

**Nutritional Management in
Anthurium andraeanum cv. Tropical**

*A Thesis submitted to
Orissa University of Agriculture and Technology in
Partial fulfilment of the Requirements for the degree of
Master of Science in Agriculture
(Floriculture and Landscaping)*

By

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CERTIFICATE-I

This is to certify that the thesis entitled “**Nutritional Management in *Anthurium andraeanum* cv. Tropical**” submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE AND LANDSCAPING)** to the Orissa University of Agriculture and Technology is a faithful record of *bona fide* and original research work carried out by **DEEPALI KAUSHAL** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

It is further certified that the assistance and help received by her from various sources during the course of investigation has been duly acknowledged.

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CERTIFICATE-II

This is to certify that the thesis entitled "Nutritional Management in *Anthurium andraeanum* cv. Tropical" submitted by DEEPALI KAUSHAL to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE AND LANDSCAPING)** has been approved by the students' advisory committee and external examiner.

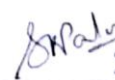
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In case of any omission or deletion does not mean lack of gratitude.

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ABSTRACT

The thesis entitled “**Nutritional Management in *Anthurium andraeanum* cv. Tropical**” was carried out under the agro shadenet structure of RKVY Project on Anthurium, Dept. of Floriculture and Landscaping at Biotechnology-Cum –Tissue Culture Centre, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha during the year 2016 - 17 with objectives to study the effect of nutrients on growth, flowering and post-harvest life of Anthurium cv. Tropical. For planting the tissue cultured anthurium plants 30 cm size earthen pots were used. The potting mixture comprised of substrates like charcoal, coconut husk, mango bark, coconut chops and bricks in equal proportion and placed under agro shadenet structure having 50% shade. The fifteen treatments comprised of substrate application of RDF- Urea:SSP :MOP@ 7.2:4.6:3.0g/plant alone and in combination with Ca as Calcium carbonate (1.6g/plant) , Mg as Magnesium sulphate (1.5g/plant) , foliar application of Sulphur as Wettable Sulphur (1.5mg/l) and MS Micro (10ml/l). Urea, SSP and MOP were applied to the plants as substrate application at 15th and 30th day of the month, Ca as Calcium carbonate and Mg as Magnesium Sulphate were applied as substrate application once a month whereas wettable sulphur and MS Micronutrients were applied once a month as foliar spray. The experiment was laid out in Completely Randomized Design and replicated thrice.

The result of the investigation revealed that substrate application of RDF Urea:SSP: MOP @ 7.2:4.6:3.0 g/plant, Ca as Calcium carbonate (1.6g/plant) , Mg as Magnesium sulphate (1.5g/plant) significantly enhanced the vegetative characters like plant height (26.94 cm) , number of leaves per plant (10.33) , petiole length (21.03cm); floral characters like stalk length (12.83 cm), number of flower per plant /month (2.15) , spathe length (8.7cm), spathe breadth (7.16cm) , spadix length(4.3cm) and spadix breadth (1.5cm) as compared to other treatments. Postharvest characters like maximum solution uptake by the plant, delay in discoloration of spathe (16.98 days), discoloration of spadix (15.04 days) and vase life (19.20 days) were found to be the best in the plants treated with RDF-Urea:SSP:MOP @ (7.2:4.6:3.0 g/plant) , Ca as Calcium carbonate (1.6g/plant) , S as Wettable Sulphur (1.5mg/l) and MS Micro (10ml/l).

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ABBREVIATIONS USED

%	:	Per cent	cm	:	
		Centimeter			
l.	:	Litre			
ml	:	Mililitre	eg	:	
Example mg	:	Miligram			
ESS	:	Error sum of square	<i>et al.</i>		
	:	And others etc.		:	
		Etcetera			
g	:	Gram			
ha	:	Hectare			
Hrs.	:	Hours			
i.e.	:	(<i>Id est.</i>)	that is		
Kg	:	Kilogram	P		
phosphorus m	:	Meter			
Max.	:	Maximum	Min.	:	Minimum
mm	:	Millimeter			
No.	:	Number			
R.H.	:	Relative humidity	RSS	:	
		Replication sum of square			
Tss	:	Treatment sum of square			
<i>Viz.</i>	:	(<i>Videlicet</i>)	Namely		
°C	:	Degree	Celsius		
CaCO	:	Calcium carbonate			
MgSO ₄	:	Magnesium sulphate			
S	:	Sulphur			

INTRODUCTION

Anthuriums are tropical plants grown for their showy cut flowers and attractive foliage. Anthurium has gained the importance as major cut flower of the modern world. Anthurium growing is a potential source of commercial farming and it makes best use of ready market for cut flowers with high returns both for its cut flower and whole plant. The plant produces blooms throughout the year, one bloom emerging from the axil of every leaf. Flowers are usually harvested once a week at three quarters maturity. Anthurium ranks ninth in the global flower trade and commands a respectable price both for its cut flower and whole plant (Desh Raj, 2015) presently the Netherlands is the world's leading producer and exporter followed by Mauritius. It is the national flower of Mauritius.

Anthurium belongs to the family Araceae and is native of tropical zones of Central and South America. The name anthurium is derived from Greek word 'anthos' meaning flower and 'oura' tail referring to the spadix. Thus, anthurium is also known as 'tail flower' (Tajuddin and Prakash, 1996). The anthurium plant possesses an underground rhizome with adventitious roots, characteristic of the Araceae family.

Anthurium is a genus of herbs often growing as epiphytes on other plants, some are terrestrial. The leaves are often clustered and are variable in shape. The inflorescence bears small flowers which are perfect, containing male and female structures. The flowers are contained in dense spirals on the spadix. The spadix is often elongated into a spike shape, but it can be globe-shaped or club-shaped. Beneath the spadix is the spathe, a type of bract. The fruits develop from the flowers on the spadix. They are juicy berries varying in color, usually containing two seeds. Anthurium is a slow growing perennial that requires shady, humid conditions as found in tropical forests.

The spadix and spathe are a main focus of *Anthurium* breeders, who develop in bright colors and unique shapes. *Anthurium scherzerianum* and *A. andraeanum*, two of the most common taxa in cultivation, are the only species that grow bright red spathes. They have also been bred to produce spathes in many other colors and pattern. The 'true' flowers are found on the spadix and have large numbers of pistils, each surrounded by

four stamens. The 'true' flowers are bisexual and protogynous, with the spadix first producing a female phase followed by, after about a month, a male phase. This prevents self-pollination of the flowers and as such, anthuriums are cross-pollinated. Bees, beetles, flies and ants effect pollination under natural conditions. Six months after pollination, colored berries develop on the spadix from bottom upwards.

Anthuriums need a well-drained soil. Anthurium is a slow growing perennial that requires shady, humid conditions as found in tropical forests. It is planted usually in Cocopeat. The spathe is usually heart-shaped. The flowers are on the spadix above the spathe. Anthuriums need full shade and can also be grown indoors in a brightly light area. Anthurium need high light but do not tolerate direct sunlight. Anthurium comes in the following colors Orange, Red, Pink, Black (Dark Brown), Purple, Green, White, Dark Blue, Light Blue, Cream, Shaded, Bicolor, Mango Color (Yellow).

In India, the anthurium cut flower industry is still in its infancy. At present anthuriums are mostly grown in some small gardens and nurseries. However, some progressive farmers started growing anthurium under protected condition around Bangalore, Belgaum, Goa, Sirsi etc. The important states cultivating anthuriums are Assam, Kerala, Tamilnadu (Salem) and Karnataka (Coorg), where the favourable climate exists.

Of the several varieties grown in the world, 'Tropical', 'Lady Jane', 'Johnson Pink', 'Agnihotri', 'Kalimpong Red', 'Honey Moon Red', 'Samba', 'Winstons Delight' 'Midori' etc., are mainly cultivated in India. There have been no systematic studies on the performance of commercial cut flower production in India.

The agroclimatic conditions of Odisha along with abundant water availability offer a natural advantage for the commercialization of several unexploited floras in various parts of the state. The climate of Odisha is represented by tropical monsoon weather. Searing hot summers with considerably high monsoon downpours and cool pleasant winters mark the Odisha climate. Rainfall is the main source of water that varies from 1200 millimetres to 1700 millimetres across the state.

In comparison to the last three years Odisha has emerged as the top states in terms of flower production and occupied third position in the country from eighth

position. Though area under floriculture has not increased but productivity has increased both in cut and loose flowers. It is a great opportunity for a state like Odisha to promote flower production especially cut flower production.in coming years. Malkangiri, parts of Koraput, Rayagada in north eastern ghats, Ganjam, Kandhamal, Kendrapada, Jagatsinghpur, Khurda, Puri, Nayagarh are suitable for anthurium cultivation in Odisha (Beura *et al.*, 2017)

The airport at Bhubaneswar and Kolkata is an added advantage to this sector providing the vital support link.flower growers are promoted in the state by demonstrations,provided with planting materials and inputs free of cost and flower cultivation is done on large scale in Cuttack, Bhubaneswar, Rourkela and Berhampur,

Even though grown by many planters, there is very less scientific information on the use of foliar application of nutrients. Standardization of nutrients is most important to obtain higher yield and quality of the flower. The present investigation entitled, “Nutritional Management in Anthurium (*Anthurium andraeanum*) var.Tropical” was taken under greenhouse of BTCC, Baramunda to find out the optimum dose of nutrients for the plant with the following objectives:

1. Effect of nutrients on vegetative growth of anthurium.
2. Effect of nutrients on flowering of anthurium.
3. Effect of nutrients on post-harvest life of anthurium



REVIEW OF LITERATURE

The experiment entitled “Nutritional Management in *Anthurium andraeanum* cv. Tropical” was undertaken in the agro shadenet structure of Biotechnology Cum Tissue culture centre Baramunda, Dept of Floriculture and Landscaping, OUAT Bhubaneswar during the year 2016-17. To make available of the literature related to the present study on various flower crops, an attempt has been made in this chapter.

The reviews are presented under the following heads:

- Effect of nutrients on vegetative growth of anthurium.
- Effect of nutrients on flowering of anthurium.
- Effect of nutrients on post-harvest life of anthurium

2.1 Effect of nutrients on Vegetative growth of anthurium

Bortje (1978) studied the effect of nutrition in anthurium with five levels of nitrogen and three levels of potash and reported that requirement of anthurium was relatively high. He further reported that an annual dressing of 20g N per m² and 30g K per m² significantly increased the number of leaves and stalk length with this dose of fertilizer.

Zinc helps in translocation of plant constituents from one part to another (Lal and Mourya, 1981) there are also report on translocation of zinc from leaves to flowers (Ricemen and Jone, 1958). Takkar and Bansal (1987) studied the effects of methods of application, sources and concentration of zinc on winter annual as well as its uptake.

Yadav *et al.*, (1985), stated that the height of plants significantly increased with high dose of N (300 kg/ha) and P (300kg/ ha) over control in tuberose cv. Single

Application of 3000 ppm Agromin (chelated form of Zn, Mn, Cu, Mg, Fe, B and MO + 2% N) improved plant height, increased the number of leaves and the floret size, but delayed spike formation in gladiolus. However, spraying agromin twice at 400 ppm was most effective in increasing the duration of flowering spike length (Chaturvedi *et al.*, 1986)

Bhattacharjee and Singh (1992) found that FeSO₄ at one per cent was the most effective in stimulating secondary shoot production.

Lodhi and Tiwari (1993), recorded the maximum plant height (47.43 cm) with the application of 45g N/m² and 40 g P/ m² in chrysanthemum.

Micronutrients are to be necessarily taken up by the plants from soil or supplemented through foliar application for good growth and yield of crops and maximizing the efficient use of applied N, P and K. In the absence of these micronutrients, the plants are known to suffer from physiological disorders which eventually lead to imbalanced growth and low yield. The role of micronutrients in various metabolic processes and the enzymes involved in these processes has been reported by Zende (1996)

Dahiya *et. al.*, (1998), reported during 1996-97 the effect of N (0, 80, 160 and 240 ppm) and Phosphorous (0, 40, 80 and 120 ppm) on the number of branches were increased upto 240 ppm N and increasing P rates significantly improved the growth parameters of potted African marigold.

Mishra (1998)), carried out field trials on a sandy loam, soil at Samastipur in 1993 and 1994 on *Gaillardia pulchella* with different levels of Nitrogen (0, 10, 20 or 30 g/m²) and reported that the plant height and plant spread were greatest at 30 g N/ m² followed by 20 g N/m² in gaillardia.

The 'Chandrama' cultivar of chrysanthemum recorded better vegetative growth and flower characters when sprayed with Zinc and Manganese at 400 ppm each, whereas, boron at 200 ppm was more effective than at 400 ppm which had adverse effect on the above characters (Barman and Pal, 1999).

Barman and Pal (1999) observed that nitrogen @ 30g/m² appreciably increased the plant height, number of branches per plant and plant spread in chrysanthemum.

Henny (1999) conducted an experiment on different levels of fertilizers on *Anthurium andreanum*. The lowest rate of fertilizer 12:12:17 NPK and Mg (200kg/ha/yr) resulted in the highest yield, while there was no significant difference between the application rates of 300 and 400kg/ha/year.

Katiyar *et al.* (1999) revealed that the highest level of nitrogen (90g/plant/year) was obtained significant in maximum plant height (127.87cm) and number of main branches per plant (9.44) as compared to control (6.55) in rose cv. “Bonne Nuit”.

Khan (2000) studied the effect of foliar application of micronutrients viz. Zn, B, Fe and Mn individually and in combination at different concentration in dahlia. Among the micronutrients tested Zn + B + Fe + Mn stimulated plant height (43.20 cm), green leaves (31.50 cm), leaf area (116.4 m²), branching (4.50) and early flowering (23 days). Similarly Zn + Fe + Mn produced maximum number of flowers (10.70), flower diameter (15.60) and flower stalk length (24.30 cm).

Rajadurai *et al.* (2000), observed with the application of NPK of 45:45:37.5 mg/kg along with combined inoculation of *Azospirillum* and VAM exhibited increased branches per plant (28.30) in African marigold.

Singh and Sangama, (2000) studied the effect of graded level of nitrogen on China aster cv. Kamini. Treatments consisted of 5 levels N (100,150, 200, 250, and 300 kg/ha.) and 4 levels of P (0, 100, 150 and 200 kg/ha.), the plant height (51.91 cm) and plant spread (21.27 cm) were found maximum with 300 kg/ha.

Dufour *et al.* (2001) conducted trial on cultivation of anthurium in soil less media under shelter. The best results regarding plant growth and yield was obtained with a solution having lowest calcium (2.25 mg/l) and the highest ammonium (2.43 mg/l) concentrations of the plant and played an important role in fertilization balance.

Misra (2001) indicated that soil application of zinc sulphate at 2.5 g m⁻² significantly increased the plant height, number of branches per plant, flower life and flower yield in chrysanthemum.

Joshi *et al.* (2002) observed the effect of sulphur and some micronutrients on the growth and flowering of *Rosa damascena*. Results revealed that nitrogen as urea recorded the highest plant height (98.40 cm), while elemental sulphur recorded the maximum flower diameter (7.6 cm) which was statistically at par with those obtained with the ZnSO₄, FeSO₄ and CuSO₄.

In tuberose, Nath and Biswas (2002) reported that foliar application of boron 100 ppm twice at monthly interval produced the maximum height of plant and increased the number of leaves per clump resulting in improved yield of spikes per plot.

Prabhat *et al.* (2002) also showed to facilitate foliar application of 0.2% ferrous sulphate alone or in different grouping produced highest value of number of leaves branch⁻¹ of gladiolus.

Singh (2002), conducted a field trial with African marigold involving 4 N levels (0, 100, 200 and 300 kg/ha) and 3 P₂O₅ levels (0, 100 and 200 kg/ha) on plant height was increased up to N 200 kg/ha and P 100 kg/ha.

Improvement in growth characters due to micronutrient application might basically be due to enhanced photosynthetic and other metabolic activities related to cell division and elongation as opined by Hatwar *et al* (2003)

Kumar *et al.* (2003) conducted studies on response of N and P fertilization on China aster. Treatments comprised of N (0,100,150, 200, 250, and 300 kg/ha.) and P (0, 100, 150 and 200 kg/ha.) fertilizers applied in split and full doses respectively. Plant height (34.80 cm), number of branches/plant (4.43) were the highest with 300 kg N /ha treatments.

Rajiv Kumar *et.al.*,(2003), studied the effect of nitrogen (0, 20, 30, 40 g/m) and Phosphorous (10, 20, 30 g/m²) and recorded maximum plant height (86.65 cm) with the application of N 30, P 30 g/m² in gladiolus.

Nagaich *et al.* (2003), the experiment was conducted during the winter seasons of 1997-99 to determine the effect of N (0, 40, 80 120 kg/ha) and P (0, 20, 40 or 60 kg/ha) and recorded maximum plant height with the application of N 80 kg/ha and P 20 kg/ha in African marigold.

Rajput *et al.* (2003) in *Tagetus minuta*, observed that application of boron individually or in combination with zinc and sulphur increased the plant height and fresh weight of plant significantly over the control. Individual application of boron increased the dry matter yield significantly by 69.8 per cent and 71.1 per cent over the control.

