EFFECT OF PRESERVATIVES ON VASE LIFE OF GLADIOLUS TUBEROSE AND GERBERA

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This is to certify that the thesis entitled, "**Effect of Preservatives on Vase Life of Gladiolus, Tuberose and Gerbera**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **Mohammad Yusuf Howlader, Registration No. 00934** under my supervision and my guidance. No part of the thesis has been submitted for any other degree in any institutes.

I further certify that any help or sources of information, received during the course of this investigation have been duly acknowledged.

Dated: June 2009
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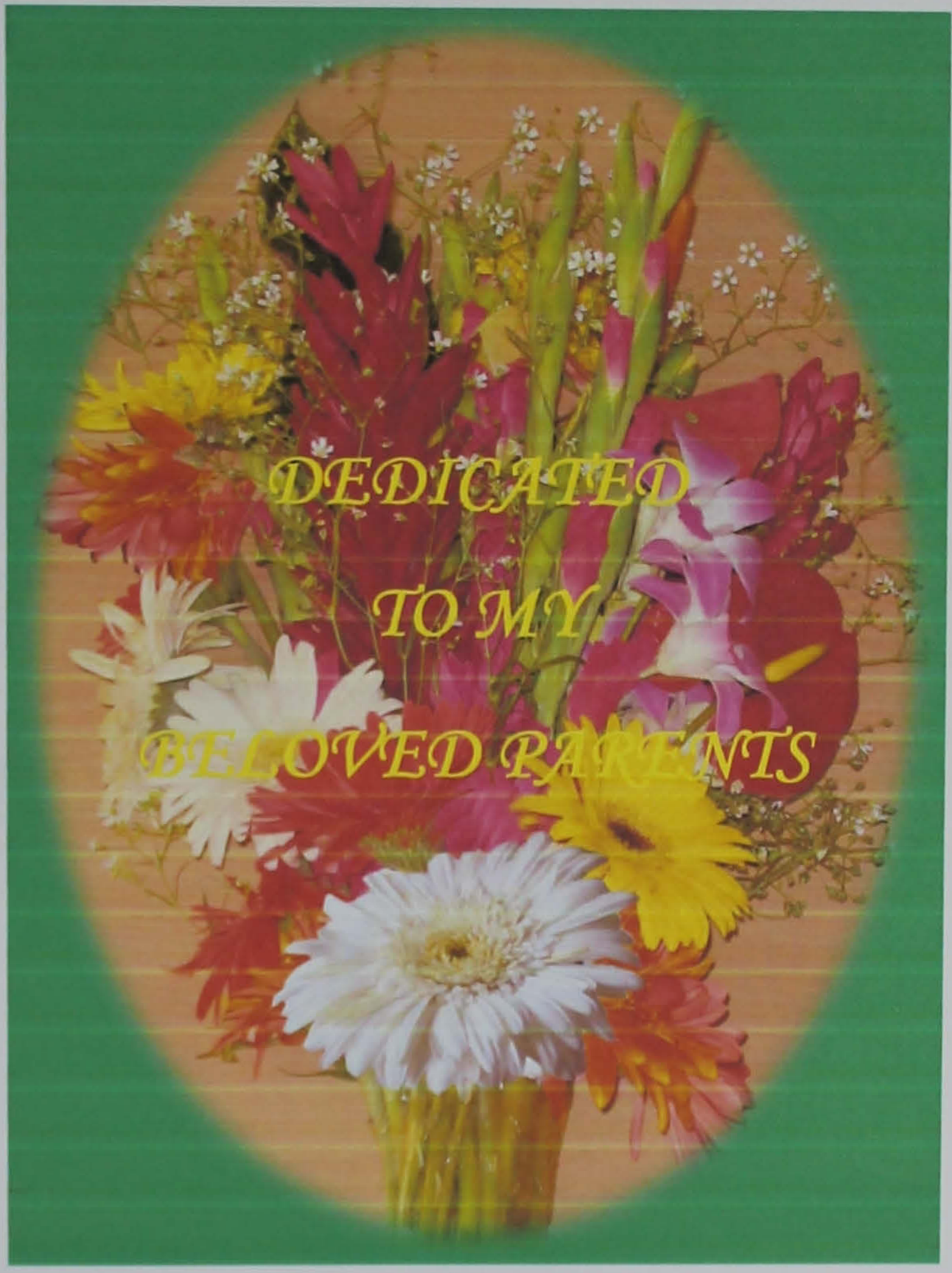

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ABSTRACT

An experiment was conducted at the Laboratory of Landscape, Ornamental and Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during the period from January 2009 to June 2009 to study the effect of different preservatives on postharvest life of gladiolus, tuberose and gerbera cut flowers. The study consisted of ten treatments- T_1= 2% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5 = 4% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6 = 4% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01 % sodium chloride, T_8= 0.05 % sodium chloride, T_9= 0.10 % sodium chloride and T_{10}= Control (tap water). Maximum vase life of 12 days was observed in gladiolus spikes held in solutions containing T_3 which was closely similar (11 days) with those held in solution T_4. In tuberose, the vase solution having a mixture of T_2 significantly increased vase life, cumulative uptake of vase solution, fresh weight and number of opened florets compared to control and other treatments. It was found that in T_1 and T_2 treatment, tuberose flowers were more fragrant followed by other treatments T_3, T_4, T_5 to T_6 and T_{10}. No fragrance was found in T_7, T_8 and T_9. A synergized effect of T_6 proved effective in delaying the senescence of cut gerbera by increasing the water uptake and reducing the water loss thereby maintaining better water balance, leading to increased fresh weight and vase life.

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The author

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF SYMBOLS AND ABBREVIATIONS

ABBREVIATION	EXPANSION
BARI	Bangladesh Agricultural Research Institute
cm	Centimeter
No	Number
Fig	Figure
DMRT	Duncan's Multiple Range Test
et al.	And others (at elli)
e.g.	For example
etc.	*Et cetera* and others
g	Gram
GA_3	Gibbrellic acid
@	At the rate of
HRC	Horticulture Research Centre
i.e.	*id est*= in other words
ANOVA	Analysis of Variance
NaCl	Sodium Chloride
mg/L	Milli gram per litre
mμ	Millimicron
mM	Millimole
$AgNO_3$	Silver Nitrate
MP	Muriate of Potash
°C	Degree Celsius
CA	Citric Acid
P^H	Hydrogen ion concentration
ppm	Parts Per Million
RCBD	Randomized Complete Block Design
CRD	Completely Randomized Design
RH	Relative humidity
SAU	Sher-e-Bangla Agricultural University
Kg/ha	Kilogram Per hectare
TSP	Triple Super Phosphate
STS	Silver Thiosulfate
$CaCl_2$	Calcium Chloride
$Ca(NO_3)_2$	Calcium Nitrate
$Al_2(SO_4)_3$	Aluminium Sulphate
KCl	Potassium Chloride
DIW	Deionized Water

Chapter 1
Introduction

CHAPTER I

INTRODUCTION

In modern era, floriculture is gaining much importance. The floriculture industry has become a good source of income. Besides, it also gives pleasure and happiness to human beings. Cut flowers are one of the most important commercial products of the aforesaid industry and also constitute 55 percent share of the total world floriculture trade. The flowers more important for cut flower trade in Bangladesh are gladiolus, tuberose, rose and gerbera. The use of cut flowers in home decoration has become an integral part of living in human society, particularly in affluent countries. According to a recent survey, the total area under floricultural crops in different parts of Bangladesh is 10,000 ha (Ara, 2010). It is also revealed from another survey that annually flower business worth of Tk. 4000 million is being held in our country (Sharifuzzaman, 2009). So, at present floriculture in our country is increasing. Maintenance of quality during post harvest period and prolonging post harvest life require careful handling and some special treatments.

Gladiolus (*Gladiolus* sp.) particularly known as Sword Lily belongs to Iridaceae family. It is one of the most important bulbous flowers in Bangladesh as well as in many parts of the world. It has been rated as the fifth most important popular flower in the world, especially from the commercial point of view (Dadlani, 2003). Gladiolus is popular for its attractive spikes having florets of huge form, richly varied in color and prolonged vase life (Chadha and Choudhury, 1986). It is used for indoor decoration and in vases, particularly in urban areas. Since it has many florets these open sequentially, extension of its vase life helps the floriculture industry.

Tuberose belongs to the family Amaryllidaceae, a native of Mexico, is an important ornamental bulbous plant. It occupies a prime position in Bangladesh among commercial flower crops, which has demand both in domestic and international markets and its production is highly profitable (Momin, 2006). In the domestic market, the flowers are used for table decoration, floral ornaments, bouquets and in mixed flower garlands (Choudhury, 2007). Tuberose has a delightful fragrance and is the source of tuberose oil. The natural flower oil of tuberose is one of the most expensive raw materials for perfume. In Bangladesh, for the last few years, tuberose has become a popular cut flower for its attractive fragrance and beautiful display in the vase. Since it has delicate flowers, sellers and consumers show their keen interest which necessitates improvement of its post harvest life.

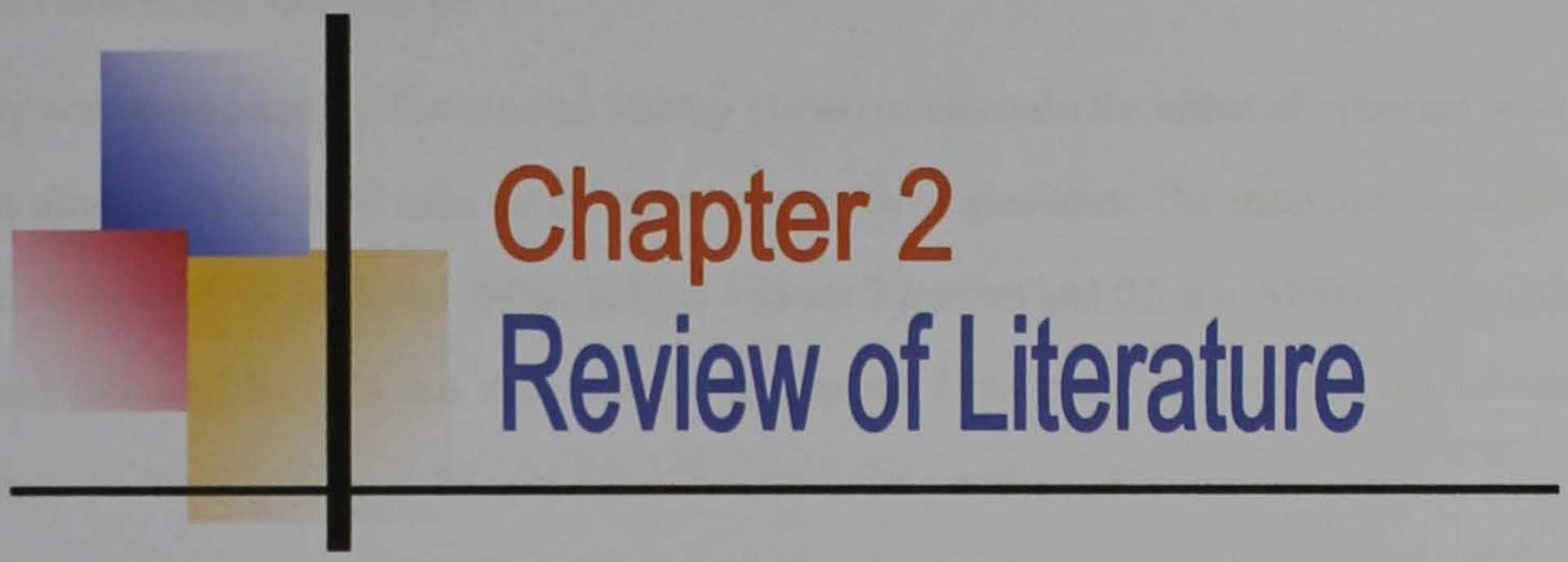
Gerbera (*Gerbera jamesonii*) belongs to Asteraceae family. It has considerable demand in both domestic and export markets (Bose *et al*., 2002). Its elegant spikes, richly varied colour and long vase life are the reasons for its ever-increasing demand (Nur, 2004). It is one of the most important herbaceous perennial flowers used commercially as cut flowers. It is also used in garden decorations, such as herbaceous borders and formal beds (Ashwath and Parthasarathy, 1994). The blooms are attractive, suitable for any type of floral arrangements and are available in different shades and hues. Besides floral arrangements, gerbera is widely used in bouquets and as dry flowers.

Improvement of keeping quality and extension of vase life of cut flowers are important areas in Floricultural research. Senescence of cut flowers is induced by several factors e. g. water stress (Sankat and Mujaffar, 1994), carbohydrate depletion (Kesta, 1989), microorganism (Van Doorn and Witte, 1991) etc. A major cause of deterioration in cut flowers is blockage of xylem vessels by microorganism that accumulate in the vase solution or in the vessels. When cut flowers are separated from parent plant, the continuity of water flow through xylem vessels into the flower is disrupted. Hence, water plays a dominant role in the post harvest physiology of cut flowers. Accomplishment of the extension of vase life depends on proper harvesting, post harvest handling and a preservative solution for ensuring an ample supply of water, metabolites and regulatory substances to petals and leaves. Investigations pertaining to extension the vase life of cut flowers by several preservative/ chemicals i.e. silver nitrate, sucrose, HQS, HQC, aluminium sulphate, cobalt sulphate, kinetin, boric acid, citric acid, ascorbic acid after harvest in different formulations and combinations have been used with varying success (Van *et al*. 1991; Saini *et al.* 1994; Ahn, 1996; Reddy *et al*. 1997; Anjum *et al*. 2001; Pruthi *et al*. 2002) in many countries of the world. But repots on vase life of cut flowers in Bangladesh is scanty. Considering the above facts, the present study was undertaken with the following objectives:

Objectives (s):

1. To identify the suitable preservative (s) in extending the vase life of gladiolus, tuberose and gerbera and

2. To determine floral preservative in improving quality of cut flowers.



Chapter 2
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Gladiolus, tuberose and gerbera are the three most important cut flowers in the world. A number of research works on vase life of different flower have been conducted in different parts of the world. Information under Bangladesh condition is scanty. However, an attempt has been taken to review the available literature related to the present study with the hope that these may contribute a lot to the present investigation.

Preservatives on Gladiolus

A study was undertaken by Gowda and Murthy (1994) to ascertain the effect of optimum level of sucrose along with metallic salts on the post harvest life of gladiolus. The maximum vase life of 14 days was observed in flower spikes held in sucrose 2 percent and 0.5 mμ $Al(SO_4)_2$ (aluminium sulphate) followed by 0.25 mμ also along with sucrose 2 percent (12 days). All the treatment combinations tried, improved the vase life of cut gladiolus compared to control (6 days).

Reddy *et al.* (1994) noted that quinoline salts and sucrose mixtures were good for extending the vase life and improve the quality of gladiolus cut flower. However, treatment with 200 ppm 8-HQS and 4% sucrose increased cut flower life, by increasing the water uptake and maintaining higher fresh weight of flowers.

Creating a light moisture stress by holding irrigation for 3 days prior to harvest of gladiolus spikes resulted in maintenance of better water relations, enhanced floret opening and extended vase life maximally (9 days) compared to the least (6 days) in those irrigated daily (Murali and Reddy, 1994). It has been demonstrated by Reddy and Murali in 1994 that dipping the gladiolus (cv. Mansoer Red) corms in 75-100 ppm concentration of Triadime improved post harvest water relations and vase life of spikes.

Opening of gladiolus spikes in an STS solution maintains higher fresh weight by encouraging more water uptake, leading to enhance longevity of florets and vase life of the spike. According to Reddy and Murali (1994), STS 0.5 mM was found best for increasing water uptake and extending the longevity of cutflower.

