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To

C766

*Hon. Padmabhushan.
Shri. Balasaheb Alias T. S. Bharde
(Dada)*

*Senior Gandhian Philosopher
And
Former Speaker of Legislative Council,
Maharashtra State.*

And

*Hon. Krishibhushan. Dr. Budhajirao Mulik,
Director,
Export – Import Bank of India,
Government of India.*

*And
President,
Bhumata Kisan Manch.*

**EFFECT OF LEVELS OF FERTIGATION ON GROWTH AND YIELD
OF GERBERA (*Gerbera jamesonii*) UNDER
POLYHOUSE CONDITION**

By

DHARMENDRAKUMAR HANMANT PHALKE
(Reg. No. 01230)

A thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI- 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA STATE (INDIA)**

In partial fulfilment of the requirements for the Degree

of

MASTER OF SCIENCE (AGRICULTURE)

In

SOIL SCIENCE

Department of Agricultural Chemistry and Soil Science,
College of Agriculture, Pune-411005

2003

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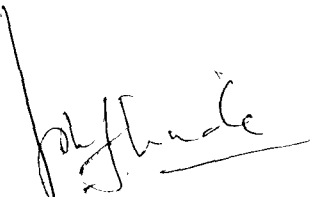
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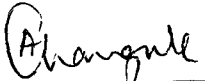
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2003

CANDIDATE'S DECLARATION

I hereby declare that the thesis entitled "EFFECT OF LEVELS OF FERTIGATION ON GROWTH AND YIELD OF GERBERA (*Gerbera jamesonii*) UNDER POLYHOUSE CONDITION" or part there of has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma.

Place : Pune

Dated : 18 JUN 2003



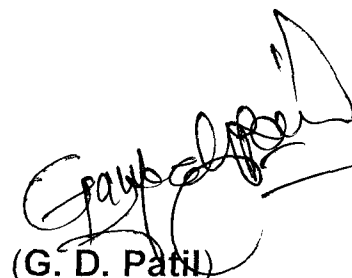
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The assistance and help rendered during the course of this investigation have been duly acknowledged.



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Place: Pune


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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF LEVELS OF FERTIGATION ON GROWTH AND YIELD OF GERBERA (*Gerbera jamesonii*) UNDER POLYHOUSE CONDITION**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE) in SOIL SCIENCE**, embodies the results of a piece *bonafide* research work carried out by **Shri. DHARMENDRAKUMAR HANMANT PHALKE**, under the guidance and supervision of **Dr. G. D. PATIL**, Assistant Professor of Agril. Chemistry and Soil Science, Department of Agricultural Chemistry and Soil Science, College of Agriculture, Pune -411 005 and that no part of the thesis has been submitted for any other Degree, Diploma or publication in any other form.


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Dated : 21.6.03

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Place : Pune

Date : 8/6/2003



(D. H. Phalke)

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LIST OF ABBREVIATIONS

Symbol	Reference
@	At the rate of
$^{\circ}\text{C}$	Degree celsius
μ	Micron
$\mu\text{g g}^{-1}$	microgram per gram
Ca	Calcium
C.D.	Critical difference
CEC	Cation exchange capacity
cm	Centimeter (s)
$\text{c mol (P}^+\text{)kg}^{-1}$	Centimole per kilogram
Cu	Copper
DAP	Days after planting
EC	Electrical conductivity
<i>et al.</i>	<i>et alli</i> (and others)
Fe	Iron
Fig.	Figure
g	Gram (s)
K	Potassium
kg	Kilogram (s)
kg ha^{-1}	Kilogram per hectare
L	Litre
M	Meter (s)
meq L^{-1}	milli equivalent per litre
mg kg^{-1}	Milligram per kilogram
mg L^{-1}	Milligram per litre
Mg	Magnesium
mg	milligram (s)
ml	millilitres

Mn	Manganese
N	Nitrogen
P	Phosphorus
ppm	Parts per million
R.D. F.	Recommended dose of fertilizer
S	Sulphur
S.E.	Standard error
Viz.,	Namely
Zn	Zinc

ABSTRACT**EFFECT OF LEVELS OF FERTIGATION ON GROWTH AND YIELD OF
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By

DHARMENDRAKUMAR HANMANT PHALKE

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE**2003**

Research Guide	:	Dr. G. D. Patil
Department	:	Agril. Chemistry and Soil Science

The present investigation was undertaken to study the effect of levels of fertigation on growth and yield of gerbera (*Gerbera jamesonii*) under polyhouse condition, at Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune-5 during 2002-2003. The four levels of fertigation and three varieties of gerbera have been tested in this experiment by using factorial completely randomized block design under controlled conditions with an objective to study the characterization of cocopeat, yield contributing parameters, flower quality parameters, flower yield, vase life, concentration, uptake of nutrients at various days after planting and leachate analysis for pH and EC.

From the data obtained on characterization study, it was observed that cocopeat is unique waste material of coconut industry acidic in nature and having lower value of EC, high water holding capacity, wide C: N ratio, higher lignin, lower cellulose: lignin ratio and good source of iron. The characterization studies indicated that cocopeat is a good growth media for gerbera cultivation under polyhouse condition.

The number of leaves, plant spread and dry matter production were significantly increased with increase in the fertigation level from 20 per cent less to prevailing dose (F_1) to 10 per cent more to prevailing dose of

fertigation (F_3) at 60, 90 and 120 days after planting. Addition of fertilizer @ 20 per cent higher fertigation to prevailing dose has significantly increased the dry matter yield as compared to rest of fertigation schedules at 60, 90 and 120 days after planting. Amongst the varieties tested Ruby red produced significantly more spread and dry matter yield than Eclips and Kozac at 60, 90 and 120 days after planting.

The decrease in fertigation level by 20 per cent to prevailing dose of Hi-tech Floriculture and Vegetable Project, significantly delayed the number of flowers as well as decreased in flower yield by 19.20 per cent. The 10 per cent more than prevailing dose (F_3) is the best and optimum for the flower production. Ruby red has recorded the significantly more flower yield than Kozac. However, it was on par with Eclips. The quality parameters viz., stalk length, diameter of flowers and vase life significantly increased with increase in fertigation level upto 10 per cent higher fertilizer dose to prevailing dose of fertigation. The maximum stalk length (61.95 cm) and vase life (11.25 days) observed in Ruby red and it was significantly superior to the Eclips and Kozac. Eclips recorded slightly higher yield per plant, stalk length, uptake of major and minor nutrients over Kozac indicating that Eclips is the best variety of gerbera next to Ruby red. Amongst the varieties Kozac had better shelf life, which was followed by Eclips and Ruby red.

The decrease in fertigation level by 20 per cent to prevailing dose (F_1) of fertigation has significantly decreased the N, P, K, Fe, Mn, Zn and Cu concentrations as well as uptake of all major and minor nutrients by gerbera at 60, 90 and 120 days after planting. The N, P, K, Fe, Mn, Zn and Cu content of the plant significantly increased with increase in fertigation level irrespective of varieties. The Ruby red recorded higher amount of N, P, Zn and Cu content than Eclips. The uptake of N, P, K, Fe, Mn, Zn and Cu was significantly increased with duration of the crop at all fertigation levels. Amongst the varieties, Ruby red showed the highest uptake of N, P, K, Fe, Mn, Zn and Cu which was followed by Eclips and Kozac.

The pH of leachate was decreased with increase in fertigation level. However, reverse trend was observed for EC of leachate.

Chapter Opener Page



INTRODUCTION

1. INTRODUCTION

Gerbera (*Gerbera jamesonii*) a beautiful ornamental flowering plant growing under polyhouse condition is a fast emerging area in the world. These plants are grown throughout the world in a wide range of climatic conditions. The climatic conditions of India especially in Maharashtra are quite favourable for growing various floricultural crops under controlled conditions. Most commercial flowers namely roses, gerberas and carnations were popularly grown under polyhouse (controlled conditions). The cut flowers are utilized in bouquets, in various floral arrangements, interior decorations of working places and dining halls of standard hotels to attract the customers. The demand for gerbera is increasing day by day because of its large size, long stalk length, attractive colour, shape and its vase-life. Therefore, it is most popular throughout the world and marketed in the international florist trade in huge quantities.

Now a days, flower sailors widely prefers the gerbera for the preparation of bouquets, interior decorations like seminars, marriage ceremonies, hotels and halls etc. The consumption of cut flowers in European countries is more during winter season as compared with rainy and summer season due to the festival like X-mas, New year, Valentine day, Mother's day and Ester. However, flower production in European countries is costly during winter due to low temperatures. The tropical regions of India have recognised the need and impressive business especially in Maharashtra is being developed for these countries (Patil and Dumbre Patil, 2001). Considering its wide scope and importance, Government of India and Government of Maharashtra has identified floriculture as thrust area for research and launched massive programme to achieve the best quality of marketable flowers. In India, there are 411 uncontrolled and 278 semi-controlled polyhouses. Maharashtra state is one of the leading state in flower production under protected cultivation having 188 small farmers green house projects of gerbera with an area of 35.5 acres and 1,19,800 number of flowers production per day (Mahalle, 2002). In Pune jurisdiction, more than 18 Hi-tech Floriculture projects have been launched by the different private organizations.

Looking for the demand of high quality cut flowers, there is great potential for the expansion of area under this crop. However, protected cultivation of gerbera is a new concept. Availability of technical aspects for producing cut flowers to meet the quality standards of the domestic and export market is the first priority of green house technology of this crop which was not scientifically published yet today. The success of the Hi-tech Floriculture project depends upon selection of right varieties, fertilizer management, agrotechniques, plant protection and post harvest management of the crop. Nutritional management for cut flowers production is of great importance, as the success of the project will depend on the production as well as quality of flowers, which will fetch good price in the market.

Very limited research work has been done on fertilizer requirement of gerbera elsewhere but not in Maharashtra. The fertilizer requirement of gerbera for different varieties is not known and hence the work on optimum nutrition has vital role in production of export quality of gerbera flowers, which fetches best prices in the market. The information in respect of effect of different levels of fertigation on morphological characters, yield and quality of flowers, concentration and uptake of nutrients, leachate analysis for pH and EC is not available in Maharashtra, which has most important practical utility to the growers and farmers. Therefore, the present investigation was undertaken with following objectives;

1. To characterize the growing media (cocopeat) for gerbera,
2. To find out optimum dose of fertilizers for higher yield of different varieties of gerbera,
3. To study the concentration and uptake of nutrients as affected by various levels of fertigation,
4. To study the periodical analysis of leachates for medium reaction (pH) and salt concentration (EC).
5. To study the keeping quality of gerbera as affected by various levels of fertigation.

Chapter Opener Page

**REVIEW OF
LITERATURE**

2. REVIEW OF LITERATURE

The protected cultivation of flowers especially roses, gerbera and carnation is increasing day by day throughout the Maharashtra state. Maharashtra is foremost state on Horticulture map of the country. The scenario in the state has metamorphosed from traditional open cultivation to commercial and Hi-tech cultivation of flowers. The state has 700 ha under traditional and commercial flowers with a total production 28,000 tones with varying soil types and agroclimatic conditions (Mahalle, 2002). Maharashtra offers tremendous scope for commercial floriculture. The climate of Deccan plateau is most suited for growing roses, gladiolus, carnation, gerbera chrysanthemum, mogra and tuberose, while the coastal climate is suitable for orchids and anthuriums. The protected cultivation of flowers and other high value plants on a commercial scale in big polyhouses came into existence during the 'nineties'. However, such cultivation was limited to corporate entities and the rich amongst the farming community as it involved very high financial outlay and technological support. The high financial outlay was mainly due to import of technology and equipment. Over the years, this technology has been indigenized to suit local conditions. This has resulted in the emergence of low cost polyhouses, with the advent of which even the small and marginal farmers are now able to exploit the benefits of protected cultivation. Gerbera (*Gerbera jamesonii*) belongs to family Compositae is one of the nature's beautiful creations and is one amongst top cut flowers of the world; having excellent flowers and exquisite shape, size and bewitching colours. The flowers having long shelf life of nearly 10 to 12 days lend themselves beautifully to different floral ornaments. The increasing demand at international level, the new policies of the Government of India and Maharashtra and the success of small floriculture units holds out major opportunities for investment as well as enlarging the floriculture sector in the state. Therefore, the present investigation entitled "Effect of levels of fertigation on growth and yield of gerbera under polyhouse condition was conducted during 2002-2003 using cocopeat as a growth media with an objective to find out a optimum dose of fertilizers for higher yield of different

varieties of export quality of gerbera flowers under polyhouse condition. The literature available is broadly reviewed under the following heads.

2.1 Characterisation of cocopeat

Pythlewsiki and Martyn (1989) suggested that the mixture of cocopeat : sand or peat : perlite with the proportion of 1:1 was suitable for gerbera cultivation.

Ranganathan and Augustine (1997) investigated the chemical composition of composted coir pith, farmyard manure and mushroom spent compost and found that composted coir pith contained the highest potassium (1.20%) and the lowest phosphorus (0.06%) as compared with FYM and mushroom spent compost.

The composition of organic manures according to Ranganathan and Augustine (1997) is as follows

Nutrients	Composted coir	Farm yard	Mushroom
	Pith	manure	spent compost
N (%)	1.06	1.08	1.84
P (%)	0.06	0.62	0.69
K (%)	1.20	0.80	1.19
Ca (%)	0.50	1.68	5.10
Mg (%)	0.48	0.62	0.38
Fe (mg kg ⁻¹)	1800	3350	2200
Zn (mg kg ⁻¹)	125	262	225
Mn (mg kg ⁻¹)	212	1500	1260
Organic C (g kg ⁻¹)	249	133	276

Dong *et al.* (1999) reported that the substrate composed of cocopeat was the most effective for seedling growth of gerbera due to its suitable porosity (70.5%), water holding capacity (57.1%), air permeability (13.4%), EC (0.38 mS cm⁻¹) and pH (5.4).

The cocopeat used for gerbera had high water holding capacity 700 to 800 per cent, total N, P, K and organic carbon were 0.5, 0.03, 0.25 and 9 to 10 per cent respectively. The EC of cocopeat was less than 0.3 mS cm^{-1} and C: N ratio 92.80. The organic matter content was 80 per cent. (Anonymous, 2000a)

Allera *et al.* (2000) reported that the coconut fibre induced higher yields and the highest quality of harvested flowers of rose with better stem length and stem weight.

