REGULATION OF FLOWERING AND POST-HARVEST BEHAVIOUR OF *Anthurium andreanum* Cv. 'Hawaiian Red'

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

(POMOLOGY AND FLORICULTURE)

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1999

DECLARATION

I hereby declare that the thesis entitled **Regulation of flowering and post-harvest behaviour of *Anthurium andreanum* cv. 'Hawaiian Red'** 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 to me of any degree, diploma, fellowship, associateship or other similar title of any other University or Society.

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We, the undersigned members of the Advisory Committee of **Mr.K.P.Abdussamed,** a candidate for the degree of **Master of Science in Horticulture,** agree that the thesis entitled '**Regulation of flowering and post-harvest behaviour of *Anthurium andreanum* cv. 'Hawaiian Red'** may be submitted by Mr.K.P.Abdussamed in partial fulfilment of the requirement for the degree.

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ACKNOWLEDGEMENT

I am at a loss of words to express my profound sense of gratitude to ***Dr.P.K.Valsalakumari****, Associate Professor, Department of Pomology and Floriculture, College of Horticulture and Chairperson of my advisory committee for her invaluable guidance, ever willing help, perpetual support, constant encouragement and above all the understanding and enthusiasm rendered during the entire period of my work without which it would have been very difficult for me to prepare this thesis. I consider myself blessed for being guided by her.*

With great respect, shall I express my extreme indebtedness and gratitude to ***Dr.P.K.Rajeevan****, Professor and Head (i/c), Department of Pomology and Floriculture and member of my advisory committee for his meticulous help, forbearance, valuable suggestions and sustained interest given throughout my course, inspite of being very busy. I shall owe a deep sense of gratitude for that.*

Heartfelt thanks are due to ***Dr.C.K.Geetha****, Assistant Professor, Department of Pomology and Floriculture and member of my advisory committee for her constant encouragement, good will, timely help and candid suggestions during the various stages of the study. Her willingness to help could never be forgotten.*

I thankfully acknowledge ***Dr.P.K.Sushama****, Associate Professor, Department of Soil Science and Agricultural Chemistry and member of my advisory committee for her whole hearted co-operation, cordial support and valuable suggestions during various stages of the study and preparation of the manuscript.*

No less is my gratefulness to Dr.V.K.G.Unnithan, Department of Agricultural Statistics for the immense help extended during the analysis of the data, constructive criticism and suggestions for the improvement of the manuscript.

I sincerely thank Dr.C.S.Gopi, Sri.Prasad and all other staff of Department of Soil Science and Agricultural Chemistry for their help in the course of chemical analysis.

The help rendered by the teachers Dr.N.K.Parameswaran, Dr.Lila Mathew, Dr.Sarah T. George, Dr.Sajan Kurien, Dr.T.P.Murali, Mrs.Sobhana and Dr.P.Suma is thankfully acknowledged.

The Research Associates Smt.Rethy, Smt.Mridula and Smt.Leena especially Musthafa and Bharathan of the Department of Pomology and Floriculture, College of Horticulture were highly helpful and it is gratefully acknowledged.

I am thankful to Mrs.Joicy, Computer Centre for her patient and efficient service in the analysis of the data.

My sincere thanks are also due to Sri.Sugathan, Sri.Natarajan, Sri.Thankappan and Sri.Haridas, Department of Pomology and Floriculture for the various help rendered during the conduct of my study.

The sincere and timely help rendered by Sri.Jailani, Smt.Valsala, Smt.Gouri and all other farm labourers of Department of Pomology and Floriculture, during the conduct of my study is gratefully acknowledged.

The co-operation and assistance offered by my friends Praveenkumar, Satheeshkumar, Sunil, Manojkumar, Ashithraj and Prasanth are gratefully remembered.

The award of ICAR Junior Research Fellowship was extremely helpful and it is gratefully acknowledged.

I am ever grateful to Sri.joy, who computerized my thesis with meticulous care, sincerity and accuracy.

I lovingly thank my parents, brothers and sisters for their constant prayers and blessings at every juncture.

Above all, I bow before ALLAH, for the unmerited blessings, which lead me every step of the way.

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Introduction

INTRODUCTION

Anthurium is an evergreen, tropical herbaceous high value ornamental cultivated for its colourful spathe and unusually attractive foliage. Known for its massive effect, elegance and variety of colours, anthurium attract a vast majority of enthusiastic growers. It is very much encouraging to learn that the global trade of anthurium is valued at US $ 50 million and it occupies the 11th position in the International market.

Originating in American tropics, the genus *Anthurium*, with over 700 species (Sheffer and Croat, 1983) which are distributed world wide, is the largest in the family Araceae. The most popular and economically important species are *Anthurium andreanum* and *A. scherzerianum*, which possess attractive long-lasting inflorescence. Several other species like *A. magnificum*, *A. digitatum*, *A. crystallinum* and *A. clarinervium* are grown for their magnificient foliage. The Anthurium derives its name from Greek legendary - anthos the flower(spathe); oura the tail(spadix).

The most popular species with floriculturists is *A. andreanum* Lind. due to its bold effect and lasting qualities of the inflorescence. The plant is erect with long, lobed, heart shaped, green leaves. Anthurium inflorescence is composed of a modified leaf (spathe) and pencil like protrusion (spadix) borneon leafless stalk or peduncle (Bhatt and Desai, 1989). The true sessile and bisexual flowers are arranged on the spadix. Anthuriums are shade loving plants. Open conditions with adequate shading facility is the best for their growth and development. Temperature and relative humidity also significantly influence the growth, development and post-harvest behaviour, the optimum being between 18 and 28°C and around 80 per cent, respectively.

Hawaii, Mauritius, Holland and Germany are the important producers of anthurium and the major importing countries are USA, Canada, Europe and Japan. In India, its cultivation is restricted to Southern parts, especially Kerala and parts of Karnataka and Tamil Nadu.

Of late, anthurium cultivation has gained much popularity and it has now become an important export oriented crop. Kerala is identified as one of the best places for growing anthurium because of the congenial climatic conditions. However, the management practices bestowed during cultivation and after the harvest of flowers are not scientific, largely due to the lack of research and developmental support available. Research work on the standardisation of agrotechniques in anthurium was initiated in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara in 1995. Based on the results obtained so far, an experiment was designed in cv. 'Hawaiian Red', the main objectives of which were

to study the effect of different ratios and concentrations of nutrients and growth regulators by foliar application on the growth, flowering and quality of flowers including the vase life,

to compare growth, development and flower production in ground and pot planting,

to extend the longevity of flowers after harvest by applying suitable post-harvest treatments,

to develop a suitable packing technique so as to prolong the senescence of flowers and

to study the effect of ethylene absorbant ($KMnO_4$) on the post-harvest longevity of flowers.

Review of Literature

REVIEW OF LITERATURE

Anthurium is an evergreen, tropical, semiterrestrial, herbaceous perennial cultivated for its colourful spathe and unusually attractive foliage. It requires high humidity and partial shade for proper growth and development. The size and number of flowers produced are influenced largely by shade and nutrition. Recently, plant growth regulators are being widely used to increase the production and post-harvest life of cut anthurium flowers. Now a days, anthurium cultivation has become one of the thrust areas in Kerala but, the knowledge about the scientific cultivation aspects is meagre. Literature pertaining to these aspects are reviewed here.

2.1 Nutrition

Anthurium requires a warm green house with shading from direct sunshine and a humid condition. The optimum temperature is between 25 and 28°C during day and 18 and 21°C during night. The relative humidity is also very important for growth and development of anthurium, the optimum being around 80 per cent. The morphological characters, flower production and quality of flowers are affected by the intensity of light. The optimum shade requirement is 80 per cent.

Anthurium requires a light, well drained medium rich in organic matter with good aeration and water holding capacity. They are usually grown in a medium consisting of sand, cowdung, brick pieces, charcoal and coconut husk, in Kerala.

Anthurium plants respond well to ample supply of nutrients and they grow satisfactorily in a wide variety of media, if appropriate practices are followed.

Experiments were conducted to test the effects of N at 0, 300 and 600 lbs/acre/year, and P and K at 0 and 300 lb/acre, on flowering and chemical composition of leaves of *A. andreanum* cv. 'Nitta' and 'Kaumana' at the Ridge Horticultural Laboratory, Florida. Major nutrients such as N, P and K enhanced flower number, stem length and spathe size in 'Nitta'. Only N enhanced flower number in 'Kaumana'. Raising of N levels increased the tissue N content but decreased P content. K application increased the K content and lowered the Mg content. Foliar N, P, K, Ca and Mg levels that produced the maximum flowers were about 2.00, 0.16, 1.10, 1.50 and 0.75 per cent dry weight respectively (Poole and Greaves, 1969).

Poole and McConnel (1971) recommended the use of a commonly used 14:14:14 dry fertilizer mixture for anthurium in Florida. Five other fertilizers tried (Mag Amp, Osmocote, ureaform and 2 formulations of Agriform) were on par with this mixture and no difference was noticed in the number of flowers produced.

According to Steen and Vijvosberg (1973), neither N nor K had any significant effect on flower yield in anthurium in Netherlands. The plants were fertilized with nitrate of lime and/or potassium sulphate immediately after planting and 5 months later, or else, were left unfertilized, and all the plants grew equally well.

Valk (1975) from Netherlands reported that when the rates of N application to *A. andreanum* increase, flower yield, flower weight and stem length tend to decline. Insufficient K levels resulted in lower flower yield and flower weight and a reduction in stem length and flower size. The optimum dose was found to be 15-20 g N and 22-30 g K_2O/m^2.

In container studies with *A. andreanum* in Netherlands, N application had an adverse effect on both flower production and flower quality. The best results were obtained with the lowest nitrate (126 mg N/12.5 l container/week). An increase in K_2O from 19 to 225 mg/container week improved both flower yield and quality, but further increase had a negative effect (Bik, 1976).

Higaki (1977) established that Ca content of the tip section of the spathe was higher than that in the lobe section (average 0.3 and 0.16%, respectively). Lower Ca levels resulted in the colour break down of the spathe. No symptom of colour break-down resulted from Ca applications of 40 ppm and above, corresponding to Ca levels of 0.16 and 0.54 per cent in the lobe and leaf tissues, respectively.

A. scherzerianum plants having the highest fresh and dry weights, the largest number of best quality flowers, the largest stems and with no leaf chlorosis were grown with 4 g $CaCO_3$/l and no B. However, the longest spadix and flower fresh weight were obtained with 4 g $CaCO_3$ and 2.0 mg B/l (Penningsfeld, 1977).

The beneficial effect of N on the quality of potted *A. scherzerianum* was discussed by Bik and Straver (1978). The best results were obtained with a medium dose of 21.6 mg N/pot/week in Holland. The dose of 22.5 mg K_2O/pot/week gave better quality plants than 1.9 mg. Insufficient levels of N and K were associated with lower flower yield, reduced stem length and smaller flowers. Deficiency symptoms like leaf necrosis and dead root tips were associated with K deficiency.

In an experiment with 5 levels of N and 3 of K in the Netherlands, the best results were obtained with an annual dressing of 20 g N + 30 g KO_2/m^2. At

optimum nutrition levels, mature leaves contained 2 per cent N and 3 per cent K (Boertje, 1978).

Higaki and Poole (1978) tried with three fertilizer levels, viz., $N:P_2O_5:K_2O$ at 448:196:376 kg/ha/year and double and triple that rate in *A. andreanum* cv. 'Ozaki' in Hawaii. The low fertilizer rate gave as good or better results in flower production as the higher rates. The double rate produced slightly larger flower stem and larger flowers than the low or triple rate. Flower production decreased with age of the plant, but both stem length and flower size increased.

Colour breakdown of spathe tissue of anthurium showed typical Ca deficiency symptom. Calcium application significantly reduced the disorder (Higaki *et al.*, 1980).

In *A. andreanum*, annual fertilizer levels of N, P_2O_5 and K_2O at 100, 200 and 400 lb/ha were tried. Flower production and flower size increased linearly with increasing fertilizer rate, but flower stem length was not affected by fertilizer rates (Higaki and Imamura, 1985).

A complex fertilizer (16:16:16) was recommended by Singh (1987) for *A. andreanum*, so as to supply 341 kg each of N, P_2O_5 and K_2O/ha/year. Henny *et al.* (1988) reported that N level affected the number of shoots, number of spathes and plant quality grade, the best results being produced with 1500 lbs N/acre.

A. andreanum cv. 'Lady Jane' was grown with a weekly application of 20:20:20 NPK fertilizer at 200, 400, 600 and 800 mg/litre, and the plant growth was best at the lower two fertilizer levels. Higher levels were found to be detrimental (Henny and Fooshee, 1988).

According to Poole *et al.* (1990), fertilizer requirement of anthurium in Florida depends up on light intensity, irrigation and medium. Excess fertilizer should be avoided to help prevent bacterial blight (*Xanthomonas campestris* pv. *diffenbachiae*). Temperature will influence growth and flowering which must also be considered.

The nutrient solution used for *A. andreanum* was added to the irrigation water so that the EC values ranged from 0.6 to 3.0 ds/m (25°C). The EC of the drainage water ranged from 0.8 to 4.7 ds/m. Flower production and vegetative growth decreased linearly with increasing nutrient concentrations. A nutrient solution with EC of 0.7 ds/m is found to be optimal (Sonneveld and Voogt, 1993).

Higaki *et al.* (1992) and Holly *et al.* (1994) reported that the maximum flower yield in anthurium was obtained when leaf tissue level was 1.87 per cent for N; 0.17 per cent for P and 2.07 per cent for K. Stem length and flower size were maximum with leaf N at 1.59 per cent and K at 1.67 per cent. However, no relationship was observed between the P content in leaves and flower size or stem length.

The effect of frequencies and rates of application of foliar fertilizer on growth and flowering of anthurium cv. 'Kaumana' was discussed by Nikado (1994). He observed no significant differences among the treatments. First bloom appeared 8 months after planting. Small flowers were produced during the first few months which later increased in size as the plant matured.

The effect of applying four different complete fertilizers on cut flower production in *A. andreanum* was reported from Germany (Dufour *et al.*, 1997). There were no significant differences in yield or quality between the treatments. It

was concluded that the fertilizer containing the lowest dose of N (3 meq/l) was adequate for cut flower production.

Studies at the Kerala Agricultural University (Salvi, 1997) revealed that 17:17:17 fertilizer complex @ 1 per cent at weekly interval produced the maximum plant height and other biometrical characters in *A. andreanum* cv. 'Hawaiian Red'. The leaf nutrient content varied from 0.49 to 2.29 per cent for N, 0.19 to 0.36 per cent for P and 1.40 to 2.44 per cent for K. Nutrient uptake was influenced by shade and growth regulators. Eighty per cent shade recorded maximum uptake for N and K, and it reduced as the shade intensify declined, whereas P was unaffected. Plants applied with BA 1500 ppm recorded the maximum uptake (0.53%) for N, BA 750 ppm recorded the maximum uptake (0.56%) for K while uptake ot P was unaffected by the treatments.

Nitrogen, potassium and calcium are the important elements required in anthurium nutrition. It is better to apply the fertilizers in smaller doses at frequent intervals than larger doses at longer intervals. A combination of organic manures such as farmyard manure with 2 g of 17:17:17:2 NPK and Mg per plant, once or twice a month is found to be highly beneficial. Foliar sprays of 0.5-1.0 per cent of 17:17:17 complex could also be given to the plants, at biweekly intervals. It is beneficial to decrease the level of N when the plant switches over from vegetative to flowering phase. An overdose of fertilizer, applied shortly before the harvest of spikes, is surely going to inhibit the vase life of flowers. Using fine chemicals as fertilizers can result in more flower yield with better quality (Rajeevan and Valsalakumari, 1998).

2.2 Growth regulators

Plant growth regulators play a vital role in the cultivation of any crop especially that of ornamentals. Recently, growth regulators are being increasingly used in ornamentals for enhancing the growth, suckering, flower production and quality and for manipulating the post harvest behaviour of cutflowers positively.

Nakasone and Kamemoto (1962) reported that light intensity and GA_3 concentration are important factors in regulating flower production in anthurium.

Higaki and Rasmussen (1979) used various growth regulators to increase shoot development on mature anthurium plants. Foliar treatment with BAP 1000 mg l^{-1} induced more shoot formation than Ethephon or PBA at 100, 500, 1000 or 1500 mg l^{-1}. Increased side shoot production was observed in mature plants treated with GA_3 concentrations of 250 to 1000 mg l^{-1}.

Juvenile *A. andreanum* plants were treated by topping and/or with foliar sprays of GA_3 or BA. With increasing concentrations (0-500 ppm) of GA_3, topped plants produced more lateral shoots than did intact sprayed plants. With increasing concentrations (0-1000 ppm) of BA, the number of lateral shoots increased in both topped and intact plants (but was lower than with GA treatments). Topping alone also increased the number of lateral shoots (Imamura and Higaki, 1988).

According to Henny (1989), flowering could be induced in aroids with a single foliar application of 250 mg l^{-1} gibberellic acid. Following GA_3 treatment, different species with-in a genus flowered simultaneously and produced significantly more inflorescences.

Henny and Hamilton (1992) reported that GA_3 was applied at 0, 125, 250, 375 or 500 mg ai/l as a foliar spray to the potted plants of *A. andreanum* cv. 'Amazone' and 'Renate'. GA_3 application resulted in a small but significant increase in flower production/plant but there were no differences between treatments. The response of cv. 'Renate' was similar to that obtained with 'Amazone' at low light intensity but at higher light intensities, there was a greater increase in flower production and the response increased with GA_3 concentration, the optimum being 375-500 ppm.

Gibberellic acid and Benzyladenine at 250, 500, 750 and 1000 ppm were tried on intact and topped anthurium plants to induce lateral branching. It was observed that topping alone increased the number and size of lateral shoots. Effect of BA was evident from fifth month after spray where as GA_3 effect was expressed only after eight months. GA_3 750 ppm produced maximum (4.67) laterals in topped plants where as BA 250 ppm was more effective on intact plants (Anu, 1997).

Application of GA, BA and Ethephon at 750 and 1500 ppm was tried in *A. andreanum* cv. 'Hawaiian Red'. BA 750 ppm at monthly interval produced more plant height, leaf length, breadth and petiole length. GA 750 ppm produced more branching than BA and Ethephon (Salvi, 1997).

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 the maximum size of spathe, length of stalk and number of inflorescences produced per year. The longevity of the inflorescence was maximum with 1500 GA which was on par with 1000 ppm GA.

2.3 Post harvest handling

Anthurium flowers are to be harvested at the correct stage of maturity for maximum longevity of cutflowers. Stage of harvest, pre harvest and post harvest factors and post harvest handling are the factors which determine the life of cutflowers. Various preservatives and growth regulators are increasingly used in anthurium to extend their vase life by means of pulsing and holding.

According to Paull *et al.* (1992) mean maximum temperature during the two months before harvest and duration of post harvest life were positively related and explained 53 per cent of the total variation. High N rate reduced post harvest life but this was alleviated by high K; while P had no effect. N and K rates explained approximately 13 per cent and 17 per cent of the variation, respectively. Pre harvest factors explained 63.71 per cent of the variation in the post harvest life.

2.3.1 Stage of harvest

The flowers are harvested after the unfolding of the spathe is complete. Development of true flowers on the spadix is also used as a criterion for harvesting the flower. According to Kamemoto (1962), flowers are cut at the leaf axil when one-third to three-quarters of the true flowers along the spadix are open.

Flowers are harvested in the morning with long stalks. Most anthurium blooms are harvested at about three-quarters maturity because at this time it is believed that they have the longest shelf-life as cutflowers (Antoine, 1994).

Salvi (1997) suggested that in inflorescence having 1/3rd flowers opened on spadix, the spathe blueing and gloss loss were late (20.0 and 22.3 days, respectively) and it also had the longest vase life (23.33 days).

Singh (1998) has specified that anthurium flowers are harvested when three-quarters of the stigma along the spadix has become receptive.

According to Prasad *et al.* (1998), anthurium flowers are harvested when the spathe completely unfurls and the spadix is well developed. When one-third of the true flowers on the spadix mature, a change of colour can be observed that moves from base to tip of spadix and at that stage, the flowers are harvested.

2.3.2 Pulsing

Short duration pulsing of cut flowers with different chemicals significantly improved the keeping quality of anthurium. According to Shirakawa *et al.* (1964), pulsing of anthurium flowers with N-6-benzyladenine (N-6-BA) provided about 19 per cent improvement in vase life.

A post harvest dip in 10 ppm N-6-BA was suggested for anthuriums destined for air freight and shipment as a result of improved keeping quality following exposure to shipping temperatures of 9 and 15°C (Shirakawa *et al.*, 1964).

Short (10-60 mts) pre treatments of stems of anthurium flowers with 1-10 mM $AgNO_3$ increased vase life by 40-60 per cent after a simulated shipping for 3 days. After this, it was necessary to remove 2 cm of stem before placing the flowers

in water or preservatives. Maximum post harvest life was obtained with 4 mM $AgNO_3$ for 20 minutes within 12 hours of harvest (Paull and Goo, 1982).

Paull and Goo (1985) reported that the rate of water uptake by cut *A. andreanum* (cv. 'Ozaki Red') flowers declined to 20 per cent of the harvest rate in 10 days. The spadix was the site of 50-60 per cent of water loss while 20-40 per cent occurred via the spathe and 10-20 per cent via the stem. Pulsing with 4 mM $AgNO_3$ for 40 mts increased the vase life. Various biocides had little effect on vase life, suggesting that wound-ethylene induced stem clogging, and not microbial clogging of vascular tissue, was probably the major factor inducing water stress and senescence, thus limiting post harvest life.

The rate of increase in respiration rate of silver treated flowers was just half of that in the controls. Senescence was probably caused by water stress due to stem plugging of an undetermined nature. Silver pulsing of the stem reduced the amount of plugging and reduced the rate of change of all senescence processes observed (Paull *et al.*, 1985).

According to Paull (1987), the optimum storage temperature for *A. andreanum* was between 14 and 17°C. Silver nitrate pulse (4 mM for 40 mts), given immediately after harvest, increased the post harvest life of stored flowers, but had no effect on flowers that were placed immediately in the vase.

Pulse treatment with BA 50 ppm for 12 hrs resulted in delayed initiation of spathe blueing and spadix necrosis (after 19.0 and 19.0 days, respectively). This treatment also recorded the maximum retention (upto 18.00 days) of spathe gloss and maximum total vase life (20.0 days) compared to other treatments (Salvi, 1997).

Studies were conducted at the Kerala Agricultural University (Valsalakumari *et al.*, 1998) to extend the vase life of three commercial varieties of anthurium, viz., Lima White, Eureka Red and Sweetheart by giving pulsing treatment for 8 hours to harvested flowers with triadimefon, BA and 8 HQ, each at concentration of 25, 50 and 100 ppm. Pulse treatment with triadimefon 25 ppm was significantly superior to all the other treatments. Eureka Red recorded the maximum total vase life of 23 days compared to 21 days in Lima White and 18 days in Sweetheart.

2.3.3 Holding solutions

Various holding solutions - preservatives and growth regulators - are used for the long term storage of anthurium cut flowers. The long term holding of cut flowers to extend their vase life was studied by Fischer (1952).

Various commercial preservatives and beverages (Sodium benzoate, benzoic acid, sodium hypochlorite, HCl, 7-up etc.) were used to prolong the shelf life of anthurium flowers. They improved the postharvest life by 1.9 to 2.7 times over controls when the flowers were held continuously in the solution (Akamine and Goo, 1975).

Continuous exposure to cytokinins in the holding water increased post harvest life of anthurium cutflowers by 2.0 to 2.5 times (Paull and Goo, 1985).

Increase in the vase life of anthurium flowers with floral preservatives and carbohydrate soft-drinks was reported by Surang (1988).

Post harvest handling of bold tropical cutflowers like *Anthurium, Alpinia purpureata* etc. was discussed by Criley and Paull (1993).

Ravindran and Shylaja (1995) have suggested various post harvest treatments and holding solutions to increase the longevity of cutflowers in anthurium.

The effect of different holding solutions on the vase life of anthurium cv. 'Hawaiian Red' was examined at the Kerala Agricultural University (Salvi, 1997). Among them, 8-HQ at 30 ppm resulted in delayed spathe blueing and spadix necrosis (after 26.0 and 21.0 days, respectively) and maximum vase life (27.0 days). Retention of gloss was maximum (upto 23.3 days) with BA 20 ppm as holding solution.

The effect of holding solutions containing $AgNO_3$, BA, CCC (chlormequat) and sucrose on the post harvest life of anthurium cv. 'Agnihotri' was studied with respect to the physiological loss in weight, water uptake, electrolyte leakage and total vase life at the Kerala Agricultural University. BA at 25 ppm produced the longest vase life of 22 days. $AgNO_3$ or sucrose had no effect on vase life. Water uptake and electrolyte leakage were directly correlated with vase life (Salvi *et al.*, 1997).

2.3.5 Other treatments

Apart from pulsing and holding treatments a few other methods are also employed to extend the post harvest longevity of the anthurium flowers.

Enclosing the anthurium inflorescence in a polythene film maintained turgidity and improved longevity (Shirakawa *et al.*, 1964).

According to Watson and Shirakawa (1967), coating the spadix of anthurium with paraffin reduced water loss and extended vase life.

Low oxygen (2%) storage enhanced post harvest life of immature anthurium flowes at air temperatures of 24 to 25°C, but provided only a slight benefit at 13°C (Akamine and Goo, 1981).

The effectiveness of eight products used to coat the flowers of anthurium was discussed by Paull (1983). FMC-819 and Carnauba-based wase wax most effective, increasing the vase life from 18 days in untreated control to 36, and imparting a high gloss.

Waxing the flowers of anthurium cv. Ozaki Red with carnauba wax reduced water loss and increased vase life from 17.9 days in control to 35.9 days (Paull and Goo, 1985).

Storage of anthurium flowers at 28°C resulted in a transpiration rate to uptake rate of 61 for the first 10 days, while at 18°C, a good balance between transpiration and uptake (ratio of approximate 1.0) was maintained for 20 days. All the components of water balance (uptake, loss and accumulation) declined rapidly for the first 5 days, after which the decline was slower. Flowers stored at 8°C were unmarketable after 10 days due to chilling injury (Sankat *et al.*, 1994).

2.3.6 Packing

Anthurium flowers are packed in cardboard cartons of various sizes. The cartons are lined with polythene sheets and layers of newspapers. Flowers are packed with their spathe face down and their stems interwoven and moistened

shredded news paper inserted to provide a cushion and maintain humidity (Akamine, 1976).

Some methods involve the use of water filled orchid tubes as a well with each fastened to a backing to prevent shifting during handling. The inflorescence may also be covered with a waxed tissue or polythene envelope to reduce mechanical damage due to the spadix oppressing the spathe (Akamine, 1976).

According to Bhattacharjee (1977), the cut ends of each flower stem should be wrapped with cotton pad soaked with water and covered with wax paper and securely tied or the stem ends are fitted in plastic vial containing water or the spadix is dipped in melted paraffin to reduce moisture loss and first packed in polythene bags and thereafter placed in cartons.

Flowers are sometimes packed in moist boxes placing the soft protective material between the spathe and spadix. Flowers are mostly presented individually. They are sometimes fixed to the bottom of the box with tape or separation papers between the layers. Care should be taken that the flowers are protected against physical injury. To maintain high humidity, polythene lining is provided in the box (Bhattacharjee, 1977).

According to Prasad *et al.* (1998), anthurium flowers are packed in corrugated boxes lined with polythene sheets and cushioned with lot of newsprint shreddings. The flowers remain fresh if the newsprint shreddings are moist. Before placing the flowers in the box, they are covered individually with polythene sleeves to prevent any damage to the spathe and spadix.

Materials and Methods

MATERIALS AND METHODS

Investigations on flowering and post harvest behaviour of anthurium cv. 'Hawaiian Red' were carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur during 1996-98. Experiments were conducted to find out the optimum amount of nutrients and growth regulators to enhance growth, flowering and quality of flowers. Two methods of planting, viz., ground planting and pot planting were also tried. Post harvest studies included the use of pulsing, plugging, waxing and their combinations to extend the vase life of cut flowers. BA, Triadimefon and Bavistin were used for pulsing and plugging. Waxing was done with paraffin on the spathe and spadix. Packaging studies were also conducted with an aim of standardising the best packing method and to study the effect of ethylene absorbant on the longevity of cut flowers in storage. The details regarding the experiments conducted, methods used for the analysis of data and an account of general management practices adopted are presented in this chapter.

3.1 Planting material

The variety used was 'Hawaiian Red' of *Anthurium andreanum* Lind. which is a popular hybrid having good demand in the international market. One year-old plants were used for the study.

3.2 Medium

A medium consisting of sand, well rotten cowdung, coconut husk, charcoal, earthern crocks and brick pieces (2:1:2:0.5:0.5:1 ratio) was used for growing the plants.

3.3 Shade

The experiment was conducted under 80 per cent shade which was found to be the best for growing anthurium under Kerala conditions (Salvi, 1997).

3.4 Methods of planting

3.4.1 Pot planting

Pots of 22.5 cm size with holes at the bottom were used for planting. A crock piece was placed on the hole of the pot at the bottom; above which 5.0 cm layer of coarse sand was spread followed by 2.5 cm layer of sand plus cowdung mixture. Pieces of bricks and charcoal were arranged over this in such a way that the plant, along with the root ball could be placed easily. Sides of the root ball were covered with pieces of coconut husk and a filler mixture of sand and cowdung was spread above it. Plants were placed firmly over the medium. The top 7.5 cm portion of the pot was left vacant to facilitate easy watering and manuring.

3.4.2 Ground planting

The field was levelled first with a slope towards one side for easy subsurface drainage. A 5.0 cm layer of brick pieces was uniformly spread on the ground over which a 2.5 cm layer of coarse sand was spread. The medium was then spread over the sand and the plants taken from the pots were firmly placed on the medium along with the root balls at a spacing of 35 cm x 35 cm. The medium was applied along the sides of the plants and the plants were then tied to plastic ropes running from one end to the other of the field, for better support.

3.5 General management

The plants were watered twice a day with the help of overhead sprinklers. Need based application of plant protection chemicals was done. Incidence of cut

Plate 1. Eighty per cent shade net were the study was conducted

Plate 2. A general view of the field after planting


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College of Horticulture, Vellanikkara.
REGULATION OF FLOWERING AND POST-HARVEST BEHAVIOUR OF ANTHURIUM CV. 'Hawaiian Red'
• No. of plants : 480
• Method of planting
A. Ground planting
B. Pot planting
• Treatments:
A. Nutrients : 18
B. Growth regulators : 6
• Design : RBD
• Replications : 3

worms, leaf caterpillars and rarely slugs and snails were noticed, for which sprays of Neemazan (2-3 ml/l) or Ekalux (3 ml/l) were very effective. Indofil M-45 (2-3 g/l) or contaf (1-2 ml/l) were very effective against leaf blight and rot. Occasionally drenching with Indofil M-45(0.2%) was done against rotting. Fresh medium was applied once a month or as and when the existing medium was exhausted.