Different concentrations of sucrose (0 %, 2 % and 4 %) and cobalt (0 ppm, 100 ppm and 500 ppm) effective in increasing the water uptake, water loss, percent floret opening, vase life and fresh weight of gladiolus spikes when these solutions were used singly by Gupta *et al.* (1994). But in combination their solution were found more effective in maintaining an increased pattern of water uptake and water loss and decrease in water loss/water uptake ratio. However, the spikes held in 2 % sucrose and 300 ppm cobalt (Co) solution was helpful in the proper development and full expansion of flowers in a vase and in maintaining improved water status.

Ezhilmathi *et al.* (2007) studied the effect of 5 sulfosalicylic acid (5-SSA) on the vase life of cut flowers of *Gladiolus grandiflora* variety 'Green Willow'. The vase solution having 5-SSA significantly increased vase life, cumulative uptake of vase solution, number of opened florets and decreased the number of unopened florets compared to the controls.

AL-Humaid (2004) conducted an experiment to find out the effect of biocide on postharvest quality and vase life of cut gladiolus. Vase life was significantly improved by placing spikes in vase solution containing antibiotics (200 ppm penicillin + 250 ppm streptomycin) and glucose (5, 10, or 20%). The addition of the biocide to the preservative solution reduced the bacterial counts in the solution, inhibited the microbial growth, improved flower-opening rates and reduced flower deterioration rate. Although there were positive proportional relationships among sugar concentration (up to 10%) and total bacterial counts in the solution, the addition of the biocide

reduced the bacterial counts, resulting in the improvement of postharvest quality of tested cultivars. The highest and lowest number of opened and deteriorated flowers, respectively, was achieved when the preservative solution contained a mixture of biocide and 20% glucose. Presence of biocide in the vase solution reduced both total carbohydrates and chlorophyll contents in the leaves of the cut gladiolus spikes.

Singh and Sharma (2001) reported that the combination of sucrose (5%) and metal salts 8-hydroxyquinoline citrate (8-HQC) 600 mg/l increased the vase life of cut gladiolus spikes cv. 'White Properity'.

Garibaldi and Deambrogio (1989) investigated an experiment with sucrose, 8-HQS, 3, 4, 5-T (Trichlorophenol) and distilled water for prolonging vase life of gladiolus. It was observed that sucrose was significantly better than distilled water for preserving cut flowers of cultivar Priscilla and Moana.

Anserwadekar and Patil (1986) carried out the vase life of gladiolus. The treatments were 6% sucrose, GA_3 at 60 ppm and distilled water. It was observed that sucrose maintained prolonged vase life for 11 days than other treatments.

Merwe *et al.* (1986) mentioned the effects of sucrose uptake from a vase medium on the starch metabolism of senescing gladiolus inflorescence. The treatments were sucrose solution of different concentrations. It was observed that the vase life, general appearance, fresh mass and volume of medium uptake of the inflorescences improved with sucrose treatment. It was recorded that a concentration of 30 g sucrose/litre (i.e. 3% sucrose) was the most effective treatment.

Mayak *et al.* (1973) observed that gladiolus flowers when treated with 1 mM STS (an anti-ethylene compound) for 2 hours improved the opening of the small buds and consequently the postharvest life of the cut stems.

Flowers of gladiolus cv. Black Jack were placed in conical flasks containing 2 and 3% of sucrose, aluminium sulfate (0.5 and 1.0 µM), aluminium chloride (0.5 and 1.0 µM) or calcium sulphate (0.5 and 1.0 µM) solution. Longest vase life (18.3 days) was with 1.0 µM aluminium sulphate, follwed by 3% sucrose (17.0 days) and 2% sucrose (15.3 days). Shortest vase life (9.1 days) was found in the control. The highest uptake of solution (48.0 ml) was with 1.0 with 1.0 µM aluminium sulphate and the lowest uptake (30.6 ml) in the control. The increase in vase life due to sucrose may result from decreased moisture stress and improved water balance (Gowda and Gowda, 1990).

Preservatives on Tuberose

Singh *et al.* (1994) investigated the physiological role of GA (25-50 ppm), 8-HQS (200-300 ppm) and sucrose (3-4%) singly and in a combination of these chemicals in extending the vaselife of tuberose cutflowers. The maximum vase life of 14 days was observed in flower spikes held in 3% sucrose, 300 ppm 8HQS along with 50 ppm GA.

Madaiah and Reddy (1994) developed a method for tuberose packaging. The tuberose florets packed in polypropylene wrapping extended the shelf life of tuberose up to 20 days when stored dry at 3^0C and 98 % relative humidity.

Nickel has been observed to inhibit ethylene production as well as extending the vase life of cut tuberose by improving water balance and preventing water stress. (Reddy *et al.*, 1994). They observed that pulsing 12 hours with 5 mM nickel sulphate was the best in enhancing the vase life (10 days) compared to any other combination.

Reid (2002) mentioned that treatment with a solution containing 20 percent sucrose and a biocide was effective to inhibit bacterial growth. Additionally, flowers of tuberose opened better, bigger and have a longer vase life.

Jowkar and Salehi (2005) conducted an experiment to find out a suitable preservative which provides the longest vase life for tuberose. The experiments carried out by applying the vase solutions.were: sucrose (1, 2 and 3%), silver thiosulphate (0.4, 0.8 and 1.2 mM), silver nitrate (50,100 and 150 mg/1), citric acid (150, 300 and 450 mg/1) and tap water as the control. The longest vase life was observed by silver nitrate 100 mg /l with 3% sucrose and 30 ppm citric acid.

Hutchinson *et al.* (2003) reported that tuberose flowers held in de-ionised water (DIW) had a vase life of 13 days with 63% floret opening. Addition of gibberellins (GA_4) in the vase solution had no effect on vase life or floret opening along the spike. Pulsing of the cut flowers with 10% sucrose for 24hr before transfer to DIW improved their vase life by 4 days and improved the floret opening by 21% above DIW controls.

Bhasker and Rao (2000) reported that the longest vase life of tuberose was observed by using 0.1% Ca $(NO_3)_2$ (calcium nitrate) and 250 ppm citric acid (CA) and 3% sucrose (14.67 days).

Singh *et al*. (2000) observed that synergized effect of BA, sucrose and 8-HQC on vase life as well as opening of buds of tuberose flowers.

The opening of tuberose buds was considerably improved with vase solution containing sucrose and 8-HQC. For cv. Single, vase solution containing 1% sucrose was best whereas for cv. Double, high sucrose concentrations (3%) were most effective (Kushal *et al.,* 2000).

Experiments were conducted by De and Barman (1998) to study the effects of stem length (30, 45, 60, 75 or 90 cm), harvesting stage (spikes with green buds, greenish white buds, creamy white buds, one floret opened and two florets opened) and sucrose concentration (0%, 2%, 4%, 6%, 8%, 10% or 12%) on vase life and cut flower quality of tuberose cv. Single. Results indicated that stem length of 75 cm, harvesting when spikes had creamy white buds or one floret opened and using 8% sucrose as the holding solution produced the highest quality, longest-lasting cut flowers. Harvesting stages of tuberose (*Polianthes tuberosa)* spikes showed increase in vase life with the advancement in the stage of bud development. The spikes of cultivar with double flowers showed very poor vase life.

The *Polianthes tuberosa* spikes were placed in solutions containing 1 or 2% sucrose and/or aluminium sulphate at 200 or 400 ppm and held for 12 days. The vase life was longest (12 days) in the following 2 solutions: 1% sucrose + 200 ppm aluminium sulphate and 2% sucrose + 400 ppm aluminium sulphate (Gowda, 1990).

Reid and Michael (2002) conducted an experiment to find out the effect of biocide1-5 % to prevent the growth of bacteria in the vase solution. The vase solution having 5% NaOCl (Sodium hypochlorite) significantly increased cumulative uptake of vase solution, vase life and number of opened florets.

Huang and Chen (2002) suggested that pulsing with gibberellic acid (GA_3) at 10 or 20 mg/L plus 8-hydroxyquinoline sulfate (200 mg/L) for 24 h followed by continuous sucrose treatments (4 or 8%) plus 8-hydroxyquinoline sulfate extended the vase life and significantly promoted flower bud opening as compared with the 8-hydroxyquinoline sulfate controls. Cut stems continuosly placed in solutions containing sucrose produced less ethylene than those without sucrose. It was suggested that gibberellic acid pulse at 10 mg/L followed by continuous sucrose treatment at 4% be recommended to growers for extending the vase life and enhancing flower bud opening in cut *Polianthes tuberosa.*

Bakhsh *et al.* (1999) conducted an experiment to find out the effect of different chemicals on vase life and quality of cut tuberose. Vase life was increased three times by using a solution containing 200 ppm silver nitrate ($AgNO_3$) and 4 ppm silver thiosulfate (STS). Pulsing cut tuberose stems in a solution containing glucose and sucrose prolonged vase life and improved quality. Flower harvested at right bud stage had significantly longer vase life compared to flowers cut at half open bud stage. The quality of flowers was also improved greatly by pulsing flowers in silver nitrate ($AgNO_3$) and silver thiosulfate (STS) chemicals.

Reid (1996) tested the effect of putting freshly-cut tuberose spikes in a preservative vase solution containing 8-HQC and 2% sucrose. The results demonstrated that holding flowers in preservative increased floret opening and vase life by over 30%.

Reddy and Singh (1996) studied the effect of aluminium sulphate and sucrose on the postharvest physiology of tuberose flower spikes. Aluminium sulphate in combination with sucrose significantly enhanced the vase life and quality of tuberose spikes by increasing the water uptake, maintaining better water balance and higher fresh weight for longer periods. Optimum concentrations for the combined treatment were 0.50 mM aluminium sulphate and 4 % sucrose.

Naidu and Reid (1989) suggested that tuberose flowers pulsed for 24 h at 20 to 25^{0}C (68 to 77^{0}F) with a preservative solution augmented with 20 % sucrose significantly improved vase life and opening of buds on the flower spikes.

Nagaraja *et al.* (1991) was carrying out an investigation to elucidate the effect of different chemicals and packaging on the shelf life of loose tuberose flowers under ambient conditions. The loose tuberose flowers treated with STS at 0.25 or 0.50 mμ and packaged in polythene bags exhibited lower physiological weight loss higher moisture content, greater freshness, better colour and fragrance and extended shelf life. The shelf life of treated flowers was 500 days as compared to one day in non-packaged controls.

Pathak (1981) reported that vase solution containing benzymidazol, SADH, ascorbic acid, sucrose and 8-HQC in appropriate proportion was found useful for improving the opening of flowers on tuberose spikes and enhancing the vase life of flowers.

De and Barman (1998) reported that boric acid (250 ppm), $Al(SO_4)_2$ (50 ppm), $CaCl_2$ (1000 ppm) and citric acid (400 ppm) proved effective in floret opening, increased flower diameter and vase life of tuberose.

Harode *et al.* (1993) observed that the vase life of tuberose was the best with 1% NaCl, which gave a significantly better flower colour and freshness together with stem colour and firmness.

Bhasker *et al.* (1999) recorded increased vase life using aluminium sulfate {$Al(SO_4)_2$}and calcium nitrate at 0.05%. These chemicals exerted a duel effect in delaying senescence of flowers by increasing the water uptake and reducing the water loss, thus by maintaining better water balance, leading to increased fresh weight and vase life.

Bhasker *et al.* (2003) reported that the longest vase life of tuberose was observed by using 0.1% Ca $(NO_3)_2$ (calcium nitrate) and 250 ppm citric acid (CA) and 3% sucrose (14.67 days).

Anjum *et al.* (2001) conducted an experiment to find out the effect of different chemicals on vase life and quality of cut tuberose. Cut spikes of tuberose were kept in $CaCl_2 2H_2O$, $AgNO_3$, ascorbic

acid and Tri-Miltox Forte (a fungicide) solutions with various concentrations to see their effects on keeping quality and vase-life of the flowers. A control (tap water) and a standard preservative were also included in the experiment. $AgNO_3$, $CaCl_2 2H_2O$ and Tri-Miltox Forte delayed flower opening as compared to ascorbic acid and standard preservative, but stood at par with control. Calcium chloride ($CaCl_2 2H_2O$) at concentrations of 750 to 1250 ppm and Tri-Miltox Forte at 1500 ppm resulted in minimum flower wilting after six days. $AgNO_3$ was found to have adverse effects on fragrance of the flowers. Water uptake by the spikes was more in those kept in standard preservative and $CaCl_2$ $2H_2O$ 750 and 1000 ppm solutions. However, $AgNO_3$, 50 and 200 ppm solutions resulted in maximum vase-life (8 days) of cut flowers. Percentage of flowers opened and wilted was significantly negatively correlated with the vase-life. However, vase life was not correlated with fragrance of the flowers and net water uptake.

Preservatives on Gerbera

Manreet *et al.* (2002) observed the effect of some biocides on the vase life of cut gerbera cv. Glory stem (50 cm long). The stems were placed in vases containing solution of each of the following: water (control), aluminium sulfate, cobalt chloride (at 100, 200 and 300 ppm each), sodium hypochlorite (at 100, 200 and 300 ppm each) and commercial bleach (25, 50 and 100 ppm each). Observations were recorded for vase life (until the occurrence of stem break or wilting of the out florets) and optical density of the solution at 480 mm (after the termination of vase life). Results showed that all the solutions increased the vase life of the flowers. However, the maximum vase life (11days) was obtained by 200 ppm aluminium sulphate.

Amariutei *et al.* (1995) conducted an experiment to observe physiological and biochemical changes of cut gerbera inflorescences of cv. Red Marleen in vase containing distilled water and preservative solution (2.5% sucrose + 150 ppm 8-HQS + 200 ppm KCl). The rate of respiration,

fresh weight and vase life of inflorescences held in preservative solution were greater than in those held in distilled water.

Thangaraj *et al.* (1990) studied the vase life of gerbera (*Gerbera jamesonii* Bolus). Freshly cut flowers placed in glass tubes with 15, 20 and 25% sucrose, were held at room temperature for 24 hours. They stated that in all cases of sucrose concentrations, no flower stalk bending, petal drooping and petal necrosis were observed after 24 hours. They noticed that pulsing cut flower stalks with 20 % sucrose significantly increased water uptake and maintaining a higher fresh weight, leading to increased vase life.

A study was conducted by Steinitz (1983) to find out the effect of chemicals on the vase life and quality of gerbera. Sticks held in vase solutions containing 4% sucrose with 250 ppm $AgNO_3$ and citric acid attained maximum vase life of 14 days as compared to control for 10 days only.

Accati and Jona (1989) carried out an experiment to find out longevity of gerbera cut flower. A mixture of 300 ppm 8-hydroxyquinoline sulphate, 300 ppm sodium benzoate and 2g/l sucrose appeared to be the best keeping solution for extending vase life of gerbera.

Steinitz (1983) reported that dry weight was more than double within 11 days and fiber and lignin increased by 40-50% when the flowers were kept in 6% solution of sucrose immediately after harvest. Placing of flowers immediately after harvest in fresh water or chrysal-VB solution improved vase life of cut gerbera flowers.

Laboratory trials were carried out by Emongor in 2004 to investigate the effect of gibberellic acid (GA_3) on the postharvest quality and vase life of gerbera cut-flowers. Freshly cut flower stems of gerbera cultivar 'Ida Red', with two outer disc florets open were put in flower vases containing 0, 2.5, 5 or 7.5 mg/l of GA_3. The treatments were arranged in a Completely Randomized Design with four replications. Gerbera cut flowers held in GA_3 at 2.5, 5 or 7.5 mg/l significantly delayed flower senescence by increasing the number of disc florets open, delayed petal fading and abscission. Gibberellic acid at 2.5, 5 or 7.5 mg/l significantly reduced dry matter content in the flower heads and stems of gerbera cut-flower. Gerbera cut-flower held in 2.5, 5 or 7.5 mg/l GA_3 had significantly higher water content in the flower heads and stems, hence maintaining flower turgidity, reduction in bent neck and flower senescence and increased flower quality after 14 days of holding compared to flowers held in distilled water.

