

STUDIES ON POST HARVEST LIFE OF CUT ROSES
(*Rosa hybrida* L.) Cvs. SUPER STAR AND GLADIATOR

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ABSTRACT

**STUDIES ON POST HARVEST LIFE OF CUT ROSES
(*Rosa hybrida* L.) cvs. SUPER STAR AND GLADIATOR.**

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A B S T R A C T

Rose (*Rosa hybrida* L.) is an important commercial flower crops in India. There is a great demand for cut rose flowers for export market as well as to meet the local demand. Cut rose^{flower} as compared to other flowers have shorter vase life and low keeping quality. Therefore, to overcome these problems an experiment was conducted on two important popular commercial roses cvs. 'Super Star' and 'Gladiator' to improve the vase life and keeping quality using sucrose and sucrose in combination with 8-hydroxy quinoline citrate, aluminium sulphate, silver nitrate and cobalt nitrate which act as chemical preservatives at the P.G. Research Laboratory, Department of Horticulture, N.M. College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari, during the winter season of 1995-96. The result of these studies have shown that the various qualitative parameters of the cut flowers such as percentage of opened petals, percentage of abscised petals, the flower diameter, petals area, fresh weight, total water uptake and the vase life had significantly improved when the cut flowers were kept in various treatment solutions.

It was further observed that the cobalt nitrate and the 8-hydroxy quinoline citrate treatments significantly improved the various quality parameters and the vase life of both the cultivars as compared to the other chemical solutions employed in combination with sucrose or sucrose alone. The cobalt nitrate treatment, with 270 ppm cobalt nitrate + sucrose 3 per cent was found to have maximum effect in enhancing all the quality parameters and the vase life. The vase life could be extended upto 9.51 days in Super Star and 7.66 days in 'Gladiator' using this combination of cobalt nitrate and sucrose. The next promising preservative chemical in extending the vase life and also the keeping quality of the rose varieties studied was the 8-hydroxy quinoline citrate of 200 ppm + sucrose 3 per cent treatment which increased the vase life upto 9.00 days in case of Super Star and 7.15 days in case of Gladiator.

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CERTIFICATE

This is to certify that the thesis entitled "Studies on Post harvest life of cut roses (*Rosa hybrida* L.) cvs. 'Super Star' and 'Gladiator'. Submitted by Mr. Nutalapati Srinivasa Rao in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE** in **HORTICULTURE** of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Navsari,
Date : 19th May, 1997.


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DECLARATION

I hereby declare that the whole of the research work now submitted in this thesis, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, is the results of investigations done by the undersigned under the direct guidance and supervision of **Dr. S.K.Dave**, Professor and Head, Department of Horticulture, N.M. College of Agriculture, Gujarat Agricultural University, Navsari campus, Navsari. and that no part of the work has been submitted for any other degree so far.

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CONTENTS

CHAPTER NO.	TITLE		PAGE NO.
1.	INTRODUCTION	1
2.	REVIEW OF LITERATURE	7
3.	MATERIALS AND METHODS	....	22
4.	EXPERIMENTAL RESULTS	....	30
5.	DISCUSSION	....	47
6.	SUMMARY AND CONCLUSION	....	61
	REFERENCES	....	64

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
4.1	Effect of various preservative chemical substances on percentage of opened petals of cut roses cvs. Super Star and Gladiator.	31
4.2	Effect of various preservative chemical substances on percentage of abscised petals of cut roses cvs. Super Star and Gladiator.	33
4.3	Effect of various preservative chemical substances on diameter of flower of cut roses cvs. Super Star and Gladiator.	34
4.4	Effect of various preservative chemical substances on petal area of of cut roses cvs. Super Star and Gladiator.	36
4.5	Effect of various preservative chemical substances on fresh weight(% I.W.) of cut roses cvs. Super Star.	38
4.6	Effect of various preservative chemical substances on fresh weight(% I.W.) of cut roses cvs. Gladiator.	41
4.7	Effect of various preservative chemical substances on water uptake of cut roses cvs. Super Star and Gladiator.	44
4.8	Effect of various preservative chemical substances on vase life of cut roses cvs. Super Star and Gladiator.	46

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
1	Effect of various preservative chemical substances on fresh weight (% I.W.) of cut roses cv. 'Super Star'.	39
2.	Effect of various preservative chemical substances on fresh weight (% I.W.) of cut roses cv. 'Gladiator'.	42

INTRODUCTION

I INTRODUCTION

Demand for flowers, especially, ornamental flowers is increasing all over the world. The world consumption of floricultural products is estimated to be worth approximately US \$ 40 billion. Of these, cut flowers contribute over \$ 25 billion, which means that they contribute nearly 60 per cent of the total global floricultural trade. Worldwide, the demand for floricultural products is ^{expected to} grow at the rate of 15 to 18 per cent per annum up to 2000 A.D. (Bagchi, 1997).

