STUDIES ON CUT FLOWER PRODUCTION AND VASE LIFE IN CHRYSANTHEMUM (*Chrysanthemum morifolium*)

By

RAKESH

Dissertation submitted to the Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfilment of the requirement for the degree of :

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IN

HORTICULTURE

COLLEGE OF AGRICULTURE
CHAUDHARY CHARAN SINGH
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HISAR

2002

DEDICATED

TO

MY REVERED PARENTS

CERTIFICATE-I

This is to certify that this dissertation entitled, "**Studies on cut flower production and vase life in chrysanthemum *(Chrysanthemum morifolium)***," submitted for the degree of **Doctor of Philosophy** in the subject of **Horticulture** of Chaudhary Charan Singh Haryana Agricultural University, Hisar is a bonafide research work carried out by **Mr. Rakesh** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of these investigations have been fully acknowledged.

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CERTIFICATE-II

This is to certify that this dissertation entitled, "**Studies on cut flower production and vase life in chrysanthemum *(Chrysanthemum morifolium)*,**" submitted by **Mr. Rakesh** to the Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfilment of the requirements for the degree of **Doctor of Philosophy** in the subject of **Horticulture** has been approved by the student's Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

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Rakesh

Hisar **[RAKESH]**

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LIST OF ABBREVIATIONS

@	at the rate of
C.D.	Critical difference
cm	centimeter
cv. (s)	cultivar (s)
et al.	et alii (and others)
g	gram
GA	Gibberellic acid (GA_3)
ha	hectare
i.e.	id est (that is)
IBA	Indole-e-butyric acid
kg	Kilogram
l^{-1}	per litre
mg	milligram
m^{-2}	per meter square
/	per
ppm	part per million
%	per cent
q	quintal
S.E.	Standard error
t	tonne

CHAPTER-1

INTRODUCTION

The commercial importance of flowers has been realised throughout the world and today, floriculture has developed into an intensive form of agriculture. Globally, floriculture occupies an area of 2.5 lakh hectares, generates a production of worth more than US $ 50 billions and has been growing at the rate of 17 per cent per annum (Anonymous, 1997a). The major flower growing countries are Holland, Germany, Columbia, Italy, Israel and Mexico. India and China with nearly 60,000 hectares each are the leading countries in terms of area under flower cultivation.

In India, the leading flower growing states are Karnatka, Tamil Nadu, Andhra Pradesh, Maharashtra, West Bengal and Uttar Pradesh (Singh, 1997). In Haryana, the area under floriculture is estimated to be only 1800 hectares, out of which 150 hectares lies under chrysanthemum cultivation with flower production of about 1200 tonnes and it ranked second to marigold in area and production (Anonymous, 1997b).

Chrysanthemum has its admirers and enthusiasts all over the world. In Europe, USA and Japan, it is grown commercially on large scale for cut flowers and as pot plants. Chrysanthemum occupies third rank in the international cut flower trade next to carnation and rose. In India also, it ranks third after Jasmine and Rose and occupies a place of pride both as a commercial flower crop and as a popular exhibition flower among various flowers of commercial importance.

Chrysanthemum, commonly known as guldaudi or Autumn Queen is cultivated world over for its commercial and aesthetic value. Chrysanthemum belongs to the family compositae and is believed to be a hybrid species evolved as a result of centuries of cross-pollination among several species viz. *C. indicum, C. sinense, C. japonicum, C. Ornatum* (Kher, 1987).

The chrysanthemum is broadly classified into two categories on the basis of size of flower viz. standard type (large flowered) and spray type (small flowered). Large flowered varieties are grown mainly in pots for exhibition and cut flower production whereas small flowered varieties are grown mainly in fields and beds for loose and cut flowers, gajra, veni, bracelet and garland making. Besides this, some dwarf or small flowered varieties named as "no pinch no stake" are very popular for their attractive flowers and for growing in pots.

A large number of cultivars exhibiting wide variation with respect to growth habit, shape, size and colour of blooms makes it suitable for every purpose conceivable for a flower crop. So, it is necessary to standardize its production technology. Various factors for successful production of cut flowers are selection of variety, spacing, nutrition, crop regulation and post harvest handling. Although some work has been done on spacing and nutrition but a very little work has been done on crop regulation and post harvest handling.

Besides increasing the production, regulation of flower production is an important aspect of commercial growing of chrysanthemum and goes a long way in meeting the ever increasing demand of cut flowers for longer period. There are few reports in the literature about gibberellic acid that it influences the growth and flowering of chrysanthemum by regulating the plant height, plant spread, size of flower, stalk length of flower, flowering time and duration. Regulation of flowering time and duration is very important to avoid glut in the market at peak production time. Similarly, pinching is an important cultural operation and is practised to recognize the fact that it regulates the crop and increases the flower production.

After successful production of chrysanthemum cut flowers, the most important aspect in the cut flower industry is the post harvest handling in order to conserve the freshness of flowers for distant markets and users to fetch good return. Because of short vase life, cut flowers in India have traditionally been cultivated in places near to their marketing centres. A very little attention was paid to extend their vase life, transportation and storage. Recently, some work has been conducted to extend vase life of cut flowers in chrysanthemum and other flower crops by using floral preservatives in eastern and southern part of the country.

A very few reports are available on crop regulation and post-harvest handling of chrysanthemum under North Indian conditions. However, no systematic study has been conducted on crop regulation and post harvest handling of chrysanthemum under agroclimatic conditions of Haryana. So, keeping in view the above problem, the studies were undertaken with the following objectives :

1. To study the effect of Gibberellic acid and pinching on cut flower production.
2. To study the effect of different chemicals on vase life of cut flowers.

CHAPTER-2

REVIEW OF LITERATURE

In the past, little attention has been paid by the scientists towards production technology of chrysanchemum under Indian condition and there is a paucity of literature about this crop especially about the effect of Gibberellic acid and pinching on its growth and flowering and also on post harvest studies of its cut flowers. Hence, literature available in India and abroad on cut flower production and vase life of chrysanthemum and other flowering plants are briefly reviewed in this chapter.

2.1 To study the effect of Gibberellic acid and pinching on cut flower production of chrysanthemum

Effect of growth regulators

In the past, one of the interesting and useful advancement in the plant science is the regulation of plant growth. The ways of modifying plant growth continued to creat interest among plant scientists. Plant grows by a combination of processes of cell division, cell expansion and cell differentiation under the control of certain growth hormones produced by the plant itself. These hormones in very small quantity can drastically chage the plant structur vegetatively by changing the growth parameters, make the plant to initiate flowering earlier and extend the vase life of cut flowers. These growth regulating hormones improve the physiological efficiency of the plant such as improvement of rate of photosynthesis, control of transpiration and respiration, efficient nutrient and water uptake, control of leaf senescence which induces resistance to environmental stresses and ultimately increases the harvest index. It is generally accepted that externally applied growth substances produce their effects through the changes in the level of naturally occurring hormones, thereby, modifying the growth and flowering of plants. The effects of GA_3 on different aspects of chrysanthemum and other related flowering plants are reviewed here.

2.1.1 Effect of Gibberellic acid

2.1.1.1 Growth parameters

Gibberellins discovered by Kurosowa (1926) are endogenous plant growth substances that can also be applied exogenously, generally as GA_3 or GA_{4+7}. Khol and Kofranek (1957) were among the first to investigate the possible uses of GA_3 on flower crops. Lang (1957) observed that gibberellins promoted shoot growth by cell elongation. Sachs (1965) reported that exogenous application of GA_3 induced formation of new meristematic region which was responsible for most of the cells, which in turn contributed to cell elongation. Dahab *et al.* (1987) recorded increased plant height and number of shoots in *Chrysanthemum frutescens* with GA_3 at 500 and 1000 ppm. Koriesh *et al.* (1989a) recorded tallest plants with two sprays of GA_3 100 ppm. Rajapakse and Kelly (1991) reported that

GA_3 application at 0.14 mM increased plant height under both the control and Cu SO_4 filters.

Antably *et al.* (1991) reported that exogenous GA_3 treatment applied as a spray 15 days after planting increased root numbers and the activity of growth promoting substances in the basal part of the cuttings of *Chrysanthemum morifolium* and *Chrysanthemum frutescens*. Talukdar and Paswan (1994) produced the tallest plants (31.3 cm) in chrysanthemum cv. Tumruli with 20 ppm GA_3 as compared to control (19.8 cm). Similarly, Talukdar and Paswan (1995) reported that treatment of rooted cuttings of chrysanthemum cv. Rajkumari 35 days after planting resulted in increased plant height and the increase was positively correlated with GA_3 concentration. Plants treated with 40 ppm GA_3 (42.5 and 57.9 cm in 1990-91 and 1991-92, respectively) were significantly taller than control plants (25.5 and 40.7 cm in 1990-91 and 1991-92, respectively). Deotale *et al.* (1995) reported that 150 ppm GA_3 recorded enhanced vegetative growth characters such as plant height and number of leaves in chrysanthemum. However, 100 ppm GA_3 gave maximum leaf area, number of primary and secondary branches. Keltawi *et al.* (1995) reported that 100 ppm GA_3 increased plant height by 9.8 per cent of the control. Talukdar and Paswan (1996) recorded significantly increased plant height with 40 ppm GA_3 (54.6 cm) compared with 41.5 cm for controls in chrysanthemum cv. Prof. Harris.

Dutta *et al.* (1998) found greatest plant height (67.4 cm), longest internode (7.5 cm) and greatest number of laterals per plant (56.3) with

150 ppm GA_3. Talukdar and Paswan (1998) in a pot experiment study with standard chrysanthemum cultivars Snow Ball, Kiku Biori, Grape Bowl and Lilac when sprayed 35 days after planting with 10, 20 or 40 ppm GA_3 reported that plant height was greatest with 40 ppm GA_3 (an average of 65.36 cm a cross cultivars). Meher *et al.* (1999) recorded tallest and broadest plants in chrysanthemum after 90 days of planting when plants were sprayed with 150 ppm GA_3.

2.1.1.2 Floral parameters

Kofranek and Cockshull (1985) observed an elongation of peduncles without inflorescence abnormalities with 20 ppm GA_3 in chrysanthemum cvs. Beauregard, Flame Belair, Hurricane, Pinoccohio and Statesman. Dahab *et al.* (1987) recorded accelerated flowering with 500 and 1000 ppm GA_3 in *Chrysanthemum frutescens*. Nagarjuna *et al.* (1988) reported that time to 50% flowering was hastened by GA_3 (100 and 200 ppm) by 17-21 days in chrysanthemum. Flower diameter (5.92-5.99 cm) was greatest with GA_3 at 200 ppm. Koriesh *et al.* (1989b) reported earlier flowering and improved the quality of inflorescence by giving two applications of GA_3 as a spray at 100 ppm in chrysanthemum cv. Forester. Holcomb *et al.* (1991) reported in chrysanthemum cv. Echo that 20 ppm GA_3 application in weeks 2 or 3 increased peduncle length and corrected the undesirable clubby appearance resulting from uniconazole treatment.

Dehale *et al.* (1993) reported that the foliar application of 100 ppm GA_3 increased the diameter of flowers and the diameter of the flower disc of several cultivars of chrysanthemum. Dutta *et al.* (1993) reported in chrysanthemum cv. Co.1 that plants sprayed twice with GA_3 at 50, 100 or 150 ppm resulted in earlier and increased duration of flowering along with improved size and stalk length of flowers by most of the treatments over control. An earliness of 15.23 and 14.11 days in bud formation and 21.78 and 21.00 days in commencement of flowering over control was recorded with GA_3 in first and second year, respectively. It was also reported that flowering was earliest (69.33 and 84.67 days) with 150 ppm GA_3 compared with control (99.00 and 113.67 days), longest (212.67 and 219 days) with 50 ppm GA_3 compared with control (83.67 and 87.33 days) in first and second year, respectively. Flower size and flower stalk length was maximum (6.40 and 6.32 cm) and (14.84 and 14.88 cm) with 150 ppm GA_3 compared with control (4.85 and 4.74 cm) and (8.23 and 8.69 cm), respectively.

Deotale *et al.* (1994) studied the effect of GA_3 (0, 50, 100 and 150 ppm) on flowering of chrysanthemum cv. Raja and found that time to bud initiation, flower opening and the difference between the two were reduced with increasing concentration of GA_3. Talukdar and Paswan (1995) reported in chrysanthemum cv. Rajkumari that 20 ppm GA_3 treatment significantly reduced the number of days to full bloom. Deotale *et al.* (1995) sprayed GA_3 at 0, 50, 100 and 150 ppm on chrysanisemum cv. Raja, twice and recorded largest flowers (6.42 cm) with 150 ppm GA_3. Keltawi *et al.* (1995) found that 100 ppm GA_3 stimulated peduncle length by 10 per cent of the control in chrysanthemum. Talukdar and Paswan (1996) recorded largest flowers (7.9 cm) with 40 ppm GA_3 compared with control (7.1 cm) in chrysanthemum cv. Prof. Harris.

Dutta *et al.* (1998) observed that plants receiving GA_3 sprays at 50 ppm produced the longest lasting flowers (219.0 days). Talukdar and Paswan (1998) reported that full bloom was advanced by GA_3 treatments and flowers were largest with 10 ppm GA_3 and lasted longest with 40 ppm GA_3. Meher *et al.* (1999) reported that flower diameter was maximum (7.14 cm) with 150 ppm GA_3 in chrysanthemum. Farooqui *et al.* (1999) studied the effect of plant growth regulators on flowering behaviour of pyrethrum in north Indian plains and reported that percentage of flowering plants increased significantly with the application of GA_3 100 ppm + kinetin 100 ppm.

2.1.1.3 Yield parameters

Experimental results presented by Syamal *et al.* (1990) indicated that GA_3 at 200 ppm increased number of flowers and seed yield as compared to other treatments in marigold and China aster. However, Singh *et al.* (1991) obtained highest number of flower and flower weight with 500 ppm GA_3 while the flower yield was more than double with 400 ppm GA_3 in African marigold. Dehale *et al.* (1993) recorded increased weight of flowers with foliar application of 100 ppm GA_3 to several cultivars of chrysanthemum. Dutta *et al.* (1993) reported in chrysanthemum cv. Co.1 that maximum weight of 100 flowers (171.90 and 172.92 g) was recorded with 50 ppm GA_3 over control (120.82 and 123.68 g) whereas maximum number of flowers (438 and 438) and yield per plant (0.682 and 0.685 kg) was recorded with 150 ppm GA_3 over control (209.33 and 213.33) and (0.253 and 0.263 kg), respectively. Deotale *et al.* (1994) found that GA_3

100 ppm gave superior performance in respect of number of flowers per plant (256) whereas GA_3 150 ppm produced significantly maximum average flower yield per plant (474 g) in chrysanthemum Cv. Raja. Rajgopalan and Abdul Khader (1994) recorded higher flower yield with 200 ppm GA_3 in chrysanthemum cv. Co.2. Talukdar and Paswan (1994) reported that 10 ppm GA_3 resulted in significantly more flowers per plant (52.2) than in control (32.2) in chrysanthemum cv. Tumruli. Deotale *et al.* (1995) after working on chrysanthemum cv. Raja recorded heaviest (2.15 g) flowers with 150 ppm GA_3. Talukdar and Pawan (1995) reported that 20 and 40 ppm GA_3 significantly increased the number of flowers per plant in chrysanthemum cv. Raj Kumari. Keltawi *et al.* (1995) found that 100 ppm GA_3 increased flower number per plant by 7.5 per cent of control in chrysanthemum. Talukdar and Paswan (1996) in a pot experiment with the spray chrysanthemum cv. Prof. Harris reported that GA_3 at 10, 20 or 40 ppm significantly increased the fresh and dry weight of flowers.

Dutta *et al.* (1996) reported that plants receiving GA_3 at 150 ppm produced the highest yield of flowers per plant (0.685 kg) in chrysanthemum. Meher *et al.* (1999) found highest yield of cut flowers with 50 ppm GA_3 in chrysanthemum. Farooqi *et al.* studied the effect of plant growth regulators on flowering behaviour of pyrethrum in north Indian plains and reported that the number of flower per plant was significantly increased over control in GA_3 treated plants.

2.1.2 Effect of pinching

Pinching is an important cultural operation in the successful production of good quality blooms in chrysanthemum. It is recognized fact that pinching reduces the plant height, promotes axillary branching,delays flowering and helps in breaking rosetting. In this operation, the terminal growing portion of the stem of the plant is removed by hand to break the apical dominance because the development of axillary branches and flower production are influenced by the presence of apical dominance. In India, labour being cheap, pinching is likely to be acceptable as a physical method of crop regulation if it brings about desirable changes in the development of axillary buds and enhances flower production. The literature available on pinching in chrysanthemum and other flowering crops is reviewed below under the following sub heads :

2.1.2.1 Growth parameters

Kumpe and Langhans (1970) pinched carnation cuttings at five different times and found that earlier the pinching, the more was the amount of fresh weight. Sen and Naik (1977) reported that pinching the apical bud after 60 days of planting reduced plant height, node number and branch number but leaf size was increased in chrysanthemum. Machin and Scopes (1978) reported that early pinching reduces plant height and promotes axillary branches than late pinching in chrysanthemum. Sekhan (1981) reported that pinching the plants of marigold cv. African Giant Double Orange after 30 days of transplanting resulted in highest reduction in plant height, fresh weight and number of branches per plant in comparison to pinching of plants after 20 or 40 days of transplanting. However, manual pinching was found insufficient in pot chrysanthemum as reported by

Fritzsche (1980). Cockshull (1982) reported that removal of axillary inflorescence buds from the branched chrysanthemum plants at various times before anthesis of terminal flowers resulted in non significant effect on either overall production of dry matter or the total amount distributed to the flower.

Hendricks and Lemper (1983) tried pinching after 0, 7, 14 and 21 days of planting in pot chrysanthemum and reported that late pinching (14 and 21 days) produced better quality plants with shorter stem and more number of branches as compared to early pinching (7 days). Patel and Arora (1983) reported that pinching the carnation plants twice (45 and 75 days after transplanting) resulted in lowest plant height. Rashauskas *et al.* (1983) opined that pinching of carnation plants after 15 days of transplanting produced less number of branches whereas pinching of plants 30 days after transplanting increased the number of branches per plant. However, pinching chrysanthemum plants once (4 weeks), twice (4 and 7 weeks) and thrice (4, 6 and 8 weeks) caused significant reduction in plant height during two years over no pinching treatment and pinching the plants thrice have greatest reduction in plant height while pinching the plants once produced large number of branches per plant than pinching twice or thrice (Chezhiyan *et al.*, 1986).

Bhati and Chitkara (1987) reported that pinching reduced plant height but increased plant spread of marigold. It was also recorded that the effect was more pronounced when pinching was done 30 days after transplanting.

Song *et al.* (1990) studied the effect of pinching time on growth and flowering of chrysanthemum and reported that delaying the pinching date from May to July/August reduced the height of plant in comparison to pinching in June. Yassin and Pappiah (1990) studied the effect of pinching on growth and flowering of chrysanthemum cv. MDU-1 and reported that pinching on 30th day produced more lateral shoots. Kumar (1992) reported that pinching reduced plant height but increased dry weight and number of branches per plant in marigold cv. African Giant Double Orange. Shin *et al.* (1995) reported that early pinching in Korean wild chrysanthemum plants increased the plant height.

2.1.2.2 Floral parameters

Seager (1974) reported that stopping was advantageous in shortening the duration of first flush of lateral flowers. Sen and Naik (1977) reported that pinching the apical bud after 40 days of planting reduced flower number but increased flower size in chrysanthemum. Machin and Scopes (1978) reported that late pinching influenced the blooming date in chrysanthemum. Yonemura (1980) reported on 'Piccadily Carnations' that flower buds were induced in day length of more than 14 hours starting 30 days after pinching. Groskhov and Angelov (1981) reported in carnation that pinching delayed development and the earliest flowers were produced by untreated control. Rashauskas *et al.* (1983) reported that pinching of plants 15 days after transplanting induced early flowering whereas pinching of plants 30 days after transplanting delayed flowering in 'Sim' carnation. Chezhiyan *et al.* (1986) reported that pinching of chrysanthemum plants once induced early flowering than pinching twice or thrice.

Arora and Khanna (1986) conducted an experiment on marigold with four pinching treatments i.e. 0, 20, 30 and 40 days after transplanting and observed that pinching of plants did not show significant increase in flower production but it delayed flowering by 10-20 days over non-pinched control plants. Klapwijk (1987) reported that carnation plants when pinched between mid March and August, the flower initiation was detectable 70 days after pinching but when pinched between October and March, the flower initiation was delayed. Gowda and Jayanti (1988) studied the effect of pinching on growth and flowering of chrysanthemum and recorded the highest flower diameter by pinching the plants twice i.e. 4 and 7 weeks after transplanting. Barman *et al.* (1993) reported that increased plant height at pinching caused the buds to appear earlier but delayed bud break in chrysanthemum cv. Chandrama.

2.1.2.3 Yield parameters

Jensen (1973) reported that pinching the carnation plants once gave higher yields and better quality flowers than pinching twice or thrice. Holland (1974) pinched potted chrysanthemum plants to five leaves, eight leaves and five and eight leaves and reported that pinching the plants to eight leaves resulted in more number of flowers per pot while third pinching (5 and 8 leaf stage) delayed flowering. In an another experiment with gomphrena, Rajasekran *et al.* (1983) reported that pinching after 15 days of transplanting recorded high yield (3165 g), number of flowers (602.5) and bigger sized flower (12.85 cm) whereas lowest yield (2455g), number of flowers (518.5) and smaller flower size (1.5 cm) were registered under non-pinched plants. Arora and Khanna (1986) reported that pinching of plants did not show significant increase in the production of marigold. However, Reiss and Lewis (1986) reported that pinching improved flower production in chrysanthemum. Bhati and Chitkara (1987) obtained higher flower yield in marigold by pinching the plants after 30 days of transplanting. Gowda and Jayanti (1988) reported that highest flower yield (7.44 t/ha) was obtained in chrysanthemum by pinching twice i.e. 4 and 7 weeks after transplanting. Cermeno (1989) also reported that pinched plants of chrysanthemum had more number of flowers per plant than non-pinched plants. Song *et al.* (1990) reported that pinching on 20th May increased the number of flowers and yield per plant in chrysanthemum in comparison to pinching in June, July/August. Yassin and Pappiah (1990) studied the effect of pinching on growth and flowering of chrysanthemum cv. MDU-1 and reported that pinching on 60th day recorded highest flower yield per plant. Although, pinching reduced flower size and flower weight but yield per unit area was highest in pinched plants of marigold cv. African Giant Double Orange (Kumar, 1992). Shin *et al.* (1995) reported that early pinching increased flower production in Korean wild chrysanthemum.

2.2 To study the effect of different chemicals on vaselife of cut flowers of chrysanthemum cvs. Flirt and Gauri

Cut flowers are complex, living and actively metabolising units including sepals, petals, androecium, gynoecium, stem and often leaves. Each of these are complex and differ both physiologically and morphologically. The vase life of cut flower is affected mainly by two factors. When the flower is cut off from the plant, this leads to deterioration in the internal carbohydrates and loss in turgidity due to loss of water. Therefore, any attempt to prolong the vase life of cut flower should involve provision of an artificial energy source and water and also measures to minimize the deterioration processes. Injury at the cut end or growth of micro-organisms in the lumen of xylem vessels (physical blockage) or accumulation of microbial secretions and metabolic byproducts (physiological blockage) could prevent absorption resulting in severe water deficit ultimately leading to the loss of turgidity. Cut flower longevity is also curtailed by ethylene (Chandra and Mohan Ram, 1980). Therefore, in addition to water and sugars, there should be antimicrobial agents and antiethylene chemicals in the vase solution to prevent microbial growth and ethylene biosynthesis.

Although, a very little work has been done in India to study the vase life of cut flowers of chrysanthemium. Hence, the published literature pertaining to post harvest handling of cut flowers of chrysanthemum and other flower crops has been reviewed and presented under the following headings.

2.2.1 Fresh weight

Flowers exhibit changes in fresh weight in the vase solution. Typically, cut flowers initially increase and subsequently decrease in fresh weight (Rogers, 1973). Gorini and Arrigo (1974) reported that presence of sucrose ensured less water uptake and reduced the increase in spike weight of gladiolus without causing wilting. The balance between water uptake and water loss affects the fresh weight of flowers (Halevy and Mayak, 1981).

