20 | $V_2G_3c_3$ | 5.70 | 5.86 | 5.64 |
| 21 | $V_2C_1$ | 5.79 | 5.32 | 5.38 |
| 22 | $V_2C_2$ | 5.82 | 5.40 | 4.38 |
| 23 | $V_3G_1c_1$ | 4.20 | 4.33 | 4.72 |
| 24 | $V_3G_1c_2$ | 4.63 | 4.76 | 4.68 |
| 25 | $V_3G_1c_3$ | 4.63 | 4.74 | 4.66 |
| 26 | $V_3G_2c_1$ | 3.64 | 3.28 | 3.34 |
| 27 | $V_3G_2c_2$ | 3.64 | 3.68 | 3.62 |
| 28 | $V_3G_2c_3$ | 3.55 | 3.58 | 3.64 |
| 29 | $V_3G_3c_1$ | 3.61 | 3.61 | 3.44 |
| 30 | $V_3G_3c_2$ | 3.69 | 3.85 | 3.52 |
| 31 | $V_3G_3c_3$ | 3.60 | 3.93 | 3.40 |
| 32 | $V_3C_1$ | 3.52 | 3.20 | 3.24 |
| 33 | $V_3C_2$ | 3.49 | 3.46 | 3.40 |
| CD (0.05) | | 0.27 | 0.27 | 0.22 |

This was on par with K.O. treated with no spray and TIBA at 100 ppm (3.28 mg/100 g tissue) and no spray (3.46 mg/100 g tissue).

Nine months after first spraying, L.R. treated with G. A. at 500 ppm recorded the highest content of carotenoid (10.07 mg/100 g tissue). This was on par with L.R. treated with G.A. at 100 ppm (10.03 mg/100 g tissue) and 300 ppm (10.05 mg/100g tissue). The lowest content of carotenoid (3.24 mg/100g tissue) is reported on K.O. - no spray. This was on par with K.O. treated with distilled water spray (3.40 mg/100g tissue), K - 500 ppm (3.40 mg/100g tissue), and 100 ppm (3.44 mg/100g tissue), TIBA - 100 ppm (3.34 mg/100g tissue).

**4.1.15 Anthocyanin**

Statistical analysis of the date revealed that growth regulators had significant effect on anthocyanin content of anthurium (Table No. 15).

In the third month after first spraying, L.R. treated with G.A. at 500 ppm recorded the highest content of anthocyanin (387.2 mg/100g tissue). This was on par with L.R. treated with distilled water spray (385.6 mg/100g tissue), no spray (385.8 mg/100g tissue), TIBA at 500 ppm (385.6 mg/100g tissue), kinetin at 300 ppm (385.4 mg/100g tissue). The lowest content of anthocyanin is recorded on K.O. - no spray (50.6 mg/100g tissue) that was on par with K.O. treated with distilled water spray (52.6 mg/100g tissue).

Six months after first spraying, L.R. treated with distilled water spray recorded the highest content (388.2 mg/100g tissue) of anthocyanin which was on par with L.R. treated with TIBA at 300 ppm (387.4 mg/100g tissue). The

**Table 15 Effect of growth regulators on anthocyanin content of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Anthocyanin (mg/100g sample) | | |
|---|---|---|---|---|
| | | $3^{rd}$ Month | $6^{th}$ Month | $8^{th}$ Month |
| 1 | $V_1G_1C_1$ | 379.20 | 384.00 | 384.00 |
| 2 | $V_1G_1C_2$ | 374.80 | 384.60 | 383.60 |
| 3 | $V_1G_1C_3$ | 387.20 | 381.20 | 381.60 |
| 4 | $V_1G_2C_1$ | 379.00 | 386.40 | 386.40 |
| 5 | $V_1G_2C_2$ | 377.80 | 387.40 | 387.60 |
| 6 | $V_1G_2C_3$ | 385.60 | 386.80 | 382.80 |
| 7 | $V_1G_3C_1$ | 381.60 | 381.80 | 382.80 |
| 8 | $V_1G_3C_2$ | 385.40 | 386.80 | 385.00 |
| 9 | $V_1G_3C_3$ | 384.20 | 386.20 | 386.80 |
| 10 | $V_1C_1$ | 385.60 | 388.20 | 386.00 |
| 11 | $V_1C_2$ | 385.80 | 384.00 | 384.80 |
| 12 | $V_2G_1C_1$ | 84.00 | 82.80 | 82.20 |
| 13 | $V_2G_1C_2$ | 83.20 | 82.20 | 83.00 |
| 14 | $V_2G_1C_3$ | 85.00 | 83.80 | 82.40 |
| 15 | $V_2G_2C_1$ | 84.20 | 85.80 | 85.00 |
| 16 | $V_2G_2C_2$ | 85.80 | 81.00 | 82.00 |
| 17 | $V_2G_2C_3$ | 85.40 | 82.00 | 80.60 |
| 18 | $V_2G_3C_1$ | 84.80 | 83.80 | 82.40 |
| 19 | $V_2G_3C_2$ | 85.40 | 85.60 | 83.30 |
| 20 | $V_2G_3C_3$ | 85.60 | 86.80 | 58.80 |
| 21 | $V_2C_1$ | 86.40 | 80.60 | 86.60 |
| 22 | $V_2C_2$ | 84.20 | 79.80 | 80.80 |
| 23 | $V_3G_1C_1$ | 59.00 | 59.00 | 57.60 |
| 24 | $V_3G_1C_2$ | 58.60 | 58.60 | 58.20 |
| 25 | $V_3G_1C_3$ | 58.60 | 59.40 | 59.20 |
| 26 | $V_3G_2C_1$ | 59.00 | 54.40 | 54.60 |
| 27 | $V_3G_2C_2$ | 54.80 | 56.20 | 56.20 |
| 28 | $V_3G_2C_3$ | 55.20 | 54.60 | 56.60 |
| 29 | $V_3G_3C_1$ | 54.60 | 57.20 | 53.40 |
| 30 | $V_3G_3C_2$ | 57.40 | 58.00 | 57.00 |
| 31 | $V_3G_3C_3$ | 57.00 | 57.80 | 58.00 |
| 32 | $V_3C_1$ | 52.60 | 50.60 | 50.80 |
| 33 | $V_3C_2$ | 50.60 | 51.20 | 51.20 |
| CD (0.05) | | 3.90 | 1.00 | 1.78 |

lowest content is recorded on K.O. treated with distilled water spray (50.6 mg/100g tissue) that was on par with no spray (51.2 mg/100g tissue).

In the nine month after first spraying, variety L.R. treated with TIBA at 300 ppm recorded the highest content of anthocyanin (387.6 mg/100g tissue) which was on par with L.R. treated with kinetin at 500 ppm (386.8 mg/100g tissue), TIBA at 100 ppm (386.4 mg/100g tissue) and distilled water spray (386.0 mg/100g tissue). The lowest content is recorded by K.O. treated with distilled water spray (50.8 mg/100g tissue) which was on par with no spray (51.2 mg/100g tissue).

### 4.1.16 Protein content

Statistical analysis of the data revealed that growth regulators had significant effect on protein content of anthurium (Table 16).

In the third month after first spraying, K.O. treated with kinetin at 500 ppm recorded the highest content of protein (108.4 mg/g tissue). This was on par with K.O. treated with kinetin at 300 ppm (108.0 mg/100g tissue). The lowest protein content (93.2 mg/g tissue) was recorded by L.R. - no spray. This was on par with L.R. treated with G.A. at 100 ppm (93.6 mg/100g tissue), TIBA at 100 ppm (94.6 mg/100g tissue) and 300 ppm (94.2 mg/100g tissue), C.R.- no spray (93.8 mg/100g tissue), G.A. at 300 ppm (93.8 mg/100g tissue).

In the six month after first spraying, K.O. treated with kinetin 500 ppm recorded the highest content of protein (109 mg/g). C.R. treated G.A. at 300 ppm (93.00 mg/g) recorded the lowest content of protein which was on par with C.R. - with no spray (93.2 mg/g).