Soil application of zinc at 20 kg per hectare increased the spike length, rachis length, number of florets per spike and number of bulbs per plant in tuberose cv. Double. (Hardeep Kumar *et al.*, 2004)

Jamkhande *et al.* (2004) studied the effect of graded levels of nitrogen and phosphorus on growth and flower production of China aster cv. Local. Plants were supplied with 50, 100, 150, or 200 kg N/ha and/or 50 or 100 kg P/ha in field experiment. Plant height, number of branches and plant dry weight increased with increasing rates of N and P.

Katiyar *et al.* (2005) observed that, application of zinc, copper and mixture of both as foliar sprays (0.2%) applied twice at vegetative growth and after emergence of spike, increased the vegetative growth and enhanced the floral characteristics like length of spike and number of florets per spike in gladiolus.

Nayak *et al.*, (2005) studied the effect of NPK nutrition on growth and flowering of *Gerbera jamesonii*. L. cv. Constance, a mixture of NPK at 4, 2 and 2 g/pot, was the best in respect of number of leaves per plant (16) and plantlets per plant (3.70).

Dalal *et al.* (2005) conducted a study on the response of phosphorus levels to growth, flowering, yield and flower quality of gerbera under poly house condition with four levels of phosphorus (0, 7.5, 10, 12.5, g/m²) It was observed that application of phosphorus @12.5, g/m² recorded the maximum plant height (39.59 cm) and leaves per plant (28.18).

Chauhan (2005) found that an application of 175 kg N/ha recorded the highest plant height (70.93 cm), number of branches per plant (6.27) and plant spread (24.40cm²) in *Chrysanthemum 'morifolium' Ramat*.

Renuka *et al.* (2005) studied the effect of phosphorus and potash on growth, flowering and yield of gerbera under poly house conditions, it was observed that the maximum plant height (42.18 cm) and leaves per plant (32.30), were recorded with K₃P₃ (15 g P₂O₅) + 15 g K₂O/sq.m).

In a study on the response to nitrogen application (0, 33, 67 and 100 kg/ ha) under natural agro-climatic conditions, maximum growth rate (6.49 cm/ week), plant

height (51.53 cm), number of lateral shoots per plant (7.39), size of lateral shoots (25.02 cm) and leaf area (20.5 cm²) was recorded in plants supplied with 100 kg N/ ha .Nitrogen application @ 100 kg /ha promoted vegetative growth. (Ahmad *et al.*2007)

(Khan *et al.*2007) studied the response of different nitrogen levels (0, 15, 20, 25 and 30 g/sq.ft.) alone and in combination with constant doses of phosphorus and potassium on the growth of *Dahlia pinnata*, the fertilizer treatments significantly affected the plant height, number of leaves per plant, primary root length, leaf area, and root stem ratio. A maximum number of days to flowering (123) was recorded with 30g N, while a minimum number of days to flowering (91) was noted with 15 g P. The plant height (106.3 cm) and primary root length (17 cm) were observed maximum in plants supplied with 25g N + 15g P + 15g K. Maximum number of leaves /plant (71), leaf area (27 cm²) and root and stem ratio (0.75) was recorded in plants receiving 25 g N only.

Naik (2007) reported that in rose cv. Grandagala and cv. Carvette combined application of Boron (0.2%) + Cu (0.20%) + Fe (1%) + Mn (1%) and Zn (1%) recorded highest plant height, number of shoots per plant in cv. Grandagala when sprayed twice with micronutrient combination at 60 and 80 days after pruning. Highest Leaf area, stalk length, neck length, number of petals per flower and number of marketable flowers per plant and per square meter were recorded when cv. Grandagala sprayed with Rose booster at 0.25 percent followed by combined application of micronutrients @ 40 and 80 days after pruning.

Singh and Kumar, 2008 in a study on the effect of NPK on growth of gerbera under polyhouse conditions, three levels of nitrogen and potassium along with common dose of phosphorus were applied in randomized complete block design with factorial arrangement. The maximum length and width of leaf were produced by application of nitrogen, phosphorus and potassium (6:2:3 g/m²).

The effect of various NPK levels on growth, flowering, and xanthophyll contents of African marigold (*Tagetes erecta*, ‘Double Eagle’) and French marigold (*Tagetes patula*, ‘Yellow’) were investigated by (Ahmad *et al.* 2009). The results revealed that plant height, number of branches/ plant and leaf area (cm²), were maximum with 15:10:10 g m² NPK application.

El-Naggar (2009) studied the influence of different concentration of foliar fertilizer (Sangral) containing macro and micronutrients (Fe, Zn, Cu, Mn, B, and Mo) in *Dianthes caryophyllus* cv. Red sim. The results revealed that, plant treated with foliar nutrition (0.6%) showed significant increase in the growth characters (Stem length, stem diameter, number of leaves per plant). Foliar application @ 0.6 per cent also stimulated the flowering parameters viz. early flowering, increased flower number and diameter compared to untreated plants. Total chlorophyll a and b, carotenoids, total carbohydrates (%) and mineral contents of leaves (N, P, K, Zn, Cu) were significantly increased as a result of foliar application at different levels

Panchal (2009) reported that an application of 175 kg N /ha gave the highest plant height (96.23cm), number of branches per plant (50.59) and plant spread (79.08)cm N-S and 78.79 cm E-W) as compared to control in annual white chrysanthemum.

Naveen Kumar *et al.* (2009) reported in chrysanthemum that zinc sulphate at 0.6 per cent recorded the maximum stem length against control.

Ganga *et al.* (2009) studied the effect of Copper, Iron, Zinc, manganese and boron on the performance of *Dendrobium* cv. Sonia 17. Among the micronutrients sprayed, 1000 ppm ferrous ammonium sulphate was superior in respect to vegetative growth viz plant height, number of leaves per plant and number of roots per plant .

Kumar and Haripriya (2010) studied the effect of iron and zinc and their combinations in *Nerium* cv. Pink Double. Among different treatments, FeSO₄ @ 0.75 per cent + ZnSO₄ @ 0.50 percent spray gave significantly maximum value on all growth attributes like plant height, number of secondary branches, number of leaves per plant, plant spread and leaf area. Significant and superior results on early flowering, duration of flowering, flower diameter, hundred flower weight, flower yield per plot and estimated flower yield per hectare were observed with FeSO₄ @ 0.75% + ZnSO₄ @ 0.50% spray followed by FeSO₄ @ 0.75% + ZnSO₄ @ 0.75% spray.

Parekh *et al.* (2010) revealed that the maximum plant height (56.87 cm) was recorded with nitrogen level (100kg/ha), while the plant spread (972 sq.cm) was obtained in the nitrogen level (200 kg/ha) in chrysanthemum cv. 'IIHR-6'.

Maharnor *et al.* (2011) recorded maximum plant height in marigold on application of 150 kg N /ha and no pinching, whereas, maximum stem diameter, number of primary branches and spread of plant were recorded with 150 kg N /ha and pinching at 30 DAT. Maximum flower yield per plant and yield/ ha were recorded with 150 kg N /ha and pinching at 30 DAT.

Dorajeerao *et al.* (2012) reported in chrysanthemum that number of flowers per plant was found highest at 150 kg N /ha, 100 kg P₂O₅ ha and 100 kg K₂O ha during both kharif and rabi seasons. With every increase in nitrogen level, at a constant level of phosphorus there was increase in plant height. A similar effect was also observed in phosphorus. Number of branches, number of leaves and leaf area per plant were maximum with 150 kg N + 100 kg P₂O₅ followed by 200 kg N + 100 kg P₂O₅ and 150 kg N + 150 kg P₂O₅ /ha.

In a study on the effect of organic and inorganic fertilizers on plant height, plant spread and flower diameter of Gaillardia (*Gaillardia pulchella*), the maximum plant height was recorded in the plot treated with 100 per cent recommended dose of NPK + press mud at 10 t/ha., followed by 75 per cent recommended dose of NPK + press mud at 10 t/ha., at 45 days and 75 per cent recommended dose of NPK + press mud at 5 t/ha., at 15, 30 and 60 days. Highest plant spread was obtained 30 and 45 days after planting in the treatments which involved 100 per cent recommended dose of NPK + press mud at 10 t/ha and at 60 days no significant differences were recorded. (Sowmyamala *et al.*2012)

2.2 Effect of nutrients on Flowering of anthurium

. Application of Fe-DTPU at @ 4 g per plant reduced rose chlorosis from 3.5 to 1.0 on a 1 to 5 point scale and increased flower yield. Fe-DTPU was found more effective than FeSO₄ and its effect lasted for three years (Eryusheva, 1971).

Steen and Vander (1972) studied the effect of nitrogen and potassium manuring in anthurium, plants were fertilized with calcium nitrate and potassium sulphate

immediately after planting and five months later all the plants grew significantly well and neither N nor K had any significant effect on flower yield. Anuradha *et al.*, (1988), noted more number of marigold flowers per plant by the application 90 kg N and 60 kg P ha.

Dhakshinamoorthy (1976) reported that foliar spray of zinc and boron on geranium plants at 0.25 per cent each separately registered highest yield of 104.70 q/ha and 37.07 q/ha, respectively in the first and second harvest while control accounted only 63.70 and 24.03 q/ha in two harvest, respectively

In addition to increase in number of flowers, foliar application of zinc enhanced earliness to flowering (Peterbuzgskii and Lyahku, 1977). They observed early emergence of flower stalk of tulip cv. Parade as compared to control. At the same time foliar application of Zinc (0.25%) thrice at 60 days interval also produced highest number of flower spikes per plot of tuberose cv. Single (Barman and Pal, 1993) and increased the production also in *Tagetes erecta* cv. African Giant, recorded highest number of branches per plant on foliar application of 0.40 per cent ZnSO₄, in an experiment conducted at Hyderabad, which also reduced the number of days to flowering.

Deficiency of boron is known to affect the meristematic tissue of rose plants. The terminal buds die, resulting in excessive branching. The leaves are crowded together at the tips of the stem giving a tufted appearance. The flowers are bullheaded or malformed and the extreme deficiency causes the death of the stem tip (Biswas, 1984).

Higaki and Imamura (1985) conducted a trial with four levels of N(125,216 ,306and 396 mg/pot per week) rates on potted anthurium plants grown in peat media. Flower production, fresh weight and stem length were adversely affected by an increase in N over the lowest rate tested. The two highest K rates produced highest yield and stem length.

In rose cv. 'Motrea' Kreij *et al.* (1985) sprayed boron at 0, 20, 40 or 80 ppm per litre and Zn at 0, 3, 9 and 27 ppm per liter nutrient solution. The results revealed that flower number per m² increased with increasing boron concentration, but at 40 and 80

ppm per litre, chlorosis of the leaf edges occurred. However, yield was progressively reduced on adding Zinc at higher concentrations.

Aouichsol and Tissaoui (1988) reported that application of Fe + Zn increased the number of flowers, stalk length and flower diameter of hybrid gladioli. Micronutrients were also found to increase the attributes in opium poppy (Anwar *et al.*, 1991). Application of Fe (75 ppm) + Zn (25 ppm) produced the largest flowers in chrysanthemum with longest flowering duration (Mostafa *et al.*, 1997).

Henny and Foshee (1989) studied response of *Anthurium andreaum* in Cv. Lady Jane under different levels of light and fertilizer. Cutting from tissue cultured plants were grown on light intensities of 1200, 2400 and 3400 ft-candles, with weekly application of NPK fertilizer at 200, 400 and 600mg/l. After 12 weeks plant growth was best at the lowest light intensity and lowest fertilizer levels. Fertilizer levels were detrimental.

Anamika and Lavania (1990), reported more number of flowers with inclusion of nitrogen along with Phosphorous in rose.

In a study on the effect of N and phosphorus on flowering, yield and quality of marigold, four levels of N and P (0, 30, 60, 90, kg/ha.) and uniform dose of K (60 kg/ha.) were applied. The results revealed that the number of days required for 50 percent flowering were reduced with increasing levels of N and P₂O₅ (Anuradha *et al.* 1990)

Sigedar *et al.*, (1991), recorded maximum number of flowers per plant in *Calendula officinalis* L. with 100.kg N, 50 kg P₂O₅ and 25 kg K₂O/ ha.

Foliar application is one of the best ways to supply micronutrients to plants (Cabrera *et al.*, 1993). Spraying of three-year old hybrid tea roses cv. Raktagandha with ZnSO₄, FeSO₄ and MnSO₄ or CuSO₄ one month after pruning was the most effective to stimulate secondary shoot production and increasing bud length, flower diameter, number of petals flower⁻¹ and flower production .

Bandyopadhyay *et al.*, (1994), observed significant positive effect of micronutrient treatments on number of flowers of marigold. Higher concentration of micronutrients increased the flower number significantly.

Bhattacharjee and Damke (1994) concluded that application of 75g N and 125g P/m² was found optimum for producing more number of flowers / plant / year and the highest number of total flowers in rose cv. 'Super Star'.

Khimani *et al.* (1995) reported that an application of 40 or 60g N+20g P/plant produced more number of flowers per plant in rose cv. *Rosa damascena* L.

Foliar nutrition with NPK in addition to soil application significantly affects vegetative growth and floral characters (Roy *et al.*, 1995). Nitrogen is the one of the most important nutrients producing growth and yield responses in gladiolus. Leaf analysis indicates that the leaves should contain on a dry weight basis 2.5 -3.0% nitrogen or more for optimum yield. The quantity of phosphorus required by gladiolus is about one-tenth of the nitrogen expressed in terms of foliar analysis. Gladiolus requires about 3-4% potassium in the leaves on a dry weight basis for the best yield and quality of flowers.

Hosni and Shoura (1996) conducted an experiment on effect of N (0.3g/pot) + P (0.3g/pot) + K (0.9g/pot) on growth, yield and flower quality of carnation Cv. Lucena, flower number, stem diameter and fresh weight was significantly increased in the treatment with highest rate of K.

Singh and Bhattachajee (1997) concluded that foliar sprays of ZnSO₄, CuSO₄, MnSO₄ and FeSO₄ applied two times followed by pruning to roses cv. Raktagandha (3 years older), significantly increased number of flowers plant⁻¹ and other quality and quantity parameter

Dahiya *et al.*, (1998), reported in the greenhouse studies, during 1996-97 to assess the effect of N (0, 80, 100 and 240 ppm) and P (0, 40, 80 and 120 ppm) on the number of flowers per plant increased up to 240 ppm N and increasing P doses significantly increased the yield of marigold.

Mishra (1998), carried out field trials on a sandy loam, soil at Samastipur in 1993 and 1994 on *Gaillardia pulchella* with different levels of Nitrogen (0, 10, 20 or 30 g/m²) and recorded that Nitrogen application 20 g./m² was significantly effective for early flower bud appearance.

Muthumanickam *et al.* (1999) studied yield and floral characters of gerbera influenced by micronutrients and found that spraying MnSO₄ + FeSO₄ + ZnSO₄ (0.2% each) gave highest flower yield per plant (46.66), stalk length (58.4 cm), flower diameter (11.80 cm) and vase life (7 days). They also reported significantly higher content of iron (80.30 ppm), manganese (98.4 ppm) and Zinc (79.30 ppm) in leaves during the 12th month of spraying.

Kumar and Arora (2000a) stated that foliar application of 0.2 per cent FeSO₄ singly or in various combinations in gladiolus at three or six leaf stages induced flowering earlier than other treatments such as ZnSO₄ and MnSO₄. Plant height, number of leaves, spike length, number of florets, weight of spike and size of florets were significantly increased with FeSO₄ (0.20%) + ZnSO₄ (0.20%) application. Flowering duration was longest with FeSO₄ @ 0.4% and ZnSO₄ @ 0.2%.

Kumar and Arora (2000) studied the effect of micro nutrients viz. Fe, Zn, Mn by spraying @ three leaf stage in gladiolus cv. White prosperity. The results have shown that, earliness in flowering (107.70), increased plant height (64.30) and number of leaves (65) under 0.20 per cent FeSO₄. Spike length (116.05 cm), number of florets, weight of spike was significantly increased with FeSO₄ + ZnSO₄ each at 0.2 per cent. Longest duration of flowering was observed under 0.40 per cent FeSO₄ + 0.20 per cent ZnSO₄.

Singh and Sangama, (2000) studied the effect of graded levels of nitrogen on China aster cv. Kamini. Treatments consisted of 5 levels of N (100,150, 200,250, and 300 kg/ha.) and 4 levels of P (0, 100, 150 and 200 kg/ha.), the length of flower stalk (27.27 cm) and numbers of flowers/plant (35.22) were found maximum with 300 kg/ha.

Vidhyasankar and Bhattacharjee (2001) found that an application of the highest dose of nitrogen (500 kg / ha / year) significantly increased the number of flowers per plant (225.50) as compared to lowest dose (200kg/ha/year) of nitrogen (129.25) in rose (*Rosa damascena* L.).

Joshi *et al.*(2001) concluded that the maximum flower yield (17.22 t/ha) was obtained with the higher level of nitrogen (40g/plant/year) as compared to lowest level of nitrogen (25g/plant/year) in rose (*Rosa damascena* L).

Mukesh *et al.* (2001a) investigated the effect of foliar application of zinc, copper and iron at 0, 250, 500 and 1000 mgL⁻¹ on yield and quality of *Gladiolus grandiflora* cv. Mirela. Plants treated with micronutrients exhibited better results with respect to growth, flowering and yield compared to control.