3.6 Design of the experiment

For field experiments, a randomised complete block design with three replications was laid out. There were 18 different treatments for nutrients and 6 for growth regulators along with a control. Each replication had 3 plants each. A separate study was conducted in the laboratory to analyse the vase life of cut flowers and to extend it by means of pulsing, plugging, waxing and their combinations. Packing studies were also carried out in the laboratory.

3.7 Lay out of the experiment

3.7.1 Pre harvest studies

3.7.1.1 Nutrients - 3 x 5 + 3 levels

$N_1C_1W_1$ - 20:20:20 complex @ 0.25% at weekly interval

$N_1C_2W_1$ - 20:20:20 complex @ 0.50% at weekly interval

$N_1C_2W_2$ - 20:20:20 complex @ 0.50% at biweekly interval

$N_1C_3W_1$ - 20:20:20 complex @ 1.00% at weekly interval

$N_1C_3W_2$ - 20:20:20 complex @ 1.00% at biweekly interval

$N_2C_1W_1$ - 20:20:40 complex @ 0.25% at weekly interval

$N_2C_2W_1$ - 20:20:40 complex @ 0.50% at weekly interval

$N_2C_2W_2$ - 20:20:40 complex @ 0.50% at biweekly interval

$N_2C_3W_1$ - 20:20:40 complex @ 1.00% at weekly interval

$N_2C_3W_2$ - 20:20:40 complex @ 1.00% at biweekly interval

$N_3C_1W_1$ - 20:40:40 complex @ 0.25% at weekly interval

$N_3C_2W_1$ - 20:40:40 complex @ 0.50% at weekly interval

$N_3C_2W_2$ - 20:40:40 complex @ 0.50% at biweekly interval

$N_3C_3W_1$ - 20:40:40 complex @ 1.00% at weekly interval

$N_3C_3W_2$ - 20:40:40 complex @ 1.00% at biweekly interval

N_0CaM - Ca @ 0.50% at monthly interval + control

N_0MgM - Mg @ 0.50% at monthly interval + control

N_0Vit.M - Vit.B_{12} @ 100 ppm at monthly interval + control

N_0 - Control (17:17:17 complex @ 1.0% at weekly interval)

3.7.1.2 Growth regulators - 2 x 3 levels

G_1C_2M - BA 500 ppm

G_1C_3M - BA 1000 ppm

G_2C_2M - GA 500 ppm

G_2C_3M - GA 1000 ppm

$(G_1+G_2)C_1M$ - (BA + GA) 250 ppm

$(G_1+G_2)C_2M$ - (BA + GA) 500 ppm

The growth regulators were given as whole plant spray at month intervals.

3.7.2 Post harvest studies

The post harvest longevity of cut anthurium flowers were studied in t laboratory and different treatments like pulsing, plugging, waxing etc. we employed to extend the vase life. Studies were also conducted to standardise t packing method and to study the effect of ethylene absorbant ($KMnO_4$) on the va life in storage.

For this, uniform sized anthurium flowers were harvested when one third of true flowers on the spadix have opened out, which is believed to be the correct stage of harvest for maximum post harvest longevity (Salvi, 1997). The flowers were harvested in the morning, the cut ends were kept immersed in water and immediately brought to the laboratory. A fine slanting cut was given at the base of the stalk to facilitate easy absorption of solutions.

The details of treatments are given below.

3.7.2.1 Pulsing treatments

P_1 - Bavistin 0.1% for 8 hrs

P_2 - Bavistin 0.2% for 8 hrs

P_3 - Triadimefon 10 ppm for 8 hrs

P_4 - Triadimefon 20 ppm for 8 hrs

P_5 - Triadimefon 25 ppm for 8 hrs

P_6 - Triadimefon 30 ppm for 8 hrs

P_7 - Triadimefon 50 ppm for 8 hrs

P_8 - BA 25 ppm for 8 hrs

P_9 - BA 50 ppm for 8 hrs

P_{10} - BA 100 ppm for 8 hrs

P_{11} - BA 150 ppm for 8 hrs

P_{12} - BA 200 ppm for 8 hrs

P_{13} - BA 250 ppm for 8 hrs

P_{14} - BA 300 ppm for 8 hrs

P_{15} - control (no pulse treatment)

After pulsing, the flowers were transferred to tap water (200 ml) for further observations.

3.7.2.2 Plugging treatments

The flowers, immediately after harvest were brought to the laboratory and their cut ends were plugged with cotton moistened with different chemicals as explained below.

P_1 - Bavistin 0.1%

P_2 - Bavistin 0.2%

P_3 - Triadimefon 10 ppm

P_4 - Triadimefon 20 ppm

P_5 - Triadimefon 30 ppm

P_6 - BA 25 ppm

P_7 - BA 50 ppm

P_8 - BA 100 ppm

P_9 - BA 25 ppm + Bavistin 0.1%

P_{10} - BA 50 ppm + Bavistin 0.1%

P_{11} - BA 100 ppm + Bavistin 0.1%

P_{12} - control (plugging with tap water)

P_{13} -Distilled water control

3.7.2.3 Waxing

The following treatments were included.

W_1 - Waxing of cut end alone

W_2 - Waxing of spadix alone

W_3 - Waxing of spathe and spadix

W_4 - Waxing of spathe, spadix and cut end

3.7.2.4 Packing studies

Flowers after harvest were taken to the laboratory and their cut ends were plugged with cotton moistened with distilled water and then packed in corrugated cardboard boxes. The effect of ethylene absorbant (KM_nO_4) on the storage life of flowers was also studied. Different methods of packing tried included,

P_1 - Inserting individual flowers in polythene sleeves

P_2 - Inserting individual flowers in polythene covers

P_3 - Packing the flowers in cardboard boxes with paper strips

These methods were tried with and without ethylene absorbant. For this, ethylene absorbant (KM_nO_4) was taken (5 g) in a muslin cloth tied with a knot and kept in the boxes meant for packing.

3.7.2.5 Combinations of different treatments in packing

The best treatments among pulsing, plugging and waxing were selected and their different combinations were tried in packing studies as explained below.

C_1 pulsing BA 150 ppm + plugging BA 50 ppm + packing in polythene covers

C_2 pulsing BA 150 ppm + waxing of spathe and spadix + packing in polythene covers

C_3 plugging BA 50 ppm + waxing of spathe and spadix + packing in polythene covers

C_4 plugging BA 50 ppm + pulsing BA 150 ppm + waxing of spathe and spadix + packing in polythene covers

C_5 pulsing BA 150 ppm + waxing of spathe and spadix + BA 50 ppm in vials + packing in polythene covers

C_6 Control (plugging with tap water alone)

These studies were carried out with and without ethylene absorbant (KM_nO_4).

The flowers used for vase life studies were kept in 200 ml of tap water after the treatments and each experiment was replicated thrice. Different parameters regarding the vase life was recorded during the experimental period as per the vase life evaluation criteria suggested by Paull (1982).

3.8 *Observations*

The following were the observations recorded during the course of the experiment.

3.8.1 Pre harvest studies

3.8.1.1 Plant characters

The following characters of plants under each treatment were recorded.

3.8.1.1.1 Plant height

The height of the plant was measured from the base to the top of the shoot at monthly intervals and recorded in centimetres.

3.8.1.1.2 Plant spread

The spread of the plant in E-W and N-S directions were measured in centimetres.

3.8.1.1.3 Leaf number

The total number of leaves present on the plant at the time of each observation was counted and recorded.

3.8.1.1.4 Length, Breadth and Area of Leaves

The length of the leaf from the basal lobe to the tip and width, at the centre of the leaf was measured in centimetres. The area of the leaf (square centimetres) was computed using the equation (Salvi *et al.*,1995).

Leaf Area = 0.72 (Leaf Length x Leaf Breadth).

3.8.1.1.5 Number of lateral shoots

The number of lateral shoots (suckers) with independant root systems arising from the base of the plant was recorded.

3.8.1.1.6 Interval of leaf production

Time taken (days) for the emergence of successive leaves was counted and recorded.

3.8.1.2 Inflorescence characters

3.8.1.2.1 Days to flower

Number of days taken for the first flower bud to appear after planting was noted and recorded.

3.8.1.2.2 Interval of flower production

Time taken (days) for the emergence of successive inflorescences was counted and recorded.

3.8.1.2.3 Number of flowers per plant

The total number of spikes produced per plant during the study period was recorded.

3.8.1.2.4 Length of flower stalk

The length of flower stalk from the point of emergence to the point of attachment with the spathe was measured and recorded in centimetres.

3.8.1.2.5 Flower size

The length of the spathe from the point of attachment of the peduncle, to the tip and width, at the centre of the spathe were measured and recorded in centimetres. Length of the spadix from the point of attachment with the spathe to the tip was also measured and recorded in centimetres.

3.8.1.3 Chemical Analysis

3.8.1.3.1 Chlorophyll content of leaves

Chlorophyll content (a, b and total) of leaves from each of the treatments was estimated using a Spectronic-20 as per the standard procedure proposed by Starnes and Hadley (1965). Fully matured second terminal green leaf was used for the analysis. One gram of the representative sample from each treatment was taken

and samples were prepared using the standard procedure. The optical density of an aliquat was measured at wavelengths of 654 nm and 663 nm. The contents of chlorophyll 'a', 'b' and total (mg g^{-1} fresh weight) were then estimated using the following relationships.

Chlorophyll a	= 12.72 A 663 - 2.58 A 645
Chlorophyll b	= 22.87 A 645 - 4.67 A 663
Total chlorophyll (a + b)	= 8.05 A 663 + 20.29 A 645

3.8.1.3.2 Anthocyanin content of flowers

Anthocyanin content of flowers was estimated by colorimetric method, as described by Sweon and Hills (1959).

Well matured anthurium spathes were used for the anthocyanin estimation. Samples were collected from each treatment and crushed in mortar with ethanol and filtered through Whatman No.1 filter paper. One millilitre of the alcohol extract was pipetted out into a test tube and 3 ml of HCl in aqueous methanol, was added to it. One ml of peroxide reagent was added to the samples and 1 ml of methanolic HCl, to the blank tubes. After 15 minutes in the dark, the OD (A) of the solutions was measured using Spectronic-20 at 525 nm against the blank. The anthocyanin present in the samples was calculated from a standard curve prepared with cyanin HCl or expressed the results as A 525- cyanin HCl 10 µg/ml in methanolic HCl given OD of 0.405 in a 1.0 cm cell at 525 nm.

3.8.1.3.3 Nutrient content of leaves

Representative samples were taken from each treatment at the final stage of the experiment and they were dried well in an oven. After proper drying, the

leaves were ground in a grinder. One gram of the powdered sample was used for the analysis.

Determination of nitrogen was done by microkjeldhal method; phosphorus by colorimetry (Vanadomolybdo-phosphoric yellow colour method) and potassium by flame photometer.

3.8.2 Post harvest studies

3.8.2.1 Vase life

Number of days taken for a fresh inflorescence to show the signs of wilting is taken as the vase life of that flower. The important changes which mark the end of vase life include spathe blueing, spadix necrosis, gloss loss and finally the total death/collapse of the flower. Number of days taken for these symptoms to appear was recorded and noted.

3.8.2.2 Physiological loss in weight

For this, the initial and final weights of inflorescences were noted at the beginning and at the end of the experiment, respectively, and by working out the difference between them the PLW is arrived at.

3.8.2.3 Water uptake

The quantity of vase solution uptaken by the inflorescence was found out by measuring the initial and final volumes of the solution and getting the difference between them.

3.8.2.4 pH

The pH values of the solution were read on a pH meter in the beginning and at the end of the experiment and the change of pH was found out by working out the difference between these values.

3.8.2.5 EC

The EC reading of the vase solutions was noted at the initial and final stages of the experiment in ms/g/cm using an electrical conductivity meter and the difference between the two values was noted as electrolyte leakage.

RESULTS

4.1 Effect of nutrients on plant characters

4.1.1 Plant height

The effect of nutrients on plant height, in ground planting, taken at monthly interval is given in Table 1.

Statistical analysis of the data revealed that, in ground planting, the effect of nutrients on plant height was significant only in the 6th and 8th months. In both the months, the treatment consisting of 20:20:20 fertilizer complex, 1.0 per cent at weekly interval ($N_1C_3W_1$) recorded the maximum height (7.68 cm and 9.29 cm, respectively). This treatment was on par with the higher concentrations of P and K (20:20:40 and 20:40:40) and intervals of application (weekly and biweekly). Control (N_0)recorded the minimum height in both the months (6.64 cm and 7.41 cm, respectively) and it was on par with the lower concentrations (0.25 per cent) of all the nutrients. Application of Ca and Vit. B_{12} along with control produced better results and they were on par with the best treatments, but the application of Mg made little effect on plant height over control.

Data presented in Table 2 gives the effect of nutrients on plant height in pot planting. Here also there was significant difference in plant height among treatments in 5th, 6th, 7th and 8th months. In the 5th and 6th months, the application of 20:20:20 fertilizer complex, 1.0 per cent at biweekly interval ($N_1C_3W_2$) recorded the highest value for plant height (7.31cm and 7.74 cm, respectively) and it was on par with the higher ratios at 0.5 per cent and 1.0 per cent of other nutrients (20:20:40 and 20:40:40). In the 7th and 8th months, biweekly application of 20:40:40 complex 1.0 per cent ($N_3C_3W_2$) resulted in the highest value for plant height (8.24 cm and 8.73 cm, respectively) and it was on par with the same treatments as in the case of previous months.

Table 1. Effect of nutrients on plant height (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.44	4.79	5.14	5.81	6.22	6.64	6.93	7.41
2	$N_1C_1W_1$	4.50	4.98	5.43	5.81	6.23	6.88	7.26	7.81
3	$N_1C_2W_1$	4.83	5.44	5.95	6.48	6.98	7.59	8.40	9.08
4	$N_1C_2W_2$	4.38	4.94	5.49	6.24	6.99	7.54	8.13	8.81
5	$N_1C_3W_1$	4.49	5.13	5.84	6.53	7.16	7.68	7.60	9.29
6	$N_1C_3W_2$	4.37	4.90	5.66	6.08	6.77	7.25	7.97	8.52
7	$N_2C_1W_1$	4.60	5.13	5.58	6.18	6.71	7.38	7.87	8.31
8	$N_2C_2W_1$	4.55	5.04	5.69	6.31	6.91	7.25	7.55	7.98
9	$N_2C_2W_2$	4.43	4.91	5.40	5.93	6.51	6.83	7.28	7.67
10	$N_2C_3W_1$	4.47	5.00	5.53	6.11	6.62	7.05	7.40	7.95
11	$N_2C_3W_2$	4.58	5.23	5.80	6.16	6.77	7.26	7.89	8.28
12	$N_3C_1W_1$	4.30	4.79	5.30	5.65	6.08	6.69	7.25	7.76
13	$N_3C_2W_1$	4.45	4.85	5.57	6.17	6.96	7.52	8.04	8.43
14	$N_3C_2W_2$	4.30	4.85	5.31	5.84	6.22	6.88	7.43	7.75
15	$N_3C_3W_1$	4.55	5.03	5.60	6.33	6.95	7.48	7.94	8.33
16	$N_3C_3W_2$	4.38	4.98	5.62	6.03	6.69	7.26	8.01	8.43
17	N_0CaM	4.28	4.85	5.29	5.97	6.55	7.08	7.51	7.91
18	N_0MgM	4.40	4.88	5.44	5.83	6.27	6.72	7.15	7.41
19	$N_0Vit.M$	4.45	4.96	5.55	5.93	6.45	7.38	7.80	8.22
CD(0.05)		NS	NS	NS	NS	NS	0.635	NS	0.571

NS - Non significant

Table 2. Effect of nutrients on plant height (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.02	4.38	4.83	5.20	5.58	5.95	6.48	7.03
2	$N_1C_1W_1$	4.30	4.63	5.07	5.44	5.90	6.52	7.02	7.48
3	$N_1C_2W_1$	4.81	5.24	5.71	6.13	6.71	7.10	7.88	8.72
4	$N_1C_2W_2$	4.25	4.68	5.21	6.02	6.49	7.20	7.72	8.35
5	$N_1C_3W_1$	4.62	5.08	5.75	6.45	7.08	7.53	8.01	8.61
6	$N_1C_3W_2$	4.88	5.57	6.08	6.75	7.31	7.74	7.96	8.30
7	$N_2C_1W_1$	4.03	4.48	4.99	5.49	6.05	6.41	6.86	7.35
8	$N_2C_2W_1$	4.73	5.31	5.77	6.30	7.01	7.36	7.76	7.95
9	$N_2C_2W_2$	3.90	4.31	4.81	5.20	5.86	6.34	6.93	7.42
10	$N_2C_3W_1$	4.64	5.05	5.69	6.07	6.56	6.99	7.70	8.19
11	$N_2C_3W_2$	4.12	4.73	5.32	5.85	6.53	7.17	6.60	7.95
12	$N_3C_1W_1$	4.25	4.65	5.00	5.44	5.95	6.62	7.00	7.36
13	$N_3C_2W_1$	4.69	5.11	5.75	6.36	6.90	7.34	7.82	8.26
14	$N_3C_2W_2$	4.27	4.84	5.21	5.64	6.21	6.58	6.94	7.30
15	$N_3C_3W_1$	4.50	5.01	5.58	6.11	6.84	7.52	7.83	8.14
16	$N_3C_3W_2$	5.11	5.57	6.22	6.74	7.15	7.73	8.24	8.73
17	N_0CaM	4.22	4.67	5.30	5.78	6.26	6.68	7.08	7.44
18	N_0MgM	3.87	4.31	4.82	5.26	5.75	6.22	6.57	6.80
19	N_0Vit.M	4.76	5.25	5.99	6.37	6.82	7.37	7.73	8.01
CD(0.05)		NS	NS	NS	NS	NS	0.978	0.911	0.859

NS - Non significant

Control (N_0) recorded the lowest value for plant height during 5th, 6th and 7th months (5.58 cm, 5.95 cm and 6.48 cm, respectively) and it was on par with the lower concentrations (0.25 per cent and 0.5 per cent) of all the nutrients. In the 8th month, the lowest height (6.80 cm) was recorded in the case of application of Mg 0.5 per cent at monthly interval (N_0 MgM) along with control. Application of Ca and Mg did not make any added advantage over control, but application of vit. B_{12} was found to be significantly better than control.

4.1.2 Plant spread - EW

Data pertaining to plant spread (EW) in ground planting, taken at monthly interval are shown in Table 3.

In ground planting, the nutrients made significant difference in plant spread among treatments only in the 6th month, where the application of 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$) resulted in the maximum spread (41.0 cm).This was significantly different from control and the lower concentrations (0.25 per cent) of 20:20:40 and 20:40:40 complexes. Treatment involving the application of 20:40:40 complex 0.5 per cent at biweekly interval ($N_3C_2W_2$) recorded minimum spread (34.11 cm) and it was on par with the control. Application of Ca, Mg and vit. B_{12} along with control produced better results and they were on par with the best treatment.

There were no significant differences in plant spread (EW) among treatments in pot planting during any of the months under observation. All the treatments were on par with each other. The spread, in all the treatments, increased readily upto the 6th month and then started declining slowly. In the 6th month, control (N_0) recorded the maximum spread (44.20 cm) while the least spread was

Table 3. Effect of nutrients on plant spread-EW (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	29.22	32.78	35.00	39.22	36.00	34.56	32.67	29.67
2	$N_1C_1W_1$	21.89	24.89	30.56	31.17	39.22	37.89	32.45	29.33
3	$N_1C_2W_1$	26.00	30.00	31.89	33.67	39.45	39.44	32.67	31.89
4	$N_1C_2W_2$	26.78	30.89	32.44	33.44	41.55	41.00	33.55	29.89
5	$N_1C_3W_1$	24.78	30.22	32.34	34.44	38.55	37.89	36.67	35.00
6	$N_1C_3W_2$	23.44	28.22	29.95	32.67	38.22	37.00	36.00	34.78
7	$N_2C_1W_1$	29.78	31.22	35.11	35.11	40.11	39.00	37.22	34.11
8	$N_2C_2W_1$	23.00	27.50	30.56	32.22	36.78	40.00	33.67	29.33
9	$N_2C_2W_2$	25.56	28.94	31.33	32.67	38.11	35.44	30.11	27.56
10	$N_2C_3W_1$	29.00	32.89	35.44	36.89	40.44	36.89	31.78	32.44
11	$N_2C_3W_2$	27.66	30.11	32.22	32.78	39.89	37.22	34.78	33.67
12	$N_3C_1W_1$	23.78	27.34	30.44	31.89	41.00	40.22	32.00	33.22
13	$N_3C_2W_1$	23.56	25.56	29.89	29.11	38.11	37.44	33.56	30.56
14	$N_3C_2W_2$	25.89	30.89	34.11	33.89	36.89	34.11	28.11	29.11
15	$N_3C_3W_1$	23.11	26.22	29.89	32.78	39.78	40.11	30.22	27.00
16	$N_3C_3W_2$	25.78	29.56	32.11	35.56	40.55	37.89	33.11	30.56
17	N_0CaM	25.34	29.83	33.00	34.89	41.11	39.44	33.44	33.78
18	N_0MgM	28.11	31.44	33.89	34.89	40.44	39.56	28.67	30.00
19	$N_0Vit.M$	25.56	30.89	32.44	34.22	38.89	38.00	34.11	31.78
CD(0.05)		NS	NS	NS	NS	NS	3.945	NS	NS

NS - Non significant

Table 4. Effect of nutrients on plant spread-EW (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	27.78	31.67	33.44	33.78	33.22	44.22	34.00	33.45
2	$N_1C_1W_1$	22.67	28.67	30.33	31.11	32.11	37.56	29.56	27.33
3	$N_1C_2W_1$	24.33	29.00	31.00	34.78	31.00	39.22	31.00	30.56
4	$N_1C_2W_2$	25.67	31.00	32.89	35.67	33.45	36.89	33.00	33.56
5	$N_1C_3W_1$	22.00	26.44	28.89	30.44	32.11	36.78	30.55	31.00
6	$N_1C_3W_2$	20.45	26.33	29.67	31.56	35.32	38.56	31.00	29.00
7	$N_2C_1W_1$	25.56	29.33	29.67	32.67	31.00	37.11	32.22	29.56
8	$N_2C_2W_1$	21.44	27.00	29.44	29.11	32.55	37.56	32.67	29.78
9	$N_2C_2W_2$	21.33	24.44	27.89	30.45	32.11	39.78	30.56	30.33
10	$N_2C_3W_1$	23.11	25.55	27.55	30.89	32.00	35.33	29.11	27.11
11	$N_2C_3W_2$	22.33	26.89	29.00	28.67	30.56	40.33	26.89	28.55
12	$N_3C_1W_1$	26.67	31.00	33.56	33.78	32.56	42.78	31.67	31.11
13	$N_3C_2W_1$	21.00	23.78	27.11	30.11	31.56	40.45	32.22	30.33
14	$N_3C_2W_2$	23.22	26.28	29.00	30.00	32.00	36.33	28.89	30.22
15	$N_3C_3W_1$	25.00	28.78	31.89	33.78	31.11	39.56	22.67	22.78
16	$N_3C_3W_2$	27.44	31.44	32.89	34.78	32.00	36.56	28.33	28.55
17	N_0CaM	21.56	25.78	28.33	30.56	33.33	41.44	28.11	26.67
18	N_0MgM	20.55	25.00	27.45	29.67	31.67	39.44	31.44	27.22
19	N_0Vit.M	23.33	27.78	30.22	32.11	34.11	42.11	32.56	29.33
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

recorded by the treatment involving the application of 20:20:40 fertilizer complex 1.0 per cent at weekly interval ($N_2C_3W_1$). The data are presented in Table 4.

4.1.3 Plant spread - NS

Data pertaining to the spread (NS) of ground plants taken at monthly interval are presented in Table 5.

Analysis of the data revealed that the spread differed significantly among the treatments only in the 5th and 8th month. In the 5th month, the treatment involving the application of 20:20:20 fertilizer complex 0.5 per cent at biweekly interval ($N_1C_2W_2$) recorded the highest value for plant spread (39.53 cm) which was on par with all the treatments except control and the lower concentrations of fertilizers. The lowest value for plant spread (31.33 cm) was recorded by 20:20:20 fertilizer complex 1.0 per cent at weekly interval ($N_1C_3W_1$) which was on par with the control. In the 8th month, maximum spread (37.57 cm) was recorded by 20:20:40 complex 0.5 per cent at biweekly interval ($N_2C_2W_2$) which was on par with the higher concentration of K (20:20:40) but differed significantly from higher concentrations of P (20:40:40) and control. Application of 20:40:40 complex 1.0 per cent at weekly interval ($N_3C_3W_1$) resulted in the lowest value for spread (17.70 cm) which was even inferior to control (27.33 cm). Application of Ca, Mg and vit. B_{12} did not make any added advantage.

In pot planting, the treatments did not make any significant difference in plant spread during any of the months (Table 6). Here, all the treatments were on par. The spread, in all the treatments, increased steadily upto the 6th month and then started declining. In the 6th month, 20:20:20 fertilizer complex 1.0 per cent at weekly interval ($N_1C_3W_1$) recorded the highest value (45.70 cm) for spread (NS) while the lowest value (34.30 cm) was given by the application of 20:20:40

Table 5. Effect of nutrients on plant spread-NS (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	27.77	29.00	31.97	34.90	33.77	37.47	32.87	27.33
2	$N_1C_1W_1$	25.90	28.47	31.20	33.77	37.37	38.57	34.23	31.10
3	$N_1C_2W_1$	26.03	30.20	32.43	33.67	37.10	38.57	34.57	33.90
4	$N_1C_2W_2$	29.77	34.23	36.00	38.57	39.53	39.57	33.00	36.97
5	$N_1C_3W_1$	26.00	30.33	33.67	34.70	31.33	35.90	36.57	33.77
6	$N_1C_3W_2$	27.80	31.77	34.10	36.43	38.90	38.00	31.90	30.10
7	$N_2C_1W_1$	30.63	32.43	34.57	35.67	39.13	38.00	34.23	31.43
8	$N_2C_2W_1$	27.00	29.97	33.67	32.67	36.03	36.90	32.20	29.00
9	$N_2C_2W_2$	27.77	31.87	33.80	35.10	37.80	35.23	35.87	37.57
10	$N_2C_3W_1$	29.43	31.67	34.77	36.90	35.57	38.33	32.47	33.30
11	$N_2C_3W_2$	22.57	25.80	30.90	34.57	32.47	36.23	31.43	28.80
12	$N_3C_1W_1$	27.67	32.57	34.57	33.00	38.77	39.23	32.57	28.47
13	$N_3C_2W_1$	30.67	34.03	35.67	37.43	37.23	39.10	35.53	33.13
14	$N_3C_2W_2$	28.43	32.33	32.43	32.57	32.67	35.23	31.77	31.77
15	$N_3C_3W_1$	27.67	32.00	32.67	32.00	38.57	38.00	26.00	17.70
16	$N_3C_3W_2$	26.20	30.20	32.57	34.67	37.47	37.87	31.33	27.23
17	N_0CaM	23.90	28.67	31.23	34.00	38.53	37.77	28.67	24.57
18	N_0MgM	28.23	33.37	35.10	34.67	38.33	38.23	30.77	28.63
19	N_0Vit.M	21.87	26.43	28.90	31.00	35.77	36.77	30.00	29.23
CD(0.05)		NS	NS	NS	NS	4.905	NS	NS	8.983

NS - Non significant

Table 6. Effect of nutrients on plant spread-NS (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	25.30	28.77	31.00	33.10	34.67	38.90	31.43	25.57
2	$N_1C_1W_1$	21.77	24.43	26.67	29.43	30.00	39.67	34.33	31.00
3	$N_1C_2W_1$	21.77	25.43	29.10	32.33	33.23	40.57	31.67	30.03
4	$N_1C_2W_2$	21.47	25.73	27.90	30.33	32.10	37.13	29.00	28.00
5	$N_1C_3W_1$	23.00	26.23	28.33	30.47	33.00	45.67	28.77	27.77
6	$N_1C_3W_2$	23.20	28.90	31.43	31.67	33.57	35.87	31.30	28.43
7	$N_2C_1W_1$	26.43	30.80	33.23	35.23	35.33	37.33	29.87	26.67
8	$N_2C_2W_1$	22.43	25.33	28.67	30.77	31.23	37.10	27.77	26.90
9	$N_2C_2W_2$	23.43	26.57	28.43	29.90	31.23	37.00	29.70	29.10
10	$N_2C_3W_1$	26.47	30.57	31.47	29.77	30.57	34.33	28.10	23.77
11	$N_2C_3W_2$	21.67	25.57	28.57	28.80	30.43	39.90	30.10	29.23
12	$N_3C_1W_1$	23.53	28.57	29.53	31.00	31.80	40.67	31.33	29.67
13	$N_3C_2W_1$	20.00	25.80	27.57	29.47	30.00	39.67	27.80	25.77
14	$N_3C_2W_2$	22.00	26.00	28.77	30.90	33.20	38.00	31.33	31.00
15	$N_3C_3W_1$	23.10	25.43	29.53	32.23	32.43	41.00	28.23	23.20
16	$N_3C_3W_2$	25.43	29.33	31.87	34.50	35.90	39.77	29.53	29.57
17	N_0CaM	23.00	28.43	30.90	31.57	31.33	41.23	28.87	30.03
18	N_0MgM	21.47	25.77	29.10	32.23	33.77	39.77	29.70	31.23
19	N_0Vit.M	21.33	25.33	27.10	28.33	30.67	41.20	34.10	28.67
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

complex 1.0 per cent at weekly interval ($N_2C_3W_1$). Application of Ca, Mg or vit. B_{12} did not make any significant difference in plant spread.

4.1.4 Number of leaves/plant

Data on the effect of nutrients on the number of leaves/plant in ground planting are presented in Table 7. The data show that there is no significant difference among the treatments with respect to the number of leaves/plant during the period of experiment. The highest values for all the treatments were recorded in the 5th month. Among them, the treatment involving the application of 20:20:20 fertilizer complex 0.5 per cent at weekly interval ($N_1C_2W_1$) recorded the maximum number of leaves/plant (6.9). Application of 20:40:40 complex 0.25 per cent at weekly interval ($N_3C_1W_1$) recorded the minimum value (5.3).

The data pertaining to the number of leaves/plant in pot planting show that the nutrients had significant effect on the number of leaves/plant only in the 5th month (Table 8). During the rest of the period, all the treatments were on par. In the 5th month, the plants in the treatment involving the application of 20:20:20 fertilizer complex 0.25 per cent at weekly interval ($N_1C_1W_1$) recorded the maximum number of leaves/plant (7.0) which was on par with the application of 0.5 per cent of the other nutrients (20:20:40 and 20:40:40) at weekly interval or 1.0 per cent at biweekly interval. Additional application of Ca, Mg or vitamins did not increase the number of leaves. The treatment involving the application of 20:20:40 complex 1.0 per cent at weekly interval ($N_2C_3W_1$) recorded the lowest value (4.22) which was found to be inferior to all the other treatments including control.