Floriculture industry has become a potential money spinner for the third world countries. The major exporting countries of cut flower products are ^{The} Netherlands (59 per cent market share), Columbia (10 per cent), Italy (6 per cent), Israel (4 per cent), Kenya (1 per cent) and others (20 per cent). Germany is the largest importer of flowers which is around 37 per cent. The largest consumer of flowers is Norway followed by Switzerland and Denmark. The contribution of India to the total global floricultural trade is a miniscule 0.2 per cent. In 1995-96, the export of floricultural products had fetched India a mere Rs.57.80 crores (Raghava, 1996). The Indian share of this market is expected to rise dramatically, with the setting up of the Agricultural products Exports Development Authority (APEDA) under the Ministry of Commerce, which, in a recent study of India's competitiveness vis-a-vis other countries, had estimated the export potential of the floricultural products to be Rs. 1000 million by the end of the eighth plan with an annual growth rate of 25-30 per cent (Chadha and Bhattacharjee, 1995).

On the basis of the data collected by the National Horticultural Board (NHB), the estimated area covered by the floricultural crops in India during 1994-95 was 53,000 hectares. Karnataka, Tamil Nadu,

Andhra Pradesh, Maharashtra, Rajasthan and West Bengal are the main states having large area under floriculture. The domestic flower trade has gone up to Rs. 300 crores annually (Raghava, 1996) and the scope for increasing further is vast due to its higher income per unit area and higher export potential. A recent study conducted by the Export-Import Bank of India (Exim Bank) showed that most of the production in India is in the form of loose flowers (200,000 MT) and about 500 million in cut flower production per annum (Anonymous, 1996).

India entered the market of floricultural products with the aim of selling in European markets. Amsterdam has been the centre of the world floricultural trade and all companies have technical and often marketing support from the Dutch/Israel companies.

The Indian government has already approved since 1991 as many as 134 Export Oriented Units (EOU'S) for technical and financial collaboration. Most of these are 100 per cent EOU'S. About 25 per cent of the approved EOU'S had commenced production and export. These projects are set up in clusters around Pune, Bangalore, Hyderabad, Delhi, Gurgaon, Coimbatore, Faridabad, Chandigarh, Lucknow, Madras, Calcutta, Nasik, Vadodara, Ahmedabad, Jalpaigudi and Amritsar (Anonymous, 1996; Raghava, 1996).

The floriculture industry has a large potential and considering India has a host of factors in its favour, it can be exploited to the hilt. India is endowed with diverse agro-climatic conditions, i.e., tropical, sub-tropical, temperate, sub-temperate and alpine which are suitable for growing all kinds of flowers throughout the year. It has fertile soils, abundant water and sunlight. In addition, skilled and low-cost labour are readily available. Due to all these favourable factors, India has

tremendous potentiality to be one of the most leading flower exporting countries in the world.

Among all the floricultural crops, roses occupy a pre-eminent position both as garden plants and ^{as} cut flowers. As per the recent estimates, rose ranks next only to carnation, followed by chrysanthemum (Swarup, 1994). Rose has been the world's most favourite and unchallenged flowers and reigned supreme as the "Queen of Flowers", a title bestowed on it by the Greek poetess 'Sappho', and none has since questioned its right to the title. In Sanskrit literature rose is referred to as "Tiruni pushpa". There is probably no other flower held in greater esteem and better known than rose. It was one of the first flowers to become domesticated and planted wherever the human civilization spread (Pal, 1966). Indeed, the rose has been associated, perhaps, more than any other flower with love and romance. The unique position of roses may be attributed to their diversified growth habit, exquisite shape, variation in sizes and form, attractive colours, delightful fragrance and innumerable varieties as well as to their wide adaptability to varied agro-ecological conditions.

Rose is recognized both as traditional and modern cut flowers and is widely used at religious places besides the common usage for decoration and also bouquet and vase purposes. Rose water, rose oil, rose essence, rose perfumes, gulkand, pankhuri, rose hair oil and incense sticks are some of the important products of rose. The syrup of rose hips is one of the richest source of vitamin-C (Vevai, 1971).

There is a great demand for cut roses in the European markets throughout the year especially during the winter months. The production of roses in India, particularly during winter months is highly profitable compared to temperate countries, where these are grown under green house conditions. Hence, There is an ample scope for commercial production of roses in India both for export and to meet internal demand.

The major producers of rose cut flowers are U.S.A., Netherlands, Israel, United Kingdom, Columbia and some of the South American and South African countries. Roses of U.S.A., and Canada contribute approximately 39 per cent of all the total flowers sold in various global markets. Rose still maintain its first place in the U.S.A., Canada, Netherlands, Israel and some other European countries (Salunkhe *et al*, 1990). The worldwide demand for rose products is growing at the rate of 17 per cent per annum (Reddy, 1996).

In India, the major rose-growing states are Rajasthan, Maharashtra, Karnataka, Uttar Pradesh and West Bengal. In Gujarat, the commercial cultivation of roses is confined to Ahmedabad, Vadodara, Anand, Surat, Navsari and Valsad (Kolavalli *et al*, 1991).

With the exception of a few cultivars, roses usually have a short vase life often of the order a few days only. As early as in 350 AD, Palladius devoted a chapter of his book to the storage of roses (Scholes, 1963). Poor keeping quality of roses is a limiting factor in their popularity among the cut flowers. For export market there is a need for increasing the shelf-life of cut flowers. The flower growers often face the problems of storage and preservation of cut roses. Therefore, improvement of keeping quality and enhancement of vase life of cut flowers are important areas of horticultural research. For several years there has been a growing interest in extending the post harvest life of cut flowers, particularly of roses.

Cut flowers are living, actively metabolizing heterogeneous organs, composed of floral and foliar parts each of which may be at a different physiologically developing stage. The development and opening of the flower is an active growth process being characterized by an increase in the respiration rate.