Bose *et al.* (1999) conducted an experiment to investigate the effect of floral preservatives to improve the keeping quality of gerbera flowers. They reported that immersing cut flowers for 24 hours in a solution containing 200 mg/l 8-hydroxyquinoline sulphate (HQS), 200 mg/l silver nitrate and 5% sucrose improved the post harvest quality and vase life of gerbera cut-flowers.

Stinson (1953) studied post harvest quality of gerbera at different pH value and $AgNO_3$ solutions. $AgNO_3$ @ 200 ppm with 3.0 pH recorded best for flower opening and long vase life.

Gerbera cut flowers kept well up to 2 weeks after pretreatment with a solution containing 50 mg/l silver nitrate + 200 mg/l 8-hydroxyquinoline citrate (HQC) + 7% sucrose (Das and Singh, 1990).

Rogers and Tija (1990) stated that flower holding a solution containing 4 % sucrose + 200 mg/l Ag NO_3 + 25 ppm citric acid was found most effective for prolonged vase life of gerbera as well as for controlling microbial growth.

Stems of gerbera flowers placed in holding solution containing, among other things, 6% sucrose increased irreversibly in rigidity and mechanical stability after harvest (Steinitz, 1982).

Van *et al.* (1991) reported that vase solution containing 4 % sucrose, 25 ppm citric acid and 300 ppm $AgNO_3$ significantly increased the water uptake and maintaining a higher fresh weight, leading to increased vase life of gerbera.

Vase life of gerbera was prolonged by using $AgNO_3$, citric acid and sucrose mixture (Harding *et al.* 1981).

Preservatives on other Flowers

Staby and Naegle (1984) studied the effect of silver thiosulphate (STS) in Alstroemeria flower. Silver thiosulphate pretreatment increased vase life of Alstroemeria. The result demonstrated that holding flowers in STS preservative increased flower opening and vase life by over 50%.

Jones and Truett (1992) studied post harvest handling of cut Gloriosa flowers. They observed that vase life was significantly extended by the use of germicides 8-HQC @ 250 mg/l. This germicides acted primarily by improving solution uptake. Sucrose, either as a continuous treatment (of 2% or 5% W/V or as a 24 hour pulse (20 %), significantly enhanced vase life, primarily by enhancing the development of immature buds and delaying senescence in open flowers.

Physostegia purpurea Blake is a native herbaceous perrenial that has potential as a field grown cutflower. Kelly and Starman (1990) reported that fresh cut flowers treated with silver

thiosulphate and held in 2 % preservative solution lasted 14 days, while control stems in deionized water (DI) lasted only 6 days.

Silver thiosulphate 1.5 mM and sucrose 2 % increased carnation cutflower life, by increasing the water uptake, maintaining higher fresh weight of flowers and longevity (Cook and Staden, 1987). The longevity of treated flowers was extended to 18 days.

Pulsing is a short treatment given by flower growers or transporters, the effect of which should last for the entire shelf life of the flower even when held in water. Gowda (1994) stated that treatment with pulsing cut rose cv. Montezuma for three hours with two percent sucrose effectively improved post harvest life by 3.0 days.

Vase life of China aster was significantly influenced by preharvest spray of CCC as reported by Nagarajaiah and Reddy (1994). They concluded that preharvest spray of CCC 100 ppm to 200 ppm on the 20th day or 30^{th} day enhanced the flower quality at harvest and vase life.

Nagarajaiah *et al.* (1994) reported that foliar sprays of Alar or B_9 1500 ppm when applied on the 20^{th} day or 20^{th} and 30^{th} day was beneficial in producing larger size china aster flowers with longer vase life.

Application of 0.75mM aluminium sulphate in vase water maintained the good keeping qality of cut calendula (Shoba and Gowda, 1994), thereby encouraging continuous water transport through the cut stem and delaying the increase in membrane permeability.

Zinc sulphate acts as a germicide (Prasanna *et al.*, 1994). They noticed that pulsing cutflowers with various concentrations of zinc sulphate significantly increased the water uptake. Cut flowers pulsed with 7.5 mM zinc sulphate for 12 hours recorded the highest total water uptake and maintained a higher fresh weight, leading to enhanced vase life.

Pulse solution of 1mM silver thiosulphate was found effective in advancing the vase life and maintenance of increased fresh weight of carnation spike (Reid *et al.*, 1990).

Ahn (1996) observed that treatment with 25% carbonated salt and 10 ppm NaOCl developed less bent neck in cut roses and produced less ethylene than other treatments. This was also the most effective treatments for prolonging vase life and maintaining flower quality.

A combination of BA pretreated and 0.4 mμ silver thiosulfate spray had synergistic effect on the vase life of Cattleya hydride (Yamane *et al.*, 1997).

Koyama *et al.* (1995) reported that the vase life of carnation flowers was extended after 12 weeks of cold storage by STS treatment.

Lee (1980) found that pretreatment with 100 ppm $AgNO_3$ followed by holding in preservative solution 200 ppm 8-HQC extended vase life 3 times longer than control in carnation.

Lee and Nowak (1981) observed that 24 hours of pretreatment with $AgNO_3$ increased the vase life of flowers from 3 to 4 days for carnation kept in water or in preservative solutions after stimulated transport conditions.

Bhat *et al.* (1999) reported that chrysanthemum cut flowers when kept in a holding solution containing 250 ppm 8-HQC and sucrose at 1.5% had the longest vase life, the greatest flower diameter and the lowest fresh weight loss in storage.

Rajagopalan and Khader (1993) stated that the longest vase life (15 days) of chrysanthemum cut flowers was obtained by pulsing with 0.1% aluminium sulfate with two percent sucrose for 6 hours.

Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

In this chapter, the materials and methods have been presented with a brief description of location of the experimental site, atmospheric condition of the vase life room, materials used for the experiment etc. The details of research procedure are described here.

Experimental site

A. Location

These experiments were conducted at the Laboratory of Landscape, Ornamental and Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during the period from January 2009 to June 2009.

B. Atmospheric condition of the vase life room

Minimum and maximum temperature in the laboratory room was 20^{O}C to 35^{O}C and relative humidity 65% to 80% during the period from January 2009 to June 2009. Temperature and humidity of the laboratory were recorded with a digital thermo- hygrometer.

Experimental materials

Three type spikes of gladiolus, tuberose and gerbera flower were selected as experimental materials. Fresh gerbera, gladiolus and tuberose spikes of about 45, 55 and 60 cm respectively were harvested from field of Landscape, Ornamental and Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur in the morning to avoid excessive heat and immediately the stems were placed in plastic buckets containing cold water in order to rehydrate the flowers. The flower spikes were brought to the laboratory within ½ hour after harvest. Flower spikes were sorted into different groups (based

on the size and number of florets per spike) in order to maintain uniformity in the material used for experiment. Stem of the spikes were again cut to uniform length of 40, 50 and 55 cm. for gerbera, gladiolus and tuberose respectively and all the leaves were removed to avoid contact with the solution.(Buys, 1969).

Treatments

The study consisted of ten treatments-

T_1= 2% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid,

T_2= 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,

T_3= 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid,

T_4= 3% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,

T_5= 4% sucrose + 100 ppm $AgNO_3$ +25 ppm citric acid,

T_6= 4% sucrose+ 200 ppm $AgNO_3$ + 25 ppm citric acid,

T_7= 0.01 % sodium chloride,

T_8= 0.05 % sodium chloride,

T_9= 0.10 % sodium chloride and

T_{10}= Control/ tap water.

Experimental design

The experiment was laid out in a Completely Randomized Design with three replications.

Methods

Single stalk of each flower was used for each bottle (Plate1a-1c). A total number of 30 flowers were used to hold the floral preservatives which were prepared freshly and dispensed into the bottles. Bottles were kept at room temperature (20-35^{0}C), relative humidity (RH) of 65-80% with adequate aeration.

Plate 1a : Placement of Gladiolus flower stick in glass bottle

Plate 1b : Placement of Tuberose flower stick in glass bottle

Plate 1c : Placement of Gerbera flower stick in glass bottle

Preparation of vase solutions

Procedure of applying different preservatives to the flowers of each type was as follows:

A. Control solution

No preservative was added here. Tap water was used and collected from the Floriculture Laboratory of Horticulture Research Centre, Bangladesh Agricultural Research Institute. One stalk of three cut flowers namely Gladiolus, Tuberose and Gerbera were separately placed in bottle containing 150 ml of tap water and kept in laboratory at room temperature.

B. Sugar solution (2-4%)

Sugar 20g was dissolved in 1 litre of water to prepare 2% solution. Similarly, 30 and 40 g sugar was dissolved in 1 litre of water to prepare 3% and 4% solution. One stalk of three cut flowers namely Gladiolus, Tuberose and Gerbera were separately placed in bottle containing 150 ml of sugar solution and kept in laboratory at room temperature.

C. $AgNO_3$ solution (100-200ppm)

100 ml of $AgNO_3$ was dissolved in 1 litre of water to prepare 100 ppm solution of $AgNO_3$. Similarly, 200 ml of $AgNO_3$ was dissolved in 1 litre of water to prepare 200 ppm solution of $AgNO_3$ .One stalk of three cut flowers namely Gladiolus, Tuberose and Gerbera were separately placed in bottle containing 150 ml of respective concentrations of $AgNO_3$ solution and kept in laboratory at room temperature.

D. Sodium chloride solution (0.01-0.05-0.10%)

100 mg sodium chloride was dissolved in 1 litre of water to prepare a 0.01% solution. Similarly, 500 mg sodium chloride was dissolved in 1 litre of water to prepare 0.05% solution and 1g sodium chloride was dissolved in 1 litre of water to prepare 0.10% solution. One stalk of three cut flowers namely gladiolus, tuberose and gerbera were separately placed in bottle containing 150 ml of respective concentrations of sodium chloride solution and kept in laboratory at room temperature.

E. Citric acid (25 ppm)

25 ml citric acid was dissolved in 1 litre of water to prepare 25 ppm solution.

F. Flower vase

Glass bottle (150 ml) was used as flower vase in this experiment. After preparing the solutions each glass bottle was filled with 150 ml of desired solution. Each bottle was marked for easy identification. Water level was marked with a permanent marker after placing flower spikes. The mouths of the glass bottles were kept open.

Collection of Data

Data were recorded for floret opening (%), floret deterioration (%), total quantity of water uptake, total quantity of water loss, loss uptake ratio, fresh weight of spike, vase life, incidence of stem rotting etc.

Floret opening (%): Recorded from the day when the first floret opening till the spike was discarded and expressed in percentage.

Floret deterioration (%): Recorded from the day when the first basal floret became dry and closed and expressed in percentage.

Water uptake (g/spike): The difference between initial and final weights of the bottle with solution (without spike) represents the water uptake.

Water loss (g/spike): The difference between the initial and final weights of bottle with solution and spike represents the transpiration loss of water.

Diameter of florets: The diameter of florets was measured and expressed in centimeters.

Vase life (days): When stick was moderately bent and petal was lost its original colour and expressed in days.

Incidence of stem rotting: Slimy substance was present and softening of stem was occurred.

Data on the above parameters were statistically analyzed as per standard procedure.

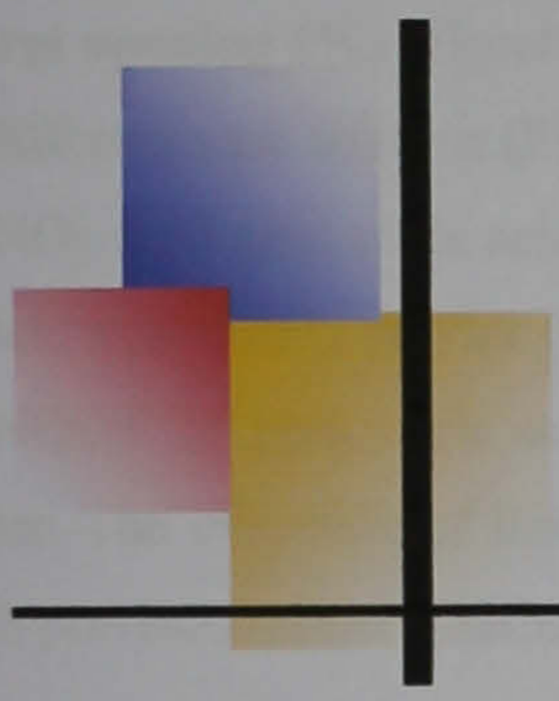
Fragrance : Fragrance was measured by organoleptic test. |

Light supply

For sufficient and equal distribution of light for each treatment, four florescent tube lights were provided in the laboratory during the experimental period.

Statistical analysis

The data recorded on different parameters were statistically analyzed with the help of 'MSTAT' software. The difference between treatment means were compared by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1960).



Chapter 4
Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

Present study was conducted to investigate the effect of different preservatives on the vase life of gladiolus, tuberose and gerbera. The results obtained from the experiment have been presented and discussed in this chapter. Detail results of different parameters studied in the present research work have been furnished under the following headings.

Effect of different preservatives on vase life of gladiolus

Floret opening (%): Floret opening for a period of 12 days by the spikes differed in case of different vase solution (Figure 1). Spikes held in vase solutions (3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid) recorded the maximum percent of floret opening (98.81%) which was closely similar (95.25%) with those held in solution (3% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid) while, only 78.57% floret was opened in control or tap water. The extension of floret opening as observed in the present investigations, accords with previous results obtained in gladiolus by Ranvir and Sashikala (2002).