4.1.5 Leaf length

Statistical analysis of the data presented in Table9 showed that, in ground planting, there was no significant difference in leaf length among the treatments during the experimental period . The highest value, for all the treatments, was

Table 7. Effect of nutrients on number of leaves per plant of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.67	4.90	5.43	5.67	5.90	5.67	5.00	4.00
2	$N_1C_1W_1$	4.80	5.33	5.67	5.67	5.67	5.00	5.10	4.67
3	$N_1C_2W_1$	5.80	6.43	6.90	6.90	6.87	6.77	6.57	5.80
4	$N_1C_2W_2$	5.23	6.00	6.33	6.80	6.67	6.33	5.67	4.47
5	$N_1C_3W_1$	5.10	5.67	6.10	6.23	6.53	5.43	5.57	4.77
6	$N_1C_3W_2$	5.67	5.90	6.43	6.33	6.47	6.10	6.47	6.13
7	$N_2C_1W_1$	4.57	5.00	5.67	5.77	5.43	5.30	5.47	4.80
8	$N_2C_2W_1$	4.10	4.67	5.10	5.47	5.10	4.90	5.10	4.13
9	$N_2C_2W_2$	5.20	5.80	6.20	6.43	6.53	6.57	6.57	5.67
10	$N_2C_3W_1$	4.77	4.90	5.77	5.43	5.57	4.87	4.77	4.10
11	$N_2C_3W_2$	4.90	5.33	5.70	5.57	5.80	5.33	5.23	4.47
12	$N_3C_1W_1$	4.20	4.80	5.20	5.33	5.80	5.23	4.90	4.37
13	$N_3C_2W_1$	4.67	5.53	5.67	5.67	5.90	5.57	5.10	4.67
14	$N_3C_2W_2$	4.33	4.87	5.20	5.43	5.80	5.00	4.77	4.23
15	$N_3C_3W_1$	4.57	5.00	5.57	5.57	5.67	4.67	4.00	2.77
16	$N_3C_3W_2$	4.80	5.43	5.80	5.77	6.20	5.80	5.00	4.77
17	N_0CaM	4.90	5.57	5.90	6.10	5.57	5.20	5.20	4.33
18	N_0MgM	4.57	5.10	5.80	6.00	6.10	5.47	5.90	5.00
19	$N_0Vit.M$	4.57	5.20	5.67	5.67	5.67	5.10	5.10	4.47
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 8. Effect of nutrients on number of leaves per plant of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.33	4.80	5.33	5.67	6.00	5.33	5.23	4.57
2	$N_1C_1W_1$	5.00	5.53	6.00	6.67	7.00	6.80	6.57	5.43
3	$N_1C_2W_1$	4.90	5.43	5.90	6.53	6.57	5.77	6.10	5.23
4	$N_1C_2W_2$	4.57	5.10	5.43	6.10	6.10	5.77	6.43	6.00
5	$N_1C_3W_1$	4.90	5.53	5.90	6.67	6.77	5.87	5.67	5.37
6	$N_1C_3W_2$	4.77	5.67	5.90	6.43	6.33	6.67	5.47	6.33
7	$N_2C_1W_1$	4.80	5.33	5.87	6.10	5.80	5.67	5.77	4.77
8	$N_2C_2W_1$	4.67	5.13	5.67	5.90	5.90	5.67	6.00	5.20
9	$N_2C_2W_2$	4.23	4.77	5.23	6.00	6.10	6.10	5.57	5.00
10	$N_2C_3W_1$	4.13	4.57	5.00	5.13	4.23	4.53	4.33	3.67
11	$N_2C_3W_2$	4.77	5.33	5.77	6.23	5.77	5.77	5.57	4.67
12	$N_3C_1W_1$	4.43	4.90	5.43	5.90	5.63	5.30	5.20	4.67
13	$N_3C_2W_1$	4.57	5.10	5.57	5.90	6.10	5.53	5.67	4.87
14	$N_3C_2W_2$	4.33	4.97	5.57	5.90	6.23	6.33	6.00	5.10
15	$N_3C_3W_1$	5.10	5.67	6.10	6.80	5.33	5.67	4.67	4.00
16	$N_3C_3W_2$	4.67	5.30	5.80	6.00	5.90	5.33	4.77	4.43
17	N_0CaM	4.67	5.23	5.67	6.10	6.00	4.53	5.33	4.53
18	N_0MgM	4.87	5.33	5.87	6.33	6.10	5.30	5.77	5.23
19	N_0Vit.M	4.33	4.90	5.23	5.33	5.90	5.67	5.43	4.43
CD(0.05)		NS	NS	NS	NS	1.022	NS	NS	NS

NS - Non significant

Table 9. Effect of nutrients on leaf length (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	8.61	10.28	11.72	13.33	15.11	14.33	13.66	13.44
2	$N_1C_1W_1$	7.78	9.00	10.78	12.67	14.56	13.22	13.11	12.67
3	$N_1C_2W_1$	8.11	9.66	11.56	12.78	13.66	14.78	13.33	13.55
4	$N_1C_2W_2$	8.11	9.89	12.00	13.45	14.67	14.67	13.22	12.55
5	$N_1C_3W_1$	9.55	11.55	13.67	15.00	16.44	14.00	13.89	13.22
6	$N_1C_3W_2$	9.22	10.78	12.22	13.00	14.11	14.34	12.78	12.78
7	$N_2C_1W_1$	9.67	10.95	12.00	13.56	14.66	14.45	14.22	15.00
8	$N_2C_2W_1$	11.11	12.78	14.56	16.22	17.22	15.67	13.44	13.33
9	$N_2C_2W_2$	10.11	11.56	13.11	14.00	15.44	14.56	14.22	14.44
10	$N_2C_3W_1$	10.55	12.33	14.00	14.89	16.33	15.78	13.89	13.67
11	$N_2C_3W_2$	8.67	10.22	12.33	13.45	14.89	15.44	13.45	13.34
12	$N_3C_1W_1$	9.67	11.44	13.22	14.44	15.56	14.33	13.00	12.67
13	$N_3C_2W_1$	8.78	10.00	11.45	12.66	13.66	15.44	13.00	13.33
14	$N_3C_2W_2$	9.55	10.67	12.34	14.55	15.33	14.78	13.56	12.67
15	$N_3C_3W_1$	9.67	11.67	12.89	14.11	14.78	14.22	12.11	12.11
16	$N_3C_3W_2$	11.33	13.11	15.22	16.67	17.78	14.56	12.44	12.89
17	N_0CaM	8.56	10.11	11.78	13.67	15.11	14.78	12.11	12.78
18	N_0MgM	10.22	12.11	14.22	15.00	16.11	15.33	13.33	13.11
19	$N_0Vit.M$	9.66	11.33	12.55	13.78	15.11	14.89	13.66	13.44
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 10. Effect of nutrients on leaf length (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	7.17	8.22	9.84	11.11	12.33	15.78	13.78	13.89
2	$N_1C_1W_1$	6.55	7.89	8.78	10.67	11.78	13.45	13.33	13.50
3	$N_1C_2W_1$	7.22	8.67	9.22	10.89	12.00	14.11	13.11	13.78
4	$N_1C_2W_2$	7.11	8.11	9.66	10.33	11.33	14.00	12.56	12.78
5	$N_1C_3W_1$	7.56	8.56	9.45	10.22	11.33	13.33	12.45	12.33
6	$N_1C_3W_2$	7.33	9.11	10.44	11.00	11.78	14.22	12.78	12.56
7	$N_2C_1W_1$	7.56	8.56	10.11	10.78	11.55	13.00	12.22	11.78
8	$N_2C_2W_1$	7.56	8.33	9.67	10.55	11.33	14.33	12.56	12.89
9	$N_2C_2W_2$	6.89	8.22	9.56	10.11	11.00	12.67	12.22	12.28
10	$N_2C_3W_1$	7.56	8.78	9.67	10.66	11.78	14.11	11.89	12.55
11	$N_2C_3W_2$	6.89	7.89	8.45	9.22	10.33	12.89	11.67	12.34
12	$N_3C_1W_1$	8.22	9.23	10.11	11.44	12.56	15.44	13.00	13.17
13	$N_3C_2W_1$	7.33	9.00	9.78	10.56	11.33	13.33	11.44	11.17
14	$N_3C_2W_2$	7.11	8.55	9.55	10.56	11.45	13.89	12.44	12.50
15	$N_3C_3W_1$	7.22	8.00	9.78	10.11	11.11	12.89	12.00	10.67
16	$N_3C_3W_2$	7.67	9.22	10.11	11.11	12.11	14.22	12.22	12.78
17	N_0CaM	6.67	7.67	9.00	10.00	11.56	11.55	11.00	11.00
18	N_0MgM	7.56	8.33	9.55	10.44	11.22	14.44	12.00	13.33
19	N_0Vit.M	7.89	8.78	10.00	10.78	11.89	15.00	12.67	13.00
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

recorded in the 5th month. The application of fertilizer complex 20:40:40 1.0 per cent at biweekly interval ($N_3C_3W_2$) had the highest leaf length (17.78 cm) and the lowest value (13.66 cm) was recorded in the treatment involving 20:20:20 complex 0.5 per cent at weekly interval ($N_1C_2W_1$) and 20:40:40 complex 0.5 per cent at weekly interval ($N_3C_2W_1$).

Table 10 gives the data on the effect of nutrients on leaf length in pot planting. The data revealed that there was no significant difference in leaf length among the treatments. The leaf length increased steadily upto the 6th month and then started declining slowly. In the 6th month, control (17:17:17 complex 1.0 per cent at weekly interval) produced the longest leaves (15.80 cm) while the plants applied with `Ca' 0.5 per cent at monthly interval (N_0CaM) along with control had the minimum (11.60 cm) leaf length.

4.1.6 Leaf breadth

In ground planting, nutrients had no significant effect on leaf breadth during the experimental period (Table 11). Maximum leaf breadth was recorded in the 5th month for all the treatments. Application of 20:40:40 complex 1.0 per cent at biweekly interval ($N_3C_3W_2$) recorded highest leaf breadth (11.00 cm) and the lowest breadth (9.56 cm) was for the treatment involving the application of 20:20:20 complex 1.0 per cent at biweekly interval ($N_1C_3W_2$).

In pot planting also, all the treatments were on par. Maximum leaf breadth was in the 6th month, where the application of 20:20:20 complex 1.0 per cent at biweekly interval ($N_1C_3W_2$) resulted in the highest leaf breadth (11.22 cm) and application of `Ca' 0.5 per cent at monthly interval (N_0CaM) along with control resulted in the lowest leaf breadth (8.89 cm) (Table 12).

Table 11. Effect of nutrients on leaf breadth (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	6.44	7.33	8.00	9.00	10.00	9.89	10.00	9.72
2	$N_1C_1W_1$	6.45	7.33	8.33	9.11	9.89	9.78	9.55	9.00
3	$N_1C_2W_1$	6.78	7.33	8.67	9.33	10.11	9.89	9.67	9.44
4	$N_1C_2W_2$	6.56	7.44	8.78	9.56	10.56	10.00	9.67	9.44
5	$N_1C_3W_1$	7.11	7.78	8.44	9.00	10.00	10.00	10.00	9.89
6	$N_1C_3W_2$	6.44	7.33	8.44	9.11	9.56	9.89	3.44	9.11
7	$N_2C_1W_1$	7.11	8.00	8.89	9.44	10.11	10.33	10.56	10.50
8	$N_2C_2W_1$	7.78	8.33	9.56	10.11	10.56	10.11	9.67	9.45
9	$N_2C_2W_2$	7.33	8.56	9.22	9.67	10.22	10.00	10.11	10.17
10	$N_2C_3W_1$	6.89	7.66	9.22	9.22	10.11	10.78	9.89	9.67
11	$N_2C_3W_2$	6.56	7.55	8.78	9.22	10.11	9.56	9.45	9.72
12	$N_3C_1W_1$	6.89	7.45	8.22	9.11	10.00	9.78	9.00	8.94
13	$N_3C_2W_1$	6.44	7.00	8.11	9.22	10.11	10.22	9.67	9.46
14	$N_3C_2W_2$	7.67	8.45	9.00	10.11	10.66	10.00	9.67	9.61
15	$N_3C_3W_1$	5.89	6.56	7.89	9.11	10.33	10.00	9.22	8.67
16	$N_3C_3W_2$	7.56	8.00	9.00	9.78	11.00	10.22	9.33	9.29
17	N_0CaM	6.55	7.44	8.11	9.22	10.45	9.89	8.67	9.00
18	N_0MgM	7.11	8.00	8.78	9.44	10.55	10.33	9.33	9.78
19	N_0Vit.M	7.56	8.00	8.89	9.44	10.22	10.22	9.78	9.56
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 12. Effect of nutrients on leaf breadth (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	5.67	6.66	7.50	8.06	8.67	11.00	9.67	9.89
2	$N_1C_1W_1$	5.11	6.11	6.78	8.33	9.11	10.11	9.67	9.83
3	$N_1C_2W_1$	5.89	7.00	7.67	8.22	8.66	10.00	10.33	10.50
4	$N_1C_2W_2$	5.22	5.67	6.44	7.11	7.67	9.67	9.44	9.55
5	$N_1C_3W_1$	5.22	5.78	6.78	7.22	7.56	10.11	9.22	9.11
6	$N_1C_3W_2$	5.89	6.56	7.55	8.00	8.33	11.22	9.44	9.55
7	$N_2C_1W_1$	5.67	6.45	7.45	8.11	8.89	9.78	9.22	8.94
8	$N_2C_2W_1$	5.33	6.33	7.55	8.22	8.55	10.33	9.11	9.00
9	$N_2C_2W_2$	5.44	6.11	7.11	8.00	8.34	9.55	8.78	9.06
10	$N_2C_3W_1$	5.66	6.67	7.78	8.11	8.44	9.78	8.67	9.11
11	$N_2C_3W_2$	4.78	5.67	6.45	7.22	7.78	9.55	8.55	9.00
12	$N_3C_1W_1$	5.78	6.78	7.55	8.11	8.67	11.00	9.56	9.29
13	$N_3C_2W_1$	5.44	6.78	7.56	8.00	8.56	9.67	9.00	8.78
14	$N_3C_2W_2$	5.45	5.89	6.78	7.56	8.22	9.67	9.11	9.17
15	$N_3C_3W_1$	5.44	6.11	7.22	7.56	8.00	9.22	8.78	8.56
16	$N_3C_3W_2$	5.78	6.44	7.00	7.89	8.38	10.44	9.00	9.34
17	N_0CaM	5.00	5.56	7.11	7.78	8.67	8.89	8.45	8.22
18	N_0MgM	5.22	5.89	7.11	7.56	8.11	10.00	9.44	9.22
19	$N_0Vit.M$	5.48	6.55	7.33	7.67	8.56	10.67	9.00	9.56
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

4.1.7 Leaf area

The data relating to leaf area in ground planting are presented in Table 13 which reveal that the leaf area do not differ significantly among treatments. The leaf area, in all the treatments increased readily upto the 5th month and then showed a slow decline. In the 5th month, application of 20:40:40 complex 1.0 per cent at biweekly interval ($N_3C_3W_2$) recorded the highest leaf area (141.37 cm^2) and that of 20:40:40 complex 0.5 per cent at weekly interval ($N_3C_2W_1$) caused the lowest leaf area (99.78 cm^2). Application of Ca, Mg or vitamin did not produce any added advantage over control.

In pots also, there were no significant differences in leaf area among the treatments (Table 14). The maximum leaf area, for all the treatments, was recorded in the 6th month, where control (N_0) recorded the highest value (126.40 cm^2) and minimum area was recorded by control + 'Ca' 0.5 per cent at monthly interval (N_0CaM). Application of Mg or vitamin B_{12} did not make any significant effect.

4.1.8 Days to flower

Table 15 gives data on the number of days taken for the first flower to appear in ground plants. It varied from 5 days in the case of plants receiving 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$), to 136.00 days in the case of the treatment involving the application of 20:40:40 complex 0.5 per cent at biweekly interval ($N_3C_2W_2$).

In pot planting, the range was from 31.33 days in the case of control (N_0) and 20:20:20 complex 0.5 per cent at weekly interval ($N_1C_2W_1$) to 154.67 days in the case of 20:40:40 complex 0.5 per cent at weekly interval i.e., $N_3C_2W_1$(Table 16).

Table 13. Effect of nutrients on leaf area (cm^2) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	40.92	56.55	70.03	87.87	109.60	101.98	98.38	94.09
2	$N_1C_1W_1$	36.22	47.50	64.76	83.73	104.66	93.20	90.98	82.56
3	$N_1C_2W_1$	40.70	52.70	72.67	86.50	100.10	105.44	93.17	92.77
4	$N_1C_2W_2$	41.45	56.85	79.87	94.43	113.22	106.62	92.44	96.30
5	$N_1C_3W_1$	48.78	64.19	82.86	96.83	117.64	101.12	100.52	95.22
6	$N_1C_3W_2$	43.74	58.18	74.62	85.33	97.57	104.26	87.74	85.06
7	$N_2C_1W_1$	50.31	63.93	77.82	93.06	107.55	108.23	110.05	114.65
8	$N_2C_2W_1$	62.60	76.65	100.39	118.21	131.09	115.54	96.08	93.03
9	$N_2C_2W_2$	53.14	71.35	87.01	97.23	113.50	105.39	103.62	105.71
10	$N_2C_3W_1$	52.80	68.45	83.27	99.72	119.68	122.70	99.08	95.12
11	$N_2C_3W_2$	41.98	56.55	78.98	89.84	108.32	106.27	92.55	94.30
12	$N_3C_1W_1$	47.91	61.05	78.15	94.60	112.11	101.07	84.37	82.03
13	$N_3C_2W_1$	40.79	50.64	66.38	83.93	99.78	113.82	90.67	90.92
14	$N_3C_2W_2$	54.77	67.32	82.71	107.90	119.40	107.11	96.03	88.53
15	$N_3C_3W_1$	41.53	56.03	74.26	93.34	110.23	102.28	80.72	76.65
16	$N_3C_3W_2$	61.61	75.48	98.61	117.82	141.37	108.20	84.58	89.12
17	N_0CaM	40.98	55.18	70.04	92.22	115.43	105.55	76.21	83.29
18	N_0MgM	52.06	69.67	89.56	101.62	121.99	115.74	90.48	92.70
19	N_0Vit.M	54.29	66.34	81.35	94.48	111.58	109.46	96.31	93.07
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 14. Effect of nutrients on leaf area (cm^2) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	29.26	29.62	53.92	65.63	77.23	126.40	95.38	99.36
2	$N_1C_1W_1$	24.14	34.75	42.86	63.98	77.16	97.90	93.36	96.02
3	$N_1C_2W_1$	34.03	44.24	51.45	64.69	75.15	102.08	97.80	104.46
4	$N_1C_2W_2$	26.69	33.11	44.96	53.01	62.64	57.47	85.33	87.73
5	$N_1C_3W_1$	28.41	35.62	46.01	53.13	61.71	97.14	82.82	81.30
6	$N_1C_3W_2$	30.93	42.82	57.04	63.46	70.74	116.63	86.88	86.44
7	$N_2C_1W_1$	31.20	39.99	54.28	63.10	74.37	92.02	81.19	76.04
8	$N_2C_2W_1$	28.64	37.91	52.57	62.56	69.90	106.62	82.34	83.61
9	$N_2C_2W_2$	27.44	36.22	48.90	58.24	65.95	87.29	77.28	80.20
10	$N_2C_3W_1$	31.72	43.06	55.10	63.46	72.81	101.19	75.62	83.44
11	$N_2C_3W_2$	23.67	31.95	39.33	48.00	58.26	90.20	71.90	79.94
12	$N_3C_1W_1$	34.56	45.27	55.14	66.92	78.73	123.38	89.67	88.34
13	$N_3C_2W_1$	28.69	43.81	51.01	61.06	69.85	92.83	74.79	71.31
14	$N_3C_2W_2$	28.25	36.29	46.70	57.64	67.81	96.71	86.37	92.00
15	$N_3C_3W_1$	30.08	36.60	48.25	55.95	64.63	87.92	76.50	66.49
16	$N_3C_3W_2$	32.22	43.09	51.19	63.39	72.85	109.39	80.30	87.83
17	N_0CaM	24.05	30.75	46.39	56.07	72.14	73.99	67.22	65.40
18	N_0MgM	28.60	35.45	48.99	57.18	66.00	104.10	82.10	88.59
19	$N_0Vit.M$	31.00	41.58	52.94	59.59	73.72	115.60	82.21	89.50
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

4.1.9 Number of flowers/plant

The effect of nutrients on the number of flowers/plant in ground plants is evident from Table 15. All the treatments were on par. The highest value of 2.11 was recorded by the application of 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) and the lowest value of 0.55 was recorded by 20:40:40 complex 1.0 per cent at weekly interval ($N_3C_3W_1$).

In pot plants also, all the treatments were on par (Table 16). The maximum number of flowers/plant (1.55) was recorded in control (N_0), and 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$) had the minimum number of flowers/plant (0.44). Application of 20:20:20 complex 1.0 per cent at biweekly interval ($N_1C_3W_2$) and 20:20:40 0.25 per cent at weekly interval ($N_2C_1W_1$) also had the same number (0.44) of flowers/plant. Application of Ca, Mg and vitamins along with control had lower values than control.

4.1.10 Interval of flower production

In ground planting as well as pot planting, there were no significant differences in the interval of flower production among treatments. In ground planting, it ranged from 21.58 days in 20:20:20 complex 1.0 per cent at weekly interval ($N_1C_3W_1$) to 35.72 days in 20:20:20 complex 0.5 per cent at biweekly interval i.e., $N_1C_2W_2$(Table 15). In pot planting, the range was from 30.50 days in 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) to 39.00 days in 20:20:40 complex 0.5 per cent at biweekly interval i.e., $N_2C_2W_2$ (Table 16).

4.1.11 Stalk length

Stalk length did not differ significantly among treatments in ground. Application of 20:40:40 fertilizer complex 0.5 per cent at biweekly interval ($N_3C_2W_2$) had the longest stalk (24.67 cm) while the shortest stalk (10.67 cm) was

Plate 3. A general view of ground planting at the end of the period of experiment

Plate 4. A general view of pot planting at the end of the period of experiment

recorded for the treatment involving the application of 20:20:40 complex 0.5 per cent at weekly interval i.e., $N_2C_1W_1$ (Table 15).

Table 16 gives an account of the effect of nutrients on stalk length in pot where, the nutrients significantly influenced the stalk length of flowers. Here also, 20:40:40 complex 0.5 per cent at biweekly interval ($N_3C_2W_2$) produced the longest stalk (26.06 cm) while 20:20:20 complex 1.0 per cent at biweekly interval ($N_1C_3W_2$) produced the shortest stalk (11.67 cm).

4.1.12 Spathe size and spadix length

There is no significant difference among treatments in spathe size or spadix length either in ground or pot. In ground, application of Mg 0.5 per cent at monthly interval (N_0MgM) along with control (N_0) resulted in the longest spathe (9.50 cm) and 20:20:40 complex 0.5 per cent at weekly interval ($N_2C_2W_1$) resulted in the lowest spathe size (4.93 cm). In the case of spadix length, highest value (3.17 cm) was for 20:20:20 complex 1.0 per cent at weekly interval ($N_1C_3W_1$) and the lowest value (1.83 cm) was for 20:40:40 complex 1.0 per cent at weekly interval, i.e., $N_3C_3W_1$ (Table 15).

In pot, the highest spathe size (9.33 cm) was for 20:20:40 complex 0.5 per cent at weekly interval ($N_2C_2W_1$) and the lowest value (2.67 cm) was for 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$). With regard to spadix length, a maximum value of 2.93 cm was recorded for 20:20:20 complex 0.25 per cent at weekly interval($N_1C_1W_1$) and a minimum value of 0.77 cm for 20:20:20 complex 0.5 per cent at biweekly interval,i.e., $N_1C_2W_2$ (Table 16).

Table 15. Effect of nutrients on flowering and flower characters of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl. No.	Treatments	Days to flower	No. of flowers per plant	Interval of flower production (days)	Stalk length (cm)	Spathe length (cm)	Spadix length (cm)
1	No	67.00	1.00	25.17	20.33	8.83	3.00
2	$N_1C_1W_1$	111.33	0.89	24.50	22.33	9.00	3.06
3	$N_1C_2W_1$	23.67	1.89	23.00	21.64	8.25	3.00
4	$N_1C_2W_2$	44.33	1.22	35.72	20.83	8.25	3.05
5	$N_1C_3W_1$	60.00	1.33	21.58	19.39	7.78	3.17
6	$N_1C_3W_2$	19.62	1.55	23.22	15.42	6.50	2.08
7	$N_2C_1W_1$	5.00	2.11	34.78	20.33	7.33	2.72
8	$N_2C_2W_1$	66.00	0.89	34.00	10.67	4.98	1.93
9	$N_2C_2W_2$	76.33	1.33	35.22	22.17	8.83	2.83
10	$N_2C_3W_1$	14.83	1.56	34.11	18.83	8.83	2.63
11	$N_2C_3W_2$	63.67	1.22	22.67	18.00	7.58	2.55
12	$N_3C_1W_1$	58.00	1.89	33.78	18.00	6.11	2.43
13	$N_3C_2W_1$	105.67	0.89	22.33	17.00	8.67	2.68
14	$N_3C_2W_2$	136.00	1.00	24.33	24.67	8.50	2.87
15	$N_3C_3W_1$	70.00	0.55	32.00	14.33	6.22	1.83
16	$N_3C_3W_2$	19.67	0.56	0.00	13.83	6.08	1.92
17	N_0CaM	38.67	2.00	33.78	19.00	7.33	2.51
18	N_0MgM	128.33	0.67	35.00	21.17	9.50	3.02
19	$N_0Vit.M$	113.33	0.67	35.00	22.67	9.33	2.91
CD(0.05)		NS	NS	NS	NS	NS	NS

NS - Non significant

Table 16. Effect of nutrients on flowering and flower characters of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl. No.	Treatments	Days to flower	No. of flowers per plant	Interval of flower production (days)	Stalk length (cm)	Spathe length (cm)	Spadix length (cm)
1	No	33.33	1.55	37.00	18.75	9.00	2.92
2	$N_1C_1W_1$	111.33	1.00	35.00	20.06	6.72	2.93
3	$N_1C_2W_1$	31.33	1.33	36.75	19.58	7.19	2.66
4	$N_1C_2W_2$	50.00	0.44	0.00	16.00	2.67	0.77
5	$N_1C_3W_1$	49.67	1.00	33.00	17.67	6.89	2.61
6	$N_1C_3W_2$	96.00	0.44	35.67	11.67	4.33	1.67
7	$N_2C_1W_1$	86.00	0.44	30.50	13.17	4.17	1.73
8	$N_2C_2W_1$	90.00	1.00	36.50	14.33	9.33	2.66
9	$N_2C_2W_2$	128.00	0.89	39.00	20.00	6.83	2.73
10	$N_2C_3W_1$	153.67	0.66	35.33	12.33	5.00	1.77
11	$N_2C_3W_2$	88.33	0.56	36.00	12.33	5.00	1.43
12	$N_3C_1W_1$	69.33	1.22	36.33	19.75	8.00	2.85
13	$N_3C_2W_1$	154.67	0.44	36.00	17.33	6.17	2.00
14	$N_3C_2W_2$	124.00	1.33	35.50	26.06	7.33	2.87
15	$N_3C_3W_1$	45.67	0.67	0.00	24.00	5.33	1.53
16	$N_3C_3W_2$	112.00	0.67	35.00	16.67	7.50	2.30
17	N_0CaM	41.33	1.11	35.00	17.17	6.33	1.88
18	N_0MgM	79.33	0.67	0.00	16.00	6.50	2.18
19	$N_0Vit.M$	45.00	1.11	0.00	18.00	3.00	0.83
CD(0.05)		NS	NS	NS	10.11	NS	NS

NS - Non significant

4.1.13 Interval of leaf production

In ground, the interval of leaf production did not vary significantly among treatments. The details are given in Table 17. Here, the minimum number of days (33.41) was taken by 20:20:20 complex 0.5 per cent at weekly interval ($N_1C_2W_1$) and the highest number of days (37.67), by 20:40:40 complex 1.0 per cent at biweekly interval ($N_3C_3W_2$).

In pot also, all the treatments were on par. The lowest interval (34.11 days) was for 20:20:20 complex 1.0 per cent at weekly interval ($N_1C_3W_1$) and highest interval (37.94 days) was for 20:40:40 complex 1.0 per cent at biweekly interval i.e., $N_3C_3W_2$ (Table 18).

4.1.14 Number of suckers/plant

Data furnished in Table 17 relate to the effect of nutrients on the number of suckers/plant in ground planting. Statistical analysis of the data revealed that nutrients had little effect on the number of suckers/plant and that all the nutrients were on par. No suckers were produced in a large number of treatments including control, 20:20:20 complex 0.25 per cent and 0.5 per cent at weekly interval, higher concentrations (0.5 per cent and 1.0 per cent) of 20:20:40 and 20:40:40 complexes.

In pot planting also, nutrients failed to make any significant effect on the number of suckers/plant (Table 18). Here the maximum number of suckers/plant (0.33) were produced by the plants receiving 20:20:20 complex 1.0 per cent at weekly interval ($N_1C_3W_1$). Control, higher levels of 20:20:40 complex as well as lower levels (0.25 per cent and 0.5 per cent) of 20:40:40 complex failed to produce any suckers.

Table 17. Effect of nutrients on number of suckers per plant and interval of leaf production of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl. No.	Treatment	Month								Interval of leaf production (days)
		1	2	3	4	5	6	7	8	
1	No	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.78
2	$N_1C_1W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.03
3	$N_1C_2W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.41
4	$N_1C_2W_2$	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	34.07
5	$N_1C_3W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.61
6	$N_1C_3W_2$	0.00	0.00	0.11	0.11	0.11	0.11	0.22	0.22	35.59
7	$N_2C_1W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	35.72
8	$N_2C_2W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.44
9	$N_2C_2W_2$	0.00	0.11	0.11	0.11	0.11	0.11	0.22	0.22	34.76
10	$N_2C_3W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.00
11	$N_2C_3W_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.38
12	$N_3C_1W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.68
13	$N_3C_2W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.44
14	$N_3C_2W_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.00
15	$N_3C_3W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.67
16	$N_3C_3W_2$	0.00	0.00	0.00	0.11	0.11	0.11	0.11	0.11	36.67
17	N_0CaM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	34.83
18	N_0MgM	0.00	0.11	0.11	0.11	0.11	0.11	0.22	0.22	35.17
19	$N_0Vit.M$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.82
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 18. Effect of nutrients on number of suckers per plant and interval of leaf production of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl. No.	Treatment	Month								Interval of leaf production (days)
		1	2	3	4	5	6	7	8	
1	No	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.75
2	$N_1C_1W_1$	0.11	0.11	0.22	0.22	0.22	0.22	0.22	0.22	35.45
3	$N_1C_2W_1$	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	34.78
4	$N_1C_2W_2$	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	35.67
5	$N_1C_3W_1$	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	34.11
6	$N_1C_3W_2$	0.00	0.22	0.22	0.22	0.22	0.22	0.22	0.22	36.41
7	$N_2C_1W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.67
8	$N_2C_2W_1$	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	35.82
9	$N_2C_2W_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.05
10	$N_2C_3W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.47
11	$N_2C_3W_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	37.49
12	$N_3C_1W_1$	0.00	0.00	0. 00	0.00	0.00	0.00	0.11	0.11	36.83
13	$N_3C_2W_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.67
14	$N_3C_2W_2$	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	35.67
15	$N_3C_3W_1$	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	37.77
16	$N_3C_3W_2$	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	37.54
17	N_0CaM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.77
18	N_0MgM	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	36.06
19	$N_0Vit.M$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.67
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

4.1.15 Leaf nutrient content

In ground planting, the treatments differed significantly with regard to the N, P and K content of leaves (Table 19 and Fig.1,2 and 3). Among the treatments, maximum value for N content (2.23 per cent) was recorded for the application of 20:20:20 complex 1.0 per cent at weekly interval ($N_1C_3W_1$) and minimum value (0.60 per cent) was for the application of vitamin B_{12} 100 ppm at monthly interval (N_0Vit.M) along with control. In the case of P content, the maximum value (0.77 per cent) was for the application of 20:40:40 complex 1.0 per cent at weekly interval ($N_3C_3W_1$) which was significantly better than all the other treatments. The minimum value (0.33 per cent) was recorded for the application of 20:20:20 complex 0.5 per cent at weekly interval ($N_1C_2W_1$) which was on par with the lower level (0.5 per cent) of 20:20:40 and 20:40:40 complex. Application of Ca, Mg or vitamin B_{12} also did not make any significant effect. Regarding K, the maximum value (1.80 per cent) was recorded for the application of 20:40:40 complex 1.0 per cent at weekly interval($N_3C_3W_1$) which was on par with all the other treatments except 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) which recorded the minimum value (1.29 per cent).