Devi *et al.* (2001) used the coir dust for evaluation of maturity of coir dust based compost. They observed that coir dust compost contains organic carbon 55.65 per cent, nitrogen 0.46 per cent, phosphorus 0.19 per cent, potassium 0.63 per cent, lignin 66.15 per cent, cellulose 17.08 per cent, total phenols $309.06 \text{ mg}100\text{g}^{-1}$, C: N ratio 120.9 and L: N ratio 143.7, respectively. They also reported that matured coir based compost should have L: N ratio < 25 , CEC > 70 , CEC / TOC > 1.6 and HI 4 -7.5.

Barreto and Jagtap (2002) assessed the different substrate media for the economical production of gerbera under the protected cultivation and reported that cocopeat combinations either with compost or vermicompost (1:1 v/v) were found to be suitable and cheaper for gerbera which produces the highest flower yield and increase the vase life of gerbera.

Chauhan *et al.* (2002) and Chauhan (2002) revealed that cocopeat is a unique waste material obtained from coconut palm (*Cocos nucifera*) industry after fiber has been extracted and plenty available in tropical countries. Cocopeat was amply available in Southern India (Cochin). The product was washed in 4 to 5 monsoons. It had low EC (less than 1 mS cm^{-1}) and pH around 5.5 to 6.0. One kg of dried cocopeat can hold about 600 per cent water and gives about 15 liters of usable material.

The suitability of cocopeat either alone or in combination with other medium leafmould with the proportion of 1:1 for floricultural potted plants has been reported by Singh and Sidhu (2002).

Kale (2002) reported that the cocopeat is byproduct of coconut husk. Now days it is commercially used in the pot cultivation of flowers in polyhouses. After soaking in water its swells 17 times more than that of its

original weight. It is more suitable to plant growth, cheaper as well available in ample quantity.

Rajhans (2003) reported that green house cultivation requires good medium having high moisture retention capacity, porous and free from pathogen and seeds of weed crops. Gerbera can be grown on medium, which is well drained and less nutrients. Gerbera is very sensitive to oxygen. Oxygen is required for root respiration. Therefore, it is important to have from the start and during the production a proper portion of 1/3 medium, 1/3 moisture and 1/3 air is required. The medium should be permeable of well drained so as to have proper salt balance. Lack of drainage can lead to too much water accumulation in the root zone causing diseases like phytophthora and pythium. Organic matter like FYM, perlite, vermicompost, sawdust, composted free bark cocopeat and rice husk will improve the structure of growing media. The pH of growing media should be between 5.5 to 6.5 with less than 1 mS cm⁻¹ salt content. The bedding material should be highly porous and well drained to provide proper aeration to the root system. The medium should not be very compact after watering. Cocopeat a byproduct of coconut palm (*Cocos nucifera*) industry after fibre extraction has been claimed to be highly suitable medium for gerbera plantation (Barreto and Jagtap, 2000).

Rajhans (2003) utilized cocopeat as growing media for commercial cultivation of gerbera under polyhouse condition, which had lower pH value (between 5.5 to 6.2). He concluded that cocopeat is permeable media, which removes the excessive salts i.e. it provides good drainage condition in polyhouse.

In view of above, it could be generalized that cocopeat found to be suitable medium for successful growing of flowering plants therefore considering the utility, the cocopeat obtained from M/s Sterling Farm Research and Services Ltd. Cochin has been characterized for its suitability for cultivation of gerbera under polyhouse condition.

2.2 Effect of fertigation levels and varieties on growth, quality and yield of gerbera

Fertigation is one of the techniques of supplying nutrients readily soluble through water. Yield of any flower crop is influenced by growth media,

nutrients, water supply, plant protection measures adopted and crop itself. Thus, gerbera is being successfully cultivated under protected condition using cocopeat as growth medium and fertigation techniques. It has been reported that various nutrients are supplied through drip are of varying quantities and differ in space and time. The literature pertaining to fertigation for floricultural plants have been reviewed and presented herewith.

Ehrle and Tresch (1958) reported that gerbera need ample nutrients, especially phosphorus and potassium for profuse flowering.

In Poland, a complete fertilizer 'flora' containing ammonium nitrate, potassium nitrate, calcium monophosphate, potassium chloride, magnesium sulphate, copper sulphate, sodium borate, manganese sulphate and zinc sulphate were applied monthly from January to August at rate of 75 g m⁻² produced the maximum number of good quality flowers (Oszkinis and Lisiecka, 1971).

Gutmane (1975) reported that the largest number of flowers was produced by ammonium nitrate + super phosphate + potassium sulphate at g L⁻¹.

Kamel *et al.* (1975) found that a ratio of 2N: 4P: 1K increased flower yield and that as N, P and K rates increased stem length and flower diameter also increased.

Lisiecka (1976) tested 25 NPK ratios and recorded best yield result with 2 : 1 : 3, viz. 281-293 mg N, 127-133 mg P₂O₅ and 360-440 mg k₂O L⁻¹ of peat substrate.

Bose and Jana (1978) observed that application of NPK proved very effective in increasing the number of leaves and suckers and in producing larger number of flower heads of bigger size. However, an excess of N reduced yield of gerbera has been observed by (Moulinier and Montarone, 1978)

Mantrova *et al.* (1982) used 3: 1: 1, peat: soil: sand mixture as a growing media where plants received NPK fertilization to determine the optimum dates and rates of fertilizers application in relation to plant developmental phases. N at 0.025 g kg⁻¹ soil applied 15-17 days after planting, N : K₂O at 0.1 : 0.15 g kg⁻¹ at the stage of rapid vegetative growth, N : P₂O₅ at 0.1 : 0.1 g kg⁻¹ at bud formation and N : P : K at 0.1 : 0.1 : 0.23 g kg⁻¹

at the beginning of flowering should give the best results for plant development and flower production of gerbera.

Kacpershka (1985) reported that the highest cut flower yield and best flower quality were produced by basal dressing of 1-2 g NPK fertilizers L⁻¹ peat providing available nutrients content *viz.*, 140-280 mg N, 30-60 mg P and 175-350 mg K L⁻¹.

Plants of gerbera were grown under glass house in a loam: peat substrate in the proportion (1:2) with basal P₂O₅ and K₂O at 50 and 70 mg 100g⁻¹, respectively and 3 nitrogen levels (10, 30 or 60 mg 100g⁻¹) and in addition the complete liquid fertilizer DAM- 390 was applied to all plants throughout the cropping cycle to maintain levels of 10, 30 or 60 mg N 100g⁻¹ of substrate. The highest¹ yield of flower (244.86 m⁻², 37.37 plant⁻¹) was produced by substrate concentration of 30 mg N 100g⁻¹ of substrate (Skalska, 1985)

Randhwa and Mukhopadhyay (1986) reported that complete balanced fertilizer dose made up of one part of ammonium sulphate, two part of super phosphate and one part of muriate of potash should be applied at the rate of 60-80 g of this mixture m³. Fertilizers containing high in nitrogen are not good for gerberas.

Fisher and Forchhammer (1987) found that application of copper @ 60 mg plant⁻¹ produced significantly better growth parameters, yield and quality flowers as compared with application of Cu @ 30 mg plant⁻¹.

De fault *et al.* (1990) carried out experiment on gerbera with increasing dosage of nutrients on yield of gerbera flowers. They found that the number of marketable flowers increased with N and K rates increased up to 110 kg ha⁻¹, but as the N rate was increased up to 220 kg ha⁻¹ cull (off type flowers) production increased. In the second year, marketable and cull yields increased as N rate increased but increasing K rate had had not affected yield of gerbera (cull flowers).

Ashwath *et al.* (1995) reported that application of nitrogen @100 kg ha⁻¹ was found to be the best for maximum number of flowers with minimum percentage of culled (off) flowers.

Bass *et al.* (1995) suggested that gerberas were less tolerant to salinity and 8 mM NaCl reduced the number of flowers and floral characters.

Fertigation with 80 per cent soluble fertilizer and water soluble fertilizer was found to be the most suitable for better growth and yield of gerbera which could be due to reduced nutrient losses by leaching and efficient use of nutrient through fertigation which is well established by Paul *et al.* (1996).

Spraying of $\text{FeSO}_4 + \text{MnSO}_4 + \text{ZnSO}_4$ @ 0.2 per cent each increased flower production of gerbera. (Bhattacharjee, 1993; Nalawadi *et al.*, 1996)

Gowada (1996) reported that well decomposed organic manure at 75 kg m^{-2} is optimum and it should be mixed well in beds before planting and application of 15: 10: 10 g NPK m^{-2} is optimum and essential for better quality of flowers and yield of gerbera grown under polyhouse condition

Hwang *et al.* (1997) studied the effect of nutrient solution strength (0.5 to 2 times) and irrigation frequency (6,12,18 days) on growth of gerbera in rice hull medium. Higher number of marketable flowers were harvested at 6 to 12 irrigations with 0.5 to 2 strength nutrient solution. The flower stalk length, diameter of flower and yield was higher in 1.5 strength nutrient solution.

The 80 per cent of recommended NPK (15:10:30 $\text{gm}^{-2} \text{month}^{-1}$) through water soluble fertilizers shows better growth of gerbera plant, yield and quality of gerbera cut flowers. (Anonymous. 1999).

Spraying of $\text{MnSO}_4 + \text{FeSO}_4 + \text{ZnSO}_4$ (0.2 per cent each) registered the highest flower yield per plant (46.66), stalk length (58.4cm), flower diameter (11.80 cm), stalk girth (2.10 cm) and plant height (76.4 cm) (Muthumanickam *et al.*, 1999)

Application of 10: 15: 20g NPK $\text{m}^{-2} \text{month}^{-1}$ around the plant during first three months of planting in two equal splits at 15 days interval helps in better establishing the growth of plant. From the 4th month onwards when flowering starts application of 15:10:30 g NPK $\text{month}^{-1} \text{m}^{-2}$ area in two splits at 15 days interval was desirable. Application of micronutrients like boron, calcium, magnesium and copper @ 0.15 per cent (1.5 mL L^{-1} water) produced better quality flowers and average yield was around 200 flowers $\text{m}^{-2} \cdot \text{year}^{-1}$ (Khan, 1999).

Three levels of nitrogen (100, 150, 200 ppm plant^{-1} alternate day⁻¹), three levels of phosphorus (40, 50 and 60 ppm plant^{-1} alternate day⁻¹) and single level of potassium (150 ppm plant^{-1} alternate day⁻¹) were tested for

naturally ventilated type green house grown gerbera. It was observed that higher levels of nitrogen and phosphorus recorded significantly more number of flowers per plant. The treatments N₂ and N₃ were significantly superior over N₁ in respect of flower stem length (36.37 cm) and diameter of flower; respectively (8.50 cm). The treatment combination N₁P₃K (100: 60: 150 ppm plant⁻¹ alternate day⁻¹) was recorded significantly maximum number of flowers per plant (Anonymous, 2000). The levels of nitrogen, phosphorus and potassium were tested for fan and pad type polyhouse grown gerbera. It was reported that N₂ (150 ppm) and P₂ levels (50 ppm plant⁻¹ alternate day⁻¹). produced higher number of flowers per plant with moderate flower quality. The diameter of flower was superior in N₃ (200 ppm) and P₃ (60 ppm) and stem length in N₂ (150 ppm) and P₁ (40 ppm). The treatment combination 150 : 160 : 150 (ppm plant⁻¹ alternate day⁻¹) showed higher flower yield per plant with best flower diameter and stem length. (Anonymous, 2000)

Under polytunnel type polyhouse condition gerbera gives highest yield at N₃ level (200 ppm plant⁻¹ alternate day⁻¹) and at P₃ Level (60 ppm plant⁻¹ alternateday⁻¹) with moderate flower diameter and stem length. The 200 : 60 :150 (ppm plant⁻¹ alternate day⁻¹) treatment combination gives the highest number of flowers (7.6) with moderate stem length and flower diameter per plant. (Anonymous, 2000)

Number of leaves per plant had the greatest positive effect on flower yield of gerbera has been reported by Anuradha *et al* (2000).

The higher levels of nitrogen recorded significantly more number of flowers per plant and also higher levels of phosphorus produced more number of flowers per plant. The treatment combination N₃P₃K that is 200:60:150 (ppm plant⁻¹ alternate day⁻¹) produced more number of flowers under naturally ventilated, fan and pad type and poly tunnel type polyhouses, respectively. (Anonymous, 2000b)

The application of N @ 15 g plant⁻¹ produced significantly more number of flowers with better stalk length, thickness of stalk and diameter of the flowers as compared with the application of N @ 10 g plant⁻¹. The application of 20g P₂O₅ plant⁻¹ produced more number of flowers plant⁻¹ having better stalk length, stalk thickness and flower diameter. The application of 20 g K₂O plant⁻¹ showed more number of flowers plant⁻¹ with better flower stalk, stalk

thickness and diameter of flower. The treatment 15: 20: 20 g NPK plant⁻¹ was found to be the best in respect of flower yield and quality (Anonymous, 2001).

The experiment was carried out at AICFIP, Ganeshkhid Pune on standardization of fertilizer dose for flower production of gerbera under protected condition by Gurav *et al.* (2002). They concluded that the addition of NPK @ 15:20:20 g NPK m⁻² month⁻¹ produces significantly highest number of gerbera flowers plant⁻¹ (35) with maximum stalk length (86.50) stalk diameter (0.93 cm) and flower diameter (10.80 cm).

Sujata *et al.* (2002) conducted an experiment with an objective to compare the effect of fertigation with straight fertilizers and water soluble fertilizers each at three levels viz., (100%, 80% and 60%) of recommended dose (15: 10: 30 g m⁻² month⁻¹) in gerbera under low cost green house. They observed that application of 80 per cent of the recommended level of fertilizers either through water soluble or straight fertilizers fertigations was the most effective for improving growth and flower production of gerbera.

The application of NPK @ 20: 10: 24 g year⁻¹ plant⁻¹ has significantly increased the flower yield, length of stalk, thickness of flower and flower diameter of gerbera in polyhouse condition (Ambad *et al.*, 2002).

Kale (2002) reported that gerbera requires plenty of organic matter (7.5 kg m⁻²) ample nutrients in the form major and minor nutrients for proper growth and flower production. Application of 10:15:20 g NPK m⁻² month⁻¹ during first three months of planting and 15: 10: 30 g NPK m⁻² month⁻¹ from forth month in two splits at 15 days intervals was desirable for good growth and increased flower yield. The spraying with micronutrients like boron, calcium, magnesium and copper @ 0.15 per cent (1.5 ml L⁻¹ water) once a month found to be better for quality of gerbera flowers.