**Table 16 Effect of growth regulators on protein content of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Protein (mg/g tissue) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 8th Month |
| 1 | $V_1G_1C_1$ | 93.60 | 93.60 | 92.60 |
| 2 | $V_1G_1C_2$ | 95.40 | 96.40 | 94.40 |
| 3 | $V_1G_1C_3$ | 101.00 | 101.80 | 99.60 |
| 4 | $V_1G_2C_1$ | 94.60 | 91.40 | 91.20 |
| 5 | $V_1G_2C_2$ | 94.20 | 93.60 | 93.80 |
| 6 | $V_1G_2C_3$ | 95.20 | 94.80 | 94.80 |
| 7 | $V_1G_3C_1$ | 104.60 | 102.80 | 102.40 |
| 8 | $V_1G_3C_2$ | 403.60 | 104.40 | 105.00 |
| 9 | $V_1G_3C_3$ | 103.00 | 105.40 | 105.80 |
| 10 | $V_1C_1$ | 95.00 | 93.80 | 92.80 |
| 11 | $V_1C_2$ | 93.20 | 93.20 | 92.80 |
| 12 | $V_2G_1C_1$ | 95.80 | 95.40 | 94.40 |
| 13 | $V_2G_1C_2$ | 94.40 | 93.00 | 91.40 |
| 14 | $V_2G_1C_3$ | 95.60 | 97.20 | 96.80 |
| 15 | $V_2G_2C_1$ | 100.40 | 94.20 | 95.00 |
| 16 | $V_2G_2C_2$ | 94.60 | 94.40 | 94.80 |
| 17 | $V_2G_2C_3$ | 94.00 | 93.60 | 93.00 |
| 18 | $V_2G_3C_1$ | 100.40 | 97.20 | 95.00 |
| 19 | $V_2G_3C_2$ | 102.80 | 105.20 | 104.00 |
| 20 | $V_2G_3C_3$ | 103.40 | 105.80 | 104.00 |
| 21 | $V_2C_1$ | 95.60 | 93.60 | 94.20 |
| 22 | $V_2C_2$ | 93.80 | 94.80 | 93.40 |
| 23 | $V_3G_1C_1$ | 105.80 | 107.20 | 107.00 |
| 24 | $V_3G_1C_2$ | 104.00 | 106.60 | 105.00 |
| 25 | $V_3G_1C_3$ | 102.80 | 105.80 | 106.60 |
| 26 | $V_3G_2C_1$ | 96.20 | 98.20 | 97.00 |
| 27 | $V_3G_2C_2$ | 95.60 | 96.40 | 95.80 |
| 28 | $V_3G_2C_3$ | 95.80 | 94.80 | 96.20 |
| 29 | $V_3G_3C_1$ | 103.00 | 104.00 | 105.80 |
| 30 | $V_3G_3C_2$ | 108.00 | 107.80 | 105.80 |
| 31 | $V_3G_3C_3$ | 108.40 | 109.00 | 107.40 |
| 32 | $V_3C_1$ | 96.00 | 97.00 | 95.00 |
| 33 | $V_3C_2$ | 95.80 | 95.40 | 95.80 |
| CD (0.05) | | 0.42 | 0.56 | 0.46 |

Ninth month after first spraying, K.O. treated with kinetin at 500 ppm recorded the highest content of protein (107.4 mg/g). This was on par with K.O. with G.A. at 100 ppm (107 mg/g). The lowest content of protein is recorded by L.R. treated with TIBA at 100 ppm (91.2 mg/g). This was on par with L.R. treated with G.A. 300 ppm (91.4 mg/g).

### 4.1.17 Total phenolics

Statistical analysis of data revealed that growth regulators had significant effect on phenol content of anthurium (Table No. 17). In all treatments total phenolic content showed an increase over control.

In the third month after first spraying, K.O. treated with kinetin at 500 ppm recorded the highest content of phenol (121.20 mg/g tissue). L.R. - no spray recorded the lowest content of phenol (92.80 mg/g tissue). This was on par with C.R. treated with TIBA at 300 ppm (93.60 mg/g tissue) and 500 ppm (93.00 mg/g tissue), no spray (93.20 mg/g tissue) and distilled water spray (94.00 mg/g tissue) and K.O. with TIBA at 500 ppm (94.00 mg/g tissue).

Six months after first spraying, K.O. treated with kinetin at 500 ppm recorded the highest content of phenol (117.00 mg/g tissue). This was on par with C.R. treated with G.A. at 500 ppm (115.60 mg/g tissue) and kinetin at 500 ppm (116.80 mg/g tissue). The lowest content of phenol (92.60 mg/g tissue) was recorded by L.R. treated with distilled water spray. This was on par with C.R. - no spray (92.80 mg/g tissue), distilled water spray (92.80 mg/g tissue), TIBA at 300 ppm (94.40 mg/g tissue) and 500 ppm (93.40 mg/g

**Table 17 Effect of growth regulators on phenol content of *Anthurium andreanum* cv. Liver Red, Ceylon Red, Kalympong Orange**

| Sl. No. | Treatment | Phenol (mg/g tissue) | | |
|---|---|---|---|---|
| | | 3rd Month | 6th Month | 8th Month |
| 1 | $V_1G_1C_1$ | 104.20 | 108.20 | 107.80 |
| 2 | $V_1G_1C_2$ | 113.00 | 112.00 | 112.40 |
| 3 | $V_1G_1C_3$ | 117.40 | 115.20 | 114.40 |
| 4 | $V_1G_2C_1$ | 96.60 | 96.60 | 96.40 |
| 5 | $V_1G_2C_2$ | 96.40 | 97.20 | 96.80 |
| 6 | $V_1G_2C_3$ | 95.40 | 94.40 | 94.60 |
| 7 | $V_1G_3C_1$ | 107.40 | 104.80 | 103.40 |
| 8 | $V_1G_3C_2$ | 111.60 | 106.00 | 105.80 |
| 9 | $V_1G_3C_3$ | 113.60 | 112.20 | 112.40 |
| 10 | $V_1C_1$ | 95.20 | 92.60 | 95.60 |
| 11 | $V_1C_2$ | 92.80 | 92.80 | 93.20 |
| 12 | $V_2G_1C_1$ | 108.60 | 107.80 | 107.40 |
| 13 | $V_2G_1C_2$ | 104.00 | 107.20 | 107.00 |
| 14 | $V_2G_1C_3$ | 116.20 | 115.60 | 116.60 |
| 15 | $V_2G_2C_1$ | 96.20 | 97.40 | 96.80 |
| 16 | $V_2G_2C_2$ | 93.60 | 94.40 | 95.20 |
| 17 | $V_2G_2C_3$ | 93.00 | 93.40 | 92.20 |
| 18 | $V_2G_3C_1$ | 101.4 | 102.00 | 101.60 |
| 19 | $V_2G_3C_2$ | 110.40 | 112.60 | 116.80 |
| 20 | $V_2G_3C_3$ | 117.60 | 116.80 | 115.60 |
| 21 | $V_2C_1$ | 94.00 | 92.80 | 93.60 |
| 22 | $V_2C_2$ | 93.20 | 92.80 | 92.20 |
| 23 | $V_3G_1C_1$ | 105.60 | 105.00 | 105.80 |
| 24 | $V_3G_1C_2$ | 106.40 | 107.40 | 106.80 |
| 25 | $V_3G_1C_3$ | 119.60 | 114.80 | 113.40 |
| 26 | $V_3G_2C_1$ | 102.00 | 97.40 | 95.40 |
| 27 | $V_3G_2C_2$ | 97.00 | 96.40 | 96.20 |
| 28 | $V_3G_2C_3$ | 94.00 | 94.00 | 94.40 |
| 29 | $V_3G_3C_1$ | 108.60 | 105.00 | 106.80 |
| 30 | $V_3G_3C_2$ | 108.60 | 106.40 | 104.80 |
| 31 | $V_3G_3C_3$ | 121.20 | 117.60 | 117.20 |
| 32 | $V_3C_1$ | 95.20 | 93.20 | 96.00 |
| 33 | $V_3C_2$ | 96.20 | 93.40 | 92.80 |
| CD (0.05) | | 1.77 | 2.23 | 1.31 |

tissue), L.R. treated with distilled water spray (92.60 mg/g tissue) and TIBA at 500 ppm (94.40 mg/g tissue) and no spray (92.80 mg/g tissue).

Nine months after first spraying, K.O. treated with kinetin at 500 ppm recorded the highest content of phenol (117.20 mg/g tissue). This was on par with C.R. treated with kinetin at 300 ppm (116.80 mg/g tissue) and G.A. at 500 ppm (116.60 mg/g tissue). The lowest content phenol is recorded by C.R. treated with TIBA at 500 ppm (92.20 mg/g tissue). This was on par with K.O. - no spray (92.80 mg/g tissue), TIBA at 500 ppm (94.40 mg/g tissue), L.R. treated TIBA at 100 ppm (96.4 mg/g tissue) and 300 ppm (96.80 mg/g tissue), no spray (93.20 mg/g tissue), C.R. treated with distilled water spray (93.60 mg/g tissue).

**4.1.18 Response to pests and diseases**

The pests observed in the field were snails, termite and spodoptera. Snails were present in all treatments during the rainy season. Others were present only in one or two plants.

Diseases observed in the field were bacterial blight and collelotrichum leaf spot.