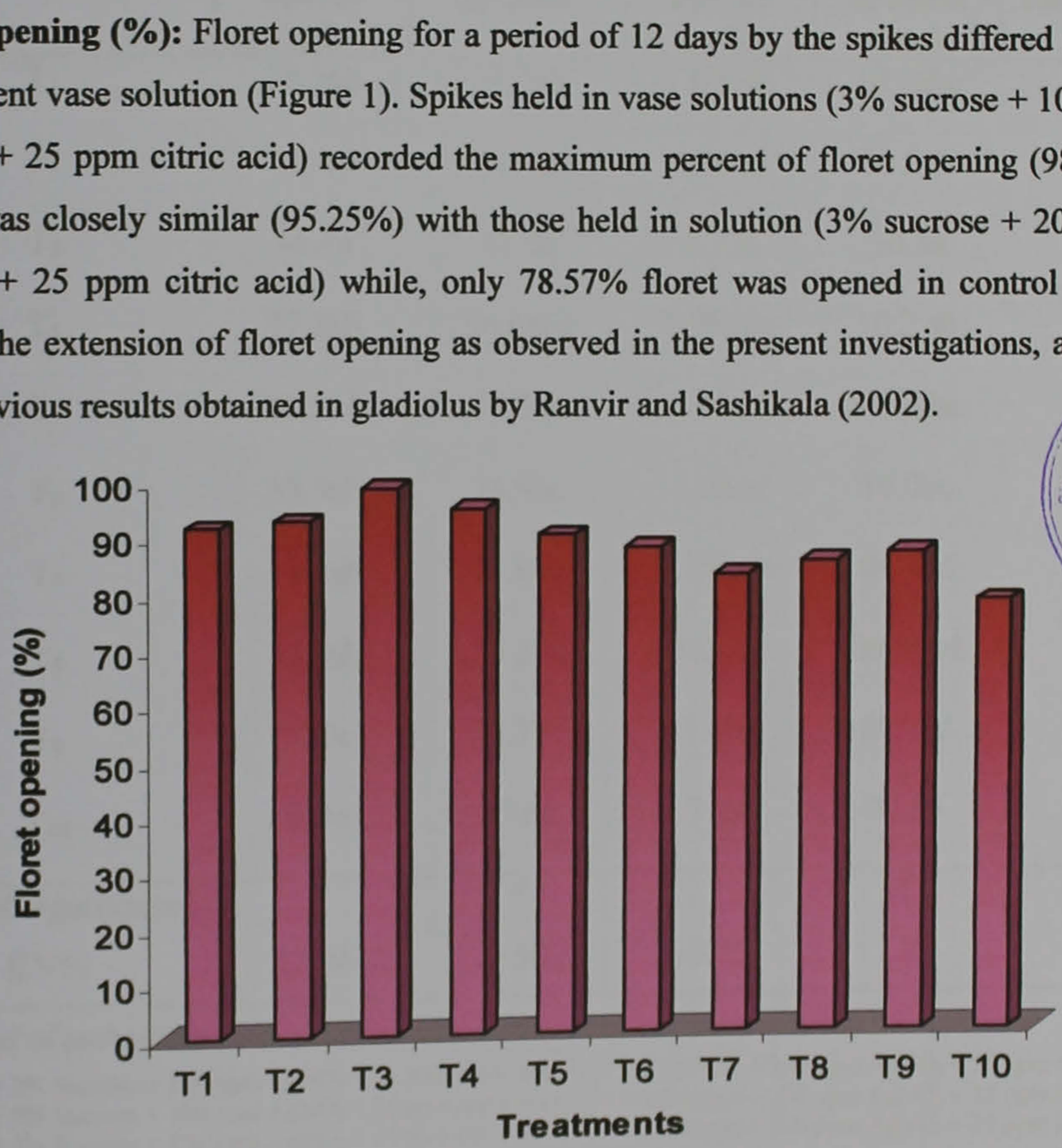


Fig.-1: Effect of preservatives on percent floret opening in gladiolus

T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,
T_3= 3% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,
T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,
T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.10% NaCl & T_{10}= Control

Water uptake (g/spike): Total water uptake for a period of 12 days by the spike differed significantly in case of different vase solutions (Table1). Spikes held in solution 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid (T3) had the highest water absorption (45.4g) followed by those held in solution 3% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid (37.2g) compared with the control and other treatments. Similar results were also reported by Dohino and Hashi (1995) in gladiolus,

Table 1. Effect of different preservatives on post harvest physiology of gladiolus

Treatment	Water uptake (g/spike)	Water loss (g/spike)	Water loss uptake ratio	Diameter of floret (cm)	Incidence of stem rotting
T_1	36.5ab	37.2ab	1.0bcde	10.1abc	-
T_2	35.1ab	36.0abc	1.0bcd	10.2ab	-
T_3	45.4a	42.0a	0.92e	10.3a	-
T_4	37.2ab	36.6abc	0.9bcde	10.2 ab	-
T_5	35.3a b	38.5ab	1.0bcd	10.1abc	-
T_6	33.3ab	34.9bc	1.0bcd	10.0bc	-
T_7	34.3ab	35.0bc	1.0bcde	09.7cd	+
T_8	35.0ab	35.3bc	1.0bcd	09.9bcd	+
T_9	30.0c	33.7bc	1.0bc	09.7cd	+
T_{10}	260d	33.6c	1.2a	09.5d	+
Level of significance	*	*	*	*	*
CV%	11.06	9.50	9.55	5.96	-

* 5% level of probability

T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,
T_3= 3% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,
T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid,
T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.10% NaCl & T_{10}= Control

Water loss (g/spike): Water loss from the tissue during the experimental period was significantly affected by different vase solution levels (Table1). The spikes held in solutions without preservatives (control), with lower water uptake, recorded the lowest water loss (33.6g); those held in solutions (3% sucrose + 100 ppm $AgNO_3$ + 20 ppm citric acid) with maximum water uptake, recorded the maximum water loss (42.0g).

Water loss uptake ratio: This ratio was significantly affected by different vase solutions. In Table 1 it was seen that the ratio was lowest (0.9) for the spikes held in solution (3% sucrose + 100 ppm + 20 ppm citric acid) and it was highest (1.2) for the spikes held in tap water (control).

Diameter of florets: All the vase solutions increased the diameter of the open floret compared to control (Table 1). The maximum diameter of floret (10.3 cm) was recorded by 3% sucrose + 100 ppm $AgNO_3$ + 20 ppm citric acid, the least diameter was found in control (9.5 cm).

Incidence of stem rotting: It would be seen from Table1 that incidence of stem rotting was present only in some sticks held in vase solutions in which $AgNO_3$ was absent. On 6^{th} day, rotting of stick was started in tap water/control while on 9^{th}, 9th and 8^{th} day it was started in 0.01% NaCl, 0.05% NaCl and 0.10% NaCl solution respectively (Fig.2). This might be due to the fact that the $AgNO_3$ present in the holding solution acted as a biocide inhibiting microbial population that might have resulted in blockage of the vascular tissues.

It is in conformity with the findings of Kesta *et al.* (1989) who opined that $AgNO_3$ prevents microbial occlusion of xylem vessels in dendrobium thereby enhancing water uptake and increasing longevity of flowers.

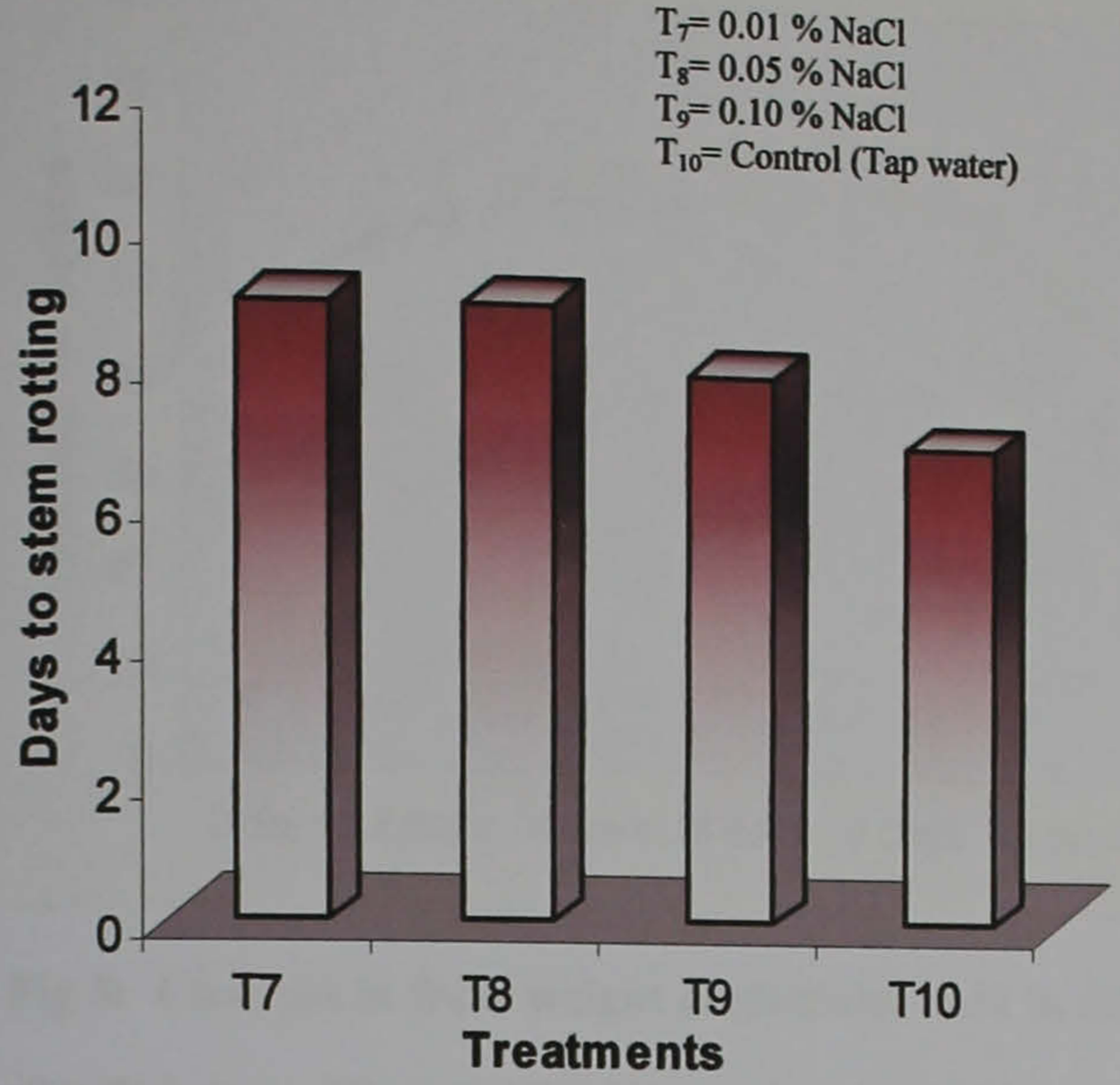


Fig-2: Stem rotting in different conc. of NaCl solutions and tap water

Figure-3 represents the changes of weight of spikes held in different vase solution up to 12th day at 2 days interval. It is seen from the graphical presentation that in all treatments including control, a gentle increase in weight of spike was noted up to the 4th day. There after depletion in weight of spike was observed, those held in tap water and solution which was free from $AgNO_3$. Increasing trend continued up to 8 days in the spikes held in solution containing different levels of sucrose, $AgNO_3$ and citric acid (T_1 to T_6). However, maximum fresh weight of spike was observed in treatment T_3 (68g) shown in Figure-3. Spikes held in solutions with different concentration of sucrose, $AgNO_3$ and citric acid maintained their weight above the initial one even up to 10 days of vase life, while those held in tap water and solutions free from sucrose, $AgNO_3$ and citric acid gained their weight below their initial weight after 6th day. These results indicated that sucrose, $AgNO_3$ and citric acid helped the spike to maintain their weight.

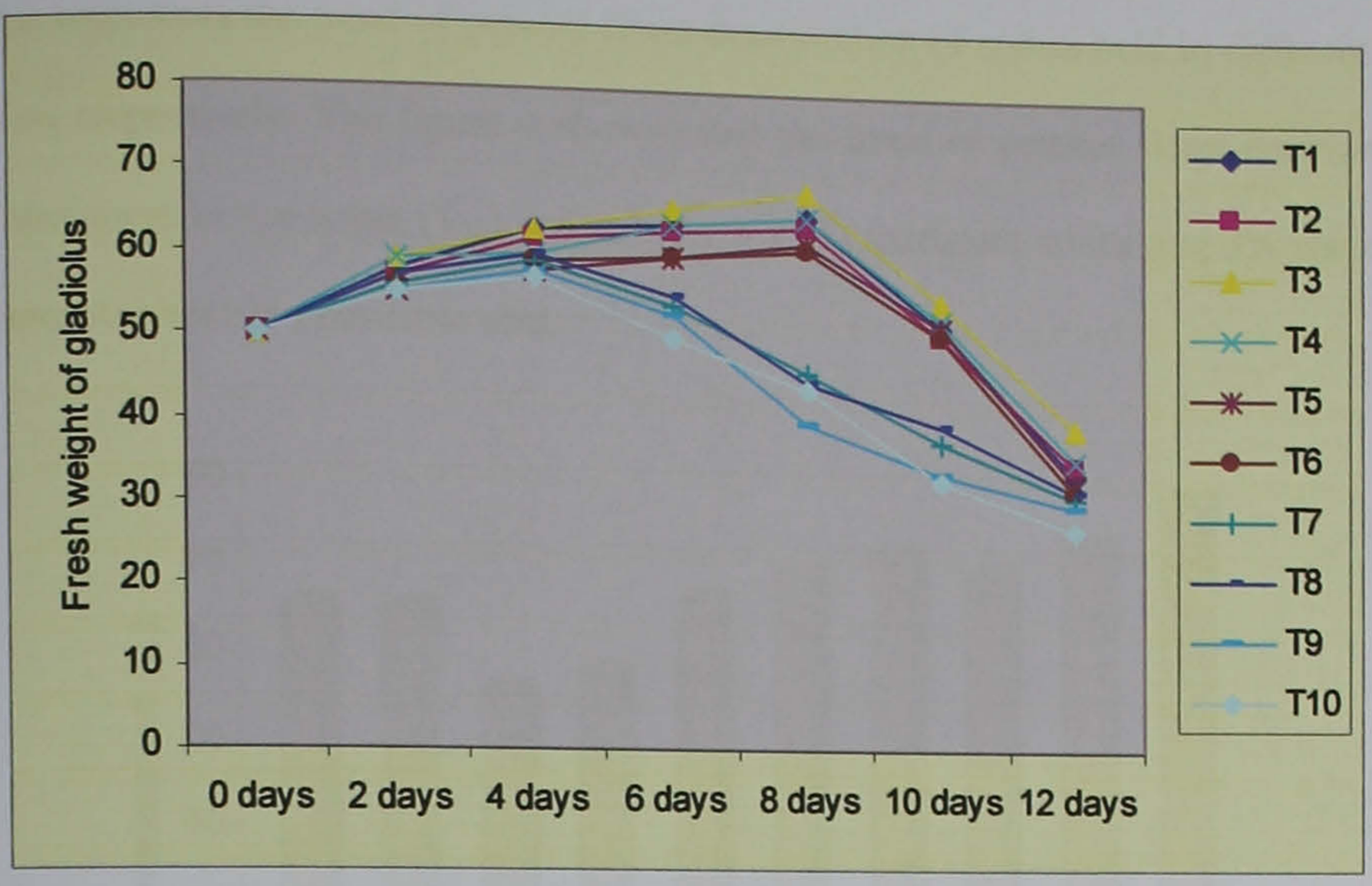


Fig 3: Changes in fresh weight of gladiolus held in different vase solution

(T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.10% NaCl & T_{10}= Control)

Plate 2: Floret deterioration of gladiolus spikes in a vase

Plate 2 represents the trend of percent floret deterioration of spikes held in different vase solution respectively. The figure 4 showed that the trend of percent floret deterioration was maximum in tap water (T_{10}) and minimum in T_3 treatment containing 3% sucrose + 100 ppm $AgNO_3$+25 ppm citric acid.