Mantur and Nalawadi (1989) found that all the preservatives (aluminium sulphate, 8-HQS and sucrose) increased the weight of spike significantly over control at all the days in China aster cut flowers. Among all the treatments, aluminium sulphate at 0.2 per cent recorded more weight 8 days after keeping in vase. Rajagopalan and Abdul Khader (1993) studied the effect of pulsing treatments on vase life of chrysanthemum cut flowers and reported that flowers kept in 0.1 per cent aluminium sulphate solution showed the maximum percentage increase in fresh weight (6.4 and 7.0%) in cv. Co.1 and Co.2, respectively.

Shobha and Gowda (1993) reported that fresh weight was increased significantly upto 4th day in rose cutflowers in 0.5 mM Cobalt Sulphate Solution (13.31 g/flower) and 0.5 mM Aluminium sulphate solution (14.97 g/flower) over control (5.59 g/flower). De *et al.* (1996) found that 20% sucrose pulsing for 16 hours significantly decreased the weight loss of Gladiolus flower spikes in cv. White Enchantress and cv. Dhanvantari. Bhattacharjee (1999) studied the effect of five different chloride salts on post-harvest life and quality of "Sonia Meilland" cut rose and found increased fresh weight with 100 ppm $Alcl_3$, 200 ppm each of $Cocl_2$ and $Mgcl_2$, 300 ppm $Nicl_2$ and 400 ppm Kcl.

Sangma and Singh (1999) studied the effect of length of flower spike on fresh weight in gladiolus cv. Pink Friendship and reported that fresh weight increased upto 3rd day in spikes of 50, 60 and 70 cm lengths, upto

5th day in spikes of 80 and 90 cm lengths and upto 7th day only in spikes of 100 cm lengths. Bhat *et al.* (1999) studied the effect of pulsing, packaging and storage treatments on vase life of chrysanthemum cut flowers and found that cut flowers kept in a holding solution of 8-hydroxyquinoline 250 ppm + sucrose 1.5% had the lowest fresh weight loss in storage. Bhaskar *et al.* (2000) reported that tuberose spikes held in treatment solutions containing calcium nitrate 0.01% + citric acid 250 ppm + sucrose 3% resulted in an increased fresh weight.

2.2.2 Water relations

Deterioration in the keeping quality of cut flowers is characterized by wilting even though they are constantly held in the vase solution. If analysis is made systematically, water uptake and its transport, water loss and the capacity of the tissue to retain its water can be distinguished as its components, which are very much inter-related, but these are discussed separately for convenience. Water uptake and water loss may fluctuate, but with an over all declining trend (Mayak *et al.*, 1974). Early changes in physiological properties of flowers which normally accompany senescence are decrease in water uptake and loss in fresh weight and an increase in water uptake and loss in fresh weight and an increase in water loss (Faragher, 1986). Simultaneous measurement of water uptake and water loss which influence and determine the water balance was determined in rose cut flowers (Nagrajaiah and Reddy, 1991; Rath *et al.*, 1991).

Water uptake

A high level of turgidity is necessary not only for the development of flower buds to full bloom maturity but also for the continuance of normal metabolic activity of the tissue in the cut flower. Turgidity in flowers depends upon the balance between rate of water uptake and water loss (Rogers, 1973). During vase life, a reduced rate of water uptake was recorded (Faragher, 1986). Reddy (1988) reported that cobalt inhibited vascular blockage in the stems of Rose cv. 'Samantha' and maintained a high flow rate through the stems, leading to significantly increased water uptake by cut flowers. Lu *et al.* (1993) studied the physiological effects of preservative in cut flowers of carnation and reported that cut flowers held in a preservative solution containing 5% sucrose, 200 ppm 8-Hydroxyquinoline and 100 ppm silver acetate showed increased rate of water uptake following 70% decrease in production of ethylene over control.

Shobha and Gowda (1993) in a study on the effect of metal salts on the vase of cut rose cv. Queen Elizabeth reported that Cobalt sulphate at 0.50 mM enhanced solution uptake (106.00 g/flower) in comparison with control (94.67 g/flower). Aluminium sulphate at 0.75 mM concentration also increased solution uptake (105.00 g/flower). Rajan and Bhattacharjee (1994) while studying the influence of some harvest factors on post-harvest life of "Eiffel Tower" roses found that water uptake increased with the increase in the stem length of cut roses from 15 cm to 85 cm and maximum water uptake (42.29 ml) was registered by flower stems of 85 cm length.

De *et al.* (1996) studied the effect of pulsing (20% sucrose) for different hours on post harvest life of gladiolus cv. "White Enchantress" and reported that maximum water uptake (62.25 ml) was resulted with 16 hours pulsing and minimum (42.5 ml) with untreated control. Bhattacharjee (1999) reported in "Sonia Meilland" cut roses that cobalt chloride at 200 ppm resulted in maximum water uptake (24.00 ml) over control (19.50 ml). Bhaskar *et al.* (2000) conducted studies on the effect of certain chemicals on post harvest life of cut tuberose cv. Double and reported that combination of calcium nitrate 0.1% + citric acid 250 ppm + sucrose 3% maintained higher rates of positive water balance throughout the vase life period compared to other treatments.

Water loss

Cut flowers loss water from all tissues depending upon the environment and internal factors. Loss of water largely depends on diffusion pressure deficit (DPD) which is a function of temperature and water content. Light also promotes water loss presumably by causing stomatal opening. Whenever the amount of transpiration exceeds the amount of absorption, water deficit and wilting will develop. The flower that absorbs maximum amount of water is not always the one that reaches the highest level of turgidity. This also depends upon the ability of flower to retain the water that it absorbs (Rogers, 1973). Faragher (1986) observed that decreased water uptake and flower abscission are the major physiological factors which limit the turgidity and vase life of cut flowers.

Nagarajaiah and Reddy (1991) studied the effect of calcium, zinc and sucrose on the post harvest behaviour of cut "Queen Elizabeth" roses and found that water loss was increased in line with the water uptake by the metal salts either alone or in combination with sucrose. However, minimum water loss (42.66 g/flower) was recorded with 4% sucrose solution. Rath *et al.* (1991) found that silver nitrate and potassium aluminium sulphate at varying concentration inhibited vascular blockage in the stem of Rose cvs. Laura, Love and Landora and increased the water uptake, reduced the water loss and water loss/ water uptake ratio by the cut flowers. Shobha and Gowda (1993) studied the effect of metal salts on the vase life of cut rose cv. Queen Elizabeth and reported that cobalt sulphate recorded a maximum loss (90.69 g/flower) at 0.75 mM concentration and aluminium sulphate (96.89 g/flower) at 0.5 mM concentration compared to control. Bhaskar *et al.* (2000) reported in tuberose cv. Double that calcium nitrate 0.01% + citric acid 250 ppm + sucrose 3% significantly increased the water balance by reducing moisture loss over the same combination without sucrose and control till the end of vase life period.

2.2.3 Chemical solution for prolonging vase life

The use of preservative solution to prolong the vase life of cut flowers has been known for many years. Flower preservatives are composed of water, sugars and germicides. The composition of tap water varies greatly at various locations and may influence the longevity of cut flowers kept in vase as well as the efficiency of chemical solution used.

Deionized or distilled water increased the longevity of cut flowers and enhanced the effect of preservatives used. The cut flowers depend on the externally supplied sugars for their metabolic requirements in the absence of photosynthetic sources. Even dilute solutions of sugar provide ideal media for microbial growth. Besides, marring the looks of otherwise beautiful flower vase and emitting bad odours, the microbes enter into the vascular bundles and may block the water uptake and reduce the vase life. Preservatives reduce microbial growth, prevent vascular blockage and allow greater solution uptake (Marousky, 1968). An ideal flower food should combine these three properties. Other desirable characteristics are non-toxicity, free availability and low cost.

Many chemicals are used experimentally or commercially to increase the vase life of cut flowers because of their inhibitory property against micro-organisms. The substances that have been evaluated include certain metals like cobalt, silver, aluminium, organic acids like citric acid and bactericide like 8-hydroxy quinoline (8 HQ). But this chemical is not very easily available to the house-wife and the retail florist. The cost is rather quite high. It is almost insoluble in water thus necessitating its use in a salt form (citrate or sulphate) or of an organic solvent for dissolving. In search for an alternative preservative, we found aluminium sulphate and cobalt sulphate as a better substitute for 8-hydroxyquinoline. The advantages are free availability, lower cost and good solubility in water. A lot of work has been carried out in the last four decades with respect to post harvest handling of many flowers using sucrose, metal salts and their combinations in order to enhance their vase life. However, relatively very little work has been done to enhance the vase life of chrysanthemum. Hence, the literature pertaining to the effects of sucrose, aluminium sulphate and cobalt sulphate on vase life of cut flowers has been reviewed.

Effects of sucrose

Sucrose is one of the most important ingredients used in preservative solutions in order to conserve the endogenous carbohydrates of the flowers. Marousky (1969) found that the roses held in solutions containing sucrose absorbed less water than roses held in water alone, but their fresh weight increased longer due to partial stomatal closure and reduced transpirational loss of water. Acock and Nichols (1979) recently confirmed that sugar improved the water balance and osmotic potential of carnation flowers. Rath *et al.* (1991) found positive effect with sucrose solution (20 ppm) alone in prolonging the vase life over control in rose cvs. Laura, Love and Landora. Nagarajaiah and Reddy (1991) reported that the combination of sucrose and metal salts increased the vase life by upto 4 days. Barman *et al.* (1992) studied the effect of aluminium sulphate and sucrose on vase life of chrysanthemum cv. Chandrama and reported aluminium sulphate 0.2% + sucrose 3.0 per cent significantly increased the vase life (12.33 days) over control (7.33 days). Lu *et al.* (1993) studied the physiological effects of preservative for prolonging the longevity of cut flowers of carnationand reported that the peaks of ethylene release and respiration climacteric were delayed and production of ethylene decreased by 70 per cent in preservative solution of 5% sucrose, 200 ppm 8-hydroxyquinoline and 100 ppm silver acetate compared with control. The rate of water uptake by the cut flowers also increased after treatment with the preservatives.

Patil and Singh (1995) conducted post harvest studies in rose and found that combination of sucrose 5%, aluminium sulphate 300 ppm and citric acid 300 ppm increased the vase life upto 7.23 days over control (5.33 days). Dohino and Hayashi (1995) reported that electron beam irradiation caused severe injuries to chrysanthemum cut flowers when they were placed in water after treatment but the injuries were prevented and vase life and the flower diameter of cut flowers were increased in preservative solution containing sugar and germicides. Song *et al.* (1995) reported that a preservative solution containing sucrose 3%+8-hydroxy-quinoline sulfate 150 ppm + $Ag\ NO_3$ 50 ppm extended vase life by about 10 days compared with the control and improved the overall quality of flowers after shipping for 24, 48 and 72h. Arriaga and Guerrero (1995) reported in chrysanthemum cv. Polaris that flowers kept in preservative solution containing 200 ppm 8 HQC+75 ppm citric acid + 5% sucrose registered vase life of 50 days under refrigeration compared with 40 days for flowers kept in water under refrigeration.

Hayashi and Todoriki (1996) suggested that sugars reduced radiation induced physiological deterioration of chrysanthemum. Florez *et al.* (1996) studied keeping quality and prolonging the post harvest longevity of spray chrysanthemum cv. White Polaris and showed that pulsing treatment with distilled water+0.52 mol/m^3 citric acid + 58.43 mol/m^3 sucrose + 0.69 mol/m^3 8-Hydroxyquinoline + 2.9 or 4.4 mol/m^3 $Ag\ No_3$ combined with foliar application of 0.058 mol/m^3 GA_3 improved the foliar quality and extended the flower vase life. De *et al.* (1996) studied pulsing and impregnation of gladiolus cut spikes with sucrose and other chemicals and found that among various concentrations and duration of pulsing treatments, 20% sucrose for 16 hours significantly improved floret opening, floret diameter, water uptake, longevity of first floret and vase life of flower spikes in cv. White Enchantress.

Bhat *et al.* (1999) studied the effect of pulsing, packaging and storage treatments on vase life of chrysanthemum cut flowers and recorded that cut flowers held in a holding solution of 8-hydroxyquinoline 250 ppm + sucrose 1.5% had the longest vase life, the greatest flower diameter and the lowest fresh weight loss in storage. The most effective pulsing solution was benzyladenine 0.025 mM + silver thiosulfate 0.4 mM + 8-hydroxyquinoline 250 ppm + sucrose 5%. Singh *et al.* (2000) studied on post harvest management of gladiolus and inferred that 2 per cent sucrose along with 200 ppm 8-HQC was the best combination for improving vase life and opening of florets in gladiolus. Singh and Arora (2000) reported that vase life in gladiolus cv. Single was maximum in vase solution containing 1% sucrose and 200 ppm 8-HQC whereas in cv. Double, vase life showed increase when sucrose concentration in solution was increased from 1 to 3 per cent. Bhaskar *et al.* (2000) after studying the effect of certain chemicals on the post-harvest life of cut tuberose cv. Double reported that calcium nitrate 0.01% + citric acid 250 ppm + sucrose 3% significantly increased the per cent of opened florets (73.25) and vase life (14.67) over the same combination without sucrose 3% and control.

Effects of Aluminium

Rameshwar (1974) conducted experiment on Friendship gladiolus using Aluminium sulphate and 8-HQ in the presence of sucrose as preservative and reported that Aluminium sulphate was equally effective in improving the keeping quality. Almost all of the florets (90%) opened on each rachis and the last floret withered after 13 days. Aluminium sulphate also acidifies the holding water, thus reducing the bacterial growth and improving water balance (Halevy and Mayak, 1981). Aluminium maintained petal membrane integrity and enhanced the vase life of gladiolus flowers (Murali, 1990). Rath *et al.* (1991) reported that potassium aluminium sulphate solutions at varying concentrations inhibited vascular blockage in the stem of rose cvs. Laura, Love and Landora and increased the water uptake, reduced the water loss and water loss/water uptake ratio by the cut flowers. As a result, the vase life of all the three varieties of rose increased. Barman *et al.* (1992) reported that aluminium sulphate 0.2%+sucrose 3.0 per cent significantly increased vase life (12.33 days) over control (7.33 days) in chrysanthemum cv. Chandrama.

Shobha and Gowda (1993) recorded that almost all the concentrations of Aluminium sulphate improved the vase life equally with a maximum prolongation at 0.75 mM (7.67 days) by 3 days over control (4.67 days). Rajgopalan and Abdul Khader (1993) reported that chrysanthemum flowers kept in 0.1 per cent solution showed the maximum number of days of vase life (10 and 11) in cv. Co.1 and Co.2, respectively. Patil and Singh (1995) conducted post harvest studies in rose cv. Gladiator and found that Aluminium sulphate 300 ppm in combination with sucrose 5% and citric acid 300 ppm significantly increased the vase life (7.23 days) over control (5.33 days). Ahn *et al.* (1996) reported that flowers pretreated with 3 mM aluminium sulphate + 3% sucrose had a longer vase life (8.6 days) compared with control (7.3 days) and exhibited good quality of flowers. Bhattacharjee (1999) while studying post harvest life in "Sonia Meilland" cut roses found longest vase life, improved water uptake, increased flower diameter and fresh weight with 100 ppm Aluminium chloride among its various concentrtions. Singh *et al.* (2000) conducted studies on post harvest management of gladiolus and reported that maximum vase life (8.55 days) was recorded when aluminium sulphate 400 ppm was combined with sucrose 2% which was significant over control (4.11 days).

Effects of Cobalt

Kang and Ray (1969) reported that cobalt is an inhibitor of ethylene action while Lau and Yang (1976) reported cobalt ion as an inhibitor of ethylene biogenesis. Venkatarayappa *et al.* (1981) found that cobalt ion improves the water balance and maintains higher fresh weight in cut Samantha roses. Cobalt solution increased the fresh weight of cut flower over control and ultimately enhanced the longevity of cut flowers of French marigold. Balakrishna (1987) recorded that cobalt delayed the loss in fresh weight, increased the water uptake and improved water balance in tuberose.

Reddy (1988) reported that cobalt inhibited vascular blockage in the stems of rose cv. 'Samantha' and maintained a high flow rate through the stems, leading to significantly increased water uptake by cut flowers. Cobalt also partially closed the stomates, and hence reduced the water loss/water uptake ratio and maintained a high water potential in the cut rose. This resulted in high fresh weight of flower and thus leading to increased vase life of cut flowers. Murali (1990) reported that cobalt treatment maintained the membrane integrity markedly by reducing ethylene evolution in gladiolus. Shobha and Gowda (1993) reported that vase life of cut rose cv. Queen Elizabeth was prolonged by 5.33 days with cobalt sulphate at 0.50 mM concentration. Bhattacharjee (1999) studied post harvest life of "Sonia Meilland" cut roses as affected by chloride salts and reported that longest vase life, improved water uptake, increased flower diameter and fresh weight were found with 200 ppm of cobalt chloride among its various concentrations. Singh *et al.* (2000) conducted studies on post harvest management of gladiolus using seven biocides in combination with sucrose and reported that cobalt chloride 500 ppm in combination with sucrose 2% significantly increased the vase life (7.67 days) over control (4.11 days).

CHAPTER-3

MATERIALS AND METHODS

The present investigation entitled, "Studies on cut flower production and vase life in Chrysanthemum (*Chrysanthemum morifolium*) was carried out at the experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during 1999 and 2000.

3.1 Geographical location and climate of the experimental site

Hisar is situated in subtropics at 29°10' North Latitude and 75°46' East Longitude with an elevation of 215.2 meters above mean sea level. This region enjoys semi-arid climate with hot and dry summer and cold winters. There is no specific pattern of rainfall during the growing season. The meteorological data are presented in the Appendix-I and II.

3.2 Soil

The soil was sandy loam in texture possessing good water holding capacity and medium in fertility.

3.3 Planting material

The planting material of cvs. Flirt and Gauri was taken from previously maintained germplasm. The terminal rooted cuttings of uniform size and vigour were selected for planting.

3.4 Rooting media

The terminal cuttings were treated with IBA before planting in small earthern pots and trays having yamuna sand. Rooting media was adequately maintained with sufficient moisture at various intervals.

3.5 Preparation of experimental field

The experimental field was ploughed well and properly levelled before preparation of experimental plots. Plots measuring 1.2×1.2 sq. m. in size were prepared. A basal dose of well rotten farm yard manure @ 5 kg m^{-2} was thoroughly mixed in soil 20 days before transplanting of rooted cuttings.

3.6 Experimental layout

Experiment-1 : To study the effect of Gibberellic acid and pinching on cut flower production in chrysanthemum cvs. Flirt and Gauri

The experiment was conducted as per details given below :

Concentration of GA_3	:	Five levels
G_0	:	0 mg l^{-1} GA_3
G_1	:	50 mg l^{-1} GA_3
G_2	:	100 mg l^{-1} GA_3
G_3	:	150 mg l^{-1} GA_3
G_4	:	200 mg l^{-1} GA_3
Stages of pinching	:	Three
P_0	:	No pinching
P_1	:	Pinching after 35 days of transplanting
P_2	:	Pinching after 45 days of transplanting
Experimental design	:	Split plot design

Replication	:	Three
Plot size	:	1.2m × 1.2 m
Number of plots	:	90
Spacing	:	30 cm × 30 cm
Number of plants/replication	:	16

Gibberellic acid was sprayed twice i.e. 30 and 40 days after transplanting and control plants were sprayed with water only.

Fertilizer application

A basal dose of nitrogen (20 g m^{-2}), phosphorus (20 g m^{-2}) and potassium (10 g m^{-2}) was applied before transplanting.

Source of nutrients	:	Urea
		Single super phosphate
		Muriate of potash

3.7 Transplanting and establishment of rooted cuttings

One month old rooted cuttings of uniform size and vigour were transplanted in the experimental plots at proper spacing upto a depth of first leaf node from below. Soil was firmly pressed around and irrigation was applied immediately after transplanting.

3.8 Other cultural operations

The experimental plots were irrigated once a week during summer and once a fortnight during winter. Weeding and hoeing were done as and when required.

3.9 Pinching

The plants were pinched as per schedule decribed earlier by removing terminal growing portion of plants with thumb and forefinger.

Observations recorded

The following observations were recorded :

A. Growth parameters

(i) Plant height (cm)

The plant height was measured in cm with the help of a meter rod from the base of the plant upto tip of the apical shoot at full bloom stage for five representative plants and averaged.

(ii) Plant spread (cm)

The plant spread was measured at full bloom stage by measuring the distance covered by the plant in East to West and North to South directions and taking mean of sum for five representative plants in each plot and averaged.

(iii) Number of branches

Number of branches were counted at full bloom stage for representative plants in each plot.

B. Floral parameters

(i) Days taken for floral bud initiation

The number of days taken for floral bud initiation were recorded from the date of transplanting upto the appearance of first flower bud for representative plants in each plot.

(ii) Number of buds per plant

The total number of buds per plant were counted for five representative plants in each plot.

(iii) Days to first flowering

The number of days required were calculated from the date of transplanting upto date of appearance of first full size flower for representative plants in each plot.

(iv) Duration of flowering

Duration of flowering was recorded as the number of days from the date of first flower opening upto the date of last flower opening for representative plants in each plot.

(v) Size of flower (cm)

Size of flower was recorded at full bloom stage by using vernier calliper by measuring the diameter between the apices of ray forets in East to West and North to South directions and taking the mean of sum for representative plants in each plot.

(vi) Length of flower stalk (cm)

The length of flower stalk of individual flower was measured with the help of meter rod from its point of attachment to the main stem upto the base of flower on the shoot.

(vii) Strength of flower stem

The strength of flower stem was determined by holding the stem horizontally at point 25 cm above the base and noting the deviation of the flower head below horizontal line.

C. Yield parameters

(i) Number of flowers per plant

The total number of flowers per plant were counted for the representative plants in each plot.

(ii) Weight of flower (g)

Average weight of ten flowers per plant for five representative plants was taken in each plot.

(iii) Yield of flower per plant (g)

Yield of flower per plant was calculated by multiplying number of flowers with average weight of flower.

Experiment II : To study the effect of different chemicals on vase life of cut flowers in chrysanthemum cvs. Flirt and Gauri

Treatments and their combinations - Nine

T_1	-	Control (Tap water)
T_2	-	Distilled water
T_3	-	Sucrose 4% (40 gl $^{-1}$)
T_4	-	Aluminium sulphate 0.2% (2 g l^{-1})
T_5	-	Cobalt sulphate 0.02% (200 mg l^{-1})
T_6	-	Sucrose 4% + Aluminium sulphate 0.2%
T_7	-	Sucrose 4% + Cobalt sulphate 0.02%
T_8	-	Aluminium sulphate 0.2% + Cobalt sulphate 0.02%
T_9	-	Sucrose 4%+Aluminium sulphate 0.2%+Cobalt sulphate 0.02%

Replication : Three

Experiment design : Completely randomized design

3.10 Preparation of solutions

Sucrose solution was prepared by dissolving sucrose in distilled water @ 40 g per litre. Aluminium sulphate solution was prepared by dissolving Aluminium sulphate in distilled water @ 2g per litre. Similarly, cobalt sulphate solution was prepared by dissolving cobalt sulphate in distilled water @ 200 mg per litre. Various treatment combinations which were nine in number were prepared by dissolving above mentioned chemicals in proportionate quantities in required distilled water.

3.11 Collection and preparation of cut bloom/flower

Flower buds of chrysanthemum cvs. Flirt and Gauri were harvested during morning hours with the help of a sharp knife when the first two whorls of petals had just opened. The flower buds containing 25 cm long stalk were kept into buckets containing water immediately after harvesting to avoid entry of air bubbles into the stalk stem vessels which causes blocking and were brought to the laboratory. In the laboratory, these flowers with stalks were again given a uniform slanting cut to increase the absorption area and immediately kept into the conical flasks, containing vase solution of different concentrations. The conical flasks were of 150 ml and 250 ml capacity, made up of glass. For cv. Gauri, 150 ml conical flasks were used where as for cv. Flirt, 250 ml conical flasks were used. The mouth of the flasks was covered with cotton plug to hold the flower bud and to minimize the loss of water through evaporation. The length of stalk from cut end to the flower bud was maintained 15 cm in cv. Gauri and 18 cm in Cv. Flirt. The cut end of flowers were dipped into vase solutions and there were three cut flowers per conical flask. The volume of vase solution was 125 ml in 150 ml conical flask and 200 ml in 250 ml conical flask. Freshness of cut flowers was considered upto the time when fifty per cent of florets had wilted.

Observations recorded

(i) Weight of flower (g)

The difference between the weight of the conical flask containing the solution and the flowers and the weight without the flowers represents fresh weight of flower. The changes in fresh weight of flower i.e. increase or decrease was recorded in grams over initial weight of flower at 4 days interval after placing them in vase solutions. Thus, the increase or decrease in weight of flower was worked out in percentage.