Since the cut flowers are severed from the parent plants, continuity of water from roots to flower is disrupted. Hence, the water relations play a dominant role in the post-harvest physiology of cut flowers. If greater importance is given to any of the vital needs of cut flowers, maintenance of turgidity would have the highest priority (Rogers, 1973). As cut flowers to be used in flower vases, they are harvested, unlike most of the agricultural crops, before they are fully developed and they are expected to continue their growth in a different environment where they are likely to be deprived of their metabolites normally supplied to them by mother plant. As the photosynthates in the leaves retained with the cut flower is normally negligible under the conditions in which they are regularly held, there is a need for adding sugar in holding solution (Halevy and Mayak, 1974). Further, to minimize the deteriorative processes, in addition to sucrose other chemicals may also be given exogenously either by a pulsing or by a continuous treatment. In addition to sucrose various mineral salts and bactericides are normally used as commercial preservatives. The main uses of water and chemical solutions are conditioning, bud opening and flower holding. This, in turn, improves water uptake and thereby maintains water balance in the flower resulting in increasing its fresh weight.

Two major factors play an important role in regulating the life of a flower. They are carbohydrate supply and water balance. Sugars, as an energy source for respiration or as osmotically active substances which aid in maintaining the turgidity, play an important role in flower development and opening. The duration of the chemical treatment as well as temperature, humidity and lighting conditions during post harvest vase life are very important factors for optimal effects.

Though longevity and quality of cut flowers are, to some extent, varietal traits, there are several other factors influencing these traits. Hence, some pre-harvest agronomic conditions do affect post harvest behaviour of the cut flowers. An ideal cut flower should remain fresh with respect of its colour, fragrance without losing its grade for a reasonable length of time. It is also estimated that two-thirds of the life of a cut flower depends upon the environment to which the flowers are exposed after harvest. Therefore, the post harvest techniques used for increasing the vase life of the cut flowers gain importance. The physiology of cut flowers is very complex in nature. Therefore, the handling techniques used in increasing the longevity of the cut flowers must achieve two seemingly conflicting purposes; promoting the growth and retardation of catabolic processes. Hence, efforts should be made to develop appropriate methods in prolonging the vase life of cut roses, which have export potential. Several attempts have been made to study the effect of different chemicals, sugars and germicides on the longevity of cut flowers having economic value (Halevy *et al.*, 1978; Marousky, 1972 and Venkatarayappa *et al.*, 1981). But the work done so far on the keeping quality of cut flowers is meagre. Therefore, the present investigation was planned with the following objectives :

1. To evaluate the effects of different chemicals on prolonging the vase life of cut roses.
2. To ascertain the effects of different chemicals on the quality of cut roses.
3. To find out a proper combination of chemicals for prolonging the vase life of cut roses.

**REVIEW OF
LITERATURE**

II REVIEW OF LITERATURE

Literature pertaining to post harvest physiology of cut flowers was reviewed in detail by several workers earlier (Rogers, 1973; Halevy and Mayak, 1979; 1981). The first review on post harvest physiology of flower was made by Aarts (1957) on the "Keepability of cut flowers".

Generally, the senescence and wilting of the petals determine the longevity of the flowers (Halevy and Mayak; 1979). Flowers removed from the plant deteriorate much more quickly than those left on the plant under similar environmental conditions (Durkin and Kuc, 1966). Since cut flowers are cut off from their natural source of raw material for metabolic functioning, efforts to supply these necessitates exogenously are seldom found to be completely successful. Water; of course, is the first and self-evident need for the excised flowers. A source of respirable substrate is also very important (Rogers, 1973).

The work done on the post harvest life of cut flowers relevant to the present study is reviewed in this chapter.

2.1 WATER RELATIONS :-

The termination of vase life of many cut flowers is characterised by wilting and therefore, many studies have been made on the evaluation of events leading to this phenomenon (Halevy and Mayak, 1981). High level of turgidity is necessary for the development of flower buds to full bloom and maturity. It is also necessary for the continuance of normal metabolic activity in the cut flower. Turgidity in plants and flowers is dependent upon the balance between the rate of water loss and water supply (Rogers, 1973).

Early change in the properties of cut flowers, which normally accompany senescence, is a decrease in the water uptake resulting in the loss of fresh weight of the cut flowers (Burdett, 1970; Mayak et al., 1974; De Stigter, 1980; Faragher et al., 1986). Cut flowers lose water from all tissues depending up on the environmental and internal factors. Gain in fresh weight occur only when the rate of water absorption is greater than the transpiration rate (Rogers, 1973).

Water uptake and flower abscission are two major physiological factors which limit the vase life (Faragher, 1986). During vase life, a decreased rate of water uptake was noticed in 'waratch' (Faragher, 1986) and cut 'anthurium' (Paull and Good, 1985). Typically, the fresh weight of cut flowers is found initially to increase and subsequently decreased (Rogers, 1973). Reduction in the water uptake coupled with continuous transpiration leads to water deficit and loss of turgidity of the petals (Durkin and Kuc, 1966; Burdett, 1970; Halevy and Mayak, 1981). This causes loss of fresh weight which ultimately reflects in the decrease of vase life of the cut flowers (Faragher et al., 1984). Water deficit-water potential relationships of the petals change with age resulting in a low water holding capacity (Acock and Nichols, 1979). A decline in water conductivity seems to be a general phenomenon in many ageing cut flowers (Halevy and Mayak, 1981). The decrease in stem conductivity is apparently caused by several factors. The major factor contributing for the rapid deterioration of cut flowers is the vascular blockage which begins at the cut end and moves upwards in the stem with time (Marousky, 1969, 1971; Sacalis, 1975; VanDoorn and Perik, 1990).