Rajhans (2003) revealed that there is no specific fertilizer schedule available in scientific literature in general for vegetative growth the application of 20 : 20 : 20 or 18 : 18 : 18 @ 0.75 g L⁻¹ day⁻¹ is to be supplied at 3-12 weeks. After 12 weeks 15: 8: 35 water soluble fertilizers @ 121.5 g L⁻¹ day⁻¹ should be given for higher yield of gerbera.

Katole (2003) suggested the water soluble fertilizer schedule for gerbera according to the various growth stages of gerbera. The fertilizer

schedule according to Katole (2003) and Anonymous (2003a) is as given below:

For development of plants – Fertilizer grade 19 : 19 : 19:- 2 kg day⁻¹acre⁻¹ for a period of 25 days, should be applied for plant growth

Fertilizer grade 10 : 36 : 10- 1 kg day⁻¹acre⁻¹ for period of 15 days should applied for root development and differentiation.

Fertilizer grade 16 : 8: 24- 2 kg day⁻¹acre⁻¹ for a period of 25 days should be apply for bud development and flower stalk and girth development.

Fertilizer grade 16 : 8 : 24 – 3 kg acre⁻¹ alternate day for 60 days should be applied for flower development, flower bloom and colour brightness etc.

Calcium nitrate, Magnesium nitrate:- 1 kg per acre alternate day for 60 days should be applied to increase cell division, cell wall substance, chlorophyll content of the plant ,swelling of buds and number of flowers. It is also applied to increase the diameter of flower and their petals.

The Fe- EDDHA – 500 g in 250 litre water to be pumped per acre though Drip Irrigation once in fortnight to irradiate iron deficiency

The Zn- EDTA- 250 g in 250 lit water to be delivered though Drip line once in fortnight

Foliar application- besides the above to meet emergent nutritional requirement of gerbera plant. 1) 14 : 42 : 14 – 2.5 g L⁻¹ + microsol B in 0.5 g L⁻¹, to be spread in the evening once in 10 days for increasing bud differentiation activity in plant. Such sprays should be taken twice a month.

2. 16: 4: 31- 6 g L⁻¹ water + Microsol B 0.5 g L⁻¹ water, this spray should be taken once in 10 days and such a three sprays should be taken in months. This is to increase the swelling of flowers and keeping quality of flowers. The spray should be given on leaves and not on the flowers or the bud of plant

2.3 Effect of fertigation levels on growth of gerbera varieties

The pertinent work carried out on different specific varieties of gerbera are highlighted herewith.

Bhattacharjee and De, (2000) reported the varietal specifications of gerbera varieties. Cultivars Eclipse produces 185 flowers m⁻² year⁻¹ having

flower diameter 9 to 10 cm, stem length 65 cm and vase life 11 to 12 days. While Ruby red produces 175 flowers m^{-2} year⁻¹ having flower diameter 9 to 10 cm, stem length 60 cm and vase life 11 to 12 days.

Ambad *et al.* (2002) Observed that the market and performance of Ruby red was better as compared with Venturia and sunsent. The Ruby red has the longest stalks (46.89 cm), flower diameter (9.02 cm) and better thickness of stalk (0.66 cm) as well as the number of flowers plant⁻¹ month⁻¹ (2.59). The flower yield (259.12 flowers m^{-2}) has been recorded by Ruby red cultivar.

The Kozac cultivars of gerbera produces 250 number of flowers with 10 to 12 cm flower diameter and 45 to 55 cm stem length in coco peat media (Anonymous, 2003).

The varieties of gerbera Eclipse and Ruby red produced 240 to 260 and 260 to 280 no. of flowers in coco peat media with 10 to 12 cm flower diameter, 65 and 60 cm stalk length, respectively. These varieties showed 12 to 14 days vase life (Anonymous, 2002).

2.4 Effect of fertigation levels and varieties on concentration and uptake of nutrients:

The growth and yield of gerbera are influenced by fertigation subsequently by their concentration and uptake of nutrients. The relevant research carried out elsewhere have been compiled and put forth herewith.

2.4.1 Concentration of nutrients

Gutamane and Griving (1975) studied that the effect of different kinds and concentrations of fertilizers on growth and developments of Gerberas and nutrient content of the plant. They stated that the largest number of flowers was produced by plants growth in peat with ammonium nitrate + super phosphate+ Potassium sulphate at 4 g L⁻¹. Raising the salt concentration from 2 to 4 g L⁻¹ improved vegetative growth and increased N, P and K concentration in the leaves and roots of gerbera.

Gerbera plants grown on three substrates composted media (piné bark, high peat and 1:1 mixture of bark and peat). From the analysis report

good flower yield was recorded when the leaves contained N 2.7 to 3.13, P 0.19 to 0.35, K 3.06 to 3.64, Ca 1.66 to 2.18 and Mg 0.3 to 0.48, per cent respectively. (Klossowski and Stronjny, 1983).

The initial Fe, Mn and Zn content in fully matured green leaves of gerbera plant were 20.2, 18.0 and 16.0 ppm, respectively. The micronutrient content in the leaves due to spraying of $\text{MnSO}_4 + \text{FeSO}_4 + \text{ZnSO}_4$ recorded the highest amount of Fe (80.3 ppm), Mn (98.4 ppm) and Zn (79.3 ppm) during the 12th month of spraying. (Muthumanickam, 1999).

Dufault *et al.* (1990) observed that with increasing doses of N from 55 to 220 kg ha⁻¹ the NO₃-N leaves has found to be increased. The K, Mg and Ca concentrations increased as N rate was increased up to 110 kg ha⁻¹. As N fertilizer rate was increased from 55 to 220 kg ha⁻¹, the N, P, K and N-NO₃ content in leaves increased but Ca content decreased. The potassium fertility generally had less effect on leaf tissue elemental composition than N fertility. The percentage of K content in leaf tissue was higher with K at 220 kg ha⁻¹ than at lower rates. For the addition of K fertilizers the P, Mg and Ca content in these were unaffected.

The gerberas were grown in pots containing four types soil which varied in EC (0.9-6.3 dS m⁻¹) and also varied in NO₃-N (42 to 69 ppm), available P (354 to 644 ppm) exchangeable K (0.41 to 1.19 meq/100 g). The order of concentrations of mineral nutrients in shoots is K₂O > CaO > T-N > MgO > Na₂O > P₂O₅ at 90 days after transplanting. The optimum concentrations of N, P₂O₅, K₂O, CaO, MgO and Na₂O in shoots for maximum biomass yield were 2.70^l, 0.40, 3.55, 2.75, 1.15 and 0.45 per cent at 90 days after transplanting (Hwang and Yoon, 1994).

Guba (1994) reported that cumulative flower yields were the highest with NH₄:NO₃ ratios of 33:67 in experiment 1 and 25:75 or 50:50 in experiment 2 flower quality deteriorated with increased NH₄:NO₃ ratio.

Gurav and Kale (2002) reported that for good flower yield gerbera leaves should content 2.7- 3.13, 0.19-0.35, 3.06-3.64, 1.66-2.18 and 0.3-0.18 per cent N, P, K, Ca and Mg, respectively.

2.4.2 Uptake of nutrients

The effect of fertilizer levels on growth and uptake of nutrients by gerberas was studied under polyhouse condition. The growth and yield of gerbera is directly influenced by the uptake of nutrients. The research work related to this has been reviewed and presented herewith.

The response of K_p uptake by crops may depend on the levels of N, since N fertility is only fully used for crop production when K supply is adequate. (Garther 1969, Heathcote, 1972)

Potassium has a role in the uptake and translocation of NO₃-N within plants has been reported by Koch and Mengel (1977).

Kacperska (1985) reported that optimal major nutrient contents in leaves of gerbera grown in peat media were 2.38 to 2.80 per cent N, 0.37 to 0.42 per cent P, and 3.43 to 4.63 per cent K, respectively.

Kreij and De (1989) reported that gerbera plants supplied with a nutrient solution with a low K : Ca ratio (0.8 to 0.3: 3 to 4 mmol L⁻¹) showed symptoms of K deficiency (shortened stems and leaf damage) whereas plant supplied with a high ratio solution (7:8 mmol L⁻¹) showed no symptoms of K deficiency. At both ratios plant supplied with 0.6 mmol mg⁻¹L⁻¹ were of better quality than those supplied with 1.7 mmol mg⁻¹ L⁻¹.

Bass *et al.* (1995) observed that average electrical conductivity needed to compensate for mineral uptake was 0.7 to 0.8 dS m⁻¹.

Sonneveld *et al.* (1997) observed that Mn had no significant effect on flower production.

Ferrante *et al.* (2000) observed that gerbera plant showed significant differences in growth and flower production when grown in two different soil less growing systems with (closed system) and without nutrient solution recycling (open system). Nutrient concentration in closed system was lower due to recycling of nutrient solution while mineral content in dry matter showed luxury consumption of N, P and K, found in open system.

2.5 Effect fertigation levels and varieties on vase life of gerbera flowers

The levels of K fertilization did not show significant effect on the vase life of Gerbera. (Moulinter and Montarone, 1978)

Improvement in keeping quality of cut flower by adding chlorine to standing water was recorded by Geers (1978).

Fertilizers containing high in nitrogen were not good for gerberas as supply of excess N reduced vase life of flower (Moulinier and Montarone, 1978)

Brandis (1979) suggested that for good vase life cut flowers should be placed immediately after harvest in fresh water but not in previously used water. The noxious effect of used water could not be corrected even if the flowers were transferred 24 hours later into fresh water. The addition of chloride solution to water increased vase life.

In a trial, on the effects of water quality on vase life, flowers held in water contraindicated by plant material kept for only about 6 days as compared with about 14 days in fresh clean water (Jong, 1985)

Differences in vase life among gerbera cut flowers due to genetic make of cultivars has been observed by Abdel-Kader and Rogers (1986).

Dufault *et al.* (1990) observed that the influence of fertigation on vase life was found to be non-significant.

Cutting the stem at base improved keeping quality, the best results being obtained with cutting just before placing in water (Bose and Yadav; 1993)

Guba *et al.* (1994) reported that cumulative flower yields were highest with $\text{NH}_4:\text{NO}_3$ ratios but vase tended to deteriorate.

Baas *et al.* (1995) demonstrated that the vase life was not significantly affected by salinity.

Alexe and Amariutei (1998) observed that experiments on gerbera cut flowers showed vase life and flower diameter were influenced by the soil N and K content cut flowers.

Muthumanickam (1999) revealed that spraying of $\text{MnSO}_4 + \text{FeSO}_4 + \text{ZnSO}_4$ (0.2 per cent each) registered the highest vase life of gerbera for 7 days.

Khan (1999) reported that the harvested gerbera flower stalks of about 2-3 cm above the base and kept in fresh chlorinated water immediately has improved the vase life of gerbera.

Post harvest dipping with 1.0 per cent CaCl_2 helped in extending the vase life of cut gerberas (Gerasopoulos and Chebli, 1999).

The 50 per cent coconut water was proved to be best in lengthening the vase life of cut gerbera flowers followed by 4 per cent sucrose + 20 ppm AgNO₃, 60 per cent coconut water and 6 per cent sucrose + 30 ppm AgNO₃. There was no significant difference between the two treatments in respect of vase life but the cost of coconut water is cheaper (Nair *et al*, 2000)

Higher levels of N reduces vase life while moderate levels of P increases the vase life. The treatment combination of NPK (150:50:150 ppm/plant/alternate day) showed highest vase life (10 days). (Anonymous, 2000).

The lower levels of N showed the highest vase life while moderate levels of P also shows highest vase life in naturally ventilated poly house condition. But in poly tunnel and fan and pad type poly houses higher levels of N and also higher levels of P increases vase life of flower. The treatment combination N₂P₂K (150:50:150 ppm plant⁻¹ alternate day⁻¹) showed superior result in respect of vase life . (Anonymous, 2000)

The treatment Aluminium sulphate @ 300 ppm significantly enhanced the vase life of gerbera which was followed by citric acid 300 ppm i.e 8.5 and 7 days, respectively (Anonymous, 2001)

Ambad *et al.* (2001) reported that 100 per cent recommended dose through water soluble fertilizer (20:10:24 gm NPK plant⁻¹ year⁻¹) showed significant vase life of 12 days of gerbera.

2.6 Effect of fertigation levels on leachate analysis

The analysis of lechates helps in understanding the reaction and salt concentration, nutrient loss, aeration status of the growth medium and balance of nutrients present which influences growth and development of plant. The relevant research related to this has been collected and presented herewith.