(ii) Water uptake

The difference between the consecutive weights of the conical flask with solution (without flower) represents the water uptake by the flower. The total water uptake was also calculated by adding water uptake during vase life of cut flower.

(iii) Water loss

The difference between the consecutive weights of conical flask containing the solution and flower represents the transpirational loss of water. The total water loss was also calculated by adding water loss during vase life of cut flower.

(iv) Water loss/water uptake ratio

It was worked out by dividing total water loss with total water uptake.

(v) pH of the vase solution

pH of the vase solution was recorded on the starting day and change in in pH (increase or decrease) of vase solution was also registered at 4 days interval during vase life of cut flower.

(vi) Vase life or freshness of flower

Cut flowers were discarded when fifty per cent of florets were wilted or faded. This stage was considered to be the end of potential useful longevity of cut flowers and the number of days taken for this was recorded by daily observation of cut flowers till they were found unfit for continuing in the vase.

CHAPTER-4

EXPERIMENTAL RESULTS

The experimental results emanating from the present study entitled "Studies on cut flower production and vase life in chrysanthemum (*Chrysanthemum morifolium*)" are presented in this chapter as detailed below :

EXPERIMENT-I

4.1 To study the effect of Gibberellic acid and pinching on cut flower production in chrysanthemum cvs. Flirt and Gauri

4.1.1 Growth parameters

4.1.1.1 Plant height

The data pertaining to effect of GA_3 and pinching on plant height of chrysanthemum are presented in Table 1. It is clear from the data that plant height was significantly increased over control by different concentrations of GA_3 in cultivars Flirt and Gauri during 1999 and 2000. Plant height increased with the increase in concentration of GA_3 from 50 to 200 ppm in both the cultivars during both the years. However, in 1999, the differences between 100 and 150 ppm and between 150 and 200 ppm

Table 1. Effect of different GA_3 and pinching treatments on plant height (cm) in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	31.14	30.52	28.84	30.16	33.49	31.82	30.99	32.10
	50	40.07	39.78	37.42	39.09	43.68	42.97	41.53	42.72
	100	44.22	43.72	41.49	43.14	47.19	45.05	43.08	45.10
	150	45.47	44.87	42.36	44.23	49.36	48.13	45.56	47.68
	200	48.08	46.85	44.74	46.55	51.38	49.06	47.81	49.41
	Mean	41.79	41.14	38.97	40.63	45.02	43.40	41.79	43.40
Gauri	0	34.34	32.32	31.87	32.84	38.24	36.49	35.24	36.65
	50	55.42	52.36	50.22	52.66	58.84	56.13	54.56	56.51
	100	63.46	57.94	55.28	58.89	66.75	65.79	63.29	65.27
	150	69.01	66.46	64.53	66.66	69.64	67.94	65.14	67.57
	200	70.39	67.28	64.97	67.54	76.06	73.03	71.49	73.52
	Mean	58.52	55.27	53.37	55.72	61.90	59.87	57.94	59.90
C.D. at 5%	Cultivar (A)			2.63				5.35	
	GA_3 (B)			1.85				1.99	
	Pinching (C)			1.43				1.54	
	Cultivar× GA_3 (AB)			2.62				2.81	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

were statistically at par in cultivar Flirt and Gauri, respectively. Likewise, in 2000, the differences between 150 and 200 ppm were statistically at par in cultivar Flirt.

Pinching of plants at 35 and 45 days after transplanting significantly decreased the plant height over control in both the cultivars during both the years except in cultivar Flirt during 1999 where only pinching of plants at 45 days after transplanting significantly reduced the plant height over control and pinching of plants at 35 days after transplanting. However, the differences between control and pinching of plants at 35 days after transplanting were found non-significant in cultivar Flirt during 1999. The data indicate that pinching at 45 days after transplanting significantly reduced the plant height in comparison to pinching at 35 days after transplanting in cultivar Flirt during 2000 and in cultivar Gauri during 1999 and 2000.

Interaction of cultivar and GA_3 exert significant influence on the height of plants during both the years and cultivar Gauri attained significantly more plant height with different concentrations of GA_3 in comparison to cultivar Flirt during both the years.

Interaction between cultivar and pinching and GA_3 and pinching was found non-significant during both the years. Interaction among cultivar, GA_3 and pinching was also found non-significant during both the years. However, maximum plant height (70.39 and 76.06 cm) was recorded in cultivar Gauri with 200 ppm GA_3 and no pinching treatment and minimum plant height (28.84 and 30.99 cm) was recorded in cultivar

Flirt in control plants pinched at 45 days after transplanting during 1999 and 2000, respectively.

4.1.1.2 Plant spread

The data presented in Table 2 on the effect of different GA_3 and pinching treatments on plant spread showed that plant spread increased significantly over control with different concentrations of GA_3 in both the cultivars during both the years. Plant spread increased progressively with the increase in the concentration of GA_3 from 50 to 200 ppm and maximum plant spread was recorded in plants treated with 200 ppm GA_3 in both the cultivars during both the years. The differences among various concentrations of GA_3 were also found significant in both the cultivars during both the years except in cultivar Gauri during 1999 where the differences between 50 and 100 ppm GA_3 were found non-significant.

It is evident from data that pinching of plants at 35 days after transplanting significantly increased the plant spread over control and even pinching at 45 days after transplanting in cultivar Flirt during both the years whereas pinching of plants at 35 days after transplanting significantly increased the plant spread over control only in cultivar Gauri during both the years. The data also revealed that pinching at 45 days after transplanting significantly increased the plant spread over control in cultivar Flirt during 2000 only and in cultivar Gauri during 1999 and 2000. The differences between control and 45 days after transplanting were at par in cultivar Flirt during 1999 whereas the differences between 35 and 45 days after transplanting were found non-significant in cultivar Gauri during both the years.

Table 2. Effect of different GA_3 and pinching treatments on plant spread (cm) in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	18.57	20.78	19.62	19.65	19.17	21.91	20.46	20.51
	50	22.91	24.72	23.32	23.65	23.53	25.97	24.84	24.78
	100	25.70	27.61	26.17	26.49	26.25	28.07	27.57	27.29
	150	28.27	30.18	29.75	29.40	28.94	30.33	30.02	29.76
	200	30.51	32.74	31.18	31.47	31.80	33.81	32.26	32.62
	Mean	25.19	27.20	26.00	26.13	25.93	28.01	27.03	26.99
Gauri	0	19.43	25.21	24.16	22.93	21.77	26.21	25.75	24.57
	50	28.41	30.31	29.63	29.45	29.32	32.27	32.11	31.23
	100	29.03	30.61	30.29	29.97	34.07	35.68	34.52	34.75
	150	33.20	35.23	34.61	34.34	35.93	37.54	36.88	36.78
	200	35.95	37.23	36.88	36.68	37.62	39.62	37.97	38.40
	Mean	29.20	31.71	31.11	30.67	31.74	34.26	33.44	33.15
C.D. at 5%	Cultivar (A)			2.55				0.94	
	GA_3 (B)			1.23				1.19	
	Pinching (C)			0.95				0.92	
	Cultivar× GA_3 (AB)			NS				NS	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

The interactions between cultivar and GA_3, cultivar and pinching and GA_3 and pinching were found non-significant during both the years. Similarly, the interaction among cultivar, GA_3 and pinching was found non-significant during both the years. However, maximum plant spread (37.23 and 39.62 cm) was recorded in plants treated with 200 ppm GA_3 and pinched at 35 days after transplanting in cultivar Gauri whereas minimum plant spread (18.57 and 19.17 cm) was recorded in control plants which were neither sprayed nor pinched in cultivar Flirt during 1999 and 2000, respectively.

4.1.1.3 Number of branches

The data in Table 3 describing the effect of GA_3 and pinching on number of branches of chrysanthemum revealed that number of branches were increased significantly over control by various concentrations of GA_3 in both the cultivars during both the years. The number of branches increased progressively with the increase in concentration of GA_3 from 50 to 200 ppm and 200 ppm GA_3 produced maximum number of branches in both the cultivars during both the years. All the treatments of GA_3 also differed significantly from one another except in cultivar Flirt during 1999 where the differences between 150 and 200 ppm GA_3 were found non-significant in view of number of branches per plant.

It is clear from the data that pinching of plants at 35 days after transplanting significantly increased the number of branches over control in cultivar Flirt during 1999 whereas pinching of plants at 35 days after transplanting significantly increased the number of branches over control

Table 3. Effect of different GA_3 and pinching treatments on number of branches per plant in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	7.20	8.20	7.93	7.77	7.60	8.33	8.06	7.99
	50	9.86	10.73	10.06	10.21	10.06	11.86	10.33	10.75
	100	10.93	11.80	11.40	11.37	11.13	12.46	11.06	11.55
	150	12.06	13.33	12.80	12.73	12.40	13.40	12.86	12.88
	200	12.53	13.40	12.86	12.93	13.80	14.46	14.33	14.19
	Mean	10.51	11.49	11.01	11.00	10.99	12.10	11.32	11.47
Gauri	0	6.93	8.33	8.13	7.79	7.20	8.40	8.20	7.93
	50	12.26	14.13	13.06	13.15	13.06	16.26	15.13	14.81
	100	12.60	14.73	14.26	13.86	14.26	17.06	15.93	15.75
	150	13.66	15.00	14.93	14.53	15.26	17.26	16.73	16.41
	200	14.46	16.26	15.26	15.32	16.46	17.53	16.93	16.97
	Mean	11.98	13.69	13.12	12.93	13.24	15.30	14.58	14.37
C.D. at 5%	Cultivar (A)			1.26				0.71	
	GA_3 (B)			0.61				0.55	
	Pinching (C)			0.48				0.43	
	Cultivar× GA_3 (AB)			0.87				0.78	
	Cultivar×Pinching (AC)			NS				0.60	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

and even pinching of plants at 45 days after transplanting in cultivar Flirt during 2000 and in cultivar Gauri during 1999 and 2000. However, in cultivar Flirt, the differences between pinching after 35 and 45 days of transplanting and between unpinched control and pinching after 45 days of transplanting were found statistically at par during 1999 and 2000, respectively.

Interaction between cultivar and GA_3 was found significant during both the years and cultivar Gauri produced significantly more number of branches with different concentrations of GA_3 as compared to cultivar Flirt during both the years.

Interaction between cultivar and pinching was found non-significant during 1999 but significant during 2000. Cultivar Gauri produced significantly more number of branches in comparison to cultivar Flirt with various stages of pinching.

Interaction between GA_3 and pinching was found non-significant in both the cultivars during both the years. Similarly, the interaction among cultivar, GA_3 and pinching was found non-significant during both the years. However, maximum number of branches (16.26 and 17.53) per plant were produced in cultivar Gauri when the plants were sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting and minimum number of branches (6.93 and 7.20) were also produced in the cultivar Gauri in control plants during 1999 and 2000, respectively.

4.1.2 Floral parameters

4.1.2.1 Days to floral bud initiation

The data presented in Table 4 on the effect of different GA_3 and pinching treatments on days to floral bud initiation indicated that different concentrations of GA_3 significantly reduced the number of days to floral bud initiation over control in both the cultivars during both the years. The number of days to floral bud initiation decreased with the increase in concentration of GA_3 from 50 to 200 ppm and minimum number of days to floral bud initiation were recorded with 200 ppm GA_3 in both the cultivars during both the years. The differences among various concentrations of GA_3 were also found significant in view of the number of days required to floral bud initiation in both cultivars during both the years.

It is also evident from the data that control plants significantly reduced the number of days to floral bud initiation in comparison to pinching at 35 and 45 days after transplanting in both the cultivars during both the years. Pinching at 35 days after transplanting also reduced significantly the number of days to floral bud initiation over pinching at 45 days after transplanting in both the cultivars during both the years.

Interaction between cultivar and GA_3 was found non-significant during 1999 whereas interaction between cultivar and GA_3 was found significant during 2000. It was observed that the reduction in number of days to floral bud initiation was significantly more pronounced in cultivar Flirt in comparison to cultivar Gauri by different treatments of GA_3.

Table 4. Effect of different GA_3 and pinching treatments on days to flower bud initiation in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	70.40	71.06	72.60	71.35	76.06	77.06	78.80	77.30
	50	65.73	66.20	66.53	66.15	69.53	70.33	71.33	70.39
	100	62.66	63.40	64.66	63.57	65.73	66.73	67.06	66.50
	150	60.93	61.06	61.80	61.26	63.26	63.86	64.53	63.88
	200	59.53	60.20	60.73	60.15	62.86	62.93	63.13	62.97
	Mean	63.85	64.38	65.26	64.50	67.48	68.18	68.97	68.21
Gauri	0	78.06	79.46	80.46	79.32	84.86	85.33	86.26	85.48
	50	74.53	75.86	76.66	75.68	80.06	81.33	81.80	81.06
	100	71.60	71.73	72.33	71.88	76.06	76.80	77.46	76.77
	150	69.93	70.26	71.13	70.44	74.53	75.40	75.46	75.13
	200	68.73	69.46	69.80	69.33	73.13	73.20	74.06	73.46
	Mean	72.57	73.35	74.07	73.33	77.72	78.41	79.00	78.38
C.D. at 5%	Cultivar (A)			0.56				0.49	
	GA_3 (B)			0.66				0.67	
	Pinching (C)			0.51				0.52	
	Cultivar× GA_3 (AB)			NS				0.95	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

Interaction between cultivar and pinching was found non-significant during both the years. Interaction among cultivar, GA_3 and pinching was also found non-significant during both the years. However, the minimum number of days (59.53 and 62.86) to floral bud initiation were recorded in cultivar Flirt where plants were sprayed with 200 ppm GA_3 and where no pinching was done and maximum number of days (80.46 and 86.26) to floral bud initiation was recorded in cultivar Gauri in plants with no GA_3 application and pinched at 45 days after transplanting during 1999 and 2000, respectively.

4.1.2.2 Number of buds per plant

The data presented in Table 5 on the effect of different GA_3 and pinching treatments on the number of buds per plant in chrysanthemum showed that the number of buds per plant increased significantly over control with different concentration of GA_3 in both the cultivars during both the years. The number of buds increased with the increase in concentration of GA_3 from 50 to 200 ppm in both the cultivars during both the years and maximum number of buds per plant were recorded at the highest concentration of GA_3 i.e. 200 ppm in both the cultivars during both the years. However, the differences between 150 ppm and 200 ppm GA_3 were statistically at par in both the cultivars during both the years. The differences between 100 and 150 ppm GA_3 were also found non-significant in cultivar Gauri during 2000.

It is also clear from the data that pinching of plants at 35 days after transplanting significantly increased the number of buds over control and

Table 5. Effect of different GA_3 and pinching treatments on number of buds per plant in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting) 1999: Control	1999: 35	1999: 45	1999: Mean	2000: Control	2000: 35	2000: 45	2000: Mean
Flirt	0	20.06	24.20	22.60	22.28	20.86	24.26	23.53	22.88
	50	26.26	30.26	28.80	28.44	26.73	31.33	29.00	29.02
	100	30.66	33.06	32.06	31.92	31.86	35.20	33.06	33.37
	150	33.66	36.80	35.53	35.33	36.66	38.66	37.26	37.52
	200	34.93	37.93	35.93	36.26	37.06	39.53	38.06	38.21
	Mean	29.11	32.45	30.98	30.85	30.63	33.79	32.18	32.20
Gauri	0	20.73	25.66	21.06	22.48	25.53	29.33	27.20	27.35
	50	28.53	33.26	29.20	30.33	31.60	36.06	33.60	33.75
	100	33.40	39.53	38.53	37.15	45.13	53.46	49.06	49.21
	150	40.46	46.73	43.46	43.55	48.00	54.66	51.13	51.26
	200	41.60	47.33	44.66	44.53	49.33	57.93	51.86	53.04
	Mean	32.94	38.50	35.38	35.61	39.91	46.28	42.57	42.92
C.D. at 5%	Cultivar (A)			1.37				1.14	
	GA_3 (B)			1.82				2.08	
	Pinching (C)			1.41				1.61	
	Cultivar× GA_3 (AB)			2.58				2.94	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

even pinching of plants at 45 days after transplanting in the both cultivars during both the years except in cultivar Flirt during 2000 where pinching of plants at 35 days after transplanting significantly increased the number of buds over control only. However, the differences between pinching at 35 and 45 days after transplanting were found non-significant. Pinching at 45 days after transplanting significantly increased the number of buds per plant over control in cv. Flirt during 1999 and in cultivar Gauri during 1999 and 2000.

Interaction between cultivar and GA_3 was found significant during both the years. The maximum number of buds (47.33 and 57.93) were recorded in cultivar Gauri when the plants were sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting whereas the minimum number of buds (20.06 and 20.86) were recorded in control plants which were neither pinched nor sprayed with GA_3 in cultivar Flirt during 1999 and 2000, respectively.

Interaction between cultivar and pinching was non-significant during both the years. Interaction between GA_3 and pinching and interaction among cultivar, GA_3 and pinching were also found non-significant during both the years.

4.1.2.3 Days to flowering

The data related to the effect of GA_3 and pinching treatment on days to flowering is presented in Table 6. It is evident from the data that the number of days to flowering decreased significantly over control by various concentrations of GA_3. The number of days to flowering decreased

Table 6. Effect of different GA_3 and pinching treatments on days to flowering in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	94.93	96.06	98.20	96.39	101.46	102.80	104.53	102.93
	50	88.66	89.46	90.46	89.52	91.80	93.33	94.26	93.13
	100	83.60	84.53	85.86	84.66	86.66	87.93	88.13	87.57
	150	80.46	80.60	81.53	80.86	82.66	83.00	83.53	83.06
	200	79.66	80.13	80.33	80.04	82.20	82.43	82.60	82.41
	Mean	85.46	86.15	87.27	86.29	88.95	89.89	90.61	89.82
Gauri	0	108.13	109.13	110.60	109.28	114.60	116.06	117.20	115.95
	50	100.46	101.46	102.53	101.48	106.06	107.66	108.80	107.50
	100	94.13	95.00	96.06	95.06	98.20	98.86	100.20	99.08
	150	92.33	93.13	94.20	93.22	96.06	97.26	97.66	96.99
	200	90.46	90.60	91.06	90.70	93.13	93.53	94.20	93.62
	Mean	97.10	97.86	98.89	97.95	101.61	102.67	103.61	102.63
C.D. at 5%	Cultivar (A)			0.68				0.64	
	GA_3 (B)			0.65				0.70	
	Pinching (C)			0.50				0.54	
	Cultivar× GA_3 (AB)			0.91				0.99	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

with the increase in the concentration of GA_3 from 50 to 200 ppm in cultivars Flirt and Gauri during both the years and minimum number of days to flowering were recorded with 200 ppm GA_3 in both the cultivars during both the years which was closely followed by 150 ppm GA_3. However, the differences between 150 and 200 ppm GA_3 were found significant in both the cultivars during both the years except in cultivar Flirt during 2000. The differences among rest of the treatments were also found significant in both the cultivars during both the years.

It is also obvious from the data that pinching of plants at 45 days after transplanting significantly increased the number of days to flowering over control and even pinching of plants at 35 days after transplanting in both the cultivars during both the years. The differences between control and pinching at 35 days after transplanting were also found significant in both the cultivars during both the years of study and earliest flowering was recorded in non-pinched plants in both the cultivars during both the years.

The interaction between cultivar and GA_3 was found significant during both the years and earliest flowering (79.66 days) was recorded in cultivar Flirt during 1999 when plants were sprayed with 200 ppm GA_3 and where no pinching was done whereas most delayed flowering (117.20 days) was recorded in cultivar Gauri during 2000 in plants with no GA_3 spray and with pinching at 45 days after transplanting.

Interactions between cultivar and pinching and GA_3 and pinching were found non-significant during both the years. Interaction among cultivar, GA_3 and pinching was also found non-significant during both the years.

4.1.2.4 Duration of flowering

The data in Table 7 describing the effect of different GA_3 and pinching treatments on duration of flowering of chrysanthemum indicated that duration of flowering was extended significantly over control with different concentrations of GA_3 in both the cultivars during both the years. However, duration of flowering was increased with the increase in concentration of GA_3 from 50 to 100 ppm. Thereafter, decrease in duration of flowering was noticed at 150 ppm and 200 ppm GA_3 concentration in both the cultivars during both the years. The differences among 50, 150 and 200 ppm GA_3 in cultivar Flirt were found non-significant during both the years. However, in cultivar Gauri, the differences between 50 and 200 ppm GA_3 and between 150 and 200 ppm GA_3 were found non-significant during 1999 and the differences between 50 and 200 ppm GA_3 and between 100 and 150 ppm GA_3 were found non-significant during 2000.

It is also evident from the data that pinching of plants at 45 days significantly extended the duration of flowering over control and pinching of plants at 35 days after transplanting in both the cultivars during both the years except in cultivar Gauri during 2000 where pinching at 45 days after transplanting extended duration of flowering significantly over control only whereas the results at 35 and 45 days after transplanting were statistically at par. Pinching at 35 days after transplanting also increased the duration of flowering significantly over control in both the cultivars during both the years.

Table 7. ***Effect of different GA_3 and pinching treatments on duration of flowering (days) in chrysanthemum cvs. Flirt and Gauri***

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	8.26	9.53	10.40	9.39	8.73	9.53	10.53	9.59
	50	10.46	11.66	11.86	11.32	10.46	11.66	11.93	11.35
	100	11.46	11.93	12.80	12.06	11.66	12.06	12.93	12.21
	150	10.93	11.13	11.66	11.24	10.93	11.53	12.46	11.64
	200	10.93	11.00	11.46	11.13	11.26	11.53	12.06	11.61
	Mean	10.40	11.05	11.63	11.03	10.60	11.26	11.98	11.28
Gauri	0	10.80	11.80	12.53	11.71	11.66	12.13	12.80	12.19
	50	11.86	13.06	13.13	12.68	12.53	14.20	14.26	13.66
	100	13.53	14.06	14.53	14.04	14.06	15.00	15.20	14.75
	150	13.06	13.20	13.86	13.37	14.06	14.60	14.93	14.53
	200	12.53	12.80	13.66	12.99	13.06	13.40	13.86	13.44
	Mean	12.35	12.98	13.54	12.96	13.07	13.86	14.21	13.71
C.D. at 5%	Cultivar (A)			1.16				0.36	
	GA_3 (B)			0.51				0.50	
	Pinching (C)			0.40				0.39	
	Cultivar× GA_3 (AB)			NS				NS	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

Interaction between cultivar and GA_3, cultivar and pinching, and GA_3 and pinching were found non-significant during both the years of study. Interaction among cultivar, GA_3 and pinching was also found non-significant during both the years. However, maximum duration of flowering (14.53 and 15.20 days) were recorded in cultivar Gauri when the plants were sprayed with 100 ppm GA_3 and pinched at 45 days after transplanting and minimum duration of flowering (8.26 and 8.73 days) were recorded in cultivar Flirt in control plants which were neither sprayed nor pinched during 1999 and 2000, respectively.

4.1.2.5 Size of flower

The data in Table 8 pertaining to effect of different GA_3 and pinching treatments on size of flower of chrysanthemum showed that different concentrations of GA_3 and various stages of pinching significantly influenced the size of flower in cultivars Flirt and Gauri during both the years. It is obvious from the data that size of flower was increased significantly over control by all concentration of GA_3 in both the cultivars during both the years except in cultivar Gauri during 2000 where GA_3 at 100, 150 and 200 ppm concentration significantly increased the size of flower over control. However, the differences between 0 and 50 ppm GA_3 were statistically at par in view of size of flower. In general, size of flower was increased with the increase in concentration of GA_3 from 50 to 200 ppm in cultivars Flirt and Gauri during both the years and maximum size of flower was recorded at 200 ppm GA_3 in both the cultivars during both the years.