**Economics of growth regulator application**

In the variety L.R. the result shows that the application of GA at 500 ppm. is the best treatment with regard to flower and sucker production with a total of Rs. 133.70 per plant per year, followed by 100 ppm TIBA (Rs. 75.60 per plant per year) and 300 ppm G.A. (Rs. 56.90 per plant

**Table 18 Number of insect pests and snails observed during the experimental period**

| Sl. No. | Treatment | Cutworm (*Spodoptera litura*) | Termite | Snails |
|---|---|---|---|---|
| 1 | $V_1G_1C_1$ | - | - | Present |
| 2 | $V_1G_1C_2$ | - | - | ” |
| 3 | $V_1G_1C_3$ | - | - | ” |
| 4 | $V_1G_2C_1$ | - | - | ” |
| 5 | $V_1G_2C_2$ | - | - | ” |
| 6 | $V_1G_2C_3$ | - | - | ” |
| 7 | $V_1G_3C_1$ | 2 | - | ” |
| 8 | $V_1G_3C_2$ | - | - | ” |
| 9 | $V_1G_3C_3$ | - | - | ” |
| 10 | $V_1C_1$ | - | Present | ” |
| 11 | $V_1C_2$ | - | - | ” |
| 12 | $V_2G_1C_1$ | - | - | ” |
| 13 | $V_2G_1C_2$ | - | - | ” |
| 14 | $V_2G_1C_3$ | - | - | ” |
| 15 | $V_2G_2C_1$ | - | Present | ” |
| 16 | $V_2G_2C_2$ | 2 | - | ” |
| 17 | $V_2G_2C_3$ | 1 | - | ” |
| 18 | $V_2G_3C_1$ | 0 | - | ” |
| 19 | $V_2G_3C_2$ | 0 | - | ” |
| 20 | $V_2G_3C_3$ | 0 | - | ” |
| 21 | $V_2C_1$ | 0 | - | ” |
| 22 | $V_2C_2$ | 0 | - | ” |
| 23 | $V_3G_1C_1$ | 0 | - | ” |
| 24 | $V_3G_1C_2$ | 0 | - | ” |
| 25 | $V_3G_1C_3$ | 1 | - | ” |
| 26 | $V_3G_2C_1$ | 0 | - | ” |
| 27 | $V_3G_2C_2$ | 0 | - | ” |
| 28 | $V_3G_2C_3$ | 0 | - | ” |
| 29 | $V_3G_3C_1$ | 0 | - | ” |
| 30 | $V_3G_3C_2$ | 0 | - | ” |
| 31 | $V_3G_3C_3$ | 0 | - | ” |
| 32 | $V_3C_1$ | 0 | - | ” |
| 33 | $V_3C_2$ | 0 | - | ” |

**Table 19 Disease incidence recorded during the observational period**

| Sl. No. | Treatment | Bacterial blight | *Colletrotrichum spot* |
|---|---|---|---|
| 1 | $V_1G_1C_1$ | - | Present |
| 2 | $V_1G_1C_2$ | - | Present |
| 3 | $V_1G_1C_3$ | - | - |
| 4 | $V_1G_2C_1$ | - | - |
| 5 | $V_1G_2C_2$ | Present | Present |
| 6 | $V_1G_2C_3$ | - | - |
| 7 | $V_1G_3C_1$ | - | - |
| 8 | $V_1G_3C_2$ | - | Present |
| 9 | $V_1G_3C_3$ | - | - |
| 10 | $V_1C_1$ | - | - |
| 11 | $V_1C_2$ | - | Present |
| 12 | $V_2G_1C_1$ | - | - |
| 13 | $V_2G_1C_2$ | - | - |
| 14 | $V_2G_1C_3$ | - | - |
| 15 | $V_2G_2C_1$ | - | - |
| 16 | $V_2G_2C_2$ | - | Present |
| 17 | $V_2G_2C_3$ | - | Present |
| 18 | $V_2G_3C_1$ | - | - |
| 19 | $V_2G_3C_2$ | - | - |
| 20 | $V_2G_3C_3$ | - | - |
| 21 | $V_2C_1$ | - | Present |
| 22 | $V_2C_2$ | - | - |
| 23 | $V_3G_1C_1$ | - | - |
| 24 | $V_3G_1C_2$ | - | Present |
| 25 | $V_3G_1C_3$ | - | - |
| 26 | $V_3G_2C_1$ | - | - |
| 27 | $V_3G_2C_2$ | Present | - |
| 28 | $V_3G_2C_3$ | - | Present |
| 29 | $V_3G_3C_1$ | - | - |
| 30 | $V_3G_3C_2$ | Present | - |
| 31 | $V_3G_3C_3$ | - | Present |
| 32 | $V_3C_1$ | - | - |
| 33 | $V_3C_2$ | - | - |

per year). Kinetin 300 ppm had a negative effect causing a loss of Rs. 11.60 per plant per year.

In the variety K.O., positive yield increase was obtained for the treatment 500 ppm G.A. with a total gain of Rs. 86.30 per plant per year. All other treatments yielded negative response, causing a loss of Rs. 34.90 to Rs. 0.60 per plant per year due to treatments.

Variety C.R. showed best response to treatment 500 ppm G.A. with a gain of Rs. 70.10 per plant per year due to the treatment. The other two concentrations of G.A. also had a positive response but not at all significant. The maximum loss due to growth regulator treatment was brought about by the application of 100 ppm kinetin (Rs. 72.40 per plant per year) followed by kinetin 300 ppm (Rs. 46.40 per plant per year) and TIBA at 300 ppm (Rs. 26.30 per plant per year).

When the total profit per plant brought about by the application of the three growth regulators in all three combinations were taken together it is found that G.A. is better in overall performance over the other two growth regulators. All three growth regulators showed a positive yield increase in the variety L.R. with G.A. producing best response followed by TIBA. In the variety K.O. and C.R. only G.A application achieved positive response. Kinetin and TIBA showed a highly negative results.

**Table 20 Economics of the effect of growth regulators on flower and sucker production in *Anthurium andreanum* cv. Liver Red**

| Treatment | Yield | | Yield increase in treatments over control | | Yield increase in terms of price (Rs.) | | Total yield increase (Rs.) | Expenditure for labour* and chemicals | Total profit/loss per plant per year due to treatment (Rs.) |
|---|---|---|---|---|---|---|---|---|---|
| | Flower | Sucker | Flower | Sucker | Flower @ 6 / flower | Sucker @ 75 / sucker | | | |
| Distilled water spray ($C_1$) | 6.8 | 2.6 | - | - | - | - | - | - | - |
| No spray ($C_2$) | 6.8 | 2.6 | - | - | - | - | - | - | - |
| GA 100 ppm | 7.2 | 2.8 | 0.4 | 0.2 | 2.40 | 15.00 | 17.40 | 3.00 | 14.40 |
| GA 300 ppm | 7.2 | 3.4 | 0.4 | 0.8 | 2.40 | 60.00 | 62.40 | 5.50 | 56.90 |
| GA 500 ppm | 8.0 | 4.4 | 1.2 | 1.8 | 7.20 | 135.00 | 142.20 | 8.50 | 133.70 |
| Kinetin 100 ppm | 7.6 | 2.8 | 0.6 | 0.2 | 3.60 | 15.00 | 18.60 | 10.50 | 8.10 |
| Kinetin 300 ppm | 7.2 | 2.8 | 0.4 | 0.2 | 2.40 | 15.00 | 17.40 | 29.00 | -11.60 |
| Kinetin 500 ppm | 8.4 | 3.4 | 1.6 | 0.8 | 9.60 | 60.00 | 69.60 | 47.50 | 22.10 |
| TIBA 100 ppm | 7.4 | 3.6 | 0.6 | 1.0 | 3.60 | 75.00 | 78.60 | 3.00 | 75.60 |
| TIBA 300 ppm | 7.2 | 3.0 | 0.4 | 0.4 | 2.40 | 30.00 | 32.40 | 6.50 | 25.90 |
| TIBA 500 ppm | 6.8 | 2.8 | 0.0 | 0.2 | 0.00 | 15.00 | 15.00 | 10.00 | 5.00 |