In a study on the effect of NPK on growth and flowering of gerbera it was observed that cv. Popular treated with N, P, and K fertilizers, at 30:10:20 g/m² had the highest plant height (45.69 cm), leaf area per plant (35.67 cm²) and suckers per plant (30.40) was highest (7.80) with no NPK fertilizers. (Terangpi and Paswan, 2003)

Kumar *et al.* (2003) conducted a study on the response of N and P fertilization on China aster. Treatments comprised of N (0,100,150, 200, 250, and 300 kg/ha.) and P (0, 100, 150 and 200 kg/ha.) fertilizers applied in split and full doses, respectively. Days to first flower bud (60.50 days), flowers/plant (35.22), flower diameter (5.13 cm), and flowering duration (37.45 days) were the highest with 300 kg N/ha treatments.

Conover and Henny (2003) conducted an experiment on effect of nitrogen and potassium on growth and flowering of anthurium hybrid at University of Florida. The highest quality plant in terms of improved flowering and better overall appearance of the plant was observed in the plant receiving lower N and P level.

Dufour and Guerin (2003) conducted a study on effect of different light intensities on plant growth, development, and yield and flower quality of tissue cultured anthurium. The largest leaves and flowers were observed under lowest light intensity.

Dufour and Guerin (2003) studied growth, development and flower production in anthurium. Young tissue cultured plants first have monopodial growth which corresponds to the juvenile and vegetative phase. After this the plants have sympodial phase, with a flower produced for each leaf.

Patil (2004) reported that the combination of organic manure with 2 g of 13:13:20 of NPK per plant per month showed significant effect on flower production.

In gladiolus cv. 'Friendship', foliar spray of zinc sulphate at 0.6 per cent increased the plant height, spike length, number of florets per spike, number of corms and cormels per plant as reported by (Sharma *et al.* 2004)

Anand and Jawaharlal (2004) carried investigation at the Botanic Garden, Coimbatore. The nutrient level of NPK 20:20:40 @ 0.2 percent with growth regulators GA₃ at 250 ppm took the lowest period of 186.5 days to reach the flowering period as well inflorescence emergence to spathe unfurling.

Dufour and Clairon (2005) reported that increasing mineral nitrogen rates (369-12) had been applied to the plants cultivated in selected substrates. Yield and flower quality were measured for a year. The lowest level of fertilization is sufficient to allow good growth and flowering.

Jianjan *et al.*, (2005) conducted an experiment on controlled release fertilizers, water soluble, fertilizers or combination of both have been used for anthurium production. Growers may use a fertilizer with N-P₂O₅ - K₂O at 1-2-2 ratio to promote flowering.

Dordas and Brown (2005) observed that boron is thought to be involved in cell viability and metabolism. Phenolic leakage, maintenance of pH of the medium, cell wall structure and function, flower fertilization, active salt absorption and cell wall pore size. It also plays a vital role as stabilizer of cell wall pectin network and photosynthesis in rose (*Rosa damascene* Mill cv. Gloide de Guilan). Further they observed that, boron deficiency resulted in death of some cells. In boron deficient cells, a small oxidative burst (indicated by the production of H₂O₂) was observed coincident with first cell death and increased thereafter.

Pratap *et al.* (2005) found foliar application of FeSO₄ (1%) at three to six leaf stage in gladiolus reduced the time taken for 50 per cent flowering by five days in the first year, FeSO₄ at 0.75 per cent or one per cent foliar spraying during second year of investigation significantly produced longer spikes of 73.71 and 73.46 cm compared to control (67.52 cm). The spray of 0.75 per cent was also beneficial in producing more number of florets per spike.

In gladiolus cv. Trade Horn foliar application of FeSO₄ @ 0.6 per cent at 3-4 leaf stage significantly increased plant height, spike length, spike weight, duration of flowering, weight of corms per plant and corm yield during first, second and third year (Rao, 2005).

Srinivasa (2006) conducted study in Karnataka, to assess the influence of fertilizer and biofertilizers on growth and flowering of anthurium. one time application of NPK at 30:20:40 g/m²/yr showed minimum plant height, number of suckers, flower stalk length, spathe length and number of flowers.

Mukesh *et al.* (2006) depicted that compound fertilizer application of N @ 50g/m² P @ 10 g/m² and K @ 20 g/m² in gladiolus produced more number of florets per spike, maximum spike weight, bigger flower size and more number of corms.

Nahed & Balba, (2007) conducted foliar spray of nutrients in blue sage (*Salvia farinacea* L.) that enhanced the length of main inflorescence and other foliage parameters. Foliar spray application of macro and micro nutrients enhanced the production of tubers plant⁻¹. Maximum numbers of tubers were obtained with treatment T2 (6.63).

Ewes *et al* (2008) studied that all vegetative and reproductive characters of dahlia plant were increased with the application of B, Zn, Fe and Mn at different concentrations. Therefore it is essential to provide optimize amount of N, P and K to obtain the best vegetative and reproductive growth.

Ganga *et al.*, (2008) indicated that foliar spray of zinc sulphate at 0.4 percent increased the flower yield per plant and total yield per hectare than other treatments in chrysanthemum cv. Col.

Monish *et al.* (2008) studied the effect of nitrogen and phosphorus on the performance of China aster cv. Poornima. Three levels, each of nitrogen (100,200 and 300 Kg/ha.) and phosphorus (100,150 and 200 Kg/ha.), were applied. Application of nitrogen and phosphorus at their higher levels, i.e. 300 Kg N and 200 Kg P₂O₅, respectively, resulted in maximum flowers, largest flower size, and longest flowering duration, maximum dry and fresh weight of flower and highest yield of flowers

Ganga *et al.* (2008) reported significant increase in plant height, early flowering (100.40 days) and lowest flowering duration (50.67 days) on with application of FeSO₄ @ 0.8 per cent. Floral parameters viz. number of flowers per plant (99.09), highest

flower stalk length (7.95 cm), flower diameter (4.72 cm) and increased flower weight were significantly influenced by the foliar application of FeSO₄ @ 0.80 per cent in orchids

There was 14% greater numbers of flowers produced with nutrients application compared with the control plants (Sajid *et al.*, 2009).

In a study on the effects on growth and flowering of African marigold as effected by nitrogen and phosphorus under varying intra-row spacing, results showed that 300 kg N/ha produced noticeably highest flower yield and yield attributes viz. number of flowers/plant, size of flower head and weight of flowers/plant. The phosphorus dose @ 200kg/ha gave sustainable increase in flower yield and yield attributes of African marigold (Solanki and Ganie 2009)

Ahmad *et al.* (2010) reported that plants without micronutrients application produced poor quality vegetative growth and less number of flowers; further concluded that application of micronutrients could help better to improve flower yield and quality of roses.

Ahmad *et al.* (2010) reported that foliar application of Fe at 1.00 % concentration on rose (*Rosa hybrida* L.) was helpful to improve flower yield and quality when applied along with other micronutrients.

In a study on the effect of nitrogen levels on growth and yield of gerbera under poly house condition, the results revealed that the days required for bud initiation, days required for flowering and number of flowers per plant were influenced with increasing levels of nitrogen. (Jadhav *et al.* 2010)

Barad *et al.* (2011) studied the effect of NPK levels on gerbera cv. Sangria under net house condition. It was observed that the interaction effect of NPK (20:10:20 g/m²) significantly influenced the floral parameters viz. flower stalk length (57.33 cm), flower diameter (12.4 cm), total numbers of flowers per plant (24.55)

Khalifa *et al.* (2011) reported that, foliar application of zinc @ 4.5 g/l combined with 20 ppm boron significantly increased the growth parameters and increased yield in iris.

Le Chang *et al.* (2011) reported that foliar application of Fe on Oriental Lily and reported positive effects on the foliage and flowering.

Khosa *et al.* (2011) reported that foliar application of micronutrients in carnation checked the occurrence and spread of diseases caused by fusarium and alternaria. However, periodic spraying of micronutrients increased the flower yield from 1.5 to 1.8 fold and produced healthy vigorous plants (Astvatsatryan, 1984)

2.3 Effect of nutrients on Post-harvest life of anthurium

Bhattacharjee (1996) observed that, the application of boron 0.10 and 0.20 per cent resulted in higher longevity of rose cut flowers. Foliar application of ZnSO₄ at 1.0 and 1.5 per cent maximized the vase life of cut flowers 8.83 and 8.23 days respectively in rose cv. Super star (Narayan Manisha and Syamal, 2002).

Pre-harvest sprays of micronutrients applied twice after pruning to 3 year old roses cv. Raktagandha, on flower improved the quality and longevity of flowers Singh and Bhattacharjee (1997)

(Buchanan *et al.*, 2000) studied that the use of calcium carbonate and calcium nitrate increases calcium concentration in aerial organs including the stem tissues which has a direct effect on increasing the life cycle of flowers after harvesting.

Cut flowers are highly perishable, so maintenance of their physiological functions varies actively even after harvesting and initiation of their senescence largely depends on ethylene synthesis. Increase in ethylene production enhances senescence in cut roses and carnations (Quesada and Valpuesta, 2000)

Valsalkumari *et al.* (2001) conducted research on nutritional aspects in anthurium with different levels of NPK and shade levels. Application of nutrients at weekly intervals resulted in longest vase life.

Higher dose of fertigation results in better quality of flowers due to increased supply of nutrients, healthy and vigorous plants than all other treatments, Dufour *et al.* (2001)

Haque *et al* (2003) studied that potash enhances the synthesis, metabolism and translocation of carbohydrates, synthesis of proteins with rapid cell differentiation and division which results in better vase life of the plant.

Flower stalks were subjected to different holding solutions by Devi and Jawaharlal (2005) and results indicate that the BA 25 ppm + sucrose 2% and 8-HQC 100 ppm + sucrose 2% were the best holding solutions for prolonging the vase life of anthurium.

Effects of benzyl adenine (BA) on vase life of imported anthurium flowers was examined by Fukui *et al.* (2005) results indicate that the post importation BA treatment is mostly effective in extending the vase life of cut anthurium during summer, but may not be reliable during winter in temperate regions.

Studies were conducted to compare different pulsing treatments with the cut flowers of anthurium (*Anthurium andraeanum*) cv. Nitta by Soumen and Roychowdhury (2006) and concluded that maximum post-harvest longevity was found in the flowers treated with 8-HQS at 400 ppm + sucrose 5% (28.17 day).

Singh *et al.* (2007) studied the effect of vase and pulsing solutions on keeping quality of standard Carnation cut flowers and reported that the vase-life of cut-flowers was maximum (11.45 days) in solution containing sucrose (5%) + aluminum sulphate (200 ppm).

Out of seven holding solutions tested, Benzyl adenine 25 ppm+2 per cent sucrose extended the vase life of anthurium (*Anthurium andraeanum* cv Temptation) up to 34.3 days was concluded by Akiladevi (2007a).

Akiladevi (2007b) concluded that ethylene evolved in the flowers due to pulsing treatments is insignificant and also concluded that longevity of anthurium is not affected by ethylene.

Thawiang *et al.* (2007a) conducted experiment for improving the quality and vase life of cut flowers of Anthurium through the application of thidiazuron (TDZ) was investigated. TDZ was the most effective in prolonging the vase life of flowers at concentration of 10 and 15 micro M (21.5 and 21 days, respectively) while treatment of

100 ppm BA had the shortest vase life (16.4 days) as compared to control (18.4 days). Besides, TDZ maintained green color on spathe in cut Anthurium. However, there were no significant differences in water uptake and changes in flower color among all treatment.

Ganga *et al.* (2009) reported that foliar application of ferrous ammonium sulphate @ 1000 ppm gave maximum vase life (16.72 days) followed by zinc spray(1000 ppm) in dendrobium cv. Sonia 17.

Ahmad *et al.*, (2010) also reported that micro-nutrients application gives early and maximum flowering plant⁻¹ in Rose. However MS Macro + MS Micro + MS Vitamins was proved to be the best in all the flowering characters like Flower length, Flower width, Bloom life of individual flower and Bloom life of whole spike.



MATERIALS AND METHODS

The experiment was conducted during the year 2016-2017 under agro shadenet structure of RKVY Project on Anthurium, Dept. of Floriculture and Landscaping, Biotechnology-cum Tissue Culture Centre, Orissa University of Agriculture and Technology Bhubaneswar, Odisha. Bhubaneswar is situated at 63 kms away from Bay of Bengal at an altitude of 25.5m above the Mean Sea Level. Geographically it is located at 20°15' North, 85°52' East. The experiment was conducted on the nutritional management of *Anthurium andraeanum* cv. Tropical. Observations on plant growth, flowering and post harvest life of flowers were recorded.

3.1 Climate

Bhubaneswar comes under the subtropical climate. The mean annual precipitation is 1522 mm out of which 1293 mm is received within June to September and the rest 229 mm is received within October to May. The relative humidity varies between 50% in summer and 90% in rainy season. The details of the weather conditions such as temperature, relative humidity under field conditions during the period of investigation have been shown below as per the meteorological data recorded at the university observatory (field condition).

3.2 Weather Conditions during the Experimental Period

The experimental site is located in subtropical humid climate and is having following meteorological observations with respect to maximum and minimum temperature, rainfall, maximum and minimum relative humidity during the experimental period as presented in Table 1.

3.3 Experimental details

Name of the crop	Anthurium (<i>Anthurium andraeanum</i>)
Name of the cultivar	Tropical
No. of Treatments	15

Pots per treatment	15
No. of Replications	3
Total no. of plants	225
Design	Complete Randomized Design

Table 1. Weekly average weather data of Bhubaneswar from April 2016 to April 2017

Week	Max Temperature(C)		Rainfall (mm)	RH%	
	Max	Min		7 AM	2 PM
2016					
1	39.1	17.7	0	91.3	40.4
2	36.8	15.1	0	76.4	53.3
3	36.7	17.8	0.5	85.9	61.6
4	38.9	15.5	0	75	56
5	33.1	20.9	0	83.4	63.7
6	32.7	20.4	0	85.4	61
7	36.1	21.6	0	78.4	54.6
8	37.3	22	0	71.9	59.9
9	33.9	22.5	6.8	82.4	62.6
10	37.1	21.9	0	78.3	42.4
11	37.1	23	0.5	78.6	56.1
12	37.1	25.1	1	74.3	58.3
13	37	25	0	74.4	65.1
14	39	26.3	0	74.4	65.7
15	43.1	26.8	0	65.9	48.9
16	40.7	27.1	0	71.3	58.4
17	42.2	27	1.7	76.4	67.7
18	42.2	27.1	1.7	65.1	50.6
19	40.5	26.9	5.6	66.9	64.3
20	39.5	28	0	64.9	63.3
21	35.6	25.9	105.2	84.6	80.1

22	38.4	27	21.3	77.3	68.3
23	34.2	26	128.6	84.3	85.7
24	36.6	27.6	19.2	80.9	72.3
25	33.1	26.2	46.3	89.4	79.3
26	33.8	26.8	11.3	83.7	79
27	31.7	26.4	102.2	91.7	89.9
Week	Max Temperature(C)		Rainfall (mm)	RH%	
	Max	Min		7 AM	2 PM
28	31.3	26.1	66.3	90.6	90
29	33.2	25.7	16.8	87.9	82.1
30	31.6	25.9	74.1	88.7	82.9
31	32.7	25.9	80.3	89.7	90.7
32	28.4	25.4	108.2	98.6	94.7
33	31.1	25.7	58	88	82.4
34	33.3	26.2	44.5	90.9	85.4
35	32.8	26.4	39.6	90.9	89.3
36	29	24.8	62.5	95	93
2017					
1	29.3	16.2	0	87.7	60.6
2	29.1	15.7	0	68	53.4
3	29.9	13.7	0	87.7	60.6
4	31	15.5	0	68	53.3
5	31.3	17.9	0	73.3	50.7
6	34.2	18.5	0	74.3	53.7
7	34.1	18.9	0	83.3	42.4
8	35.2	19.4	0	83.9	44.3
9	36.1	22.8	0	77.4	44.3
10	32.5	21.3	0	83.3	57.1
11	33.2	22.9	36.7	84.6	49.9

12	33.5	21.3	0.5	88.3	76.7
13	34.6	22.5	0	83.2	76.3
14	34.3	21.6	22.3	81.2	77.2
15	33.5	22.4	0.6	83.2	64.3
16	34.8	21.3	21.4	82.1	69.2

3.4 Selection of anthurium type

The anthurium used in the study for the experiment was one year old anthurium hybrid *Anthurium andraeanum* var. Tropical. Inflorescence bears small flowers which are perfect containing male and female structures. Flowers are contained in dense spirals on the spadix, beneath the spadix is the spathe, a type of red colored bract.

Table 2 Scientific classification

ORDER	Alismatales
FAMILY	Araceae
GENUS	<i>Anthurium</i>
SPECIES	<i>andraeanum</i>
CULTIVAR	Tropical

3.5. Collection of experiment materials

The six months old anthurium tissue cultured plants planted in the pots of the RKVY project on Anthurium running at the BTCC were used for the experiment purpose.

3.6 Sorting of materials

The following criteria were followed while selecting the anthurium plants for experiment.

- a. Plants must have uniformity in growth and age of the plants
- b. Plants must be free from injury particularly, growing shoots and roots
- c. Plants must be free from disease ,pest infestation

3.7 Type of pots used

Clay pots of 30 cm diameter and 25cm height were used for planting anthurium plants. Pots were provided with holes in the base for proper drainage and aeration.