Stem plugging was found to reduce the water transport capacity having relation to the presence of microorganism in holding solutions (Ford et al., 1961) which can result directly from the physical

plugging action of masses of microbial cells clustered around the base of the flower stem or indirectly from the accumulation of plugging substances released into water by microbial contaminants (Aarts, 1957). When germicides were added to the vase solution, they are found to control microbial growth and reduce the resistance to water flow (Aarts, 1957; Larsen and Cromarty, 1967; Marousky, 1969; VanDoorn and Perik, 1990; Jones and Hills, 1993).

Bacterial plugging appears to be a much greater practical problem in naturally long-lived flowers like tuberose and gladiolus than in short lived ones like roses, since, there is more time for large population of micro organism to build up in the former (Rogers, 1973). Therefore, microorganisms were considered to be one of the main cause to reduced water uptake by cut flowers.

Direct or indirect bacterial stem plugging is not, however, the only cause of impeded water movement in cut flower stems as cut roses held in sterile water were also found to have a decreased rate of water uptake (Morousky, 1969). In addition to microbial-induced stem plugging, there are instances of "physiological stem plugging" that occurs even under aseptic conditions (Rogers, 1973). Vascular blockage is of an oxidative nature resulting either from substances secreted by damaged cells (Aarts, 1957) or harvesting injury (Durkin and Kuc, 1966; Burdett, 1970; Marousky, 1971). Enzymatically mediated physiological blocking is atleast practically responsible for the difficulty which a cut flower faces in meeting its water requirements for maximum vase life (Burdett, 1970).

Longevity of cut flowers is curtailed by ethylene (Rogers, 1973) because it decreases the water uptake (Mayak and Dilley, 1976) and fresh weight (Nichols, 1968) of flowers. Ethylene is emitted at the beginning of senescence associated with microbial modification which leads of

membrane integrity (Paulin, 1986). A loss of membrane integrity causes an increase in permeability and leakage which had been recorded during senescence of roses (Parups and Chan, 1973; Woodson, 1991). Water stress in cut flowers results in higher sensitivity to ethylene. (Mayak and Dilley, 1976).

2.2 USE OF CHEMICAL PRESERVATIVES TO EXTEND THE POST HARVEST LIFE AND IMPROVEMENT OF KEEPING QUALITY OF CUT FLOWERS :-

Eversince the rose has become one of the most important commercial flower crops, the flower growers have been facing the problems of storage and preservation of cut roses. It has been observed that the chemical preservatives reduce the rate of respiration and thus prolong the life of cut flower. They also found to control the bacterial and fungal growth in the vase water mainly because of their antimicrobial property (Coorts et al., 1965; Marousky 1969, 1971; Rogers, 1973; Halevy and Mayak, 1981). Flower preservatives are composed of mainly sugars and chemicals.

Certain non-toxic mineral salts, notably silver nitrate, aluminium sulphate (Aarts, 1957) cobalt salt (Venkatarayappa et al., 1980); calcium nitrate (Mayak et al., 1978); zinc (Rogers, 1973); nickel (Aharoni and Halevy, 1977); organic acid (Parups and Chan, 1973) and germicide like 8-hydroxy quinoline salts (Marousky 1972, 1973; Rogers, 1973) were found to increase osmotic concentration and pressure potential of petal cells thus improving their water balance and extending the longevity of the cut flowers. Several attempts have been made to study the effect of different chemicals, germicides, sugars and hormones on the longevity of cut flowers having economic value (Mayak et al., 1978). Hence the available literature pertaining to the extension of vase life of cut rose flowers and other similar commercial flower crops like

carnation, china aster, chrysanthemum, gladiolus, tuberose etc. have been reviewed here.

2.2.1 Effect of sucrose :-

For a long time, sucrose was used as a respiratory substrate to extend the vase life and improve the keeping quality of cut flowers either alone or in combination with other chemical substances. Supplying cut flowers with exogenous sugar maintains the total dry matter and respirable substrates especially in petals, promotes respiration (Coorts, 1973), encourages protein synthesis (Rogers, 1973) and extends longevity (Rogers, 1973). Hence, the post harvest life of cut flowers is correlated with carbohydrate level of the flowers. Addition of sucrose in the holding solution helps in the continuation of normal metabolic activity after harvest and inhibits the processes associated with senescence. Therefore, the rose cut blooms supplied with a sugar solution develop complete blooming (Bhattacharjee, 1995).

The addition of sucrose to cut flower vase solutions was also found to decrease the water potential of the tissues, thereby improving water uptake by stem (Kofranek and Halevy, 1976). It has also been shown that sucrose limits transpiration in cut roses by reducing stomatal opening (Marousky, 1969). Sucrose or glucose supplied either alone or with quinoline salts was observed to promote the normal development of cut flowers, lengthen their vase life, diminish changes in petal colour and reduce proteolytic breakdown (Aarts, 1957; Borochoy *et al.*, 1976; Larsen Frolich 1969; Larsen and Scholes, 1965; Paulin, 1975). It has also been shown to act as an oxidisable respiratory substrate (Larsen and Frolich, 1969; Nichols, 1975, Lu. kszewska, 1986) and as an antidesiccant (Marousky, 1969) and thereby increasing the flower fresh weight and longevity (Marousky, 1971).