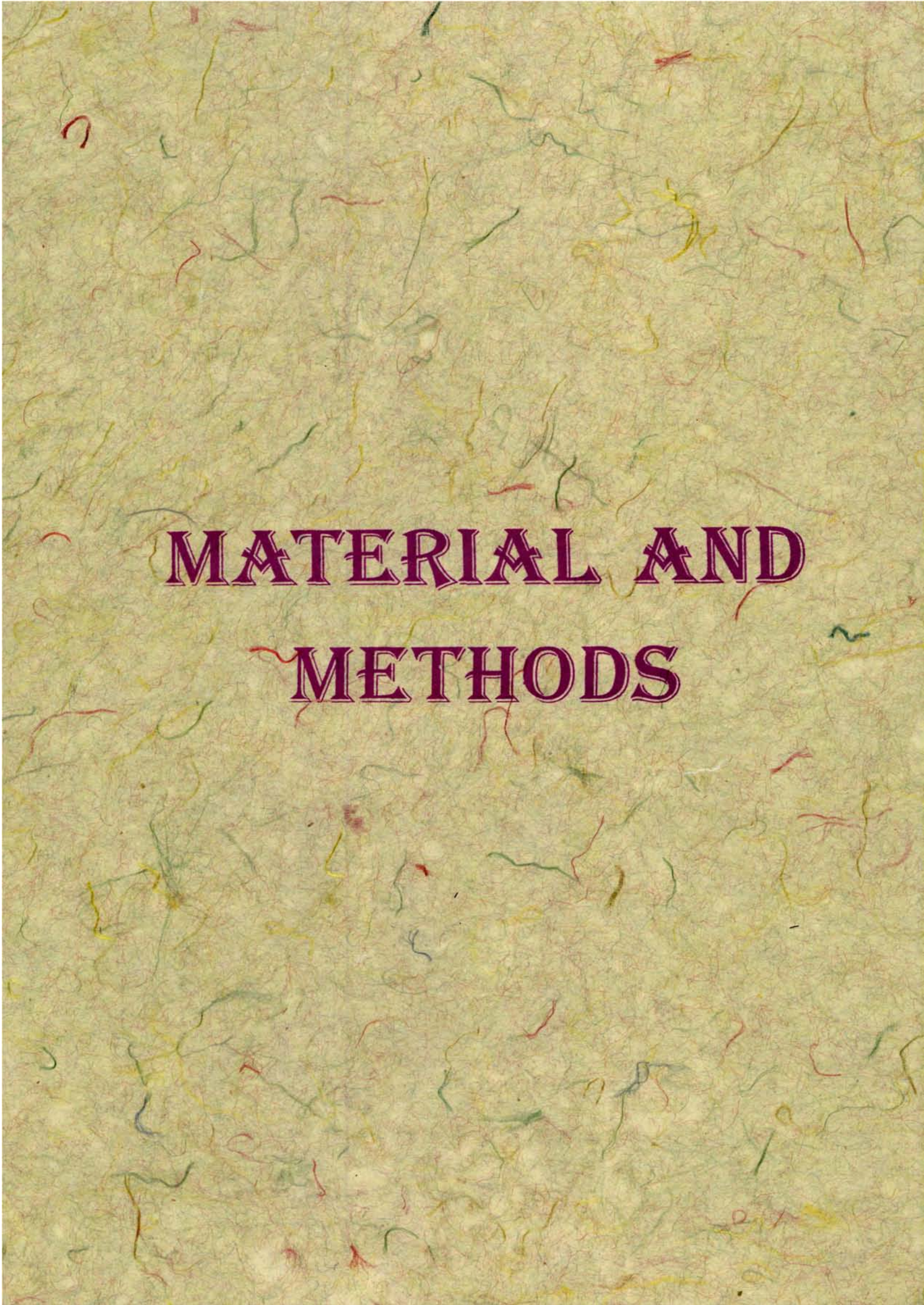
Komosa and Gapys (1998) observed that there was change in composition of nutrient solution collected from drippers, growing media and drainage water. The changes varied with growing medium. The nutrient concentration was higher in the growing medium than in the drainage water Copper was the nutrient which exhibited the greatest increase in the drainage water.

No major differences were detected between the nutrient composition of the drainage water (nutrient solution) for both cultivation systems and substrates. Reuse of the nutrient solution resulted in fertilizer saving of 30-35 per cent. No differences in flower production and in flower quality were found with reuse of the nutrient solution in comparison with an open drain system (Labeke *et al.*, 1998)

Gerbera plants were planted in four liters pots filled with pumice and supplied via a fully automated installation with nutrients and water. The addition of nutrients and water to the drain solution was based on real time measurement of its volume and electrical conductivity. The results of sample indicated that the K : Ca, Mg :Ca and P : (SO₄+NO₃)⁻¹ ratios in the reference nutrient solution should be higher than the values suggested for the supply of solutions (Savvas *et al.*, 2001).

Analysis of recycled solution in sub irrigation and drip irrigation showed some changes in its composition. These changes were less with sub irrigation than with drip irrigation. High evaporation rates were the probable cause in first case and selective absorption by roots in second. (Lenzi *et al.*, 2002).

Chapter Opener Page



**MATERIAL AND
METHODS**

3. MATERIALS AND METHODS

The present investigation on “Effect of fertigation levels on growth and yield of gerbera (*Gerbera jamesonii*) under polyhouse condition” was undertaken during the year 2002-2003 at Hi-Tech Floriculture and Vegetable Project, College of Agriculture, Pune-411 005 with a view 1) to characterize the growing media (cocopeat) for gerbera, 2) to find out optimum dose of fertilizers for higher yield of different varieties of export quality gerbera, 3) to study the concentration and uptake of nutrients in gerbera, 4) to assess leachates for salt concentration and reaction (pH) of leachates and 5) to study the keeping quality of gerbera as affected by various levels of fertigation.

3.1 Climatic conditions

Pune city lies on 18^o. 32' North latitude and 73^o. 51' East longitude having altitude of 557.74 meters above mean sea level. The average annual rainfall of Pune city is 675 mm. Mostly distributed in monsoon season with 670 mm rainfall in 60-70 days. The maximum and minimum temperature ranges from 42.2 °C to 7.5°C, respectively. The maximum temperature in summer seldom exceed 45°C and minimum temperature rarely falls below 5°C.

3.2 Materials

The details of the materials used and analytical techniques adopted for this investigation are presented herewith.

3.2.1 Cocopeat

The growing area should be open, porous and well drained. Gerbera is very sensitive to an oxygen poor environment. Therefore, it is important to have highly permeable material. Cocopeat was used as growing media and obtained from Sterling Farm Research and Services Pvt. Ltd, Cochin (Kerala, South India). Cocopeat is a waste from coconut palm (*Cocos nucifera*) industry after fiber has been extracted and allowed to be washed in 4 to 5

monsoons for low pH and EC was procured. The cocopeat was analysed for different chemical properties and presented in Table 7.

3.2.2 Fertilizers

A list of commercial grade water soluble inorganic fertilizers which were used for experiment and their elemental composition is presented in Table-1. The quality of fertilizers used for preparation of stock solution and quantities of nutrients supplied through fertigation are presented in Tables 2 and 3, respectively. The A/B tank system was used for the method of application of fertilizer solution as per the method described by Patil (2002).

3.2.3 Earthen pots

Earthen pots (15 cm height, 30 cm upper diameter and 4 liters capacity) were used for experiment. Each pot was filled manually with 1.5 kg cocopeat.

3.2.4 Plants

Three varieties of gerbera were selected on the basis of performance of Hi-Tech Floriculture and Vegetable Project, College of Agriculture, Pune-5. The tissue cultured plants of three cultivars were obtained from Kumar Florist Gerbera's Pvt. Ltd., Pune-36. Kozac, Eclips and Ruby red cultivars were selected for carrying out this study. The salient features of varieties used for this investigation are presented in Table 4.

3.2.5 Polyhouse

The polyhouse installed at Hi-Tech Floriculture Project, College of Agriculture, Pune-5 was used for experiment. The polyhouse was naturally ventilated (GH-1) type and U. V. stabilized 200 micron thickness polythene film was used as cladding material. For maintaining temperature 50 per cent shade net was provided in the polyhouse. The two ventilators were kept on both sides of polyhouse covered by anti-insect net. To cover ventilators manually operated, movable curtains were provided on side walls. For control of temperature and humidity misting system was provided. The polyhouse was constructed by SRIROZ Consultant Pvt. Ltd., Pune-44.

3.2.6 Misting system

Four ways, 5 to 7 litre per second discharge and 100 to 150 micron size of droplet, non drain type and openable foggers were installed in polyhouse to maintain humidity in the range of 50 to 60 per cent and temperature was maintained in the range of 20 to 30 °C. This system was installed by Finolex Plastro Pvt. Ltd., Urse. Dist. Pune.

3.2.7 Plant Protection

The following chemical (pesticides and fungicides) were used to control the insect pests and diseases as and when required.

Sr. No	Chemicals	Concentration
1.	Aliate	- @ 1.5 g/L
2.	Vertimec	- @ 0.5 ml/L
3.	Hostathion	- @ 1.0 ml/L
4.	Cypermethrin	- @ 1.5 ml/L
5.	Confidor	- @ 1.5 ml/L
6.	Methion	- @ 2.5 ml/L
7.	Flufenoxuron	- @ 1.0 ml/L
8.	Bavistin	- @ 1.5 g/L
9.	Dimethoate	- @ 2.0 g/L
10.	Captan	- @ 2.0 g/L
11.	Sulphur	- @ 2.0 g/L
12.	Endosulfan	- @ 2.5-3.0 ml/L

3.2.8 Plastic buckets

The plastic buckets of 25 litres capacity were used to prepare A and B tank fertilizer solutions.

3.3 Experimental methods

The information on type of experiment, medium used, treatment details along with fertigation levels, gerbera varieties used and preparation of fertilizer solution is given below.

Types of experiment	- Pot culture
Growing media	- Cocopeat
Levels of fertigation	- Four
No of replications	- Three
No of pots	- 36
Pot capacity	- Four liters
Design	- Factorial Complete Randomized Block Design

A) Levels of fertigation

- F₁ Twenty per cent lower dose of fertilizers than prevailing dose of fertilizer in polyhouse condition in Hi-Tech Floriculture and Vegetable Project.
- F₂ Prevailing dose of fertilizers in polyhouse condition in Hi- Tech Floriculture and Vegetable Project.
- F₃ Ten per cent higher dose of fertilizers than prevailing dose of fertilizer in Hi- Tech Floriculture and Vegetable Project.
- F₄ Twenty per cent higher dose of fertilizers than prevailing dose of fertilizer in polyhouse condition in Hi- Tech Floriculture and Vegetable Project.

B) Varieties

- V₁ - Kozac
- V₂ - Eclips
- V₃ - Ruby Red

3.3.1 Preparation of fertilizer solution

The fertigation method utilized for fertilizing or fertilization of gerbera plants was A /B tank system. The fertilizer quantities were utilized for the preparation of nutrient stock solution (10 litres) are presented in Table 3. A tank contained only nitrates and B tank contained phosphorus, potash and micronutrients. These solutions were used daily for preparation of working solutions. After seven days of period new stock solutions of fertilizers were prepared to avoid contaminations in nutrient solutions.

Twenty ml solution from A and twenty ml solution from tank B dissolved in 5 litres of irrigation water (C₁S₁) class to prepare a different levels of

fertilizer solutions (F_1 , F_2 , F_3 and F_4). Five hundred ml fertilizer solution mixed irrigation water was given to plant manually every day at early in the morning.

3.4 Experimental details

A pot culture experiment was conducted to study the effect of different levels of fertigation on growth and yield of gerbera under polyhouse condition in simple naturally ventilated gerbera polyhouse. For this study four fertilizer levels on the basis of prevailing dose of Hi-Tech Floriculture Project and three varieties of gerbera on the performance of Hi-Tech floriculture Project were selected and replicated three times in factorial completely randomized block design.

For this pot culture experiment, four liters capacity earthen pots were used. Initially keeping a small hole at the bottom of earthen pot and by dipping the pots in water for few minutes for filling of pores. The pots were simultaneously filled with approximately 1.5 kg cocopeat. Prior to filling the pots, cocopeat was drained with water and solution of calcium nitrate to avoid nutrient deficiency at a later stage, to maintain the moisture level before planting. The gerbera plants were planted in pots and Bavistin drenching was given on next day as preventive measure against root rot. The plants were planted on 19th April 2002 and the observations were recorded after 60 days flowering for yield of flowers and biometric observations were recorded at 60, 90 and 120 days after planting of gerbera plants. Final observation related to yield was recorded upto 9 month from date of planting.

Up to 15 days from planting only plain water was given manually as per the water requirement per plant (200 ml). After 15 days, fertilizer treatments were given daily and till the date of completion of study. Plants require about 8 weeks to develop the first flower. This first flower bud was removed to develop plant further and next flower was harvested. The gerbera flowers were harvested when the second circle of disc florates shows pollen development. During the span of study, the morphological observations such as number of leaves per plant, size of flower, plant spread, number of days required for flowering, flower yield per plant, length of flower stalk were recorded.

3.5 Methods of analysis

Standard methods were used for analysis of cocopeat, plant samples and lechates which are presented in Tables 5 and 6.

Methods for leachate analysis

The lechate samples were collected periodically and analysed simultaneously in laboratory for EC and pH as per conductometric and potentiometric method respectively (Jackson, 1973).

Vase life

The flower should be harvested by bending sideways from heart and pulled rather than cutting. The keeping quality of flowers as affected by different levels of fertigation was determined by keeping the flowers in conical flasks containing 100 ml water. The basal tips affected by water were cut for every day while replacing the water. Finally the vase life was determined.

3.6 Statistical analysis

Statistical analysis was carried out as per the methods described by Panse and Sukhatme (1973).

Table 1. Types of fertilizers used for experimentation

Sr. No.	Fertilizers used	Elemental composition (%)
1	Calcium nitrate	N (15.5), Ca (18.5)
2	Potassium nitrate	N (13), K (38)
3	Mono-ammonium phosphate	N (11), P (26.9)
4	Potassium sulphate	K (41.5), S (18)
5	Magnesium sulphate	Mg (9.7), S (13)
6	Manganese sulphate	Mn (31), S (19.9)
7	Zinc sulphate	Zn (23), S (11.1)
8	Sodium molybdate	Mo (39)
9	Borax	B (11)
10	Iron chelated EDTA	Fe (12-13)
11	Nitric acid (38%)	N (22.2), H (1.6)

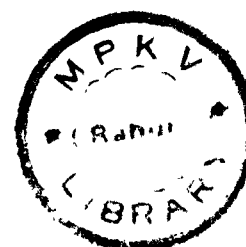


Table 2. Quantity of fertilizers used for preparation of stock solution

Tank	Fertilizers	Fertilizer levels			
		F ₁	F ₂	F ₃	F ₄
		----- g / 10 litre of water -----			
A	Calcium nitrate	480	600	660	720
A	Nitric acid 38 % (ml)	120	150	165	180
A	Chelated Fe EDTA	37.6	47.0	51.7	56.4
B	Nitric acid 38 % (ml)	120	150	165	180
B	Mono-Ammonium phosphate	184	230	253	276
B	Sulphate of potash	232	290	319	348
B	Magnesium sulphate	288	110	121	132
B	Manganese sulphate	0.96	1.19	1.31	1.43
B	Zinc sulphate	1.36	1.70	1.87	2.04
B	Borax	2.16	2.69	2.96	3.23
B	Copper sulphate	0.26	0.32	0.36	0.39
B	Sodium molybdate	0.41	0.51	0.57	0.62