Table 20 and Fig.1,2 and 3 depict the effect of the nutrients on the NPK content of leaves in pot planting. There is significant difference among treatments with respect to the content of N, but with respect to the content of P and K, all the treatments were on par. The highest value for N content (3.38 per cent) was recorded for the treatment involving the application of 20:20:20 fertilizer compex 0.25 per cent at weekly interval ($N_1C_1W_1$) and the lowest value (1.18 per cent) was for the treatment involving the application of 20:20:20 complex 1.0 per cent at biweekly interval ($N_1C_3W_2$). In the case of P, the highest (0.78 per cent) value was for the treatment involving the application of 20:40:40 complex 1.0 per cent at weekly interval ($N_3C_3W_1$) and the application of 20:20:40 complex 0.5 per cent at

biweekly interval ($N_2C_2W_2$) recorded the lowest value (0.40 per cent). Regarding K content, application of 20:20:40 complex 1.0 per cent at weekly interval ($N_2C_3W_1$) recorded the highest value (1.91 per cent) and the lowest value (1.61 per cent) was for the application of vitamin B_{12} @ 100 ppm along with control (N_0Vit.M).

4.1.16 Chlorophyll content

In ground planting, chlorophyll content of leaves differed significantly among treatments (Table 19 and Fig.4). Maximum value for chlorophyll a (14.36 mg/g tissue) was recorded for the application of Ca 0.5 per cent at monthly interval (N_0CaM) along with control which was on par with the lower concentrations (0.25 per cent and 0.5 per cent) of 20:20:20 and 20:40:40. The lowest value (11.28 mg/g) was for the application of 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$). For chlorophyll b, the highest value (5.50 mg/g) was for 20:20:20 complex 0.25 per cent at weekly interval ($N_1C_1W_1$). and the lowest value (3.73 mg/g) was for 20:40:40 complex 1.0 per cent at biweekly interval ($N_3C_3W_2$). Regarding total chlorophyll content, application of 20:20:20 complex 0.25 per cent at weekly interval ($N_1C_1W_1$) recorded the highest value (19.08 mg/g) and the lowest value was for the application of 20:20:20 complex 1.0 per cent at biweekly interval ($N_1C_3W_2$).

Analysis of the data revealed that, in pot planting, there was significant difference among treatments in the chlorophyll content (a, b and total) of leaves. Here, the highest value for chlorophyll a (15.44 mg/g) was for the application of 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$) and the minimum value (11.56 mg/g) was for the application of 20:20:40 complex 0.5 per cent at weekly interval ($N_2C_2W_1$). In the case of chlorophyll b, application of 20:20:40 complex 0.5 per cent at biweekly interval ($N_2C_2W_2$) recorded the highest value (6.45 mg/g) and the lowest value (4.11 mg/g) was for the application of 20:20:40

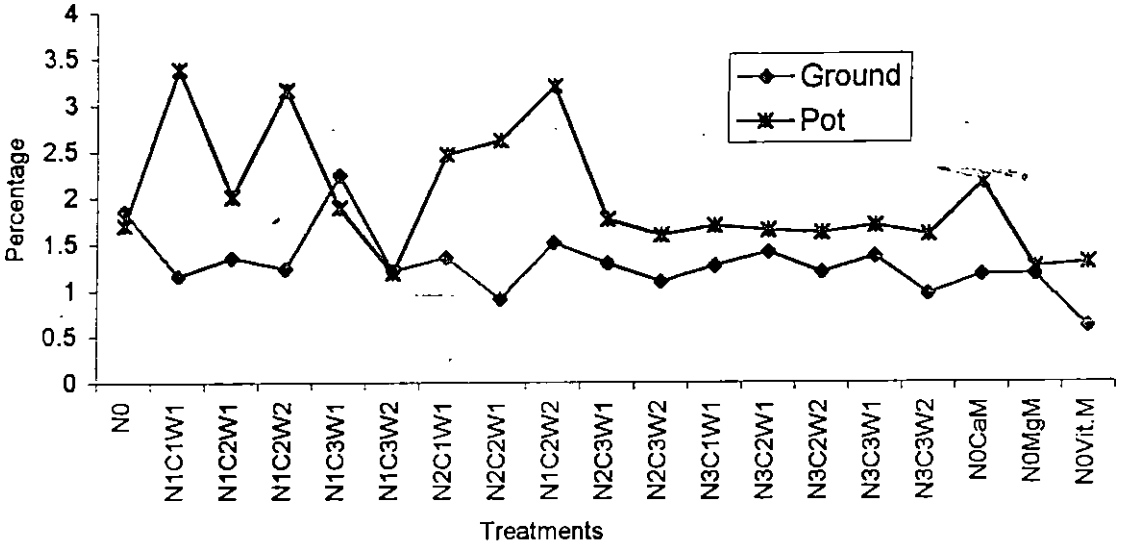


Figure 1. Effect of nutrient applications on the N content of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

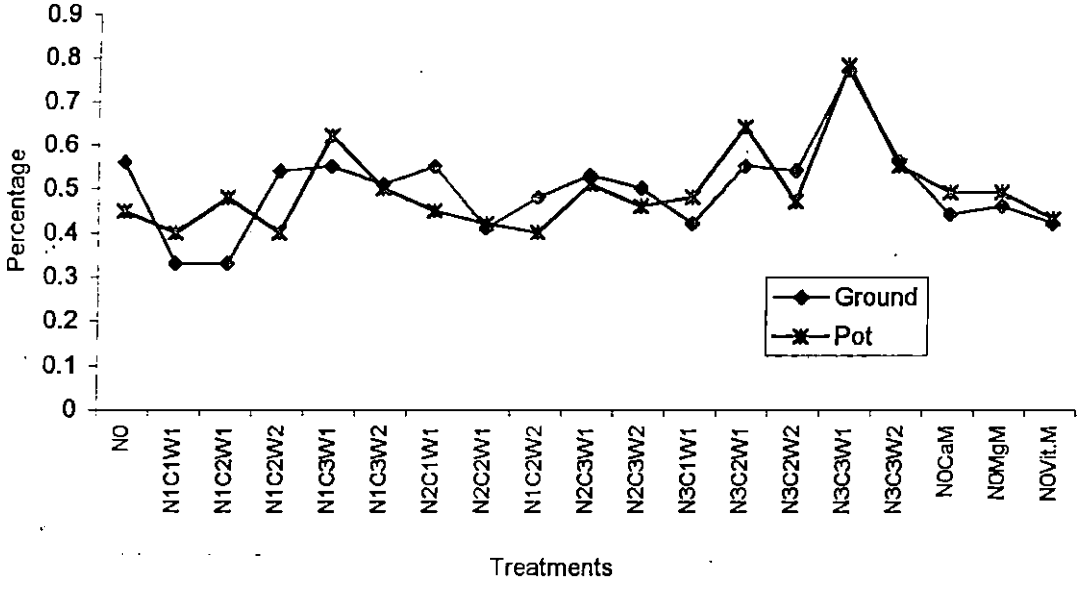


Figure 2. Effect of nutrient applications on the P content of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

Table 19. Effect of nutrient applications on the NPK, chlorophyll and anthocyanin contents of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	NPK content (%)			Chlorophyll content (mg/g)			Anthocyanin content (mg/g)
		N	P	K	a	b	Total	
1	No	1.85	0.56	1.63	12.45	4.49	16.95	29.15
2	$N_1C_1W_1$	1.15	0.33	1.63	13.59	5.50	19.08	82.28
3	$N_1C_2W_1$	1.35	0.33	1.55	13.46	5.23	18.69	81.43
4	$N_1C_2W_2$	1.23	0.54	1.70	11.37	4.41	15.77	85.68
5	$N_1C_3W_1$	2.23	0.55	1.55	13.45	5.08	18.53	36.75
6	$N_1C_3W_2$	1.20	0.51	1.75	11.30	4.34	15.64	36.45
7	$N_2C_1W_1$	1.35	0.55	1.29	11.28	4.60	15.88	66.35
8	$N_2C_2W_1$	0.90	0.41	1.60	12.55	4.40	16.94	73.65
9	$N_2C_2W_2$	1.50	0.48	1.59	12.71	4.53	17.24	70.05
10	$N_2C_3W_1$	1.28	0.53	1.76	12.04	4.59	16.63	38.18
11	$N_2C_3W_2$	1.08	0.50	1.65	13.02	4.42	17.44	40.50
12	$N_3C_1W_1$	1.25	0.42	1.48	13.56	4.12	17.68	43.13
13	$N_3C_2W_1$	1.40	0.55	1.73	13.65	4.19	17.84	69.03
14	$N_3C_2W_2$	1.18	0.54	1.55	12.25	4.62	16.27	40.73
15	$N_3C_3W_1$	1.35	0.77	1.80	12.53	4.00	16.52	40.33
16	$N_3C_3W_2$	0.95	0.56	1.79	12.65	3.73	16.89	27.85
17	N_0CaM	1.15	0.44	1.45	14.36	4.35	18.71	39.92
18	N_0MgM	1.15	0.46	1.60	12.06	3.80	15.86	42.83
19	$N_0Vit.M$	0.60	0.42	1.53	13.39	5.05	18.44	33.78
CD(0.05)		1.706	0.175	0.453	0.913	0.911	1.063	3.280

Table 20. Effect of nutrient applications on the NPK, chlorophyll and anthocyanin contents of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	NPK content (%)			Chlorophyll content (mg/g)			Anthocyanin content (mg/g)
		N	P	K	a	b	Total	
1	No	1.70	0.45	1.65	13.39	4.58	17.97	84.18
2	$N_1C_1W_1$	3.38	0.40	1.78	14.73	6.13	20.86	88.53
3	$N_1C_2W_1$	2.00	0.48	1.75	13.79	5.18	18.96	93.90
4	$N_1C_2W_2$	3.15	0.40	1.78	15.44	6.40	21.84	71.75
5	$N_1C_3W_1$	1.88	0.62	1.75	12.45	4.82	17.27	54.55
6	$N_1C_3W_2$	1.18	0.50	1.74	14.33	5.53	19.86	41.28
7	$N_2C_1W_1$	2.45	0.45	1.75	11.62	4.11	15.74	64.88
8	$N_2C_2W_1$	2.60	0.42	1.85	11.56	4.55	16.12	77.15
9	$N_2C_2W_2$	3.18	0.40	1.80	13.92	6.43	20.37	76.23
10	$N_2C_3W_1$	1.75	0.51	1.91	13.14	4.76	17.91	42.90
11	$N_2C_3W_2$	1.58	0.46	1.73	13.99	5.50	19.50	72.78
12	$N_3C_1W_1$	1.68	0.48	1.78	15.34	5.77	21.11	67.18
13	$N_3C_2W_1$	1.63	0.64	1.81	13.81	5.41	19.22	67.35
14	$N_3C_2W_2$	1.60	0.47	1.73	14.02	5.46	19.48	41.23
15	$N_3C_3W_1$	1.68	0.78	1.80	13.52	4.52	18.04	44.15
16	$N_3C_3W_2$	1.58	0.55	1.75	14.76	5.30	20.07	39.33
17	N_0CaM	2.13	0.49	1.69	13.68	5.38	19.06	60.43
18	N_0MgM	1.23	0.49	1.81	11.76	4.43	16.19	40.80
19	$N_0Vit.M$	1.28	0.43	1.61	12.02	4.85	16.87	41.35
CD(0.05)		0.543	NS	NS	0.896	0.988	1.123	3.286

NS - Non significant

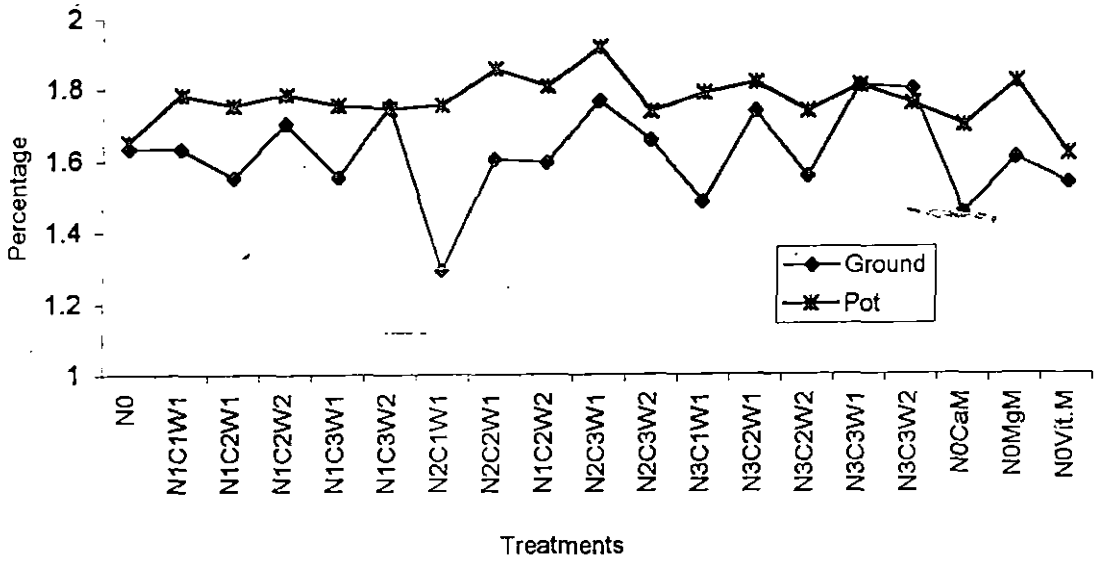


Figure 3. Effect of nutrient applications on the K content of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

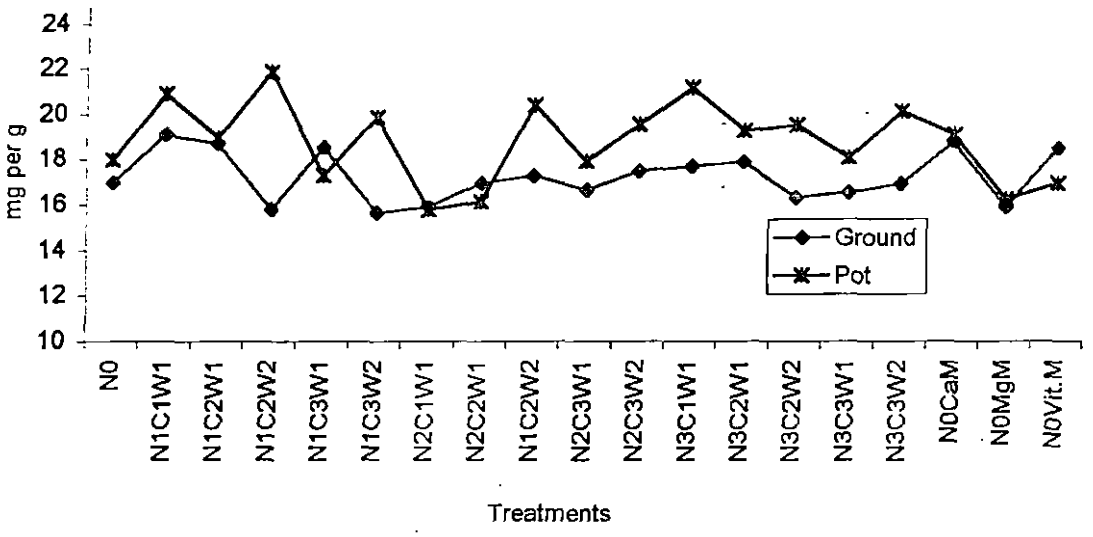


Figure 4. Effect of nutrient applications on the chlorophyll content of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

complex 0.25 per cent at weekly interval ($N_2C_1W_1$). For total chlorophyll content, the highest value (21.84 mg/g) was for 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$) which was on par with the application of 0.25 per cent of 20:20:20 and 20:40:40 complexes at weekly interval and the lowest value (15.74 mg/g) was for 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$). Application of Ca, Mg and Vitamin did not produce any significant effect (Table 20 and Fig.4).

4.1.17 Anthocyanin content of flowers

In ground planting, nutrients made significant effect on the anthocyanin content (Table 19 and Fig.5). Application of 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$) recorded the highest value (85.68) which was on par with 0.25 per cent at weekly interval of the same complex fertilizer. The lowest value (29.15) was recorded for control (N_0).

In pot planting, the treatments differed significantly with respect to the anthocyanin content of flowers (Table 20 and Fig.5). Among the treatments, application of 20:20:20 complex 0.5 per cent at weekly interval ($N_1C_2W_1$) recorded the highest value (93.90 mg/g of flower) which was significantly better than all the other treatments and the lowest value (39.33 mg/g of flower) was for the application of 20:40:40 complex 1.0 per cent at biweekly interval ($N_3C_3W_2$).

4.1.18 Effect of nutrients on the vase life of flowers

Data presented in Table 22 and Fig.6 reveal the effect of nutrients on the vase life of flowers with respect to the initiation of spadix necrosis, spathe blueing, gloss loss and total death in pot planting. The data revealed that nutrients had got significant effect on the vase life of flowers.

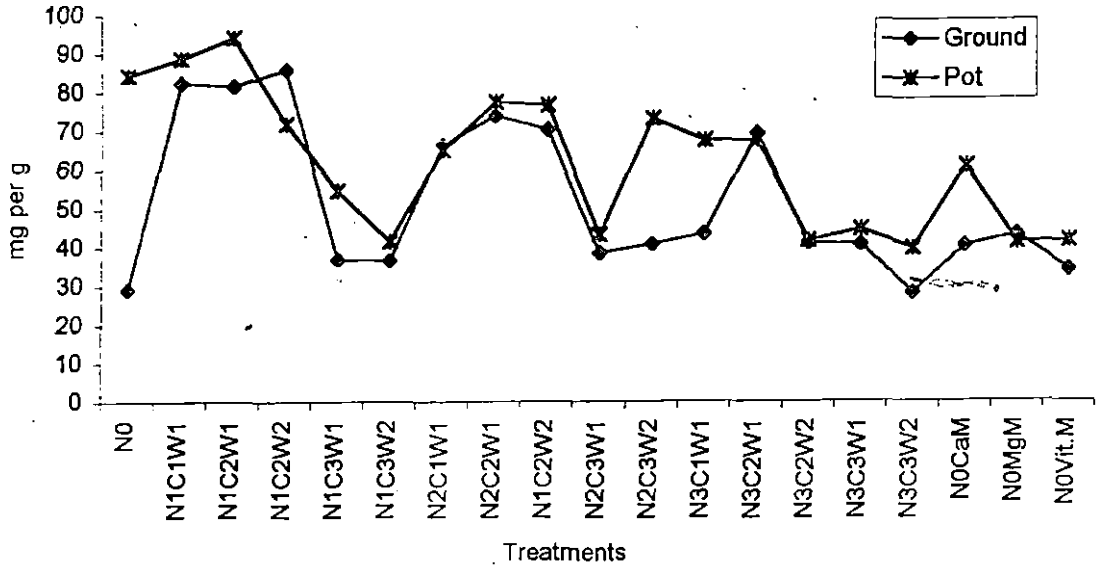


Figure 5. Effect of nutrient applications on the anthocyanin content of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

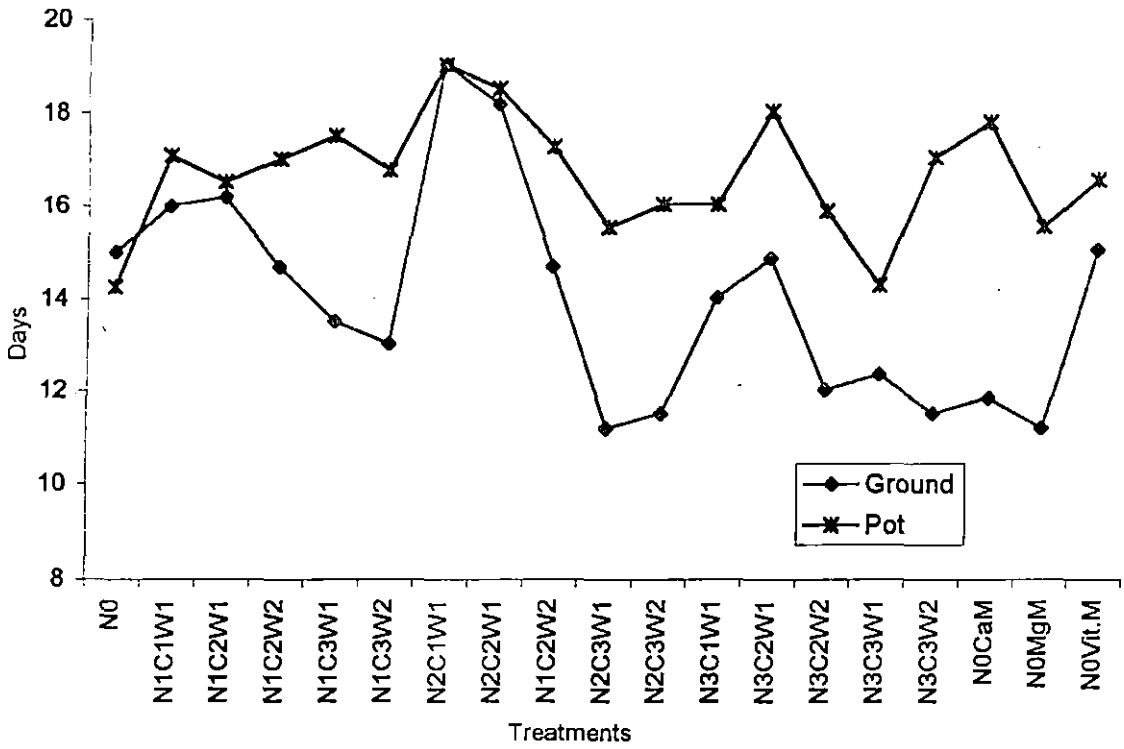


Figure 6: Effect of nutrients on vase life of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

In the case of spathe blueing the maximum number of days (18.75) was taken by 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) which was on par with the application of 20:40:40 complex 0.5 per cent at weekly interval ($N_3C_2W_1$) and the symptoms was first shown (after 12.75 days) by the plants receiving Mg 0.5 per cent at monthly interval along with control (N_0MgM).

Application of 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) took the maximum number of days (19.00) for the spadix necrosis to set in which was on par with the application of 0.5 per cent of the same nutrient at weekly interval, 0.5 per cent of 20:40:40 complex at weekly interval and Ca 0.5 per cent at monthly interval; and control (N_0) and 20:40:40 complex 1.0 per cent at weekly interval ($N_3C_3W_1$) showed the earliest symptom of spadix necrosis (within 14.25 days).

In the case of gloss loss, the maximum number of days (20.50) was taken by the plants receiving 20:40:40 complex 0.5 per cent at weekly interval ($N_3C_2W_1$) which was on par with the application of 20:20:40 complex 0.25 per cent and 0.5 per cent each at weekly interval and the symptom was first shown (within 14.50 days) by the control (N_0) and it was found on par with the application of 20:40:40 complex 1.0 per cent at weekly interval.

Regarding total death, application of 20:20:20 complex 0.25 per cent at weekly interval ($N_1C_1W_1$) took the maximum number of days (27.50) which was found to be on par with the application of 0.5 per cent of the same nutrient at weekly interval and 0.5 per cent of 20:40:40 complex at weekly interval and it was first shown (after 19.5 days) by the control (N_0) and 20:40:40 complex 1.0 per cent at weekly interval ($N_3C_3W_1$). Application of Ca, Mg or vitamin did not produce any significant effect.

Plate 5. *Control* (N_0) *plants in ground planting*

Plate 6. Plants in the treatment which gave maximum vase life to flowers, produced the highest number of flowers per plant and showed early flowering ($N_2C_1W_1$)


$N_2C_1W_1$


N_0

Data pertaining to the vase life of flowers in ground planting are presented in Table 21 and Fig.6 where the nutrients had significant effect on the vase life and senescence of flowers.

Regarding spadix necrosis, application of 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) took the maximum number of days (19.00) and it was on par with 0.5 per cent of the same mixture at weekly interval. Treatment of 20:20:40 complex 1.0 per cent at weekly interval ($N_2C_3W_1$) showed the earliest symptom (within 11.17 days) which was on par with the higher concentration (0.5 and 1.0 per cent) of 20:20:40 and 20:40:40 complex. Application of Ca, Mg or vitamin B_{12} also did not make any added advantage.

In the case of spathe blueing, application of 20:20:40 0.25 per cent at weekly interval ($N_2C_1W_1$) delayed the symptom upto 18.67 days and was statistically better than all the other treatments. Application of Mg 0.5 per cent at monthly interval along with control (N_0MgM) took minimum number of days (10.33) for the symptom to appear and it was on par with 1.0 per cent at biweekly interval of 20:20:40 and 20:40:40.

Application of 20:20:40 complex 1.0 per cent at weekly interval ($N_2C_3W_1$) showed the earliest symptom of gloss loss (12.67 days) and was on par with 1.0 per cent at biweekly interval of the same mixture and 20:40:40 complex. Application of Ca, Mg or Vit. B_{12} along with control did not make any significant effect. The maximum number of days (20.83) was taken by 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) and was on par with 0.5 per cent at weekly interval of the same complex as well as 20:20:20 complex.

With respect to the total death of flowers, application of 20:20:40 complex 1.0 per cent at weekly interval ($N_2C_3W_1$) much delayed the symptom (upto

Table 21. Effect of nutrients on the vaselife of flowers of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Days to total death
1	No	15.00	12.67	17.00	21.33
2	$N_1C_1W_1$	16.00	14.25	16.67	24.67
3	$N_1C_2W_1$	16.17	15.50	20.83	24.67
4	$N_1C_2W_2$	14.67	12.83	14.83	22.67
5	$N_1C_3W_1$	13.50	12.83	16.33	24.00
6	$N_1C_3W_2$	13.00	11.83	15.33	21.00
7	$N_2C_1W_1$	19.00	18.67	20.83	25.17
8	$N_2C_2W_1$	18.17	16.83	20.67	25.67
9	$N_2C_2W_2$	14.67	13.67	16.67	19.67
10	$N_2C_3W_1$	11.17	11.83	12.67	27.67
11	$N_2C_3W_2$	11.50	11.00	13.83	22.33
12	$N_3C_1W_1$	14.00	13.18	16.17	24.17
13	$N_3C_2W_1$	14.83	15.67	18.50	21.67
14	$N_3C_2W_2$	12.00	12.67	15.67	25.83
15	$N_3C_3W_1$	12.33	11.17	15.67	20.33
16	$N_3C_3W_2$	11.50	10.83	13.17	18.33
17	N_0CaM	11.83	12.00	15.00	22.33
18	N_0MgM	11.17	10.33	14.17	18.67
19	$N_0Vit.M$	15.00	13.83	15.67	21.83
CD(0.05)		1.351	1.088	1.631	2.141

Table 22. Effect of nutrients on the vaselife of flowers of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Days to total death
1	No	14.25	13.50	14.50	19.50
2	$N_1C_1W_1$	17.09	16.00	18.00	23.84
3	$N_1C_2W_1$	16.50	15.50	16.75	24.75
4	$N_1C_2W_2$	17.00	15.50	18.00	24.50
5	$N_1C_3W_1$	17.50	16.95	18.00	23.00
6	$N_1C_3W_2$	16.75	16.00	17.25	21.50
7	$N_2C_1W_1$	19.00	18.75	19.50	27.50
8	$N_2C_2W_1$	18.50	16.75	20.25	25.50
9	$N_2C_2W_2$	17.25	14.75	19.25	23.00
10	$N_2C_3W_1$	15.50	13.77	18.25	20.50
11	$N_2C_3W_2$	16.00	14.75	18.25	21.50
12	$N_3C_1W_1$	16.00	14.25	16.25	20.00
13	$N_3C_2W_1$	18.00	17.25	20.50	26.50
14	$N_3C_2W_2$	15.84	15.42	17.59	21.59
15	$N_3C_3W_1$	14.25	13.25	15.25	19.50
16	$N_3C_3W_2$	17.00	14.25	19.25	21.00
17	N_0CaM	17.75	15.50	18.75	24.50
18	N_0MgM	15.50	12.75	17.50	20.50
19	N_0Vit.M	16.50	16.00	18.50	23.50
CD(0.05)		1.276	1.576	1.344	2.260

27.67 days) and application of 20:40:40 complex 1.0 per cent at biweekly interval ($N_3C_3W_2$) took the lowest number of days (18.33) and was on par with 1.0 per cent at weekly interval of the same treatment. Application of Ca, Mg or Vit. B_{12} did not make any significant effect.

4.2 Effect of growth regulators on plant characters

4.2.1 Plant height

In ground planting plant height differed significantly among treatments in the 4th, 5th, 6th, 7th and 8th months. In the 4th, 7th and 8th months, application of BA 500 ppm (G_1C_2M) recorded the highest value for height (5.97 cm, 7.90 cm and 8.40 cm, respectively) which was on par with BA 1000 ppm (G_1C_3M) and lower concentrations (250 and 500 ppm) of combined application of BA and GA. During 5th and 6th months, application of BA and GA 500 ppm each at monthly interval [$(G_1+G_2)C_2M$] recorded highest value for height (6.70 cm and 7.13 cm respectively) which was on par with the different concentrations of BA (Table 23). In all the months, application of GA 1000 ppm at monthly interval (G_2C_3M) recorded the lowest value for height (4.7 cm, 4.97 cm, 5.33 cm, 5.57 cm and 5.73cm respectively) and it was inferior to all the other treatments.

Data pertaining to plant height in pot plants are presented in Table 24. Statistical analysis revealed that growth regulators had significant effect or plant height in 6th, 7th and 8th months. Combined application of BA and GA 250 ppm, each, [$(G_1 + G_2)C_2M$] resulted in the highest values for height in all the three months (7.37 cm, 7.83 cm and 8.17 cm, respectively) which was on par with 500 ppm of BA. The minimum height, in all the three months was recorded by the plants receiving BA 1000 ppm i.e., G_1C_3M (5.07 cm, 5.40 cm and 5.63 cm, respectively) and it was on par with GA 1000 ppm (G_2C_3M) and control (N_0), but control was superior to it in the last month.