Need for sugars to maintain the red colour of rose petals has been elucidated by Scholes (1963). A gradual decline in respiration of ageing flowers is caused by a short supply of readily respirable substrates, mainly sugars. Breakdown of protein caused accumulation of ammonia in the cells, which is responsible for blueing of the petals of red roses. An exogenous supply of sugars delays the onset of excessive protein degradation and also serves substrate for protein synthesis (Bhattacharjee, 1994). Increase in vase life due to sugar is mainly attributed to decrease in moisture stress and improving water status of flowers. The translocated sugars accumulated in the flowers increase their osmotic concentration thus maintaining turgidity (Acock and Nichols, 1979; Gowda, 1986; Halevy, 1976; Halevy and Mayak, 1974).

Sucrose was also found to enhance the effect of cytokinin in delaying senescence of flowers by reducing the effect of ethylene in promoting it, thereby increasing the vase life of the flowers (Mayak and Dilley, 1976). Senescence during vase life was observed to correlate with decrease in sugar content of flowers (Ferreira and De Swardt, 1980). Sugars delay the onset of senescence of cut flowers by slowing protein degradation (Halevy and Mayak, 1979; 1981). It is known that sucrose improves the water balance in cut flowers. The weight of the sucrose-treated rose flowers was initially higher than that of control, since less water was absorbed presumably due to lower water potential of the sugar solution (Borochoy *et al.*, 1974). The main effect of applied sugar in extending longevity is to maintain mitochondrial structure and functions (Kaltaler and Steponkus, 1976).

Treatment with sugar-rich solutions promotes full opening of standard carnation cut flower when buds are still tightly closed (Halevy, 1987). Sugars were found to be effective in inducing bud growth and development, delaying the abscission of the buds and flower showing

greater percentage of full bloomed flowers (Pathak et al., 1979). Borochoy et al. (1976) found that sucrose-treated cut roses cv. "Super Star" resulted in delaying senescence and increasing petal area thus extending longevity. Lower incidence of bent-neck and increased fresh weight of cut roses, cv. 'Samantha' were observed when held in a solution containing different concentrations of sucrose alone or in combination with cobalt (Venkatarayappa et al., 1981). Pulsing of 'Super Star' cut roses with 2 per cent sucrose was found to be very effective in improving the post harvest life and quality (Gowda et al., 1989).

Rath et al. (1991) and Mohanthy et al. (1993) reported that 20 mg/l sucrose solution treatment to three different cultivars of cut roses like 'Laura', 'Love' and 'Landora' increased the water uptake and prolonged vase life. Jones and Truett (1992) found that sucrose 2 or 5 per cent solution treated to cut 'Gloriosa' had resulted in the increase of fresh weight, solution uptake and enhancing the development of immature buds and delaying senescence in open flowers. Mukhopadhyay (1993) postulated that the increased longevity of tuberose cut flower spike and floral development due to sucrose treatment may be explained in two ways : first it is a source of energy and secondly a good respiratory substrate for the maintenance of osmotic potentiality.

Bhattacharjee (1993) used sucrose at 10,000ppm concentration and got significant and positive results in respect of water uptake, flower diameter, petal area and vase life of cut rose cv. 'Priyadarshini'. Complete flower bud opening characterised by an increased diameter, petal area and enhanced fresh weight of the petals along with prolonged vase life of cut rose cv. 'Madelon' was observed when it was kept in the solution of 45 mM concentration (Daankupier et al., 1995).

2.2.2 Effect of 8-hydroxy quinoline :-

Hydroxy quinoline base or its esters mainly in a salt form of sulphate (8-HQS) and citrate (8-HQC) were the most commonly used germicides in the last decade (Marousky, 1969^{and}, 1971^{and}, Rogers, 1973). Apart from being a broad spectrum bactericide and fungicide, the 8-hydroxy quinoline compounds have also been reported to reduce the "physiological stem blockage" in sterile tissue by Halevy and Mayak (1981). It was suggested that this effect is related to the chelating properties of the quinoline compounds/esters. These chemicals probably chelated the metal ions of enzymes active in creating the stem blockage (Marousky, 1972). Albert *et al.*, (1953) emphasized the role of antibacterial activity of chelating action of 8-HQC with divalent metals (especially Fe and Cu). 8-HQS and 8-HQC may effect flower longevity by acidifying the water.

Solution of ester of 8-hydroxy quinoline plus sucrose sustained quality, increased weight and prolonged cut flower life (Scholes, 1963; Coorts *et al.*, 1965; Larsen and Scholes, 1965; Larsen and Cromatry, 1967; Larsen Frolich, 1969). Marousky (1969, 1971) reported that a solution of 200 ppm 8-hydroxy quinoline citrate and 3 per cent sucrose improved longevity of cut roses by reducing moisture stress through an increased water absorption and fresh weight due to reduce a vascular blockage in stems and stomatal closure. Parups and Chan (1973) recommended that 'Ottawa' solution containing 50 ppm 8-HQS + 100 ppm Na-iso-Ascorbic acid + 4 per cent sucrose extended vase life and keeping quality of cut flowers of roses, carnation and snapdragons. The combination of 2 or 4 per cent sucrose and 200 ppm 8-HQC solution treated to immature bud-chrysanthemum resulted in bud opening, increase flower diameter, fresh weight, and solution uptake, thereby prolonging vase life (Marousky, 1973; Gladon and Slaby, 1976).