Table 3. Quantity of fertilizers applied to gerbera

Tank	Fertilizers	Fertilizer levels			
		F ₁	F ₂	F ₃	F ₄
		-----mg / 500ml of water/day/plant-----			
A	Calcium nitrate	96.00	120.00	132.00	144.00
A	Nitric acid 38 % (µl)	24.00	30.00	33.00	36.00
A	Chelated Fe EDTA	75.20	94.00	103.40	112.80
B	Nitric acid 38 % (µl)	24.00	30.00	33.00	36.00
B	Mono-Ammonium phosphate	36.80	46.00	50.60	55.20
B	Sulphate of potash	46.4	58.00	63.80	69.60
B	Magnesium sulphate	17.6	22.00	24.20	26.40
B	Manganese sulphate	0.190	0.238	0.261	0.285
B	Zinc sulphate	0.272	0.340	0.374	0.408
B	Borax	0.431	0.538	0.591	0.645
B	Copper sulphate	0.052	0.064	0.070	0.076
B	Sodium molybdate	0.082	0.102	0.112	0.122

Table 4. Sailable features of gerbera varieties

Sr. No.	Character	Varieties		
		Kozac	Eclips	Ruby red
1	Colour of flower petal	Yellow Red	Red Purple	Red
2	No. of flowers produced per year per sq m	250	260	280
3	Stalk length of flower (cm)	45 to 55	60 to 65	60
4	Diameter of flower (cm)	9 to 10	10 to 12	10 to 12
5	Vase life (days)	11 to 12	12 to 14	12 to 14

* Anonymous (2003) and Anonymous (2002)

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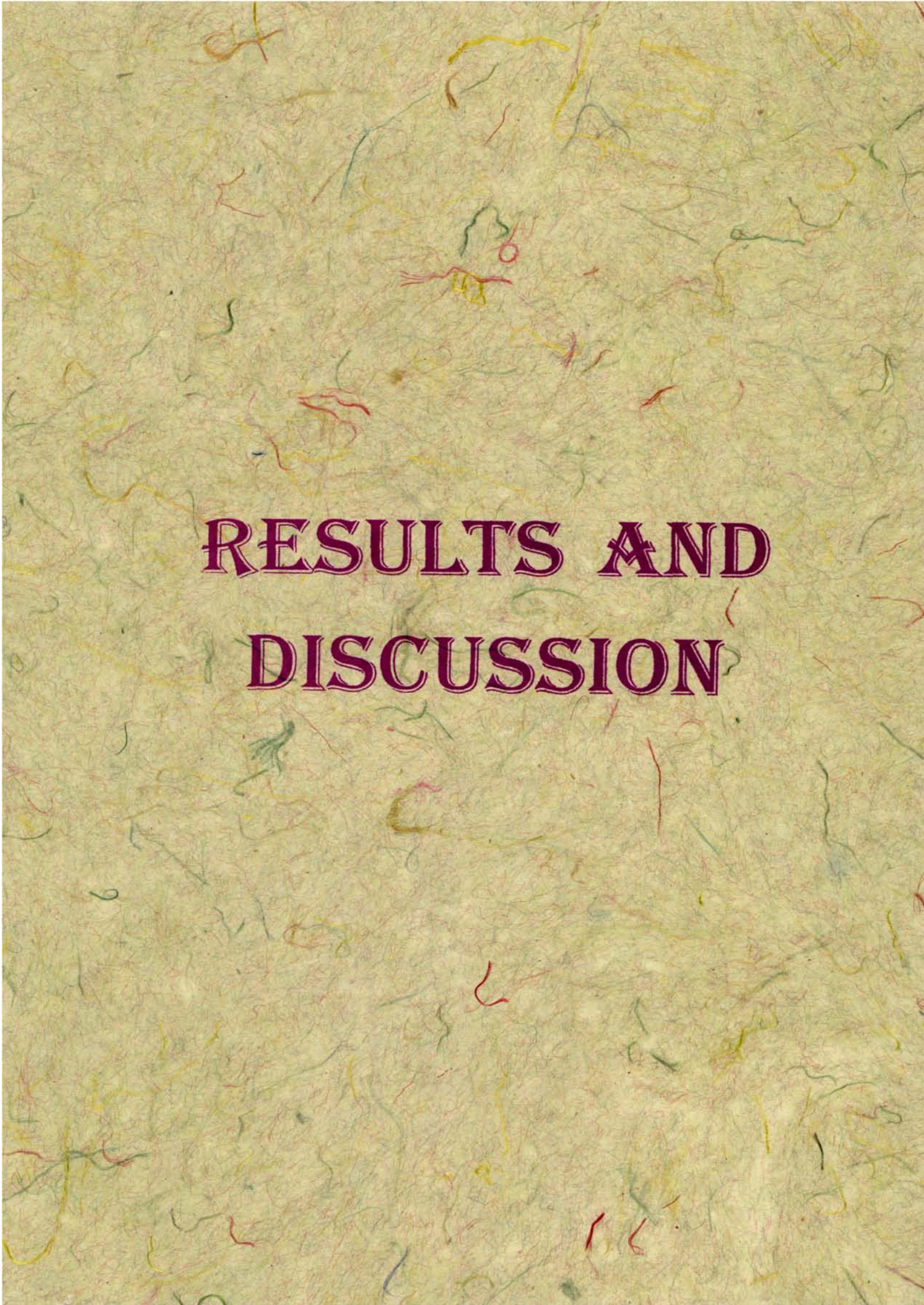
Table 5. Methods used for characterization of cocopeat

Sr. No.	Parameter	Method	Reference
1	pH	Potentiometric	Jackson (1973)
2	EC	Conductometric	Jackson (1973)
3	Preparation of acid extract	Binary mixture of conc. H ₂ SO ₄ and 30 per cent H ₂ O ₂ (1: 1)	Parkinson and Allen (1975)
4	Organic matter	Dry ashing	Gorsuch (1970)
5	Organic carbon	By multiplying the per cent organic matter by 0.58	Gorsuch (1970)
6	Nitrogen	Micro Kjeldahl's	Bremner and Mulvaney (1982)
7	Phosphorus	Vandomolybdate yellow colour	Jackson (1973)
8	Potassium	Flame photometer	Chapman and Pratt (1961)
9	Calcium and magnesium	Versenate	Lanyon and Heald (1982)
10	Micronutrients (Fe, Mn, Zn, Cu)	Atomic absorption spectrophotometric (Perkin Elmer- Model 2380)	Lindsay and Norvell (1978)
11	C. E. C.	Barium acetate solution and NaOH titration	Harada and Inoko (1980)
12	Lignin	Gravimetric (ADL)	A. O. A. C. (1975)
13	Cellulose	Gravimetric (ADF)	A. O. A. C. (1975)
14	Water holding capacity	Keen-Raczkowski cup method	Piper (1966)
15	Moisture	Oven drying at 65 °C	Black (1965)

Table 6. Methods used for gerbera plant analysis

Sr. No.	Parameter	Method	Reference
1	Preparation of acid extract	Binary mixture of conc. H ₂ SO ₄ and 30 per cent H ₂ O ₂ (1: 1)	Parkinson and Allen (1975)
2	Nitrogen	Micro Kjeldahl's method	Bremner and Mulvaney (1982)
3	Phosphorus	Vandomolybdate yellow colour method	Jackson (1973)
4	Potassium	Flame photometer	Chapman and Pratt (1961)
5	Micronutrients (Fe, Mn, Zn, Cu)	Atomic absorption spectrophotometer (Perkin Elmer- Model 2380)	Lindsay and Norvell (1978)

Chapter Opener Page



**RESULTS AND
DISCUSSION**

4. RESULT AND DISCUSSIONS

Gerbera is an important commercial cut flower grown throughout the world in a wide range of climatic conditions having wider physiological adaptability. The gerbera is grown commercially in polyhouses. The yield and quality of gerbera is governed by the growth media, fertilizer requirement and plant protection measures adopted under controlled condition. The quality of gerbera flowers are mainly governed by the nutritional status of the plant. Therefore, in order to know the effect of fertigation levels on growth and yield of different varieties of gerbera, the present investigation was carried out using cocopeat as a growth media under polyhouse conditions.

The present investigation was undertaken at Hi-Tech Floriculture and Vegetable Project of College of Agriculture, Pune under Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra). The gerbera plants were grown on soil less media (cocopeat) for 120 days under polyhouse condition. The information regarding types and quantity of fertilizers used for the experiment are given in Table 2 and the methods used for cocopeat and gerbera plant analysis have been given in Tables 5 and 6. The pertinent data with respect to characterization of cocopeat, growth and yield parameters of gerbera, the salt concentration and reaction of leachate and keeping quality of gerbera have been recorded and presented herewith.

4.1 Characterisation of cocopeat

Cocopeat obtained from M/s Stearrling Farm Research and Services Pvt. Ltd., Cochin has been used for experimental purpose. The data pertinent to characterization of cocopeat is reported in Table 7. From the Table 7 it is seen that the cocopeat is acidic in nature (pH 5.8) having very high water holding capacity (850) and wider C:N ratio (62.5 :1). It has high lignin content (66.15%). It contains all the nutrients, in limited quantities but rich in iron. It has EC less than one (0.90 dS m^{-1}). The cocopeat is also having high cation exchange capacity and is responsible for holding the nutrients added in the growth media. Amongst the micronutrients, comparatively higher values of iron than that of zinc, manganese and copper were found in cocopeat. The

Table 7. Characterisation of cocopeat

Sr. No	Parameter	Value
1	Colour	Brown
2	Moisture (%)	8.45
3	pH (1:10, cocopeat : water)	5.80
4	EC (1:10, cocopeat : water, dSm ⁻¹)	0.90
5	Organic carbon (%)	48.75
6	Water holding capacity (%)	850
7	Nitrogen (%)	0.78
8	Phosphorous (%)	0.35
9	Potassium (%)	0.60
10	C : N ratio	62.50
11	Lignin (%)	66.15
12	L : N ratio	84.80
13	Cellulose (%)	17.00
14	C : L	0.73
14	Organic matter (%)	84.05
15	C. E. C. (cmol (p ⁺) kg ⁻¹)	82
16	Calcium (%)	0.45
17	Magnesium (%)	0.42
18	Iron (mg kg ⁻¹)	2640
19	Manganese (mg kg ⁻¹)	90
22	Zinc (mg kg ⁻¹)	102
21	Copper (mg kg ⁻¹)	20

Table 8. Effect of fertigation levels and gerbera varieties on number of leaves per plant

Treatment	Days after planting		
	60	90	120
A) Fertigation levels	----- Number of leaves per plant -----		
F ₁ – RDF 20 % less	15.33 (17.88)	20.11 (19.56)	22.44 (12.54)
F ₂ – RDF	18.67 (Check)	25.00 (Check)	25.66 (Check)
F ₃ – RDF 10 % more	21.78 (16.65)	26.78 (7.12)	27.44 (6.93)
F ₄ – RDF 20 % more	23.00 (23.19)	27.22 (8.88)	29.11 (13.44)
S. E. ±	0.29	0.38	0.49
C. D. at 5%	0.86	1.10	1.45
B) Varieties	-		
V ₁ - Kozac	22.17	31.67	30.08
V ₂ - Eclips	19.42	23.00	26.08
V ₃ - Ruby red	17.50	19.67	22.33
S. E. ±	0.25	0.32	0.43
C. D. at 5%	0.74	0.95	1.25
C) Interactions (AXB)			
S. E. ±	0.51	0.65	0.86
C. D. at 5%	NS	NS	NS

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

cocopeat has been characterized by Dong *et al.* (1999), Devi *et al.* (2001) and Baretto and Jagtap (2002) and reported similar observations as stated above. The suitability of cocopeat for gerbera cultivation has been reported by Singh and Sidhu (2002). Rajhans (2003) has reported that cocopeat is utilized as a growing media for commercial cultivation of gerbera under polyhouse condition. It serves as a permeable media which removes the excessive salts through drainage and equally has high nutrient storage capacity. In view of above data on characterization of cocopeat, it can be inferred that the cocopeat has been found to be suitable media for cultivation of gerbera under controlled condition.

4.2 Effect of fertigation levels and varieties on growth parameters of gerbera

The effect of fertigation levels on number of leaves, spread of gerbera and dry matter production was studied using different varieties of gerbera. The data in respect to above has been given from Tables 8 to 10.

4.2.1 Number of leaves of gerbera

The data on number of leaves as influenced by fertigation levels on different varieties of gerbera were recorded at 60, 90 and 120 days after transplanting and presented in Table 8.

It is observed from the data that with increase in the fertigation level there was significant increase in the number of leaves irrespective of varieties at 60, 90 and 120 days. With increase in the fertigation level by 10 per cent to the prevailing recommended dose, there was significant increase in number of leaves of gerbera (Table 8). The number of leaves were decreased with decrease in fertigation level from prevailing dose of fertilizer (F_2) to 20 per cent less than prevailing dose of fertilizer (F_1). This might be due to stunted growth of the plants that resulted in lower number of leaves (Table 8). Further, there is linear increase in number of leaves with increase in fertigation levels from F_2 to F_4 indicating that the yield contributing character such as number of leaves could be increased even by 20 per cent more than the prevailing recommended fertigation level. This might be because of

optimum supply of major as well as micronutrients through readily water soluble fertilizers.

It is revealed from the data presented in Table-8 that Kozac variety has recorded maximum number of leaves per plant at 60, 90 and 120 days. It was followed by Eclips and Ruby red respectively. Similar observations were recorded by Anonymous (2003) and Anonymous (2002).

Further, the interaction effect of fertigation levels with gerbera varieties on number of leaves were found to be non significant at all growth stages of gerbera indicating inherent varietal characteristics of gerbera (Table 8).

4.2.2 Plant spread

The data on effect of fertigation levels and gerbera varieties on plant spread are presented in Table 9. There was significant increase in spread of gerbera plant by increasing fertigation level by 10 per cent of the prevailing fertilizer recommended dose at all the days of observations. However, as compared with F_2 and F_1 fertigation level there was no significant difference between F_3 and F_4 fertigation level. More over there was slight decrease in spread of gerbera plant has been recorded due to addition of 20 per cent more fertilizers than prevailing dose (F_2). This has indicated that 20 per cent more fertigation level (F_4) is not beneficial in improving the growth of gerbera plant. Similarly, the decrease in fertigation level further decreased the spread of gerbera plant at all growth stages irrespective of gerbera varieties. It might be because of decreasing the number of leaves per plant (Table 9) which results in decreased spread of gerbera. This has indicated that neither lower or higher levels (20%) of fertigation level is suitable for improving performance of gerberas.

Among the varieties studied Ruby red gave maximum spread over Eclips and Kozac at all growth stages of the plant. Ruby red gave significantly more spread over other varieties (Table 9).

The interaction effects of fertigation levels and varieties on spread of gerbera plant was found to be non significant indicating the varietal characteristics are independent in giving response to fertigation levels (Table 9).