Table 23. Effect of growth regulators on plant height (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.43	4.80	5.13	5.80	6.23	6.63	6.93	7.40
2	G_1C_2M	4.13	4.57	5.27	5.97	6.67	7.13	7.90	8.40
3	G_1C_3M	4.50	4.83	5.17	5.63	5.90	6.37	6.53	6.67
4	G_2C_2M	3.87	4.17	4.67	5.00	5.50	5.93	6.17	6.43
5	G_2C_3M	3.63	3.97	4.27	4.70	4.97	5.33	5.57	5.73
6	$(G_1+G_2)C_1M$	4.43	4.87	5.33	5.77	6.33	6.90	7.23	7.60
7	$(G_1+G_2)C_2M$	4.17	4.80	5.20	5.77	6.70	7.13	7.57	8.03
CD(0.05)		NS	NS	NS	0.751	0.742	0.589	0.494	0.691

NS - Non significant

Table 24. Effect of growth regulators on plant height (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.00	4.40	4.83	5.20	5.60	5.97	6.47	7.03
2	G_1C_2M	3.87	4.63	5.43	5.87	6.43	7.03	7.50	8.03
3	G_1C_3M	3.67	4.03	4.30	4.57	4.87	5.07	5.40	5.63
4	G_2C_2M	4.27	4.67	5.03	5.50	5.90	6.30	6.73	6.87
5	G_2C_3M	4.50	4.73	5.03	5.37	5.67	5.93	6.07	6.23
6	$(G_1+G_2)C_1M$	4.60	5.23	6.10	6.53	6.97	7.37	7.83	8.17
7	$(G_1+G_2)C_2M$	4.53	4.83	5.40	5.70	6.20	6.87	7.30	7.87
CD(0.05)		NS	NS	NS	NS	NS	1.225	1.135	1.094

NS - Non significant

4.2.2 Plant spread - EW

Growth regulators had significant effect on plant spread (EW) in ground planting in the first 4 months. In all the four months, application GA and BA 250 ppm each [$(G_1 + G_2)C_1M$]recorded maximum spread with a value of 41.23 cm in the 4th month and it was on par with control and lower concentrations of BA and GA. Application of GA 1000 ppm (G_2C_3M) caused the lowest spread in all the months with a value of 32.20 cm in the 4th month and it was on par with BA 1000 ppm and (BA + GA) 500 ppm. The details are given in Table 25.

In pot planting, the EW spread did not differ significantly among the treatments in any of the months (Table 26). For all the treatments, hgihest spread was recorded in the 6th month. Application of growth regulators decreased the spread than in control. In the 6th months, control (N_0) had the highest value for spread - EW - (44.20 cm) and the lowest value (37.40 cm) was recorded by the plants sprayed with GA 500 ppm at monthly interval (G_2C_2M).

4.2.3 Plant spread - NS

In ground plants, all the treatments were on par, with respect to NS spread. The highest value for plant spread for all the treatments were recorded in the 6th month after which it started declining slowly. In the 6th months application of BA 500 ppm (G_1C_2M) caused maximum spread (39.60 cm) and BA 100 ppm (G_1C_3M) and GA 1000 ppm (G_2C_3M) caused the least spread (37.20 cm each). The data are presented in Table 27.

The treatments did not differ significantly with regard to NS spread in pot plants also (Table 28). The spread, in all the treatments increased steadily upto the 6th month and then showed a slow decline. In the 6th month, plants sprayed with

Table 25. Effect of growth regulators on plant spread-EW (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	29.23	32.77	35.00	39.23	36.00	34.57	32.67	29.70
2	G_1C_2M	31.00	36.13	37.90	37.90	39.90	39.80	39.43	39.57
3	G_1C_3M	25.97	29.47	32.57	34.57	39.30	37.67	34.00	28.77
4	G_2C_2M	30.43	32.90	35.33	36.23	40.37	37.57	34.03	28.77
5	G_2C_3M	24.57	29.20	31.23	32.20	40.10	38.33	29.57	24.03
6	$(G_1+G_2)C_1M$	32.33	36.23	39.00	41.23	42.10	38.57	34.37	32.23
7	$(G_1+G_2)C_2M$	27.23	31.23	33.67	35.70	40.47	38.70	40.77	38.90
CD(0.05)		3.793	4.563	4.372	4.920	NS	NS	NS	NS

NS - Non significant

Table 26. Effect of growth regulators on plant spread-EW (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	27.77	31.67	33.43	33.77	33.23	44.23	34.00	33.47
2	G_1C_2M	28.00	32.10	34.80	31.13	29.90	40.77	31.03	27.00
3	G_1C_3M	24.20	28.57	30.70	33.23	34.33	38.57	31.33	24.37
4	G_2C_2M --	19.53	22.87	25.43	28.23	29.77	37.43	26.23	23.47
5	G_2C_3M	23.57	27.57	31.43	33.23	35.53	38.00	32.77	31.70
6	$(G_1+G_2)C_1M$	19.53	23.47	26.43	29.47	30.67	41.67	33.10	31.33
7	$(G_1+G_2)C_2M$	24.30	27.43	28.53	31.13	32.70	42.37	33.43	30.57
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 27. Effect of growth regulators on plant spread-NS (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	27.77	29.00	31.97	34.90	33.77	37.47	32.87	27.33
2	G_1C_2M	26.10	31.43	34.13	36.43	38.13	39.53	35.23	33.13
3	G_1C_3M	24.20	28.33	30.57	32.53	38.33	37.23	31.47	29.33
4	G_2C_2M	28.33	32.37	34.87	39.20	35.47	38.10	30.77	26.80
5	G_2C_3M	24.57	28.47	31.77	35.13	37.77	37.23	31.00	31.77
6	$(G_1+G_2)C_1M$	30.23	34.57	37.47	39.00	38.00	37.77	35.57	31.87
7	$(G_1+G_2)C_2M$	26.90	29.67	33.67	36.53	36.10	38.67	34.57	27.57
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 28. Effect of growth regulators on plant spread-NS (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	25.30	28.77	31.00	33.10	34.67	38.90	31.43	25.57
2	G_1C_2M	23.37	28.23	30.77	31.80	35.13	38.70	31.77	30.10
3	G_1C_3M	23.00	28.33	30.37	32.00	35.13	39.33	28.67	22.67
4	G_2C_2M	23.67	28.50	30.10	29.57	34.57	36.90	26.10	19.47
5	G_2C_3M	22.67	27.13	29.97	32.43	32.33	39.00	29.43	27.10
6	$(G_1+G_2)C_1M$	24.00	29.10	31.57	32.57	33.48	42.10	31.57	25.90
7	$(G_1+G_2)C_2M$	20.47	24.67	27.90	31.10	30.37	40.20	34.77	30.57
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

BA + GA 250 ppm each [$(G_1 + G_2)C_1M$] recorded the maximum spread (42.10 cm) and those with GA 500 ppm (G_2C_2M) recorded the minimum spread (36.90 cm).

4.2.4 Number of leaves/plant

Data pertaining to the effect of growth regulators on the number of leaves/plant in ground planting are given in Table 29. The data revealed that there were significant differences among treatments with regard to the number of leaves/plant in the 6th and 8th months. In the 6th month plants sprayed with BA 500 ppm (G_1C_2M) recorded the maximum number of leaves/plant (7.33) which was significantly better than all the other growth regulators. Application of GA 500 ppm (G_2C_2M) recorded the lowest value (4.33) and it was on par with the other growth regulators. In the 8th month also, BA 500 ppm (G_1C_2M) recorded the maximum value (6.33) which was on par with BA 1000 ppm. Lowest value (2.67) was recorded by GA 1000 ppm (G_2C_3M) and it was on par with BA 1000 ppm, GA 500 ppm and the combinations of BA and GA each at 500 ppm.

In pots, all the treatments were on par during the period of the experiment. The number of leaves/plant increased upto the 5th month and then declined slowly. In the 5th month, BA + GA 250 ppm [$(G_1+G_2)C_1M$]recorded the maximum number of leaves/plant (8.1) and the minimum value (5.5) was for GA 1000 ppm (G_2C_3M). The data are presented in Table 30.

4.2.5 Leaf length

Application of growth regulators decreased leaf length both in ground and pot planting. The effect was significant in ground planting only in the 7th month. During the other months, all the treatments were on par. In the 7th month, application of GA 1000 ppm (G_2C_3M) recorded the lowest leaf length (10.89 cm)

Table 29. Effect of growth regulators on number of leaves per plant of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.67	4.990	5.43	5.67	5.90	5.67	5.00	4.00
2	G_1C_2M	5.67	6.33	6.67	7.10	7.43	7.33	6.87	6.33
3	G_1C_3M	4.77	5.20	5.67	6.00	6.53	5.33	5.23	4.47
4	G_2C_2M	5.00	5.33	5.90	5.80	5.67	4.33	3.70	2.80
5	G_2C_3M	5.10	5.67	6.10	6.20	6.23	5.23	4.00	2.67
6	$(G_1+G_2)C_1M$	4.57	4.90	5.33	5.53	5.87	5.33	4.80	4.00
7	$(G_1+G_2)C_2M$	4.90	5.57	6.00	6.43	6.43	5.57	4.77	3.77
CD(0.05)		NS	NS	NS	NS	NS	1.589	NS	2.023

NS - Non significant

Table 30. Effect of growth regulators on number of leaves per plant of *A. andreanum* cv. 'Hawaiian Red' pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	4.33	4.80	5.33	5.67	6.00	5.33	5.23	4.57
2	G_1C_2M	4.43	4.80	5.43	5.80	6.20	5.77	5.53	4.77
3	G_1C_3M	4.33	4.87	5.57	5.97	6.10	4.47	4.33	3.37
4	G_2C_2M	4.97	5.43	5.87	5.77	5.90	5.67	4.00	3.10
5	G_2C_3M	4.33	5.03	5.33	5.77	5.47	4.67	4.33	2.90
6	$(G_1+G_2)C_1M$	5.70	6.10	6.70	7.23	8.13	6.87	5.90	4.57
7	$(G_1+G_2)C_2M$	5.10	5.57	6.10	6.43	6.43	5.67	6.10	5.00
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS - Non significant

Table 31. Effect of growth regulators on leaf length (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	8.61	10.28	11.72	13.33	15.11	14.33	13.66	13.44
2	G_1C_2M	8.45	10.44	12.45	13.56	14.89	15.78	13.11	13.00
3	G_1C_3M	8.33	9.72	11.89	13.00	14.44	13.56	12.00	12.11
4	G_2C_2M	9.89	11.67	13.33	14.56	15.89	15.78	13.11	11.28
5	G_2C_3M	7.89	9.56	10.89	12.00	13.33	14.22	10.89	11.44
6	$(G_1+G_2)C_1M$	10.56	12.45	14.33	16.22	17.56	16.89	13.00	12.67
7	$(G_1+G_2)C_2M$	9.44	10.56	12.78	14.22	15.11	15.67	12.56	12.78
CD(0.05)		NS	NS	NS	NS	NS	NS	1.674	NS

NS - Non significant

Table 32. Effect of growth regulators on leaf length (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	7.17	8.22	9.84	11.11	12.33	15.78	13.78	13.89
2	G_1C_2M	7.78	8.89	10.22	11.78	13.22	15.44	13.22	13.78
3	G_1C_3M	7.67	9.00	10.22	11.56	12.89	14.00	12.33	11.89
4	G_2C_2M	7.00	8.00	9.22	10.78	11.67	13.78	11.22	10.11
5	G_2C_3M	7.22	8.11	9.67	10.56	11.78	15.22	11.00	10.67
6	$(G_1+G_2)C_1M$	7.56	9.22	10.33	11.00	12.11	14.44	11.89	11.44
7	$(G_1+G_2)C_2M$	6.89	8.55	9.66	10.89	11.89	13.78	11.89	12.84
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	2.632

NS - Non significant

and all the other treatments were significantly better than this. Control (N_0) recorded the highest leaf length (13.66 cm) which was on par with all the treatments except GA 1000 ppm (Table 31).

In pot, growth regulators made significant effect on leaf length only in the 8th month (Table 32). The lowest leaf length (10.11) was for GA 500 ppm (G_2C_2M) which was on par with GA 1000 ppm (G_2C_3M) and BA 1000 ppm (G_1C_3M). Control (N_0) recorded the maximum leaf length (13.89 cm) which was on par with BA 500 ppm and combinations of BA and GA at 500 ppm each.

4.2.6 Leaf breadth

Data pertaining to leaf breadth in ground planting taken at monthly interval are presented in Table 33. Leaf breadth differed significantly among treatments in the 3rd and 7th months due to the effect of growth regulators. In the 3rd month, application of a combination of BA and GA 250 ppm [$(G_1+G_2)C_1M$] each produced the broadest leaves (9.44 cm) which was on par with all the other treatments except GA 1000 ppm (G_2C_3M) which recorded the least breadth (7.56 cm). In the 7th month, BA 500 ppm (G_1C_2M) recorded maximum breadth (9.78 cm) which was on par with all the concentrations of BA, GA and their combinations except GA 1000 ppm which recorded the lowest breadth (7.78 cm) and was inferior to all the other treatments.

Growth regulators made significant effect on leaf breadth in pot plants in the 8th month only (Table 34). Here also, application of growth regulators decreased the leaf breadth. Application of GA 500 ppm (G_2C_2M) recorded the lowest breadth (7.33 cm) which was on par with GA 1000 ppm, BA 1000 ppm and different concentrations (250 and 500 ppm) of BA + GA. Control (N_0) recorded the highest

Table 33. Effect of growth regulators on leaf breadth (cm) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	6.44	7.33	8.00	9.00	10.00	9.89	10.00	9.72
2	G_1C_2M	6.11	7.33	8.45	9.44	10.33	11.22	9.78	9.61
3	G_1C_3M	6.11	7.11	8.67	9.00	10.00	9.89	9.33	8.95
4	G_2C_2M	7.33	8.00	9.22	9.67	10.33	10.33	9.22	7.89
5	G_2C_3M	5.78	6.11	7.56	8.33	9.67	9.67	7.78	8.11
6	$(G_1+G_2)C_1M$	7.33	8.55	9.44	10.00	10.22	10.67	9.00	8.55
7	$(G_1+G_2)C_2M$	6.78	7.78	9.11	9.78	10.78	10.56	9.45	8.94
CD(0.05)		NS	NS	1.231	NS	NS	NS	1.212	NS

NS - Non significant

Table 34. Effect of growth regulators on leaf breadth (cm) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	5.67	6.66	7.50	8.06	8.67	11.00	9.66	9.89
2	G_1C_2M	6.00	7.33	8.00	8.44	9.11	10.56	9.55	9.89
3	G_1C_3M	6.22	7.22	7.89	8.44	8.89	10.56	9.33	8.78
4	G_2C_2M	5.11	6.11	7.11	7.78	8.33	9.89	7.89	7.33
5	G_2C_3M	5.89	6.55	7.44	8.11	8.78	10.00	8.22	7.67
6	$(G_1+G_2)C_1M$	5.34	6.89	7.34	7.67	8.33	10.44	8.45	8.39
7	$(G_1+G_2)C_2M$	5.11	6.56	7.22	7.89	8.67	9.89	9.00	8.94
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	1.687

NS - Non significant

breadth (9.89 cm) which was on par with the different concentrations of BA and combinations of BA and GA.

4.2.7 Leaf area

In ground planting leaf area differed significantly among treatments only in the 7th month and during the rest of the period, all of them were on par. Leaf area did not increase by the application of growth regulators. In the 7th month, control (N_0) recorded the maximum leaf area (98.38 cm^2) which was on par with all the other treatments except GA 1000 ppm (G_2C_3M) which had the lowest leaf area (61.68 cm^2). The details are given in Table 35 and Fig.7.

The data for pot plants (Table 36 and Fig.7) show that the leaf area do not differ significantly between treatments upto the 7th month. But in the 8th month, there was notable difference in leaf area where, control (N_0) had the highest leaf area (99.36 cm^2) which was on par with the combined application of BA and GA while the minimum leaf area (53.91 cm^2) was for the application of GA 500 ppm (G_2C_2M) which was on par with GA 1000 ppm (G_2C_3M) and BA 1000 ppm (G_1C_3M).

4.2.8 Days to flower

The effect of growth regulators on the number of days to flower in ground plants is evident from Table 37. The data show that, there is no significant difference among treatments with respect to days to flower. The lowest number of days was taken by BA 1000 ppm i.e., G_1C_3M (34.67) and highest number of days (79.33) was taken by GA 1000 ppm (G_2C_3M).

Table 35. Effect of growth regulators on leaf area (cm^2) of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	40.92	56.55	70.03	87.87	109.60	101.98	98.38	94.09
2	G_1C_2M	38.40	56.23	76.64	93.33	111.95	128.95	92.68	90.28
3	G_1C_3M	38.26	50.99	75.12	85.10	105.04	96.58	81.39	78.98
4	G_2C_2M	53.00	68.90	89.51	101.53	118.85	119.16	89.09	66.07
5	G_2C_3M	32.60	41.73	59.39	71.97	92.58	99.61	61.68	65.00
6	$(G_1+G_2)C_1M$	57.29	77.54	98.23	117.30	129.62	129.85	84.51	78.06
7	$(G_1+G_2)C_2M$	46.03	59.41	84.12	100.26	117.53	120.01	85.79	76.53
CD(0.05)		NS	NS	NS	NS	NS	NS	19.96	NS

NS - Non significant

Table 36. Effect of growth regulators on leaf area (cm^2) of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	Month							
		1	2	3	4	5	6	7	8
1	No	29.26	29.62	53.92	65.63	77.23	126.40	95.38	99.36
2	G_1C_2M	33.89	47.50	59.45	72.33	87.42	118.06	91.27	98.81
3	G_1C_3M	54.46	46.83	58.17	70.37	82.56	107.53	83.49	75.78
4	G_2C_2M	26.54	35.66	47.79	60.59	79.19	98.13	64.39	53.91
5	G_2C_3M	31.43	38.85	52.45	62.66	75.55	110.62	65.74	60.24
6	$(G_1+G_2)C_1M$	29.41	45.47	54.33	60.67	72.63	108.81	72.83	69.30
7	$(G_1+G_2)C_2M$	25.71	40.39	50.28	62.13	74.46	98.13	77.50	83.26
CD(0.05)		NS	NS	NS	NS	NS	NS	NS	29.98

NS - Non significant

In pot also, there was no significant difference between treatments in the number of days to flower (Table 38). Here the range was from 31.33 days for control (N_0) to 77.67 days for BA 500 ppm (G_1C_2M).

4.2.9 Number of flowers/plant

In ground planting the number of flowers/plant did not differ significantly among treatments (Table 37). Application of BA + GA 250 ppm each [$(G_1+G_2)C_1M$] produced the highest number of flowers/plant (2.34) and control (N_0) plants the lowest number of flowers/plant (1.00).

In pot planting also, there was no significant difference in the number of flowers/plant. Plants receiving BA 500 ppm (G_1C_2M), GA 1000 ppm (G_2C_3M) and BA + GA 500 ppm [$(G_1+G_2)C_2M$] produced the highest number of flowers/plant (1.78 each) while the application of GA 500 ppm (G_2C_2M) produced the lowest number of flowers/plant (0.33). The details are available in Table 38.

4.2.10 Interval of flower production

The number of days taken for the successive flowers to appear in ground planting did not differ significantly among treatments. Control (N_0) had the lowest interval (25.17 days) whereas GA 1000 ppm (G_2C_3M) had the highest interval (37.44 days). The data are presented in Table 37.

Table 38 gives the details of the interval of flower production in pot plants. Here also, there is no significant difference among treatments. The interval ranged from 31.50 days for the combined application of BA and GA 250ppm each [$(G_1+G_2)C_1M$] to 37.00 days for GA 1000 ppm (G_2C_3M).

Table 37. Effect of growth regulators on flowering and flower characters of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl. No.	Treatments	Days to flower	No. of flowers per plant	Interval of flower production (days)	Stalk length (cm)	Spathe length (cm)	Spadix length (cm)
1	No	67.00	1.003	25.17	20.33	8.83	3.00
2	G_1C_2M	50.33	2.00	35.11	19.17	7.33	2.41
3	G_1C_3M	34.67	1.89	34.67	22.92	8.75	2.92
4	G_2C_2M	39.33	1.22	33.5	22.75	8.33	3.08
5	G_2C_3M	79.33	1.44	37.44	17.33	7.67	2.55
6	$(G_1+G_2)C_1M$	39.00	2.34	36.00	18.02	6.53	2.62
7	$(G_1+G_2)C_2M$	63.67	1.78	33.00	20.17	6.08	2.77
CD(0.05)		NS	NS	NS	NS	NS	NS

NS - Non significant

Table 38. Effect of growth regulators on flowering and flower characters of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl. No.	Treatments	Days to flower	No. of flowers per plant	Interval of flower production (days)	Stalk length (cm)	Spathe length (cm)	Spadix length (cm)
1	No	31.33	1.55	25.17	18.75	9.00	2.92
2	G_1C_2M	77.67	1.78	35.11	17.89	7.06	2.32
3	G_1C_3M	43.33	1.11	34.67	19.92	6.60	2.58
4	G_2C_2M	46.67	0.33	22.33	11.67	5.33	1.17
5	G_2C_3M	49.33	1.78	37.44	17.83	6.67	2.32
6	$(G_1+G_2)C_1M$	71.00	1.10	36.00	16.22	6.56	2.22
7	$(G_1+G_2)C_2M$	66.33	1.78	33.00	17.39	6.33	2.28
CD(0.05)		NS	NS	NS	NS	NS	NS

NS - Non significant

4.2.11 Stalk length

In ground as well as pot planting, there is no significant difference in stalk length among different treatments. In ground, the longest stalk (22.92 cm) was for the application of BA 1000 ppm (G_1C_3M) and plants sprayed with GA 1000 ppm (G_2C_3M) had the shortest stalk (17.33 cm). The data are presented in Table 37.

In pot plants, control (N_0) was having the longest stalk (18.75 cm) and application of GA 500 ppm (G_2C_2M) recorded the shortest (11.67 cm) stalk length (Table 38).

4.2.12 Spathe and spadix length

In ground plants, different growth regulators did not produce any significant effect on the spathe size or spadix length (Table 37). Control (N_0) had the longest spathe (8.83 cm) and BA + GA 500 ppm each [$(G_1+G_2)C_2M$] had the shortest spathe (6.08 cm). In the case of spadix length highest value (3.08cm) was for GA 500 ppm (G_2C_2M) and lowest (2.41cm) for BA 500 ppm (G_1C_2M).

In plants maintained in pots also, the response of growth regulators was similar to that of ground planting (Table 38).

The highest spathe size (9.00 cm) was for control (N_0) and, GA 500 ppm (G_2C_2M) had the lowest value (5.33 cm). With regard to spadix length, control (N_0) had the highest length (2.92 cm) and GA 500 ppm (G_2C_2M) had the lowest length (1.17 cm).

4.2.13 Interval of leaf production

Number of days taken for the successive leaves to appear on the same plant do not differ significantly among the treatments in ground as well as pot planting. In ground plants, the lowest interval (35.33 days) was recorded for the

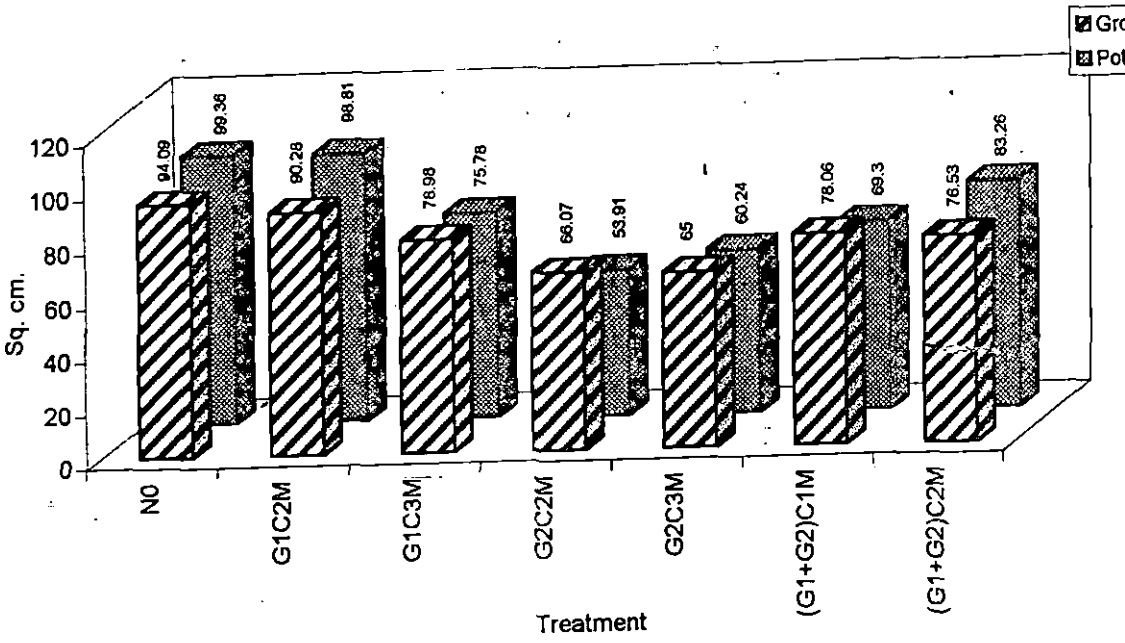


Figure 7. Effect of growth regulators on the leaf area of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

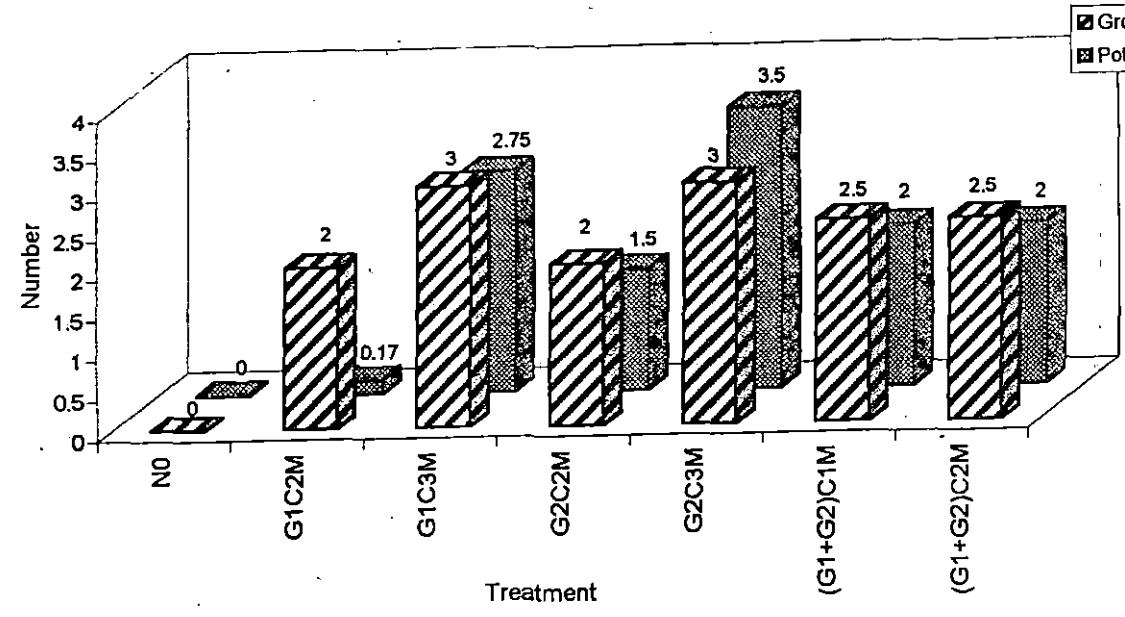


Figure 8. Effect of growth regulators on the number of suckers per plant of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

application of BA + GA 250 ppm each [$(G_1+G_2)C_1M$] and the highest interval (36.78 days) was recorded for control (N_0). The data are presented in Table 39.

The data for pot plants are presented in Table 40. Where the interval of leaf production ranged from 34.67 days for the plants receiving BA + GA 500 ppm, each, [$(G_1+G_2)C_2M$] to 37.75 days for control (N_0).

4.2.14 Number of suckers/plant

Growth regulators significantly influenced the number of suckers produced per plant in ground planting. Their effects were significant from the fourth month onwards (Table 39 and Fig.8). In all the months (4th, 5th, 6th, 7th and 8th), the highest number of suckers was produced by the plants receiving GA 1000 ppm at monthly interval (G_2C_3M) which was on par with application of BA 1000 ppm (G_1C_3M), combination of BA and GA at 250 and 500 ppm each. The highest number of suckers per plant for all the treatments was produced in the 8th month with a maximum value of 3.00 for the plants receiving GA 1000 ppm at monthly interval (G_2C_3M). Control (N_0) produced no suckers at all and it was inferior to all the others.

In pot planting also, the effect of growth regulators on the number of suckers per plant was significant from the 6th month onwards. The maximum value was recorded in the 8th month for all the treatment. Among them, application of GA 1000 ppm (G_2C_3M) produced the highest number (3.50) of suckers per plant which was on par with the application of BA 1000ppm whereas no sucker was produced in control (N_0). The data are presented in Table 40 and Fig.8.

Table 39. Effect of growth regulators on the number of suckers per plant and interval of leaf production of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl. No.	Treatment	Month								Interval of leaf production (days)
		1	2	3	4	5	6	7	8	
1	No	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.78
2	G_1C_2M	0.22	0.22	0.22	0.22	0.22	0.44	1.28	2.00	35.67
3	G_1C_3M	0.00	0.00	0.33	0.33	0.50	1.67	2.00	3.00	35.94
4	G_2C_2M	0.11	0.22	0.22	0.22	1.33	1.84	2.00	2.00	35.83
5	G_2C_3M	0.00	0.00	0.00	1.67	2.00	2.00	3.00	3.00	36.43
6	$(G_1+G_2)C_1M$	0.33	0.33	0.67	0.67	1.00	2.00	2.00	2.50	35.33
7	$(G_1+G_2)C_2M$	0.00	0.00	0.50	1.00	1.84	1.84	2.00	2.50	35.78
CD(0.05)		NS	NS	NS	0.871	0.761	0.887	0.353	1.064	NS

NS - Non significant

Table 40. Effect of growth regulators on the number of suckers per plant and interval of leaf production of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl. No.	Treatment	Month								Interval of leaf production (days)
		1	2	3	4	5	6	7	8	
1	No	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.75
2	G_1C_2M	0.00	0.00	0.17	0.17	0.17	0.17	0.17	0.17	36.94
3	G_1C_3M	0.34	0.34	0.34	0.50	1.00	1.50	2.50	2.75	37.33
4	G_2C_2M	0.33	0.33	0.33	0.33	0.50	0.50	1.50	1.50	37.44
5	G_2C_3M	0.50	0.50	0.50	0.50	1.50	2.00	2.50	3.50	36.67
6	$(G_1+G_2)C_1M$	0.50	0.50	0.67	1.17	1.17	1.50	2.00	2.00	35.78
7	$(G_1+G_2)C_2M$	0.00	0.00	0.50	1.00	1.00	2.00	2.00	2.00	34.67
CD(0.05)		NS	NS	NS	NS	NS	1.670	1.437	1.341	NS

NS - Non significant

Plate 7. Plants treated with GA 1000ppm (G_2C_3M) which produced the highest number of suckers per plant

Plate 8. Plants in the treatment with combination of BA and GA 500ppm, each [$(G_1+G_2)C_2M$] which were on par with GA 1000ppm


C_2 M
(G_1+G_2)


G_2 C_3 M

4.2.15 Leaf nutrient content

In ground planting, the treatments differed significantly in the content of N,P and K (Table 41). The highest value for N content (1.85 per cent) was recorded for control (N_0) which was on par with the application of BA 500 ppm (G_1C_2M). Application of GA 1000 ppm (G_2C_3M) recorded the lowest value (1.15 per cent) which was on par with all the other growth regulators except BA 500 ppm. For P content, control (N_0) recorded the highest value (0.56 per cent) which was on par with all the other treatments except GA 1000 ppm (G_2C_3M) which recorded the lowest value (0.40 per cent). Regarding K content, the highest value of 1.79 per cent was for the combined application of BA and GA 250 ppm, each, [$(G_1+G_2)C_1M$] which was on par with the other treatments except 500 ppm each of the combination of BA and GA [$(G_1+G_2)C_2M$] which recorded the lowest value of 1.60 per cent.