Ferreira and De Swardt (1980) tested seven different chemicals including 8-HQS and reported increase in longevity and keeping quality of cut roses cv. 'Sonia'. Mahr and Hannan (1980) reported that the vase life of six different cultivars of cut roses was improved with the treatment of 8-HQC at 200 ppm concentration. [Mclean and Rasmussen (1980) evaluated vase life of four cultivars of roses, in eight floral preservatives including 1 per cent sucrose+200 ppm 8-HQC and reported marked increase in vase life and keeping quality of all cultivars over control. Treatment of cut roses cv. 'Sonia' with preservative solutions of 8-HQC plus sucrose was found to be of greater value by enhancing development of immature tight buds and increasing flower diameter and petal area] (Goszcynska and Reid, 1985). Marousky and Carlyle (1986) reported beneficial effect of 8-HQC in combination with sucrose on floral life and qualitative characters of rose flowers. Gowda (1986) reported that 0.4 per cent 8-HQS and 2 per cent solution treated to cut china aster cv. 'Ostrich plume' increased vase life and keeping quality. There was an increased vase life, water uptake, fresh weight and water conductivity with decreasing blueing, bent-neck and stem blockage when treated with sucrose and 8-HQS in cut roses cv. 'Christian Dior'. (Kesta and Treetaruyanondha, 1988). Goszcynska et al., (1989) reported that a preservative solution of 8-HQC at 200 ppm and 2 per cent sucrose on keeping quality of cut roses cv. 'Sonia' resulted in increasing flower opening, fresh weight, diameter and extended flower longevity.

Michalczuk et al., (1989) reported that in four cultivars of cut roses kept in a solution combination of 200 ppm 8-HQC and 2 per cent sucrose had resulted in promoting bud opening, increasing flower diameter and extended longevity. Wauter et al., (1990) reported that a low P^H solution on 8-HQC prevented vascular blockage by reducing bacterial growth in stems of cut roses. Bhattacharjee (1993) studied the vase life, flower diameter, petal area and water uptake of cut roses

cv. 'Priyadarshini' in a holding solution of 250 ppm 8-HQC. Johnes and Hills, (1993) found vase life of 14 popular cut flower species including cut roses cv. 'Gabrielle' in three germicide solutions including 8-HQC and reported marked significant increase in solution uptake, fresh weight and longevity as compared to those held in control. In rose cv. 'Happiness' the treatment combination of glucose (2 per cent) and 8-HQC (200 ppm) was found to extend the vase life (Sangma, 1993). Bhattacharjee, (1994) evaluated the vase life and keeping quality of ten most popular cultivars of cut roses including 'Super Star' using a combination of preservative solutions containing sucrose and 8-HQC and reported marked increase in flower diameter, petal area and water uptake thereby enhancing vase life. Patil and Singh, (1995) studied the vase life and keeping quality of cut roses cv. 'Gladiator' in a holding solution of 200 ppm 8-HQC and 5 per cent sucrose and observed that the vase life was extended by 7.13 days.

2.2.3 Effect of aluminium :-

Aluminium sulphate has also been used in many preservative formulations for roses (Halevy *et al.*, 1978; Halevy and Mayak, 1981); Carnations (Schnabl, 1976); gladiolus (Mayak *et al.*, 1973; Rameswar, 1974) and tuberose (Mukhopadhyay, 1980). Effect of aluminium was found to lower petal P^H and stabilize the anthocyanins (Halevy and Mayak, 1979) and thereby increasing the vase life (Weinstein and Laurencot, 1963). Aluminium sulphate acidifies holding solution and reduces bacterial growth thus improving water uptake (Halevy and Mayak, 1981; Gowda, 1986; 1987); colour, form and longevity. Addition of aluminium was found to improve the vase life of rose flowers (Weinstein, 1957) and gladiolus (Rameswar, 1974). Aluminium sulphate in the holding solution reduces transpiration and improves the water balance of cut roses by inducing stomatal closure. Aluminium sulphate proved to be effective in showing the greater percentage of bloomed flowers,

significantly promoting the vase life in rose (Gowda and Langhans, 1988) and tuberose (Mukhopadhyay, 1980).

Aluminium sulphate in combination with sucrose was found to be ^{the} best for normal opening of even the most tightly closed buds of carnation (Besemer and Hasek, 1973; Accati and Sulis, 1980). The combination was also effective in maintaining flower colour (Weinstein, 1959) and extending vase life of roses (Cho and Lee, 1979; Ghergi *et al.*, 1983). Vase life of cut china aster can be increased by 8 to 9 days as compared to control in combination with 2 per cent sucrose and 0.4 per cent aluminium sulphate (Gowda, 1986).