*Labour charge @ Rs. 0.50 per treatment per plant

**Table 21 Economics of the effect of growth regulators on flower and sucker production in *Anthurium andreanum* cv. Ceylon Red**

| Treatment | Yield | | Yield increase in treatments over control | | Yield increase in terms of price (Rs.) | | Total yield increase (Rs.) | Expenditure for labour* and chemicals | Total profit/loss per plant per year due to treatment (Rs.) |
|---|---|---|---|---|---|---|---|---|---|
| | Flower | Sucker | Flower | Sucker | Flower @ 6 / flower | Sucker @ 75 / sucker | | | |
| Distilled water spray ($C_1$) | 8.4 | 2.4 | - | - | - | | - | - | - |
| No spray ($C_2$) | 8.4 | 2.4 | - | - | - | - | - | - | - |
| GA 100 ppm | 8.8 | 2.6 | 0.4 | 0.2 | 2.40 | 15.00 | 17.40 | 3.00 | 14.40 |
| GA 300 ppm | 9.0 | 2.6 | 0.6 | 0.2 | 3.60 | 15.00 | 18.60 | 5.50 | 13.10 |
| GA 500 ppm | 9.0 | 3.4 | 0.6 | 1.0 | 3.60 | 75.00 | 78.60 | 8.50 | 70.10 |
| Kinetin 100 ppm | 8.0 | 1.6 | -0.4 | -0.8 | -2.40 | -60.00 | -62.40 | 10.00 | -72.40 |
| Kinetin 300 ppm | 8.0 | 2.2 | -0.4 | -0.2 | -2.40 | -15.00 | -17.40 | 29.00 | -46.40 |
| Kinetin 500 ppm | 7.6 | 2.6 | -0.8 | 0.2 | -4.80 | 15.00 | 10.20 | 47.50 | -37.30 |
| TIBA 100 ppm | 7.6 | 2.2 | -0.8 | -0.2 | -4.80 | -15.00 | -19.80 | 3.00 | -22.80 |
| TIBA 300 ppm | 7.6 | 2.2 | -0.8 | -0.2 | -4.80 | -15.00 | -19.80 | 6.50 | -26.30 |
| TIBA 500 ppm | 7.8 | 2.6 | -0.6 | 0.2 | -3.60 | 15.00 | 11.40 | 10.00 | 1.40 |

* Labour charge @ Rs. 0.50 per treatment per plant

**Table 22 Economics of the effect of growth regulators on flower and sucker production in *Anthurium andreanum* cv. Kalympong Red**

| Treatment | Yield | | Yield increase in treatments over control | | Yield increase in terms of price (Rs.) | | Total yield increase (Rs.) | Expenditure for labour* and chemicals | Total profit/loss per plant per year due to treatment (Rs.) |
|---|---|---|---|---|---|---|---|---|---|
| | Flower | Sucker | Flower | Sucker | Flower @ 6 / flower | Sucker @ 75 / sucker | | | |
| Distilled water spray ($C_1$) | 7.8 | 3.4 | - | - | - | - | - | - | - |
| No spray ($C_2$) | 7.8 | 3.4 | - | - | - | - | - | - | - |
| GA 100 ppm | 8.2 | 3.4 | 0.4 | 0.0 | 2.40 | 0.00 | 2.40 | 3.00 | -0.60 |
| GA 300 ppm | 8.4 | 3.4 | 0.6 | 0.0 | 3.60 | 0.00 | 3.60 | 5.50 | -1.90 |
| GA 500 ppm | 8.6 | 4.6 | 0.8 | 1.20 | 4.80 | 90.00 | 94.80 | 8.50 | 86.30 |
| Kinetin 100 ppm | 7.0 | 3.4 | -0.8 | 0.0 | -4.80 | 0.00 | -4.80 | 10.50 | -15.30 |
| Kinetin 300 ppm | 7.4 | 3.6 | -0.4 | 0.2 | -2.40 | 15.00 | 12.60 | 29.00 | -16.40 |
| Kinetin 500 ppm | 7.4 | 3.6 | -0.4 | 0.2 | -2.40 | 15.00 | 12.60 | 47.50 | -34.90 |
| TIBA 100 ppm | 8.2 | 3.0 | 0.4 | -0.4 | 2.40 | -30.00 | -27.60 | 3.00 | -30.60 |
| TIBA 300 ppm | 8.2 | 3.4 | 0.4 | 0.0 | 2.40 | 0.00 | 2.40 | 6.50 | -4.10 |
| TIBA 500 ppm | 8.4 | 3.4 | 0.6 | 0.0 | 3.60 | 0.00 | 3.60 | 10.00 | -6.40 |

* Labour charge @ Rs. 0.50 per treatment per plant

**Table 23 Total profit/loss per plant per year by the application of GA, TIBA and Kinetin (all treatments combined) in *Anthurium andreanum* cv. Liver Red, Kalympong Orange and Ceylon Red**

| Growth regulator \ Variety | LR | KO | CR |
|---|---|---|---|
| GA | 205.00 | 83.80 | 97.60 |
| Kinetin | 18.60 | -66.60 | -156.10 |
| TIBA | 106.50 | -41.10 | -47.70 |

# DISCUSSION

# 5. DISCUSSION

The results of the present investigations carried out to improve the growth and flowering behaviour of *Anthurium andreanum* cv. Liver Red, Ceylon Red and Kalympong Orange are discussed in this chapter.

*Anthurium* is a tropical, evergreen high value ornamental cultivated for its colourful long lasting flowers and handsome foliage. It is gaining popularity as one of the most important commercial ornamental crops of the world. Management practices adopted by farmers are varying due to the lack of planned scientific research. So the present investigation was aimed at studying the effect of foliar application of growth regulators in enhancing the growth, yield and pigmentation of flowers in this crop.

The role of growth regulators in growth and flowering of ornamental plants has received considerable attention only recently. Many growth regulating chemicals have been tried, of which auxins, gibberellins and cytokinins occupy a special position (Bhattacharjee *et al.*, 1976 ; Biswas *et al.*, 1983 ; Boss *et al.*, 1980 ; Corr and Widmer, 1987 and Mittal, 1967). Of late, growth regulators are being increasingly used in anthurium for enhancing growth and flowering. With a view to ascertain the effect of certain regulators on anthurium, the present investigation to study the effect of G.A., kinetin and TIBA on growth and flowering of *Anthurium andreanum* cv. Liver Red, Ceylon Red and Kalympong Orange, was undertaken.

## 5.1 Effect of growth regulators on plant characters

The parameters which are used to estimate the quality of a variety in the study are :

1. Plant height
2. Plant spread
3. Number of leaves or spadices per year
4. Rate of leaf or spadix production
5. Suckering ability
6. Length and type of axis of spadix
7. Spathe size
8. Spathe colour
9. Spathe texture
10. Longevity of spadix
11. Inclination of candle
12. Candle size
13. Leaf area
14. Leaf area index
15. Chlorophyll
16. Carotenoid
17. Anthocyanin
18. Protein

19. Total phenolics

20. Response to pest and diseases

**5.1.1 Plant height**

In all the three periods of observation, it is found that growth regulators had significant effect on plant height. The variety K.O. treated with G.A. at 500 ppm recorded the maximum height (64.68 cm, 68.72 cm and 69.82 cm respectively). TIBA at 500 ppm recorded the lowest height in the variety C.R. (24.14 cm, 26.1 cm, 28.2 cm respectively).

These findings are in line with the reports of Higaki and Rasmussen (1979), Imamura and Higaki (1988), Anu (1997), Salvi (1997), Abdussammed (1999), that in anthurium, application of G.A. increased the plant height. The increase in plant height caused by G.A. is due to increased cell division and cell elongation. The reduction in height caused by the application of TIBA is probably due to its antiauxin character, i.e., it can prevent the transport of naturally produced auxin and thereby reduced the cell elongation effect caused by auxin.

**5.1.2 Plant spread (EW) and plant spread (NS)**

As anthurium is a crop that is grown under artificially shaded condition, i.e., in shade houses constructed to provide 75 percentage shade with the help of agro-shade nets. The space needed by each plant is important as space is a limited commodity always. So the more compact the plant is, the more number of them can be accommodated within a given space. Thus reduction in plant spread is desirable over increased plant spread.

In the third, six and nine months after the first spray C.R. – no spray, L.R. – no spray and K.O. treated with TIBA at 100 ppm respectively recorded the lowest plant spread (EW). The variety C.R. treated with kinetin at 500 ppm recorded the maximum plant spread (EW) (67.74 cm) during the three periods of observation.

Third, six and nine months after the first spray, the variety K.O. treated with TIBA at 500 ppm recorded the lowest plant spread in the NS direction and C.R. treated with kinetin at 500 ppm recorded the highest plant spread (NS). These results are supported by the observations of Salvi (1997) and Abdussammed (1999). Salvi found that in *Anthurium* cv. "Hawaiian Red", application of B.A. at 750 and 1500 ppm had significantly improved the plant spread in EW and NS direction. Abdussammed (1999) observed that B.A. at 500 and 1000 ppm strength had significant effect on plant spread in both direction.

### 5.1.3 Number of leaves or spadices per year

One of the most important commercial character of Anthurium is the number of leaves or spadices that a variety can produce in a year.

In the present study it was seen that growth regulators had a significant effect on this character. The highest number of leaves or spadices were recorded by the variety C.R. treated with GA at 300 and 500 ppm. L.R. treated with distilled water spray, TIBA at 500 ppm and no spray showed the lowest number of leaves or spadices per year.

Results similar to these have also been reported in other anthurium varieties by Higaki and Rasmussen (1979), Imamura and Higaki (1988), Henny and Hamilton (1992), Anu (1997), Salvi (1997), Valsalakumari *et al.* (1998) and Abdussammed (1999). Application of BA at 100 – 1000 ppm increased the production of number of leaves per plant. This may be due to an enhanced induction of leaf-initial break i.e., differentiation of leaf primordia in the apical growing region leading to an increased production of leaves per plant per year.