Table 9. Effect of fertigation levels and gerbera varieties on plant spread

Treatment	Days after planting		
	60	90	120
A) Fertigation levels	----- Spread (cm) -----		
F ₁ – RDF 20 % less	56.83 (3.51)	72.30 (2.09)	78.00 (2.04)
F ₂ – RDF	58.90 (Check)	73.85 (Check)	79.63 (Check)
F ₃ – RDF 10 % more	64.90 (10.18)	75.56 (2.31)	80.60 (1.21)
F ₄ – RDF 20 % more	62.33 (5.82)	75.20 (1.82)	79.60 (0.03)
S. E. ±	0.30	0.36	0.34
C. D. at 5%	0.88	1.05	1.00
B) Varieties			
V ₁ - Kozac	59.20	73.21	77.10
V ₂ - Eclips	60.42	74.30	79.60
V ₃ - Ruby red	62.60	75.17	81.45
S. E. ±	0.26	0.31	0.29
C. D. at 5%	0.76	0.91	0.87
C) Interactions (AXB)			
S. E. ±	0.52	0.62	0.59
C. D. at 5%	N S	N.S	NS

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

4. 2.3 Dry matter yield of gerbera

The data on dry matter yield has been recorded at 60, 90 and 120 days and given in Table.10. It has been found that fertigation level (F₄) has significantly increased the dry matter yield as compared to rest of the fertilizer treatments at 60, 90 and 120 days after planting. The decrease in fertigation level by 20 per cent (F₁) has significantly decreased the dry matter yield by 15.07 per cent at 60 days of planting. It is attributed to decrease in number of leaves and spread of plant which results in decrease in dry matter yield in F₁ treatment.

At 90 days after transplanting, it was observed that increase in fertigation level although significantly increased the dry matter by increasing fertilizer dose from 10 to 20 per cent, owing to increase in number of leaves per plant and plant spread. There was drastic decrease in dry matter yield by lowering the fertigation level by 20 per cent of the recommended fertigation level (Table 10). This has indicated that gerbera responds to higher level of fertilizer, similar trend was also observed at 120 days after transplanting. This has clearly indicated that gerbera responded to fertilizer application. The role of N, P and K fertilizers in influencing the growth and development of gerbera needs hardly any emphasis.

As regards gerbera varieties, Ruby red has significantly produced more dry matter over Eclips and Kozac gerberas at 60, 90 and 120 days after transplanting. This has indicated that Ruby red appeared to be more fertilizer responsive gerbera variety than Eclips and Kozac. The research work carried out elsewhere by Gutmane (1975), Hwang (1997), Khan *et al.* (1999) and Muthumanickam (1999) have also recorded similar observations. Further, it was observed that variety Eclips also produced significantly more dry matter per plant than variety Kozac at all the days of observations.

The variety with fertilizer interactions were found to be highly significant. The Ruby red has given significantly more response to fertigation levels with increase in the duration of the crop.

4.3 Effect of fertigation levels and varieties on yield of gerbera

The data on number of days required for flowering and flower yield of gerbera are presented in Table 11.

Table 10. Effect of fertigation levels and gerbera varieties on dry matter production per plant

Treatment	Days after planting		
	60	90	120
A) Fertigation levels	-----Dry matter production (g/plant)-----		
F ₁ – RDF 20 % less	17.92 (15.07)	28.37 (18.82)	35.40 (12.54)
F ₂ – RDF	21.10 (Check)	34.95 (Check)	40.48 (Check)
F ₃ – RDF 10 % more	24.46 (15.92)	37.33 (26.80)	45.40 (10.83)
F ₄ – RDF 20 % more	25.27 (19.76)	38.65 (10.58)	47.33 (16.92)
S. E. ±	0.01	0.06	0.01
C. D. at 5%	0.03	0.18	0.05
B) Varieties	-----Dry matter production (g)-----		
V ₁ - Kozac	19.59	32.78	38.97
V ₂ - Eclips	22.32	35.37	43.02
V ₃ - Ruby red	24.65	36.33	44.47
S. E. ±	0.01	0.05	0.01
C. D. at 5%	0.03	0.16	0.04
C) Interactions (AXB)			
S. E. ±	0.02	0.11	0.03
C. D. at 5%	0.06	0.32	0.09

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

4.3.1 Number of days required for flowering

It has been observed that decrease in fertigation level significantly delayed the flowering. The less number of days were required for flowering of gerbera with increase in levels of fertigation upto 10 per cent more fertilizers than rest of the treatments. There was no significant difference at F₃ and F₄ level. This might be due to optimum availability of nutrients for all physiological and metabolic activities of plant which inturn resulted in early growth and flowering.

Among the gerbera varieties, Ruby red significantly produced earlier flowering and Kozac and Eclips followed it. It attributes to genetic make up of genotype and specific gene interaction under protected environment. Kozac started flowering at 53.41 days. The interaction effects of variety with fertigation levels were found to non significant. This might be due to inherent varietal characteristics of gerbera. The research work carried out by Bose and Jana (1978) Ashwath *et al.* (1995), Dufault *et al.* (1990) and Bhattacharjee and De (2000) have recorded similar observations.

4.3.2 Flower yield

As regards, the data in respect of number of flowers produced per plant by gerbera as influenced by fertigation levels and variety is are presented Table 11. From this result it inferred that there was significant increase in yield of flowers per plant due to fertigation levels irrespective of varieties. With increase in fertigaion level from F₂ to F₃ and F₄ by 10 and 20 per cent more as compared with prevailing fertilizer dose has resulted in increased number of flowers by 23.79 and 15.59 per cent, respectively. The maximum number of flowers per plant (28.22) were recorded by addition of fertilizers @ 10 per cent higher than prevailing dose of Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune (F₂) and it was significantly superior to rest of the fertilizer levels. Significantly the lowest flower yield was recorded by F₁ treatment. It might be because of insufficient supply of essential plant nutrients to gerbera plants. The decrease in fertigation level from F₂ to F₁ results in decrease in flower yield by 19.20 per cent. This has clearly indicated that gerbera has well responded to higher levels of fertigation. The flower

Table 11. Effect of fertigation levels and varieties on number of days required for flowering and flower yield. from 60 days after planting

Treatment	No. of days required for flowering (days)	Half yearly yield (No of flowers/ plant)
A) Fertigation levels		
F ₁ – RDF 20 % less	54.00 (-3.40)	17.88 (-17.20)
F ₂ – RDF	52.22 (Check)	22.22 (Check)
F ₃ – RDF 10 % more	49.77 (+4.69)	28.22 (+23.79)
F ₄ – RDF 20 % more	50.44 (+3.40)	26.88 (+15.59)
S. E. ±	0.60	0.57
C. D. at 5%	1.76	1.66
B) Varieties		
V ₁ - Kozac	51.58	20.83
V ₂ - Eclips	53.41	24.66
V ₃ - Ruby red	49.83	25.91
S. E. ±	0.52	0.49
C. D. at 5%	1.53	1.44
C) Interactions (AXB)		
S. E. ±	1.04	0.99
C. D. at 5%	NS	NS

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

yield of crop significantly increases with increase in levels of fertigation upto 10 per cent higher fertilizer dose. There was moreover, decrease in flower yield by increasing the fertigation level from F₃ to F₄ indicating that there is scope for improvement in increasing the fertigation level upto 10 per cent only (Table 11). Thus, the prevailing fertigation level can be increased by 10 per cent in order to achieve higher flower yield per plant irrespective of gerbera varieties. Thus, from the results, it can be concluded that 10 per cent more than prevailing dose of fertigation level is optimum for higher flower production.

Amongst the gerbera varieties, it has been observed that Ruby red and Eclips have produced significantly more number of flowers per plant than Kozac indicating Ruby red and Eclips were high yielding varieties than Kozac. The finding obtained by Default *et al.* (1990), Gutmane (1975), Bose and Jena (1978) and Mouliner and Monfarone (1978) have also reported similar observations. However, the effect of varieties into fertigation levels were found to be non significant.

4.4 Effect of fertigation levels and varieties on quality parameters of gerbera

The quality parameters such as stalk length, flower diameter and vase life of flowers as influenced by fertigation levels on different gerbera varieties were studied.

4.4.1 Stalk length of gerbera

There was significant influence of different levels of fertigation and varieties on stalk length of gerbera (Table 12). It is observed from the data that the stalk length of gerbera flower has significantly influenced by fertigation levels irrespective of varieties. The increase in fertigation level by 10 per cent of the prevailing recommended dose of Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune-5 (F₃) has significantly increased the stalk length of flower by 5.51 per cent as compared to all the fertilizer levels. Further increase in fertigation level by 20 per cent of the prevailing fertilizer dose (F₄) has significantly increased the stalk length by 3.57 per cent over check but decreased the stalk length over F₃ fertigation level, indicating there

Table 12. Effect of fertigation levels and gerbera varieties on quality parameters

Treatments	Stalk length of flower (cm)	Flower Diameter (cm)	Vase life (days)
A) Fertigation levels			
F ₁ – RDF 20 % less	54.96 (3.12)	9.01 (7.39)	9.22 (7.8)
F ₂ – RDF	56.73 (Check)	9.73 (Check)	10.00 (Check)
F ₃ – RDF 10 % more	59.86 (5.51)	10.30 (5.85)	10.44 (4.4)
F ₄ – RDF 20 % more	58.76 (3.57)	10.00 (2.77)	9.88 (1.2)
S. E. ±	0.13	0.08	0.26
C. D. at 5%	0.38	0.24	0.76
B) Varieties			
V ₁ - Kozac	52.95	11.22	11.25
V ₂ - Eclips	57.85	8.80	10.08
V ₃ - Ruby red	61.95	9.25	8.33
S. E. ±	0.11	0.07	0.22
C. D. at 5%	0.32	0.21	0.65
C) Interactions (AXB)			
S. E. ±	0.22	0.14	0.45
C. D. at 5%	0.65	NS	NS

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

is limited scope for increasing the fertigation level. This has resulted more in vegetative growth rather than influencing reproductive phase.

Amongst the varieties, Ruby red has produced significantly more stalk length of flower (61.95 cm) than Eclips (57.85 cm) followed by Kozac (52.95 cm). This might be due to inherent varietal characteristics of Ruby red. The research work carried out by Montrova *et al.* (1982), Randhava and Mukhopadhyay (1986), Bhattacharjee and De (2000) and Ambad *et al.* (2002) have reported similar findings. The fertigation levels and varietal interaction showed significant difference with respect to stalk length, indicating fertilizer has synergistic effect in developing stalk length of gerbera varieties.

4.4.2 Flower diameter of gerbera

The data on effect of fertigation levels and varieties on flower diameter has been reported in Table 12.

It was observed that there was significant difference in flower diameter as influenced by fertigaion levels irrespective of varieties. The fertigation level F_3 has given maximum diameter of flower (10.30 cm) and found to increase by 5.85 per cent over the prevailing fertilizer dose (F_2). Although significantly increased the flower diameter of (10 cm) by the supply of nutrients 20 per cent more to prevailing dose (F_4) over F_2 level but decreased flower diameter against F_3 level. The decrease in fertigation over level (F_1) by 20 per cent of F_2 significantly decreased the flower diameter of (9.01 cm) i.e. by 7.39 per cent as against F_2 level. Thus, fertigation levels played an important role in influencing the flower diameter of gerbera varieties. This might be due to adequate supply of major and micronutrients required for normal growth and development of gerbera.

Amongst the gerbera varieties, Kozac has produced significantly more (11.22 cm) flower diameter followed by Ruby red (9.25 cm) and Eclips (8.80 cm). This is in conformity with result obtained by Anonymous (2000), Anonymous (2002) and Anonymous (1999)

The interaction effects of fertigation levels with varieties however found to be non significant. This might be due to inherent varietal characteristics responding to fertilizer application.

4.4.3 Vase life of gerbera

Application of fertilizers and varieties had significant influence on vase life of gerbera (Table 12). With increase in fertigation level from F₂ to F₃ by 10 per cent, the shelf life of the flower extended from 10 to 10.44 days, it was found to be non significant. The fertigation level (F₁) reduced by 20 per cent of F₂, significantly reduced the vase life of gerbera varieties indicating that fertilizers applied at F₂ and F₃ levels were found to be optimum in extending the shelf life of gerbera varieties.

Application of fertigation at F₄ level has decreased the shelf life of gerbera varieties indicating neither lower level nor higher levels by 20 per cent of fertilizer application found to be suitable in sustaining vase life of gerbera varieties.

Among the gerbera varieties, Kozac had significantly better shelf life followed by Eclips and Ruby red. The vase life varied from 8.33 to 11.25 days. The Kozac variety of gerbera was significantly superior over both the varieties of gerbera.

The interaction effects of fertigation levels with gerbera varieties were found to be non significant indicating that the difference are mainly due to inherent characteristics of cultivars. The results are in conformity with the observations recorded by Mouliner and Monferone (1978), Bradis (1979), Abdel- and Roger (1986) and Ambad *et al.* (2001)

4.5 Effect of fertigation levels and varieties on concentration of N, P, K and micronutrients

The gerbera varieties viz., Kozac, Eclips and Ruby red were planted on cocopeat and were fertilized with four fertigation levels. The plant samples at 60, 90 and 120 days after plantation were harvested and analysed for nutrient contents. The data with respect to concentration of N, P and K nutrients of gerbera are presented in Table 13. It was observed that fertigation levels has significantly increased the concentration of nitrogen, phosphorus and potassium at all growth stages of gerbera irrespective of varieties.