In pot planting, growth regulators failed to make any significant effect on the NPK content of leaves (Table 42). i.e., all the treatments were on par with respect to their contents.

4.2.16 Chlorophyll content

Data pertaining to chlorophyll (a, b and total) content of ground plants are given in Table 41 and Fig.9. There was significant difference among the treatments with respect to the chlorophyll content. For chlorophyll a, application of GA 500 ppm (G_2C_2M), recorded the highest value (15.45 mg/g) which was significantly better than all the other treatments. The lowest value (9.76 mg/g) was for the combined application of BA and GA each at 500 ppm, [$(G_1+G_2)C_2M$] which was inferior to all the other treatments. In the case of chlorophyll b content also, plants receiving GA 500 ppm (G_2C_2M) recorded the highest value (6.62 mg/g) and was

Plate 9. A general view of the field eight months after planting

Plate 10. Plants in the treatment with 20:20:20 complex 0.50 per cent at biweekly interval ($N_1C_2W_2$)


N1 C2 W2

significantly better than others. The lowest chlorophyll b content (3.63 mg/g) was for the combined application of BA and GA 500 ppm, each [$(G_1+G_2)C_2M$]. With respect to the total chlorophyll, the highest content (22.06 mg/g) was recorded by the plants sprayed with GA 500 ppm (G_2C_2M) and the lowest content (13.36 mg/g) was for the combination of BA and GA each at 500 ppm, [$(G_1+G_2)C_2M$] and it was inferior to all the other treatments.

In pot planting, there was significant difference among treatments with respect to the chlorophyll (a, b and total) content of leaves (Table 42 and Fig.9). In the case of chlorophyll a, combined application of BA and GA 250 ppm each [$(G_1+G_2)C_1M$] recorded the highest content (15.48 mg/g) which was significantly better than all the other treatments and the lowest content (11.25 mg/g) was for the plants receiving GA 1000 ppm (G_2C_3M) and it was found to be inferior to all the other treatments. Contents of chlorophyll b and total chlorophyll were also the highest (5.80 mg/g and 21.27 mg/g respectively) in the case of combined application of BA and GA 250 ppm each [$(G_1+G_2)C_1M$] and it was significantly better than all the other treatments. The lowest content of chlorophyll b (4.32 mg/g) was for GA 500 ppm (G_2C_2M) and that of total chlorophyll (16.07 mg/g) was for the application of GA 1000 ppm at monthly interval (G_2C_3M).

4.2.17 Anthocyanin content of flowers

In ground planting, the treatments differed significantly in the anthocyanin content (Table 41 and Fig.10). The highest value (67.88 mg/g) was for the combined application of BA and GA 500 ppm [$(G_1+G_2)C_2M$] each and the lowest value (29.15 mg/g) was for control (N_0) which was inferior to all the other treatments.

Table 41. Effect of growth regulators on the NPK, chlorophyll and anthocyanin contents of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatment	NPK content (%)			Chlorophyll content (mg/g)			Anthocyanin content (mg/g)
		N	P	K	a	b	Total	
1	No	1.85	0.56	1.63	12.45	4.49	16.95	29.15
2	G_1C_2M	1.45	0.45	1.69	11.71	5.17	16.37	59.75
3	G_1C_3M	1.35	0.53	1.70	12.57	4.82	17.39	61.45
4	G_2C_2M	1.18	0.48	1.69	15.45	6.62	22.06	63.25
5	G_2C_3M	1.15	0.40	1.61	12.64	4.40	17.04	53.85
6	$(G_1+G_2)C_1M$	1.28	0.55	1.79	11.19	4.21	15.91	62.88
7	$(G_1+G_2)C_2M$	1.20	0.48	1.60	9.76	3.63	13.36	67.88
CD(0.05)		0.427	0.200	0.507	1.237	1.063	1.723	3.991

Table 42. Effect of growth regulators on the NPK, chlorophyll and anthocyanin contents of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatment	NPK content (%)			Chlorophyll content (mg/g)			Anthocyanin content (mg/g)
		N	P	K	a	b	Total	
1	No	1.70	0.45	1.65	13.39	4.58	17.97	84.18
2	G_1C_2M	1.70	0.46	1.78	13.66	5.54	19.20	66.73
3	G_1C_3M	1.75	0.49	1.65	12.87	4.42	17.29	62.83
4	G_2C_2M	1.45	0.40	1.66	12.71	4.32	17.04	67.93
5	G_2C_3M	1.68	0.46	1.78	11.25	4.83	16.07	56.23
6	$(G_1+G_2)C_1M$	1.78	0.48	1.80	15.48	4.79	21.27	67.20
7	$(G_1+G_2)C_2M$	1.45	0.48	1.73	12.31	4.55	16.86	70.23
CD(0.05)		NS	NS	NS	0.996	NS	1.173	4.170

NS - Non significant

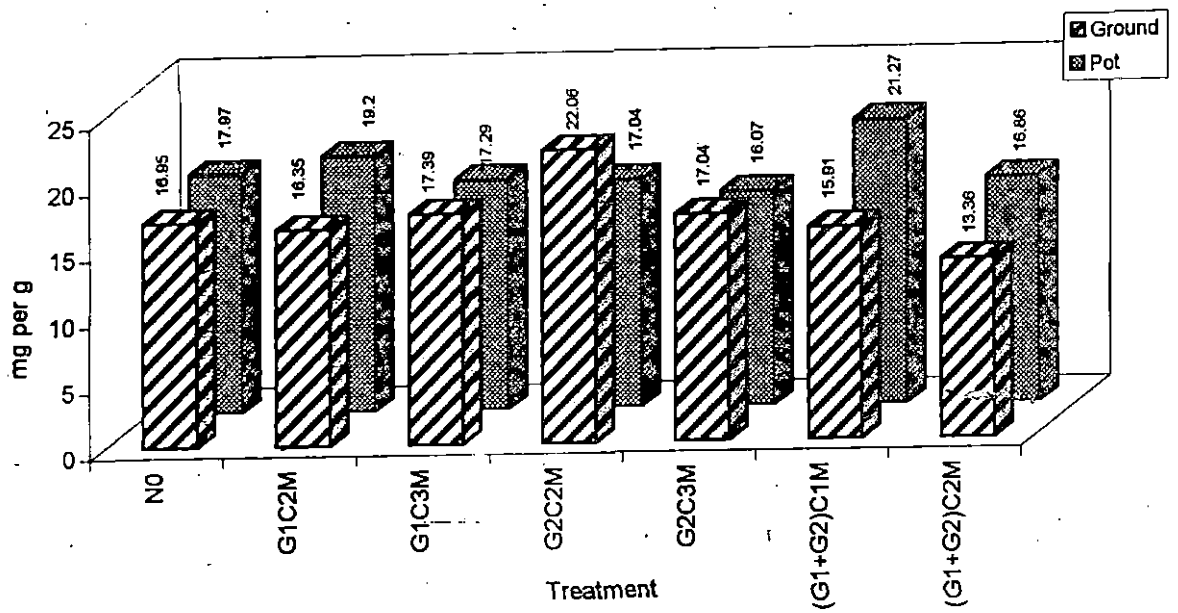


Figure 9. Effect of growth regulators on the total chlorophyll content of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

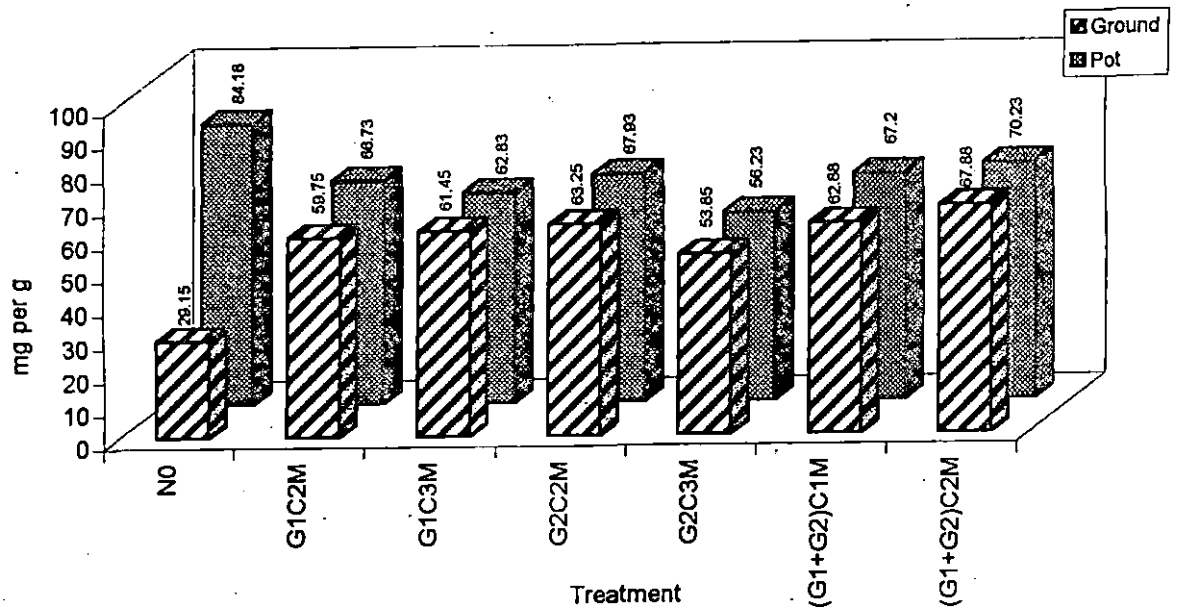


Figure 10. Effect of growth regulators on the anthocyanin content of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

Application of growth regulators decreased the anthocyanin content in pot planting (Table 42 and Fig.10). and they were not statistically significant. The highest value (84.18 mg/g) was recorded for control (N_0) whidh was significantly better than all the other treatments and the lowest value (56.23 mg/g) was for GA 1000 ppm (G_2C_3M) and it was inferior to all the other treatments.

4.2.18 Vase life of flowers

Application of growth regulators increased the vase life of flowers over control in ground as well as pot planting. The data regarding the vase life of flowers in ground planting are presented in Table 43 and Fig.11. Here, growth regulators significantly influenced the vase life of flowers.

Plants receiving BA 1000 ppm at monthly interval (G_1C_3M) showed the symptom of spadix necrosis only after 20.67 days and those receiving GA 500 ppm (G_2C_2M) were first to show the symptom (after 12.67 days).

The highest number of days for spathe blueing to set in (20.33) was taken by plants receiving BA 1000 ppm (G_1C_3M) and the minimum number of days (10.67) was taken by the palnts sprayed with GA 500 ppm (G_2C_3M).

In the case of gloss loss, combined application of BA and GA at 500 ppm, each [$(G_1+G_2)C_2M$] took the highest number of days for the symptom to begin (24.67) and application of GA 500 ppm (G_2C_2M) took the lowest number of days (15.33 days).

Regarding total vase life of flowers, plants receiving BA 500 ppm (G_1C_2M) showed the highest total vase life (34.56 days) and the minimum value (21.33 days) was for control (N_0).

Table 43. Effect of growth regulators on the vase life of flowers of *A. andreanum* cv. 'Hawaiian Red' in ground planting

Sl.No.	Treatments	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Total vaselife (days)
1	No	15.00	12.67	17.00	21.33
2	G_1C_2M	17.89	16.83	19.89	34.56
3	G_1C_3M	20.67	20.33	22.67	30.00
4	G_2C_2M	12.67	10.67	15.33	21.67
5	G_2C_3M	19.83	19.17	21.00	25.67
6	$(G_1+G_2)C_1M$	19.33	18.83	20.33	24.33
7	$(G_1+G_2)C_2M$	19.33	17.00	24.67	28.67
CD(0.05)		1.312	0.999	1.471	1.740

Table 44. Effect of growth regulators on the vase life of flowers of *A. andreanum* cv. 'Hawaiian Red' in pot planting

Sl.No.	Treatments	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Total vaselife (days)
1	No	14.25	13.50	14.50	19.50
2	G_1C_2M	20.50	18.75	24.00	29.00
3	G_1C_3M	23.50	21.75	23.50	34.50
4	G_2C_2M	17.25	16.00	19.25	22.50
5	G_2C_3M	21.50	20.75	22.50	29.50
6	$(G_1+G_2)C_1M$	23.50	20.50	24.00	29.00
7	$(G_1+G_2)C_2M$	19.25	17.75	20.50	26.50
CD (0.05)		1.604	1.455	1.794	2.843

In the case of pot planting also, the treatments differed significantly with respect to the vase life of flowers (Table 44 and Fig.11).

Application of BA 1000 ppm (G_1C_3M) much delayed the symptom of spadix necrosis (upto 23.50 days) which was on par with the combined application of BA and GA each at 250 ppm [$(G_1+G_2)C_1M$] and the symptom was first shown by the control (N_0) plants and they were inferior to all the other treatments.

The highest number of days for spathe blueing to begin (21.75) was taken by the plants applied with BA 1000 ppm at monthly interval (G_1C_3M) which was on par with the application of GA 1000 ppm (G_2C_3M) and combination of BA and GA each at 250 ppm [$(G_1+G_2)C_1M$]. Control (N_0) was first to show the symptom (after 13.50 days) and it was inferior to all the other treatments.

Regarding gloss loss, application of BA 500ppm at monthly interval (G_1C_2M) took the highest number of days (24.00) for the symptom to set in which was on par with the application of BA 1000ppm, GA 1000ppm and combination of BA and GA each at 250ppm. As we have seen before, the symptom was first shown by control (N_0).

The highest total vaselife of flowers (34.50days) was recorded by the plants receiving BA 1000ppm at monthly interval (G_1C_3M) which was statistically better than all the other treatments and the lowest total vase life (19.50days) was for control (N_0).

When we compare the effects of nutrients and growth regulators on the plant characters studied in ground and pot planting, it showed that there were no significant differences among treatments and methods of planting with respect to these characters (Table 45).

Table 45. Effect of nutrients and growth regulators on plant characters in ground and pot planting - a general comparison

Plant characters	Nutrients		Growth regulators	
	Ground	Pot	Ground	Pot
1. Plant height (cm)	9.29	8.72	8.40	8.17
2. Spread - EW (cm)	35.00	33.56	39.57	33.47
3. Spread-NS (cm)	37.57	31.23	33.13	30.57
4. No. of leaves per plant	6.13	6.33	6.33	5.00
5. Leaf length (cm)	15.00	13.89	13.44	13.89
6. Leaf breadth (cm)	10.50	10.50	9.72	9.89
7. Leaf area (cm^2)	114.65	104.46	94.09	99.36
8. No. of suckers per plant	0.22	0.33	3.00	3.50
9. Interval of leaf production	33.41	34.11	35.33	35.78
10. Days to flower	5.00	31.33	34.67	31.33
11. No. of flowers per plant	2.11	1.55	2.34	1.78
12. Stalk length (cm)	24.67	26.06	22.92	19.92
13. Spathe length (cm)	9.50	9.33	8.83	9.00
14. Spadix length (cm)	3.17	2.93	3.08	2.92
15. Interval of flower production	21.58	30.50	25.17	34.11
16. Nutrient content - N (%)	2.23	3.38	1.85	1.78
P (%)	0.77	0.78	0.56	0.49
K (%)	1.80	1.91	1.79	1.80
17. Chlorophyll content (mg/g)				
a	14.36	15.44	15.45	15.48
b	5.50	6.43	6.62	5.54
Total	19.08	21.84	22.06	21.27
18. Anthocyanin content (mg/g)	85.68	93.90	67.88	84.18
19. Vaselife of flowers	19.00	19.00	20.67	23.50

4.3 Post harvest studies

4.3.1 Pulsing

Fifteen different treatments were included for pulsing. Statistical analysis of the data revealed that there were significant differences among treatments with respect to the physiological loss in weight, changes in volume, pH and EC of vase solution and symptoms of senescence viz., spadix necrosis, spathe blueing, gloss loss and complete death of the flowers (Table 46 and Fig 12).

In the case of spadix necrosis, pulsing with BA 150 ppm for 8 hours showed the symptom much later than all the other treatments (after 19.50 days) and it was significantly better than all the other treatments. The symptom was first shown (within 8.89 days) by BA 250 ppm which was on par with all the other treatments except Triadimefon 10 ppm, BA 25 ppm and BA 150 ppm. Spathe blueing, gloss loss and total collapse of the flowers were also much delayed by BA 150 ppm (after 37.83, 32.0 and 43.33 days, respectively) and it was significantly better than all the other treatments.

Spathe blueing was first shown (after 12.22 days) by the control which was on par with all the others except BA 25 ppm and BA 150 ppm. Gloss loss was also first manifested in control (after 13.44 days) which differed significantly from BA 150 ppm, BA 100 ppm and Bavistin 0.1 per cent. Regarding total collapse of flowers, it was first shown by BA 250 ppm (after 15.33 days) which was on par with control, higher concentrations (250 ppm and 300 ppm) of BA, Bavistin 0.1 per cent and 0.2 per cent and higher concentrations (25 and 50 ppm) of Triadimefon.

Uptake of holding solution was maximum in BA 150 ppm (41.0 ml) which differed significantly from all the other treatments. Uptake of holding

Table 46. Effect of pulsing on the longevity of anthurium cv. 'Hawaiian Red'

Sl. No	Treatment	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Total vaselife	Change in volume (ml)	Change in pH	Change in EC (ms/cm)	Physiological loss in weight (g)
1	Bavistin 0.1% for 8 hours	9.56	13.22	16.33	17.22	-7.33	1.02	-0.01	4.23
2	Bavistin 0.2% for 8 hours	10.45	12.78	14.33	17.11	-9.67	1.23	-0.01	4.50
3	Triadimefon 10 ppm for 8 hours	12.17	14.17	14.17	23.33	-13.67	-0.20	0.03	5.13
4	Triadimefon 20 ppm for 8 hours	11.83	14.00	14.00	22.83	-12.00	-0.23	-0.01	5.08
5	Triadimefon 25 ppm for 8 hours	10.33	14.11	14.44	17.45	-10.33	1.23	0.00	5.00
6	Triadimefon 30 ppm for 8 hours	11.50	13.50	13.50	19.83	-14.00	-0.23	0.00	4.80
7	Triadimefon 50 ppm for 8 hours	9.78	14.11	14.55	17.23	-10.00	1.20	-0.01	3.73
8	BA 25 ppm for 8 hours	12.83	15.83	14.83	23.17	-17.33	-0.30	-0.03	4.30
9	BA 50 ppm for 8 hours	10.44	15.11	15.00	17.78	-9.00	1.27	-0.01	3.50
10	BA 100 ppm for 8 hours	10.67	15.00	16.45	19.67	-7.33	1.23	0.00	3.63
11	BA 150 ppm for 8 hours	19.50	37.83	32.00	43.33	-41.00	-0.20	-0.01	6.75
12	BA 200 ppm for 8 hours	11.00	13.50	15.00	18.83	-8.67	-0.29	0.02	5.03
13	BA 250 ppm for 8 hours	8.89	13.11	13.78	15.33	-6.00	-0.36	0.03	3.53
14	BA 300 ppm for 8 hours	9.00	12.44	14.33	15.83	-6.33	-0.46	0.04	3.60
15	Control	9.00	12.22	13.44	15.34	-6.33	0.30	0.03	3.75
	CD(0.05)	2.951	3.07	2.04	3.315	5.202	0.346	0.053	NS

NS - Non significant

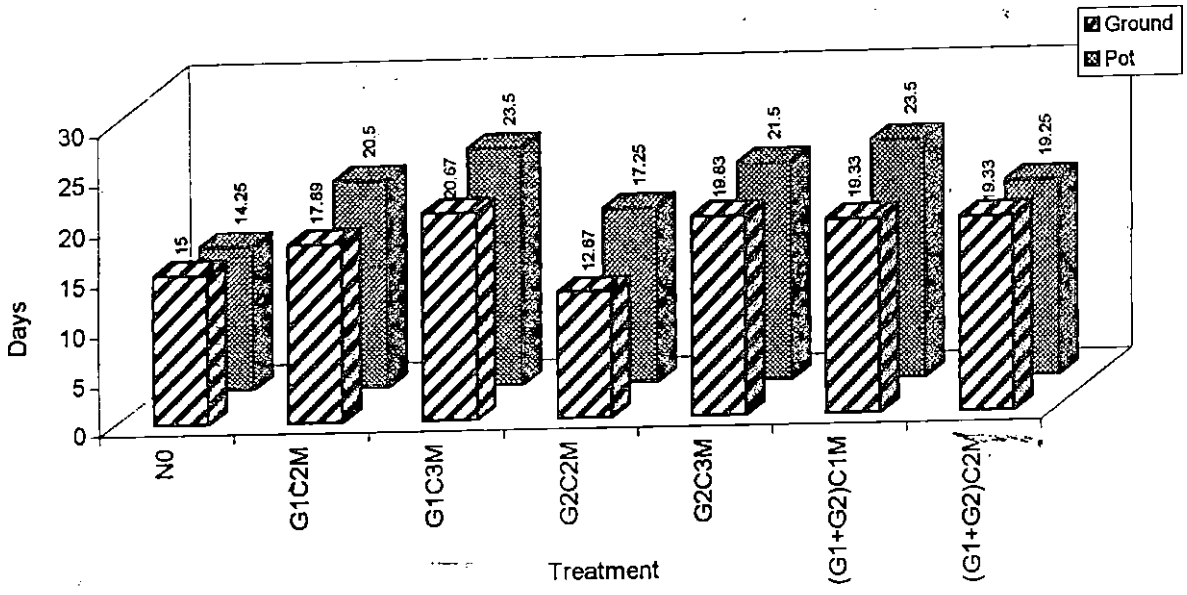


Figure 11. Effect of growth regulators on the vaselife of flowers of *A. andreanum* cv. 'Hawaiian Red' in ground and pot planting

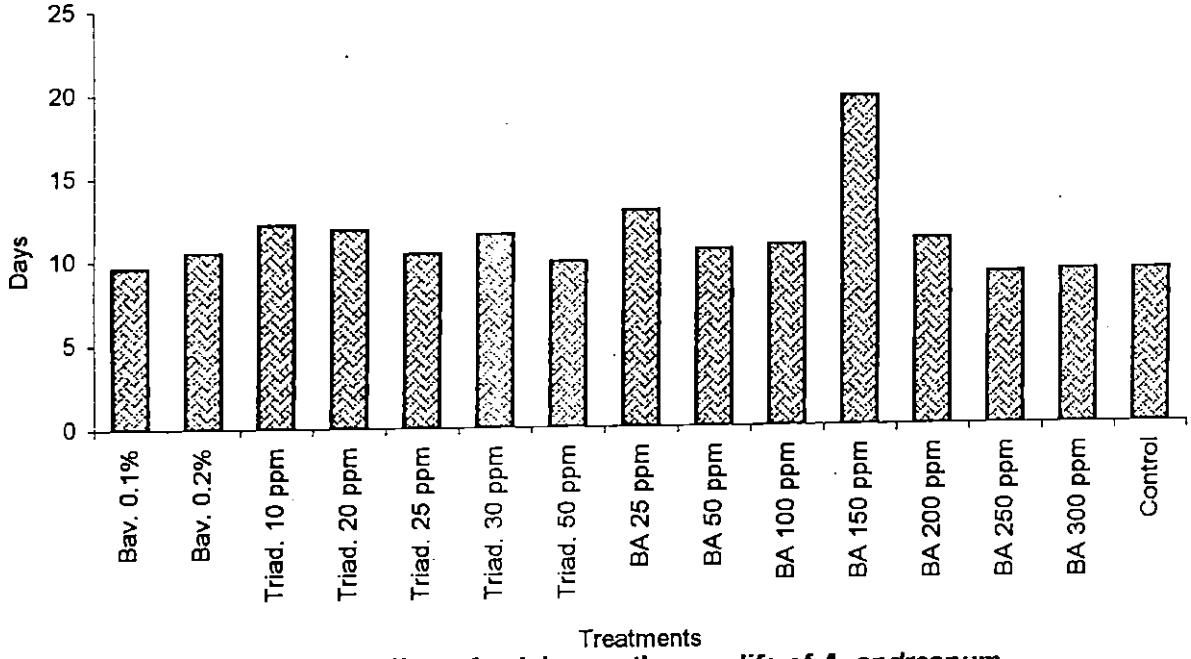
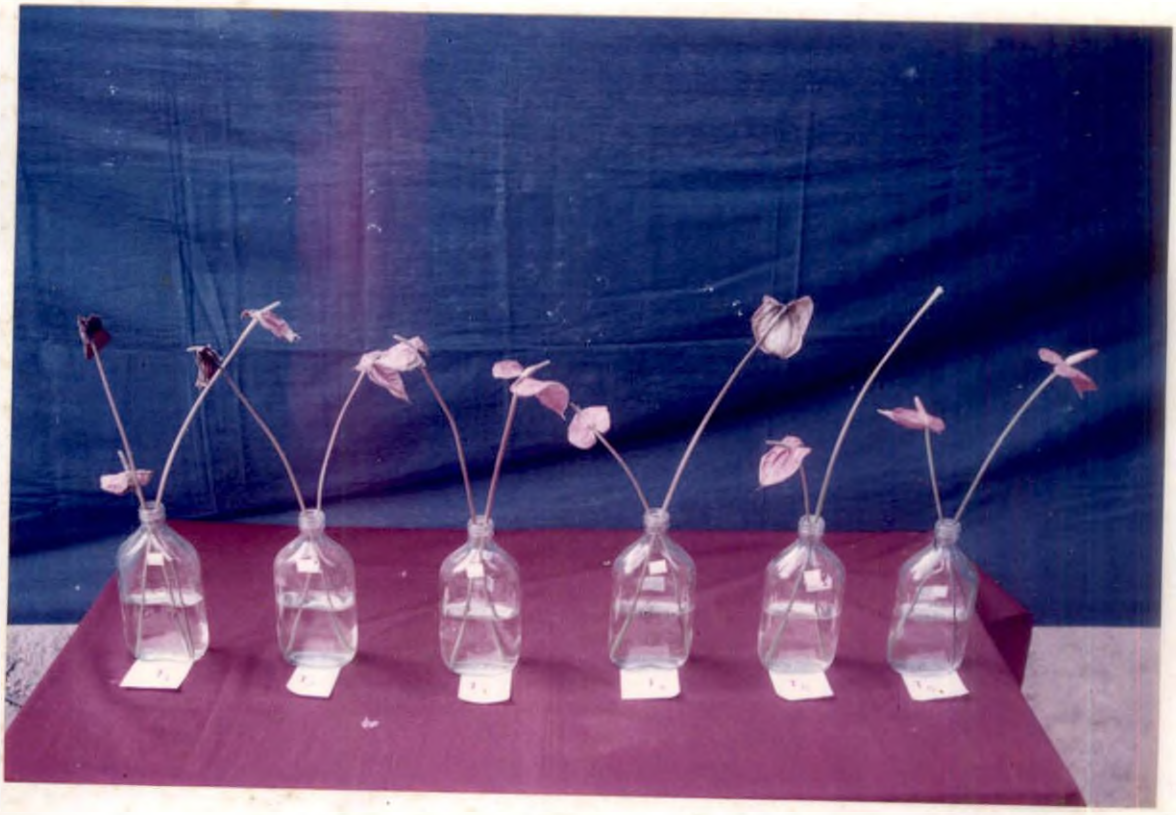


Figure 12. Effect of pulsing on the vaselife of *A. andreanum* cv. 'Hawaiian Red'.

Plate 11. Effect of pulsing on the vase life of anthurium flowers
(T1-Control, T2- Triadimefon 10ppm, T3- Triadimefon 20ppm,
T4- Triadimefon 30ppm, T5- BA 25ppm, T6- BA 150ppm)



solutions in all the other treatments were on par and the minimum uptake (6.0 ml) was in BA 250 ppm.

Increase of pH was seen in Bavistin, higher levels (25 and 50 ppm) of Triadimefon, lower levels (50 and 100 ppm) of BA and control. All these were on par with each other. Among them highest increase (+1.23) was seen in BA 50 ppm. Reduction in pH was seen in the lower levels (10 and 20 ppm) of Triadimefon and higher levels (150, 200, 250 and 300 ppm) of BA, all of which were on par.

Regarding EC of the holding solution, it increased in the case of higher levels of BA and the maximum increase was in the case of BA 300 ppm (+0.042 ms/cm) which was on par with all the other treatments except BA 25 ppm which showed maximum reduction in EC (-0.026 ms/cm). Pulsing with Bavistin and higher levels of Triadimefon also showed reduction in EC, but they were not significant.

In the case of physiological loss of weight, all the treatments were on par. The highest loss (-6.75g) was in the case of pulsing with BA 150ppm and the lowest (-3.50g) was in the case of pulsing with BA 50ppm.

4.3.2 Plugging

The basal portions of flowers, immediately after harvest, were plugged with a piece of cotton dipped in different chemicals like Triadimefon, Bavistin and BA and observations were taken on the symptoms of senescence as in the case of plusing. Analysis of the data revealed that the treatments differed significantly with respect to the parameters studied (Table 47 and Fig.13).