Table 8. Effect of different GA_3 and pinching treatments on size of flower (cm) in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	7.46	7.14	7.25	7.28	7.53	7.22	7.34	7.36
	50	7.56	7.38	7.52	7.48	7.63	7.45	7.54	7.54
	100	7.69	7.54	7.59	7.60	7.68	7.56	7.61	7.62
	150	7.78	7.56	7.70	7.68	7.75	7.62	7.67	7.68
	200	7.88	7.75	7.82	7.82	8.07	7.78	7.89	7.91
	Mean	7.67	7.47	7.57	7.57	7.73	7.53	7.61	7.62
Gauri	0	4.11	3.92	4.04	4.02	4.20	4.05	4.16	4.14
	50	4.21	4.09	4.18	4.16	4.25	4.10	4.18	4.18
	100	4.28	4.13	4.22	4.21	4.30	4.12	4.23	4.22
	150	4.33	4.14	4.24	4.24	4.36	4.16	4.28	4.27
	200	4.39	4.17	4.29	4.28	4.42	4.22	4.32	4.32
	Mean	4.26	4.09	4.19	4.18	4.31	4.13	4.23	4.23
C.D. at 5%	Cultivar (A)			0.04				0.06	
	GA_3 (B)			0.05				0.05	
	Pinching (C)			0.04				0.04	
	Cultivar× GA_3 (AB)			0.07				0.07	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

The data indicate that pinching of plants at 35 and 45 days after transplanting significantly decreased the size of flower over control in both the cultivars during both the years. Further more, pinching of plants at 35 days after transplanting also decreased the size of flower significantly over pinching of plants at 45 days after transplanting in both the cultivars during both the years.

Interaction between cultivar and GA_3 was found significant during both the years. Maximum size of flower (7.88 and 8.07 cm) was recorded in cultivar Flirt when the plants were sprayed with 200 ppm GA_3 and where no pinching was done and minimum size of flower (3.92 cm and 4.05cm) was recorded in cultivar Gauri in untreated plants pinched at 35 days after transplanting during 1999 and 2000, respectively.

Interactions between cultivar and pinching and GA_3 and pinching were found non-significant during both the years. Interaction among cultivar, GA_3 and pinching was also found non-significant during both the years.

4.1.2.6 Length of flower stalk

The data presented in Table 9 on the effect of different GA_3 and pinching treatments on the length of flower stalk of chrysanthemum revealed that different concentrations of GA_3 and various stages of pinching significantly influenced the length of flower stalk in cultivars Flirt and Gauri during both the years. Flower stalk length increased significantly over control by various concentration of GA_3 in both the cultivars during both the years. There was progressive increase in the length of flower

Table 9. Effect of different GA_3 and pinching treatments on stalk length of flower (cm) in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	10.01	9.30	9.09	9.47	12.34	11.80	11.39	11.84
	50	18.95	16.51	16.49	17.32	21.23	18.90	18.66	19.60
	100	22.96	18.94	17.69	19.86	25.57	20.39	20.01	21.99
	150	28.95	25.25	24.23	26.14	30.93	28.48	27.38	28.93
	200	38.28	31.96	31.76	34.00	41.68	32.11	31.69	35.16
	Mean	23.83	20.39	19.85	21.36	26.35	22.34	21.83	23.50
Gauri	0	12.96	12.09	11.05	12.03	13.66	12.17	12.04	12.62
	50	20.92	18.57	18.41	19.30	26.72	20.65	20.13	22.50
	100	28.44	23.66	22.33	24.81	30.06	25.04	24.12	26.41
	150	36.26	32.80	32.19	33.75	38.81	32.21	31.65	34.22
	200	39.58	35.81	35.23	36.87	40.51	36.59	36.42	37.84
	Mean	27.63	24.59	23.84	25.35	29.95	25.33	24.87	26.72
C.D. at 5%	Cultivar (A)			1.71				0.64	
	GA_3 (B)			1.02				0.83	
	Pinching (C)			0.79				0.65	
	Cultivar× GA_3 (AB)			1.44				1.18	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			1.76				1.44	
	Cultivar×GA_3×Pinching(ABC)			NS				2.04	

stalk with the increase in concentration of GA_3 from 50 to 200 ppm in both the cultivars during both the years and maximum length of flower stalk was recorded at 200 ppm GA_3 in both the cultivars during both the years. All the treatments of GA_3 also differed significantly from one another in view of length of flower stalk in both the cultivars during both the years.

It is clear from the data that pinching at 35 and 45 days after transplanting significantly decreased the length of flower stalk over control in both the cultivars during both the years. However, the differences between pinching at 35 and 45 days after transplanting were statistically at par in both the cultivars during both the years as far as length of flower stalk was concerned.

Interaction between cultivar and GA_3 was found significant during both the years. Interaction between cultivar and pinching was found non-significant during both the years whereas interaction between GA_3 and pinching was found significant during both the years. Interaction among cultivar, GA_3 and pinching was found non-significant during 1999 whereas it was found significant during the year 2000. However, maximum length of flower stalk (41.68 cm) was recorded in cultivar Flirt during 2000 where the plants were sprayed with 200 ppm GA_3 and where no pinching was done and minimum length of flower stalk (9.09 cm) was also recorded in cultivar Flirt during 1999 in untreated plants pinched at 45 days after transplanting. Cultivar Gauri recorded significantly more stalk length in comparison to cultivar Flirt during both the years.

Plate 1 : Effect of GA_3 and pinching on flower stalk length of chrysanthemum cv. Flirt

Plate 2 : Effect of GA_3 and pinching on flower stalk length of chrysanthemum cv. Gauri

4.1.2.7 Strength of flower stem

The data pertaining to effect of different GA_3 and pinching treatments on strength of flower stem of chrysanthemum is presented in Table 10. It is obvious from the data that different concentrations of GA_3 and various stages of pinching markedly influenced the strength of flower stem in both the cultivars during both the years.

The strength of flower stem was graded as 'A' in cultivar Flirt during both the years in all the treatment combinations of GA_3 and pinching except in plants sprayed with 200 ppm GA_3 and where no pinching was done and in this treatment combination, the strength of flower stem was graded as 'B' since the deviation of flower head below the horizontal line made an angle of 15°-30°.

Cultivar Gauri behaved differently by various treatment combinations of GA_3 and pinching in view of strength of flower stem during both the years of study. It is obvious from the data that strength of flower stem was decreased with the increase in concentration of GA_3 from 100 to 200 ppm and also decreased in plants where pinching was not followed. The strength of flower stem was graded as 'A' in treatment combination of 0, 50 and 100 ppm GA_3 with various stages of pinching in cultivar Gauri during 1999 except in treatment combination of 100 ppm GA_3 and no pinching in which strength of flower stem was graded as 'B'. The strength of flower stem further decreased with the increase in concentration of GA_3 upto 150 and 200 ppm combined with all the stages of pinching and in these treatment combinations, the strength of flower stem was graded as 'C'.

Table 10. Effect of different GA_3 and pinching treatments on strength of flower stem in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)					
		Control	35	45	Control	35	45
		1999			2000		
Flirt	0	A	A	A	A	A	A
	50	A	A	A	A	A	A
	100	A	A	A	A	A	A
	150	A	A	A	A	A	A
	200	B	A	A	B	A	A
Gauri	0	A	A	A	A	A	A
	50	A	A	A	B	A	A
	100	B	A	A	C	B	B
	150	C	C	C	C	C	C
	200	C	C	C	C	C	C

A = 0-15°
B = 15°-30°
C = >30°

The decrease in strength of flower stem was more pronounced in various treatment combinations of GA_3 and pinching in cv. Gauri during 2000. The strength of flower stem was graded as 'A' in treatment combination of 0 and 50 ppm GA_3 with no pinching and pinching at 35 and 45 days after transplanting in cultivar Gauri during 2000 except in treatment combination of 50 ppm GA_3 with no pinching in which 'B' grade of strength of flower stem was adjudged. The strength of flower stem was further decreased with the increase in concentration of GA_3 from 100 to 200 ppm at all the stages of pinching. The strength of flower stem was awarded 'C' grade in all the treatment combinations of 100, 150 and 200 ppm GA_3 with no pinching and pinching at 35 and 45 days after transplanting in cultivar Gauri during 2000 except treatment combinations of 100 ppm GA_3 with pinching at 35 and 45 days after transplanting where strength of flower stem was graded as 'B' showing deviation of flower head below horizontal line between 15°-30°.

4.1.3 Yield parameters

4.1.3.1 Number of flowers per plant

The data presented in Table 11 on the effect of different GA_3 and pinching treatments on the number of flowers per plant in chrysanthemum showed that the number of flowers per plant increased significantly over control by various concentrations of GA_3 in cultivars Flirt and Gauri during 1999 and 2000. The number of flowers per plant increased with the increase in the concentration of GA_3 from 50 to 200 ppm in both the cultivars during both the years and maximum number of flowers were recorded

Table 11. Effect of different GA_3 and pinching treatments on number of flowers per plant in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	17.33	21.86	19.80	19.66	18.40	21.66	20.33	20.13
	50	24.66	27.60	26.26	26.17	24.20	28.86	25.60	26.22
	100	28.06	30.53	29.06	29.22	29.93	32.46	30.73	31.04
	150	30.66	33.26	31.93	31.95	32.33	35.13	33.06	33.51
	200	31.06	33.73	32.13	32.30	32.60	35.60	33.33	33.84
	Mean	26.35	29.39	27.84	27.86	27.49	30.74	28.61	28.95
Gauri	0	17.46	20.93	18.40	18.93	19.73	23.73	21.73	21.73
	50	24.06	28.13	26.00	26.06	25.86	31.53	28.60	28.66
	100	28.46	34.66	32.13	31.75	39.60	46.26	41.40	42.42
	150	34.93	40.13	36.86	37.31	42.13	49.06	43.20	44.80
	200	35.73	40.80	37.40	37.98	42.86	50.06	44.13	45.68
	Mean	28.13	32.93	30.16	30.41	34.04	40.13	35.81	36.66
C.D. at 5%	Cultivar (A)			1.88				1.87	
	GA_3 (B)			1.52				1.91	
	Pinching (C)			1.18				1.48	
	Cultivar× GA_3 (AB)			2.16				2.70	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

with 200 ppm GA_3 which was closely followed by 150 ppm GA_3 in both the cultivars during both the years. Hence, the differences between 150 and 200 ppm GA_3 were found non-significant in both the cultivars during both the years.

It is also clear from the data that pinching of plants at 35 days after transplanting significantly increased the number of flowers per plant over control and even pinching of plants at 45 days after transplanting in both the cultivars during both the years. The differences between control and pinching of plants at 45 days after transplanting were also found significant in both the cultivars during both the years except in cultivar Flirt during 2000 where the differences between these two were found statistically at par.

Interaction of cultivar and GA_3 exert significant influence on the number of flowers during both the years. Interaction between cultivar and pinching and GA_3 and pinching was found non significant during both the years. Interaction among cultivar, GA_3 and pinching was also non-significant during both the years. However, maximum number (40.80 and 50.06) of flowers were recorded in cultivar Gauri when the plants were sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting during 1999 and 2000, respectively and minimum number (17.33 and 18.40) of flowers were registered in cultivar Flirt in plants which were neither sprayed nor pinched during 1999 and 2000, respectively.

4.1.3.2 Weight of flower

The data describing the effect of different GA_3 and pinching treatments on weight of flower of chrysanthemum are presented in Table 12. It is revealed from the data that different concentrations of GA_3 significantly increased the weight of flower over control in both the cultivars during both the years except in cultivar Gauri during 2000 where results in control and 200 ppm GA_3 treatments were statistically at par. The differences among most of treatments of GA_3 were found non-significant in both the cultivars during both the years. A gradual decline in weight of flower was recorded from 50 to 200 ppm GA_3 in both the cultivars during both the years. However, maximum flower weight was recorded at 50 ppm GA_3 and minimum flower weight was recorded in control plants in both the cultivars during both the years.

The data clearly indicate that pinching at 35 and 45 after transplanting significantly decreased the weight of flower over control in both the cultivars during both the years. However, the differences between control and pinching at 45 days after transplanting were found non-significant in cv. Gauri during 1999. The differences between 35 and 45 days after transplanting were also found significant during both the years in both the cultivars under study.

Interactions of cultivar and GA_3 and cultivar and pinching were found significant in case of weight of flower during both the years. However, interaction between GA_3 and pinching and interaction among cultivar, GA_3 and pinching were found non-significant during both the years. Maximum weight of flower (3.73 and 3.70 g) was recorded in cultivar Flirt where the plants were sprayed with 50 ppm GA_3 and where

Table 12. Effect of different GA_3 and pinching treatments on weight of flower (g) in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	3.56	3.23	3.34	3.38	3.59	3.31	3.43	3.44
	50	3.73	3.52	3.64	3.63	3.70	3.58	3.64	3.64
	100	3.72	3.50	3.61	3.61	3.68	3.54	3.62	3.61
	150	3.69	3.47	3.58	3.58	3.66	3.51	3.60	3.59
	200	3.66	3.45	3.57	3.56	3.64	3.48	3.58	3.57
	Mean	3.67	3.43	3.55	3.55	3.65	3.48	3.57	3.57
Gauri	0	2.01	1.91	1.96	1.96	2.04	1.94	2.02	2.00
	50	2.12	2.02	2.09	2.08	2.15	2.06	2.10	2.10
	100	2.08	2.01	2.05	2.05	2.12	2.02	2.08	2.07
	150	2.06	2.00	2.03	2.03	2.09	1.99	2.05	2.04
	200	2.04	1.98	2.01	2.01	2.06	1.96	2.02	2.01
	Mean	2.06	1.98	2.03	2.03	2.09	1.99	2.05	2.04
C.D. at 5%	Cultivar (A)			0.02				0.02	
	GA_3 (B)			0.04				0.03	
	Pinching (C)			0.03				0.02	
	Cultivar× GA_3 (AB)			0.05				0.04	
	Cultivar×Pinching (AC)			0.04				0.03	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching(ABC)			NS				NS	

no pinching was done whereas minimum weight of flower (1.91 and 1.94 g) was recorded in cultivar Gauri in untreated plants pinched at 35 days after transplanting during 1999 and 2000, respectively.

4.1.3.3 Yield of flower per plant

The data presented in Table 13 on the effect of different GA_3 and pinching treatments on yield per plant clearly showed that the yield per plant increased significantly over control by different concentrations of GA_3 and yield per plant increased with the increase in concentration of GA_3 from 50 to 200 ppm and maximum yield per plant was recorded at 200 ppm GA_3 in both the cultivars during both the years. However, the differences between 150 and 200 ppm GA_3 were statistically at par in both the cultivars during both the years. Although, in cultivar Gauri during 2000, the differences between 100 and 150 ppm GA_3 were also found non-significant as far as yield per plant was concerned.

It is also evident from the data that pinching of plants at 35 days after transplanting caused significant increase in yield per plant over control and even pinching of plants at 45 days after transplanting in both the cultivars during both the years except in cultivar Flirt during 1999 in which differences between control and pinching at 35 days after transplanting were found significant but the differences between control and pinching at 45 days after transplanting and between pinching at 35 and 45 days after transplanting were found non-significant. The differences between control and pinching at 45 days after transplanting were found statistically at par in cultivar Flirt during 2000 and in cultivar Gauri during 1999 and 2000 in case of yield of flower per plant.

Table 13. Effect of different GA_3 and pinching treatments on yield per plant (g) in chrysanthemum cvs. Flirt and Gauri

Cultivars	Treatments GA_3 (ppm)	Pinching (Days after transplanting)							
		Control	35	45	Mean	Control	35	45	Mean
		1999				2000			
Flirt	0	61.70	70.56	66.06	66.11	67.21	71.73	69.76	69.57
	50	92.00	97.21	95.59	94.93	89.48	103.41	93.18	95.36
	100	104.41	106.83	104.78	105.34	110.17	114.96	111.23	112.12
	150	113.16	115.41	114.34	114.30	118.39	123.37	118.95	120.24
	200	113.73	116.39	114.84	114.99	118.54	123.83	119.21	120.53
	Mean	97.00	101.28	99.12	99.13	100.76	107.46	102.47	103.56
Gauri	0	34.99	39.94	36.13	37.02	40.24	46.12	43.87	43.41
	50	51.03	56.81	54.32	54.05	55.50	65.06	60.15	60.24
	100	59.32	69.69	65.77	64.93	83.93	93.62	86.25	87.93
	150	72.09	80.28	74.87	75.75	88.05	97.68	88.53	91.42
	200	72.90	80.74	75.16	76.27	88.38	98.05	89.11	91.85
	Mean	58.07	65.49	61.25	61.60	71.22	80.11	73.58	74.97
C.D. at 5%	Cultivar (A)			4.52				3.80	
	GA_3 (B)			4.23				5.59	
	Pinching (C)			3.28				4.33	
	Cultivar× GA_3 (AB)			5.98				NS	
	Cultivar×Pinching (AC)			NS				NS	
	GA_3×Pinching (BC)			NS				NS	
	Cultivar×GA_3×Pinching (ABC)			NS				NS	

Interaction between cultivar and GA_3 was found significant during 1999 but was found non-significant during 2000. However, maximum yield per plant (116.39 and 123.83 g) was recorded in cultivar Flirt where the plants were sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting during 1999 and 2000, respectively. It was statistically at par with 150 ppm GA_3 treatment in combination with pinching at 35 days after transplanting in cv. Flirt during both the years. Minimum yield per plant (34.99 and 40.24 g) was recorded in control plants in cultivar Gauri during 1999 and 2000, respectively.

Interactions between cultivar and pinching and GA_3 and pinching were found non-significant during both the years. Interaction among cultivar, GA_3 and pinching was also found non-significant during both the years. Cultivar Flirt recorded significantly more yield of flower per plant over cultivar Gauri with different treatment combinations of GA_3 and pinching during both the years.

EXPERIMENT-II

4.2 To Study the effect of different chemicals on vase life of cut flowers of chrysanthemum cvs. Flirt and gauri

4.2.1 Fresh Weight of Cut flower

4.2.1.1 Increase/Decrease (%) in fresh weight in cv. Flirt during 1999

The data recorded on per cent increase or decrease in fresh weight of cut flower of chrysanthemum cv. Flirt during 1999 are presented in Table 14. It is obvious from the data that fresh weight of cut flower was influenced markedly over control after keeping in different vase solutions

Table 14. Effect of different chemical treatments on increase/decrease (%) in fresh weight of cut flower at different days of vase life in chrysanthemum cv. Flirt during 1999

Treatments	Increase/decrease (%) in fresh weight at different days of vase life					
	4	8	12	16	20	24
T_1 - Control (Tap water)	+6.82	+0.23	-9.64	-14.35	-27.05	-47.52
T_2 - Distilled water	+6.50	+5.54	-8.43	-12.04	-19.75	-40.24
T_3 - Sucrose 4%	+13.64	+18.89	+17.32	-2.62	-18.63	-33.07
T_4 - Aluminium sulphate 0.2%	+7.10	+8.15	+3.94	-12.63	-35.78	-39.47
T_5 - Cobalt sulphate 0.02%	+3.49	+5.37	+0.80	-13.97	-34.94	-40.05
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	+15.69	+18.61	+18.35	+3.45	-13.56	-26.86
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	+11.79	+12.77	+10.07	+1.71	-19.90	-27.27
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	+8.70	+9.70	+1.99	-0.74	-29.35	-33.33
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	+13.60	+19.14	+17.38	+3.52	-8.81	-24.18

of sucrose 4%, aluminium sulphate 0.2%, cobalt sulphate 0.02% and their possible combinations. In control and distilled water treatment, fresh weight of cut flower increased upto 8 days after which decrease in fresh weight of cut flower was noticed upto day 24 of vase life. Maximum gain weight (6.82%) and maximum loss in weight (-47.52%) were recorded in control treatment on day 4 and 24, respectively.

Fresh weight of cut flower increased over initial weight upto day 12 in vase solutions of sucrose 4%, aluminium sulphate 0.2%, and cobalt sulphate 0.02%. Maximum gain in weight (18.89%) was recorded in sucrose 4% solution on day 8 and minimum gain in weight (0.80%) was recorded in cobalt sulphate 0.02% solution on day 12 of vase life. On day 16 and onwards, fresh weights of cut flowers decreased over their initial weights and this decrease continued till day 24. However, among vase solutions of sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02%, maximum loss in weight (-40.05%) was registered in cobalt sulphate 0.02% solution and minimum loss in weight (-33.07%) was registered in sucrose 4% solution on day 24 of vase life.

Various combinations of sucrose, aluminium sulphate and cobalt sulphate further proved beneficial in retaining fresh weight of flowers over their individual effects and fresh weight increased upto day 16 of vase life except vase solution of aluminium sulphate 0.2% + cobalt sulphate 0.02%. However, maximum gain in weight (19.14%) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 8 of vase life whereas minimum gain in weight (1.71%) was recorded in vase solution of sucrose 4% + cobalt sulphate 0.02% on day 16 of vase life. After day 20 and onwards, loss in weight over initial weight was noticed and maximum loss in weight (-33.33%) was recorded in vase solution of aluminium sulphate 0.2% + cobalt sulphate 0.02% and minimum loss in weight (-24.18%) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 24 of vase life.

4.2.1.2 Increase/Decrease (%) in fresh weight in cv. Flirt during 2000

The data recorded on increase or decrease (%) in fresh weight of cut flower of chrysanthemum cv. Flirt during 2000 are presented in Table 15. It is clear from the data that fresh weight of cut flower was significantly increased over control in all the chemical treatments. In control treatment, fresh weight of cut flower increased upto day 4 after which a significant decrease in fresh weight was recorded upto day 24 of vase life where maximum loss in fresh weight (-48.10%) was recorded. In distilled water treatment, fresh weight increased upto day 4, maintained upto day 8 and significantly decreased after day 12 onwards upto day 24 of vase life.

Fresh weight of cut flower increased over initial weight upto day 12 in individual vase solutions of sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02%. However, maximum gain in weight (25.58%) over initial weight was recorded in aluminium sulphate 0.2% solution on day 8 and minimum gain in weight (8.73%) was recorded in cobalt sulphate 0.02% solution on day 12 of vase life. On day 16 and onwards, loss in fresh weights over initial weights was recorded in vase solutions of sucrose

Table 15. Effect of different chemical treatments on increase/decrease (%) in fresh weight of cut flower at different days of vase life in chrysanthemum cv. Flirt during 2000

Treatments	Increase/decrease (%) in fresh weight at different days of vase life					
	4	8	12	16	20	24
T_1 - Control (Tap water)	+14.86	-10.54	-14.05	-21.08	-34.32	-48.10
T_2 - Distilled water	+14.00	-	-13.72	-18.76	-32.49	-43.69
T_3 - Sucrose 4%	+18.27	+21.48	+13.08	-9.13	-20.98	-31.11
T_4 - Aluminium sulphate 0.2%	+16.27	+25.58	+12.40	-10.59	-24.03	-31.78
T_5 - Cobalt sulphate 0.02%	+14.02	+15.87	+8.73	-12.69	-26.71	-35.18
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	+20.37	+24.86	+14.55	+2.11	-9.78	-28.30
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	+14.04	+22.06	+18.91	+2.29	-13.18	-30.65
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	+15.45	+20.90	+9.69	+0.90	-18.18	-33.93
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	+14.84	+26.30	+15.36	+3.64	-9.37	-23.69

4%, aluminium sulphate 0.2% and cobalt sulphate 0.02% and maximum loss in weight was registered on day 24 of vase life in vase solutions of sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02%. However, maximum loss in weight (-35.18%) was recorded in cobalt sulphate 0.02% solution and minimum loss in weight (-31.11%) was recorded in sucrose 4% solution on day 24 of vase life.

Various possible combinations of sucrose, aluminium sulphate and cobalt sulphate further increased the fresh weight of flower over their individual vase solutions and gain in fresh weight was recorded upto day 16. However, maximum gain in weight (26.30%) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 8 of vase life and minimum gain in weight (0.90%) was registered in vase solution of aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 16 of vase life. After day 20 and onwards, loss in weight of cut flower was recorded upto day 24 of vase life. On 24 day of vase life, maximum loss in weight (-33.93%) was noticed in aluminium sulphate 0.2%+ cobalt sulphate 0.02% solution whereas minimum loss in weight (-23.69%) was registered in sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% solution.

4.2.1.3 Increase/decrease (%) in fresh weight in cv. Gauri during 1999

The data recorded on increase or decrease (%) in fresh weight of cut flower of chrysanthemum cv. Gauri during 1999 are presented in Table 16. It is clear from the data that fresh weight of cut flower was influenced markedly over control by various chemical treatments. In

Table 16. Effect of different chemical treatments on increase/decrease (%) in fresh weight of cut flower at different days of vase life in chrysanthemum cv. Gauri during 1999

Treatments	Increase/decrease (%) in fresh weight at different days of vase life						
	4	8	12	16	20	24	28
T_1 - Control (Tap water)	+2.06	-1.03	-4.12	-11.34	-17.86	-31.61	-42.95
T_2 - Distilled water	+3.71	+1.68	-2.03	-3.04	-15.20	-28.04	-40.87
T_3 - Sucrose 4%	+6.90	+11.27	+22.90	+9.81	-2.54	-11.27	-28.72
T_4 - Aluminium sulphate 0.2%	+3.01	+5.35	+7.69	+4.68	-4.01	-20.06	-37.12
T_5 - Cobalt sulphate 0.02%	+2.48	+3.54	+13.82	+1.06	-11.35	-29.43	-37.94
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	+9.09	+13.80	+26.26	+14.81	+1.01	-8.08	-23.56
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	+15.32	+18.61	+17.15	+12.04	+1.45	-10.21	-27.73
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	+4.89	+7.69	+9.44	+6.29	-3.49	-16.78	-36.01
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	+20.40	+27.09	+28.76	+12.37	+4.68	-6.02	-15.71

control treatment, fresh weight of cut flower increased upto day 4 after which decrease in fresh weight of cut flower over the initial weight was noticed upto day 28. In distilled water, increase in fresh weight was recorded upto day 8 after which decrease in fresh weight of cut flower was recorded upto day 28. However, on day 28 of vase life, maximum loss in fresh weight (-42.95%) was recorded in control treatment compared to (-40.87%) in distilled water.