Aluminium sulphate increased vase life and increased fresh weight in cut roses (Strigter, 1978). In rose cv. 'Montezuma' increased vase life of 4 to 5 days was recorded by Gowda (1987) by keeping the cut flower in 0.3 per cent aluminium sulphate and 2 per cent sucrose. In gladiolus cv. 'Friendship' the treatment combinations of 4 per cent sucrose and 0.5 mM solution of aluminium sulphate was most suitable for increasing water uptake, fresh weight, opened florets and diameter thus extending the vase life (Murali, 1990; Murali and Reddy, 1993). In three cultivars of rose, namely 'Laura', 'Love' and 'Landora', the effects of potassium aluminium sulphate (25 and 50 mg/l) alongwith sucrose (20mg/l) was studied by Rath *et al.*, (1991). They noticed maximum vase life of all cultivars at 50 mg/l of potassium aluminium sulphate with 20 mg/l sucrose. In the same three cultivars, potassium aluminium sulphate (25 and 50 mg/l) alongwith sucrose (20mg/l) inhibited vascular blockage in the stem, increased water uptake and extended vase life (Mohanthly *et al.*, 1993).

In rose cv. 'Priyadarshini', the treatment of 50 ppm aluminium sulphate was found to have maximum beneficial effect for increasing water uptake, flower diameter, petal area, thereby enhancing the vase

life (Bhattacharjee, 1993). Immersing the stems of 'Queen Elizabeth' cut roses in a solution of aluminium sulphate exhibited a longer vase life with good keeping quality (Shobha and Gowda, 1993). In cv. 'Gladiator', the treatment combinations of Sucrose and aluminium sulphate were most suitable for extending the vase life and keeping quality (Patil and Singh, 1995). Barmam *et al.* (1996) found combination of solution containing 3 per cent and 0.2 per cent aluminium sulphate resulted in a significantly increased vase life and keeping quality of cut chrysanthemum cv. 'Chandrm'.

2.2.4 Effect of silver :-

Silver nitrate acts as an effective bactericide and fungicide and it is also an inhibitor of ethylene biosynthesis and action (Aarts, 1957; Mayak *et al.*, 1973; Kofranek and Paul, 1975; Beyer, 1976). Thus it delays the senescence of cut flowers and improves the vase life. Pre-treatment with silver salts had increased the vase life of cut carnations (Halevy and Kofranek, 1977). Nowak and Rudnicki (1978) reported that a solution containing 0.003 per cent silver nitrate and 4 per cent sucrose was most effective in prolonging the vase life of cut carnation cv. 'Cherry pink' which resulted in having double vase life. Ferreira and De Swardt (1980) obtained best results with 25 mg/dm³ silver nitrate or in combination with other preservative solutions in cut roses cv. 'Sonia'. Lee *et al.*, (1980) reported that a solution containing sucrose and silver nitrate increased significantly the flower diameter, fresh weight and longevity of cut carnations, cv. 'Coral'. The vase life of anthurium flower was extended by a 10 minutes pulse with 1mM silver nitrate (Paulland Goo, 1982). Reid *et al.* (1980) used silver thiosulphate complex prepared by combining silver nitrate with sodium thiosulphate (Molar ratio 1:4) as a source of silver which doubled the vase life of carnation.

Silver nitrate delayed senescence of rose flowers cv. 'Garbiella' after 3 weeks of cold storage by 3 to 4 days and carnation silver thiosulphate treatment doubled vase life (Veen, 1983). Lukaszewska (1986) reported that a solution of glucose plus silver nitrate increased longevity of cut dahlia cv. 'Purple Green'. 'Queen Elizabeth' roses pulsed for 10 and 20 minutes in silver nitrate solution the vase life remained for 6 and 5 days respectively, while in control it was only 3 days (Reddy and Nagarajaiah, 1988). Combining the S.T.S. treatment with sucrose pulse had an additive effect in increasing the vase life of stored rose flowers (Mor *et al.*, 1989). Bud opening and vase life of dendrobium flowers were increased by glucose, sucrose and Silver nitrate treatments (Kesta and Boonrote, 1990).

In rose cvs. 'Laura', 'Love' and 'Landora' the treatment combinations of sucrose (20mg/l) and silver nitrate (25 and 50 mg/l) reduced vascular blockage in the stems thus increasing the water uptake and prolonging vase life (Rath *et al.*, 1991; Mohanthy, *et al.*, 1993). Bhattacharjee (1993) reported that 25 ppm of silver nitrate treated to cut roses cv. 'Priyadarshini' had resulted in increasing the petal areas, the flower diameter and the water uptake thus prolonging the vase life. Immersing the stems of 'Queen Elizabeth' cut roses in a solution of silver thiosulphate exhibited a longer vase life with good keeping quality (Shobha and Gowda, 1993). In gladiolus cv. 'Friendship', the treatment combinations of 4 per cent sucrose and 0.25 mM silver thiosulphate was found to be more suitable for increasing water uptake, fresh weight, opened florets and diameter thereby, leading to a enhanced vase life (Murali, 1990; Murali and Reddy, 1993).