3.8 Substrates

The drainage holes of the plant were covered with broken crocks for proper drainage. The anthurium plants were planted in potting mixture comprising of charcoal, coconut husk pieces, coconut chops, mango bark and broken brick pieces in equal proportion, coarse sand and broken bricks. The coconut husks were collected from mature coconuts, cut into 2”X 2” pieces (approx.) and were washed thoroughly before being used as potting mixture .The plants were then planted in middle of the plant and watered.

3.9 Placing of pots

Anthurium plants were kept in a shade net house having 50% shade. Fifty percent shade was provided by green color shade net .The pots were placed in a shady place.

3.10 Treatment details

The experiment was laid out with fifteen treatments. The detailed information regarding treatments are as follow

Table 3 Treatment detail

Sl. No.	FERTILIZERS	SYMBOL
1	RDF,Urea :SSP:MOP@ 7.2:4.6:3.0g/plant	T ₁
2	RDF+ Calcium carbonate(1.6g)/plant	T ₂
3	RDF +Magnesium sulphate(1.5g/plant)	T ₃
4	RDF + Wettable Sulphur(1.5mg/l)	T ₄
5	RDF + Calcium carbonate(1.6g)/plant+ Magnesium sulphate (1.5g/plant)	T ₅
6	RDF+ Calcium carbonate(1.6g)/plant +Wettable Sulphur(1.5mg/l)	T ₆
7	RDF +Magnesium sulphate(1.5g/plant)+ Wettable Sulphur(1.5mg/l)	T ₇
8	RDF+Magnesium sulphate(1.5g/plant)+Calcium carbonate(1.6g)/plant + Wettable Sulphur(1.5mg/l)	T ₈
9	RDF +Calcium carbonate(1.6g)/plant+ MS Micro (10 ml/litre)	T ₉

10	RDF +Magnesium sulphate(1.5g/plant)+ MS Micro (10 ml/litre)	T ₁₀
11	RDF +Wettable Sulphur(1.5mg/l)+ MS Micro (10 ml/litre)	T ₁₁
12	RDF +Calcium carbonate(1.6g)/plant+ Magnesium sulphate(1.5g/plant) +MS Micro (10 ml/litre)	T ₁₂
13	RDF+Calcium carbonate(1.6g)/plant+Wettable Sulphur(1.5mg/l) +MS Micro (10 ml/litre)	T ₁₃
14	RDF + Magnesium sulphate(1.5g/plant)+Wettable Sulphur(1.5mg/l) MS Micro(10 ml/litre)	T ₁₄
15	RDF+Calcium carbonate(1.6g)/plant+Magnesium sulphate(1.5g/plant) +Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	T ₁₅

3.10.1 Nutrients used

- Urea (7.2g/plant) -Applied in two splits in a month, substrate application was done at 15th and 30th day of the month.
- Single super phosphate (SSP) (4.6 g/plant) - Applied twice a month through substrate application 15th and 30th day of the month.
- Murate of potash (MOP) 3g/plant- Applied twice a month through substrate application 15th and 30th day of the month
- Ca as Calcium carbonate (1.6 g /plant) – Once a month through substrate application.
- Mg as Magnesium sulphate (1.5 g /plant) – Once a month through substrate application.
- Sulphur as Wettable Sulphur (1.5 mg/l) – Spray was done once a month
- MS Micronutrient solution @(10ml/l) – Applied once a month as foliar spray

Fertilizers containing macronutrients, readily available in the market were used in the experiment. MS Stock solution was used for micronutrient spray

Table 4: Important micronutrients required in anthurium

Micronutrient	Role in anthurium
BORON	<ul style="list-style-type: none">• Boron is believed to be involved in carbohydrate transport in plants.• It also assists in metabolic regulation.• Boron deficiency will often result in bud dieback in anthurium.
CHLORINE	<ul style="list-style-type: none">• Chlorine is necessary for osmosis and ionic balance in the plants.• It also plays a role in photosynthesis.
COPPER	<ul style="list-style-type: none">• Copper is a component of some enzymes.• Symptoms of copper deficiency include browning of leaf tips and chlorosis.
IRON	<ul style="list-style-type: none">• Iron is essential for chlorophyll synthesis, which is why an iron deficiency results in chlorosis.
MANGANESE	<ul style="list-style-type: none">• Manganese activates some important enzymes involved in chlorophyll formation.• Manganese deficient anthurium plants will develop chlorosis between the veins of its leaves.• The availability of manganese is partially dependent on soil pH.
MOLYBDENUM	<ul style="list-style-type: none">• Molybdenum is essential to anthurium plant health.• Molybdenum is used by plants to reduce nitrates into usable forms.
ZINC	<ul style="list-style-type: none">• Zinc participates in chlorophyll formation, and also activates many enzymes. Symptoms of zinc deficiency in anthurium plants include chlorosis and stunted growth
COBALT	<ul style="list-style-type: none">• Retards the senescence of the leaves.



Fig. 3.1 Raw material for preparation of substrates



Fig. 3.2 Substrate preparation for growing anthurium



Fig 3.3 Tissue cultured anthurium plants for planting



Fig 3.4: Anthurium plants treated with Bavistin solution before planting



Fig. 3.5 Anthurium plant in the shade net house



Fig. 3.6: Irrigation to the anthurium plant



Fig. 3.7 Topdressing of anthurium plant

3.10.2 Availability of nutrients

The fertilizers used in this experiment are available in the local market and farmers can get them easily

3.10.3 Equipment and glassware used

Electronic balance for weighing, beakers, measuring cylinder, stirring rod and hand pump sprayer

3.11 Mode of application

Urea was given twice a month i.e 15th and 30th day of the month through direct substrate application. Calcium Carbonate and Magnesium Sulphate were given once a month through substrate application.

Micronutrient spray was done with a clean hand pump sprayer. While spraying, utmost care was taken to prevent the adjoining plants getting sprayed. Spraying was done thoroughly so that all parts of the plants were fully drenched. After each spraying, the sprayer, the sprayer was thoroughly washed with clean water to avoid residual effect of the nutrients.

3.12 Floriculture practices adopted

3.12.1 Irrigation

The plants were watered every day, the frequency of watering was dependent on the season. During summer season and winter, the plants were watered twice a day i.e morning and afternoon. Watering was with-held during rainy days.

3.12.2 Weeding

Weeds were removed manually, as and when noticed to keep the plants healthy and disease free. Substrates were stirred once a week to improve aeration.

3.12.3 Plant protection measures

After the plants were planted in the pots they were sprayed with 0.2% Blitox to keep the plants free from leaf spot disease. This was done by spraying the individual plants till the whole parts drenched. This was applied as a prophylactic measures to prevent the fungal diseases. To prevent mite attack Dicofol was sprayed @ 0.02 %.

3.13 Observations of growth and floral parameters

3.13.1 Plant height: Plant height was measured in centimeter from plant level to tip of the leaf stretched vertically by measuring scale and mean was taken.

3.13.2 Number of leaves per plant: This was determined by counting the number of leaves present in an individual plant and mean was calculated.

3.13.3 Leaf length: This was measured from the base of the midrib to the tip of leaf of the randomly selected leaves and mean was calculated.

3.13.4 Leaf breadth: Breadth was measured as highest width region using scale in centimeters.

3.13.5 Stalk length: It was measured from the base of stalk upto the base of the flower (spathe)

3.13.6 Petiole length: It was measured from the base of the petiole to the base of leaf.

3.14.7 No. of flowers/plant/month: This was determined by counting all the flowers bloom present in an individual plant per month.

3.13.8 Spathe length: This was measured by using scale from the base of the spathe to the apex in centimetres after 30 days.

3.13.9 Spathe width: This was measured by measuring scale in centimeters cross section wise at highest region.

3.13.10 Spadix length: This was measured with the measuring scale from the base of the spadix to the tip.

3.13.11 Spadix width: Width of the spadix was measured with the help of measuring scale cross section wise after 30 days.

3.13.12 Spathe colour: Colour of the spathe was determined after full opening of spathe

3.13.13 Spadix colour: Spadix colour was recorded by visual observation.

3.13.14 Vase life: This was determined by counting the days from putting the spikes in a vase containing tap water till it retains its freshness in the vase.

3.14 Statistical analysis

The data obtained from various growth and yield parameters were statistically analyzed in a complete randomized design to obtain the analysis of variance. The variance was tested at 5 % level of significance, standard error of mean (SEM) and critical difference (CD) were calculated for comparing the mean value. The significance of difference between any two means tested through computation of critical difference (CD)

$$\text{S.E. (m)} \pm = \text{Standard error of mean} = \frac{\sqrt{EMS}}{r}$$

Where EMS = Error Mean of square

r = number of replications

$$\text{CV} = \frac{\sqrt{EMS}}{\text{MEAN}} \times 100$$

CD = Critical Difference = SED × t value at 5% at error degree of freedom

$$\text{SED} = \frac{\sqrt{2EMS}}{r}$$

Where SED = standard error of difference between two treatments

r = no. of replicatons



RESULTS

The data on vegetative growth, flowering and post-harvest life of *Anthurium cv.* Tropical were recorded during the course of experiment, which was carried out in the agro shadenet structure of BTCC, Baramunda, Dept. of Floriculture and Landscaping, OUAT , Bhubaneswar . Data were subjected to statistical analysis as per the design of the experiment and are presented in this section under the following sub sections.

4.1 Effect of nutrients on vegetative growth of anthurium.

4.2 Effect of nutrients on flowering of anthurium.

4.3 Effect of nutrients on post-harvest life of anthurium.

4.1 Effect of nutrients on vegetative growth of *Anthurium*

Observations on different parameters like plant height, petiole length, number of leaves per plant, leaf length, leaf breadth were recorded during the experiment. The results are as follows:

4.1.1 Effect of nutrients on vegetative growth of *Anthurium cv.* Tropical

It is evident from the data presented in Table 5 that the plant height varied significantly due to application of nutrients on *Anthurium cv.* Tropical. Among the different treatments, treatment T₅ RDF, Urea:SSP:MOP @ 7.2:4.6:3.0 g/plant, Calcium carbonate 1.6 g/plant and Magnesium sulphate 1.5 g/plant showed highest plant height (26.94cm) which stood at par with the treatments T₁₃ (RDF, Calcium carbonate, Wettable Sulphur and MS Micro) and T₁₅ (RDF, Calcium carbonate, Magnesium sulphate, Wettable Sulphur and MS Micro). With the application of different macro nutrients and micronutrients on *Anthurium cv.* Tropical the minimum plant height was observed in T₁ (Control) which was followed by the Treatment T₂ (RDF + Ca).

The data presented in Table 5 revealed that the number of leaves per plant varied significantly among different treatments of nutrients application on *Anthurium cv.* Tropical. Plants treated with (RDF+ Ca+ Mg) treatment T₅, showed highest number of leaves per plant. (10.33) which was statistically at par with treatments T₁₃ (RDF +Ca +S+MS Micro) and treatment T₇ (RDF+Mg+Ca+S)

Table 5. Effect of nutrients on vegetative growth of *Anthurium* cv. Tropical

Treatments		Vegetative characters				
		Plant height (cm)	Number of leaves per plant	Petiole length (cm)	Leaf length (cm)	Leaf breadth (cm)
T ₁	RDF, Urea:SSP:MOP @7.2:4.6:3.0 g/plant	18.06	7.00	16.73	10.33	6.46
T ₂	RDF+ CaCO ₃ (1.6g)/plant	21.53	7.66	18.66	11.20	7.16
T ₃	RDF+MgSO ₄ (1.5g/plant)	22.33	8.66	17.70	10.80	6.66
T ₄	RDF+Wettable Sulphur(1.5mg/l)	24.06	7.67	19.10	11.36	7.00
T ₅	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)	26.94	10.33	21.03	12.00	7.90
T ₆	RDF+CaCO ₃ (1.6g)/plant+Wettable Sulphur(1.5mg/l)	23.16	9.00	20.13	12.66	7.86
T ₇	RDF+MgSO ₄ (1.5g/plant)+Wettable Sulphur(1.5mg/l)	21.20	9.33	19.60	13.10	7.20
T ₈	RDF+MgSO ₄ (1.5g/plant)+CaCO ₃ (1.6g)/plant+Wettable Sulphur(1.5mg/l)	22.30	8.50	20.26	11.60	6.86
T ₉	RDF+CaCO ₃ (1.6g)/plant+MS Micro (10 ml/litre)	24.14	7.66	20.03	12.26	7.46
T ₁₀	RDF+MgSO ₄ (1.5g/plant)+MS Micronutrients(10 ml/litre)	21.80	9.00	20.23	13.46	7.50
T ₁₁	RDF+WettableSulphur(1.5mg/l)+MS Micro (10 ml/litre)	23.60	8.00	18.80	12.16	6.73
T ₁₂	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+MS Micro (10 ml/litre)	24.33	8.66	19.53	11.70	7.30
T ₁₃	RDF+CaCO ₃ (1.6g)/plant+Wettable Sulphur (1.5mg/l)+MS Micro (10 ml/litre)	26.30	10.00	20.03	12.63	7.33
T ₁₄	RDF+MgSO ₄ (1.5g/plant)+Wettable Sulphur(1.5mg/l)+MSMicro (10 ml/litre)	24.56	8.11	18.73	13.33	7.53
T ₁₅	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+WettableSulphur(1.5mg/l)+MS Micro (10 ml/litre)	26.40	8.00	18.5	13.56	8.10
	SEm(±)	0.16	0.44	0.12	0.10	0.11
	C.D. 5%	0.47	1.26	0.35	0.29	0.31



Fig. 4. 1 Full view of anthurium plants under agro shade net



Fig 4.2 Vegetative growth of the plants treated with RDF + CaCO₃ +MgSO₄



Fig 4.3: Anthurium flowering in control

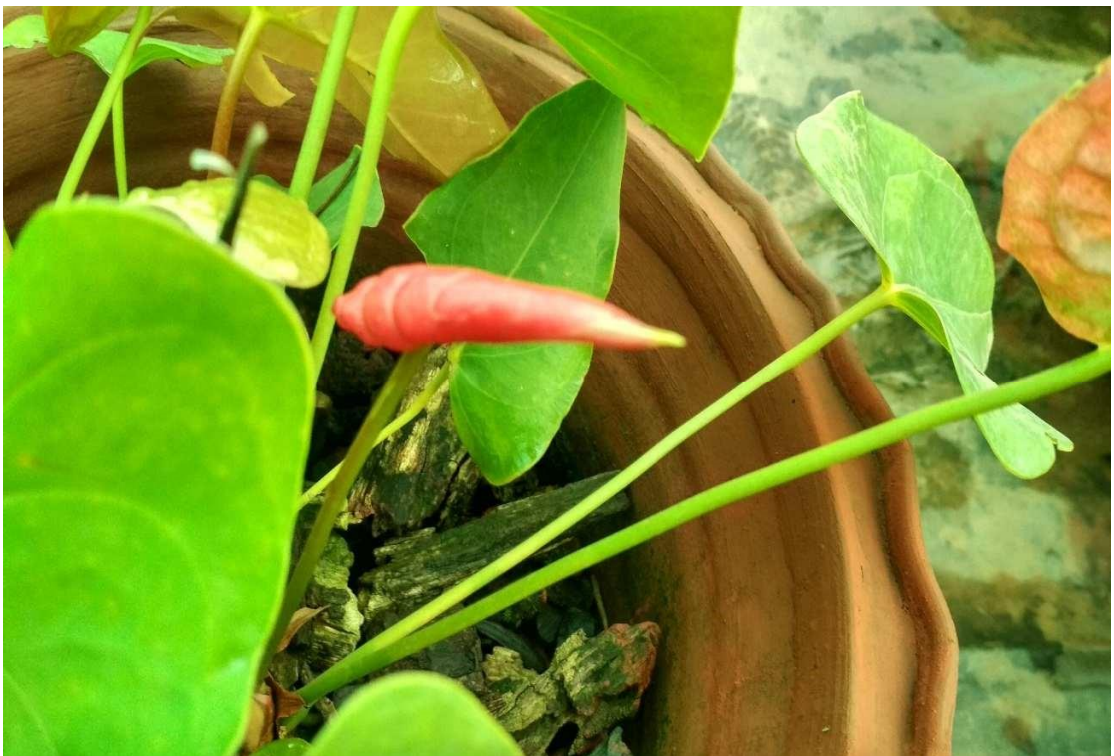


Fig 4.4 Folded spathe of anthurium

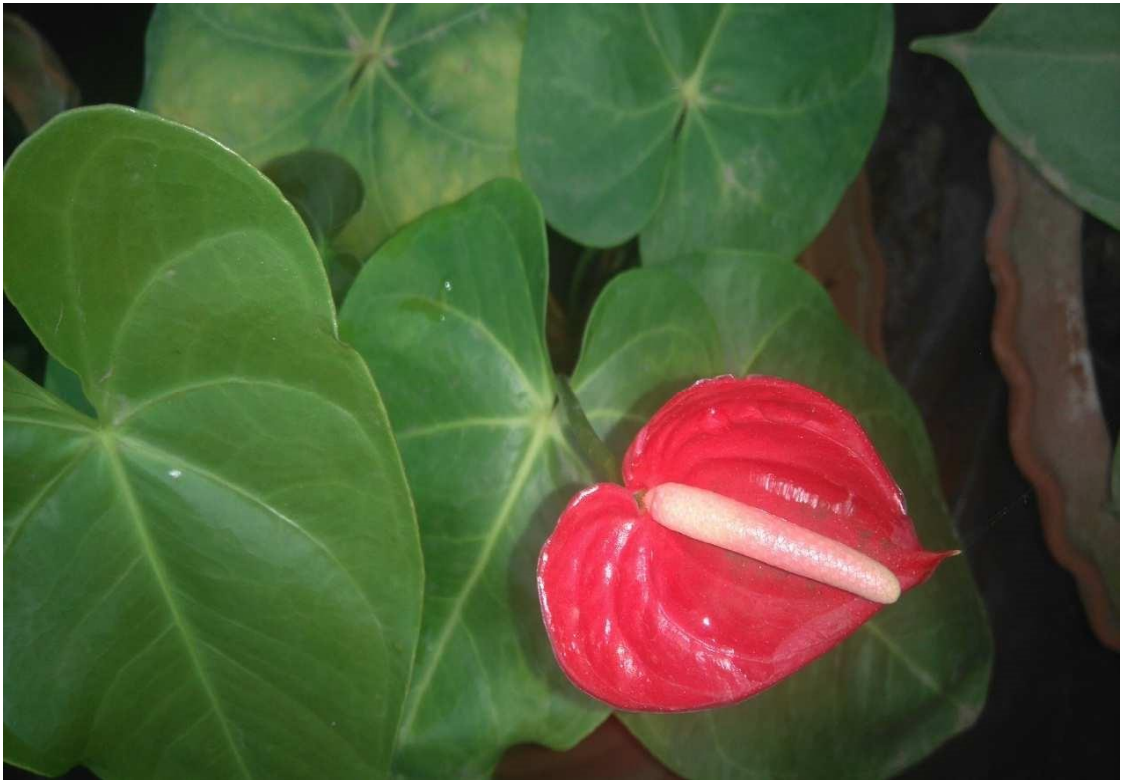


Fig. 4.5 Unfurling of anthurium spathe in T₅ (RDF+Ca+ Mg)