### 5.1.4 Rate of leaf or spadix production

This character is based on the number of days required for successive leaf production. The lower the number of days between successive leaf emergence, the higher the commercial value of the variety.

The study showed that growth regulators had significant effect on the rate of leaf or spadix production. The variety C.R. treated with GA at 300 and 500 ppm was observed as the best treatment with lowest days of interval of leaf production (40.6 days). The variety L.R treated with TIBA at 500 ppm showed highest interval (53.6 days). These results are in contrast to the results of Salvi (1997) and Abdussammed (1999). They reported that growth regulators (G.A. and kinetin) had no significant effect on the number of days taken for the successive leaves or spadices to appear on the same plant. This may be due to the difference in the response of varieties to the growth regulators.

### 5.1.5 Suckering ability

Normally all the three varieties have an average sucker production ability of one to three suckers per year.

With respect to suckering ability anthurium showed a positive response to the application of growth regulators. In the three periods of observation the variety K.O. treated with G.A. at 500 ppm recorded the highest number of suckers per plant (3.4, 4.2 and 4.6 respectively) and minimum number in all three periods are showed by both the controls of L.R. and C.R. (0.6), C.R. treated with kinetin at 300 ppm (1.4), C.R. treated with kinetin at 100 ppm respectively. In general the growth regulator treatment enhanced the sucker production. This is in accordance with the results of Imamura and Higaki (1988); Mercy and Dale (1994); Anu (1997); Salvi (1997) and Abdussammed (1999). They found that in general G.A. at 500 – 1000 ppm increased the sucker production in anthurium and Henny and Norman (1999) reported that in *Syngonium*, G.A. increased the number of vines per plant. In contrast to these Henny and Hamilton (1992) in *Anthurium scherzerianum* and Henny (1980, 1981, 1983) in aroids showed that G.A. can only induce flowering but not increase in branching. This may be due to breaking of the apical dominance by G.A. and induction of lateral bud production.

### 5.1.6 Length and type of axis of spadix

A long straight and strong floral axis is a must for anthurium spadix.

Analysis of the data revealed that growth regulators had significant effect on the length of floral axis. In the third and sixth month after the first spray the variety L.R. treated with G.A. at 500 ppm recorded the maximum height for the inflorescence axis. But nine months after the first spray highest length of spadix is observed in C.R. treated with G.A. at 500 ppm. Lowest length of inflorescence axis recorded during the three periods of observations were for L.R. – no spray, L.R. treated with distilled water spray and K.O. – no spray respectively. The increase in length of axis of the spadix with G.A. at 500 ppm can be due to its increased cell division (Saches *et al.*, 1959) and cell elongation(Haber and Luippoid,1969). This is in conformity with the results of Salvi (1997) and Valsalakumari *et al.* (1998), that growth regulators especially G.A. increase the length of stalk of anthurium inflorescence. However, Abdussammed in 1999 reported that the length of stalk of inflorescences were not influenced by growth regulators.

All the varieties had strong and straight types of floral axis in control as well as in treatments.

**5.1.7 Spathe size**

Spathe size decides the price of anthurium flowers and hence it is the most important economic character.

The present study showed that size of spathe is significantly influenced by the growth regulators. In the third, sixth and nine months after the first spray the variety K.O. treated with G.A. at 500 ppm recorded the largest spathe. The smallest spathe is shown by C.R. treated with TIBA at 300 and 500 ppm. This observation is supported by Salvi (1997) and Valsalakumari *et al.* (1998) who reported that application of G.A. resulted in the maximum size of spathe. However, according to Abdussammed (1999) the length and breadth of spathe are not influenced by growth regulators.

Increase in the size spathe may be due to its increased cell division and cell elongation.

### 5.1.8 Spathe colour

Colour of spathe is also a critical character in anthurium, with dark coloured spathe types usually preferred over lighter shades by buyers. The relative concentration of cyanidin and pelargonidin affecting spathe colour in anthurium. It is a difficult task to relate the visible colour with the anthocyanins content in the spathe (Nirmala *et al.*, 1999). So by visual observation it is found that there is no difference among treatments within a variety. The variety L.R. with deep meroon colour, C.R. with red colour, K.O. with light orange colour. However variability in the pigment content were observed when anthocyanins and carotenoids were estimated individually as discussed later.

### 5.1.9 Spathe texture

Birdsey (1956) described the spathe texture of *Anthurium andreanum* based on its degrees of smoothness and blistering. According to Mercy and Dale (1994) the spathe in floral anthuriums may be smooth, thick and glossy without prominent veins or it may be thinner, deeply veined and blistered.

In the present study growth regulators had no effect on spathe texture of anthurium variety L.R. has a thick, smooth and glossy texture, while C.R. and K.O. have medium thick shallowly blistered and glossy texture before and after treatments.

### 5.1.10 Longevity of spadix

Long-lasting spathe is desired in anthurium. Growth regulators had significant effect in this character. Maximum longevity of spadix was recorded by the variety L.R. treated with kinetin at 500 ppm (103 days). This was on par with G.A. at 500 ppm (102.4 days). The variety K.O. treated with TIBA at 100 ppm recorded the minimum longevity of spadix (66.8). This was in accordance with the results of Salvi (1997), Valsalakumari *et al.* (1998) and Abdussammed (1999), who reported that both B.A. and G.A. can enhance the longevity of spadix.

Increase in the longevity of spathe with kinetin may be due to increased protein synthesis, rapid nutrient mobilization and prevent the chlorophyll degradation (Quinlan and Weaver, 1969)

**5.1.11 Inclination of candle**

According to Mercy and Dale (1994) in good commercial varieties of *Anthurium andreanum* the flower bearing candle was attached to the base of the spathe at an angle of $25^0$ to $40^0$. They also recommended that ideal anthurium varieties should have a short candle, curving towards the tip of the spathe and held at an angle less than $45^0$. This low angled position of the candle helps in the close packing of the spadices in boxes during transport. In the present study it is found that growth regulators had no significant effect on the inclination of candle. No change in the character was observed in any of the treatments due to growth regulator application. This observation was in contrast to the result of Anu (1997) who reported that both BAP and G.A. increased the angle between the spathe and candle.

**5.1.12 Candle size**

The smaller and thinner the candle, the better the variety. While the candles of C.R. and L.R. are small and thin that of K.O. i.e., long and thicker. The present study it was found that growth regulators had significant effect with regard to candle size. In the third and sixth month after first spray, K.O. treated with G.A. at 500 ppm recorded the largest candle. Nine months after the first spray, K.O. treated TIBA at 100 ppm recorded the maximum size of candle. The variety L.R. treated with G.A. at 100 ppm recorded the smallest candle, during the third months after the first spray. But six months after the first spray L.R. treated with TIBA at 500 ppm recorded the minimum size of candle and in the ninth month of observation C.R. treated with TIBA at 500 ppm recorded the smallest candle.

### 5.1.13 Leaf area

In the 3rd, 6th and 9th month after first spray maximum leaf area recorded by the variety K.O. treated with G.A. at 500 ppm (1353.20 $cm^2$, 1264.68 $cm^2$, 1273.00 $cm^2$ respectively). The minimum leaf area during the three periods of observation was recorded by the variety C.R. treated with TIBA at 500 ppm (460.58 $cm^2$, 473.30 $cm^2$, 477.60 $cm^2$ respectively). The highest leaf area recorded by G.A. may be due to increased cell division and cell elongation. Reduction in leaf area due to TIBA may be due to its antiauxin property.

### 5.1.14 Leaf area index

In the 3rd, 6th and 9th month after first spray highest leaf area index recorded by the variety K.O. treated with G.A. at 500 ppm (0.67, 0.62, 0.63 respectively). In the three periods of observation the lowest leaf area was recorded by C.R. treated with TIBA at 500 ppm (0.23, 0.23, 0.24 respectively).

### 5.1.15 Chlorophyll content

Chlorophyll is the pigment primarily responsible for harvesting light energy used in photosynthesis. Growth regulators had significant effect on the chlorophyll content of leaves. In the third month after the first spray, the variety L.R. treated with G.A. at 500 ppm recorded the highest content of chlorophyll (2.12 mg/g tissue). Six and nine months after spraying, K.O. treated with G.A. at 500 ppm recorded the highest content (2.05 mg/g tissue, 2.16 mg/g tissue respectively) and in the third sixth and ninth month after spraying, C.R. treated with G.A. at 100 ppm recorded the lowest content of chlorophyll (0.58 mg/g tissue, 0.57 mg/g tissue, 0.58 mg/g tissue respectively).

This observation is supported by Abussammed (1999) that monthly spraying of G.A. at 500 ppm recorded the highest content of chlorophyll (2.127 mg/g tissue) in the anthurium variety Hawaiian Red. Highest content of chlorophyll by the application of G.A. at 500 ppm is probably due to the enhanced synthesis of chlorophyll precursors as reported by Singhvi (1991).