Table 47. Effect of plugging on the longevity of *A. andreanum* cv. 'Hawaiian Red'

Sl.No.	Treatment	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Days to total death
1	BA 25 ppm	8.33	12.67	10.67	20.67
2	BA 50 ppm	10.44	15.67	10.56	24.44
3	BA 100 ppm	6.00	9.33	6.33	18.67
4	Triadimefon 10 ppm	6.89	9.67	8.33	17.33
5	Triadimefon 20 ppm	8.00	10.44	9.33	18.78
6	Triadimefon 30 ppm	8.11	8.33	7.89	19.22
7	Bavistin 0.1%	6.33	7.56	7.00	19.56
8	Bavistin 0.2%	7.00	9.00	8.67	19.55
9	BA 25 ppm + Bavistin 0.1%	9.22	12.11	10.11	22.78
10	BA 50 ppm + Bavistin 0.1%	6.44	8.44	7.22	18.89
11	BA 100 ppm + Bavistin 0.1%	6.44	8.44	7.78	22.67
12	Distilled water control	6.67	7.45	7.00	17.00
13	Control (tap water)	5.67	8.33	5.89	16.67
	CD (0.05)	0.579	0.762	0.581	0.563

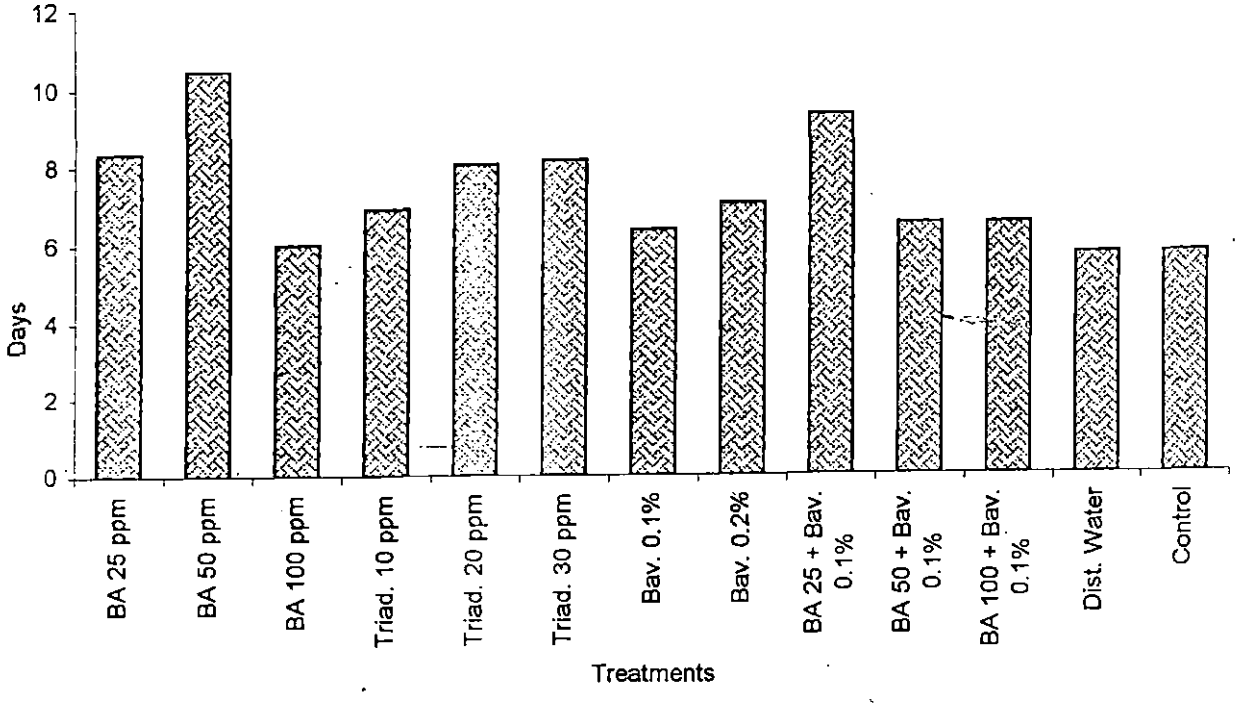


Figure 13. Effect of plugging on the vaselife of *A. andreanum* cv. 'Hawaiian Red'.

Flowers plugged with BA 50 ppm took maximum number of days (10.44) for the spadix necrosis to appear and differed significantly from all the other treatments. The symptom was first manifested (within 5.67 days) in flowers plugged with tap water (control) which was on par with flowers plugged with BA 100 ppm.

In the case of spathe blueing, flowers plugged with BA 50 ppm showed the symptom only after 15.67 days which was significantly better than all the other treatment and the minimum number of days (7.45) was taken by the flowers in tap water control and it was on par with flowers plugged with Bavistin 0.1 per cent. BA 25 ppm took 12.67 days for the symptom to appear.

Symptoms of gloss loss was much delayed in flowers plugged with BA 25 ppm (after 10.67 days) which was on par with flowers in BA 50 ppm (10.56 days) and combination of BA 25 ppm and Bavistin 0.1 per cent (10.11 days). The symptom was first seen (within 5.89 days) in flowers plugged with tap water which was on par with that of BA 100 ppm (6.33 days).

Regarding the total vase life of flowers, the highest value (24.44 days) was recorded in the case of plugging with BA 50 ppm and the lowest total vaselife (16.67 days) was recorded in the case of control.

4.3.3 Waxing

Table 48 depicts the effect of waxing of different parts of anthuriam cut flowers on their vase life. Waxing of spathe and spadix took maximum number of days (12.33) for the symptoms of spadix necrosis to appear and it was on par with the other treatments. The lowest number of days (11.83) was taken by the flowers which were given waxing to spadix alone or to spathe, spadix and cut end.

Table 48. Effect of waxing on the longevity of *A. andreanum* cv. 'Hawaiian Red'

Sl.No.	Treatment	Days to spadix Necrosis	Days to spathe blueing	Days to gloss loss	Days to total death
1	Base alone	12.00	12.33	14.17	15.50
2	Spadix alone	11.83	12.83	14.67	17.17
3	Spathe + spadix	12.33	14.17	16.33	17.50
4	Spathe + spadix + base	11.83	14.00	15.33	16.83
5	Control - no waxing	12.00	13.33	14.33	16.00
	CD(0.05)	NS	NS	NS	NS

NS- Non significant

Regarding spathe blueing, flowers with spathe and spadix waxed showed the symptom only after 14.17 days and the symptom was first manifested (within 12.33 days) in flowers which were given waxing to the cut ends.

In the case of gloss loss also, flowers in which spathe and spadix were waxed took the highest number of days (16.33) for the symptom to appear and the flowers in which the cut ends were waxed took the lowest number of days (14.17) for the symptoms to appear.

Total collapse of the flowers was also much delayed (up to 17.50 days) in flowers in which the spathe and spadix were waxed and the symptom was first seen (within 15.50 days) in flowers with waxing on cut ends.

4.3.4 Packing studies

Anthurium flowers were harvested in the morning, the cut ends were plugged with cotton dipped in distilled water. They were then given waxing on spathe and spadix which was found to be the best method of waxing in the study conducted earlier. The spathe and spadix were then covered with polythene sleeves and covers and packed in card board boxes with and without $KMnO_4$. Observations were taken on the symptoms of senescence and the data are presented in Table 49. Analysis of the data revealed that there was significant difference among treatments with respect to the onset of the symptoms of senescence.

The flowers packed in boxes with the spathe covered with polythene bags after waxing and with $KMnO_4$ took the highest number of days (13.45) for the symptom of spadix necrosis to set in which was on par with covering of polythene sleeves of the same treatment. Flowers packed without any treatment, waxing, $KMnO_4$ or polythene bags/sleeves, (control) took the lowest number of days (10.47)

for the symptom to appear and it was on par with the treatment involving covering the spathe with polythene covers and packing without waxing and $KMnO_4$.

The treatment involving covering the spathe in poly bags with $KMnO_4$ after waxing manifested the symptom of spathe blueing only after 16.95 days which was significantly better than all the other treatments. The minimum number of days (12.13) was taken by the flowers packed without any treatment (control) as in the case of spadix necrosis. Control with $KMnO_4$ only and flowers packed in polythene sleeves with $KMnO_4$ and wthout waxing were also on par with this.

Regarding gloss loss also, the symptom was much delayed in the case of flowers packed in polythene covers with $KMnO_4$ after waxing (upto 17.52 days) which was on par with the same treatment without $KMnO_4$. The symptom was first seen (after 14.08 days) in control with $KMnO_4$ but without waxing which was on par with the controls in the experiment with and without $KMnO_4$ and waxing.

In the case of total vase life of flowers, highest value (19.60 days) was obtained for flowers packed in polythene covers with $KMnO_4$ after waxing which was significantly better than all the other treatments. The shortest total vase life (15.67 days) was recorded for the flowers packed without polythene covers/sleeves, $KMnO_4$ and waxing (control) which was on par with controls in the experiment with and without $KMnO_4$ and waxing, flowers packed in polythene covers without $KMnO_4$ and waxing, and flowers packed in polythene sleeves with $KMnO_4$ and without waxing.

Packing in polythene covers was significantly better than that in polythene sleeves. Ethylene absorbant ($KMnO_4$) did not make any significant effect on the senescence process of flowers but waxing made significant effect on these

Table 49. Effect of packing methods on the longevity of *A. andreanum* cv. 'Hawaiian Red'

Sl.No.	Treatment	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Days to total death
1	Polythene sleeves without $KMnO_4$	11.60	14.13	16.40	17.20
2	Polythene covers without $KMnO_4$	10.73	14.53	15.57	16.47
3	Control without $KMnO_4$	10.47	12.13	14.73	15.67
4	Polythene sleeves with $KMnO_4$	11.75	12.42	14.50	16.08
5	Polythene covers with $KMnO_4$	12.00	14.17	15.75	16.92
6	Control with $KMnO_4$	11.67	12.33	14.08	15.83
7	Polythene sleeves + waxing without $KMnO_4$	12.25	14.17	15.33	16.83
8	Polythene covers + waxing without $KMnO_4$	12.78	15.58	16.58	18.08
9	Control + waxing without $KMnO_4$	11.75	14.08	15.17	16.34
10	Polythene sleeves + waxing with $KMnO_4$	12.83	15.50	16.33	17.92
11	Polythene covers + waxing with $KMnO_4$	13.45	16.95	17.52	19.60
12	Control + waxing with $KMnO_4$	12.08	14.18	15.67	16.68
	CD(0.05)	0.635	1.21	1.15	0.817

characters i.e., waxed flowers showed the symptoms one to four days after that of unwaxed flowers.

4.3.5 Packing with combination of treatments

The best treatments from the above experiments i.e., pulsing (BA 150 ppm), plugging (BA 50 ppm), waxing (to spathe and spadix) and packing (polythene covers) were selected and their different combinations were tried in packing studies. Observations were taken on the initiation of senescence processes and the data are presented in Table 50. Analysis of the data revealed that the treatments differed significantly with respect to these characters. The experiment was conducted with and without $KMnO_4$ and the flowers were packed in polythene covers in packing boxes.

Flowers given pulsing with BA 150 ppm for 8 hours and then plugged with BA 50 ppm and packed in polythene covers with $KMnO_4$ after waxing showed the symptom of spadix necrosis only after 13.62 days which was on par with flowers given pulsing with BA 150 ppm and kept in plastic vials with BA 50 ppm and packed in polythene covers with $KMnO_4$ after waxing. The symptom was first seen (after 9.92 days) in flowers packed with $KMnO_4$ but without any other treatment and those given pulsing with BA 150 ppm and plugging with BA 50 ppm.

Same was the case with spathe blueing. The maximum number of days (17.08) - for the symptom to appear - was taken in the case of flowers given pulsing with BA 150 ppm and plugging with BA 50 ppm and then packed with $KMnO_4$ in polythene covers after waxing and it was significantly better than all others. The symptoms was first set in (within 11.70 days) in control with $KMnO_4$ which was on par with flowers given pulsing with BA 150 ppm and plugging with BA 50 ppm without $KMnO_4$ and pulsing + plugging + waxing without $KMnO_4$.

Table 50. Effect of combination of pulsing, plugging, waxing and packing methods on the longevity of *A. andreanum* cv. 'Hawaiian Red'

Sl.No.	Treatment	Days to spadix necrosis	Days to spathe blueing	Days to gloss loss	Days to total death
1	Pulsing BA 150 ppm + plugging BA 50ppm without $KMnO_4$	10.11	11.78	12.17	13.47
2	Pulsing BA 150 ppm + waxing without $KMnO_4$	12.79	15.55	17.03	17.93
3	Plugging BA 50 ppm + waxing without $KMnO_4$	11.72	14.57	15.23	16.03
4	Pulsing BA 150 ppm + plugging BA 50ppm + waxing without $KMnO_4$	12.08	13.68	15.00	15.00
5	Pulsing BA 150 ppm + BA 50ppm in plastic vials + waxing without $KMnO_4$	10.63	12.08	13.55	14.93
6	Control without $KMnO_4$	10.72	14.08	14.70	16.32
7	Pulsing BA 150 ppm + plugging BA 50ppm with $KMnO_4$	11.08	13.32	14.08	15.40
8	Pulsing BA 150 ppm + waxing with $KMnO_4$	11.92	14.92	15.85	16.23
9	Plugging BA 50 ppm + waxing with $KMnO_4$	11.38	15.38	16.48	17.85
10	Pulsing BA 150 ppm + plugging BA 50ppm + waxing with $KMnO_4$	13.62	17.08	17.48	18.57
11	Pulsing BA 150 ppm + BA 50ppm in plastic vials + waxing with $KMnO_4$	13.38	16.08	16.63	17.67
12	Control with $KMnO_4$	9.92	11.70	12.83	13.45
CD (0.05)		0.596	0.805	0.736	0.793

As in the case of spadix necrosis and spathe blueing, the same treatment showed much delayed gloss loss and total vase life (after 17.48 and 18.57 days respectively) which was on par with the flowers given pulsing with BA 150 ppm and waxing and packed without $KMnO_4$. Gloss loss was first seen in the treatment involving pulsing with BA 150 ppm + plugging with BA 50 ppm and packing without $KMnO_4$ (after 12.17 days) and it was inferior to all the other treatments. Regarding total vase life, the lowest value (13.45 days) was recorded for control with $KMnO_4$ which was on par with flowers receiving pulsing with BA 150 ppm + plugging BA 50 ppm and packing without $KMnO_4$.

Use of $KMnO_4$ delayed the senescence by one to two days in all the parameters under study.

Discussion

DISCUSSION

The results of the experiments carried out to regulate the flowering and post-harvest behaviour of anthurium cv. 'Hawaiian Red' using nutrients and growth regulators in ground as well as pot plantings are discussed here.

Anthuriums, which are grown for the colourful longlasting flowers and unusually attractive foliage, belong to the family Araceae and are originated in American tropics. The commercial cultivation of anthurium is gaining importance in Kerala. But due to the lack of research and development support available in the state, the management practices adopted by farmers during cultivation and after harvest are not scientific. So the present investigation was aimed at studying the effects of foliar application of nutrients and growth regulators to enhance growth, yield and quality of flowers in this crop. Experiments were conducted to enhance the vase life of cut flowers by means of pulsing, plugging, waxing and their combinations using different chemicals like BA, Bavistin and Triadimefon. The effect of ethylene absorbant ($KMnO_4$) on the vase life of cut flowers was also studied. Standardisation of the best method of packing for anthurium cut flowers was another objective.

Anthurium plants grow satisfactorily in a wide variety of media if appropriate practices are followed (Poole *et al.*, 1990). Fertilization requirements depend upon light intensity, irrigation and medium of growth. Excess fertilizer should be avoided to prevent diseases. Temperature will influence growth and flowering and must be considered.

Anthurium responds well to ample supply of nutrients and the major elements for the proper growth and flowering of the plants are N, K, Ca and Mg. Poole and Mc Connel (1971) recommended the use of a commonly used 14:14:14

dry fertilizer mixture for anthuriums in Florida. Valk (1975) suggested that a fertilizer dose of 15-20 g N and 22-30 g K_2O/m^2 was optimum for anthuriums in Netherlands. Salvi (1997) recommended the use of 17:17:17 fertilizer complex 1.00 per cent at weekly interval for better growth and flowering in anthurium. Under these circumstances, three different fertilizer mixtures (20:20:20, 20:20:40 and 20:40:40) 0.25 per cent, 0.50 per cent and 1.00 per cent each at weekly and biweekly intervals were used in the present study. The commonly used 17:17:17 fertilizer complex 1.0 per cent at weekly interval was given as the control.

Growth regulators play a very important role in the cultivation of any ornamental plant. Of late, growth regulators are being increasingly used in anthurium for enhancing the growth, flowering and the post harvest longevity of cut flowers. According to Henny (1989), flowering could be induced in aroids with a single foliar application of 250 mg l^{-1} of gibberellic acid. GA_3 750 ppm produced maximum laterals in topped plants whereas BA 250 ppm was more effective on intact plants (Anu,G.K. 1997). Salvi (1997) suggested that spraying of BA 750 ppm at monthly interval produced more plant height, leaf length, breadth and petiole length. According to Valsalakumari *et al.* (1998), GA 1000 ppm resulted in the maximum size of spathe, length of stalk and number of inflorescences produced per year. Taking into account these factors, two growth regulators, viz., BA and GA_3 were used in the study at two different concentrations (500 and 1000 ppm) and their combinations at 250 and 500 ppm, each.

5.1 Influence of nutrients and growth regulators on plant characters

The parameters which are used to estimate the quality of a variety are plant height, spread, number and size of leaves, number of suckers and number and size of flowers. In the present study, it was seen that nutrients and growth regulators influenced these characters.

5.1.1 Plant height

In ground planting, nutrients had significant effect on plant height in the 6th and 8th months only. The maximum height (9.29 cm) was recorded in the treatment involving the application of 20:20:20 fertilizer complex 1.0 per cent at weekly interval which was on par with the higher levels of P and K (20:20:40 and 20:40:40 complexes).

In pot planting, plant height was influenced significantly by the nutrients in the 5th, 6th, 7th and 8th months. The highest value for plant height (8.73 cm) was recorded in the case of 20:40:40 fertilizer complex applied at 1.0 per cent at biweekly interval and it was on par with the other complexes (20:20:20 and 20:20:40) applied at 0.5 per cent and 1.0 per cent levels. The incidence of leaf blight was more at the higher levels of nutrients. These results are in conformity with the reports of Boertje (1978), Higaki and Poole (1978), Henny *et al.* (1988) and Salvi (1997) who reported increase in plant height which have received optimum dose of nutrients for their proper growth. The reports of Poole *et al.*, (1990) that excess fertilizer favoured bacterial blight is also correct here. In the present study, the optimum dose of N, P, K for ground plants was found to be 20:20:20 complex 1.0 per cent at weekly interval and that for pot plants was 20:40:40 complex 1.0 per cent at biweekly interval.

Growth regulators had significant effect on plant height in ground planting from 4th month to 8th month. The maximum height (8.40 cm) was recorded in the case of BA 500 ppm which was on par with BA 1000 ppm and the combined application of BA and GA at 250 and 500 ppm each.

In pot planting, the height was significantly influenced by growth regulators from 6th to 8th month. Combined application of BA and GA at 250 ppm

each recorded the maximum height (8.17 cm) which was on par with 500 ppm of BA and combination of BA and GA. These findings are in line with the reports of Higaki and Rasmussen (1979), Imamura and Higaki (1988) and Anu (1997), that the use of BA and GA in anthurium increased the shoot formation, suckering and lateral shoot production. In the present study, the optimum dose of growth regulators for ground plants was BA 500 ppm and for pot plants, a combination of BA and GA 250 ppm, each. The increase in height may be due to the increased cell division as a result of application of BA alone is in combination with GA.

5.1.2 Spread

In ground planting, nutrients had significant effect on the plant spread in EW and NS directions. Application of nutrients had significant effect on EW spread in the 6th month only. The maximum EW spread (41.0 cm) was recorded for the application of 20:20:20 complex 0.5 per cent at biweekly interval. There was significant difference in NS spread in the 5th and 8th month. Here also, the maximum spread (39.53 cm) was recorded for 20:20:20 complex 0.5 per cent at biweekly interval.

In pot planting, the nutrients failed to make any significant effect on plant spread in NS and EW direction. Control recorded the highest spread (44.20 cm) in EW direction and the highest NS spread (45.70 cm) was recorded for the application of 20:20:20 complex 1.0 per cent at weekly interval.

Growth regulators were unable to make any significant effect on plant spread in EW and NS direction, either in ground planting or pot planting, except EW spread in ground. Here the maximum spread (42.23 cm) was recorded in the case of combined application of BA and GA at 250 ppm each and the highest NS spread (39.60 cm) was in the case of BA 500 ppm.

In pot planting, control recorded the highest EW spread (44.20 cm) and the highest NS spread (42.10 cm) was in the case of combined application of BA and GA 250 ppm, each.

Maximum spread for all the treatments was recorded in the 6th month which then started declining. This may be due to the reduced length of petioles of leaves emerged in the later stages. The results in nutrient studies in ground are in accordance with the findings of Poole and Greaves (1969) that application of N, P and K enhanced the growth and flowering in anthurium. The reports of Salvi (1997) that growth regulators had little effect on the NS and EW spread of anthuriums are on similar lines.

5.1.3 Number of leaves/plant

The effect of nutrients on the number of leaves/plant was not significant in ground planting. But in pot planting, the effect was significant in the 5th month. The maximum number of leaves (7.0) was produced by the plants receiving 20:20:20 complex 0.25 per cent at weekly interval which was on par with 0.50 per cent of other complexes (20:20:40 and 20:40:40) at weekly interval or 1.00 per cent at biweekly interval. This result is in line with the report of Henny and Fooshee (1989) that the plant growth in anthurium was best at the lower fertilizer levels.

Regarding growth regulators, their effect was significant in ground planting only. The maximum number of leaves (7.33) was produced by the plants sprayed with BA 500 ppm. In pot planting, all the growth regulators were on par and the maximum number of leaves (8.1) was produced by plants receiving combination of BA and GA 250 ppm each. These results are supported by those of Higaki and Rasmussen (1979), Imamura and Higaki (1988), Anu (1997) and Salvi (1997), that the application of BA and GA increased the production of lateral

shoots/branches and suckers and enhanced their growth too. The increased production of shoots will naturally lead to more number of leaves per plant. In the present study, the optimum dose of growth regulators is BA 500 ppm for ground plants and for pot plants it is the combination of BA and GA 250 ppm, each.

5.1.4 Leaf length and breadth

Nutrients produced no significant effect on leaf length and breadth either in ground or pot plantings, but growth regulators influenced significantly these parameters, both in ground as well as pot plantings.

In ground planting, the highest leaf length (13.66 cm) was recorded for control and the broadest leaf (9.44 cm) was produced by the combined application of BA and GA 250 ppm, each.

The longest leaf in pot planting (13.89 cm) was recorded for control and leaf breadth was also maximum (9.89 cm) for control. Generally, application of growth regulators decreased the leaf length and breadth as is evident from the data. This may be because of the fact that application of growth regulators increased the shoot production which in turn lead to more number of leaves per plant. As the number of leaves increases, the size generally decreases. This is in accordance with the reports of Higaki and Rasmussen (1979), Anu (1997) and Salvi (1997).

5.1.5 Leaf area

The leaf area did not differ significantly among the nutrient levels either in ground or pot planting. Application of Ca, Mg or vit. B_{12} also did not make any significant effect.

The effects of growth regulators on leaf area were significant both in ground as well as pot planting. Their application generally decreased the leaf area. Maximum values for leaf area in ground as well pot (98.38 cm^2 and 99.36 cm^2 respectively) were recorded for control. This indicates that growth regulators decreased the leaf area over nutrients (control). As the application of growth regulators decreased the length and breadth of leaves, leaf area was also decreased due to the application of growth regulators.

5.1.6 Number of suckers/plant

The effects of nutrients on the number of suckers produced per plant were not enough to produce any significant difference either in ground or in pot planting. Application of Ca, Mg or vit. B_{12} also did not produce any added advantage over control. But growth regulators produced significant effects in ground as well as pot planting. In ground the highest number of suckers per plant (3.00) was recorded by the plants sprayed with GA 1000 ppm at monthly interval which was on par with BA 1000 ppm and their combinations at 250 and 500 ppm, each. Instead of going for the higher concentrations of growth regulators, a combination of BA and GA 250ppm, each could be better. In pot also, growth regulators made significant effect on the number of suckers produced per plant from the 6th month onwards. Here also, the highest number of suckers per plant (3.50) was produced by the plants sprayed with GA 1000 ppm at monthly interval, which was on par with the application of BA 1000 ppm. In both ground and pot plantings, control plants produced no suckers at all. These results are in conformity with the reports of Higaki and Rasmussen (1979), that increased side shoot production was observed in mature plants treated with GA_3 concentrations of 250 to 1000 mg l^{-1}. This is also supported by the report of Imamura and Higaki (1988) that, with increasing concentrations (0-500 ppm) of GA_3 and BA (0-1000 ppm), the number of lateral

shoots per plant increased both in intact and topped plants. Similar results are also reported by Anu (1997) and Salvi (1997).

5.1.7 Interval of leaf production

Neither nutrients nor growth regulators had any significant effect on the interval of leaf production either in ground or pot planting. In ground planting, the lowest intervals for nutrients and growth regulators (33.41 and 35.33 days, respectively) were recorded in the case of 20:20:20 complex 0.5 per cent at weekly interval and combination of BA and GA 250 ppm, each, at monthly interval. In pot planting, the corresponding values were 34.11 days and 34.67 days, respectively, for 20:20:20 complex 1.0 per cent at weekly interval and combination of BA and GA 500 ppm, each.

5.2 Flowering and flower characters

Anthurium andreanum plants have a juvenile phase during which a vegetative bud is produced in the leaf axil, but in the subsequent generative phase a flower bud is produced. These buds become dormant after initation, and flower development depends on dormancy breaking, although some may die before this occurs. Initially anthurium inflorescences are produced by a dominant central stem and later, it is by laterals. Cultivars with many lateral shoots tend to flower later than those with strong apical dominance (Christensen, 1971). Therefore, how the application of nutrients and growth regulators affect the number of days taken for the first flower to appear, type and number of flowers produced per plant, interval of flower production, size of spathe, length of inflorescence stalk and spadix etc. were studied in detail. The results revealed that these parameters are not influenced significantly by the nutrients and growth regulators, either in ground or pot planting.

Time taken for the first flower to appear in ground planting varied from 5 to 136 days in the case of nutrients. The lowest number of days (5.00) was taken by plants receiving 20:20:40 complex 0.25 per cent at weekly interval. In pot planting, the lowest number of days (31.33) was taken by control.

Regarding growth regulators, the lowest number of days in ground planting (34.67) was taken by the plants sprayed with BA 1000 ppm and in pot, the lowest value (31.33 days) was for control. All the plants have got a juvenile phase after which it starts flowering. So this is in line with the reports of Christensen (1971).

Regarding the number of flowers produced per plant, neither nutrients nor growth regulators could make any significant effect in ground or pot planting. In ground planting, the highest number of flowers per plant in nutrient studies was produced by the plants sprayed with 20:20:40 complex 0.25 per cent at weekly interval. In the case of growth regulators, the highest value in ground was for combined application of BA and GA 250 ppm, each and in pot, the highest value was for the application of BA 500 ppm or GA 1000 ppm or BA and GA 500 ppm, each. The results show that, average number of flowers per plant was more in ground planting and application of growth regulators exerted better results than nutrients. These results are in line with the findings of Nakasone and Kamemoto (1962), Henny (1989), Henny and Hamilton (1992) and Valsalakumari *et al.* (1998) that application of growth regulators like BA and GA enhanced the number of flowers produced per plant.

Regarding the interval of flower production for nutrients, the lowest value in ground (21.58 days) was for 20:20:20 complex 1.0 per cent at weekly interval and in pot, the value (30.50 days) was for 20:20:40 complex 0.25 per cent at weekly

interval. Growth regulators also did not have any significant effect. The lowest intervals were recorded for control.

Different nutrient concentrations failed to make any significant effect on the size of spathe and spadix. Both in nutrient and growth regulator studies, their sizes were more in ground planting than in pot planting. In nutrient studies, the highest spathe size in ground was 9.50cm with the application of Mg 0.5 per cent and for pot, it was 9.33cm in the case of application of 20:20:40 complex 0.5 per cent at weekly interval. Values for Spadix length in ground and pot were the highest (3.06 and 2.93cm, respectievely) in the case of application of 20:20:20 complex 0.25 per cent at weekly interval. Similarly growth regulators produced larger spathe and spadix than nutrients which is evident from the fact that the spathe size and spadix length in nutrients ranged from 2.67cm to 9.50cm and 0.77cm to 3.06cm, respectively, but in growth regulators, the corresponding ranges were from 5.33 to 9.00cm and 1.17 to 3.00cm, respectively. These results are supported by Salvi (1997) and Valsalakumari *et al.* (1998) who reported that application growth regulators increased the size of spathe, spadix and length of stalk of anthurium inflorescences.

The length of stalk of inflorescences was not influenced by the nutrients and growth regulators. The length ranged from 10.67 cm to 24.67 cm in ground and 11.67 cm to 26.06 cm in pots. Here, pot plants were found to produce slightly longer stalks than ground plants.

5.3 Nutrient content of leaves

Application of nutrients made significant effect on the N,P and K contents of leaves in ground planting. As the concentration of nutrients increased, there was a corresponding increase in the nutrient content of leaves. The highest content of N

(2.23 %) was recorded by the plants receiving 20:20:20 complex 1.0 per cent at weekly interval, and the highest P content (0.77 %) was recorded by the plants applied with 20:40:40 complex 1.0 per cent at weekly interval. In the case of K content, the highest value (1.80 %) was recorded for the application of 20:40:40 complex 1.0 per cent at weekly interval. In pot planting, nutrients made significant effect on the N content of leaves only where the highest N content(3.38 %) was recorded in the treatment involving the application of 20:20:20 complex 0.25 per cent at weekly interval. The content of P and K were not affected by the nutrients. From this, it is very clear that, application of nutrients at lower concentrations and frequent intervals is very good for anthurium plants and it enhances the absorption of nutrients too. These results are in conformity with the reports of Higaki *et al.* (1992), that the N content in anthurium leaves is between 1.70 and 2.11 per cent, P content between 0.21 and 0.58 per cent and K content between 2.05 and 3.16 per cent. This is also supported by the findings of Salvi (1997), that the maximum N, P and K contents of anthurium leaves were 2.29 per cent, 0.36 per cent and 2.09 per cent, respectively.

This significant effect of nutrients in ground and the absence of the same in pots may be due to the increased growth of plants in ground which leads to increased photosynthesis and other physiological activities which in turn leads to the increased absorption of nutrients. Interestingly the highest content of N was reported from the treatment which recorded the highest value for height in ground. These results also reveal that higher levels of P and K application increased the contents of the same in leaves as reported by Poole and Greaves (1969).

Growth regulators increased the absorption of K only. The highest value for K (1.79 %) was recorded by the plants sprayed with a combination of BA and GA, each at 250 ppm at monthly interval. In pot planting, their effects were not

strong enough to make any significant difference. These results are in line with the reports of Higaki *et al.* (1992) and Salvi (1997), as seen earlier.

5.4 Pigment content

Nutrients made significant effect on the anthocyamin content of anthurium in pot as well as ground planting. In ground, the highest value (85.07 mg/g) was recorded by the flowers of the plants receiving 20:20:20 complex 0.5 per cent at biweekly interval and in pot, the highest content (93.90mg/g) was for the application of 20:20:20 complex 0.5 per cent at weekly interval.

In growth regulator studies also, their effects were significant in ground as well as pot planting. In ground the highest value (67.88 mg/g) was recorded for the combined application of BA and GA 500 ppm, each, and in pot the highest content (84.18mg/g) was for control.