Fig. 4.6 Flowering in Micro nutrient treated plants



Fig. 4.7 Anthurium plants during flowering stage



Fig. 4.8 Spathe colour (Deep Red) in T₅ (RDF + Calcium carbonate and Magnesium sulphate)



Fig. 4.9 Spadix colour in T₅ (RDF + Calcium carbonate and Magnesium sulphate)



Fig. 4.10 Flowering in T₅ plant

Among the different nutrient treatments, treatment T₅ (RDF + Ca + Mg) showed maximum petiole length (21.03cm) which stood at par with the treatments T₈ (RDF+Mg+Ca+S), T₁₀ (RDF +Mg+MS Micro), T₁₃ (RDF+Ca+S+MS Micro), T₉ (RDF+Ca+MsMicro)

The leaf length significantly increased by application of different treatments on *Anthurium* cv. Tropical. Among the different treatments of nutrients on *Anthurium* cv. Tropical maximum leaf length (13.56cm) was observed in treatment T₁₅ (RDF +Ca +Mg +S+MS Micro which was statistically at par with T₁₀ (RDF +Mg +MS Micro), T₁₄ (RDF+Mg+S+MS Micro), T₁₅ (RDF+Ca+Mg+S+MS Micro).

From table 5 it is evident that application of different nutrients had significant effect on the vegetative characters of *Anthurium* cv. Tropical. Considering above mentioned characters it was concluded that the application of RDF, Urea:SSP:MOP @ 7.2:4.2:3.0 g/plant, CaCO₃ @ 1.6 g/plant and MgSO₄ @ 1.5 g/plant significantly enhanced the plant height (26.94cm), number of leaves per plant (10.33), leaf petiole length (21.03cm) whereas Leaf length (13.56 cm) and leaf breadth (8.10cm) were found maximum in T₁₅ (RDF+Ca+Mg+S+MS Micronutrients)

4.2. Effect of nutrients on flowering of Anthurium

4.2.1 Effect of nutrients on flowering of Anthurium cv. Tropical

Minimum days for flower opening (120.43 days) was found in treatment T₁₂ (RDF+Ca +Mg+MS Micro) and data stood at par with the treatment T₂ (123.16) i.e. RDF+ Ca and T₃ (RDF+Mg)

The treatment T₅ (RDF+ Ca+ Mg) significantly enhanced the number of flowers (2.15) and the data stood at par with T₁₃ (RDF+Ca+S+MSMicro), T₁₄ (RDF+Mg +S+MS Micro and T₁₀ (RDF+Mg+MS Micro)

It is evident from Table 6 that stalk length(12.83cm) was found maximum in treatment T₅ (RDF + Ca +Mg) which was at par with treatment T₈ (RDF+Mg+Ca+S), T₁₁ (RDF+S+MSMicro), T₁₄ (RDF+Mg+S+MS Micro)

Spathe length varied significantly among different treatments of nutrients on *Anthurium* cv. Tropical. Among the different treatments, treatment T₅ (RDF+ Ca+ Mg) showed maximum spathe length (8.7cm) followed by treatment T₉ (RDF+Ca+MS Micro) (8.3 cm).

Table 6 Effect of nutrients on flowering characters of Anthurium cv. Tropical

Treatment		Flowering characters		
		Stalk Length (cm)	Days to flower opening	Number of flowers
T ₁	RDF, Urea:SSP:MOP @ 7.2:4.6:3.0 g/ plant	11.39	154.33	2.0
T ₂	RDF+ CaCO ₃ (1.6g)/plant	12.33	123.16	0.5
T ₃	RDF+MgSO ₄ (1.5g/plant)	11.82	133.45	1.23
T ₄	RDF+Wettable Sulphur(1.5mg/l)	11.53	143.56	1.12
T ₅	RDF+ CaCO ₃ (1.6g)/plant+ MgSO ₄ (1.5g/plant)	12.83	145.65	2.15
T ₆	RDF+ CaCO ₃ (1.6g)/plant+ Wettable Sulphur(1.5mg/l)	12.23	167.43	1.30
T ₇	RDF +MgSO ₄ (1.5g/plant)+ Wettable Sulphur(1.5mg/l)	12.44	170.25	1.12
T ₈	RDF+MgSO ₄ (1.5g/plant)+ CaCO ₃ (1.6g)/plant+ Wettble Sulphur(1.5mg/l)	12.67	171.36	2.02
T ₉	RDF+CaCO ₃ (1.6g)/plant+MS Micro (10 ml/litre)	12.46	168.53	0.71
T ₁₀	RDF+MgSO ₄ (1.5g/plant)+MS Micro (10 ml/litre)	12.06	146.73	1.00
T ₁₁	RDF+Wettable Sulfur(1.5mg/l)+MS Micro (10 ml/litre)	12.76	150.29	1.42
T ₁₂	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+ MS Micro (10 ml/litre)	12.21	120.43	1.23
T ₁₃	RDF+CaCO ₃ (1.6g)/plant+Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	12.42	138.50	1.15
T ₁₄	RDF+MgSO ₄ (1.5g/plant)+ +Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	12.75	140.00	1.65
T ₁₅	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+ +Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	13.46	160.33	1.31
	SEm(±)	0.11	0.13	0.1
	C.D. 5%	0.32	0.39	0.28

Table 7 Effect of nutrients on floral characters of Anthurium cv. Tropical

Treatment		Floral characters					
		Spathe length (cm)	Spathe breadth (cm)	Spathe colour	Spadix length (cm)	Spadix breadth (cm)	Spadix colour
T ₁	RDF(Urea:SSP:MOP)(7.2:4.6:3.0g/plant)	5.43	5.75	Light Red	2.84	1	Light Yellow
T ₂	RDF+ CaCO ₃ (1.6g)/plant	6.8	6.46	Red	3.23	1.3	Yellowish Green
T ₃	RDF+MgSO ₄ (1.5g/plant)	7.10	6.86	Light Red	3.46	1.4	Green Yellow
T ₄	RDF+ Wettable Sulphur(1.5mg/l)	7.76	6.43	Red	3.60	1.5	Yellow
T ₅	RDF+ CaCO ₃ (1.6g)/plant+ MgSO ₄ (1.5g/plant)	8.72	7.16	Deep Red	4.32	1.5	Yellow
T ₆	RDF+ CaCO ₃ (1.6g)/plant+ Wettable Sulphur(1.5mg/l)	7.70	6.56	Red	4.06	1.2	Light Yellow
T ₇	RDF+MgSO ₄ (1.5g/plant)+Wettable Sulphur(1.5mg/l)	7.23	6.53	Red	3.70	1.3	Light Yellow
T ₈	RDF+MgSO ₄ (1.5g/plant)+ CaSO ₄ (1.6g)/pot+ Wettable Sulphur(1.5mg/l)	7.35	6.72	Red	4.14	1.1	Yellow
T ₉	RDF+CaCO ₃ (1.6g)/plant+MS Micro(10 ml/litre)	8.32	6.96	Red	3.90	1.3	Yellow
T ₁₀	RDF+MgSO ₄ (1.5g/plant)++MS Micro10 ml/litre)	7.66	6.53	Red	3.50	1.2	Yellow
T ₁₁	RDF+Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	7.23	6.93	Red	4.14	1	Yellow
T ₁₂	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+ MS Micro (10 ml/litre)	8.03	6.21	Red	3.54	1.1	Yellow
T ₁₃	RDF+CaCO ₃ (1.6g)/plant+Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	7.06	5.96	Red	4.13	1.2	Yellow
T ₁₄	RDF+MgSO ₄ (1.5g/plant)+ Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	7.43	6.96	Red	3.73	1.32	Yellow
T ₁₅	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+ Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	8.26	7	Red	4.10	1.07	Yellow
	SEm(±)	0.12	0.11		0.53	0.06	
	C.D. 5%	0.35	0.31		1.5	0.17	

Among all the treatments maximum spathe breadth was recorded in treatment T₅ (7.16cm) i.e. RDF + Ca + Mg and the data stood at par with treatment T₃ (RDF+Mg), T₉ (RDF +Ca+MS Micro) and T₁₁ RDF +S+MS Micro)

Spadix length significantly increased on application of different nutrients. The treatment T₅ (RDF+Ca+Mg) significantly enhanced the spadix length (4.3cm) followed by treatment T₂ (RDF+Ca).

Treatment T₅ i.e (RDF+Ca+Mg) significantly enhanced the spadix breadth (1.5cm) which stood at par with the treatments T₂ (RDF+Ca), T₉ (RDF+Ca+MS Micro), T₁₄(RDF+Mg+S+MSMicro

RDF (Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant) in combination with Calcium Carbonate and Magnesium Sulphate significantly enhanced the color (red) and quality of spathe and spadix.

Integrated application of macro and micronutrients revealed significant result on flowering of Anthurium cv. Tropical. From the above data we concluded that the plants treated with RDF (Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant), Calcium carbonate 1.6 g/plant and Magnesium sulphate @ 1.5 g/plant (T₅) showed maximum stalk length (12.83 cm), number of flowers (5.6), spathe length (8.7cm), spathe breadth (7.16cm), spadix length (4.3cm) and spadix breadth (1.5cm), whereas days to flower opening (120.43) was found minimum in treatment T₁₂(RDF+Ca+Mg+MS Micro) which was at par with T₂ (RDF+Ca).

4.3 Effect of nutrients on post-harvest life of *Anthurium*

4.3.1 Effect of nutrients on post-harvest life of *Anthurium* cv. Tropical

The observations of solution uptake after every 3 days were recorded. Solution uptake after every 3 days increased significantly in *Anthurium* cv. Tropical. Among the different treatments the maximum solution uptake after 3 days (3.98ml) was recorded in treatment T₁₂ (RDF+Ca+Mg+MS Micronutrients)

After 6 days the maximum solution uptake (3.93ml) was recorded in the treatment T₁₂ (RDF+Ca+Mg+MS Micronutrients) which was at par with the treatments T₁₀ (RDF+Mg+MS Micronutrients) and T₁₁ (RDF+S+MS Micronutrients)

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Treatment T₁₂ (RDF+Ca+Mg+MS Micronutrients) showed maximum solution uptake (4.30ml) after 9 days and the data stood at par with T₂ (RDF+Ca), T₁₀ (RDF+Mg+MS Micronutrients) and T₁₄ (RDF+Mg+S+MS Micronutrients)

Solution uptake was recorded maximum after 12 days (4.30ml) in treatment T₁₂ (RDF+Ca+Mg+MS Micronutrients) which stood at par with treatments T₂ (RDF+Ca), T₄ (RDF+S), T₅ (RDF+Ca+Mg), T₈ (RDF+Mg+Ca+S), T₉ (RDF+Ca+MS Micronutrients), T₁₁ (RDF+S+MS Micronutrients).

Days to delay in discoloration of spathe was found maximum (16.98 days) in the plants treated with (RDF+Ca+S+MS Micronutrients) i.e. treatment T₁₃ which was statistically at par with the treatments T₅ (RDF+Ca+Mg) and T₇

(RDF+Mg+S)

Treatment T₇ (RDF+Mg+S) showed maximum days to delay in discoloration of spadix (15.04) days which stood at par with treatment T₅ (RDF+Ca+Mg) (14.85)

Days to maturity of spadix (17.45 days) was found maximum in treatment T₁₃ (RDF+Ca+S+MS Micronutrients) which stood at par with the treatment T₅ (RDF+Ca+Mg) (16.62). Treatment T₁₃ (RDF+Ca+S+MS Micronutrients) showed the longest vase life i.e (19.20)

Hence data in table 8 revealed that the nutrient and micronutrient application had significant effect on *Anthurium* cv. Tropical. Solution uptake after 3, 6,9,12 days was found maximum in the plants treated with RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant) CaCO₃ 1.6 g/plant, MgSO₄ 1.5 g/plant and MS Micro 10 ml/litre i.e. treatment T₁₂ which stood at par with the treatments T₂ (RDF+Ca), T₅ (RDF+Ca+Mg), T₁₁ (RDF+S+MSMicro), T₁₂ (RDF+Ca+Mg+MS Micro). In terms of days taken for delay in discoloration of spathe, days taken for delay in maturity of spadix and longest vase life was found to be maximum in plants treated with T₁₃ (RDF+Ca+S+MS Micro) while days to discoloration of spadix was recorded highest in plants treated with T₇ (RDF+Mg+S) which stood at par with treatment T₅ (RDF+Ca+Mg). Longest vase life (19.20days) was recorded in T₁₃ (RDF+Ca+S+MS Micro).

Table 8 Effect of nutrients on post-harvest life of *Anthurium* cv .Tropical

Treatment		Solution uptake after 3 days(ml)	Solution uptake after 6 days(ml)	Solution uptake after 9 days(ml)	Solution uptake after 12 days(ml)
T ₁	RDF (Urea:SSP:MOP)(7.2:4.6:3.0g/plant)	2.34	2.90	3.07	3.58
T ₂	RDF+ CaCO ₃ (1.6g)/plant	3.28	3.30	3.81	3.88
T ₃	RDF +MgSO ₄ (1.5g/plant)	3.53	3.34	3.74	3.98
T ₄	RDF +Wettable Sulphur(1.5mg/l)	3.05	3.18	3.51	3.87
T ₅	RDF + CaCO ₃ (1.6g)/plant+ MgSO ₄ (1.5g/plant)	3.07	3.12	3.56	3.87
T ₆	RDF + CaCO ₃ (1.6g)/plant + Wettable Sulphur(1.5mg/l)	3.0	3.20	3.40	3.69
T ₇	RDF+MgSO ₄ (1.5g/plant)+ Wettable Sulphur(1.5mg/l)	2.97	3.07	3.24	3.37
T ₈	RDF(30:20:50)g/m ² +MgSO ₄ (1.5g/plant)+ CaCO ₃ (1.6g)/plant+ Wettable Sulphur(1.5mg/l)	3.10	3.31	3.59	3.86
T ₉	RDF+CaCO ₃ (1.6g)/plant+MS Micro(10 ml/litre)	3.18	3.51	3.71	3.88
T ₁₀	RDF+MgSO ₄ (1.5g/plant)+ MS Micro (10 ml/litre)	3.36	3.42	3.83	4.02
T ₁₁	RDF +Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	3.13	3.47	3.67	3.84
T ₁₂	RDF +CaCO ₃ (1.6g)/plant+Mg(1.5g/plant)+ MS Micro (10 ml/litre)	3.98	3.93	4.30	4.30
T ₁₃	RDF +CaCO ₃ (1.6g)/plant+S(1.5mg/l)+MS Micro (10 ml/litre)	3.25	3.50	3.79	3.97
T ₁₄	RDF+MgSO ₄ (1.5g/plant)+WettableSulphur(1.5mg/l)+MSMicro (10 ml/litre)	3.21	3.74	3.87	4.07
T ₁₅	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+WettableSulphur(1.5mg/l)+MS Micro (10 ml/litre)	3.34	3.45	3.67	3.77
	SEm(±)	0.11	0.16	0.15	0.15
	CD 5%	0.32	0.45	0.43	0.43