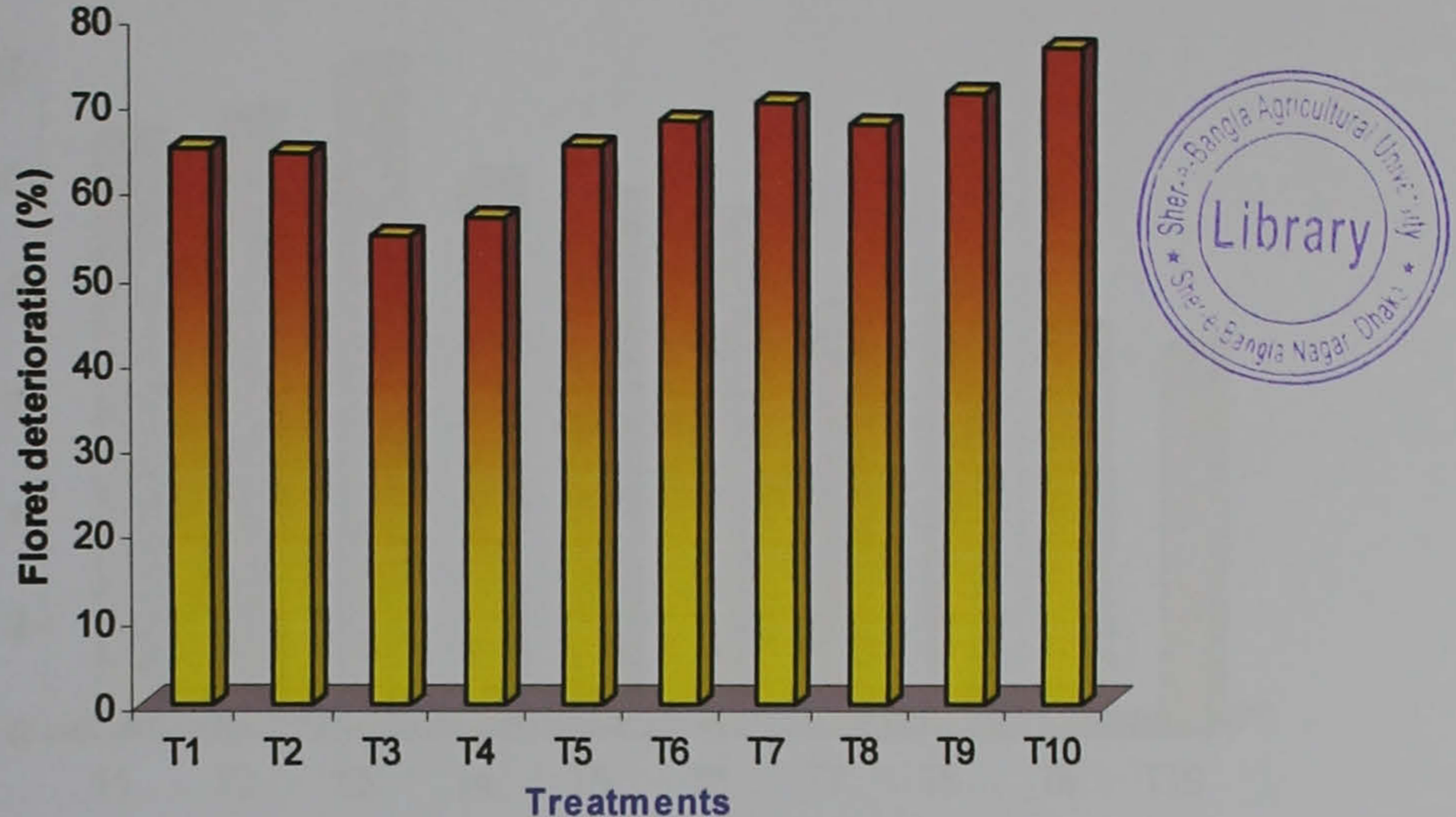


Fig-4: Effect of preservatives on % floret deterioration in gladiolus

(T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.05% NaCl & T_{10}= Control)

Vase life (day): In Figure 5 it was seen that vase life differed in case of different vase solutions. Spikes held in solution (3% sucrose + 100 ppm $AgNO_3$ + 25ppm citric acid) maintained a maximum vase life for 12 days which was closely similar (11 days) with those held in solution (3% sucrose + 200 ppm $AgNO_3$ + 25ppm citric acid) compared with the control and other treatments. It was clear from the above results that 3% sucrose + 200 ppm $AgNO_3$ + 20ppm citric acid proved to be effective in increasing the water uptake and decreasing floret deterioration resulting prolongation of vase life. These might be due to a synergistic effect which improved water balance and osmotic potential since citric acid inhibits the microbial growth, sugar was observed to reduce moisture stress in cut flowers

by affecting stomatal closure, preventing transpiration and water loss (Aarts, 1957). The findings of the experiment are further supported by those of Suneetha and Kumar (2002) in gladiolus. Similar results were also reported by Awad *et al.* (1986) and Reid *et al.* (2002)) in gerbera and gladiolus respectively.

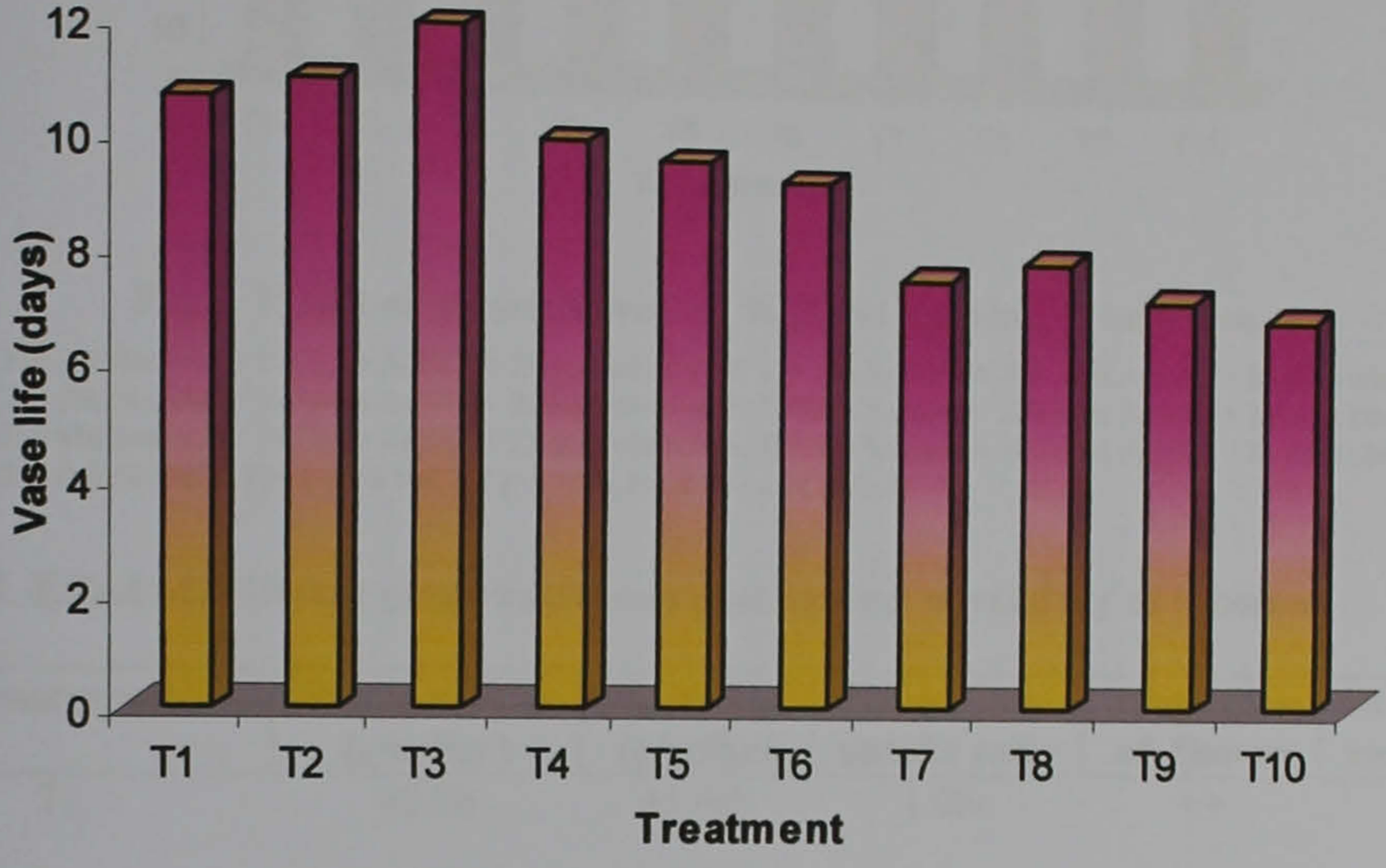


Fig. 5: Effect of preservatives on vase life of gladiolus

T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.05% NaCl & T_{10}= Control

Effect of different preservatives on vase life of tuberose

Floret opening (%): Floret opening for a period of 8 days by the spikes differed in case of different vase solution (Figure 6). Spikes held in vase solutions (2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid) recorded maximum % of floret opening (97.76%) which was closely similar (95.24%) with those held in solution (2% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid) while, only 65.78% floret was found open in control or tap water.

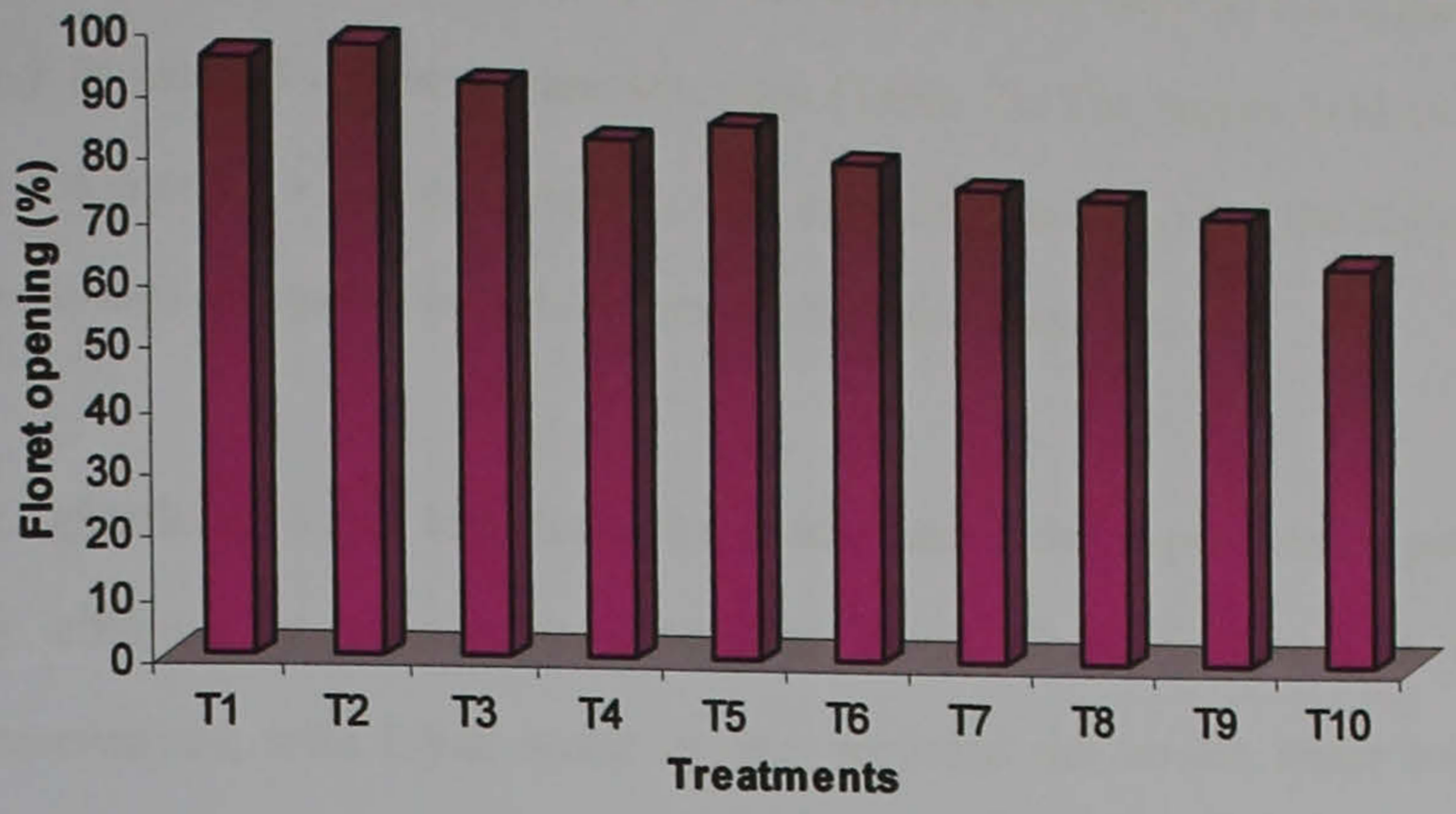


Fig 6: Effect of preservatives on % floret opening of tuberose

T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.05% NaCl & T_{10}= Control

Table 2. Effect of different preservatives on post harvest physiology of tuberose

Treatment	Water uptake (g/spike)	Water loss (g/spike)	Water loss uptake ratio	Fragrance of flower	Incidence of stem rotting
T_1	45.0b	45.6ab	1.0bc	++	-
T_2	49.6a	47.2a	0.9c	++	-
T_3	46.0b	45.3ab	0.9bc	+	-
T_4	44.0bc	45.6abc	1.0b	+	-
T_5	44.6b	44.8ab	1.0bc	+	-
T_6	40.0d	42.6abc	1.0b	+	-
T_7	39.3d	40.3bcd	1.0bc	-	+
T_8	40.9cd	42.6abc	1.0bc	-	+
T_9	38.0d	39.0cd	1.0bc	-	+
T_{10}	30.0e	36.0d	1.2a	+	+
Level of significance	*	*	*		
CV%	5.0	7.7	4.2	-	-

* 5% level of probability

(T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.10% NaCl & T_{10}= Control)

Water uptake (g/spike): Total water uptake for a period of 8 days by the spike differed significantly in case of different vase solutions (Table 2). The spikes held in solution containing 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid (T_2) had the highest water absorption (49.6g) compared with the control and other treatments.

Water loss (g/spike): Water loss from the tissue during the experimental period was significantly affected by different vase solution levels. The spikes held in solutions without preservatives, with lower water uptake, recorded the lowest water loss (36g); those held in solutions (2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid) with maximum water uptake, recorded the maximum water loss (47.2g).

Water loss uptake ratio: This ratio was significantly affected by different vase solutions. Table-2 it was seen that the ratio was lowest (0.9) for the spikes held in solution containing 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid and it was highest (1.2) for the spikes held in tap water (control).

The results presented in Table 2 demonstrated that the flowers in T_2 treatment containing 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid and T_1 treatment 2% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid were more fragrant followed by other treatment T_3 to T_6 and T_{10}. No fragrance was found in NaCl treatments (T_7 to T_9) indicating adverse effects of this chemical on fragrance of the flowers. Fragrance is an important quality parameter. When flowers are kept for interior decoration it makes the environment pleasant. Fragrance might be lost due to the fungal attack at stem cut ends; hence if a suitable preservative is added in the vase solution, this may help in maintaining the fragrance of flowers for a longer period.

Incidence of stem rotting: It was seen from Table 2 that incidence of stem rotting was present only in some sticks held in vase solutions in which $AgNO_3$ was absent. On 4th day, rotting of stick was started held in tap water/control while on 5th, 6th and 5th day it was started in 0.01% NaCl, 0.05% NaCl and 0.10% NaCl solution respectively (Fig 7). This

might be due to the fact that the $AgNO_3$ present in the holding solution acted as a biocide inhibiting microbial population that might have resulted in blockage of the vascular tissues.

It is in conformity with the findings of Nagaraja *et al.* (1999) who opined that $AgNO_3$ prevents microbial occlusion of xylem vessels in tuberose thereby enhancing water uptake and increasing longevity of flowers.