### 5.1.16 Carotenoid content

Carotenoids are predominantly orange or red orange pigments. They prevent chlorophyll degradation and pass the energy to chlorophyll for ultimate use in photosynthesis. Growth regulators had significant effect on the carotenoid content of flowers. Three and six months after spraying, the variety L.R. treated with G.A. at 300 ppm recorded the highest content of carotenoid (10.38 mg/100 g tissue). Nine months after spraying L.R. treated with G.A. at 500 ppm recorded highest content of carotenoid (10.07 mg./100 tissue). Three and nine months after spraying the variety K.O. – no spray recorded the lowest content(3.49 mg/100 tissue) of carotenoid and six months after spraying K.O. treated with distilled water spray recorded the lowest content of carotenoid (3.2 mg/100 g tissue).

### 5.1.17 Anthocyanin content

Anthocyanin contribute various colour to the spathe of anthurium Application of growth regulators had significant effect on the anthocyanin content of anthurium spathe. Three, six and nine months after spraying, L.R. treated with G.A. at 500 ppm (387.2 mg/100 g tissue), L.R. treated with distilled water spray (388.2 mg/100 g tissue), L.R. treated with TIBA at 300 ppm (387.6 mg/100 g tissue) respectively recorded the highest content of anthocyanins.

Three months after spraying K.O. – no spray recorded the lowest content of anthocyanins. Six and nine months after spraying K.O. treated with distilled water spray recorded the lowest content of anthocyanins (52.6 mg/100 g tissue). Abdussammed (1999) also reported that application of G.A. 500 ppm recorded the highest content of anthocyanin in the anthurium variety Hawaiian Red (84.18 mg/100 g tissue). This was in contrast to the result obtained by Salvi (1997) that growth regulators had no significant effect on anthocyanin content of anthurium spathe.

### 5.1.18 Protein content

Growth regulators had significant effect on the protein content of anthurium. Three, six and nine month after first spraying, the variety K.O. treated with kinetin at 500 ppm recorded the highest content of protein. Three months after spraying the variety L.R. – no spray recorded the lowest content of protein. Six and nine months after spraying the variety L.R. treated with TIBA at 100 ppm recorded the lowest content of protein.

The increase in protein content by the application of growth regulator kinetin may be due to the increased transcription of DNA.

### 5.1.19 Total phenolics

Growth regulators had significant effect on total phenolic content of anthurium. In the third, sixth and ninth months after spraying K.O. treated with kinetin at 500 ppm recorded the highest (121.2 mg/g tissue) content of phenol. Three and six months after spraying LR. – no spray (92.8 mg/g tissue) and distilled water (92.6 mg/g tissue) spray recorded the lowest content of phenol. Nine months after spraying TIBA at 500 ppm recorded the lowest content of phenol.

### 5.1.20 Response to pests and diseases

It is found that growth regulators had no significant effect on pest and disease.

With regard to the economics of the growth regulator treatments, the three varieties responded differentially to the three growth regulators.

The variety L.R. appears to be the best overall performer. In this variety G.A. at 500 ppm showed a significant increase in the economic out put, which in actual terms appears to be about Rs. 133.70 per plant per year. This is a very creditable increase in profit and will help the grower to have a substantial annual profit balance. This is followed by TIBA at 100 ppm (Rs. 75.60 per plant per year) and G.A. at 300 ppm (Rs. 56.90 per plant per year) with both treatments also giving a significantly high annual profit.

In the variety K.O. also G.A. at 500 ppm scored the highest profit i.e., Rs. 86.30 per plant per year which is significantly high. Other treatments showed a negative response to growth regulators indicating that it is highly unprofitable to resort their application.

In the case of C.R. also, G.A. at 500 ppm recorded the highest profit (Rs. 70.10 per plant per year). The treatments G.A. at 100 ppm (Rs. 14.40 per plant per year), G.A. at 300 ppm (Rs. 13.10 per plant per year) and TIBA at 500 ppm (Rs. 1.40 per plant per year) also had a positive effect but not significant at all indicating that profit brought about by the application of these chemicals will be negligible.

Based on the overall performance it is clear that the growth regulator G.A. is the best in increasing the economic output achieving a positive and significantly high profit in all the three varieties. The hormone TIBA could produce a significantly positive increase only in the variety L.R. which though quite high was still much lower than the positive response brought about by G.A. Thus it appears that among the three growth regulators tried, G.A. is the only growth regulator whose application generally recommended for enhancing flower and sucker-production *Anthurium andreanum* which can bring about a significantly high increase in the grower's profit.

To sum up the application of growth regulators has been found to have a significant effect on most of the characters considered under the present study in *Anthurium andreanum*. Among different growth regulators G.A. at 500 ppm is seen as the best treatment for improving the characters like plant height, leaf area, leaf area index, suckering ability, length of spadix, spathe size, chlorophyll content, maximum number of leaves or spadix per year and minimum number of days taken for successive leaf production. For highest longevity of spadix, highest protein and phenol content kinetin at 500 ppm is the best treatment. Minimum plant spread is achieved by TIBA at 100 ppm and for other characters such as highest carotenoid content – G.A. 500 ppm; smallest candle size – TIBA at 500 ppm and highest anthocyanin content distilled water spray, are the best treatments.

Among the three varieties K.O. was found to respond best for growth regulator treatment for characters maximum plant height, minimum plant spread, highest number of suckers per plant, largest leaf area, leaf area index, largest spathe, highest chlorophyll content, highest protein and phenol content. The variety L.R. showed best response highest longevity of spadix highest carotenoid and anthocyanin content. For the characters maximum number of leaves or spadix per year minimum number of days for successive leaf production and smallest candle, the variety C.R. showed best response to the treatment.

# SUMMARY

# 6. SUMMARY

The salient findings of the investigation on the effect of growth regulators on growth and flowering of *Anthurium andreanum* Linden, conducted in the Department of Plant Physiology, College of Agriculture, Vellayani during the year 1998-2000 are summarised below.

- The present study revealed that growth regulators had significant effect on plant height. Maximum height was recorded nine months after the first spray by the variety Kalympong Orange (K.O.) treated with Gibberellic acid (GA) at 500 ppm (69.82 cm) and minimum was recorded three months after the first spray by Ceylon Red (C.R.) treated with Triodobenzoic acid (TIBA) at 500 ppm (24.14 cm).
- Minimum plant spread (EW) (28.44 cm) was observed nine months after the first spray by K.O. treated with TIBA at 100 ppm and maximum (68.18 cm) was recorded six months after the first spray by C.R. treated with kinetin at 500 ppm.
- Lowest value for plant spread (NS) (28.02 cm) was recorded nine months after the first spray by K.O. – no spray and maximum plant spread (NS) – (69.74 cm) was observed nine months after the first spray by C.R. treated with kinetin at 300 ppm.
- The maximum number of leaves/spadices (9.0) was recorded by the variety C.R. treated with GA at 300 and 500 ppm. The variety L.R. – no spray with distilled water spray (6.8) and TIBA at 500 ppm (6.8) recorded the minimum number of leaves/spadices per year.

- C.R. treated with G.A. at 500 and 300 ppm recorded the minimum number of days (40.6) taken per successive leaf production and L.R. treated with TIBA at 500 ppm showed the maximum number of days (53.6) taken for successive leaf production.

- Maximum number of suckers/plant (4.6) was produced by K.O. treated with G.A. at 500 ppm and minimum number of suckers/plant (0.6) by both the control of L.R. and C.R. in the third month of observation period.

- In the sixth month after the first spray, the variety L.R. treated with G.A. at 500 ppm recorded the highest length of spadix (43.52 cm) and the lowest length by L.R. – no spray (19.98 cm) in the third month of observation period.

- The variety K.O. treated with G.A. at 500 ppm in the third month of observation recorded the largest spathe (95.4 $cm^2$) and smallest (17.71 $cm^2$) by C.R. treated with TIBA at 500 ppm in the sixth month of observation period.

- Spathe colour, spathe texture, inclination of candle were not observed to be influenced significantly by growth regulators.

- The variety L.R. treated with kinetin at 500 ppm recorded the highest longevity of spadix (103 days) and lowest by K.O. treated with TIBA at 100 ppm (66.8 days).

- In the sixth month of observation, K.O. treated with G.A. at 500 ppm recorded the largest candle (11.2 cm and smallest (4.1 cm) by C.R. treated with TIBA at 500 ppm in the ninth month of observation.

- Chlorophyll content is significantly influenced by growth regulators. Highest chlorophyll content (2.16 mg/g tissue) is recorded by K.O. treated with G.A. at 500 ppm in the ninth month of observation. In the sixth month of observation, C.R. treated with G.A. at 100 ppm recorded the lowest content of chlorophyll (0.57 mg/g tissue).