Table 9 Effect of nutrients on post-harvest life of *Anthurium* cv. Tropical

Treatment		Days to discoloration of spadix	Days to discoloration of spathe	Days to maturity of spadix	Vase life (days)
T ₁	RDF (Urea:SSP:MOP)(7.2:4.6:3.0g/plant)	10.73	11.29	11.66	12.13
T ₂	RDF + CaCO ₃ (1.6g)/plant	10.25	12.32	12.60	13.40
T ₃	RDF +MgSO ₄ (1.5g/plant)	10.40	11.10	11.53	12.53
T ₄	RDF + Wettable Sulphur(1.5mg/l)	11.27	12.48	12.87	13.53
T ₅	RDF + CaCO ₃ (1.6g)/plant+ MgSO ₄ (1.5g/plant)	14.85	16.51	16.06	17.43
T ₆	RDF + CaCO ₃ (1.6g)/plant +Wettable Sulphur(1.5mg/l)	11.17	14.32	14.60	15.73
T ₇	RDF +MgSO ₄ (1.5g/plant)+ Wettable Sulphur(1.5mg/l)	14.04	16.32	16.77	17.49
T ₈	RDF +MgSO ₄ (1.5g/plant)+ CaCO ₃ (1.6g)/plant+ Wettable Sulphur(1.5mg/l)	13.29	13.28	13.66	14.30
T ₉	RDF +CaCO ₃ (1.6g)/plant+MS Micro (10 ml/litre)	13.63	14.22	14.76	15.47
T ₁₀	RDF +MgSO ₄ (1.5g/plant)+ MS Micro (10 ml/litre)	13.21	14.28	14.87	15.33
T ₁₁	RDF +Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	11.89	12.37	12.69	13.90
T ₁₂	RDF +CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+ MS Microns (10 ml/litre)	13.95	14.25	14.61	15.56
T ₁₃	RDF +CaCO ₃ (1.6g)/plant+Wettable Sulphur(1.5mg/l)+MS Micro (10 ml/litre)	15.04	16.98	17.45	19.20
T ₁₄	RDF +MgSO ₄ (1.5g/plant)+WettableSulphur(1.5mg/l)+MS Micro (10 ml/litre)	13.48	14.43	14.69	15.00
T ₁₅	RDF+CaCO ₃ (1.6g)/plant+MgSO ₄ (1.5g/plant)+Wettable Sulphur(1.5mg/l)+ MSMicro (10 ml/litre)	13.20	14.03	15.23	15.67
	SEm(±)	0.28	0.33	0.37	0.19
	CD 5%	0.82	0.96	1.07	0.56



Fig 4.11. Solution uptake by T₁ plants



Fig: 4.12 Spadix discoloration in T₂ and T₃



Fig 4.13: Spathe discoloration in T₇ plants



DISCUSSION

Anthurium is one of the top ten cut flowers of the world grown for its colorful spathe and attractive foliage. Anthurium ranks ninth in the global flower trade and commands a respectable price both for its cut flower and whole plant (Desh Raj, 2015). Anthurium is very popular as cut flowers for its beauty, vibrant colors and long lasting qualities which are essential pre-requisites for any floral arrangement. In India, the anthurium cut flower industry is still in its infancy. The integrated application of both macro and micronutrients may open a new aspect to obtain good vegetative growth and higher flower yield in Anthurium.

Anthurium is a slow growing perennial that requires shady, humid conditions as found in tropical forests. It includes more than 100 genera and about 1599 species, chiefly from tropics (Higaki *et al.*, 1994). *Anthurium andraeanum* is getting a great attention among the floriculturists for its attractive spathe and flower possessing a tail like spadix. It is introduced as floricultural crops in India and particularly southern states in recent years. At present it is necessary to work out nutritional requirement for best growth and producing export quality flowers of anthurium under greenhouse.

Mineral nutrition of flower crops assumes fundamental importance in floriculture, while micronutrients play a vital role in quality flower production. Commercial flowers are grown for their attractive colour, shape, size and also for foliage. Achieving and maintaining higher yield and quality level has become one of the focal points of sustainable production both under open and polyhouse condition. Plant nutrients are the essential elements needed for successful growth and development of flower crops. Although plants absorb more than 35 elements, only 18 elements are known to be essential to them. Iron, manganese, zinc, copper, boron, molybdenum, chlorine, cobalt and nickel are known as essential micronutrients for plant growth and development. Plant must have these micronutrient elements to complete their life cycle though it is required in small amount.

Very less work has been conducted on Nutrient management in Anthurium. Considering the need of this, the present investigation was undertaken. The experiment was contained with the fifteen treatments *viz*, RDF (Urea:SSP:MOP), MS Micro,

Macronutrients Ca as Calcium carbonate, Mg as Magnesium sulphate, S as Wettable Sulphur in different combinations. One among 15 treatments was left for control without applying any nutrient source and normal plant growth and development that occur within the plant. It is very important to standardize the nutritional dose for optimum flower production and growth. Experiment on evaluation of different levels of nutrients to find out the optimum dose for growth and flower production for commercial cultivation of Anthurium under agro shadenet structures was carried out under RKVY Project of BTCC, Baramunda.

5.1 Effect of nutrients on vegetative growth of Anthurium cv. Tropical

Among the 15 treatments **maximum plant height** (26.94 cm) was found with the application of recommended dose of fertilizers Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant followed by substrate application of macronutrients Calcium carbonate 1.6 g/plant and Magnesium sulphate 1.5 g/plant. It might be due to balanced dose of NPK which increase the vegetative growth, favourable for the synthesis of peptide bond, protein and carbohydrate metabolism that are essential for plant development. Nitrogen being important in cell division and vegetative growth resulted better plant height. Its combining effect with calcium and other nutrients utilizes vitamins in better proportion and catalyzes enzymatic activity for greater vegetation. The productivity and quality of flowers are closely related to nutrient supplement. Nitrogen, phosphorus and potassium are the three important nutrients that play very important role in altering growth, yield and quality attributes (Abdussamed, 1999). It showed that there is increase in plant height which has been boost up by nutritional level of macronutrients i.e. NPK up to certain level; this result is in line up with Scagel *et al.* (2007), according to whom lowering the levels of macro nutrients takes more time and gives less production and fertilization improves the gerbera growth and development by providing essential macro nutrients (i.e. NPK). The results are in confirmatory with the results of Baumgrat, Roy *et al.* that gerbera require balance nutrition at early stages of growth.

Phosphorus acts as the energy currency of the plant and constituent of nucleic acid. An adequate supply of phosphorus in early stage of plant life is important in laying down the primordia for the reproductive parts. It is also an essential component of majority of enzymes while potash helps to build a strong framework of plant. Yawalkar *et al.*, (1996). Potassium imparts increased vigour and disease resistance to plant. It also

regulates water conduction within the plant cell and water loss from the plant by maintaining the balance between anabolism, respiration and transpiration. Thus reduces tendency to wilt and helps in better utilization of available water which ultimately help in the formation of protein and chlorophyll and quality (Rutkauskiene and Poderys, 1999)

Magnesium being the component of chlorophyll aids in photosynthesis. Exogeneous application of combination of nutrients resulted a better vegetation. This result coincides with the research findings of Muneeb *et al.*, (2015), Calcium nitrate significantly improved plant height, leaf area in *Lilium cv. Sereda* and *Navona*. Similarly Deswal *et.al.* (1983); observed the positive influence of nitrogen and Phosphorous on height of *gladiolus* plants.

These results were similar to Henny (1999) who found better growth in *anthurium* due to application of nutrients. Similar results were reported by Sunita devi *et al* (2003) and Sujatha *et al* (2002) who reported that the higher dose of N and K increased height of the plants in *gerbera*. Amelia and Nicado (1993). Valasal Kumari *et al.* (2001) and Srinivas (2006) support these findings that the height of plants was less at low level of nutrients. Lee and Zhang (2002) also referred application of N resulted in better growth of *anthurium*. Salazar *et al;* (2011) also reported that higher calcium concentration increased the plant height. As per the findings of Anamika and Lavania, (1990) application of N₂ (25 g/plant), P₂O₅ and K₂O(15 gm/ plant) each improved the plant height of *rose* likewise Sigedar *et al.*, (1991), reported maximum plant height and plant spread with 100 kg N, 50 kg P₂O₅ and 25 kg K₂O in *Calendula officinalis*.

Maximum **number of leaves** (10.33) was found maximum in plants treated with substrate application of macronutrients (Calcium + Magnesium + Sulphur) treatment T₅. Similar results were obtained by Sunita Devi *et al.* (2003) who reported more number of leaves and growth in *carnation* due to increased level of nutrients .The availability of macronutrients reflected into better number of leaves per year. High dose of macro nutrients (NPK) resulted in maximum number of leaves wich is confirmed by the finding of Javaid *et al*, Qasim *et al* and Gohar *et al.* Neerja *et al.*,(2005) who reported the response of cultivars towards the different levels of nitrogen in increasing the

number of leaves per plant. Nitrogen at 20 g/m² was reported to increase the number of leaves in liliun cultivar “Elite”

Results of the present investigation showed that macronutrients play judicial role in increasing vegetative growth of the plant. These results were similar to the findings of Sawan *et al.*; who studied the balanced fertilization with the micro nutrients in plant nutrition that is important for the production of highly quality products. The number of leaves per plant directly influenced the flower quality. A greater number of leaves produces better quality flower. Leaf production enhances the size of photosynthetic tissue, which leads to accelerated growth of main stem as well as branches.

Petiole length (21.03cm) was found maximum in treatment T₅ with the application of RDF (Urea: SSP: MOP) @ 7.2:4.6:3.0 g/plant, Calcium carbonate 1.6 g/plant and Magnesium sulphate 1.5 g/plant. It might be due to proper supply of nitrogen which increases synthesis of proteins and consequence of which there is an increased meristematic activity leading to higher plant growth. Similar results were found by Dufour *et al.* (2001) who conducted trial on cultivation of anthurium in soil less media under polyhouse. The best results regarding plant growth and yield was obtained with a solution having lowest calcium (2.25 mg/l) and the highest ammonium (2.43 mg/l) concentrations of the plant and played an important role in fertilization balance.

Leaf length was found maximum 13.56 cm in treatment T₁₅ (RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant, wettable Sulphur 1.5 mg/litre and MS Micro 10 ml/litre). The result may be due to major effect of macronutrients and micronutrients. Nitrogen being important in vegetative growth in combination with Sulphur, Magnesium Calcium and micronutrients aids in the growth of plant. Phosphorus helps in energy transfer and potassium helps in providing better quality to the plant and Potassium provides disease resistance.

Leaf breadth was found maximum in the plants treated T₁₅ ((RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant, wettable Sulphur 1.5 mg/litre and MS Micro 10 ml/litre)). Nitrogen plays an important role in vegetative growth of plant. Magnesium being important component of chlorophyll aids

in photosynthesis. Best results in this treatments were found due to sufficient nutrients available to the plants and performing ability of the cultivar. Vallasal Kumari *et al.* (2001) found same results in anthurium.

In many cases, aerial spray of nutrients is preferred and gives quicker and better results than the media application of chemical nutrients. Under such conditions, when the quick supply of nutrient is obviated or the media conditions are not conducive for the absorption of nutrients, foliar application can be preferred. The method of foliar application is useful only into those crops that are tolerant to aerial spray and are not damaged by this treatment. In young leaves, the nutrient solution is absorbed through minute hair (trichomes) on the leaf surface. So the absorption through the stomata is possible and probably does take place but this is not the major pathway. Most of the absorption by the leaf takes place by diffusion through the cuticle (Salisbury and Ross, 1985). The nutrients used in the present studies consisted of N, P and K in various combinations provided to the plants.

As far as the effect of different nutrients on vegetative growth parameters is concerned, it was observed that growth parameters viz., plant height, number of leaves, plant spread, leaf petiole length were significantly influenced. Increase in plant height, number of leaves and plant spread could be attributed to optimum dose of N received by the plants for their proper growth.

Nitrogen is the major constituent of chlorophyll and involved in major physiological process like photosynthesis (Baboo and Singh, 2006). It has been observed with proper supply of nitrogen increased synthesis of proteins and consequence of which there is an increased meristematic activity leading to higher plant growth. (Arney, 1950; Salvi, 1997; Valsala Kumari *et al* 2001); (Srinivasa and Reddy, 2005). For the plant height, the results are in close conformity with the findings of Barad *et al.* (2008) in chrysanthemum, Singh (2005) in rose, Dubey and Misra (2006) in gladiolus.

Nitrogen, phosphorous, potassium and organic carbon content influence the plant growth and development. Phosphorus is a main constituent of chlorophyll and is involved in many physiological processes including cell division, development of

meristematic tissue, photosynthesis, metabolism of carbohydrates, fats and proteins for synthesis of nucleic acids and main role in stimulation of roots.

Potassium which is necessary for nitrogen assimilation into protein and major osmotically active component in the plant cells contributes to cell turgor and enhances the capacity of plant cell to retain water and nutrients, in this function K seems to be particularly important in young tissue. The turgor in the young leaves has direct effect on the cell size and growth rate of entire plant. Activating apical meristems beside the protoplasm formation, division and elongation of meristems cell, enhancing the biosynthesis of proteins and carbohydrates. These together led to enhancing the growth. As the dosage increases, the absorption of the nutrient also increases which contributes to the increased photosynthesis and eventual assimilation of cellular material in the leaves, increases leaf area index and duration for which it is operated.

5.2 Effect of nutrients on flowering of anthurium cv. Tropical

Stalk length (12.83cm) was found maximum in the treatment T₅ (RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant). This finding concurred with those of Higaki & Poole (1978), who observed that nutrient application did not affect the length of the anthurium floral stem in the first year of growth. In the same study, in the second and third years, the nutrient treatment of two times the recommended level produced flowers with greater stem length, but not being economically viable. There is also similarity with Devecchi & Remoti (2003), who studied Calla lily (*Zantedeschia aethiopica*) in which different doses of nitrogen and potassium did not significantly affect length of floral stem. The comparison of mean indicated that higher fertilization of macro nutrients was required for good length of branches which was essential for excellent flower production. These results were in alliance with Frett *et al.*, who stated highest branch length by the use of macronutrient in combination with calcium.

Minimum days to flower opening (120.43days) were recorded in the plants treated with RDF, Ca, Mg and MS Micro. From the whole observations it was found that any treatment containing MS Micronutrients, induced earliness. Ahmad *et al.* (2011) also reported that micronutrient application gave early and maximum flowering/plant in Rose. As reported by Elangaivendhan *et al.*, (2016) the foliar spray

for both zinc and iron deficiency exhibited favourable influence on flowering parameters in spider lily, the highest flowering duration and minimum days for first flower emergence.

Number of flowers (2.15) was found maximum in treatment T₅ (RDF, Ca and Magnesium (RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant). Generally 10 to 12 numbers of flower are produced per year in an anthurium plant. In this experiment the treatment T₅ (RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant) produced 2.15 number of flowers/plant and 0.5 number of flowers/plant in control. This characteristic may have played a role in the response to fertilization not having been immediate, especially since it was the first year of cultivation, when the plant had still not expressed all its production potential.

There are several factors affecting growth and flower production in anthurium, nutrition is one of the important aspects. Under suitable agro-climatic condition, it is main factor, which influence the growth and yield of quality flowers of anthurium. Nutrient needs of anthurium can be met through different sources, where the major source of plant nutrients is chemical nutrients. Application of nutrients in foliar spray has been found beneficial to improve the growth and flower production in anthurium (Valsala Kumari *et al.*, 2001). However, the secret of success for commercial cultivation is to have good nutrient application in anthurium.

Dufour and Guérin (2005) and Higaki *et al.* (1992) also found that the effects of various nutrient solutions on *Anthurium* flower yield were different, although the observed difference in flower yield was less than one flower per year (Higaki *et al.*, 1992) or two flowers per year (Dufour and Guérin, 2005). Higher dose of nutrients resulted in better quality of flowers due to increased supply of nutrients, healthy and vigorous plants than all other treatments, Dufour *et al.* (2001), Jawaharlal *et al.* (2001) and Karuna *et al.* (1999) also recorded same findings.

Spathe length (8.7cm) was found maximum in treatment T₅ (RDF+Ca+Magnesium). The low K and Mg concentrations can be attributed to the antagonistic effect between N and K or between N and Mg (Marschner, 1995; Poole and Sheehan, 1974).

Spathe breadth (7.16cm) was recorded best in the plants treated with RDF - Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant. Floral characters depend upon supply of nutrients, growth and climate. Higher dose of nutrients resulted in better quality of flowers and good spathe color and spathe area. Due to increased supply of nutrients healthy and vigorous plants are produced Dufour *et al.* (2001), Jawaharlal *et al.* (2001) and Karuna *et al.* (1999) also recorded same findings.

Spadix length (4.3cm) and **spadix breadth** (1.5cm) were found best in the same treatment (T₅) RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant. Results recorded were similar to that of Dufour *et al.* (2001), Jawaharlal *et al.* (2001) and Karuna *et al.* (1999) who studied that increased supply of nutrients produce better quality plants.

The increase in the size of inflorescence may be due to the cumulative effect of all growth parameters observed throughout the growing period. The increase in the growth parameters increased the size of the flower in different growing media. Higher Nitrogen greatly influences leaf growth, leaf area and photosynthetic rate per unit leaf area to control production of carbohydrates and other photosynthetic products (source activity) and influences numbers and size of vegetative and reproductive storage organs (sink capacity) as reported by Enggels and Marschner (1995).

The significant influence on flower quality parameters were also recorded best from the treatments of Micronutrients. As a constituent of various enzymes, iron plays the part of a vital catalyst in the plant. Iron acts as the catalyst in the synthesis of chlorophyll molecule and helps in the absorption of other elements. It is a key element in redox reactions of respiration, photosynthesis and reduction of nitrates and sulphates. Zinc is effective in plant nutrition for the synthesis of plant hormones and balancing uptake of P and K inside the plant cells. Copper is essential for photosynthesis and mitochondrial respiration, for carbon and nitrogen metabolism, for oxidative stress protection, and is required for cell wall synthesis.