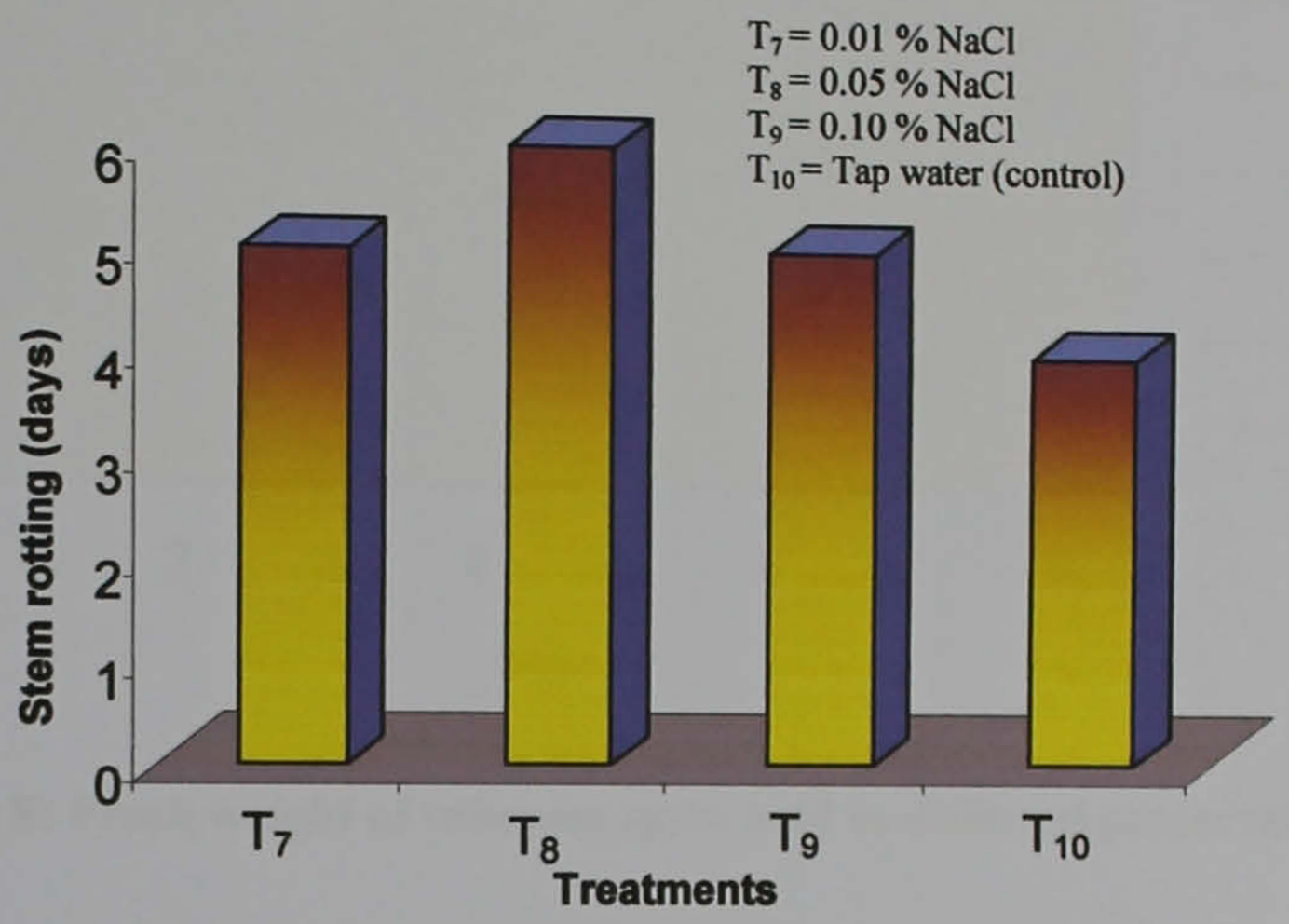


Fig 7: Stem rotting in different conc. of NaCl solutions and tap water

Fresh weight of spikes: Figure-8 represents the changes of fresh weight of spikes held in different vase solution up to 8th day 1 day interval. It was seen from the graphical presentation that in all treatments including control, a gentle increase in weight of spike was noted up to the 3rd day. There after depletion in weight of spike was observed, those held in tap water and solution which was free from $AgNO_3$. Increasing trend continued up to 6 days in the spikes held in solution containing different levels of sucrose, $AgNO_3$ and citric acid (T_1 to T_6). However, the maximum fresh weight of spike was observed in treatment T_2 (70g) shown in Figure 6. Spikes held in solutions with different concentration of sucrose, $AgNO_3$ and citric acid maintained their weight above the initial one even up to 7th day of vase life, while those held in tap water and solutions free from sucrose, $AgNO_3$

and citric acid gained their weight below their initial weight after 4th day. These results indicated that sucrose, $AgNO_3$ and citric acid help the spike to maintain their weight.

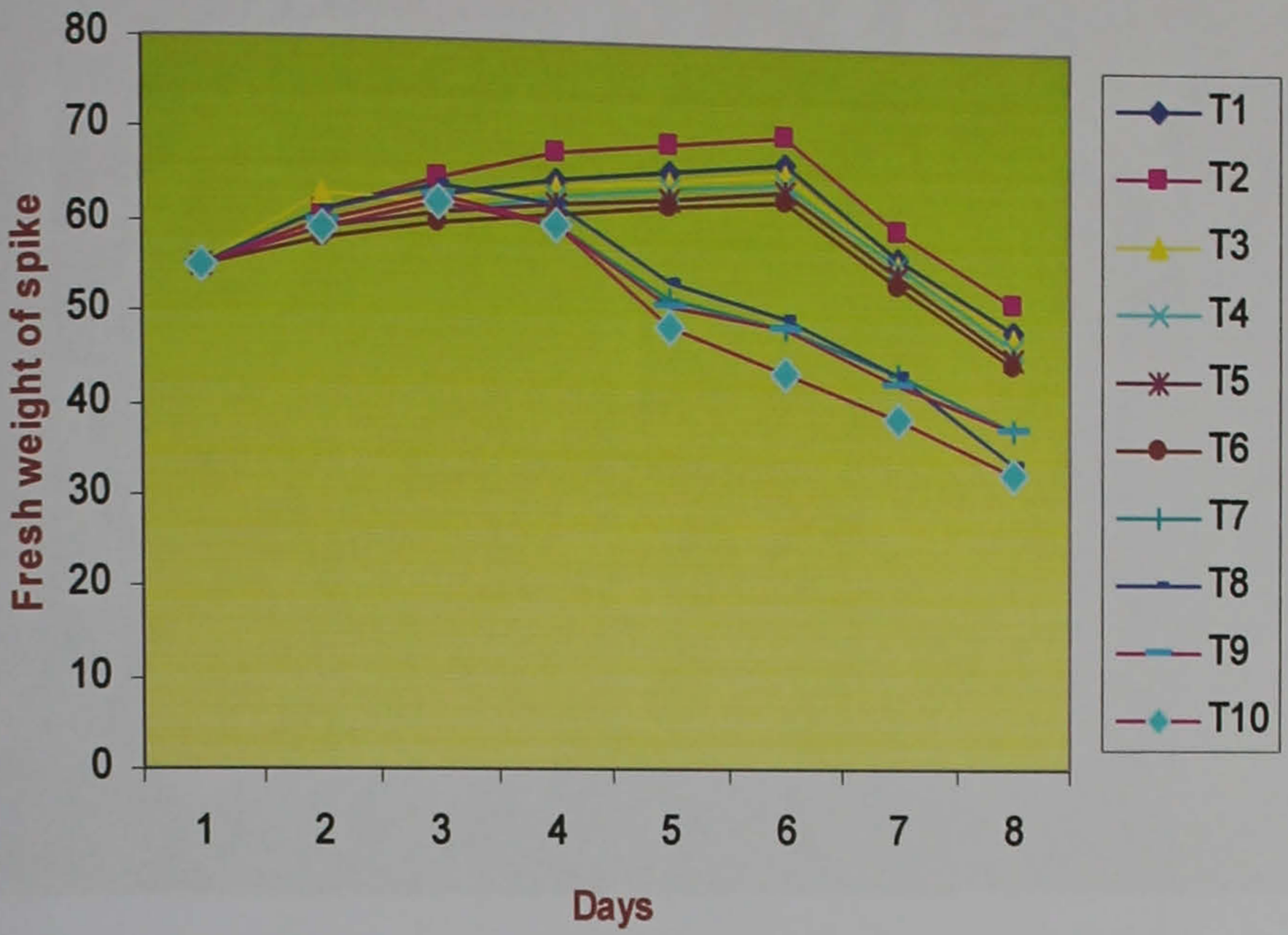


Fig 8: Fresh weight of tuberose spike held in different preservatives

Plate 3 represents the trend of percent floret deterioration of spikes held in different vase solution respectively. Figure 9 showed that the trend of percent floret deterioration was maximum in tap water (T_{10}) and minimum in T_2 treatment containing 2% sucrose + 200 ppm $AgNO_3$+25 ppm citric acid.

Plate 3: Floret deterioration in tuberose spikes in vase

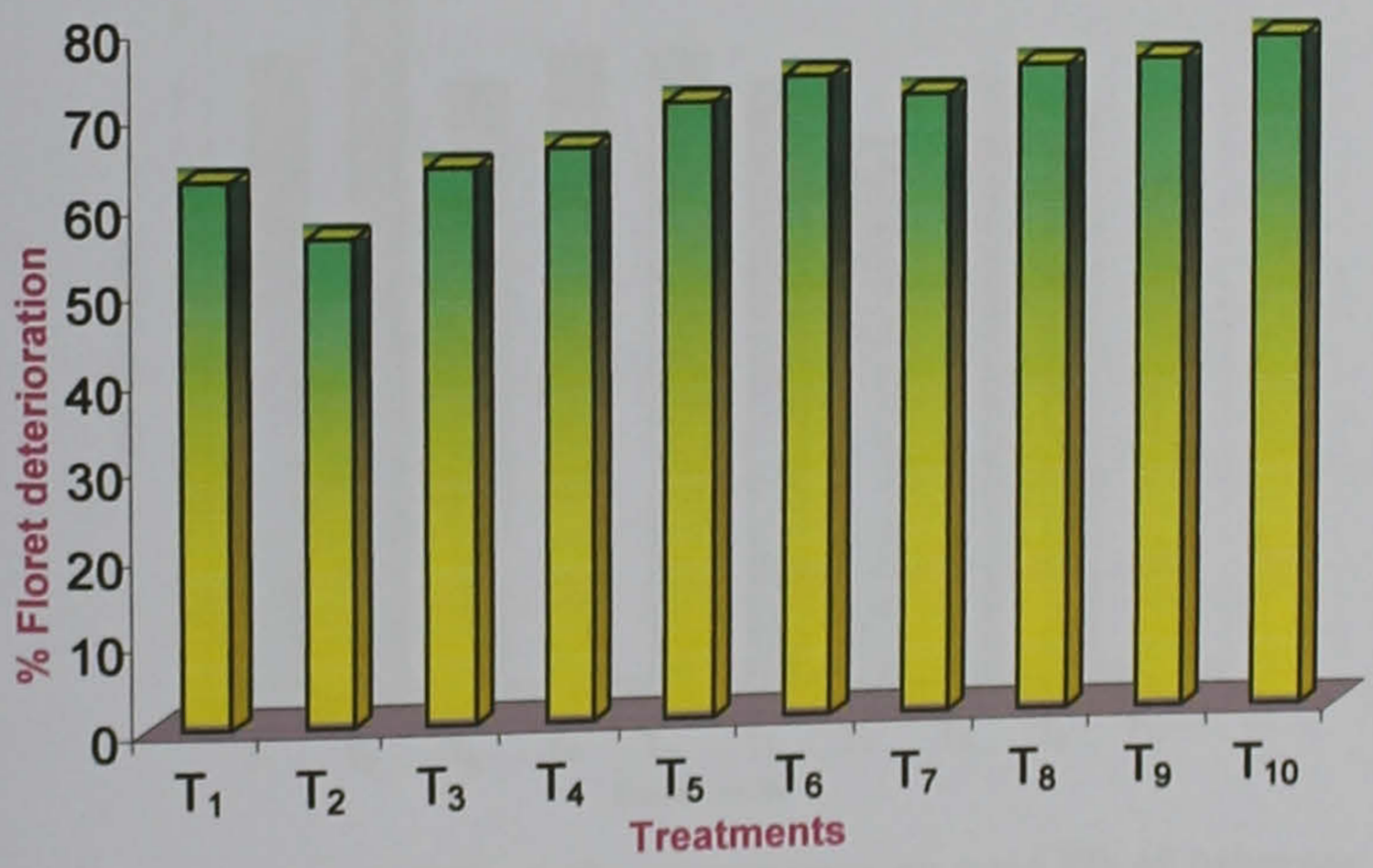


Fig 9: Effect of preservatives on % floret deterioration in tuberose

(T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.05% NaCl & T_{10}= Control)

Vase life (day): In figure 10 it was seen that vase life differed in case of different vase solutions. Spikes held in solution (2% sucrose + 200 ppm $AgNO_3$ + 25ppm citric acid) maintained a maximum vase life for 8 days compared with the control (5 days) and other treatments. Water absoption was greatly influenced by a mixture of sucrose, $AgNO_3$ and citric acid. Tuberose spikes held in vase solutions containing 2% sucrose + 200 ppm $AgNO_3$ + 25ppm citric acid had a highest absoption index than those held in solution without it. This might be due to the inhibition of vascular blockage by sucrose + $AgNO_3$ + citric acid, as suggested by Marousky (1969) in roses, as well as retardation of microbial growth, as suggested by Larsen and Cromary (1968) in carnation. Cut flower longevity has been shown to be associated with maintenance of fresh weight (Marousky, 1968). Spike held in 2% sucrose + 200 ppm $AgNO_3$ + 25ppm citric acid solution maintained their fresh weights above initial weight even up to 7 days of vase life, while those held in tap water and solutions free from $AgNO_3$, sucrose and citric acid, gained their weight below their initial weight after 4th day. These results indicated that $AgNO_3$, sucrose and citric acid helped the spike to maintain their weight.

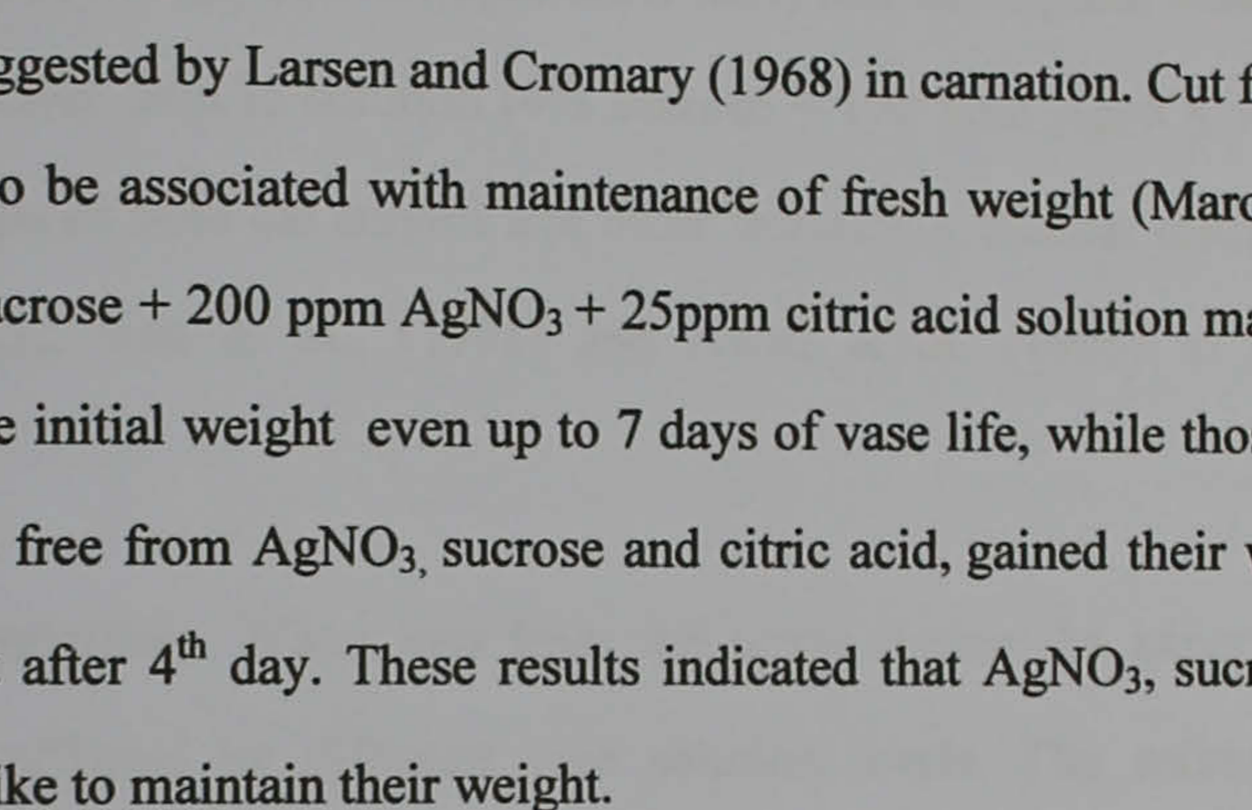


Fig 10: Effect of preservatives on vase life of tuberose

(T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.05% NaCl & T_{10}= Control)

Results of this experiment supported other published reports that sucrose + $AgNO_3$ + citric acid increased cut flower life, by increasing the water and maintaining higher fresh weight of flowers (Kofranek and Paull, 1972; Saini *et al*., 1994; Sathynarayana *et al.*, 1996).