- Six months after the first spray, L.R. treated with G.A. at 300 ppm recorded the highest content of carotenoid (10.41 mg/100g tissue) and K.O. treated with distilled water spray recorded the lowest carotenoid content (3.2 mg/100g tissue).

- In the sixth month of observation, L.R. with distilled water spray recorded the highest content of anthocyanin (388.2 mg/100g tissue). Three and six months after the first spray, K.O. – no spray. K.O. treated with distilled water spray respectively recorded the lowest content of antthocyanin (50.6 mg/100g tissue).

- Sixth months after the first spray, K.O. treated with kinetin at 500 ppm recorded the highest content of protein (109 mg/g tissue) and in the ninth month of observation, L.R. treated with TIBA at 100 ppm recorded the lowest content of protein (91.2 mg/g tissue).

- In the sixth month of observation, the variety K.O. treated with kinetin at 500 ppm recorded the highest content of phenol (121.2 mg/g tissue) and nine months after the first spray C.R. treated with TIBA at 500 ppm recorded the lowest content of phenol (92.2 mg/g tissue).

With regard to the economics of the growth regulator application, it is found that among the three growth regulators, G.A. is the best in increasing the flower and sucker production in all the three varieties. Its application enhanced the profit per plant per year substantially to Rs. 205.00 in L.R., Rs. 97.6 in C.R. and Rs. 83.80 in K.O. So its use can be recommended for commercial cultivation of anthurium. In the variety L.R., the other two growth regulators viz., kinetin and TIBA also had a positive effect. While TIBA produced about 50 per cent increase when compared to G.A., the increase brought about by kinetin was negligible. In C.R. and K.O. only G.A. had positive response, while two other growth regulators showed negative influence on flower and sucker production indicating that their application is highly unprofitable.

**Future line of work**

The results of present investigation point towards taking up further detailed studies on the effect of growth regulators on *Anthurium*. Studies on the effect of plant growth regulators have been restricted predominantly to aerial parts. Due attention has not been paid with respect to their effect on root growth and plant establishment. Studies on absorption, transport and utilization are very essential in crops responding to growth regulator applications.

With changes in environmental variables and increase in pests and diseases potential of growth regulator in protecting ornamental crops could be explored. This would help in minimising the cost of crop production under protected environments. The knowledge on endogenous growth regulator should be analysed so as to understand their relevance in various plant growth processes. This would be helpful in efficient usage of exogenously applied growth regulators.

Possibility of enhancing the efficiency of metabolic processes, such as photosynthesis, partitioning, translocation and nitrogen fixation by growth regulators need intensive experimentation for making an impact on crop productivity contained by their application. Researches are vital on molecular basis of hormone regulation of gene expression and on the regulation of genes encoding for enzymes involved in the flowering processes and plant growth in ornamental crops. Besides, the search for new growth regulators for inducing and manipulating flowering in ornamental crops should be continued without neglecting the environmental safety and cost of production.

# REFERENCES

# REFERENCES


Abdussammed, K. P. 1999. Regulation of flower and postharvest behaviour of *Anthurium andreanum* Linden. *M.Sc. (Ag.) thesis* submitted to Kerala Agricultural University, Thrissur

Anonymous. 2000. *Production and Marketing of ornamentals worldwide Flower Tech.***3** (1) : 16

Anu, G. K. 1997. Improvement of propagation efficiency of *Anthurium andreanum* Andre. *M.Sc. (Hort.) thesis* submitted to Kerala Agricultural University, Thrissur

*Arndt, G. 1991. Anthurium *(A. scherzerianum)* var. 'Arabella' (Commercial synonym Arndt's Flamenco Arabella). *Plant Varieties J.* **4** : 1-14

Arnon, D. I. 1949. Copper enzymes in isolated chloroplasts. Polyphenol oxidase in *Beta vulgaris. Plant Physiol.* **24** : 1-15

Bhattacharjee, S. K., Mukhopadhyay, T. P. and Bose, T. K. 1976. Interaction of auxin and gibberellin with growth retardants on growth and flowering of *Dahlia variabilis* and *Maviscus cozattii. Indian Agric.* **20** (3) : 193-199

Bindu, M. R. and Mercry, S. T. 1994. Cytological studies in *Anthurium andreanum* Lind. Paper presented in the I[st] National Seminar on *Anthurium* from May 6-9, 1994 held at Trivandrum (Abstract to be published)

*Birdsey, M. R. 1956. The Cultivated Aroids. Gillick Press, Berkeley

Biswas, J., Bose, T. K. and Maiti, R. G. 1983. Effect of growth substances on growth and flowering of tuberose (*Polianthes tuberosa* L.). *South Indian Hort.* **31** (2/3) : 129-132

*Blacquiere, T. and De, K. R. 1990. Manipulation with plant hormones- Flower induction in spathiphyllum. *Vakblad var de Bloemisterji* **45** : 54-55

Bose, T. K., Jana, B. K. and Mukhopadhyay, T. P. 1980. Effect of growth regulators on growth and flowering in *Hippcastrum hybridum. Hort. Scientia Hort.* **12** (2) : 195-200

Bray, G. G. and Thorpe, W. V. 1954. Analysis of phenolic compounds of interest in metabolism. *Methods Biochem. Anal.* **1** : 27-52

*Corr, B. E. and Widmer, R. E. 1987. Gibberellic acid increases flower number in *Zantedeschia elliottiana* and *Z. rehmannii. Hort. Sci.* **22** (4) : 605-607

Criely, R. A. 1989. Culture and cultivar selection for anthurium in Hawaii. *Acta Hort.* **246** : 227-236

*Croat, T. B. 1980. Flowering behaviour of the neotropical genus *Anthurium* (Araceae). *Amer. J. Bot.* **67** (6) : 888-904

*Forsyth, W. G. C. and Simmonds, N. W. 1954. A survey of the anthocyanins of some tropical plants. *Proc. Roy. Soc. B.* **142** : 549-564

*Gajek, W. and Schwarz, K. H. 1980. *Anthurium andreanum* hybrids, valuable all-the-year-round cut flowers which use a limited energy input. *Gartenbau* **27** (11) : 343

Galston, A. W. 1947. *Amer. J. Bot.* **34** : 356-360

Haber, A.H. and Luippoid, H.J. 1960. Effect of Gibberellin on gamma-irradiated wheat *Amer. J. Bot.* **47** : 140-144

Hata, T. Y., Hara, A., Nagao, M. A. and Hu, B. K. S. 1994. Hot water treatment and indole - 3 - butyric acid stimulates rooting and shoot development of tropical ornamental cuttings. *Hort. Technology* **4** : 159-162

Henny, R. J. 1980. Gibberellic acid ($GA_3$) induces flowering in *Dieffenbachia maculata* 'Perfection'. *Hort. Sci.* **15** : 613

Henny, R. J. 1981. Promotion of flowering in *Spathyphyllum* 'Mauna Loa' with gibberellic acid. *Hort. Sci.* **16** : 554-555

Henny, R. J. 1983. Flowering of *Aglaonema commutatum* 'Treubii' following treatment with gibberellic acid. *Hort. Sci.* **18** : 374

Henny, R. J. 1983. Stimulation of flowering in *Aglaonema* with $GA_3$. *Aroideana* **6** (3) : 71-72

Henny, R. J. 1986. Increasing basal shoot production in a non-branching *Dieffenbachia* hybrid with BAP. *Hort. Sci.* **21** :1386-1388

Henny, R. J. 1999. 'Red Hot' *Anthurium*. *Hort. Sci.* **34** (1) : 153-154

Henny, R. J. and Fooshee, W. C. 1983. Flowering of *Aglaonema* with $GA_3$ – A follow-up report. *Aroideana* **6** (4) : 135-136

Henny, R. J. and Fooshee, W. C. 1985. Induction of basal shoots in *Spathyphyllum* 'Tasson' following treatment with BA. *Hort. Science* **20** : 715-717

Henny, R. J. and Hamilton, R. J. 1992. Flowering of *Anthurium* following treatment with gibberellic acid. *Hort. Sci.* **27** : 1328

Henny, R. J. and Rasmussen, E. M. 1980. Stimulation of flowering in *Dieffenbachia. Aroideana* **3** : 96-97

Henny, R. J., Poole, R. T., Conover, C. A. 1988. 'Southern Blush'- A hybrid *Anthurium* for foliage producers. *Hort. Sci.* **23** (5) : 922-923

Henny, R. J.and Fooshee, W. C. 1986. Comparison of BA, Kinetin and 2ip for inducing basal shoot production in *Spathyphyllum* 'bennett'. *AREC-A Research Report* **13** : 110

Henny, R.J. and Norman, D.J. 1999. Gibberellic Acid induced flowering of *Syngonium podophyllum* Schott 'White Butterfly' *Hort. Sci* **34** (4) : 676-677