It is also obvious from the data that fresh weight of cut flower increased upto day 16 in vase solutions of sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02%. However, maximum gain in weight (22.90%) was recorded in sucrose 4% solution on day 12 and minimum gain in weight (1.06%) was recorded in cobalt sulphate 0.02% solution on day 16 of vase life. On day 20 and onwards, decrease in fresh weight over initial weight was recorded in sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02% solution. However, maximum loss in weight (-37.94%) was recorded in cobalt sulphate 0.02% solution closely followed by aluminium sulphate 0.2% solution (-37.12%) and minimum loss in weight (-28.72%) was recorded in sucrose 4% solution on day 28 of vase life.

It is evident from the data that various combinations of sucrose, aluminium sulphate and cobalt sulphate further enhanced the fresh weights of cut flowers over their individual effects and gain in fresh weight was recorded upto day 20 in all combinations of sucrose, aluminium sulphate and cobalt sulphate except treatment combination of aluminium sulphate

0.2% + cobalt sulphate 0.02% in which fresh weight of cut flower increased upto day 16 only after which decrease in fresh weight was noticed upto day 28 of vase life. In other combinations, fresh weight decreased after day 24 and onwards. However, maximum loss in weight of cut flower (-36.01%) was recorded in vase solution of aluminium sulphate 0.2%+cobalt sulphate 0.02% and minimum loss in weight (-15.71%) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 28 of vase life. Among various combinations, maximum gain in weight (28.76%) was also recorded in treatment combination of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 12 of vase life.

4.2.1.4 Increase/decrease (%) in fresh weight in cv. Gauri during 2000

The data describing increase or decrease (%) in fresh weight of cut flower of chrysanthemum cv. Gauri during 2000 are presented in Table 17. The data revealed that fresh weight of cut flower was markedly affected by various chemical treatments over control. In control and distilled water treatments, fresh weight of cut flower increased upto day 8 after which decrease in fresh weight of cut flower was noticed upto day 28 of vase life. However, maximum gain in weight (5.37%) was recorded in distilled water on day 4 of vase life and minimum gain in weight (0.84%) was recorded in control treatment on day 8 of vase life. On the other hand, maximum loss in weight (-45.56%) was recorded in control treatment compared to (-41.32%) loss in weight in distilled water treatment.

Table 17. Effect of different chemical treatments on increase/decrease (%) in fresh weight of cut flower at different days of vase life in chrysanthemum cv. Gauri during 2000

Treatments	Increase/decrease (%) in fresh weight at different days of vase life						
	4	8	12	16	20	24	28
T_1 - Control (Tap water)	+2.11	+0.84	-3.37	-9.70	-20.25	-37.97	-45.56
T_2 - Distilled water	+5.37	+3.72	-3.72	-7.44	-16.94	-33.06	-41.32
T_3 - Sucrose 4%	+6.74	+11.23	+12.36	+9.36	-3.74	-22.47	-26.59
T_4 - Aluminium sulphate 0.2%	+3.57	+7.86	+12.14	+3.57	-8.21	-22.86	-37.86
T_5 - Cobalt sulphate 0.02%	+3.16	+8.30	+13.44	+2.37	-13.44	-28.85	-38.73
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	+9.13	+16.96	+25.65	+13.04	+8.26	-12.61	-24.78
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	+7.48	+10.24	+13.38	+9.84	+6.69	-15.35	-25.59
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	+6.22	+12.89	+20.00	+5.33	+0.44	-19.11	-36.89
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	+21.30	+26.35	+33.21	+26.71	+10.47	-4.69	-17.69

It is also revealed from the data that fresh weight of cut flower increased upto day 16 in sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02% solution after which decrease in fresh weight of cut flower was noticed upto day 28 of vase life. However, maximum gain in fresh weight (13.44%) and minimum gain in fresh weight (2.37%) was recorded in cobalt sulphate 0.02% on day 12 and 16 of vase life. On day 28, maximum loss in weight (-38.73%) was recorded in cobalt sulphate 0.02% solution closely followed by aluminium sulphate 0.2% solution (-37.86%) and minimum loss in weight (-26.59%) was recorded in sucrose 4% solution.

It is also evident from the data in Table 17 that various combinations of sucrose, aluminium sulphate and cobalt sulphate further increased the fresh weight of cut flowers over their individual effects. Gain in fresh weight was recorded upto day 20 in various combinations of sucrose, aluminium sulphate and cobalt sulphate after which loss in fresh weight was recorded upto day 28 of vase life. However, maximum gain in weight (33.21%) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 12 of vase life and minimum gain in weight (0.44%) was recorded in vase solution of aluminium sulphate 0.2%+ cobalt sulphate 0.02% on day 20 of vase life. On the other hand, maximum loss in weight (-36.89%) was recorded in aluminium sulphate 0.2% + cobalt sulphate 0.02% solution and minimum loss in weight (-17.69%) was recorded in sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% solution on day 28 of vase life.

4.2.2 Water Uptake

4.2.2.1 Water uptake in cv. Flirt during 1999

The data describing effect of different chemical treatments on water uptake (g/flower) at different days of vase life in chrysanthemum cv. Flirt during 1999 are presented in Table 18. It is obvious from the data that water uptake decreased with the increase in period of vase life in all the treatments including control. Mean of water uptake of individual days was recorded maximum (1.30 g/flower) in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% and minimum (1.08 g/flower) in control. The differences among control, distilled water, sucrose, aluminium sulphate and cobalt sulphate were found non-significant in view of water uptake. The differences among sucrose 4% + aluminium sulphate 0.2%, sucrose 4% + cobalt sulphate 0.02% and aluminium sulphate 0.2%+ cobalt + sulphate 0.02% were also found statistically at par as far as water uptake by cut flower was concerned. Interaction between treatment and day was also found significant and maximum water uptake (1.71 g/flower) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2%+ cobalt sulphate 0.02% on day 4 whereas minimum water uptake (0.28 g/flower) was recorded in control treatment on day 24 of vase life.

4.2.2.2 Water uptake in cv. Flirt during 2000

The data with respect to effect of different chemical treatments on water uptake (g/flower) at different days of vase life in chrysanthemum cv. Flirt during 2000 are presented in Table 19. The data indicate that water uptake decreased gradually with the increase in period of vase life

Table 18. Effect of different chemical treatments on water uptake (g/flower) at different days of vase life in chrysanthemum cv. Flirt during 1999

Treatments	Water uptake (g/flower) at different days of vase life						
	4	8	12	16	20	24	Mean
T_1 - Control (Tap water)	1.61	1.53	1.30	1.08	0.71	0.28	1.08
T_2 - Distilled water	1.67	1.62	1.29	1.03	0.63	0.34	1.10
T_3 - Sucrose 4%	1.56	1.43	1.27	1.00	0.82	0.74	1.13
T_4 - Aluminium sulphate 0.2%	1.61	1.43	1.27	0.99	0.81	0.67	1.13
T_5 - Cobalt sulphate 0.02%	1.54	1.45	1.22	1.10	0.81	0.53	1.11
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	1.57	1.44	1.23	1.09	0.94	0.85	1.19
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.65	1.38	1.22	1.06	0.95	0.81	1.18
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.60	1.33	1.19	1.09	0.92	0.81	1.16
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	1.71	1.52	1.43	1.20	1.01	0.93	1.30
Mean	1.61	1.46	1.27	1.07	0.84	0.66	
C.D. at 5% Treatment (T)	0.06						
Day (D)	0.05						
T×D	0.15						

Table 19. Effect of different chemical treatments on water uptake (g/flower) at different days of vase life in chrysanthemum cv. Flirt during 2000

Treatments		Water uptake (g/flower) at different days of vase life					
	4	8	12	16	20	24	Mean
T_1 - Control (Tap water)	1.64	1.06	0.85	0.78	0.51	0.21	0.84
T_2 - Distilled water	1.76	1.09	0.90	0.72	0.42	0.22	0.85
T_3 - Sucrose 4%	1.72	1.46	1.18	0.98	0.76	0.41	1.08
T_4 - Aluminium sulphate 0.2%	1.58	1.24	1.04	0.90	0.59	0.38	0.96
T_5 - Cobalt sulphate 0.02%	1.59	1.38	1.01	0.84	0.49	0.26	0.93
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	1.90	1.42	1.22	1.09	0.85	0.61	1.18
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.76	1.36	1.11	0.96	0.78	0.58	1.09
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.68	1.26	1.03	0.92	0.62	0.41	0.99
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	1.89	1.56	1.26	1.02	0.86	0.57	1.19
Mean	1.72	1.32	1.07	0.91	0.65	0.41	
C.D. at 5% Treatment (T)	0.07						
Day (D)	0.06						
T×D	NS						

in all the treatments including control and minimum water uptake (0.41 g/flower) was recorded on day 24 of vase life. All the chemical treatments significantly increased water uptake over control. Among various treatments, maximum water uptake (1.19 g/flower) was recorded in treatment combination of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% which was statistically at par with treatment combination of sucrose 4% + aluminium sulphate 0.2% (1.18 g/flower). The differences between control and distilled water, between sucrose 4% and sucrose 4% + cobalt sulphate 0.02% and among aluminium sulphate 0.2%, cobalt sulphate 0.02% and aluminium sulphate 0.2% + cobalt sulphate 0.02% were found non-significant in case of water uptake by cut flower. Interaction between treatment and day did not exert significant influence on water uptake in cultivar Flirt during 2000.

4.2.2.3 Water uptake in cv. Gauri during 1999

The data pertaining to effect of different chemical treatment on water uptake (g/flower) at different days of vase life in chrysanthemum cv. Gauri during 1999 are presented in Table 20 which clearly indicates that water uptake by cut flower decreased with the increase in period of vase life in all the treatments including control. Water uptake decreased from 1.47 g/flower to 0.35 g/flower from day 4 to day 28. All the chemical treatments significantly increased the water uptake over control treatment. Among various treatments, maximum water uptake (1.06 g/flower) was recorded in vase solutions of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% and sucrose 4% + aluminium sulphate 0.2% (1.06g flower)

Table 20. Effect of different chemical treatments on water uptake (g/flower) at different days of vase life in chrysanthemum cv. Gauri during 1999

Treatments	Water uptake (g/flower) at different days of vase life							
	4	8	12	16	20	24	28	Mean
T_1 - Control (Tap water)	1.32	1.12	0.92	0.57	0.42	0.36	0.21	0.70
T_2 - Distilled water	1.23	1.13	0.94	0.68	0.48	0.42	0.25	0.73
T_3 - Sucrose 4%	1.68	1.27	1.07	0.91	0.71	0.58	0.33	0.94
T_4 - Aluminium sulphate 0.2%	1.52	1.30	1.12	0.91	0.84	0.49	0.32	0.93
T_5 - Cobalt sulphate 0.02%	1.22	1.12	0.98	0.82	0.69	0.43	0.31	0.79
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	1.82	1.40	1.19	1.01	0.87	0.65	0.47	1.06
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.48	1.40	1.24	1.16	1.01	0.65	0.40	1.05
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.38	1.22	1.07	0.99	0.89	0.56	0.41	0.93
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	1.60	1.47	1.31	1.10	0.85	0.64	0.47	1.06
Mean	1.47	1.27	1.09	0.90	0.75	0.53	0.35	
C.D. at 5% Treatment (T)	0.04							
Day (D)	0.04							
T×D	0.11							

which were at par with sucrose 4% + cobalt sulphate 0.02% (1.05 g/flower). The differences between control and distilled water and among sucrose 4%, aluminium sulphate 0.2% and aluminium sulphate 2% + cobalt sulphate 0.02% were also found non-significant in case of water uptake by cut flower. Minimum water uptake (0.70 g/flower) was recorded in control treatment. Interaction between treatment and day was found significant and maximum water uptake (1.82 g/flower) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% on day 4 and minimum water uptake (0.21 g/flower) was recorded in control treatment on day 28 of vase life.

4.2.2.4 Water uptake in cv. Gauri during 2000

The data on the effect of different chemical treatments on water uptake by cut flowers of chrysanthemum cv. Flirt during vase life in 2000 are presented in Table 21. It is evident from the data that water uptake decreased with the increase in period of vase life in all the treatments including control. All the chemical treatments significantly increased the water uptake over control except cobalt sulphate 0.02% solution which was statistically at par with control and distilled water both. Among various treatments, vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% recorded maximum water uptake (0.88 g/flower) which was highly significant over all the treatments except sucrose 4% + aluminium sulphate 0.2% and sucrose 4% + cobalt sulphate 0.02%.

The differences among rest of the treatments were also found statistically at par. Interaction between treatment and day exhibit

Table 21. Effect of different chemical treatments on water uptake (g/flower) at different days of vase life in chrysanthemum cv. Gauri during 2000

Treatments	Water uptake (g/flower) at different days of vase life							
	4	8	12	16	20	24	28	Mean
T_1 - Control (Tap water)	1.23	1.02	0.94	0.69	0.53	0.20	0.14	0.68
T_2 - Distilled water	1.35	1.10	0.86	0.62	0.45	0.24	0.15	0.68
T_3 - Sucrose 4%	1.46	1.11	0.97	0.79	0.59	0.46	0.37	0.82
T_4 - Aluminium sulphate 0.2%	1.33	1.16	1.01	0.94	0.72	0.29	0.16	0.80
T_5 - Cobalt sulphate 0.02%	1.26	1.09	0.91	0.75	0.47	0.22	0.15	0.69
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	1.30	1.04	0.95	0.78	0.73	0.59	0.49	0.84
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.28	1.06	0.94	0.86	0.75	0.56	0.41	0.84
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.60	1.14	0.94	0.75	0.60	0.37	0.27	0.81
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	1.53	1.18	1.05	0.90	0.66	0.49	0.33	0.88
Mean	1.37	1.10	0.95	0.78	0.61	0.38	0.27	

C.D. at 5%	Treatment (T)	0.05
	Day (D)	0.04
	T×D	0.13

significant influence on water uptake in cv. Gauri during 2000. Maximum water uptake (1.60 g/flower) was recorded in vase solution of aluminium sulphate 0.2%+ cobalt sulphate 0.02% on day 4 of vase life and minimum water uptake (0.14 g/flower) was recorded in control treatment on day 28 of vase life.

4.2.3 Water Loss

4.2.3.1 Water loss in cv. Flirt during 1999

The data on the effect of different chemical treatments on water loss (g/flower) at different days of vase life in chrysanthemum cv. Flirt during 1999 are presented in Table 22. It is clear from the data that water loss did not show a proper pattern and there were ups and downs in water loss during vase life of cut flower in various treatments. However, mean water loss increased upto day 20 and then decreased on day 24. All the treatments did not differ significantly except sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% solution in which water loss increased significantly over all other treatments excluding control and aluminium sulphate 0.2% + cobalt sulphate 0.02%. Interaction between treatment and day was found significant. Maximum water loss (2.07 g/ flower) was recorded in aluminium sulphate 0.2% + cobalt sulphate 0.02% solution on day 20 and minimum water loss (0.72 g/flower) was recorded in cobalt sulphate 0.02% solution on day 24 of vase life.

4.2.3.2 Water loss in cv. Flirt during 2000

The data pertaining to effect of different chemical treatments on water loss at different days of vase life in chrysanthemum cv. Flirt during

Table 22. Effect of different chemical treatments on water loss (g/flower) at different days of vase life in chrysanthemum cv. Flirt during 1999

Treatments	Water loss (g/flower) at different days of vase life						
	4	8	12	16	20	24	Mean
T_1 - Control (Tap water)	1.32	1.81	1.71	1.28	1.26	1.15	1.42
T_2 - Distilled water	1.40	1.67	1.86	1.19	0.95	1.19	1.38
T_3 - Sucrose 4%	1.04	1.22	1.33	1.77	1.43	1.29	1.35
T_4 - Aluminium sulphate 0.2%	1.34	1.39	1.43	1.61	1.65	0.81	1.37
T_5 - Cobalt sulphate 0.02%	1.41	1.38	1.39	1.65	1.58	0.72	1.36
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	0.98	1.33	1.24	1.65	1.58	1.34	1.36
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.18	1.34	1.33	1.39	1.83	1.11	1.36
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.24	1.29	1.50	1.23	2.07	0.97	1.39
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	1.17	1.31	1.50	1.75	1.50	1.54	1.46
Mean	1.23	1.42	1.48	1.50	1.54	1.13	
C.D. at 5% Treatment (T)	0.07						
Day (D)	0.05						
T×D	0.17						

2000 are presented in Table 23. It is obvious from the data that water loss increased or decreased at different days of vase life. However, mean water loss increased upto day 16 and then decreased on day 20 and 24. All the treatments differed from one another either significantly or non-significantly. However, maximum water loss (1.36 g/flower) by cut flowers was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% which was closely followed by water loss in vase solution of sucrose 4%+ aluminium sulphate 0.2% + cobalt sulphate 0.02% (1.34 g/flower). The differences among sucrose 4% and sucrose 4% + cobalt sulphate 0.02% and sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% were also found non-significant in the light of water loss by cut flowers. Similarly, the differences among rest of the treatments were also found statistically at par. Interaction between treatment and day exert significant influence on water loss by cut flowers. However, maximum water loss (2.01 g/flower) was recorded in control treatment on day 8 and minimum water loss (0.58 g/flower) was recorded in cobalt sulphate 0.02% solution on day 24 of vase life.

4.2.3.3 Water loss in cv. Gauri during 1999

The data describing the effect of different chemical treatments on water loss at different days of vase life in chrysanthemum cv. Gauri during 1999 are presented in Table 24. The data indicate that water lost by cut flowers did not show a fixed trend and ups and downs were recorded in case of water loss in all the treatments at different days of vase life. However, mean water loss decreased upto day 12 and then increased on

Table 23. Effect of different chemical treatments on water loss (g/flower) at different days of vase life in chrysanthemum cv. Flirt during 2000

Treatments	Water loss (g/flower) at different days of vase life						
	4	8	12	16	20	24	Mean
T_1 - Control (Tap water)	1.09	2.01	0.98	1.03	1.00	0.71	1.14
T_2 - Distilled water	1.27	1.59	1.39	0.90	0.91	0.62	1.11
T_3 - Sucrose 4%	0.98	1.33	1.51	1.88	1.24	0.82	1.29
T_4 - Aluminium sulphate 0.2%	0.95	0.88	1.55	1.79	1.11	0.69	1.16
T_5 - Cobalt sulphate 0.02%	1.06	1.31	1.28	1.65	1.02	0.58	1.15
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	1.13	1.25	1.61	1.56	1.30	1.31	1.36
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.27	1.08	1.23	1.54	1.31	1.19	1.27
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.18	1.08	1.40	1.21	1.25	0.93	1.17
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	1.32	1.12	1.68	1.48	1.35	1.12	1.34
Mean	1.14	1.29	1.40	1.45	1.17	0.88	
C.D. at 5% Treatment (T)	0.08						
Day (D)	0.06						
T×D	0.19						

Table 24. Effect of different chemical treatments on waterloss (g/flower) at different days of vase life in chrysanthemum cv. Gauri during 1999

Treatments	Water loss (g/flower) at different days of vase life							
	4	8	12	16	20	24	28	Mean
T_1 - Control (Tap water)	1.26	1.21	1.00	0.78	0.61	0.77	0.54	0.88
T_2 - Distilled water	1.12	1.19	1.05	0.71	0.84	0.79	0.64	0.90
T_3 - Sucrose 4%	1.49	1.15	0.74	1.27	1.05	0.83	0.81	1.05
T_4 - Aluminium sulphate 0.2%	1.43	1.23	1.05	0.99	1.10	0.97	0.83	1.09
T_5 - Cobalt sulphate 0.02%	1.15	1.09	0.69	1.18	1.03	0.95	0.55	0.95
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	1.54	1.26	0.82	1.35	1.28	0.91	0.94	1.16
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.05	1.32	1.28	1.29	1.30	0.98	0.88	1.16
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.24	1.13	1.02	1.08	1.17	0.94	0.96	1.08
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	0.98	1.27	1.26	1.58	1.08	0.96	0.77	1.13
Mean	1.25	1.20	0.99	1.14	1.05	0.90	0.77	
C.D. at 5% Treatment (T)	0.04							
Day (D)	0.04							
T×D	0.11							

day 16 and again showed a declining trend till day 28. All the chemical treatments significantly increased the water loss over control. However, maximum water loss (1.16 g/flower) was recorded in sucrose 4% + aluminium sulphate 0.2% and sucrose 4% + cobalt sulphate 0.02% solution. The differences among sucrose 4% + aluminium sulphate 0.2%, sucrose 4% + cobalt sulphate 0.02% and sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% were found non-significant. The differences among sucrose 4%, aluminium sulphate 0.2% and aluminium sulphate 0.2%+ cobalt sulphate 0.02% were also found at par in view of water loss by cut flowers. The differences between control and distilled water were also found non-significant. Interaction between treatment and day was also found significant. However, maximum water loss (1.58 g/flower) was recorded in treatment combination of sucrose 4% + aluminium sulphate 0.2%+ cobalt sulphate 0.02% on day 16 of vase life whereas minimum water loss (0.54 g/flower) was recorded in control treatment on day 28 of vase life.

4.2.3.4 Water loss in cv. Gauri during 2000

The data pertaining to effect of different chemical treatments on water loss at different days of vase life in chrysanthemum cv. Gauri during 2000 are presented in Table 25. The data showed that water loss showed abrupt changes in all the treatments including control at different days of vase life. However, mean water loss showed a decline upto day 12, increased on day 16 and again showed a declining trend till day 28 of vase life. All the chemical treatments except cobalt sulphate 0.02% solution

Table 25. Effect of different chemical treatments on waterloss (g/flower) at different days of vase life in chrysanthemum cv. Gauri during 2000

Treatments	Water loss (g/flower) at different days of vase life							
	4	8	12	16	20	24	28	Mean
T_1 - Control (Tap water)	1.19	1.04	1.04	0.84	0.78	0.62	0.38	0.84
T_2 - Distilled water	1.22	1.14	1.04	0.71	0.69	0.63	0.35	0.82
T_3 - Sucrose 4%	1.27	0.99	0.94	0.87	0.94	0.96	0.48	0.92
T_4 - Aluminium sulphate 0.2%	1.23	1.05	0.89	1.17	1.06	0.70	0.57	0.95
T_5 - Cobalt sulphate 0.02%	1.18	0.97	0.77	1.04	0.86	0.61	0.41	0.83
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	1.10	0.86	0.75	1.07	0.84	1.06	0.77	0.92
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	1.09	0.99	0.86	0.94	0.82	1.13	0.66	0.93
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	1.46	0.99	0.78	1.08	0.71	0.81	0.67	0.93
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	0.95	1.04	0.85	1.08	1.12	0.91	0.69	0.95
Mean	1.19	1.01	0.88	0.98	0.87	0.82	0.55	
C.D. at 5% Treatment (T)	0.05							
Day (D)	0.04							
T×D	0.13							

significantly increased water loss over control. The differences among control, distilled water and cobalt sulphate 0.02% were found non-significant in view of water loss. The differences among rest of the treatments were also found statistically at par. However, interaction between treatment and day was found significant and maximum water loss (1.46 g/flower) was recorded in aluminium sulphate 0.2% + cobalt sulphate 0.02% on day 4 of vase life whereas it was minimum (0.35 g/flower) in distilled water on day 28 of vase life.

4.2.4 Water Relations

The data describing the effect of different chemical treatments on water relations of cut flower of chrysanthemum cvs. Flirt and Gauri during vase life in 1999 and 2000 are presented in Table 26 and 27, respectively.