5.3 Effect of nutrients on post-harvest life of anthurium cv. Tropical

Nutrient and micronutrient application had significant effect on *Anthurium* cv. Tropical. Solution uptake after 3, 6, 9 and 12 days was found maximum in the plants

treated with RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant, MS Micro 10 ml/litre). By adding sucrose and anti-ethylene agents to the holding solutions and curtailing the growth of microorganisms at the cut end of the stems could be an effective means to prolong vase-life (Marousky, 1968). Calcium being the building blocks of cell wall protects the tissues from spoilage resulting better shelf life. Calcium enhanced life cycle of flowers of cut liliun grown hydroponically as reported by Sewyedi *et al.*, (2013) with the use of calcium in nutrition. The use of Calcium carbonate and Calcium nitrate increases calcium concentration in aerial organs including the stem tissues which has a direct effect on increasing the life cycle of flowers after harvesting. (Buchanan *et al.*, 2000).

Maximum vase life (19.20) was recorded in the plants treated with ((RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant, wettable Sulphur 1.5 mg/litre and MS Micro 10 ml/litre). The higher vase life might be due to optimum availability of nutrients and higher level of potash. Since potash enhances the synthesis, metabolism and translocation of carbohydrates, synthesis of proteins with rapid cell differentiation and division which results in better vase life of the plant (Haque *et al.*).

Sulphur increases vase life of the plant and acts as floral preservative. Singh and Tiwari (2002) also reported a strikingly enhanced vase life and solution uptake, whereas minimum weight loss was noticed with AgNO₃ (300ppm) pulsing, which was due to the bactericidal properties of AgNO₃ (Mayak *et al.*). Floral characters, yield and vase life depends upon supply of nutrients, growth and climate. Higher dose of fertigation results in better quality of flowers due to increased supply of nutrients, healthy and vigorous plants than all other treatments, Dufour *et al.* (2001), Jawaharlal *et al.* (2001) and Karuna *et al.* (1999) also recorded same findings.

Effect of nutrients and their interaction on physiological parameters:

In the present study different physiological parameters were significantly influenced by the different treatments levels of macronutrients (N, P, K, Ca, Mg and S) in combination with micronutrients as compared to control. The earliest first flower bud appearance, longest duration of flowering, the maximum number of flowers per plant, maximum length of stalk were recorded by nutrient application. These results are in congruence with Mishra (2004), Kumar and Misra (2003) in gladiolus and Kumar *et al.*

(2009) in tuberosse. The longest vase life, earliest first flower bud appearance, longest duration of flowering, the maximum number of flowers per plant were recorded. Nutrition plays an important role in the overall growth performance of the anthurium crop. Plant analysis has been found to be a useful diagnostic tool to work out the amount of fertilizers to be applied.



SUMMARY AND CONCLUSION

The experiment entitled “Nutritional Management in *Anthurium andraeanum* cv. Tropical” was carried out in agro shadenet structures of RKVY project, Dept. of Floriculture and Landscaping at Biotechnology–cum-Tissue Culture Centre, College of Agriculture, OUAT, Bhubaneswar, during the year 2016-17. The tissue cultured Anthurium plants (Tropical) were taken as experimental material on which 15 treatments of different nutrients were carried out. The experimental findings were done with the following objectives and the results were analysed using Complete Randomized Design.

Objectives

- Effect of nutrients on vegetative growth of anthurium.
- Effect of nutrients on flowering of anthurium.
- Effect of nutrients on post-harvest life of anthurium

Success for commercial cultivation is to have better nutrition availability and efficient utilization by plant. Under suitable agro-climatic conditions, mineral nutrition is the main factor, which influences the growth yield and quality of anthurium owners. Foliar application of nutrients is easy and quick approach to provide its requirement. Nutrient needs of anthurium can be met through different sources like macro nutrients and micro nutrients. The nutrients supplied by the macro- and micro-elements are necessary for the various biochemical processes. With the introduction of fertilizers (Macro and Micro respectively), which are essential for plant growth, it has become possible to get the plants of better growth (Jitendra *et al.*, 2006).

The application of foliar fertilizer is the quickest way to deliver nutrients to the tissues and organs of the crops. Optimum balance of NPK along with micronutrients is very important to maintain the balance between vegetative and reproductive growth in plants. So, present study was planned to examine the appropriate doses of major macronutrients and also to verify the effect of these elements along with the spray of micro power on plant efficiency (vegetative growth, plant height and yield) of anthurium.

The observations were recorded on the various parameters like vegetative, flowering and post-harvest life of the plant. Statistical analysis was done using CRD and significant difference was found from the application of nutrients on Anthurium cv. Tropical.

The results of the experiment are summarized as follows

6.1 Effect of nutrients on vegetative growth of anthurium.

6.1.1 Effect of nutrients on vegetative growth of anthurium cv. Tropical

- RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant significantly enhanced the vegetative characters.

Application of different nutrients had significant effect on the vegetative characters of Anthurium cv. Tropical. It was concluded that the application of RDF (Urea:SSP:MOP)in combination with Calcium carbonate and Magnesium sulphate i.e treatment T₅ significantly enhanced the plant height (26.94cm), number of leaves per plant (10.33) and petiole length (21.03cm).

6.2 Effect of nutrients on flowering of anthurium.

6.2.1 Effect of nutrients on flowering of anthurium cv. Tropical

- RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant in combination with Ca and Magnesium resulted in best flowering characters.

Application of macro and micronutrients revealed significant result on flowering of Anthurium cv. Tropical. From the data recorded, it has been concluded that the

plants treated with RDF (Urea: SSP: MOP), Calcium carbonate and Magnesium sulphate i.e. treatment (T₅) showed maximum stalk length (12.83 cm), number of flowers (5.6), spathe length (8.7cm), spathe breadth (7.16cm), spadix length (4.3cm) and spadix breadth (1.5cm), whereas earliness in flower opening (120.43days) was found to be in the treatment T₁₂ (RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant and MS Micro 10 ml/litre).

6.3 Effect of nutrients on post-harvest life of anthurium

6.3.1 Effect of nutrients on post-harvest life of anthurium cv. Tropical

- Post-harvest characters like delay in discoloration of spathe and spadix, longest vase life were recorded best in the plants treated with RDF in combination with Ca, Sulphur and MS Micro.

Nutrients application had significant effect on the vase life of *Anthurium* cv. Tropical. Solution uptake after 3, 6, 9, 12 days was found maximum in the plants treated with RDF (RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, MgSO₄ 1.5 g/plant and MS Micro 10 ml/litre), i.e. treatment T₁₂ which stood at par with treatments T₂ (RDF+Ca), T₅ (RDF+Ca+Mg), T₁₁ (RDF+S+MS Micro). Discoloration of spathe and days to maturity of spadix were significantly delayed by the treatment T₁₃ (RDF- Urea: SSP: MOP @ 7.2:4.6:3.0 g/plant, CaCO₃ @ 1.6 g/plant, wettable Sulphur 1.5 mg/litre and MS Micro 10 ml/litre). Longest vase life (19.20days) was also recorded in T₁₃ (RDF+Ca+S+MS Micro).

CONCLUSION

Anthurium is an important tropical ornamental plant and belongs to the family Araceae. Anthurium is commercially grown for its colorful spathe. Nutrition plays an important role in the overall growth performance of the anthurium crop. Successful commercial cultivation of anthurium crop depends on the nutrient availability and better absorption by the plant.

In terms of flower production Odisha has emerged as the top states and occupies third position in the country from eighth position. Though area under floriculture has not increased but productivity has increased both in cut and loose flowers It is a great

opportunity for a state like Odisha to promote flower production especially cut flower production in coming years. Malkangiri, parts of Koraput, Rayagada in north Eastern Ghats, Ganjam, Kandhamal, Kendrapada, Jagatsinghpur, Khurda, Puri, and Nayagarh are suitable for anthurium cultivation in Odisha (Beura *et al.*, 2017). In India, the anthurium cut flower industry is still in its infancy. Therefore research findings on “Nutritional Management in *Anthurium andraeanum* cv. Tropical” is of utmost importance for enhancing the production of this highly priced cut flower in Odisha.

From the above experiment entitled “Nutritional Management in *Anthurium andraeanum* cv. Tropical” it has been concluded that overall vegetative growth in terms of plant height (26.94 cm), number of leaves per plant (10.33) and petiole length (21.03 cm) was recorded maximum in the plants treated with RDF (Urea, SSP and MOP 7.2: 4.6:3.0 g/plant), Calcium carbonate (1.6 g/plant) and Magnesium sulphate (1.5 g/plant). Similarly flowering characteristics like stalk length, number of flowers, spathe length, spathe breadth, spadix length and breadth were found best with application of RDF, Calcium carbonate and Magnesium sulphate. In terms of postharvest characters like delay in discoloration of spathe, delay in discoloration of spadix and vase life, the plants treated with RDF, Calcium carbonate, Wettable Sulphur and MS Micro were found to be the best. The research work will play a pivotal role for anthurium cultivation in Odisha and the country as well in coming future. The flower growers may be advised to take up cultivation of *Anthurium* cv. Tropical on a commercial scale to cater the need of local as well as distant market. This beautiful flower crop anthurium cultivation will bring happiness and prosperity to the highly educated unemployed youth and women as it is found to be highly lucrative.



REFERENCES

- Ahmad, I., Ahmad, T., Zafar, M. S. and Nadeem, A. 2007 .Response of an elite cultivar of zinnia (*Zinnia elegans* cv. Giant Dahlia flowered) to varying levels of nitrogenous fertilizer. *Sarhad Journal of Agriculture*, **23**(2): 309-312.
- Ahmad, I.I., Asif, M., Amjad, A. and Ahmad, S. 2009. Fertilization enhances growth, yield and xanthophyll contents of marigold. *Turkish Journal of Agriculture*, **35**: 641-648
- Ahmed I, Aslam Khan M, Qasim M, Ahmad R, Randhawa M. 2010. Growth yield and quality of *Rosa hybrid* L. as influenced by various micronutrients. *Pak J Agric Sci.***47** (1):5-12
- Akiladevi, R., Jawaharlal, M. and Prabhakaran, T. S. 2007a. Effect of ethylene on postharvest life of cut anthurium (*Anthurium andraeanum* cv.temptation). *J. Ecobiol.*, **20**(1): 73-77.
- Akiladevi, R., Jawaharlal, M., Prabhakaran, T. S. and Gomathi, M., 2007b. Effect of ethylene on post-harvest life of cut anthurium (*Anthurium andraeanum* cv. temptation). *J. Ecobiol.*, **20**(2): 179-182.
- Anamika and M.L. Lavania .1990. Effect of phosphorous, Phosphorous and potassium on growth, yield and quality of rose. *Haryana. J. Hort. Sc.*, **19**(3-4): 291-298.
- Anand, S. and M. Jawaharlal. 2004. Effect of foliar spray of nutrient and growth regulators an inflorescence emergence and spathe unfurling in *Anthurium andraeanum* var.Temptation. *J. Ornamental Hort*, **7**(3-4):117-121
- Anasubai 2010. Effect of GA3 and foliar nutrients along with biofertilizers on growth and flowering of anthurium (*Anthurium andraeanum* Lind) cv. TROPICAL RED. *Asian Journal of Horticulture*, **(8)**:71-74
- Anuradha, K., Pampapathy. And Narayana, N. 1990. Effect of N and phosphorus on flowering, Yield and quality of marigold. *Indian Journal of Horticulture*, **47**(3): 353-35

- Baboo, R. and Singh R. D. 2006. Response of nitrogen, phosphorus and corm size on flowering and corm production in gladiolus. *J. Ornam. Hort.*, **9**(1): 66-68.
- Bandyopadhyay, P., Das DK and T.K. Chattopadhyay .1994. Effect of micronutrients on flower character and yield of marigold (*Tagetes erecta* L.) cv. African Giant (Lemon). *Crop Res.*, **7** (1): 13-16.
- Bankar, G. J.and Mukhopadhyay, A. 1990. Effect of NPK on growth and flowering in tuberose cv. Double. *Indian Journal of Horticulture*, **47**(1): 120-126.
- Banker, G.J. and A. Mukhopadhyay .1985. Response of *Polianthes tuberosa* L. cv. Single to high doses of NPK. *South India Hort.*, **33**(2): 214-216.
- Barad, A. V., Nandre, B. M. and Sonwalkar, N.H. 2010. Effect of NPK levels on gerbera cv.Sangria under net house conditions. *Journal of Horticulture*, **67** (3): 421-424.
- Beura S, Toppo R, Jagadev PN, Palai SK.2017. Protected cultivation of Anthurium for High Profit, *Souvenir on Germplasm Evaluation and In vitro Cloning of Anthurium and Lilium*, pp-1-13
- Bhattacharjee, S. K. and Damke, M.M. 1994: Response of “SuperStar” rose to N, P and K fertilization.*Indian J. Hort.*, **51**(2):207-213.
- Bhattacharjee, S.K. 1999. Post-harvest management of cut flowers, cut foliage and post production management of potted plants.*J. Orna. Hort. New Series*, **2** (1):32-39.
- Bhattacharjee, S.K: and T. Mukherjee .1976. Influence of phosphorous on growth and flowering in Dahlia. *Punjab J. Hort.*, **16** (1-3): 111-115.’
- Bhattacharjee, S.K., 1993, Efficiency of foliar application of Mg and zn on growth and flowering of *Jasminium grandiflorum* L., *J. Primary Industries*, **18** (2): 96-101

- Bhattacharjee, S.K., 1996. Influence of Boron on growth, flowering, post harvest life and nutrient remobilization in 'Raktagandha' roses. *Indian J. Hort.*, **53**(2):155-159.
- Biswas, T.D., 1984 .Rose growing principles and practices, Associate publishing company, New Delhi.
- Bortje, G.A. 1978. Substrate and the nutrition of *Anthurium andraeanum*. *Acta Hort*, **82**:159-164
- Buchanan, B.B, Gruissem, W. and Jones, R.L. 2000. Biochemistry and molecular biology of plants, *American Soc . Plant Biology* 152-153
- Chaitra, R. and Patil, V. S. 2007. Integrated nutrient management studies in growth, yield and flower quality in China aster (*Callistephus chinensis* (L.) Nees). *Karnataka Journal of Agriculture Science*, **20**(3): 689–690.
- Chavan, M.D., Jadhav, P.B. and Ruge, V.C. 2010. Performance of China aster varieties and their response to different levels of nitrogen. *Indian Journal of Horticulture*, **67**(Special Issue), November: 378-381.
- Choudhari, C.K., Jadhav, R. G. and Masu, M.M. 2009. Effect of various biofertilizers and their combinations with nitrogen fertilizer on growth, yield and quality of rose (*Rosa damascena* L.). *The Asian journal of Horticulture*, **4** (2): 373-376.
- Conover CA and Henny RJ 2003 .Effect of Nitrogen and potassium fertilization ratio on growth and flowering of three Anthurium hybrids. *CFREC, APOPKA Research Report, University of Florida*.
- Conover, C.A. and R.J. Henny. 1996. Lowering N and K rates improves Anthurium Growth and flowering. *Proceeding of the Florida State Horticultural Society*, **108**: 5-10
- Dahiya, S.S., N. Singh and S. Singh. 1998. Effect of phosphorous and Phosphorous on growth flowering and yield of African marigold (*Tagetes erecta* L.). *Environment and Ecology*, **16**(4): 855-857.

- Dalal, S. R., Gonge, V. S., Pimple, A. G., Deshmukh, R. and Utgikar, S. 2005. Response of phosphorus levels to growth, flowering, yield and flower quality of gerbera under polyhouse. *Annals of Plant Physiology*, **19** (1): 120-121.
- Das, T. K., 1998, Corm and cormel production in gladiolus as affected by spike removal and K application. *Indian J. Hort.*, **55**(4):327-331.
- Devecci M; Remoti D. 2003. Influence of fertilization on vegetative growth and flowering of the calla (*Zantedeschia aethiopica* Spreng). *Acta Horticulturae* 614:541-545.
- Dorajeerao, A.V. 2012. Effect of graded levels of nitrogen and phosphorus on growth and yield of garland chrysanthemum (*Chrysanthemum grandiflorum* L.) *Karnataka J. Agric. Sci.*, **25** (2): 224-228
- Dubey, R.K., Misra, R.L., Singh, S.K. and Manisha. 2010. Efficiency of bio and chemical fertilizers on certain floral qualities of gladiolus. *Indian Journal of Horticulture*, **67**(Special Issue), November: 382-385.
- Dufour, L and V Guerin .2003 Low light intensity promotes growth, photosynthesis and yield of *Anthurium andraeanum* Lin tropical conditions. *Advances in Horticultural Science*, **17**:1, 914.
- Dufour, L and V. Guerin ,2005 .Nutrient solution effects on the development and yield of anthurium in tropical soilless condition, *Scientia Hort.*, **105**(2):269-282.
- Dufour, L. and V. Guerin. 2003 Growth developmental features and flower production of *Anthurium andraeanum*. L in tropical conditions. *Scientia Hort.*, **98**:1, 25-35.
- Enggels, C and Marschner, H. 1995. Plant uptake and utilization of nitrogen, In: P. E. Bacon (ed.) *Nitrogen Fertilization in the Environment*. New York: Marcel Dekker, pp. 41-81.
- Fukui, R., Kikuchi, S., Ichida, Y. and Honjo, H., 2005, Vase life of imported *Anthurium* flowers evaluated in Japan in relation to the effects of post importation benzyladenine treatment. *Hort Science*, **40**(5): 1439-1443.