Effect of different preservatives on vase life of gerbera

Water uptake (g/spike): Total water uptake for a period of 14 days by the spike differed significantly in case of different vase solutions (Table 3). The spikes held in solution (4% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid) had the highest water absorption (33 g) followed by those held in solution (4% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid (31.3 g) compared with the control and other treatments. Similar results were reported by Steinitz (1983), Van *et al.*, (1991) and Awad *et al.* (1986) in gerbera and zinnia respectively.

Water loss (g/spike): Water loss from the tissue during the experimental period was significantly affected by different vase solution levels. The spikes held in solutions without preservatives , with lower water uptake, recorded the lowest water loss (22 g); those held in solutions (4% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid) with maximum water uptake, recorded the maximum water loss (32.5 g).

Water loss uptake ratio: This ratio was significantly affected by different vase solutions. In Table 3, it was seen that the ratio was lowest (0.9) for the spikes held in solution (4% sucrose + 200 ppm + 25 ppm citric acid) and it was highest (1.2) for the spikes held in tap water (control).

Table 3. Effect of different preservatives on post harvest physiology of gerbera

Treatment	Water uptake (g/spike)	Water loss (g/spike)	Water loss uptake ratio	Incidence of stem rotting
T_1	24.6cde	27.0abcd	1.0bcde	-
T_2	26.3bcd	28.0abc	1.0bcde	-
T_3	28.6abc	30.3ab	1.0cde	-
T_4	30.0abc	31.0a	1.0de	-
T_5	31.3ab	31.4	1.0e	-
T_6	33.0a	32.5a	0.9e	-
T_7	21.0def	24.1cd	1.1abcd	+
T_8	22.0def	25.0bcd	1.1abc	+
T_9	20.3ef	24.0bcd	1.1ab	+
T_{10}	18.0f	22.0d	1.2a	+
Level of significance	*	*	*	*
CV%	12.2	12.7	6.6	-

* 5% level of probability

(T_1= 2% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.05% NaCl & T_{10}= Control)

Incidence of stem rotting: It was seen from Table 3 that incidence of stem rotting was present only in some sticks held in vase solutions in which $AgNO_3$ was absent. This might be due to the fact that the $AgNO_3$ present in the holding solution acted as a biocide inhibiting microbial population that might have resulted in blockage of the vascular tissues.

It is in conformity with the findings of Reddy *et al.* (2002) who opined that $AgNO_3$ prevents microbial occlusion of xylem vessels in gerbera thereby enhancing water uptake and increasing longevity of flowers. The name of this stem rotting is called "soft rot" cause by bacteria.

In 7th day, rotting of stick was started in tap water/control while on 9th, 9th and 8th day it was started in 0.01% NaCl, 0.05% NaCl and 0.10% NaCl solution (Figure 11).

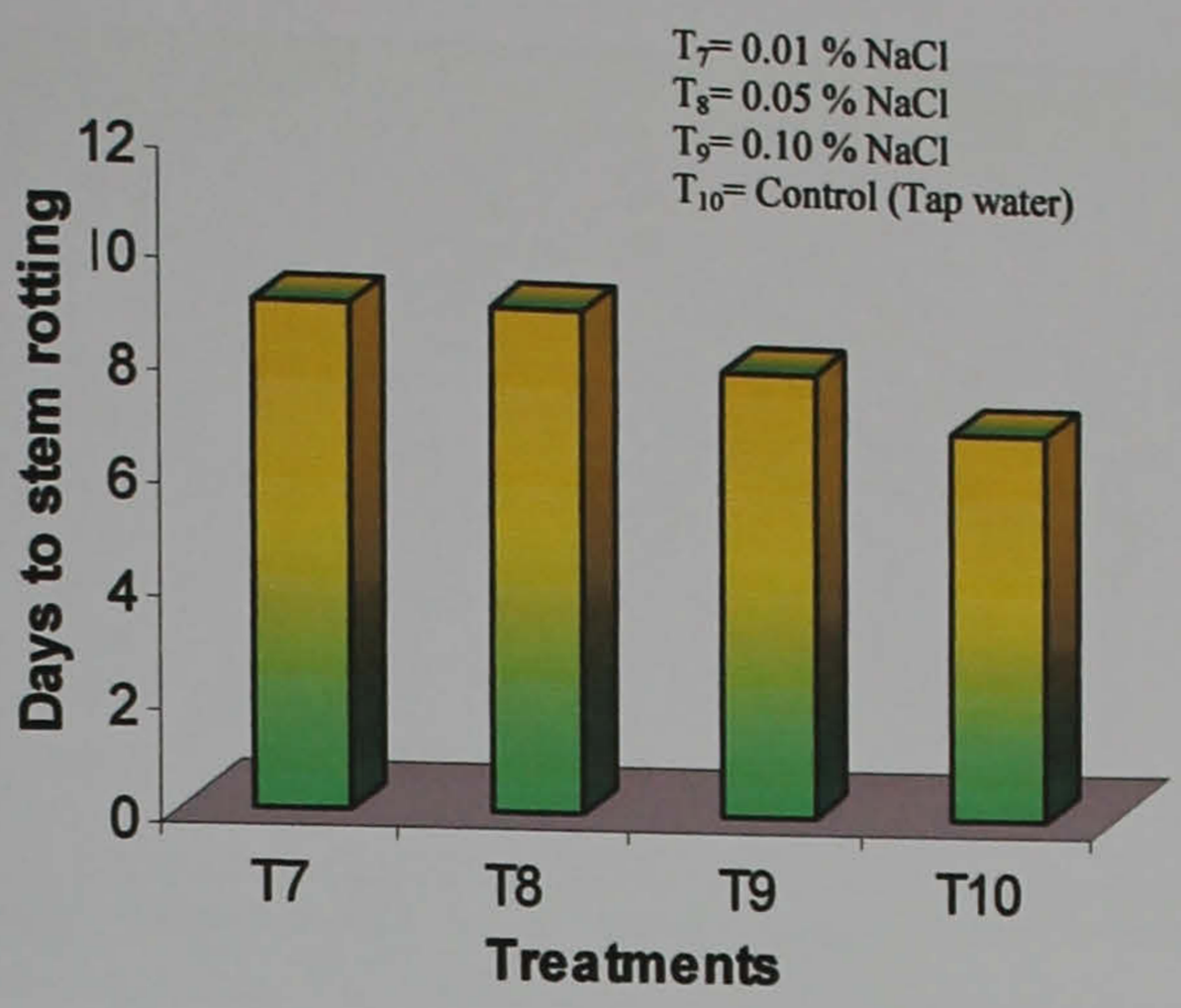


Fig. 11: Stem rotting in different conc. of NaCl solutions and tap water.

Figure 12 represents the changes of weight of spikes held in different vase solution up to 14th day at 2 days interval. It is seen from the graphical presentation that in all treatments including control, a gentle increase in weight of spike occurred up to the 4th day. There after depletion in weight of spike was observed, those held in tap water and solution which was free from $AgNO_3$. Increasing trend continued up to 8 days in the spikes held in solution containing different levels of sucrose, $AgNO_3$ and citric acid (T_1 to T_6). However, the maximum fresh weight of spike was observed in treatment T_6 (65g) shown in Figure-12. Spikes held in solutions with different concentration of sucrose, $AgNO_3$ and citric acid maintained their weight above the initial one even up to 10 days of vase life, while those held in tap water and solutions free from sucrose, $AgNO_3$ and citric acid gained their weight below their initial weight after 8th day. These results indicated that sucrose, $AgNO_3$ and citric acid helped the spike to maintain their weight.

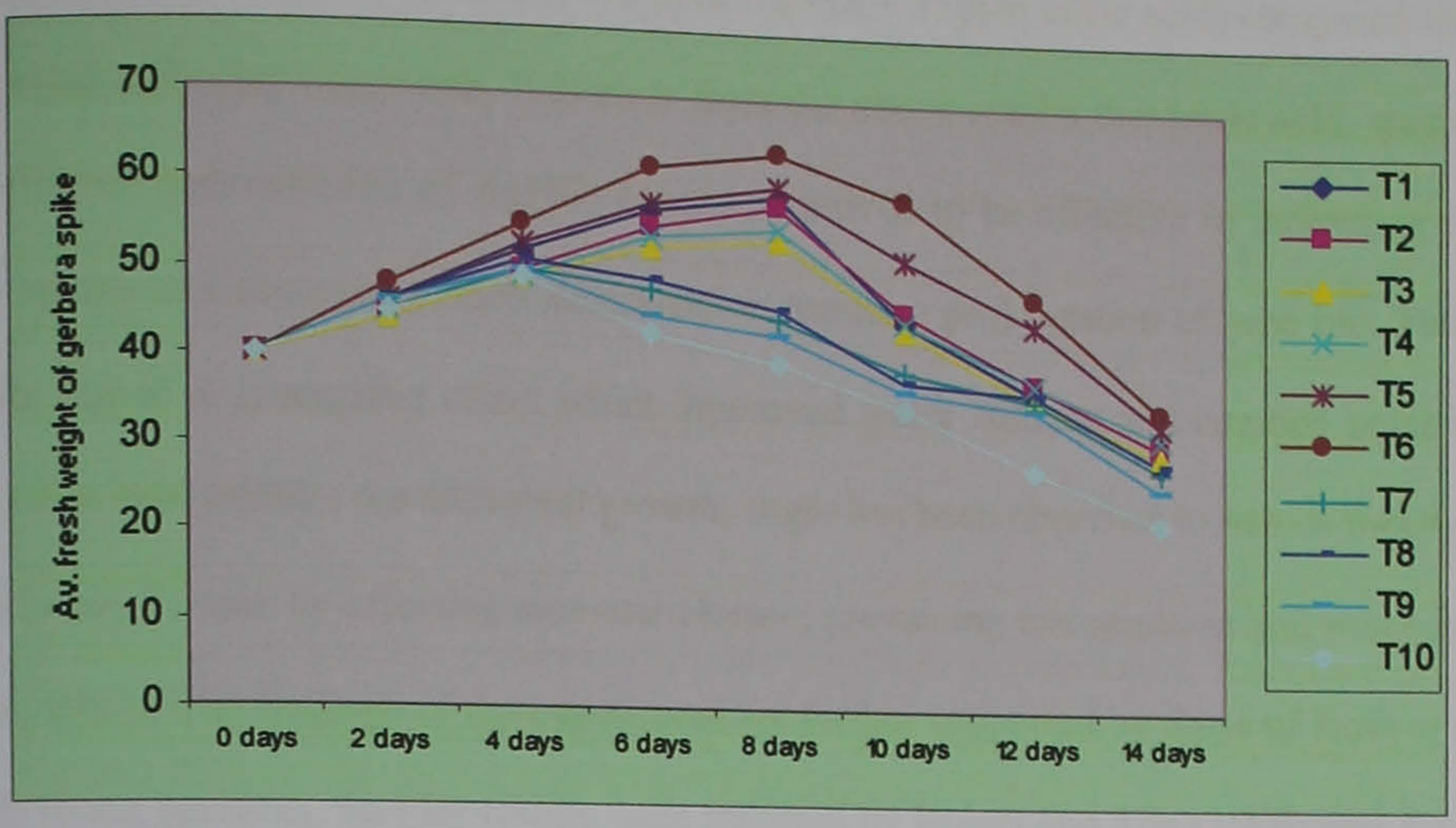


Fig. 12: Fresh weight of gerbera spike held in different preservatives

Plate 4 represents the trend of percent floret deterioration of spikes held in different vase solution respectively. It was observed that the trend of percent floret deterioration was maximum in tap water (T_{10}) and minimum in T_6 treatment containing 4% sucrose + 200 ppm $AgNO_3$+25 ppm citric acid.

Plate 4: Floret deterioration of gerbera spikes in a vase

Vase life (day): In Figure 13 it was seen that vase life differed in case of different vase solutions. Spikes held in solution (4% sucrose + 200 ppm $AgNO_3$ + 25ppm citric acid) maintained a maximum vase life for 14 days which was closely similar (13 days) with

those held in solution (4% sucrose + 100 ppm $AgNO_3$ + 25ppm citric acid) compared with the control and other treatments. It is clear from the above results that citric acid, sucrose and different concentration of $AgNO_3$ solutions, proved to be effective in increasing the water uptake and decreasing floret deterioration resulting prolongation of vase life. These may be due to a synergistic effect which improved water balance and osmotic potential since citric acid inhibits the microbial growth, sugar has been observed to reduce moisture stress in cut flowers by affecting stomatal closure, preventing transpiration and water loss (Aarts, 1957). The findings of the experiment are further supported by those of Bose *et al.* (1999) in cut gerberas. Similar results were reported by Rojers and Tija (1990) and Awad *et al.* (1986) in gerbera.