In the case of chlorophyll (a, b and total) contents of leaves, the treatments differed significantly in ground and pot planting. In ground, the highest value for chlorophyll a content (14.36 mg/g) was recorded for the application of Ca 0.50 per cent along with control, for chlorophyll b (5.50 mg/g) it was in the case of 20:20:20 complex 0.25 per cent at weekly interval and for total chlorophyll (19.08 mg/g) also, it was the same as that of chlorophyll b. In pot planting, the highest chlorophyll (a and total) content (15.44 and 21.84 mg/g, respectively) was in the case of application of 20:20:20 complex 0.50 per cent at biweekly interval. For chlorophyll b, the highest content (6.43mg/g) was in the case of application of 20:20:40 complex 0.50 per cent at biweekly interval.

The effect of growth regulators on the chlorophyll content was similar to that of nutrients. Here the highest values in ground for chlorophyll a (15.45 mg/g),

chlorophyll b (6.62 mg/g) and total chlorophyll (22.06 mg/g) were recorded by the plants receiving GA 500 ppm, at monthly interval. In pot, the highest contents of chlorophyll (a and total) were recorded in the case of combined application of BA and GA 250ppm, each (15.48 and 21.27mg/g, respectively). The highest content of chlorophyll b (5.54mg/g) was in the case of application of BA 500ppm.

From the results, it is very clear that the significant difference in chlorophyll content among treatments in ground planting is not merely due to the effect of either nutrients or growth regulators. As we have seen earlier the performance of plants in ground is much better which leads to the higher content of chlorophyll in ground planting.

5.5 Vase life

The vase life of flowers from all the treatments was studied with respect to the number of days taken for spadix necrosis, spathe blueing, gloss loss and total collapse of flowers. The results revealed that, there were significant differences among treatments in the vase life of flowers in pot planting as well as in ground planting.

In ground planting, the highest number of days for the expression of the symptom of spadix necrosis, spathe blueing and gloss loss (19.00, 18.67 and 20.83 days, respectively) were taken by the flowers receiving 20:20:40 complex 0.50 per cent at weekly interval. The total vase life of flowers was the highest (27.67 days) in the case of flowers receiving 1.00 per cent of 20:20:20 complex at weekly interval. In pot planting, the highest number of days for the symptoms of spadix necrosis and spathe blueing to set in (19.00 and 18.75days, repectively) was taken by the plants receiving 20:20:40 complex 0.25 per cent at weekly interval. The total vaselife was also the highest (27.50 days) in the same treatment. Retension of gloss was the

highest (20.50days) in the application of 20:40:40 complex 0.50 per cent at weekly interval. Here the highest vase life was obtained at lower levels of N and higher levels of K. Reports of Bik (1976), that the maximum number of best quality flowers in anthurium was produced at low N levels; Bik and Straver (1978) that the best quality flowers are produced at medium dose of N and higher doses of K also support this.

Regarding growth regulators, their effect on vase life was significant in ground as well as in pot planting. Generally, growth regulators improved the vase life of flowers much better than nutrients, both in ground as well as pot plantings. In ground planting, the highest number of days for spadix necrosis and spathe blueing to set in (20.67 and 20.33 days, respectively) was taken by flowers receiving BA 1000 ppm at monthly interval. Combination of BA and GA, each at 500 ppm, took the highest number of days (24.67) for gloss loss and application of BA 500 ppm gave the longest total vase life (34.56 days) to flowers. In pot planting, the highest number of days for the symptoms of spadix necrosis and spathe blueing to set in (23.50 and 21.75 days, respectively) was taken by the plants sprayed with BA 1000ppm at monthly interval. Total vaselife was also the highest (34.50 days) in the same treatment. Retension of gloss was the highest (24.00 days) in the case of application of BA 500ppm and combination of BA and GA 250ppm, each. This treatment also recorded the highest content of K (1.80 per cent) in leaves. So the increased retension of gloss may be due to the higher content of K in leaves. From the data, it is very clear that growth regulators extended the vase life of flowers more than the nutrients. These results are in conformity with the reports of Shirakawa *et al.* (1964) that pulse treatment with 10ppm N-6-Benzyladenine, to anthurium cutflowers before shipment reduced the injury during shipment and extended the holding period of flowers.. Treatment with BA was found to generally impart some tolerance to chilling injury and extend the usable period by reducing the respiration rate of flowers. Akamine and Goo (1975); Paull and Goo (1982);

Paull (1987); Salvi (1997) and Valsalakumari *et al.* (1998) have also reported that the use of various growth regulators like BA, GA etc. and chemicals like $AgNO_3$, 8-HQ etc. were much useful in extending the vase life of anthurium flowers.

5.6 Post-harvest studies

Flowers harvested at the correct stage of maturity maintain better quality and vase life. If harvested at immature stage, they do not develop properly in holding solutions after harvest, and over matured flowers last only for a short durations. Generally anthurium flowers are harvested when the spadix is fully developed. According to Antoine (1995),anthurium flowers are harvested at about three-quarters maturity which gives the maximum shelf-life to flowers. According to Paull *et al.* (1992) pre harvest and post harvest factors influence the longevity of cut flowers. He suggested that pre harvest factors explained 63.71 per cent of the variation in the post harvest life. Senescence is generally caused by vascular plugging of unknown origin. Spadix necrosis, spathe blueing, gloss loss, stem collapse, abscission of spathe and spadix and physiological loss in weight are the visible changes associated with senescence (Akamine, 1976).

5.6.1 Pulsing

Pulsing is a short term treatment given to cut flowers immediately after harvest which improves the keeping quality of flowers. It's effect lasts even when the flowers are removed from the chemical and kept in water. In the present study, pulsing of anthurium flowers was done with different chemicals like BA, Triadimefon, Bavistin etc. for 8 hours and their effects on the symptoms of flower senescence (spadix necrosis, spathe blueing, gloss loss and total vase life), changes in the pH, EC and volume of holding solutions and physiological loss of weight

were studied. The data revealed that pulsing has got significant effect on these characters.

Pusling with BA 150 ppm for 8 hours took the maximum number of days (19.50 and 37.83 days, respectively) for spadix recrosis and spathe blueing to set in. Retension of spathe gloss and total vase life of the flowers were also the highest (upto 32.0 and 43.33 days, respectively) in the same treatment. These results are in line with the reports of Shirakawa *et al.* (1964) that pulsing anthurium flowers with N-6-Benzyladenine provided about 19 per cent improvement in vase life. The reports of Salvi (1997) and Valsalakumari *et al.* (1998) that pulsing with BA improved the vase life of anthurium flowers also support this findings. Earlier, the positive effect of pulsing with $AgNO_3$ on the vase life of anthurium flowers was reported by Paull and Goo (1982); Paull *et al.* (1985) and Paull (1987). These reports reveal that the use of growth regulators like BA, GA etc. and chemicals like 8-HQ, $AgNO_3$ etc. imparted resistance to chilling injury, reduced the respiration rate of flowers, prevented microbial contamination of vascular tissues and acted as germicides, there by reducing the injury to flowers and extending their vaselife positively.

Uptake of holding solution was the highest in the case of BA 150 ppm (41.0 ml). Similarly, physiological loss of weight was also the highest in this treatment (-6.75g). This treatment recorded the highest vase life and hence the uptake of vase solution and loss of weight will naturally be high. The pH of holding solution increased in the case of Bavistin, higher levels of Triadimefon and lower levels of BA, the maximum (+1.23) being in the case of BA 50 ppm. Reduction in pH was seen in the case of lower levels of Triadimefon and higher levels of BA, the highest reduction (-0.46) being in the case of BA 300 ppm. Change in EC of holding solution was just reverse to what happended in the case of pH. The highest increase (+0.042 ms/cm) was in the case of BA 300 ppm and reduction (-0.026

ms/cm) was in the case of BA 25 ppm. These changes in the pH and EC of holding solutions may be due to the leakage of solutes from the flowers which might have been absorbed at the time of pulsing. In general, pulsing enhanced the vase life of anthurium flowers by one to two weeks.

5.6.2 Plugging

Immediately after harvest, the cut ends of flowers were plugged with a piece of cotton dipped in chemicals like Bavistin, BA and Triadimefon and observations were taken on the symptoms of senescence. The results revealed that, plugging has got significant effect on the vase life of flowers.

Here the maximum number of days for spadix necrosis and spathe blueing to set in (10.44 and 15.67 days, respectively) were taken by the flowers plugged with BA 50 ppm. Plugging with BA 25 ppm much delayed the gloss loss (upto 10.67 days) and total vase life was the highest (24.44 days) in the case of plugging with BA 50ppm. These results are in accordance with the reports of Shirakawa *et al.* (1964); Salvi (1997) and Valsalakumari *et al.* (1998) that pulsing with BA enhanced the vase life of anthurium flowers. Here, the vase life is less when compared to pulsing. The reason may be that the quantity of solution is very less in cotton, when compared to the volume of pulsing solutions and hence their effect will be comparatively lesser.

5.6.3 Waxing

The results of waxing studies revealed that, waxing of flowers enhanced the vase life of anthurium flowers over unwaxed flowers, but its effects were not statistically significant. The highest vase life was recorded in the case of flowers whose spathe and spadix were waxed. The reports of Watson and Shirakawa

(1967); Paull (1983) and Paull and Goo (1985), that waxing of anthurium very much enhanced the vase life, by reducing the loss of water from spathe and spadix strongly support these findings.

5.6.4 Packing studies

The results of the packing studies revealed that both packing materials (polythene sleeves and covers) and ethylene absorbant ($KMnO_4$) were effective in reducing the vase life of anthurium flowers significantly. The highest values for the number of days taken for spadix necrosis, spathe blueing, gloss loss and total death to set in (13.45, 16.95, 17.52 and 19.60 days, respectively) were recorded for flowers packed in polythene covers with $KMnO_4$. So, generally polythene covers were found to be the best packing material. This is supported by the reports of Shirakawa *et al.* (1964) that enclosing the anthurium inflorescence in a polythene film maintained turgidity and improved longevity. The major cause of flower senescence or wilting is the production of ethylene. So the use of ethylene absorbant ($KMnO_4$) is sure to improve the vase life of flowers and in this study, it is true that the use of $KMnO_4$ enhanced the vase life of flowers.

5.6.5 Packing with combination of treatments

The best treatments from the above studies, viz., pulsing (BA 150 ppm), plugging (BA 50 ppm), waxing (of spathe and spadix) and packing (polythene covers) were selected and their different combinations were tried in packing. The experiment was carried out with and without $KMnO_4$. Since we are using combinations of best treatments, it is sure that the combination of all the best treatments will give maximum vase life. As expected, the highest number of days for spadix recrosis, spathe blueing, gloss loss and total collapse of flowers (13.62, 17.08, 17.48 and 18.57 days, respectively) were taken by flowers given pulsing with

BA 150 ppm for 8 hours and then plugged with BA 50 ppm and packed in polythene covers with $KMnO_4$ after waxing the spathe and spadix. Here the total vase life of control flowers was only 13.45 days.

The use of combination of treatments enhanced the vase life atleast by one week. Similarly, the use of $KMnO_4$ enhanced the vase life by 1 to 2 days than those without $KMnO_4$. So if we are able to give the optimum combination of these treatments, it is sure that the vase life of anthurium flowers can be increased very much.

Having discussed the results obtained in detail we can highlight the following.

The treatments which involved the use of major nutrients in different ratios (1:1:1, 1:1:2 and 1:2:2), concentrations (0.25 per cent, 0.50 per cent and 1.00 per cent) and intervals of application (weekly and biweekly) did not make any significant difference in vegetative characters and flowering of anthurium cv. 'Hawaiian Red' grown in a medium rich in organic matter. Application of Ca, Mg and vitamin B_{12} in addition to major nutrients also failed to show any advantage. But the effect of the nutrients on post harvest longevity of flowers was significant. As the concentration of nutrients increased, the post-harvest longevity of flowers decreased. Flowers from the treatment involving the weekly application of NPK at 20:20:40 0.25 per cent was the best with respect to the post-harvest life. The plants receiving this treatment also flowered earlier and produced the highest total number of flowers.

Regarding the effect of growth regulators, the most significant effect was on sucker production. Among the treatments, a maximum of 3.5 suckers per plant was produced in the treatment involving the application of 1000 ppm GA, whereas

no suckers were produced in control. This treatment also produced the highest number of flowers per plant, highest potassium and chlorophyll contents in leaves and extended the vase life of flowers. This treatment which involved the use of GA at higher concentration, was on par with the treatment involving the combined application of BA and GA, each at 250 ppm, which can be used economically to obtain the same results. Reduction in leaf area was associated with application of growth regulators, which, in no way, affected the flower production.

Use of BA in pulsing after harvest and plugging the cut end of stalk while in transport, significantly increased the post-harvest longevity of flowers. A combination of treatments involving pulsing with BA 150 ppm, plugging the cut end of the stalk with BA 50 ppm, covering the spathe and spadix with polythene covers after waxing and keeping $KMnO_4$ in packing cases delayed the first symptom of senescence to appear on flowers by 4 days.

It is concluded that, when ground and pot plantings are compared, the former was found to be generally better than the latter during the period of the present study with respect to the important vegetative and floral characters of the plant.

Summary

SUMMARY

The salient findings of the investigations on the regulation of flowering and post-harvest behaviour of anthuium cv. 'Hawaiian Red' conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the year 1996-98 are summarised here.

* Nutrients significantly influenced the plant height, both in ground as well as pot planting. Maximum plant height of 9.29 cm for ground planting was recorded in the treatment with 20:20:20 fertilizer complex, 1.0 per cent at weekly interval ($N_1C_3W_2$). In pot planting, the maximum height (8.73 cm) was recorded by the plants receiving 20:40:40 complex 1.0 per cent at biweekly interval ($N_3C_3W_2$). The effect of growth regulators on plant height was also significant in both ground and pot planting.

* Plant spread in EW and NS directions were significantly influenced by the nutrients in ground planting only, where the highest spread in EW and NS directions were recorded for the application of 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$) (41.0 and 39.53 cm respectively). In pot their effects were not significant.

  Growth regulators made significant effect on plant spread only in ground planting, where the application of a combination of BA and GA 250 ppm each at monthly interval [$(G_1+G_2)C_1M$] recorded the highest spread in EW direction (41.23 cm) and the application of BA 500 ppm (G_1C_2M) recorded the highest spread in NS direction (39.60 cm).

* Only in pot planting, the effect of nutrients on the mean number of leaves produced per plant was significant, where the highest number of leaves per

plant (7.0) was produced by the plants sprayed with 20:20:20 complex 0.25 per cent at weekly interval ($N_1C_1W_1$).

Growth regulators significantly influenced the mean number of leaves per plant only in ground planting and the application of BA 500 ppm at monthly interval (G_1C_2M) recorded the highest value of 7.33.

* Leaf length, breadth and area were not influenced significantly by the nutrients either in ground or pot planting. In the case of growth regulators, length, breadth and area of leaves were significantly lesser in treatments than in control.

* Nutrients failed to make any significant effect on the number of suckers produced per plant both in ground as well as pot, but growth regulators significantly influenced the sucker production in both, the highest values for ground and pot (3.00 and 3.50 respectively) being recorded by the plants receiving GA 1000 ppm at monthly interval (G_2C_3M) which was on par with BA and GA, at 250 ppm each.

* Neither nutrients nor growth regulators were able to make any significant effect on the interval of leaf production either in ground or pot.

* Effect of nutrients and growth regulators on the number of days taken for the first flower to appear, interval of flower production and flower characters like size of spathe, spadix and length of stalk were not significant either in ground or pot planting. The plants sprayed with 20:20:40 complex 0.25 per cent at weekly interval ($N_2C_1W_1$) were found to be performing better than plants in the other treatments with higher values for the above characters.

* Application of nutrients significantly influenced the NPK content of leaves in ground and the N content in pot planting. In ground, the highest content of N (2.23%) was recorded by the plants receiving the fertilizer complex 20:20:20 1.0 per cent at weekly interval ($N_1C_3W_1$) and the highest values for P and K contents (0.77% and 1.80% respectively) were recorded by the plants receiving higher levels of P and K (20:40:40) 1.0 per cent at weekly interval ($N_3C_3W_1$). In pot, the highest content of N (3.38%) was recorded by the plants receiving 20:20:20 complex 0.25 per cent at weekly interval ($N_1C_1W_1$).

  Application of growth regulators significantly reduced the N and P contents of leaves compared to control in ground planting, and the highest K content (1.79%) was recorded by the plants sprayed with a combination of BA and GA each at 250 ppm at monthly interval [$(G_1+G_2)C_1M$]. In pot, their effects were not significant.

* Anthocyanin content of flowers in nutrient as well as growth regulator treatments differed significantly both in ground and pot planting. The highest values for anthocyanin content in ground and pot for nutrient treatment were 85.07 mg/g and 93.90 mg/g respectively for the plants receiving 20:20:20 complex 0.5 per cent at biweekly and weekly intervals, respectively. For growth regulators, the corresponding values were 67.88 mg/g and 84.18 mg/g respectively, for a combined application of BA and GA each at 500 ppm [$(G_1+G_2)C_2M$] and control (N_0) respectively.

* Nutrients significantly influenced the chlorophyll content of leaves both in ground and pot. The highest total chlorophyll content (19.08 mg/g) in ground was recorded in the application of 20:20:20 complex 0.25 per cent at weekly interval ($N_1C_1W_1$) and that for pot plants (21.84 mg/g) was recorded in the treatment involving the application of 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$).

Growth regulators also significantly influenced the chlorophyll content. Here the highest content in ground planting (22.06 mg/g) was recorded by the plants receiving GA 500 ppm (G_2C_2M) and in pot plants, the highest content (21.27 mg/g) was recorded in the case of combined application of BA and GA each at 250 ppm [$(G_1+G_2)C_1M$].

* The vase life of flowers was significantly influenced by the nutrients and growth regulators both in ground and pot planting. Among nutrients, the highest vase life for ground and pot plants (19.0, 19.0 days each) was recorded by the plants sprayed with lower levels of N and higher levels of K (20:20:40) 0.25 per cent at weekly interval ($N_2C_1W_1$).

  In growth regulator studies, the highest vase life in ground (20.67 days) was recorded by the plants receiving BA 1000 ppm (G_1C_3M). In pot also, the highest vase life (23.50 days) was for the same treatment and it was on par with combined application of BA and GA each at 250 ppm.

* There was no significant difference between ground planting and pot planting with respect to the growth and flowering during the period of the experiment.

* Pulsing significantly influenced the vase life of flowers, uptake of holding solution, pH and EC of holding solution and physiological loss of weight. The highest number of days for spadix necrosis, spathe blueing and gloss loss to set in (19.50, 37.33 and 32.00 days respectively) were taken by the flowers pulsed with BA 150 ppm for 8 hours, compared to 9.00, 12.22 and 13.44 days respectively in control. Total vase life of flowers, uptake of holding solution and physiological loss of weight (43.33 days, 41.00 ml and 6.75g, respectively) were also the highest in the same.

  pH and EC of the holding solutions increased in some treatments and decreased in some others. The highest increase in pH (+ 1.23) was in the case of pulsing

with BA 50 ppm and reduction (- 0.46) was in the case of BA 300 ppm. Regarding EC, the highest increase (+ 0.42 ms/cm) was in the case of pulsing with BA 300 ppm and reduction (- 0.026 ms/cm) was in the case of pulsing with BA 25 ppm.

* Plugging of cut ends of flowers with different chemicals also significantly influenced the vase life of flowers. The highest number of days for spadix necrosis and spathe blueing to begin (10.44 and 15.67 days, respectively) was taken by the flowers plugged with BA 50 ppm. Gloss loss was much delayed (upto 10.67 days) in the case of plugging with BA 25 ppm. Total vase life of flowers was the highest (24.44 days) in the case of plugging with BA 50 ppm.

* Waxing of different parts of the inflorescence enhanced the vase life, the maximum being in the case of waxing of spathe and spadix, but their effects were not statistically significant.

* Different packing materials (polythene sleeves and covers) significantly influenced the vase life of flowers. Spadix necrosis, spathe blueing and gloss loss were much delayed (upto 13.45, 16.95 and 17.52 days respectively) in the case of flowers packed in polythene covers. Total vase life of flowers was also the highest (19.60 days) in this treatment compared to 16.68 days in control. Use of ethylene absorbant ($KMnO_4$) also enhanced the vase life.

* The effect of combinations of the best treatments including pulsing, plugging and waxing in packing was also significant in enhancing the keeping quality of anthurium flowers. The highest number of days for spadix necrosis, spathe blueing and gloss loss to set in (13.62, 17.08 and 17.48 days, respectively) was the highest in the flowers pulsed with BA 150 ppm for 8 hours, cut end of the stalk plugged with BA 50 ppm and then packed in polythene covers with

$KMnO_4$ after waxing the spathe and spadix. Total vase life of the flowers was also the highest (18.57 days), in the same treatment compared to 13.45 days in control.

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* Originals not seen

Appendix

APPENDIX-I

ANALYSIS OF VARIENCE FOR THE EFFECT OF DIFFERENT TREATMENTS IN GROUND AND POT PLANTING.

Character (source)		DF	Treatment mean sum of squares (months) 1	2	3	4	5	6	7	8
Plant height										
Pot	N	18	6.98	8.49	10.77	13.51	14.80	15.65	15.36	18.08
	G	6	2.40	2.47	5.68	6.64	8.13	11.21	13.23	16.67
Ground	N	18	0.89	1.42	2.24	3.11	5.57	5.76	8.24	14.48
	G	6	1.89	2.51	2.75	4.07	7.25	8.04	11.95	16.07
Plant spread-EW										
Pot	N	18	291.53	318.61	233.32	238.59	74.82	318.18	377.58	329.91
	G	6	210.71	231.62	291.05	78.63	91.40	114.65	125.57	273.16
Ground	N	18	281.56	282.24	185.19	259.77	133.07	199.89	322.24	310.42
	G	6	154.24	147.12	139.19	163.27	62.48	48.47	270.62	581.99
Plant spread-NS										
Pot	N	18	176.47	207.88	168.81	179.81	184.44	349.45	198.01	298.65
	G	6	39.27	41.54	24.60	24.59	56.50	45.06	137.01	278.43
Ground	N	18	316.87	300.50	181.02	197.96	328.22	87.95	351.92	1092.81
	G	6	81.86	101.46	95.97	99.79	53.92	12.96	76.07	118.35
No. of leaves										
Pot	N	18	4.03	5.35	4.86	10.17	17.81	18.22	17.42	21.78
	G	6	5.08	4.36	4.56	5.74	13.11	11.35	12.66	13.92
Ground	N	18	10.59	12.08	10.91	11.58	11.94	18.80	23.72	29.08
	G	6	2.41	4.54	3.68	5.19	6.33	14.46	18.80	26.80
Leaf length										
Pot	N	18	9.16	11.73	12.97	13.48	14.06	55.57	23.95	42.76
	G	6	2.11	4.09	2.91	3.37	6.18	12.63	18.37	39.07
Ground	N	18	53.21	66.31	75.27	68.28	14.88	21.23	20.49	24.66
	G	6	16.64	19.53	23.11	32.30	30.58	24.39	15.28	11.99

Leaf breadth										
Pot	N	18	5.05	10.27	8.88	7.36	9.05	20.76	11.34	13.98
	G	6	3.54	3.23	1.97	1.68	1.44	3.20	8.65	17.79
Ground	N	18	14.28	13.76	10.96	6.11	5.86	3.87	9.60	10.58
	G	6	6.83	10.66	8.49	5.96	2.19	5.35	9.32	8.72
Leaf area										
Pot	N	18	518.77	1293.57	1197.05	1355.25	1760.78	9372.06	3429.91	5627.06
	G	6	203.82	774.53	304.82	402.65	640.07	1868.29	2604.09	5667.97
Ground	N	18	3109.67	3746.62	5008.89	5382.63	6135.83	2321.93	3531.86	4021.50
	G	6	1395.92	2453.08	2976.68	3724.15	2457.05	3576.40	2436.66	2169.04
No. of suckers										
Pot	N	18	0.60	0.85	1.35	1.80	2.50	4.85	4.30	4.95
	G	6	0.65	0.65	0.60	2.16	3.65	8.77	13.06	19.62
Ground	N	18	0.58	1.20	1.50	2.36	2.50	3.35	3.80	4.23
	G	6	0.21	0.24	0.73	4.04	7.33	8.10	10.20	12.71
Interval of leaf production										
Pot	N	18	59.03							
	G	6	21.28							
Ground	N	18	61.56							
	G	6	27.62							

Infl.char.		DF	dtf	f/p	iofp	stalk l	spathe l	spadix l
Pot	N	18	83964.88	7.95	6347.75	1504.01	180.24	25.41
	G	6	5087.81	5.20	3955.40	126.58	22.17	5.21
Ground	N	18	86133.26	13.40	5256.60	666.14	90.61	9.72
	G	6	5185.33	3.93	610.62	83.64	12.15	1.13

Pigment and nutrient content		DF	Cha	Cha b	Cha Tot	Antho	N	P	K
Pot	N	18	51.17	16.09	113.55	11817.46	16.02	0.33	0.17
	G	6	60.62	3.98	39.14	868.43	0.22	0.10	0.05
Ground	N	18	27.65	8.09	43.88	13182.62	4.25	0.36	0.60
	G	6	36.23	10.80	80.37	2009.33	0.72	0.04	0.05

Vaselife study		DF	Sp. blu	Spd.nec	Gloss	Vaselife	PLW	CpH	CEC	C.vol.
Pot	N	18	81.22	58.44	86.08	205.07				
	G	6	102.93	136.36	143.68	293.80				
Ground	N	18	254.87	287.71	316.26	353.72				
	G	6	229.00	153.75	182.03	411.67				
Pulsing		14	1660.22	284.56	881.56	2007.99	123.50	22.96	0.02	3156.80
Plugging		12	203.49	69.50	89.23	199.97				
Packing		11	66.69	23.23	31.05	40.93				
Waxing		4	7.17	0.50	9.40	8.27				
Packing with combination of treatments		11	100.08	48.22	94.83	96.12				

REGULATION OF FLOWERING AND POST-HARVEST BEHAVIOUR OF *Anthurium andreanum* Cv. 'Hawaiian Red'

By
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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

(POMOLOGY AND FLORICULTURE)

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1999

ABSTRACT

Investigations on regulation of flowering and post-harvest behaviour of anthurium cv. 'Hawaiian Red' were conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, during 1996-98.

The treatments included the application of nutrient solutions with different ratios of NPK (1:1:1, 1:1:2 and 1:2:2), at different concentrations (0.25%, 0.50% and 1.00%) and intervals of application (weekly and biweekly); Ca (0.50%), Mg (0.50%) and Vitamin B_{12} (100 ppm), all along with control at monthly interval; and growth regulators (BA and GA) at 500 and 1000 ppm and their combinations at 250 and 500 ppm, each, at monthly interval. The treatments were applied on plants growing in ground as well as in pots. The effects of the treatments on growth, flowering and post-harvest longevity of flowers were studied. Experiments were also conducted to enhance the vase life of flowers by means of pulsing, plugging and waxing; to standardise the best method of packing of flowers and to study the effect of ethylene absorbant ($KMnO_4$) on the post harvest longevity of flowers.

Results of the experiments revealed that the different ratios of major nutrients, their concentrations and intervals of application did not differ significantly with respect to the vegetative characters of the plant. Their effect on time taken for flowering and flower characters were also not significant during the period of the experiment. Application of Ca, Mg and Vit. B_{12} also did not make any significant effect.

The nutrient content of leaves increased, in general, with the increase in the ratio of the respective nutrient and concentration of the solution applied. In ground, the highest N content (2.23%) was recorded in the case of application of 20:20:20 complex 1.0 per cent at weekly interval ($N_1C_3W_1$) and the highest P and K

contents (0.77 per cent and 1.80 per cent respectively) were recorded in the case of 20:40:40 complex applied at 1.0 per cent at weekly interval ($N_3C_3W_1$). In pot, the highest N content (3.38%) was for the application of 20:20:20 complex 0.25 per cent at weekly interval ($N_1C_1W_1$), P (0.78%) for 20:40:40 complex applied at 1.0 per cent at weekly interval ($N_3C_3W_1$) and K (1.91%) for 20:20:40 complex applied at 1.0 per cent at weekly interval ($N_2C_3W_1$).

The chlorophyll content of leaves also differed significantly among treatments. Total chlorophyll content in ground planting was the highest (19.08 mg/g) for 20:20:20 complex applied at 0.25 per cent at weekly interval ($N_1C_1W_1$) and in pot planting, the highest content (21.84 mg/g) was for the application of 20:20:20 complex 0.5 per cent at biweekly interval ($N_1C_2W_2$).

Plants in ground planting were not significantly better than those in pots with respect to the plant and flower characters studied, during the course of the experiment.

Vase life of flowers differed significantly among treatments. Flowers from the treatment with high ratio of K at lower concentration (20:20:40 complex at 0.25%) at weekly interval showed the maximum vase life of 19.00 days, each, in ground and pot planting, compared to 15.00 and 14.25 days, respectively, in the corresponding controls. Plants in this treatment flowered earlier and produced the highest number of flowers.

With regard to the application growth regulators, the most significant effect was on the production of suckers. Application of GA 1000 ppm at monthly interval (G_2C_3M) produced the maximum number of suckers in ground (3.00) and pot (3.50) while the control plants produced no suckers. This treatment was on par with the treatment involving the lowest concentrations of BA and GA combined

together (250 ppm + 250 ppm). This treatment also retained the highest content of K in leaves. With respect to the vase life of flowers also, this treatment was on par with the treatment which recorded the highest value (20.67 and 23.50 days, respectively) for vase life of flowers in ground and pot, while the vase life was only 15.00 and 14.25 days, respectively, in the corresponding controls.

The chlorophyll content of leaves significantly differed among treatments. In ground, the highest content (22.06 mg/g) was in the case of application of GA 500 ppm at monthly interval (G_2C_2M) and in pot, it was 21.27 mg/g for the combined application of BA and GA, each at 250 ppm [$(G_1+G_2)C_1M$].

With respect to the anthocyanin content of flowers, the combined application of BA and GA (500 ppm, each) was significantly better in ground planting than the application of either of these growth regulators alone.

The highest number of flowers/plant in ground (2.34) was produced by the combined application of BA and GA 250 ppm, each [$(G_1+G_2)C_1M$] compared to 1.00 in control and in pot, the highest value was 1.78 in BA 500 ppm, GA 1000 ppm and combination of BA and GA 500 ppm, each, compared to 1.55 in control.

Post harvest studies revealed that, pulsing with BA 150 ppm for 8 hours recorded the highest vase life (19.50 days) compared to 9.00 days in control. Among the plugging treatments, BA 50 ppm recorded the highest vase life (10.44 days) compared to 5.67 days in control. Among the packing methods, that in polythene covers with waxing and $KMnO_4$ in packing cases, extended the vase life to 13.5 days, compared to 10.5 days in control.

In the study using the combination of treatments in packing, pulsing with BA 150 ppm for 8 hours, plugging with BA 50 ppm and packing in polythene

covers with $KMnO_4$ after waxing the spathe and spadix recorded the highest vase life of the flowers of anthurium cv. 'Hawaiian Red' (13.62 days) compared to 9.92 days in the method now used for packing anthurium flowers which involves plugging the cut end of the stalk with a cotton dipped in water and covering the spathe and spadix with a polythene cover.