Table 13. Effect fertigation levels and gerbera varieties on concentration of major nutrients (%)

Treatment	Days after planting			
	60	90	120	120
A) Fertigation levels				
F ₁ – RDF 20 % less	3.18	2.96	2.55	2.94
F ₂ – RDF	3.26	3.07	2.72	3.12
F ₃ – RDF 10 % more	3.35	3.16	2.91	3.24
F ₄ – RDF 20 % more	3.40	3.25	3.28	3.32
S. E. ±	0.009	0.012	0.010	0.011
C. D. at 5%	0.028	0.036	0.030	0.033
B) Varieties				
V ₁ - Kozac	3.15	2.97	2.82	3.07
V ₂ - Eclips	3.36	3.17	2.78	3.08
V ₃ - Ruby red	3.37	3.18	2.99	3.33
S. E. ±	0.008	0.010	0.009	0.009
C. D. at 5%	0.024	0.030	0.027	0.027
C) Interactions (AXB)				
S. E. ±	0.016	0.021	0.018	0.019
C. D. at 5%	0.048	0.063	0.055	0.057
Days after planting				
N				
	60	90	120	120
	0.51	0.47	0.43	2.92
	0.54	0.51	0.48	2.98
	0.58	0.53	0.49	3.06
	0.60	0.55	0.53	3.16
	0.007	0.007	0.012	0.008
	0.021	0.021	0.037	0.024
P				
	0.51	0.51	0.49	2.96
	0.55	0.51	0.48	2.99
	0.54	0.52	0.48	3.14
	0.006	0.006	0.011	0.007
	0.018	NS	NS	0.021
K				
	0.013	0.013	0.022	0.014
	NS	NS	NS	0.041
	NS	NS	NS	NS

4.5.1. Nitrogen

It has been observed that with increase in fertigation levels there was increase in concentration of nitrogen in leaves. The nitrogen content in leaves ranged from 3.18 to 3.40 per cent at 60 days after plantation. There was linear increase in the nitrogen concentration with increase in fertigation level. The decrease in fertigation level (F_1) has significantly decreased the nitrogen concentration in gerbera plants indicating gerbera are highly responsive to graded levels of nitrogen. On an average, 0.1 per cent more N in the leaves of gerbera was found in F_3 treatment as compared to F_2 treatment.

The nitrogen although significantly increased with fertigation levels, the N content decreased with increased duration of the crop. The decrease in leaf N with increase duration may be attributed to higher number of leaves and dry matter weight per plant i.e. dilution effect. The nitrogen content has decreased from 3.18 to 2.55 at F_1 level whereas it has decreased from 3.26 to 2.72, 3.35 to 2.91 and 3.40 to 3.28 at F_2 , F_3 and F_4 fertigation levels, respectively. This has indicated that with increase in duration of the crop the photosynthesis have been transported to the economic production of gerbera flower.

Amongst the different varieties, it has been observed that the Ruby red contains more nitrogen than Eclips and Kozac at all growth stages of plant. The interaction effect of fertigation level with varieties were found to be significant indicating varieties are highly responsive to fertilizer application

4.5.2. Phosphorus

The data on Table 13 showd that phosphrus concentration varies from 0.51 to 0.60, 0.47 to 0.55 and 0.43 to 0.53 per cent at 60, 90 and 120 days after planting F_1 and F_4 level, respectively (Table 13). With increase in fertigation level there was significant increase in concentration of phosphrus. The phosphrus concentration was however, decreased from 0.51 to 0.43, 0.54 to 0.48, 0.58 to 0.49 and 0.60 to 0.53 at F_1 , F_2 , F_3 and F_4 levels, respectively over a period of 60 to 120 days after plantation of gerbera indicating phosphrus was also transported for the production of flowers.

Amongst the varieties, Kozac leaves contained more phosphorus followed by Eclips and Ruby red. The phosphrus content was decreased as crop duration increased irrespective of varieties. However, the decrease in

phosphorus content at 90 and 120 days after plantation due to varietal effect was found to be non significant. The interaction effects of phosphorus levels with varieties were found to be non significant at all growth stages of gerbera.

4.5.3 Potassium

The influence of potassium fertilizers on potassium content has been given in Table. 13. It was observed that with increase in potassium level there was corresponding significant increase in the potassium concentration of gerbera leaves irrespective of the varieties. The potassium content varied from 2.94 to 3.32 per cent at F_1 and F_4 levels, respectively at 60 days after planting. The potassium content of the plant at given level of fertigation decreased the potassium content from 60 to 120 days after plantation at all levels of fertilizer application. This has indicated that the potassium was also transported for flower production. The significantly lowest values of the potassium had observed in gerbera leaves under F_1 treatment at 60, 90 and 120 days after planting.

As regards varieties Ruby red and Kozac, the potassium content varied from 3.33 to 3.07 per cent at 60 days after plantation. The potassium content, however, increased from 3.07 to 3.15 per cent by having sink at 90 days after plantation in case of Kozac. Similarly, the potassium content was increased from 3.08 to 3.10 per cent having sink of 60 days (2.99 per cent) but there was decrease in potassium concentration from 3.33 to 3.09 per cent in case of Ruby red. The potassium content although showed significant variation amongst varieties at 60 and 90 days. The difference was found to be non significant at 120 days, suggesting that potassium transported for flower development.

The interaction of effect of varieties with fertigation levels were found to be significant at early growth stage i.e. at 60 & 90 days but non significant at 120 days.

Thus, it could be generalized that with increase in fertigation level there was corresponding significant increase in the N, P, K content and uptake by gerbera irrespective of varieties. The phosphorus concentration however decreased with duration of crop growth period. Amongst the varieties Ruby red responded more to nitrogen and potassium rather than phosphorus

application over Kozac and Eclips. Similar observations were recorded by Default *et al.* (1990) and Kale (2002).

4.5.4 Micronutrients

Similar to N, P and K concentration of gerbera, the plants were also analysed for micronutrient concentrations and the data obtained are presented in Table 14. It was observed that the micronutrients *viz.*, Fe, Mn, Zn and Cu were significantly increased with increase in the fertigation levels. Further, it was observed that the concentration of Fe, Mn and Zn decreased with increase in the crop duration from 60 to 120 days at a given fertigation level however, the concentration of copper increased in the plant with increase in crop duration from 60 to 120 days after planting.

Amongst the varieties, the concentration of Fe and Mn were not influenced significantly at all growth stages of gerbera. Although the effects of varieties on Mn content in the leaves were tend to be non significant at 60, 90 and 120 days after planting. Mn of Kozac was significantly increased as compared to Eclips and Ruby red varieties of gerbera. More or less exactly similar values of Mn concentration were observed in Eclips and Ruby red.

As regards Zn, Ruby red showed positive response followed by Kozac and Eclips at 60 and 90 days. The difference between Kozac and Eclips was however found to be non significant at all growth stages.

The Cu content of Ruby red and Kozac was significantly more than Eclips at 90 and 120 days.

The interaction effect of fertigation levels with varieties found to be non significant at 90 and 120 days Fe, Mn, Zn and Cu concentration. The interaction effects were found to be significant for Fe concentration at 60 days after planting only.

Thus, it could be generalized that fertigation levels have direct role in supplying micronutrients to the gerbera. The varieties however differ in their absorption and utilization of micronutrients. The results on concentration of major and micronutrients indicated that significantly lower N, P, K, Fe, Mn, Zn and Cu concentrations were found in leaves in treatment receiving 20 per cent less fertigation to prevailing dose of fertilizer as adopted by Hi- tech Floriculture and Vegetable Project, College of Agriculture, Pune. This might

be due to reduction in dose of fertilizers or insufficient supply of all the nutrients to gerbera plant. This study indicates that, 10 per cent higher dose of fertigation level is essential for better gerbera crop growth as well as flower production. The results obtained by Gutmane and Griving (1975), Dufault *et al.* (1990), Kale (2002) and Hwang and Yoon (1994) are in conformity with the results obtained above.

4.6. Effect of fertigation levels and varieties on uptake of nutrients

The influence of fertigation levels on the uptake of nitrogen at 60, 90 and 120 days by Kozac, Eclips and Ruby red varieties have been studied, along with their interactions.

4.6.1 Nitrogen uptake

Nitrogen uptake by gerbera leaves was influenced significantly by levels of fertigation and varieties (Table 15). The uptake of nitrogen ranged from 0.57 to 0.86, 0.84 to 1.25 and 0.90 to 1.56 g plant⁻¹ at 60, 90 and 120 days after plantation of gerbera at F₁, F₂, F₃ and F₄ levels, respectively. It is revealed that there was significant increase in the uptake of nitrogen with increase in fertigation levels, at all the days after planting indicating that either F₃ or F₄ treatment was significant (Table 15). The higher uptake of N at latter stages could be due to more dry matter yield by the fertilizer application. The N uptake was tends to be maximum (1.56 g /plant) at F₄ level of fertilizer application at 120 days after planting. Further, it was observed that with increase in crop duration there was concomitant increase in nitrogen uptake at a given fertility level. This has clearly indicated that nitrogen plays an important role in influencing the growth and development of gerbera irrespective of varieties.

Amongst the varieties, Ruby red produced significantly more nitrogen uptake than Eclips followed by Kozac at all growth stages of the plant. The interaction effects were found to be significant indicating all the varieties were responded to fertilizer application. The results obtained are in conformity with the data reported by Dufault *et al.* (1990) and Muthumanickam (1999)

Table 15. Effect of fertigation levels and gerbera varieties on uptake of nitrogen (g plant^{-1})

Treatment	Days after planting		
	60	90	120
A) Fertigation levels	----- Nitrogen (g plant^{-1})-----		
F ₁ – RDF 20 % less	0.57 (17.39)	0.84 (21.49)	0.90 (17.43)
F ₂ – RDF	0.69 (Check)	1.07 (Check)	1.09 (Check)
F ₃ – RDF 10 % more	0.82 (18.84)	1.17 (9.34)	1.32 (21.10)
F ₄ – RDF 20 % more	0.86 (24.63)	1.25 (16.82)	1.56 (43.11)
S. E. \pm	0.002	0.004	0.004
C. D. at 5%	0.006	0.012	0.012
B) Varieties	----- Nitrogen (g plant^{-1})-----		
V ₁ - Kozac	0.62	0.97	1.10
V ₂ - Eclips	0.75	1.12	1.20
V ₃ - Ruby red	0.83	1.16	1.35
S. E. \pm	0.001	0.003	0.004
C. D. at 5%	0.005	0.010	0.012
C) Interactions (AXB)			
S. E. \pm	0.003	0.007	0.008
C. D. at 5%	0.010	0.022	0.024

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

4.6.2 Phosphorus uptake

The data regarding phosphorus uptake as influenced by fertigation levels and varieties of gerbera at various stages of plant growth are presented in Table 16. Data showed that application of fertilizers significantly increased the phosphorus content of the plant. Under various levels of fertigation, the range of phosphorus uptake was from 0.09 to 0.15, 0.13 to 0.21 and 0.15 to 0.25 per cent at 60, 90 and 120 days, respectively. The uptake of phosphorus was maximum (0.25g /plant) under F₄ treatment at 120 days after planting and minimum (0.09 g/ plant) under F₁ treatment at 60 days after planting. The phosphorus uptake was increased with increasing levels of fertigation (Table 16).

Among the varieties, there was also significant difference in phosphorus uptake of gerbera at all growth stages. The Ruby red has given more response to phosphorus application followed by Eclips and Kozac at 60, 90 and 120 days after planting. The uptake of phosphorus varies from 0.11 to 0.13, 0.16 to 0.18 and 0.19 to 0.21 per cent increase of Kozac and Ruby red respectively, at all growth stages of gerbera plant.

The interaction effects of fertilizer with variety of gerbera were also found to be significant at 60 and 90 days however there was no significant difference at later stage of plant growth, indicating phosphorus was very much essential for the root and canopy development in early stage of crop growth. The findings are in conformity with the results obtained by Gutmane and Griving (1975), Dufalult et al. (1990) , Muthumanikiam (1999) and Farrente *et al.* (2000)

4.6.3 Potassium uptake

The effects of fertigation level and varieties on uptake of potassium were studied at various growth stages of gerbera plant and the data obtained are presented in Table 17.

It was observed that application of potassium through fertigation levels has significantly increased potassium uptake by gerbera irrespective of varieties. The potassium uptake increased from 0.52 to 1.04, 0.67 to 1.26, 0.79 to 1.35 and 0.84 to 1.55 g/plant at F₁, F₂, F₃ and F₄ fertigation levels at 60 and 120 days after planting, respectively. Further, it has been observed

Table 16. Effect of fertigation levels and gerbera varieties on uptake of phosphorus (g plant⁻¹)

Treatment	Days after planting		
	60	90	120
A) Fertigation levels	----- Phosphorus (g plant ⁻¹) -----		
F ₁ – RDF 20 % less	0.09 (18.18)	0.13 (27.77)	0.15 (21.05)
F ₂ – RDF	0.11 (Check)	0.18 (Check)	0.19 (Check)
F ₃ – RDF 10 % more	0.14 (27.27)	0.19 (5.55)	0.22 (15.78)
F ₄ – RDF 20 % more	0.15 (36.36)	0.21 (16.66)	0.25 (15.78)
S. E. ±	0.001	0.002	0.006
C. D. at 5%	0.005	0.007	0.019
B) Varieties	----- Phosphorus (g plant ⁻¹) -----		
V ₁ - Kozac	0.11	0.16	0.19
V ₂ - Eclips	0.12	0.18	0.20
V ₃ - Ruby red	0.13	0.18	0.21
S. E. ±	0.001	0.002	0.005
C. D. at 5%	0.004	0.006	0.017
C) Interactions (AXB)			
S. E. ±	0.003	0.004	0.011
C. D. at 5%	0.008	0.013	NS

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

Table 17. Effect of fertigation levels and gerbera varieties on uptake of potassium (g plant⁻¹)

Treatment	Days after planting		
	60	90	120
A) Fertigation levels	----- Potassium (g/ plant) -----		
F ₁ – RDF 20 % less	0.52 (22.38)	0.83 (20.19)	1.04 (17.46)
F ₂ – RDF	0.67 (Check)	1.04 (Check)	1.26 (Check)
F ₃ – RDF 10 % more	0.79 (17.91)	1.14 (6.61)	1.35 (7.14)
F ₄ – RDF 20 % more	0.84 (25.37)	1.22 (17.30)	1.55 (20.01)
S. E. ±	0.009	0.002	0.026
C. D. at 5%	0.027	0.006	0.078
B) Varieties			
V ₁ - Kozac	0.60	0.97	1.23
V ₂ - Eclips	0.70	1.06	1.33
V ₃ - Ruby red	0.82	1.14	1.34
S. E. ±	0.008	0.002	0.023
C. D. at 5%	0.024	0.006	0.067
C) Interactions (AXB)			
S. E. ±	0.016	0.004	0.046
C. D. at 5%	0.047	0.013	0.134

* Figures indicated in paranthesis are in per cent decrease or increase over check (F₂)

that the potassium uptake not only increased with fertigation level but also increased with duration of the crop growth.