*Hetman, J., Laskowska, H. and Martyn, W. 1981. Effect of substrate on physical properties of the growth of *Anthurium andreanum. Prace Instytutu sadonictwa wskiernie wicach.* **6** : 43-53

*Higaki, T. 1976. Anatomical study of the anthurium plant, *Anthurium andreanum L.* and a colour breakdown disorder of its flower. *Ph. D. thesis*, Michigan State University, East Lansing. p. 252

*Higaki, T. and Imamura, J. 1988. Nutritional studies. *Proc. First Anthurium Blight Conf.* Alvarez, A. M. (Ed.), Univ. Hawaii HITAHR 02. 04. 88. p. 19-20

*Higaki, T. and Poole, R. T. 1978. A media and fertilizer study in anthurium. *J. Amer. Soc. Hort. Sci.* **103** : 98-100

Higaki, T. and Rasmussen, H. D. 1979. Chemical induction of adventitious shoots in Anthurium. *Hort. Sci.* **14** : 64-65

Imamura, J. S. and Higaki, T. 1988. Effect of $GA_3$ and BA on lateral shoot production in Anthurium. *Hort. Sci.* **2** : 353-354

Iwata, R. Y., Tang, C. S. and Kamemoto, H. 1979. Anthocyanins of *Anthurium andreanum* Lind. *J. Amer. Soc. Hort. Sci.* **104** (4) : 464-466

Iwata, R. Y., Tang, C. S. and Kamemoto, H. 1985. Concentration of anthocyanins affecting spathe colour in anthuriums. *J. Amer. Soc. Hort. Sci.* **110** (3) : 383-385

Leffering, L. 1975. Influence of climatic conditions on growth and flower yield of *Anthurium andreanum* Lind. Acta. Hort. **51** : 63-68

Lowry, J. B. 1972. Anthocyanins in tropical phytochemistry. *Malaysian J. Sci.* **1** (A) : 133-140

Lowry, O.H., Rosebrough, N.J., Farr, A. L. and Randall, R.J. 1951. *J. Biol. Chem.* 193 : 265

Mai, K. and Radhakrishnaiah, M. 1993. A note on the phenolic constituents of *Acorus. Aroideana* **16** : 21-23

Malick, C. P. and Singh, M. B. 1980. In : *Plant Enzymology* and *Histo Enzymology.* Kalyani Publishers, New Delhi. p. 286

Mercy, S. T. and Dale, B. 1994. "*Anthurium*" St. Joseph's press, Thiruvananthapuram pp. 64

Mittal, S. P. 1967. Studies on the effect of gibberellic acid on growth and flowering of dahlia. *Madras Agric. J.* **54** : 103-107

Nedunzhiyan, M. and Ray, R. C. 1996. Leaf let area estimation in yan bean. *J. Root Crops* **22** (2) : 128-134

Nirmala, K.S., Singh, F. and Chandravadana, M.V. 1999. Anthocyanins of *Anthurium andreanum Lind.*- presence of an unknown pigment. *J. Appl. Hort.* **1** (1) : 29-31

Paull, R. E. 1982. Anthurium *(A. andreanum Andre*) vase life evaluation criteria. *Hort. Sci.* **17** (4) : 606-607

Quinlan, J.D. and Weaver, R.J. 1969. *Plant Physiol.* **44** : 1247-52

*Ranganna, S. 1977. Manual of analysis of fruit and vegetable products. Tata Mc. Graw-Hill Pub. Co. Ltd., New Delhi

Renu, R. S. 1999. Intervarietal hybridization in *Anthurium andreanum* Linden. *M.Sc. (Ag.) thesis* submitted to Kerala Agricultural University, Thrissur

Saches, R.M., Bretz, C. and Lang, A. 1959. Shoot histogenesis: the early effects of gibberellin upon stem elongation on two rosette plants. *Amer. J. Bot.* **46** : 376-384

Salvi, B. R. 1997. Optimization of shade, nutrients and growth regulators for cut flower production in *Anthurium*. *Ph.D. thesis*, Kerala Agricultural University

*Sheffer, R.D. and Croat, T. B. 1983. Chromosome numbers in the genus Anthurium(Araceae). *Amer. J. Bot.* **70** (6): 557-558

Sindhu, K. 1995. Cross compatibility *Anthurium andreanum* Lind. *M.Sc. (Ag.) thesis* submitted to Kerala Agricultural University

Singh, F. 1987. *Anthurium* - Vyeing for a place among commercial flower crops. *Ind. Hort.* p. 14-16

Singhvi, N.R. 1991. Effect of certain growth regulators on seedling growth, dry matter production and chlorophyll biosynthesis in *Raphanus sativus* L. *Acta Botanica Indica* **19** (1) : 97-99

Tisdale, S. L., Nelson, W. L. and Beaton, J. D. 1985. Soil Fertility and Fertilizers (4$^{th}$ Ed.) Macmillian Pub. Co. Inc. New York pp. 1-73

Valsalakumari, P. K., Salvi, B. R., Rajeevan, P. K. and Geetha, C. K. 1998. Growth and flowering in *Anthurium andreanum* var. 'Agnihotri' as influenced by shade and growth regulators. Paper presented at the national seminar on anthurium production, organised by IIHR, Bangalore, 2-3 June, Coorg at Chethali

Williams, R. F. 1946. The physiology of plant growth with special reference to the concept of the net assimilation rate. *Ann. Bot.* **10** : 41-72

Wilson, M. R. and Nell, T. A. 1983. Foliar applications of BA increase branching of 'Welkeri' dieffenbachia. *Hort. Science* **18** : 447-448

*Original not seen

# EFFECT OF GROWTH REGULATORS ON THE GROWTH AND FLOWERING OF ANTHURIUM (*Anthurium andreanum* Linden)


BY

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ABSTRACT OF THE THESIS
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# ABSTRACT

An investigation on the effect of growth regulators on growth and flowering of *Anthurium andreanum* Linden was conducted in the Department of Plant Physiology, College of Agriculture, Vellayani during 1998-2000.

Mature plants of three varieties of *Anthurium andreanum* Linden formed the material. The varieties used were Liver Red (L.R.), Ceylon Red (C.R.) and Kalympong Orange (K.O.). Three growth regulators namely Gibberellic Acid (GA), Tri Iodo Benzoic Acid (TIBA) and Kinetin (K) were used at 100 ppm, 300 ppm and 500 ppm concentrations. Two controls i.e., distilled water spray and no spray were also included. Each concentration of the growth regulator was sprayed three times at one month intervals. Observations were taken three months after the first spray and then at three months intervals, twice more. The effect of treatments on morphological floral, physiological and bio-chemical aspects was studied.

Results of the experiments revealed that growth regulators had significant effect on most of the characters under study. They are listed below.

- Maximum plant height was obtained nine months after the first spray for K.O. treated with GA at 500 ppm (69.82 cm).
- Minimum plant spread (EW) – nine months after the first spray was obtained for K.O. treated with TIBA at 100 ppm (28.44 cm) and minimum plant spread (NS) was recorded by K.O. – no spray (28.02 cm) in the ninth month of observation.

- Maximum number of leaves/spadices per year (9.0) was recorded by C.R. treated with GA at 300 and 500 ppm.
- Minimum number of days (40.8) taken for successive leaf production was obtained for C.R. treated with GA at 300 and 500 ppm.
- Highest number of suckers/plant (4.6) was produced by K.O. treated with GA at 500 ppm, obtained nine months after the first spray.
- The highest length of spadix (43.52 cm) was showed six months after the first spray by L.R. treated with GA at 500 ppm.
- Largest spathe (95.4 $cm^2$) was recorded three months after the first spray by K.O. treated with GA at 500 ppm.
- Highest longevity of spadix (103 days) was obtained for L.R. treated with kinetin at 500 ppm.
- Smallest candle size was obtained nine months after the first spray by the variety C.R. treated with TIBA at 500 ppm (4.1 cm).
- Highest chlorophyll content (2.16 mg/g tissue) was recorded nine months after the first spray by K.O. treated with GA at 500 ppm.
- Highest carotenoid content (10.41 mg/100 g sample) was obtained six months after the first spray by L.R. treated with GA at 300 ppm.
- Highest anthocyanin content (388.2 mg/100g sample) was recorded six months after the first spray by L.R. (control 1) distilled water spray.
- Highest protein content (109 mg/g tissue) was obtained six months after the first spray by K.O. treated with kinetin at 500 ppm.
- Highest phenol content (121.2 mg/g tissue) was recorded three months after the first spray by K.O. treated with kinetin at 500 ppm.

Based on the economics of growth regulator application, G.A. 500 ppm was the best treatment with positive profit increase in all the three varieties. This treatment achieved an enhanced profit of Rs. 133.70 per plant per year in the variety L.R., Rs. 86.30 enhanced profit in K.O. and Rs. 70.10 in the variety C.R.