- Gaikwad, S.A., Patil,SSD., Patil, G.D(2004). Effect of different levels of nitrogen and phosphorus on the growth and flower production of China aster [*Callistephus chinensis* (L.) Nees]. *Journal of Maharashtra Agricultural Universities*, **29**(2):140-142
- Ganga, M. JegadeeswarI, C. Padmadevi, K. and Jawaharlal, M., 2008, Response of chrysanthemum cv. Co-1 to the application of micronutrients. *J. ornamentl. Hortic.*, 119 (3)220-223.
- Ganga, M. Jegadeeswari, C. PadmadevI, K. and Jawaharlal, M., 2009, Performance of Dendrobium cv. Sonia 17 as influenced by micronutrients. *J. ornamentl. Hortic.*, **12**(1): 39-43.
- Gohar, A.K, S. Muhammad and Amanullah, 2007. Response of Dhalia (*Dhalia pinnata*) to different levels of nitrogen alone and in combination with constant doses of phosphorus and potassium. *Am. Eurasian J. Sustain. Agric.*, 1(1): 25-31.
- Gurjar, R.A and Dhaduk.B.K. 2010. Standardisation of foliar nutrient (NPK) spray in anthurium cv.Flame.*Indian Journal of Horticulture*, **69**(3):390-394
- Hardeep Kumar, Sukhbir Singh VP, Ahlawat, Yadav BS. 2003. Influence of nitrogen and zinc application on growth, flowering and chlorophyll content of tuberose (*Polianthes tuberosa* Linn.) cv. Double. *Haryana J Hort Sci.*;**32** (3&4): 212-215
- Hardeep Kumar, Ahlawat VP, Yadav BS, Sehrawat SK. 2004.Response of nitrogen and zinc application on spike length, bulb production and nutrient content in tuberose (*Polianthes tuberosa* Linn.) cv. Double. *Haryana J Hort Sci.*; 33(3&4): 221-223
- Hatwar GP, Gondane SU, Urkude SM, Gahukar OV. 2003. Effect of micronutrients on growth and yield of chilli. *Soils and Crops.*;13: 123-125.
- Henny, R. J. and Norman, D. J., 2001, Anthurium “Show Biz”. *Hort Science*. **36**(6): 1140-1141.
- Henny, R. J., 1999, ‘Red Hot’ anthurium. *Hort Science*, **34**(1): 153-154.
- Henny, R. J., Norman, D. J. and Chen, J., 2003, ‘Orange Hot’ Anthurium. *Hort Science*. **38**(1): 133-134.

- Higaki T; Poole R. 1978. A media and fertilizer study in anthurium. *Journal of American Society for Horticultural Science* 103:98-100.
- Ivanova, V. and Vassilev, A.2002. Biometric and physiological characteristics of chrysanthemum (*Chrysanthemum indicum* L.) Plants grown at different rates of nitrogen fertilization. *Journal of Central European Agriculture*, **4**(1).
- Jadhao, A., Tamgadge, S., Deshmukh, A., Telgote, N.and Bodakhe, V. 2010. Effect of nitrogen levels and gibberellic acid on growth and yield of gerbera under polyhouse condition. *The Asian Journal of Horticulture*, **5** (2): 341-343.
- Jadhav, A., Tamgadge, S., Deshmukh, A., Telgote, N. and Bodakhe, V. 2010. Effect of nitrogen levels and gibberellic acid on growth and yield of gerbera under polyhouse condition. *The Asian Journal of Horticulture*, **5** (2): 341-343.
- Jamkhande, M., Paithankar, D.H.,Warade, A.D., Mohariya, A., Ambare, T. P.2004. Effect of graded levels of nitrogen and phosphorus on growth and flower production of china aster cv. Local. *Advances in Plant Sciences*, **17**(1): 163-165.
- Jawaharlal, M., J. P. Joshua, T. Arumugam, s. Subramanian, and M. Vijayakumar. 2001. Standardization of nutrients and growth regulators to reduce prebloom period and to promote growth and flowering in Anthurium. *South Indian Hort.*, **49**: 342-344.
- Joshi, K. I., Jadav, R. G. Parekh, N. S. and Kikani, K. P.2001. Nutritional effect on flower quality and yield of *Rosa damascena*. *The Indian Rose Annual*, **17**: 105-108.
- Joshi, K.I., Parekh N.S and Kikani K.P., 2002, Effect of sulfur and micronutrients on rose (*Rosae damasciana*). *Floriculture-researchtrend in India. Proceedings of the national symposium on floriculture in the new millennium*. 5(3): 234-235.
- Joy, K.W. and Hageman, R.H., 1966. The purification and properties of nitrate reductase from higher plants and its dependence on ferredoxin. *Biochem. J.*, 100:263-273.

- Khalifa, R. K. H. M., Ahaban, S. H. A. and Raswia, A. 2011. Effect of foliar application of zinc sulphate and boric acid on growth, yield and chemical constituents of iris plants. *Ozean J. Applied Sciences*, **4**(2):129-143
- Khan, F.U., 1999, Effect of micronutrients on Dahlia. *J. ornamentl. Hortic.*, **3**(2):122-123.
- Khimani, R. A., Patel, M. S. and Kikani, K. P. 1995. Effect of Nitrogen, phosphorus and potassium levels on shelf life of cut flowers of Rose (*Rosa damascena* L.). *The Indian Rose Annual*, **13**: 133-136.
- Kumar, H. Ahlawat, V. P. Yadav, B. S. and sehrawat .2004. Response of nitrogen and Zinc application on spike, length, bulb production and nutrient content in tuberose (*Polianthes tuberosa* Linn.) cv. Double, *Haryana journal of horticulture science*, **33**(3-4). 221-223.
- Kumar, J., Chouhan, S. S. and Singh, P. V. 2003. Response of N and P fertilization on China aster. *Journal of Ornamental Horticulture, (New series)*. **6**(1):82.
- Kumar, J., Singh, K. A. and Pal, K. 2009. Effect of GA₃ and urea on growth and flowering in tuberose (*Polianthes tuberosa* L.) cv. Pearl Double. *Annals of Horticulture*, **2**(2): 201-203.
- Kumar, J. amin Mir and Singh P.V., 2003.Effect of Mn and Zn sprays on carnation. *J. ornamentl. Hortic.*, **6**(1):83.
- Kumar, P. and Arora, J. S., 2000. Effect of micronutrients on Gladiolus. *J. ornamentl. Hortic.*, New Series, **3**: 91-93.
- Kumar, R., Singh, G. N. and Misra., 2003. Effect of boron, calcium and zinc on gladiolus. *J. ornamentl. Hortic.* **6** (2):104-103.
- Kumar, S. and Haripriya, K., 2010. Effect of foliar application of Iron and zinc on growth, flowering and yield of Nerium (*Nerium odoratum* L.). *Plant Archives*, **10**(2): 637-640.

- Kumar, S. A., 2002. Studies on effect of zinc and boron on the growth and flowering in tuberosc cv. Double. *M.Sc. Ag. Thesis. G.B. Pant University of Agril. And Tech., Pantnagar*. Pp. 65-69.
- Kumar, P., Vijai, J. K., Umrao, K. and Rajbeer. 2010. Effect of nitrogen and iron on growth and flowering parameters in African marigold (*Tagetes erecta* L.) cv. Pusa Narangi gairda. *Annals of Horticulture*, **3**(1): 118-119.
- Manna, M.S., J.S. Josan, G.S. Chohan and V.K. Vij, 1985. Effect of foliar application of micronutrients on leaf composition, fruit yield and quality of sweet orange (*Citrus sinensis* L.). C.V. Blood red. *Ind. J. Hort.*, **42**: 45-49.
- Marousky, F.J. 1968. Influence of 8-HQC and sucrose on vase life and quality of cut gladiolus. *Proc. Florida State Hort. Soc.*, **81**: 415-419.
- Mayak, S., Garibaldi, A.E. and Kofranek, A.M. 1977. Carnation flower longevity: Microbial populations as related to silver nitrate stem impregnation. *J. Amer. Soc. Hort. Sci.*, **102**: 637-639.
- Mishra, Sarada and Ramani, S., 1991, Inhibition of iron absorption by zinc induced Fe deficiency in Japanese mint, *Acta-physiological plantarum*, **13**: 137-42
- Monish, M., Umrao, V. K., Tyagi, A. K. and Meena, P. M. 2008. Effect of nitrogen and phosphorus levels on growth, flowering and yield of China aster. *Agricultural Science Digest*, **28**(2): 97-100.
- Mostafa, M. M., El-Hadad, E. H. and Amar, M.A., 1997. Effectiveness of foliar nutrition with some micro-elements of chrysanthemum plants. *Alexandria J. Agric. Res*, **42**(1): 81-93.
- Mostafa, M. M., 1996. Effect of boron, manganese and magnesium fertilization on carnation plants. *Alexandria J. Agric. Res.*, **41**(3): 109-122.
- Mukesh, K., T.K. Chattopadhyay, D.K. Das and M. Kumar. 2001. Effect of foliar application of zinc, copper and iron on the yield and quality of Gladiolus cv. Mirela. *J. Interacademia* **5**: 300-303.

- Muneeb, A., (2015). Effect of split application of ammonical and nitrate sources of nitrogen on liliium growth and yield. *Journal of plant stress physiology*, **1(1)**:7-12
- Muthumanickam D, Rajamani K, Jawaharlal M. 1999.Effect of micronutrients on flower production in gerbera. *J Orn Hort.*; 2: 131-132.
- Nath MR, Biswas J. Studies on effect of boron on vegetative and reproductive growth in tuberose (*Polianthes tuberosa* L.) cv. Single. *The Orissa J Hort.* (2002); 30(2): **39-42**
- Naveenkumar, Misra RL, Dhiman SR, Ganga M, Kameswari L. 2009. Effect of micronutrient sprays on growth and flowering of chrysanthemum. *Indian J Agric Sci.* ;**79(6)**: 426-428
- Nagaich, K.N., S.K. Trivedi, R. Lekhi. 2003. Effect of phosphorous and Phosphorous on growth, flowering yield and quality of marigold. *Scientific Horticulture*, **8**: 203-209.
- Neeja, R, Kumar R, Dhatt KK.2005. Effect of nitrogen levels and growing media on growth, flowering and bulb production of Lilium cultivars, *J Ornamental Hortic*; 8:36-40.
- Parekh, N. S; Patel, H. C; Sitapara, H. H Parmar; A. B. and Nayee,D.D. 2010 . Response of nitrogen, phosphorus and potash on growth and flower production of Chrysanthemum (*Chrysanthemum morifolium*) Ramat cv.IIHR-6.*The asian Journal of Horticulture*, **5(1)**: 139-142.
- Patil, M. T. and P. V. Patil. (2004). Anthurium. Commercial Protected Floriculture. *Indian Council of Agricultural Research*, New Delhi, India, 73-80.
- *Penningfield, F., 1977, Significance of soil reaction and Boron applications in growth and flowering of *Anthurium scherzerianum* in a peat substrate, *Jahresbericht,Fachhochschule-Weihenstephan*, **3**:8-13.
- Pratap, M., Amarender Reddy, S. AND Reddy, Y.N., 2005. Effect of foliar application of FeSO₄ and ZnSO₄ on flower production and anthocyanin content of

- gladiolus spikes. *J. ornamentl. Hortic.*, **7** (2):159-163.
- Qasim, M., Iftikhar, A. and Azhar, N., 2003, Influence of various nitrogen level on growth and biomass of *Jasminum sambac*. *Pak. Agri. Sci.*, **40**(3-4).
- Qasim, M., A. Iftikhar and N. Azhar, 2003. Influence of various nitrogen level on growth of *Jasminum sambac*. *Pak. Agri. Sci.*, **40**(3-4).
- Rajeevan, P. K. 2006. It is boom time for Anthurium flower growers. *The Hindu*, pp.11.
- Rajeevan, R.K. 2001. Anthurium, Handbook of Horticulture. Pub. By *Indian Council of Agricultural Research*, New Delhi, India, pp.544-547.
- Rajiv, K., Chaturvedi, O.P. and Misra, R.L. 2003. Effect of N and P on growth and flowering of gladiolus. *Journal of Ornamental Horticulture New Series*, **6**(2): 100-103.
- Rajput DK, Megh Naresh, Srivastava PC, Singh SK, Gangawar MS. 2003. Effect of S, B and Zn application and their interactions on growth, yield and nutrients uptake of *Tagetes minuta* L. *Indian Perfumers*. **47**(1): 91-97.
- Salazar-OG, Valdez L, Tello MJ, Grassotti A, Burchi Gand Castillo-Gonzaler, A.M.(2011). Calcium affects quality and nutrition of cut lily flowers. *Acta Horticulturae*. **900**, 113-117
- Salisbury, F. B. and Ross, C. W. 1985 . In: *Plant Physiology*. Third Edition. *Wadsworth Publishing Co, Belmont, California*.
- Scagel, B.I.G,C.F. Fuchigami and R.P. Regan,2007. Difference in growth, nitrogen uptake and storage between two container grown *Rhododendron* cultivars. *J. Environ. Hort*, **25**: 13-20
- Sharma, D. P., Gupta, N. and Ahirwar, M. K. 2009 . Growth, yield and quality of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi gainda as influenced by spacing, nitrogen and phosphorus levels. *Journal of Ornamental Horticulture*, **12**(1): 68-72.

- Shiva, K.N., Chatterjee, S.R. and Bhattacharjee, S.K. 2002 . Changes in protease activity of cut roses as affected by pulsing and cold storage. *Indian J. Hort.*, **59**(2): 196-200.
- Sigedar, PD, Anserwadekar KW, Rodge BM .1991. Effect of different levels of nitrogen, phosphorous and potassium on growth and yield of *Calendula officinalis*Linn.*S Indian Horti*, **39**: 308 -311.
- Singh, K. P. and Sangama. 2000. Effect of graded levels of nitrogen on China aster cv. Kamini. *Indian Journal of Horticulture*, **57** (1): 87-89.
- Singh, Lodhi, A.K. and Tiwari, G.N. 1993 .Nutritional requirement of chrysanthemum under filed condition. *Fertilizer News*, **38** (3): 39-45.
- Singh, M. K. and Kumar, S. 2008. Effect of NPK on flower production of gerbera under polyhouse conditions. Book of abstracts: *National conference on floriculture for livelihood and profitability*, 16-19 march, IARI, New Delhi. 139.
- Singh, U.C. and S.K. Bhattacharjee. 1997. Effect of pre-harvest micronutrients on postharvest life of Raktagandha roses. *Ann. Agri. Res.* **18**: 375-360
- Solanki, R.B. and Ganie, N.A. 2009). Growth and flowering of African marigold as affected by nitrogen and phosphorus under varying intra-row spacing. *The Asian journal of Horticulture*, **4** (2): 418-420.
- Soumen-Maitra and Roychowdhury, N., 2005, Effect of pulsing and holding solutions on postharvest life of cut flowers in *Anthurium andraeanum* Lind. cv. Nitta. *J. Ornamental Hort. New Series*, **8**(3): 186-190.
- Sowmyamala, B. V., Kumar, R. V., Nagaraj, H.T., Kulkarni, B. S., Hiremath, J. B. and Turamari, R. M. 2012. Effect of organic and inorganic fertilizers on plant height, spread and flower diameter of gaillardia (*Gaillardia pulchella*). *International journal of applied biology and pharmaceutical technology*, **3** (1): Jan–Mar.

- Srinivas, V. 2006. Influence of biofertilizers on growth and flowering of *Anthurium andreanum*. Environment and Ecology. *MKK Publication, Calcutta, India*, **24S** (Special): 137-140.
- Srinivas, V. 2006. Studies on the performance of the some varieties of Anthurium. *Crop Res.*, **31**(1):75-77.
- Steen, J. A. and Vander. 1972. Nitrogen and Potassium manuring for *Anthurium andreanum*. *Vakblad-Voor-de-Bloemisterej.*, **27**:8.
- Vallasalkumari, P. K., K. P. Abdussammed, P. K Rajeen and C. K. Geetha. 2001. Shade and Nutrient management in *Anthurium andreanum* *South Indian Hort.*, **49**: 326-331.
- Vidhya Sankar, M. and Bhattacharjee S.K. 2001. Response of “Iceberg” Roses to different nitrogen doses. *The Indian Rose Annual*, **17**: 86-91.
- Yadav, L.P., T.K. Bose and R.G. Maiti .1985. Response of tuberose (*Polianthes tuberosa* L.) to phosphorous and Phosphorous fertilization. *Prog. Hon.*, **17**(2): 83-86.
- Yadav BS, Singh S, Ahlawat VP, Malik AS. Studies on removal of macro and micro nutrients by tuberose (*Polianthes tuberosa* L.). *Haryana J Hort Sci.* 2002; **31**(1&2): 44-46.
- Yellamandha Reddy T, Sankara Reddi GH. 2002. Principles of Agronomy. *Kalyani Publishers, Ludhiana*. Pp: 204-206.
- Zende GK. 1996 . Integrated nutrient supply in relation to micronutrients for sustainable agriculture. *Micronutrient News.*; **10**(11):1-9.