4.2.4.1 Water relations in cv. Flirt during 1999

Total water uptake

It is evident from the data in Table 26 that total water uptake by cut flower was significantly increased over control in vase solutions of sucrose 4%+ aluminium sulphate 0.2%, sucrose 4% + cobalt sulphate 0.02%, aluminium sulphate 0.2% + cobalt sulphate 0.02% and sucrose 4%+ aluminium sulphate 0.2% + cobalt sulphate 0.02%. The differences among distilled water, sucrose 4%, aluminium sulphate 0.2%, cobalt sulphate 0.02% and aluminium sulphate 0.2% + cobalt sulphate 0.02% were found non-significant in view of total water uptake.

Total water loss

The data in Table 26 showed that the differences among various

Table 26. Effect of different chemical treatments on water relations of cut flower of chrysanthemum cvs. Flirt and Gauri during vase life in 1999

Treatments	Flirt			Gauri		
	Total water uptake (g/flower)	Total water loss (g/flower)	Ratio of water loss/ water uptake	Total water uptake (g/flower)	Total water loss (g/flower)	Ratio of water loss/ water uptake
T_1 - Control (Tap water)	6.51	8.53	1.31	4.92	6.16	1.25
T_2 - Distilled water	6.59	8.26	1.26	5.13	6.34	1.23
T_3 - Sucrose 4%	6.81	8.07	1.19	6.55	7.33	1.12
T_4 - Aluminium sulphate 0.2%	6.78	8.24	1.22	6.49	7.60	1.17
T_5 - Cobalt sulphate 0.02%	6.65	8.14	1.23	5.57	6.64	1.19
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	7.13	8.13	1.14	7.40	8.10	1.09
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	7.07	8.21	1.16	7.34	8.10	1.10
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	6.94	8.37	1.21	6.51	7.53	1.16
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	7.80	8.76	1.12	7.44	7.90	1.06
C.D. at 5%	0.40	NS	0.04	0.54	0.54	0.02

treatments were found non-significant in case of total water loss. However, maximum water loss (8.76 g/flower) was recorded in vase solutions of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% whereas it was minimum (8.07 g/flower) in sucrose 4% solution.

Water loss/water uptake ratio

It is obvious from the data that all the treatments including distilled water significantly decreased the water loss and uptake ratio of cut flowers over control indicating better water balance in their cut flowers during display period. The minimum water loss and uptake ratio (1.12) was recorded in sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% solution whereas maximum water loss and uptake ratio (1.31) was recorded in control treatment.

4.2.4.2 Water relations in cv. Gauri during 1999

Total water uptake

The data in Table 26 shows that total water uptake by cut flower was significantly increased in all the chemical treatments over control. The differences between distilled water and cobalt sulphate 0.02% were found non-significant in the light of total water uptake. However, maximum water uptake (7.44 g/flower) was recorded by cut flowers kept in vase solutions of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% whereas it was recorded minimum (4.92 g/flower) in control treatment.

Total water loss

It is obvious from the data in Table 26 that all the chemical treatments significantly increased the total water loss over control except cobalt sulphate 0.02% solution. The differences among control, distilled water and cobalt sulphate 0.02% solution were at par in view of total water loss. However, maximum water loss (8.10 g/flower) was recorded in vase solutions of sucrose 4% + aluminium sulphate 0.2% and sucrose 4%+ cobalt sulphate 0.02% whereas minimum water loss (6.16 g/flower) was recorded in control treatment (tap water).

Water loss/water uptake ratio

The data in Table 26 showed that all the chemical treatments significantly decreased the water loss and water uptake ratio of cut flowers over control indicating better water balance in their cut flowers during vase life. However, minimum water loss and uptake ratio (1.06) was observed in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% whereas it was recorded maximum (1.25) in control treatment. The differences between control and distilled water were statistically at par in case of water loss and uptake ratio.

4.2.4.3 Water relations in cv. Flirt during 2000

Total water uptake

It is quite obvious from the data in Table 27 that all chemical treatments significantly increased the total water uptake over control excluding cobalt sulphate 0.02%. In this treatment, the total water uptake was statistically at par with control and distilled water. However, water uptake was recorded maximum (7.15 g/flower) in cut flowers kept in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02%

Table 27. Effect of different chemical treatments on water relations of cut flower of chrysanthemum cvs. Flirt and Gauri during vase life in 2000

Treatments	Flirt			Gauri		
	Total water uptake (g/flower)	Total water loss (g/flower)	Ratio of water loss/ water uptake	Total water uptake (g/flower)	Total water loss (g/flower)	Ratio of water loss/ water uptake
T_1 - Control (Tap water)	5.05	6.83	1.35	4.74	5.82	1.23
T_2 - Distilled water	5.12	6.68	1.31	4.77	5.77	1.21
T_3 - Sucrose 4%	6.51	7.77	1.19	5.75	6.46	1.13
T_4 - Aluminium sulphate 0.2%	5.73	6.96	1.22	5.61	6.67	1.19
T_5 - Cobalt sulphate 0.02%	5.57	6.89	1.24	4.85	5.83	1.20
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	7.10	7.83	1.15	5.89	6.46	1.10
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	6.54	7.61	1.16	5.85	6.50	1.11
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	5.92	7.04	1.19	5.66	6.49	1.15
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	7.15	8.06	1.12	6.14	6.63	1.08
C.D. at 5%	0.61	0.69	0.02	0.37	0.36	0.02

whereas water uptake was recorded minimum (5.05 g/flower) in control treatment (tap water).

Total water loss

The data in Table 27 revealed that vase solutions of sucrose 4%, sucrose 4% + aluminium sulphate 0.2%, sucrose 4% + cobalt sulphate 0.02% and sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% significantly increased the water loss of cut flowers over control. The differences among water loss by cut flower in these vase solutions were also found non-significant. The differences among rest of the treatments were also found statistically at par in view of total water loss. However, maximum water loss (8.06 g/flower) was recorded in sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% and minimum water loss (6.68 g/flower) was recorded in distilled water.

Water loss/water uptake ratio

It is clear from data in Table 27 that all the chemical treatments significantly decreased the water loss and uptake ratio over control indicating better water balance in their cut flowers during vase life. However, minimum water loss and uptake ratio (1.12) was observed in cut flowers held in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% and maximum water loss and uptake ratio (1.35) was recorded in control treatment indicating less water uptake and more of water loss during their vase life. The differences between control and distilled water were also found significant in case of water loss and uptake ratio.

4.2.4.4 Water relations in cv. Gauri during 2000

Total water uptake

The data in Table 27 clearly indicate that all chemical treatments except cobalt sulphate 0.02% significantly increased the water uptake of cut flowers over control. The differences among control, distilled water and cobalt sulphate 0.02% were found non-significant. However, maximum water uptake (6.14 g/flower) was recorded in sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% solution and minimum water uptake (4.74 g/flower) was recorded in control treatment (tap water).

Total water loss

It is quite obvious from the data in Table 27 that all chemical treatments except cobalt sulphate 0.02% significantly increased the water loss of cut flowers over control. The differences among control, distilled water and cobalt sulphate 0.02% solution, however, were found statistically at par. Maximum water loss (6.67 g/flower) was recorded in aluminium sulphate 0.2% solution whereas minimum water loss (5.77 g/flower) was recorded in distilled water .

Water loss/water uptake ratio

The data in Table 27 showed that all the chemical treatments significantly decreased the water loss and uptake ratio of cut flowers over control treatment indicating improved water balance in their cut flowers during their display period. The minimum water loss and uptake ratio (1.08) was recorded in cut flowers held in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% and maximum water loss and uptake ratio (1.23) was recorded in control treatment indicating less water uptake and more of water loss during their vase life. The differences between control and distilled water were, however, found non-significant.

4.2.5 pH of vase solution

4.2.5.1 pH of vase solution in cv. Flirt during 1999

It is clear from Fig. 1 that pH of vase solutions was influenced significantly in all the treatments during vase life. In control, pH decreased initially at day 4 of vase life and then showed increase over initial pH at all the days of vase life. In distilled water also, pH was found decreased over initial pH at day 4 and 8 of vase life, remained same on day 12 and then increased over initial pH at all the days of vase life. pH of individual solutions of sucrose 4% and aluminium sulphate 0.2% decreased continuously over initial pH at all the days of vase life. In cobalt sulphate 0.02% solution, pH showed continuous increase over its initial value at all the days of vase life.

Vase solution of sucrose 4% + aluminium sulphate 0.2% showed continuous decline in its pH values over initial one at all the days of vase life. pH of vase solution of sucrose 4% + cobalt sulphate 0.02% increased over its initial value upto day 12 and after day 16 and onwards decreased over it's initial pH value. Aluminium sulphate 0.2% + cobalt sulphate 0.02% solution showed a continuous increase in its pH over initial pH at all the days of vase life. pH of vase solution of sucrose 4% +aluminium sulphate 0.2% + cobalt sulphate 0.02% increased upto day 8 over its initial pH and then showed continuous decline after day 12 and onwards.

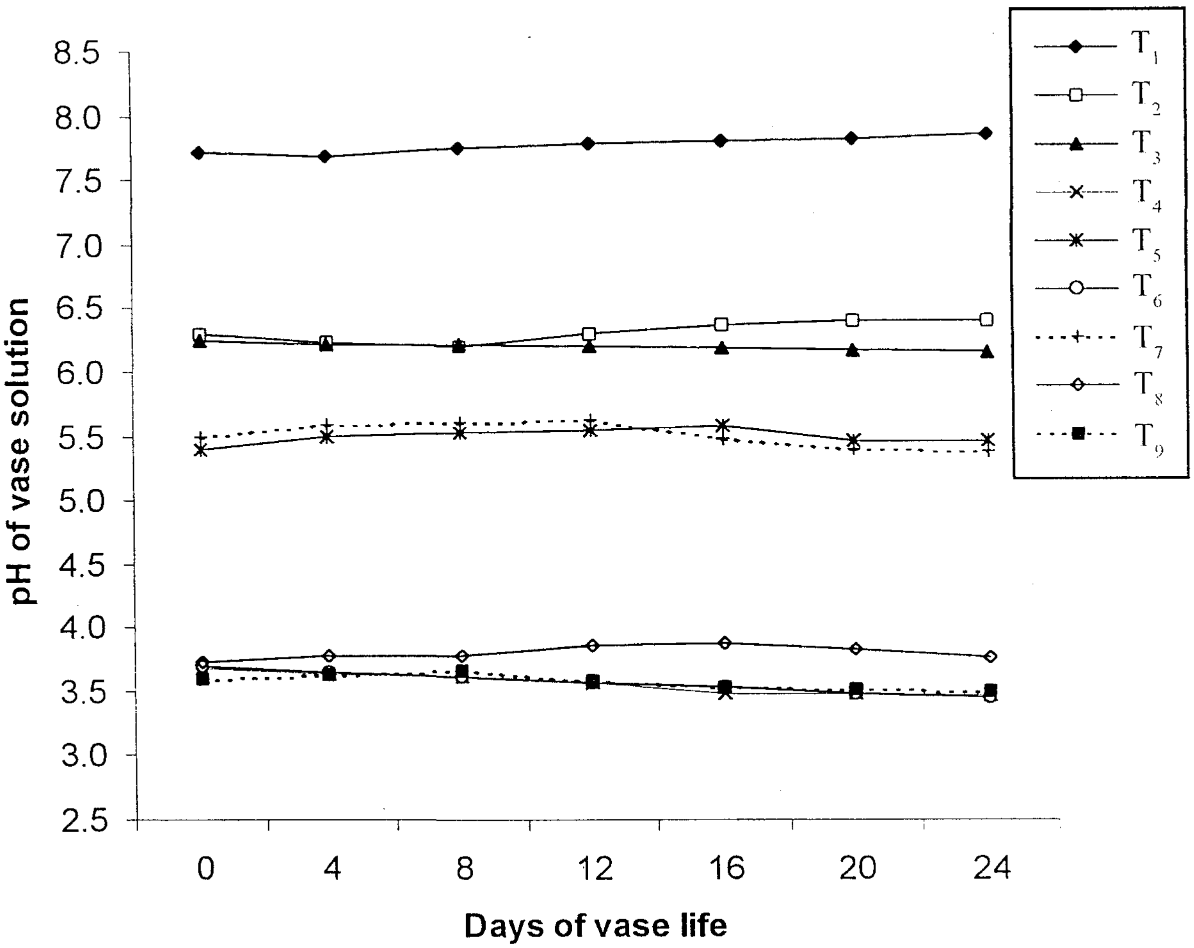

Fig. 1 : Effect of different chemical treatments on pH of vase solution at different days of vase life in chrysanthemum cv. Flirt during 1999

4.2.5.2 pH of vase solution in cv. Gauri during 1999

It is obvious from the Fig. 2 that pH of control treatment decreased initially upto day 8 over its initial value and then increased upto 28 of vase life. The distilled water treatment also showed decline in pH values over initial one upto day 12 and then showed increase in pH over initial value from day 16 to 28. pH of sucrose 4% solution was found increased on day 4 and then decreased over its initial value at all the days of vase life. Aluminium sulphate 0.2% showed continuous decline in its pH values over initial one during all days of vase life. pH of vase solution of cobalt sulphate 0.02% showed increase over its initial value upto day 16 after which a continuous decline in pH values was recorded upto day 28 of vase life.

Sucrose 4% + aluminium sulphate 0.2% solution showed continuous decline in its pH values over the initial one at all the days of vase life. pH of vase solution of sucrose 4% + cobalt sulphate 0.02% was found increased over initial one upto day 12 after which it showed decline till day 28 of vase life. Aluminium sulphate 0.2% + cobalt sulphate 0.02% solution recorded continuous increase in its pH value over the initial one at all the days of vase life. However, vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% showed slight increase in pH over initial one only upto day 4 after which a continuous decline in pH was recorded upto day 28 of vase life.

4.2.5.3 pH of vase solution in cv. Flirt during 2000

It is evident from Fig. 3 that pH value of control treatment decreased

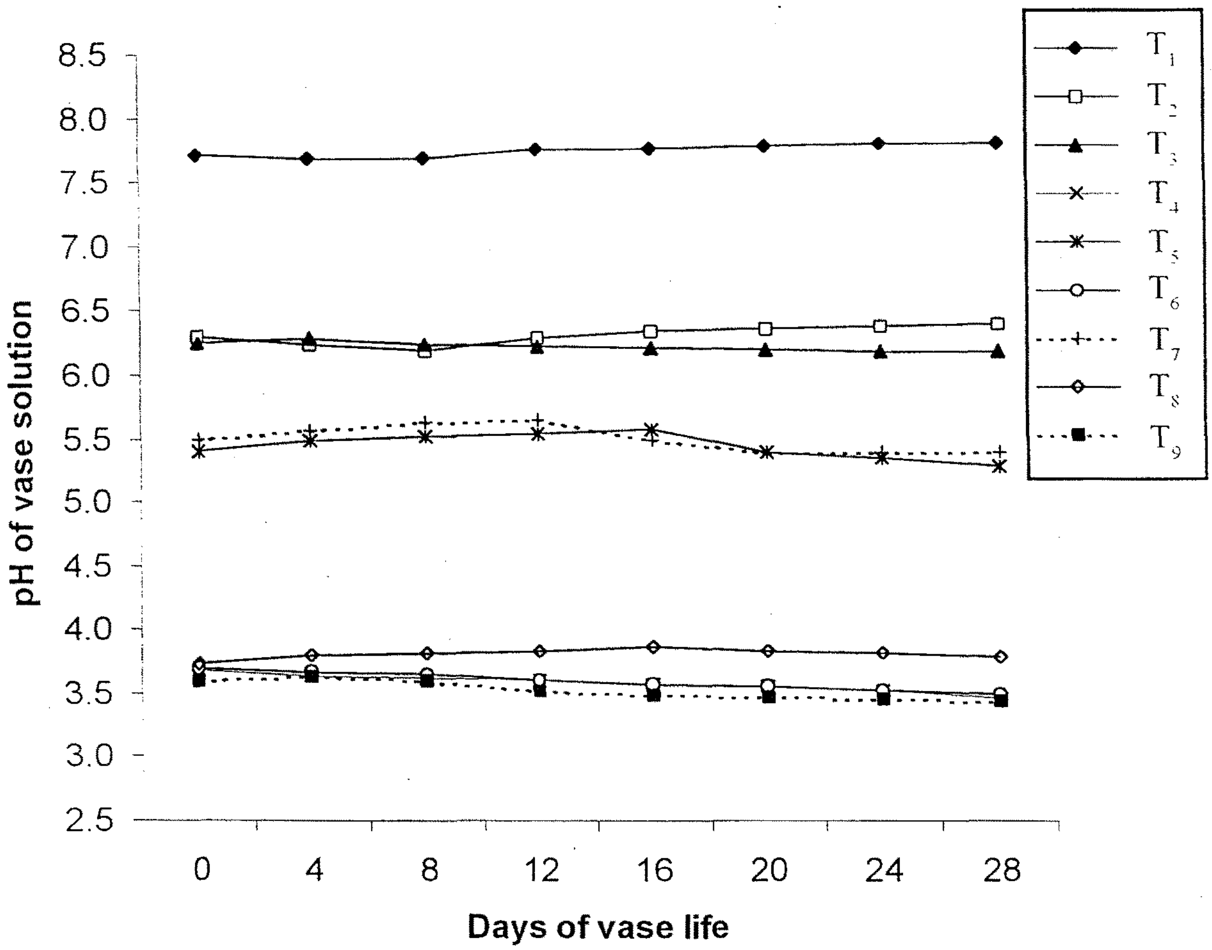

Fig. 2 : Effect of different chemical treatments on pH of vase solution at different days of vase life in chrysanthemum cv. Gauri during 1999

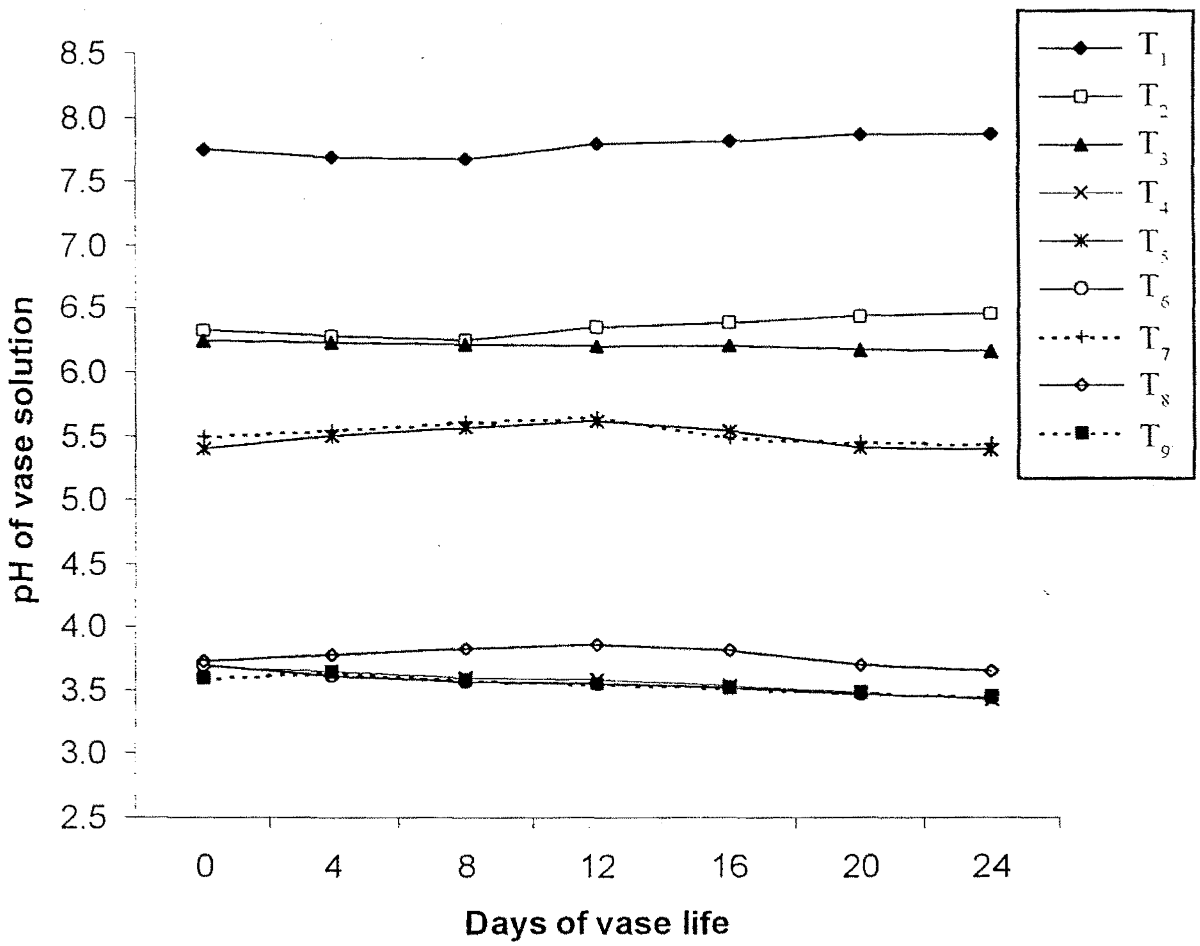

Fig. 3 : Effect of different chemical treatments on pH of vase solution at different days of vase life in chrysanthemum cv. Flirt during 2000

on day 4 and 8 over pH value of starting day. After day 12 and onwards, a continuous increase in pH was noticed upto day 24. In distilled water, pH showed decline upto day 8 over its initial value after which a continuous increase in pH was noticed upto day 24. Sucrose 4% and aluminium sulphate 0.2% solutions individually showed continuous decline in their pH values over the initial values at all the days of vase life whereas cobalt sulphate 0.02% solution showed increase in pH over initial one upto 16 after which decrease in pH was recorded till day 24. Sucrose 4%+aluminium sulphate 0.2% solution recorded decline in pH over initial value at all the days of vase life. Sucrose 4% + cobalt sulphate 0.02% solution recorded increase in pH over initial one upto day 12 after which decrease in pH was recorded upto day 24. Aluminium sulphate 0.2% + cobalt sulphate 0.02% solution recorded increase in pH over the initial pH upto day 16 after which decline in pH over the initial one was registered upto day 24. Sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% solution recorded increase in pH only upto day 4 after which a continuous decline over initial value was recorded till day 24 of vase life.

4.2.5.4 pH of vase solution in cv. Gauri during 2000

It is clear from Fig. 4 that in control treatment, pH was found decreased upto day 12 over its initial value after which an increase in pH was recorded upto day 28. In distilled water, pH showed decline only upto day 8 over its initial value after which an increase in pH was noticed at all the days of vase life. Sucrose 4% and aluminium sulphate 0.2% solutions individually showed continuous decline in their pH values over

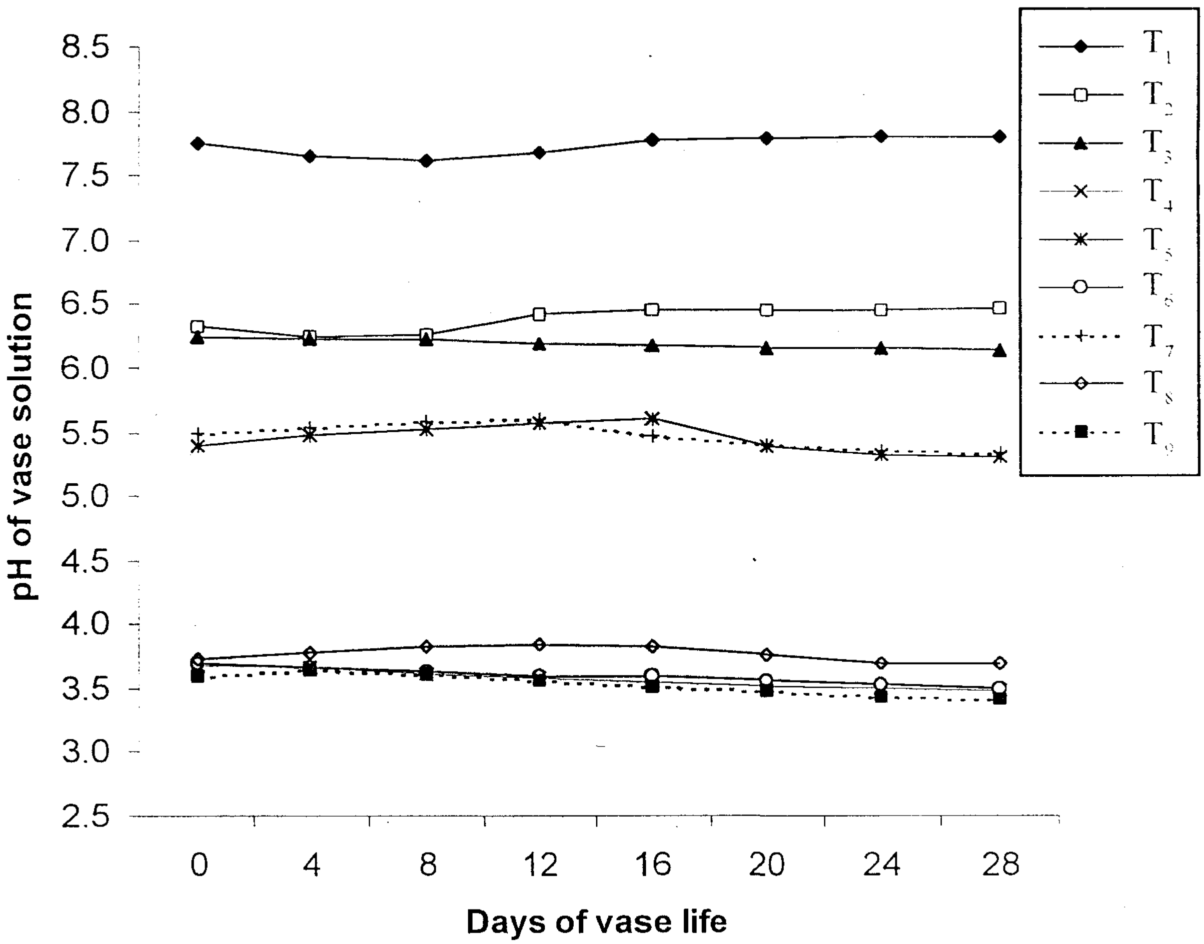

Fig. 4 : Effect of different chemical treatments on pH of vase solution at different days of vase life in chrysanthemum cv. Gauri during 2000

initial one with the increase in period of vase life. On the other hand, cobalt sulphate 0.02% solution recorded increase in pH over initial one upto day 16 after which a continuous decline in pH was observed till day 28.