With increase in fertigation level by 10 and 20 per cent there was increase in potassium uptake by 17.91 and 25.37 per cent at 60 days after planting. Further, with decrease in potassium by 20 per cent it has resulted in decrease in potassium uptake by 22.38 per cent (Table 17). Similar trend was observed at later stage of crop growth. This has indicated that potassium plays an important role in growth and development of gerbera plant at all growth stages.

Amongst the varieties, there was significant difference in the uptake of potassium. The potassium uptake varied from 0.60 to 0.82, 0.97 to 1.14 and 1.23 to 1.34 g/plant at 60, 90 and 120 days by Kozac and Ruby red varieties of gerbera. Thus, Ruby red was highly responsive to potassium application followed by Eclips and Kozac. The interaction effects at given fertigation level with varieties of gerbera found to be significant indicating all the varieties of gerbera are highly responsive to application of potassium. The above findings are in agreement with the reports of Default et al. (1990) and Muthumanickam (1999). They have reported that potassium is very much essential for enhancing the growth of gerbera varieties which influences the number of leaves, spread of leaves, stalk length and flower diameter of gerbera. The role of potassium was very much pronounced along with nitrogen application. The application of nitrogen and potassium together has given synergistic effect on the performance of gerbera.

4.6.4 Micronutrient uptake

In greenhouse, the studies on fertigation levels including micronutrients were conducted using three varieties of gerbera. The data on micronutrients viz., Fe, Mn, Zn and Cu content at 60, 90 and 120 days after plantation were recorded and presented in Table-18. It was observed that there was significant increase in the uptake of Fe, Mn, Zn and Cu with increased fertigation levels from F₁ to F₄. The uptake of micronutrients further enhanced with the age of the crop irrespective of gerbera varieties. The Fe uptake increased from 5.91 to 8.70, 9.22 to 13.10 and 10.97 to 15.48 mg/plant at 60, 90 and 120 days at F₁ and F₄ fertility levels, respectively. There was

significant difference in the uptake of micronutrients studied at all fertility levels. The Mn concentration was increased from 3.94 to 5.84, 6.10 to 8.61 and 7.26 to 10.31 mg/plant at 60, 90 and 120 days, respectively due to F₁ and F₄ fertigation levels, respectively.

Similar to Fe and Mn uptake of Zn was also influenced by fertigation levels. The uptake of Zn was increased from 2.0 to 2.11, 3.12 to 4.52 and 3.36 to 4.97 mg/plant at at 60, 90 and 120 days, respectively due to F₁ and F₄ fertigation levels, respectively.

The Cu uptake by gerbera plant was also influenced significantly by fertigation levels, respectively. The uptake of Cu increased from 0.20 to 0.40, 0.43 to 0.71 and 0.67 to 1.05 mg/ plant at 60, 90 and 120 days, respectively due to F₁ and F₄ fertigation levels respectively. Thus, it could be generalized that application of graded levels from F₁ and F₄, there was linear response of gerbera varieties as indicated by uptake of all metal micronutrients.

Amongst the varieties, Ruby red contented significantly more uptake of Fe, Mn, Zn and Cu than Eclips followed by Kozac variety of gerbera. It was further observed that irrespective of fertigation levels, there was continuous more uptake of all the micronutrients with increase in the duration of the crop growth.

The interaction effects of fertigation level with varieties have also shown significant increase in the uptake of Fe and Cu at 60, 90 and 120 days growth stages while uptake of Mn and Zn was not influenced significantly at later stage of crop growth.

Thus, it could be generalized that application of graded levels of fertilizers to all the gerbera varieties found to be beneficial in improving the crop performance by more uptake of micronutrients. Similar findings were also recorded by Gartner (1969), Hethcote (1972), Kotch and Mengel (1977) Ferrante *et al.* (2000).

These micronutrients play an important role in the plant metabolic activities for healthy and vigorous growth of the plant.

4.7 Effect of fertigation levels on salt concentration and reaction of the leachate

The fertigation method utilized for fertilizing gerbera plants consist of A and B tanks containing N, P, K and micronutrients. The details are outlined in chapter 3. Five hundred ml fertilizer solution was given to each plant every day having F_1 , F_2 , F_3 and F_4 levels having pH around 5.5 to 6.0 and EC less than 1.6 dS m^{-1} . In order to maintain pH and salt concentration of media within limits it has been adovated that leaching/ drainage need to be provided. Accordingly, the leachates were collected at 60, 90 and 120 days in order to know the extent of change in leachate reaction (pH) and salt concentration (EC). The data obtained on pH and EC of the leachates as influenced by fertigation levels and varieties have been recorded and presented in Table 19.

4.7.1 Leachates reaction (pH)

It is revealed from the data that with increase in the fertigation levels, there was reduction in the pH of the drainage solution. The pH was declined from 6.71 to 5.81 at 60 days after plantation.

Similarly, the leachates was also analysed after 90 days of plantation. It was observed that pH was further declined from 6.53 to 5.78 with increased fertigation levels. The pH at 120 days after planting was also recorded. It was observed that the pH of 6.43 declined to 5.64. Fertilizer solution being given to the plant was acidic in nature therefore, the pH of the growth media has declined considerably because of acidic salt content in it.

Amongst the varieties, the leachate analysed for reaction indicated that there was no much variation in the pH of the leachate indicating the pH of the leachate was mainly conditioned by the growth medium.

The interaction effects were found to be non significant.

4.7.2 Electrical conductivity (EC)

The data on the influence of fertigation levels and the varieties on salt concentration of the leachate were also recorded and presented in Table 19. It was observed that the salt concentration has increased with increase in the fertigation level irrespective of varieties. However, at 60 days after planting,

the salt concentration of the leachate was less than the added fertilizer solution.

At 90 days after planting, the leachate was also analysed for salt concentration. The data presented in Table 19. revealed that the salt concentration of leachate has increased considerably. There was increase in the salt concentration with increase in fertigation level irrespective of varieties. Similarly, the leachate was also analysed at 120 days after planting. The salt concentration of the leachate further increased with increase in the duration of crop. The salt concentration has increased from 0.97 to 1.96, 1.27 to 2.68, 1.29 to 2.74 and 1.41 to 3.05 dS m^{-1} at F_1 to F_4 level at 60 and 120 days after planting, respectively. This was clearly indicated the built up of salt concentration in the growth media which resulted in more loss of salts along with nutrients through leachates. Chauhan *et al.* (2002) has reported that EC of the feed solution should be 1.1 to 2.0 mS cm^{-1} and that of drain it should be 1.3 to 2.3 mS cm^{-1} . The above findings are in agreement with the reports of Komasa and Gapys (1998), Labeke *et al.* (1998) and Savvas *et al.* (2001).

Table 19. Effect of fertigation levels and gerbera varieties on leachate characteristics pH and EC (dSm^{-1})

Treatments	Days after planting						
	60		90		120		
	pH		pH		EC (dS m^{-1})		
A) Fertigation levels							
F ₁ – RDF 20 % less	6.71	6.53	6.43	6.43	0.97	1.54	1.96
F ₂ – RDF	6.46	6.18	6.17	6.17	1.27	1.86	2.68
F ₃ – RDF 10 % more	6.22	5.81	6.03	6.03	1.29	1.95	2.74
F ₄ – RDF 20 % more	5.81	5.78	5.64	5.64	1.41	2.27	3.05
S. E. \pm	0.01	0.07	0.012	0.012	0.008	0.009	0.05
C. D. at 5%	0.30	0.20	0.35	0.35	0.02	0.03	0.15
B) Varieties							
V ₁ - Kozac	6.33	6.22	6.12	6.12	1.20	1.71	2.51
V ₂ - Eclips	6.29	6.07	6.07	6.07	1.24	1.84	2.60
V ₃ - Ruby red	6.26	5.96	5.86	5.86	1.27	2.08	2.64
S. E. \pm	0.09	0.06	0.09	0.09	0.07	0.008	0.04
C. D. at 5%	0.27	0.18	0.27	0.27	0.21	0.02	0.12
C) Interactions (AXB)							
S. E. \pm	0.020	0.015	0.025	0.025	0.015	0.019	0.10
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS

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**SUMMARY AND
CONCLUSION**

5. SUMMARY AND CONCLUSION

Gerbera (*Gerbera jamesonii*) is an important commercial cut flower grown throughout the world in wide range of climatic conditions having varied physiological adaptability.

The present investigation was undertaken on the effect of levels of fertigation on growth and yield of gerbera under polyhouse condition at Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune-5. The experiment was conducted using Factorial Complete Randomized Block Design with three replications consisting of four fertigation levels including prevailing dose of fertilizer followed in Hi-tech floriculture and Vegetable Project and three varieties of gerbera (V_1 - Kozac, V_2 - Eclips, V_3 -Ruby red) were used as a test crop. The four litre capacity pots used for filling the cocopeat (1.5kg) as a growth media. Four fertigation levels (F_1 to F_4) were used in the present experiment the types and the quantities of the fertilizers used for fertigation have been outlined.

The present investigation was carried out during 2002-2003 with a view, to characterize the growing media (cocopeat) of gerbera to find out optimum dose of fertilizers for higher yield of different varieties of export quality gerbera, to study the concentration and uptake of nutrients by gerbera, to assess the leachate for salt concentration (EC) and reaction (pH) and to study the keeping quality of gerberas as influenced by fertigation levels. The results obtained are summarized below.

5.1 Characterisation of cocopeat

The cocopeat is a unique waste material of coconut industry has low electrical conductivity (0.9 dS m^{-1}) and pH (5.8) i.e. acidic in reaction. It has very high water holding capacity (850 %) and wider C: N ratio (62.5 : 1). It has also high lignin content (66.15 %) and limited amounts of essential nutrients. Cocopeat was a rich source of iron. However, it had limited amount of copper.

5.2 Growth parameters

It was observed that with increase in fertigation levels there was significant increase in number of leaves per plant irrespective of varieties and further increased with increase in the duration of the crop from 60 to 120 days. Amongst the varieties, Kozac has given maximum number of leaves at all growth stages which was followed by Eclips and Ruby red. Ruby red has less number of leaves per plant. The interaction effects of fertigation levels with varieties were found to be significant.

As regards spread of gerbera plants with increase in fertigation level from F_2 to F_3 (by 10%) there was increase in canopy growth of gerbera plants irrespective of varieties and it has decreased either by decreasing the fertilizer dose (less than 20%) or increasing fertilizer dose (by 20%).

The biomass production of gerbera was significantly influenced by fertigation levels. With increase in fertigation levels (F_1 to F_4) the biomass production has increased from 15.07 to 19.76 per cent at 60 days after plantation. The biomass produced has increased in the crop duration irrespective of varieties. Amongst the varieties Ruby red has produced more biomass followed by Eclips and Kozac.

5.3 Number of days required for flowering and yield

Increase in fertigation level hastens the flower initiation and Ruby red produced earlier flower at 49.83 days followed by Kozac (51.58 days) and Eclips (53.41 days). The flower yield of gerbera was influenced significantly by fertigation levels. The increase in fertigation level from F_2 to F_3 the flower yield increased by (23.79 per cent). The fertigation level (F_1) either decreased by 20 per cent or increased by 20 per cent (F_4) over prevailing recommended fertilizer dose (F_2) has resulted in decrease in flower yield by 17.20 and 15.59 per cent respectively. Amongst the varieties, Ruby red has given significantly more flower yield per plant (25.91) followed by Eclips (24.66) and Kozac (21.83). The interaction effects of fertigation with varieties of gerbera were however found to be non significant.

5.4 Quality parameters

It was observed that the stalk length of flower of gerbera increased by increasing the fertigation level upto 10 per cent of the prevailing fertilizer

dose. The stalk length, however, decreased by either reducing or increasing fertigation level by 20 per cent of prevailing dose as compared with check.

Amongst the varieties, Ruby red has recorded maximum stalk length (61.95 cm) of flower followed by Eclips (57.85 cm) and Kozac (52.95 cm).

As regards flower diameter, similar observations were recorded with respect to fertigation levels. However, Kozac has maximum flower diameter (11.22 cm) followed by Ruby red (9.25 cm) and Eclips (8.80 cm).

Fertilizers applied at F₂ and F₃ level has shown maximum vase life (10.0 to 10.44 days). The vase life of flower, however, decreased either by decreasing or increasing fertigation level by 20 per cent of the prevailing dose of Hi-tech Floriculture and Vegetable Project. Kozac was found to have better vase life than Eclips followed by Ruby red.

5.5 Concentration of nutrients

Concentrations of nitrogen, phosphorus, potassium and micronutrients by gerbera plants were studied at 60, 90 and 120 days. It was observed from the data on concentration of nutrients viz., nitrogen, phosphorus, potassium content of the plant significantly increased with increase in fertigation levels irrespective of varieties. Similarly, the micronutrients concentration viz., iron, manganese, zinc and copper were also significantly increased with increasing fertigation level from F₁ to F₄ irrespective of gerbera varieties. The nitrogen, phosphorus, potassium and micronutrients concentration of the plant were however, decreased with increase in duration of crop from 60 to 120 days at given fertility level. Ruby red contains higher amount of nitrogen and potassium over Eclips and Kozac however, Kozac, contained more phosphorus than Eclips and Ruby red varieties of gerbera. Similarly, micronutrient contained of Kozac with respect to iron and manganese was higher than Eclips and Ruby red, but Ruby red contains more zinc and copper than Eclips. The interaction effects were found to be non significant with manganese at all growth stages of the gerbera.

5.6 Uptake of nutrients

The uptake of nitrogen, phosphorus, potassium and micronutrients was significantly increased with the duration of the crop at all fertigation levels.

Amongst the varieties, Ruby red recorded more uptake of nitrogen, phosphorus, potassium and micronutrients at all growth stages of gerbera over Eclips and Kozac. The interaction effects were also found to be significant at 60 and 90 days of plant growth suggesting that Ruby red variety of gerbera is more responsive to higher fertigation levels.

From the above results, it could be concluded that fertilizer application @ 10 per cent more dose of fertilizer to prevailing dose of Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune-5 proved to be the best dose of fertilizer in improving the flower yield and flower quality parameters of gerbera. Amongst the varieties Ruby red was found to be superior in producing higher yield as well as good quality of flowers as compared with Eclips and Kozac. Eclips recorded slightly higher yield plant⁻¹, stalk length, vase life, uptake of major and minor nutrients over Kozac indicating that Eclips is the best variety of gerbera next to Ruby red.

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* Originals not seen

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VITA

7. VITA

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of

MASTER OF SCIENCE (AGRICULTURE)

2003

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