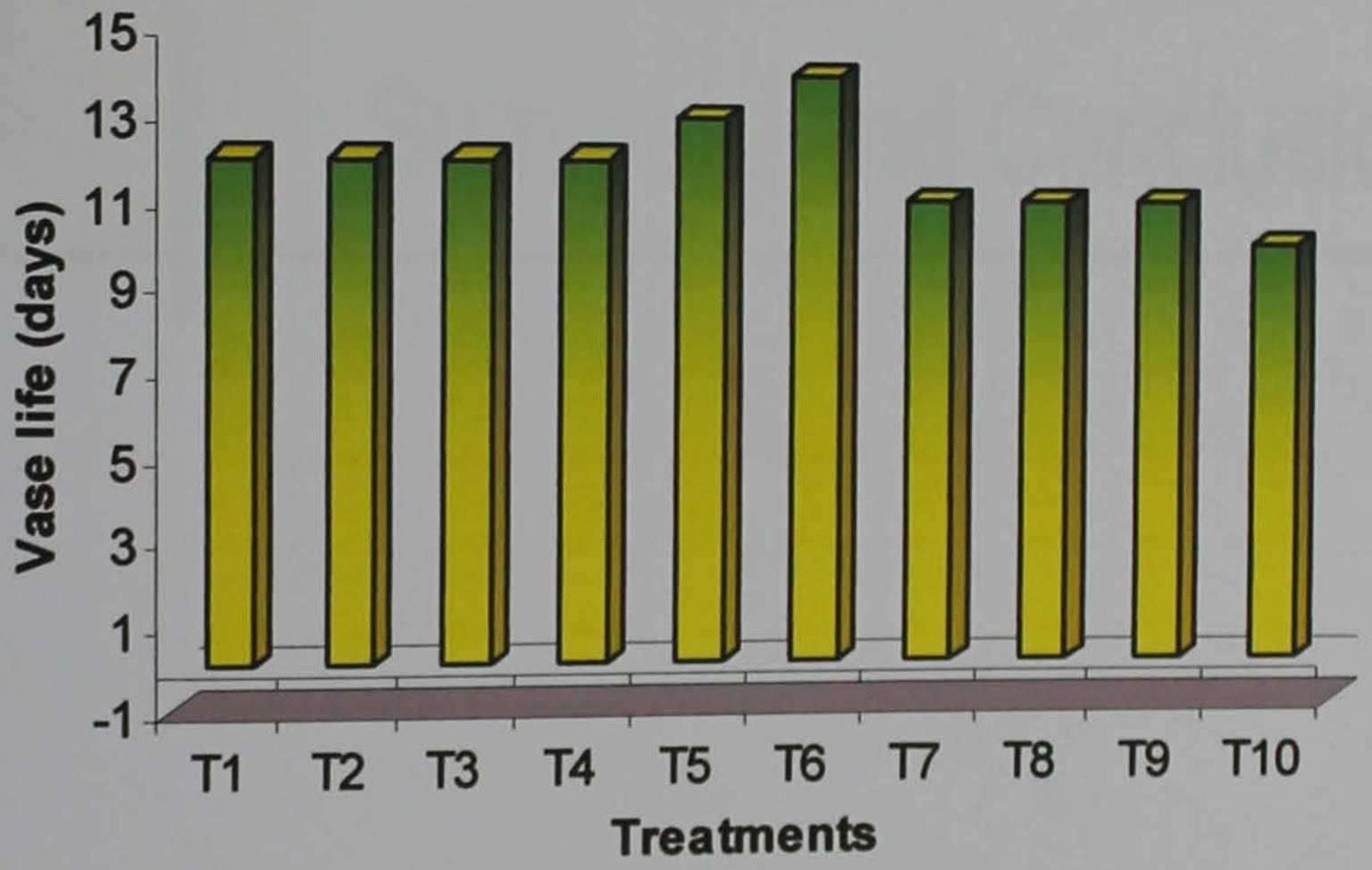
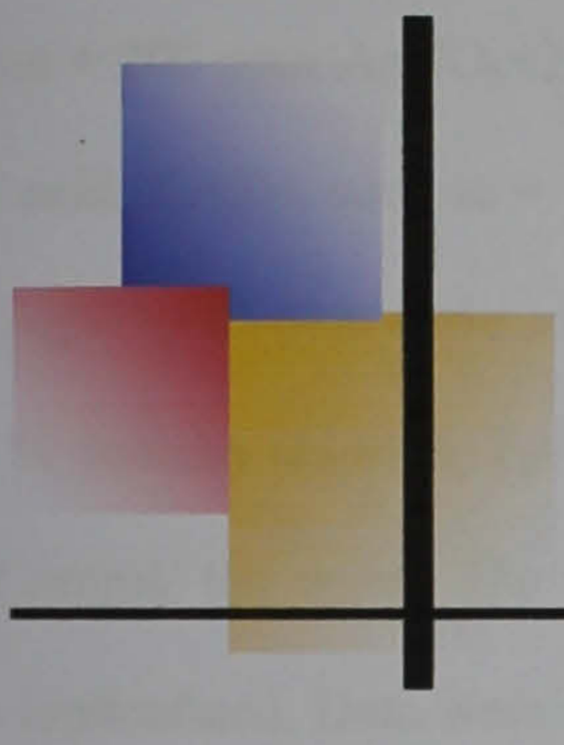


Fig 13: Effect of preservatives on vase life of Gerbera

(T_1= 2% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_2= 2% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_3= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_4= 3% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_5= 4% Sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, T_6= 4% Sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid, T_7= 0.01% NaCl, T_8= 0.05% NaCl, T_9= 0.10% NaCl & T_{10}= Control)



Chapter 5

Summary and Conclusion

CHAPTER - V

SUMMARY AND CONCLUSION

The experiment was carried out at the Laboratory of Landscape, Ornamental and Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during the period January 2009 to June 2009 to study the water relation effects of floral preservative in improving quality of cut flowers and identifying the suitable preservative (s) in extending the vase life of gladiolus, tuberose and gerbera. The study consisted of ten treatments: T_1=2% sucrose + 100 ppm $AgNO_3$+25 ppm citric acid, T_2= 2% sucrose + 200 ppm $AgNO_3$+25 ppm citric acid, T_3=3% sucrose + 100 ppm $AgNO_3$+25 ppm citric acid, T_4=3% sucrose + 200 ppm $AgNO_3$+25 ppm citric acid, T_5=4% sucrose + 100 ppm $AgNO_3$+25 ppm citric acid, T_6= 4% sucrose+ 200 ppm $AgNO_3$+25 ppm citric acid, T_7= 0.01 % sodium chloride, T_8= 0.05 % sodium chloride, T_9= 0.10 % sodium chloride and T_{10}=Control/ tap water. The trial was laid out in a Completely Randomized Design with three replications. Data were recorded on floret opening (%), floret deterioration (%), total quantity of water uptake, total quantity of water loss, water loss uptake ratio, fresh weight of spike, vase life, incidence of stem rotting etc. The collected data on different parameters were statistically analyzed.

Floret opening by the spikes of gladiolus and tuberose differed in case of different vase solution. In response of different preservatives, gladiolus spikes in vase solutions with 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid (T_3) recorded the maximum % of floret opening (98.81%), whereas vase solutions containing 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid (T_2) recorded the maximum % of floret opening (97.76%) in tuberose .

Water uptake by the spike of gladiolus, tuberose and gerbera was greatly influenced by vase solutions. The gladiolus spikes held in a solution 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid (T_3) had the highest water absorption (45.4g) followed by those held in solution 3% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid (37.2g) compared with the control and other treatments. In case of tuberose, maximum water absorption (49.6g) was recorded in vase solutions with 2 % sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid (T_2) whereas the highest water absorption (33g) in gerbera was found when spikes were held in solution 4% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid (T_6). The control treatment which received no vase solutions had the minimum water absorption in both tuberose and gerbera.

Water loss from the tissue during the experimental period was significantly affected by different vase solution levels. The spikes held in solutions without preservatives (control), with lower water uptake, recorded the lowest water loss (33.6g), (36.0g) (22.0g); those held in solutions containing 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid, 2% sucrose + 200 ppm $AgNO_3$ + 20 ppm citric acid and 4% sucrose + 200 ppm $AgNO_3$ + 20 ppm citric acid with maximum water uptake, recorded the maximum water loss (42.0g, 47.2g and 32.5g) in gladiolus, tuberose and gerbera respectively.

The water loss uptake ratio was significantly affected by different vase solutions. The ratio was lowest (0.9) for the gladiolus spikes held in solution (3% sucrose + 100 ppm + 25 ppm citric acid) and it was highest (1.2) for the spikes held in tap water (control). The spikes which recorded the highest water uptake held in solutions containing 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid and 4% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid showed the lowest water loss uptake ratio (0.9) and (0.9) in tuberose and gerbera respectively.

All the vase solutions increased the diameter of the open floret compared to control in gladiolus spikes. However maximum diameter of floret (10.3cm) was recorded by 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid (T_3), the least diameter was in control (9.5cm).

It was demonstated that the tuberose flowers in T_2 treatment containing 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid and T_1 treatment with 2% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid were more fragrant followed by other treatment T_3, T_4, T_5, T_6 and T_{10}. No fragrance was found in NaCl treatments (T_7, T_8 and T_9) indicating adverse effects of this chemical on fragrance of the flowers.

It was observed that incidence of stem rotting was present in spike of gladiolus, tuberose and gerbera by vase solutions containing 0.01% NaCl (T_7), 0.05% NaCl (T_8) and 0.10% NaCl (T_9) and without vase solutions, i.e. tap water or control (T_{10}).

The changes of fresh weight of spikes held in vase solution differed in case of different vase solution. It was observed that in all treatments including control, a gentle increase in weight of gladiolus spike was noted up to the 4th day. There after depletion in weight of spike was observed, those held in tap water and solution which was free from $AgNO_3$. Increasing trend continued up to 8 days in the spikes held in solution containing different levels of sucrose, $AgNO_3$ and citric acid (T_1, T_2, T_3, T_4, T_5 and T_6). However, maximum fresh weight (68g) of gladiolus spike was observed in treatment T_3 (3% sucrose+ 100 ppm $AgNO_3$+25 ppm citric acid).

It was observed that in all treatments including control, a gentle increase in weight of spike was noted up to the 3rd day in tuberose. There after depletion in weight of spike was observed, those held in tap water and solution which was free from $AgNO_3$. Increasing trend continued up to 6 days in the spikes held in solution containing different levels of sucrose, $AgNO_3$ and citric acid (T_1, T_2, T_3, T_4, T_5 and T_6). However, the maximum fresh weight of spike was observed in treatment T_2 (70g). Spikes held in solutions with different concentration of sucrose, $AgNO_3$ and citric acid maintained their weight above the initial one even up to 7^{th} day of vase life, while those held in tap water and solutions free from sucrose, $AgNO_3$ and citric acid gained their weight below to their initial weight after 4^{th} day.

In gerbera, a gentle increase in weight of spike was noted up to the 4^{th} day in all treatments including control. There after depletion in weight of spike was observed, those held in tap water and solution which was free of $AgNO_3$. Increasing trend continued up to 8 days in the spikes held in solution containing different levels of sucrose, $AgNO_3$ and citric acid (T_1, T_2, T_3, T_4, T_5 and T_6). However, the maximum fresh weight of gerbera spike was observed in treatment T_6 (65g). Spikes held in solutions with different concentration of sucrose, $AgNO_3$ and citric acid maintained their weight above the initial one even up to 10 days of vase life, while those held in tap water and solutions free from sucrose, $AgNO_3$ and citric acid gained their weight below to their initial weight after 8^{th} day.

Vase life differed in case of different vase solutions. Spikes held in solution 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid (T_3) maintained a maximum vase life for 12 days which was closely similar (11 days) with those held in solution 3% sucrose + 200 ppm $AgNO_3$ + 20ppm citric acid (T_4) compared with the control and other treatments. Tuberose spikes held in solution containing 2% sucrose + 200 ppm $AgNO_3$ + 20ppm citric acid (T_2)

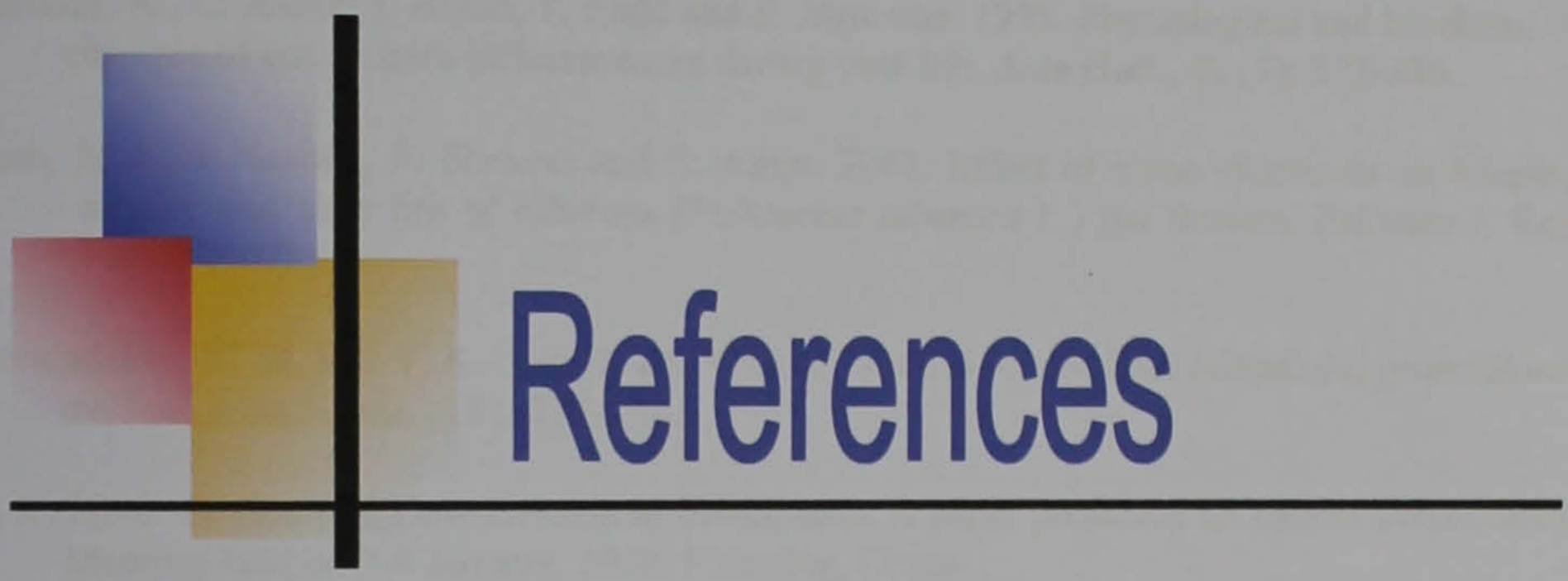
maintained a maximum vase life for 8 days compared with the control and other treatments. Gerbera spikes held in solution 4% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid (T_6) maintained a maximum vase life for 14 days which was closely similar (13 days) with those held in solution with 4% sucrose + 100 ppm $AgNO_3$ + 20ppm citric acid (T_5) compared to the control and other treatments.

Analyzing the results, the following conclusion may be drawn.

Gladiolus spike held in vase solution containing 3% sucrose + 100 ppm $AgNO_3$ + 25 ppm citric acid increased vase life (12days), by increasing the water uptake, floret opening, floret diameter and maintaining higher fresh weight of flower.

Application of 2% sucrose + 200 ppm $AgNO_3$ + 25 ppm citric acid increased tuberose cut flower life, by increasing the water uptake, maintaining higher fresh weight of flower and longevity. The longevity of treated tuberose cut flowers was extended to 8 days.

A mixture of 4% sucrose + 200 ppm $AgNO_3$ + 25ppm citric acid was found best keeping solution for improving post harvest quality and vase(14 days) life of gerbera.



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Appendices

Appendices

Appendix : I. Analysis of variance of the data on post harvest physiology and quality of Gladiolus influenced by different preservative solutions

Source of variation	Degrees of freedom (df)	Mean sum of square			
		Water uptake	Water loss	Water loss uptake ratio	Diameter of floret
Replication	2	05.35*	11.01*	0.02*	0.28*
Treatment	9	81.11*	25.37*	0.03*	0.29*
Error	18	06.68	12.08	0.01	0.07

* = Significant at 5% level of probability

Appendix : II. Analysis of variance of the data on post harvest physiology and quality of Tuberose influenced by different preservative solutions

Source of variation	Degrees of freedom (df)	Mean sum of square		
		Water uptake	Water loss	Water loss uptake ratio
Replication	2	04.24*	18.88*	0.01*
Treatment	9	88.83*	35.89*	0.02*
Error	18	04.42	10.01	0.01

* = Significant at 5% level of probability

Appendix : III. Analysis of variance of the data on post harvest physiology and quality of Gerbera influenced by different preservative solutions

Source of variation	Degrees of freedom (df)	Mean sum of square		
		Water uptake	Water loss	Water loss uptake ratio
Replication	2	06.88*	23.67*	0.04*
Treatment	9	79.11*	35.15*	0.02*
Error	18	09.76	12.20	0.01

* = Significant at 5% level of probability