Sucrose 4% + aluminium sulphate 0.2% solution recorded continuous decline in pH value over initial one at all the days of vase life where as sucrose 4% + cobalt sulphate 0.02% solution recorded increase in pH over initial one upto day 12 after which a continuous decline in pH was recorded till day 28. Aluminium sulphate 0.2% + cobalt sulphate 0.02% solution recorded increase in pH over initial value till day 20 after which a continuous decline in pH was registered till day 28. Sucrose 4%+ aluminium sulphate 0.2% + cobalt sulphate 0.02% solution recorded increase in pH value over initial one only upto day 8 after which a continuous decline in pH of vase solution was recorded till day 28 of vase life.

4.2.6 Vase Life (Freshness of flower)

The data describing effect of different chemical treatments on vase life of cut flower of chrysanthemum cvs. Flirt and Gauri are presented in Table 28. The data clearly indicate that all chemical treatments significantly increased the vase life of cut flower over control in both the cultivars during both the years. Vase life ranged from 14.33 to 25.33 days and 12.67 to 24.33 days in cultivar Flirt and 18.67 to 28.33 days and 17.33 to 27.67 days in cultivar Gauri during 1999 and 2000, respectively. However, maximum vase life (28.33 days) was recorded in vase solution

Table 28. Effect of different chemical treatments on vase life of cut flower of chrysanthemum cvs. Flirt and Gauri

Treatments	Vase life (days)			
	1999		2000	
	Flirt	Gauri	Flirt	Gauri
T_1 - Control (Tap water)	14.33	18.67	12.67	17.33
T_2 - Distilled water	15.67	20.67	14.33	19.00
T_3 - Sucrose 4%	21.33	25.33	20.67	24.67
T_4 - Aluminium sulphate 0.2%	20.33	23.33	19.00	21.33
T_5 - Cobalt sulphate 0.02%	19.00	22.33	18.33	20.67
T_6 - Sucrose 4% +Aluminium sulphate 0.2%	24.33	27.67	23.67	26.00
T_7 - Sucrose 4% + Cobalt sulphate 0.02%	23.67	26.67	22.00	25.67
T_8 - Aluminium sulphate 0.2%+ Cobalt sulphate 0.02%	21.00	24.00	20.33	22.67
T_9 - Sucrose 4% + Aluminium sulphate 0.2% + Cobalt sulphate 0.02%	25.33	28.33	24.33	27.67
C.D. at 5%	1.76	2.05	2.18	2.18

Plate 3 : Cut flowers of chrysanthemum cv. Flirt in different vase solutions (T_1 to T_9) on 0 day of vase life

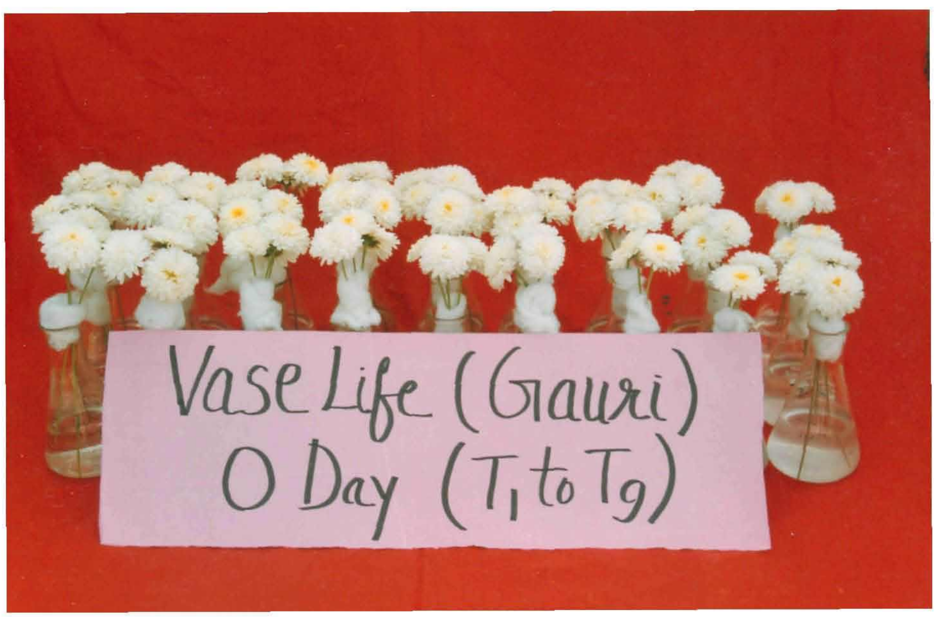

Plate 4 : Cut flowers of chrysanthemum cv. Gauri in different vase solutions (T_1 to T_9) on 0 day of vase life

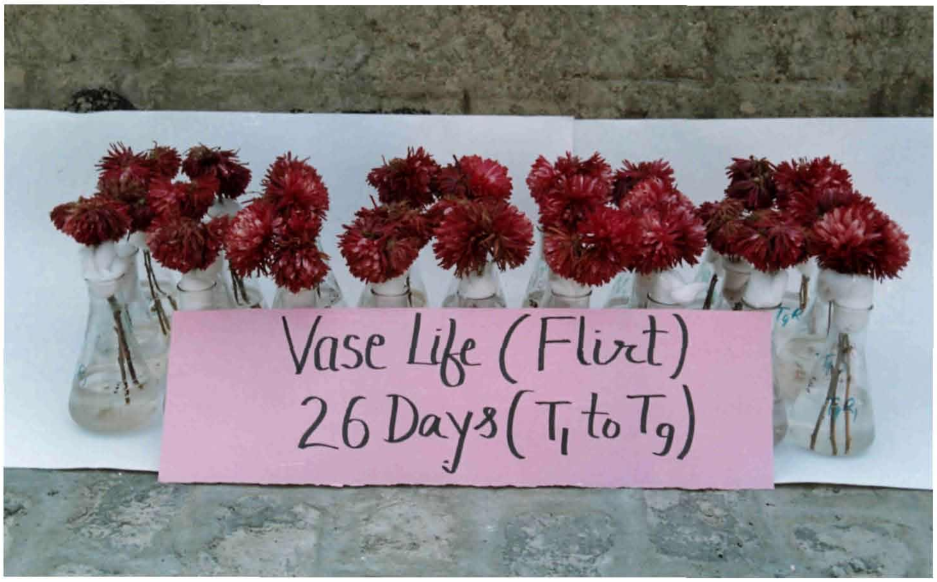

Plate 5 : Comparative effect of different chemicals (T_1 to T_9) on freshness of cut flowers of chrysanthemum cv. Flirt on 26th day of vase life

Plate 6 : Comparative effect of different chemicals (T_1 to T_9) on freshness of cut flowers of chrysanthemum cv. Gauri on 30th day of vase life

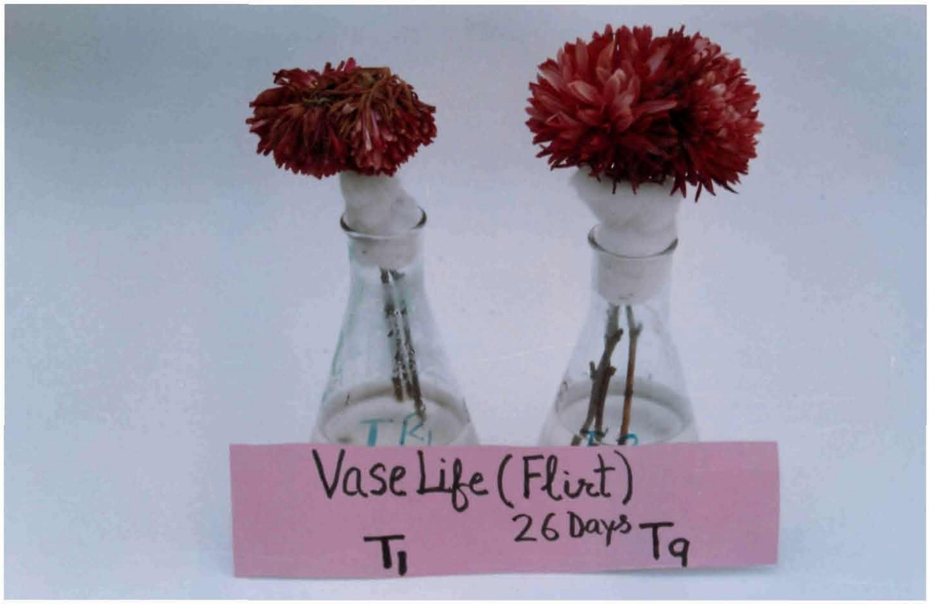

Plate 7 : Comparative performance of sucrose 4%+aluminium sulphate 0.2%+cobalt sulphate 0.02% (T_9) with control/ tap water (T_1) on freshness of cut flowers of chrysanthemum cv. Flirt on 26th day of vase life

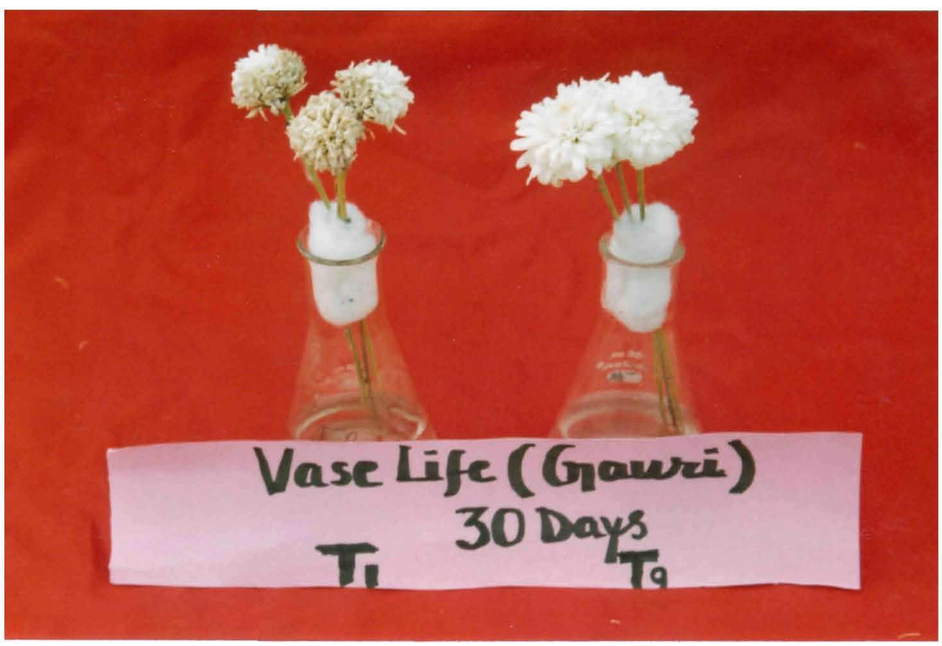

Plate 8 : Comparative performance of sucrose 4%+aluminium sulphate 0.2%+cobalt sulphate 0.02% (T_9) with control/ tap water (T_1) on freshness of cut flowers of chrysanthemum cv. Gauri on 30th day of vase life

of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% in cultivar Gauri during 1999 whereas it was minimum (12.67 days) in control treatment in cultivar Flirt during 2000. The cut flowers held in distilled water also increased the vase life over control (tap water) in both the cultivars during both the years. It is also clear from the data that cultivar Gauri registered significantly more vase life than cv. Flirt during both the years. The cut flowers of both the cultivars in year 1999 recorded slight increase in their vase life over year 2000.

CHAPTER-5

DISCUSSION

Genetic and cultural manipulations help in increasing the productivity of crop plants. Flowering of chrysanthemum under Haryana conditions is very seasonal, generally from October to December and there is glut in the market during periods of peak production. Therefore, staggering production and making available cut flowers throughout the year is a desired objective in chrysanthemum to cash in substantial income. Various agrotechniques such as spraying of growth regulators like Gibberellic acid and manual pinching are adopted to increase and regulate the production of quality blooms. After successful production of good quality cut flowers, another important aspect in the cut flower industry is the post harvest handling in order to conserve the freshness of cut flowers for distant markets to fetch good returns. In view of the above, the present investigation entitled "Studies on cut flower production and vase life in chrysanthemum" was conducted under field and laboratory conditions. The results obtained have been discussed here in the light of available information.

5.1 To study the effect of gibberellic acid and pinching on cut flower production in chrysanthemum cvs. flirt and gauri

5.1.1 Growth parameters

The results presented in Table 1-3 indicated that different concentrations of GA_3 along with pinching at various stages proved effective in influencing the growth in terms of plant height, plant spread and number of branches per plant in cultivars Flirt and Gauri during 1999 and 2000. Plant height, plant spread and number of branches increased significantly over control by all concentrations of GA_3 in both the cultivars under study. The increase in plant height, plant spread and number of branches with the application of GA_3 seems to be due to enhanced cell division and cell enlargement, promotion of protein synthesis coupled with dry matter accumulation and auxin effectiveness. Stimulation of branching may possibly be attributed to the breakage of apical dominance and thereby setting up of auxin balance as well as enhanced differentiation of internodes. These results are in accordance with the findings of Koriesh *et al.* (1989a), Deotale *et al.* (1995), Keltawi *et al.* (1995), Talukdar and Paswan (1995, 1996 and 1998), Dutta *et al.* (1998) and Meher *et al.* (1998).

Pinching of plants at 35 and 45 days after transplanting increased the plant spread and number of branches but decreased the plant height over control in both the cultivars during both the years. Pinching of plants at 35 days after transplanting resulted in maximum plant spread and number of branches. This might be due to the fact that the removal of apical portion of the plant made the axillary buds present on the main shoot free from correlative inhibition which were suppressed due to apical dominance phenomenon and started fast growth. Furthermore, there was an even distribution of assimilates among several growing points rather than one, resulted in increase in plant spread and number of branches. Pinching of plants at 45 days after transplanting recorded significant decrease in plant height over control. The fact that pinching caused reduction in plant height due to elimination of apical dominance. These results are in close conformity with those of Sen and Naik (1977), Chezhiyan *et al.* (1986b), Bhati and Chitkara (1987), Gowda and Jayanti (1988), Song *et al.* (1990), Yassin and Pappiah (1990) and Kumar (1992).

It is also clear from the data that plant height, plant spread and number of branches increased in cultivar Gauri in comparison to cultivar Flirt during both the years. The reason for different behaviour of cultivars to these characters under different set of conditions might be attributed to different genetic make up of the cultivars. The reason for registering less plant height, plant spread and number of branches during 1999 may be due to less favourable environment for vegetative growth.

5.1.2 Floral characters

It is also obvious from the data presented in Table 4 to 10 that different concentration of GA_3 with various stages of pinching proved effective in influencing the floral development in terms of days to flower bud initiation, number of buds, days to flowering, duration of flowering, size of flower, stalk length of flower and strength of flower stem. The floral parameters like days to floral bud initiation and days to flowering were decreased significantly with the increase in concentration of GA_3

over control in cultivars Flirt and Gauri during both the years. The effect of GA_3 on early initiation of flower bud and flowering is well known. This may be due to production of laterals at an early stage which then had sufficient time to accumulate reserve carbohydrates for advanced bud formation and onset of flowering in GA_3 treated plants. Similar observations were recorded by Nagarjuna *et al.* (1988), Dutta *et al.* (1993) and Deotale *et al.* (1994).

Duration of flowering was also extended significantly by different concentrations of GA_3 over control in both the cultivars during both the years. The extension in duration of flowering by application of GA_3 could be due to its anti-senescence effect. The earlier findings of Nagarjuna *et al.* (1988), Koriesh *et al.* (1989b), Dutta *et al.* (1993, 1998), Deotale *et al.* (1994) and Talukdar and Paswan (1998) also support the above discussed results. The number of buds per plant also increased significantly over control by different concentrations of GA_3 in both the cultivars during both the years. The increase in number of buds per plant may be due to increase in plant spread and number of branches per plant due to application of GA_3.

The size of flower and stalk length of flower were increased significantly over control by various concentrations of GA_3 in both the cultivars during both the years. However, maximum beneficial effects were obtained with 200 ppm GA_3 in all the floral parameters and it was closely followed by 150 pm GA_3. The increase in flower size with GA application may be due to elongation of cells resulting in increased size of florets which is in accordance with the findings of Keltawi *et al.* (1995), Nagarjuna *et al.* (1988), Koriesh *et al.* (1989b), Dutta *et al.* (1993), Talukdar and Paswan (1998) and Meher *et al.* (1999).

The increase in stalk length with GA_3 application seems to be obvious due to elongation of nodes and internodes. These results are in accordance with the findings of Kofranek and Cockshull (1985), Holcomb *et al.* (1991), Dutta *et al.* (1993) and Keltawi *et al.* (1995). The strength of flower stem decreased with the increase in concentration of GA_3 in cultivar Gauri only during both years. It may be due to weak, thin and lengthy flower stalk in cultivar Gauri at higher concentrations of GA_3.

It is obvious from the data that days to bud initiation, days to flowering and duration of flowering delayed significantly with late pinching. The delay in floral parameters due to late pinching might be attributed to the fact that during the process of pinching, physiological mature portion of the shoot was removed and the new shoots which emerged on the pinched plants took more time for the initiation of reproductive phase after becoming physiologically mature. These results are in accordance with those earlier reported by Groskhov and Angelov (1981), Rashauskas *et al.* (1983), Arora and Khanna (1986) and Klapwijk (1987).

The pinching treatment resulted in decreased flower size. The decrease in flower size might be attributed to the fact that in pinched plants, the energy is shared by the developing side branches, whereas, in case of non-pinched plants, the energy sharing is limited to the flowers developing on the main branch only. These results are in close conformity with those of Patel and Arora (1983) in chrysanthemum.

It is also revealed from the present investigation that the number of buds per plant increased significantly over control in plants pinched at 35 days after transplanting. This was mainly due to increased plant spread and increased number of branches in pinched plants.

Pinching of plants reduced the flower stalk length. The reduction of flower stalk length in pinched plants might be ascribed on the basis of fact that with pinching, number of branches and number of leaves increased whereas the quantity of food material distributed in such large number of branches and leaves was the same. On the other hand, in non-pinched plants, all the metabolites are diverted towards relatively less number of branches and leaves, improvement in length of flower stalk is obvious. These results are in close conformity with the findings of Holland (1974), Rajasekaran *et al.* (1983) and Bhati and Chitkara (1987). The strength of flower stem decreased in non-pinched plants in comparison to pinching at 35 and 45 days after transplanting in cultivar Gauri during both the years. It could be due to very weak, thin and long flower stalks in non-pinched plants in cultivar Gauri. Cultivar Gauri behaved differently from cultivar Flirt in view of floret parameters due to its different genetic make up.

5.1.3 Yield parameters

The results presented in Table 11 to 13 indicated that different concentrations of GA_3 and various stages of pinching proved effective in influencing the yield parameters in both the cultivars during both the years. Application of GA_3 has been proved effective in the regulation of growth and flowering and hence also improved the flower yield in terms of number and weight of flowers significantly over control in the present investigation. Treated plants produced greater number of flowers being heavier than non-treated plants. The increase in numbers of flowers owing to GA_3 application may be due to increase in plant height, plant spread and number of branches per plant whereas decrease in number of flowers in untreated plants was due to decrease in plant height, plant spread and number of branches per plant. Subsequently, the increase in weight of flower in treated plants might be attributed to the fact that GA_3 promoted the efficacy of plants in terms of photosynthetic activity by increasing the number and size of leaves, promotion of chlorophyll synthesis or formation and maintenance of chloroplast, enhanced uptake of nutrients and their translocation, better mobilization and distribution of photosynthates and inducing resistance to low temperature or frost. The results are supported by the findings of Syamal *et al.* (1990), Dehale *et al.* (1993), Dutta *et al.* (1993, 1998) and Deotale *et al.* (1994, 1995). However, there were no significant differences in plants treated with 150 and 200 ppm GA_3 in case of number of flowers per plant, weight of flower and yield per plant. This might be due to the fact that once the optimum requirement is met, further increase in GA_3 concentration may not benefit the plants. It is evident from the data that cultivar Gauri recorded significantly more number of flowers over cultivar Flirt but due to very less weight of flowers in cultivar Gauri, yield per plant in cultivar Gauri decreased significantly over cultivar Flirt during both the years.

The results of the present investigation also revealed that number of flowers per plant, fresh weight of flower and flower yield per plant was influenced significantly over control by pinching of plants at 35 and 45 days after transplanting. However, maximum number of flowers and flower yield per plant were observed in plants pinched at 35 days after transplanting. This was mainly due to increased plant spread and increased number of branches in plants pinched at 35 days after transplanting. The results are in accordance with the findings of Rajasekaran *et al.* (1983), Reiss and Lewis (1986), Bhati and Chitkara (1987), Gowda and Jayanti (1988), Cermeno (1990) and Yassin and Pappiah (1990). Pinching of plants at 35 and 45 days after transplanting also recorded decrease in flower weight over control. The reduction in flower weight in pinched plants might be attributed to the fact that in pinched plants, more energy is utilized for the development of side branches whereas in non-pinched plants, more energy is utilized for the development of flowers. Reduction in flower weight due to pinching has also been reported earlier by Kumar (1992) and Gowda and Jayanti (1988).

5.2 To study the effect of different chemicals on vase life of cut flowers of chrysanthemum cvs. Flirt and Gauri

Cut flowers are living, actively metabolizing plant parts and are subjected to save ageing phenomenon as an entire plant. Since flowers are cut off from the natural sources of raw materials, they deteriorate much more quickly than the flowers left on the plants. Hence, efforts to supply these materials exogenously for various metabolic functions are successful in prolonging the vase life of cut flowers. An extended vase life of flowers depends on its water relations and retarded rate of senescence which can be achieved by using certain chemicals. Vase life of cut flowers can be increased by holding it in a solution containing sucrose, provided the growth of micro-organisms at the cut end is kept in check (Marousky, 1969). Vase life of cut flowers can be extended further by adding some antiethylene agents to these solutions. Keeping this in view sucrose, aluminium sulphate and cobalt sulphate individually and in various possible combinations were tried in this investigation to extend vase life of cut flowers. The results of these studies are discussed below :

5.2.1 Sucrose

It is evident from Tables 14 to 28 and Fig. 1 to 4 that sucrose 4% solution alone and in various possible combinations with aluminium sulphate 0.2% and cobalt sulphate 0.02% significantly increased the fresh weight (%), water uptake and water loss over control at different days of vase life in cvs. Flirt and Gauri during both the years. The water loss and uptake ratio of cut flowers kept in above vase solutions recorded a significant decrease over control in both the cultivars during both the years.

The pH of vase solution showed more or less continuous decline over initial pH in various possible combinations of sucrose, aluminium sulphate and cobalt sulphate at all days of vase life except sucrose 4% + cobalt sulphate 0.02% solution which showed decline in pH after day 12 of vase life. As a consequence of reduction in pH of vase solution, there was increased uptake of water by cut flowers of both the cultivars of chrysanthemum held in various solutions of sucrose and its combinations with aluminium sulphate and cobalt sulphate resulting in improved water balance and increased vase life of cut flowers. A strongly acid solution inhibits endogenous enzyme essential for stem plugging process and also reduces the microbial growth resulting in increased water uptake (Marousky, 1971). The results of present investigation support the hypothesis that adequate moisture levels can be maintained in cut flowers by maintaining higher water uptake or water retention or both (Marousky, 1969). However, cut flowers reached the highest fresh weight and maintained it upto day 16 and 20 in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% in cultivar Flirt and Gauri, respectively. Gain in fresh weight can occur only when the rate of water absorption is greater than transpirational loss. Acock and Nichols (1979) confirmed that sugar improved water balance and osmotic potential of carnation flowers.

Although, water loss was increased in line with the water uptake by the sucrose and its combinations with aluminium sulphate and cobalt sulphate, water loss and uptake ratio was reduced by sucrose either alone or its combination with aluminium sulphate and cobalt sulphate (Table 26 and Table 27). These results are in accordance with the findings of Nagarajaiah and Reddy (1991) and Rath *et al.* (1991).

Sucrose alone and in various possible combinations with aluminium sulphate and cobalt sulphate significantly increased the vase life over control. These results are in accordance with the findings of Rath *et al.* (1991), Reddy (1991), Barman *et al.* (1992), Lu *et al.* (1993), Patil and Singh (1995), Dohino and Hayashi (1995), Song *et al.* (1995), Arriaga and Guerrero (1995), De *et al.* (1996), Bhat *et al.* (1999), Singh *et al.* (2000), Singh and Arora (2000) and Bhaskar *et al.* (2000).

It is evident from Table 28 that even distilled water also extended the average vase life of cut flower by a day or two over control (tap water). It may be ascribed to the fact that distilled water minimizes the microbial growth and prevents plugging of vascular bundles thereby increasing water uptake, water balance, fresh weight and vase life of cut flowers over control. Cultivar Flirt and Gauri behaved differently in view of vase life under the influence of same chemical. However, cultivar Gauri significantly increased the vase life over cultivar Flirt during both the years. The extended vase life in cut flowers of cultivar Gauri might be due to its white small sized flower with yellow centre which took more time for wilting than red coloured flowers of cultivar Flirt during display life.

5.2.2 Aluminium sulphate

It is obvious from Table 14 to 28 and Fig. 1 to 4 that aluminium sulphate 0.2% solution alone and in combination with cobalt sulphate 0.02% increased and maintained the fresh weight of cut flower upto day 12 to 20 in cultivar Flirt and Gauri during 1999 and 2000. The water uptake and water loss also increased but water loss and uptake ratio decreased significantly over control in flowers kept in vase solution of aluminium sulphate either alone or in combination with cobalt sulphate in both the cultivars during both the years. pH of vase solution of aluminium sulphate was found decreased whereas pH of vase solution of aluminium sulphate in combination with cobalt sulphate initially increased but later on decreased with the increase in period of vase life in both cultivars during both the years. Aluminium sulphate either alone or in combination with cobalt sulphate significantly increased the vase life of cut flower over control in both the cultivars during both the years. The differences between aluminium sulphate and aluminium sulphate + cobalt sulphate were found non-significant in relation to vase life of cut flower. Rath *et al.* (1991) reported similar observations in rose cultivars where potassium aluminium sulphate solution inhibited vascular blockage and increased water uptake, reduced water loss and water loss and uptake ratio by cut flowers as a result the vase life of all the three rose cultivars increased. Barman *et al.* (1992) also reported increased vase life in chrysanthemum with aluminium sulphate 0.2% + sucrose 3% vase solution. Rajgopalan and Abdul Khader (1993) also confirmed the present findings that cut flowers kept in 0.1% aluminium sulphate showed maximum percentage increase in fresh weight and maximum number of days of vase life. These results are also in accordance with the findings of Shobha and Gowda (1993) in rose, Patil and Singh (1995) in gladiolus and Ahn *et al.* (1996) in rose.

Bhattacharjee (1999) also found longest vase life, improved water uptake, increased flower diameter and fresh weight with 100 ppm aluminium chloride in "Sonia Meilland" cut roses. Similar results were obtained by Singh *et al.* (2000) in gladiolus with aluminium sulphate 400 ppm in combination with sucrose 2%. Aluminium sulphate acidified the holding water, reduced pH of solution, thereby reducing bacterial growth and improving water balance (Halevy and Mayak, 1981). Murali (1990) also reported that aluminium maintained petal membrane integrity and enhanced vase life of gladiolus flowers.

5.2.3 Cobalt sulphate

The results of present investigation as evident from Tables 14 to 28 and Fig. 1 to 4 indicated that cut flowers held in vase solution of cobalt sulphate significantly increased and maintained their fresh weights upto day 12 in cultivar Flirt and upto day 16 in cultivar Gauri during 1999 and 2000, respectively. Water uptake and water loss also increased over control in cut flowers of both the cultivars during both years except in cultivar Flirt during 1999 where water loss was found decreased over control. Water loss and uptake ratio also decreased significantly over control indicating better water balance in cut flowers held in cobalt sulphate 0.02% solution. It is also clear from the figure 1 to 4 that pH of vase solution of cobalt sulphate increased initially and then decreased later on during vase life except in cultivar Flirt during 1999 where pH of cobalt solution showed increase over initial pH throughout vase life. Cut flowers of both the cultivars showed significant increase in vase life over control during both the years when kept in vase solution of cobalt sulphate 0.02%. The findings of earlier workers also support the results of the present investigation. Kang and Ray (1969) reported that cobalt is an inhibitor of ethylene action while Lau and Yang (1976) found cobalt ion as an inhibitor of ethylene biogenesis. Cobalt ion improves water balance and maintains higher fresh weight in roses as reported by Venkatarayappa *et al.* (1981). Similar findings were reported by Chandra *et al.* (1981) in marigold and Balakrishna (1987) in tuberose.

Reddy (1988) reported that cobalt inhibited vascular blockage in stems of rose cv. Samantha and maintained a high flow rate through stems, leading to significantly increased water uptake by cut flower. Cobalt also partially closed the stomates, and hence reduced water loss and uptake ratio and maintained a high water potential in cut roses. This ultimately resulted in high fresh weight of flower and thus leading to increased vase life of cut flowers. Murali (1990) observed that cobalt maintained the membrane integrity markedly by reducing ethylene evolution in gladiolus. The useful effect of cobalt treatment on vase life of cut flowers has also been reported by Shobha and Gowda (1993) and Bhattacharjee (1999) in rose. Singh *et al.* (2000) also reported similar findings in gladiolus.

CHAPTER-6

SUMMARY AND CONCLUSION

The present investigation entitled, "Studies on cut flower production and vase life in chrysanthemum (*Chrysanthemum morifolium*)" was carried out during the years 1999 and 2000 at Experimental Farm and Laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar. The main objectives of the investigation were to study the effect of Gibberellic acid and pinching on cut flower production and to increase the vase life of cut flowers through use of various chemicals. The salient findings of the investigation are summarized as under :

Experiment 1 : To study the effect of Gibberellic acid and pinching on cut flower production in chrysanthemum cvs. Flirt and Gauri

The experiment was conducted to study the effect of GA_3 and pinching on vegetative, floral and yield parameters by spraying GA_3 (0, 50, 100, 150 and 200 ppm) twice i.e. 30 and 40 days after transplanting and pinching (No pinching, pinching after 35 days of transplanting and pinching after 45 days of transplanting) on cultivars Flirt and Gauri.

1. Maximum plant height (48.08 cm and 70.39 cm) and (51.38 cm and 76.06 cm) was recorded in plants sprayed with 200 ppm GA_3 and no pinching treatment in cultivar Flirt and Gauri during 1999 and 2000, respectively.

2. Maximum plant spread (32.74 cm and 37.23 cm) and (33.81 cm and 39.62 cm) was recorded in plants sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting in cultivar Flirt and Gauri during 1999 and 2000, respectively.

3. Similarly, maximum number of branches per plant (13.40 and 16.26) and (14.46 and 17.53) were observed in plants sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting in cultivar Flirt and Gauri during 1999 and 2000, respectively.

4. The minimum days (59.53 and 68.73) and (62.86 and 73.13) for flower bud initiation were recorded in plants sprayed with 200 ppm GA_3 and no pinching treatment in cultivar Flirt and Gauri during 1999 and 2000, respectively.

5. Number of buds per plant increased with the increase in concentration of GA_3 from 50 to 200 ppm in both the cultivars during both the years. However, maximum number of buds per plant (37.93 and 47.33) and (39.53 and 57.93) were recorded in plants sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting in cultivars Flirt and Gauri during 1999 and 2000, respectively. However, number of buds per plant were statistically at par at 150 and 200 ppm GA_3 in both the cultivars during both the years.

6. Minimum days (79.66 and 90.46) and (82.20 and 93.13) to flowering were recorded in plants sprayed with 200 ppm GA_3 and no pinching treatment in cultivar Flirt and Gauri during 1999 and 2000, respectively.

7. Maximum duration of flowering (12.80 and 14.53 days) and 12.93 and 15.20 days) was recorded in plants sprayed with 100 ppm GA_3

and pinched at 45 days after transplanting in cultivar Flirt and Gauri during 1999 and 2000, respectively.

8. Size of flower increased with the increase in the concentration of GA_3 from 50 to 200 ppm in both the cultivars during both the years. However, maximum size of flower (7.88 and 4.39 cm) and (8.07 and 4.42 cm) was observed in plants sprayed with 200 ppm GA_3 and no pinching treatment in cultivar Flirt and Gauri during 1999 and 2000, respectively.

9. Maximum flower stalk length (38.28 and 39.58 cm) and (41.68 and 40.51 cm) was recorded in plants sprayed with 200 ppm GA_3 and no pinching treatment in cultivar Flirt and Gauri during 1999 and 2000, respectively. The differences between pinching at 35 and 45 days after transplanting were statistically at par in case of length of flower stalk in both the cultivars during both the years.

10. Strength of flower stem decreased with the increase in concentration of GA_3 from 100 to 200 ppm (B to C grade) and 50 to 200 ppm (B to C grade) in cultivar Gauri during 1999 and 2000, respectively. The strength of flower stem, however, decreased in cultivar Flirt (B grade) only when the plants were sprayed with 200 ppm GA_3 and where no pinching was done.

11. Number of flowers per plant increased with the increase in concentration of GA_3 from 50 to 200 ppm and all the treatments of GA_3 significantly increased the number of flowers per plant over control in both the cultivars during both the years. However, maximum number of flowers (33.73 and 40.80) and (35.60 and 50.06) per plant were recorded in plants sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting in cultivar Flirt and Gauri during 1999 and 2000, respectively.

12. Maximum weight (3.73 g and 2.12 g) and (3.70 g and 2.15 g) of flower was registered in plants sprayed with 50 ppm GA_3 and no

pinching treatment in cultivar Flirt and Gauri during 1999 and 2000, respectively.

13. All the treatments of GA_3 and pinching significantly increased the flower yield per plant over control in both the cultivars during both the years. However, maximum flower yield per plant (116.39g and 80.74 g) and (123.83 g and 98.05 g) were recorded in plants sprayed with 200 ppm GA_3 and pinched at 35 days after transplanting in cultivar Flirt and Gauri during 1999 and 2000, respectively. The differences between 150 and 200 ppm GA_3 were statistically at par in view of flower yield per plant in both the cultivars during both the years.

14. Cultivar Gauri produced significantly more number of flowers over cultivar Flirt but flower yield per plant in cultivar Gauri decreased significantly over cultivar Flirt due to small size and less weight of flower in cultivar Gauri during both the years.

Experiment II : To study the effect of different chemicals on vase life of cut flowers of chrysanthemum cvs. Flirt and Gauri

The experiment was conducted to study the effect of vase solutions of sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02% individually and in various possible combinations on fresh weight, water relations and vase life of cut flowers. Changes in pH of vase solutions were also studied. The results are summarized as below :

1. All the chemical treatments proved effective over control in increasing and retaining the fresh weight of cut flower for more number of days in cultivars Flirt and Gauri during 1999 and 2000, respectively. However, cut flowers held in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% increased and retained their fresh weights for maximum number of days in both the cultivars during both the years.

2. All the chemical treatments increased the total water uptake of cut flowers over control in both the cultivar during both the years. However, cut flowers kept in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% recorded maximum water uptake throughout their display period in both the cultivars during both the years.

3. All the chemical treatments increased the total water loss of cut flower over control in cultivar Flirt during 2000 and in cultivar Gauri during 1999 and 2000. The total water loss of cut flower decreased over control in all the chemical treatments except vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% in cultivar Flirt during 1999.

4. All the chemical treatments significantly decreased the water loss and uptake ratio of cut flowers over control in both the cultivars during both the years indicating better water balance in their cut flowers during vase life.

5. pH of vase solution of sucrose and aluminium sulphate declined over initial pH during vase life in cultivar Flirt and Gauri during 1999 and 2000, respectively. pH of vase solution of cobalt sulphate increased over initial pH during earlier days of vase life whereas later on, decrease in pH over initial pH was recorded. Various combinations of sucrose, aluminium sulphate and cobalt sulphate, however, showed increase in pH over initial pH during earlier days of vase life whereas later on, decline in pH over initial pH was recorded.

6. All the chemical treatments significantly increased the vase life of cut flower over control in both the cultivars during both the years. However, maximum vase life (25.33 and 28.33 days) and (24.33 and 27.67 days) was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% in cultivar Flirt and Gauri during 1999 and 2000, respectively.

CONCLUSION

1. On the basis of these investigations it can be concluded that 150 and 200 ppm GA_3 sprays along with pinching of plants at 35 days after transplanting seemed to be optimum treatment combination for better growth, flowering and yield of chrysanthemum cvs. Flirt and Gauri.

2. On the basis of these investigations, it can also be concluded that sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% solution seemed to be optimum vase solution for extending vase life of cut flowers of chrysanthemum cvs. Flirt and Gauri.

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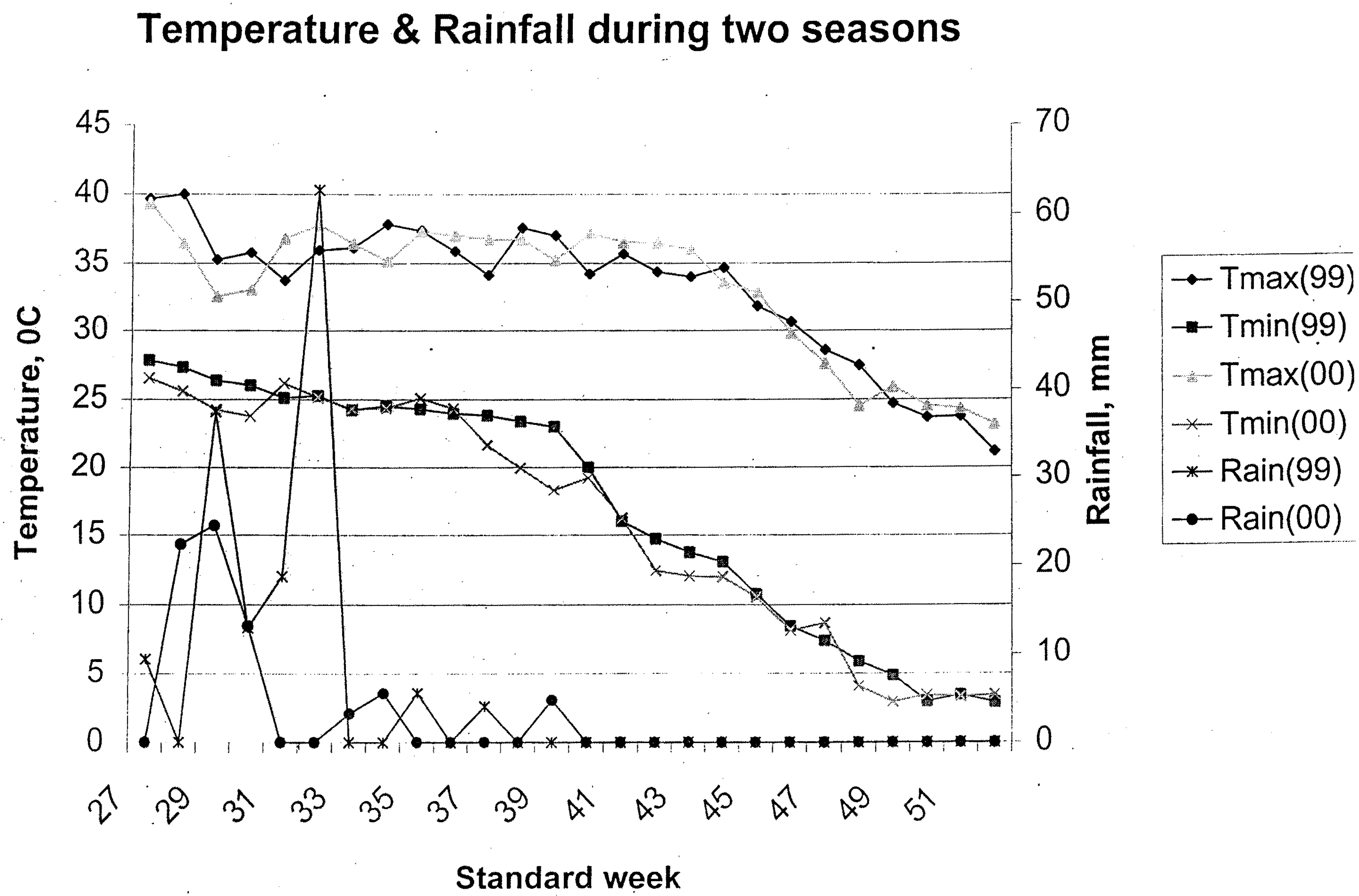
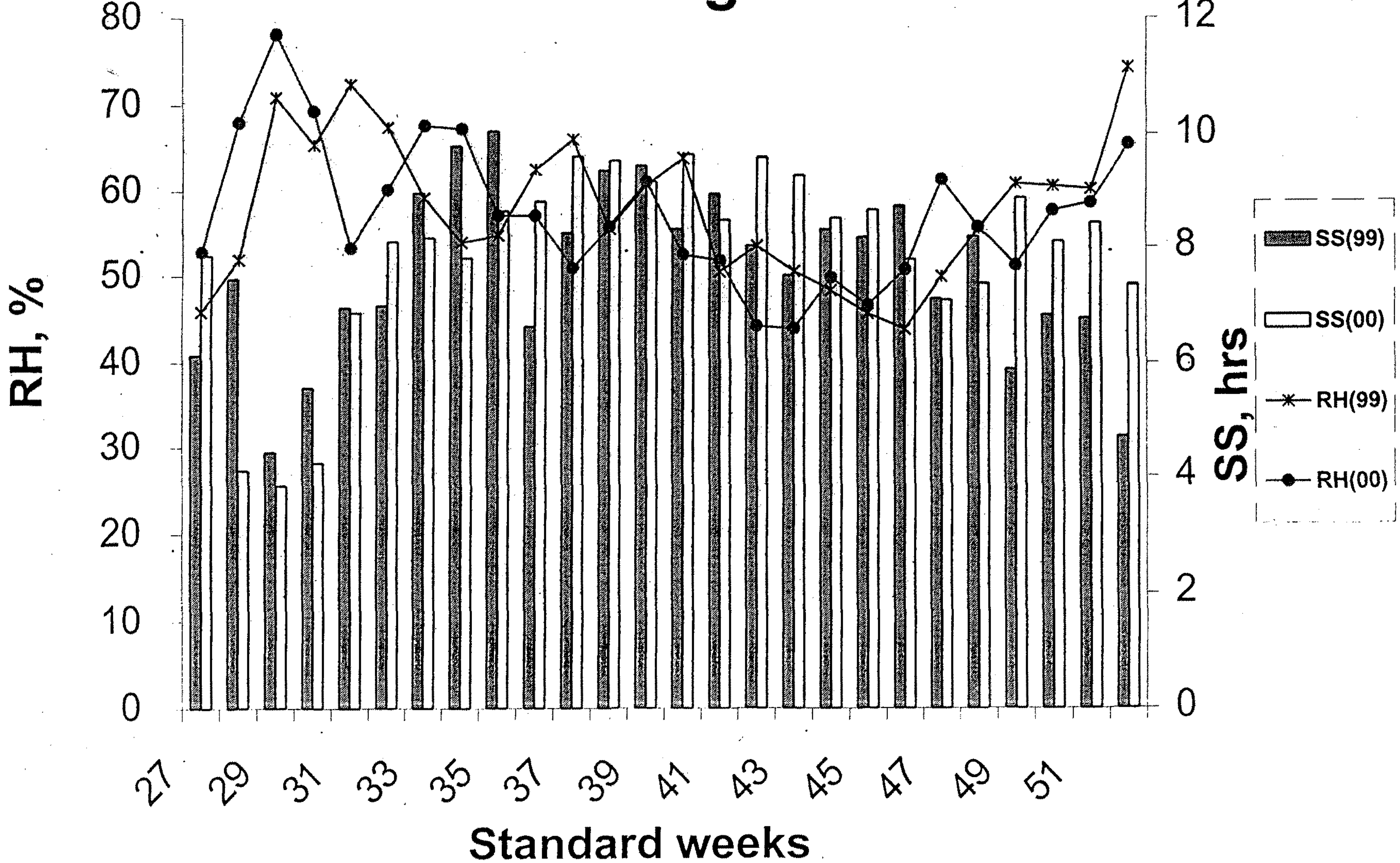
APPENDIX-I



Temperature & Rainfall during two seasons
45
40
35
30
25
20
15
10
5
0
Temperature, 0C
70
60
50
40
30
20
10
0
Rainfall, mm
27
29
31
33
35
37
39
41
43
45
47
49
51
Standard week
Tmax(99)
Tmin(99)
Tmax(00)
Tmin(00)
Rain(99)
Rain(00)

APPENDIX-II

Weekly Relative humidity and Sunshine during two seasons



ABSTRACT

a.	Title of Dissertation	:	**"Studies on cut flower production and vase life in chrysanthemum (*Chrysanthemum morifolium*)"**
b.	Full name of degree holder	:	**RAKESH**
c.	Title of Degree	:	Doctor of Philosophy
d.	Name and address of Major Advisor	:	DR. RAN SINGH SINGHROT, Professor of Horticulture, Deptt. of Horticulture, College of Agriculture, CCS Haryana Agricultural University, Hisar - 125 004.
e.	Degree awarding University/Institute	:	Chaudhary Charan Singh Haryana Agricultural University Hisar-125004 (Haryana), India
f.	Degree awarding year	:	2002
g.	Major subject	:	Horticulture
h.	Total number of pages in dissertation	:	127+x
i.	Number of words in the abstract	:	Approx. 260 words

The present study was carried out during the years 1999 and 2000 with a view to increase and regulate the cut flower production in chrysanthemum cvs. Flirt and Gauri by various GA_3 and pinching treatments under agroclimatic conditions of Haryana. After increasing and regulating the production of good quality blooms, post-harvest study was also conducted with an objective to the extend the vase life of cut flowers in chrysanthemum cvs. Flirt and Gauri by using sucrose, aluminium sulphate and cobalt sulphate individually and in various possible combinations. The field experiment on cut flower production in chrysanthemum cvs. Flirt and Gauri revealed that growth, flowering and yield were significantly increased over control in plants sprayed with 150 and 200 ppm GA_3 and pinched at 35 days after transplanting in cultivars Flirt and Gauri during both the years. However, maximum plant height, earliest flowering, maximum size of flower and

maximum stalk length of flower were recorded in non-pinched plants sprayed with 200 ppm GA_3 in cultivar Flirt and Gauri during both the years.

The laboratory experiment on vase life studies in chrysanthemum cvs. Flirt and Gauri revealed that all the vase solutions of sucrose 4%, aluminium sulphate 0.2% and cobalt sulphate 0.02% either individually or in various possible treatment combinations proved effective over control. The above treatments were effective in retaining fresh weight of cut flower for more number of days, increasing total water uptake of cut flowers, decreasing water loss and uptake ratio of cut flower resulting in better water balance in their cut flowers and thereby increased vase life. The maximum vase life of cut flower was recorded in vase solution of sucrose 4% + aluminium sulphate 0.2% + cobalt sulphate 0.02% in both the cultivars during both the years.

MAJOR ADVISOR

STUDENT

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