2.2.5 Effect of Cobalt :-

Influence of cobalt on post harvest behaviour of different cultivars of roses and other cut flowers were investigated by several

workers. Cobalt ion (Co^{+2}) is reported to be an inhibitor of ethylene biogenesis (Lau and Yang, 1976; Paull and Good, 1985). Cobalt nitrate is highly effective in delaying or preventing the development of bent-neck, increasing water uptake and extending the longevity of cut 'Samantha' roses (Murr et al., 1979; Mahr and Hannan, 1980; Venkatrarayappa et al., 1980). A combination of cobalt chloride and sucrose was observed to extend the vase life of cut flowers of french marigold and chrysanthemum (Chandra et al., 1981). They have also recorded a greater gain in fresh weight, delay in loss of fresh weight and better expansion of ray florets on opening of disc florets due to the above treatment. Cobalt had been shown to have inhibitive effects on the vascular blockage of stems and partial closure of stomata which helps in maintaining higher water retention of cut roses (Venkatarayappa, 1983). Cobalt treatment reduced ethylene responsiveness and delayed the senescence of cut carnations (Cook et al., 1985).

Cobalt inhibited vascular blockage in the stems, maintained a higher water flow rate through the stems leading to significantly closed stomates, maintained a higher water potential and a higher fresh weight, thereby increasing vase life of cut 'Samantha' roses (Reddy, 1988). Balakrishna et al., (1989) reported that cobalt increased the vase life of cut tuberose spikes by increasing water uptake, improving water balance and delaying the loss of fresh weight. Nagarajaiah et al., (1989) studied the effect of cobalt sulphate on the post harvest behaviour of cut 'Queen Elizabeth' roses. They have reported that CoSO_4 increased the vase life of roses through maintenance of better water relations and increased fresh weight which was far better when used alongwith sucrose.

Senescence of cut chrysanthemum reduced prolonging vase life by cobalt chloride alongwith sucrose (Saradhi et al., 1989). In gladiolus, cv. 'Friendship', a solution combination of sucrose at 4 per cent

and cobalt at 0.5 mM was investigated as a suitable medium for increasing water uptake, fresh weight, opened florets and diameter, hence extended the vase life and keeping quality by Murali (1990) and Murali and Reddy, (1991, 1993). Immersing stems of 'Queen Elizabeth' cut roses in a solution of cobalt sulphate exhibited a long vase life with good keeping quality (Shobha and Gowda, 1993). It also increased solution uptake and retained maximum fresh weight.

The beneficial effects of cobalt in combination of sucrose was attributed primarily to the greater retention of water when held in the combined solution as compared to either of them using separately (Venkatarayappa *et al.*, 1981).

From the above review it can be seen that considerable work has been carried out in the past on the use of sucrose alone and in combination with various chemical preservatives to extend the vase life and improve the keeping quality of cut rose and other cut flowers. However, the rose varieties, Super Star and Gladiator, which have a greater commercial potential for export have not been investigated in detail for improving the vase life and keeping quality using sucrose alongwith various chemical preservatives. Hence, the present investigation was taken up with these objectives.

**MATERIALS
AND
METHODS**

III MATERIALS AND METHODS

Materials used and the techniques adopted in the present investigation are described in this chapter.

3.1 EXPERIMENTAL SITE :-

The present investigation on "studies on post harvest life of cut roses, cvs. Super Star (= Tropicana) and Gladiator" was carried out at the P.G. Research Laboratory, Department of Horticulture, N.M. College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari, during the winter season of 1995-96.

3.2 GENERAL DESCRIPTION :-

3.2.1 Location :

Navsari is situated at 20°.57'N latitude, 75°.54'E longitude and at an elevation of 10 metres above the mean sea level. Navsari campus is located on the historic road to Dandi and 13 km away from Arabian Sea shore.

3.2.2 Climate and weather conditions :

The climate of this region is typically tropical, characterised by fairly hot and humid summer, moderately cool winter and warm monsoon with heavy rains. Monsoon commences mostly from the second week of June and last upto the first week of October. The average annual rainfall is about 1536 mm. The winter season sets in by the end of October and continues till the end of February, with the lowest temperature of about 10°C during December - January. The temperature starts rising by the end of February and reaches maximum at about 37,8° in the month of May.

The average temperature and relative humidity during the period of experimentation that prevailed in the laboratory were 22.5° C with 70% R.H.

3.3 EXPERIMENTAL MATERIAL :-

3.3.1 Selection and preparation of plant material :

Rose, cv. 'Super Star' and Gladiator flowers harvested from the commercial field of a progressive local farmer of Navsari were used in the present experiment. The flowers were harvested when the outer one to two petals unfurled from the tip in case of 'Super Star', whereas five to eight in case of 'Gladiator' at tight bud stage; having a good keeping quality. The flowers having the same size were used in the experiment in order to maintain uniformity within the replications. The stems were cut into a uniform length of 45 cm and all leaves were stripped except two 3-leaflet leaves and one 5-leaflet leaf from the tip of each stem. The bases of these stems were recut before placing them in the solution (Lemper, 1981) and after their fresh weight was recorded.

3.4 DETAILS OF THE EXPERIMENTAL PROCEDURE :-

The details of the experimental procedure are given below :

3.4.1 Design of experiment :

The experiment was laid out in completely randomized design (C.R.D.) with 19 treatments, each with three replications.

3.4.2 Treatment details :

Varieties : Two

1. Super Star - (V₁)

2. Gladiator - (V₂)

Sucrose : Two levels 2% and 3% concentrations

Chemicals and their concentrations : Four (Each at two levels in combination with two sucrose levels)

1. 8- hydroxy quinoline citrate : 150 and 200 ppm Concentrations.
2. Aluminium sulphate : 25 and 50 ppm concentrations
3. Silver nitrate : 15 and 25 ppm concentrations.
4. Cobalt nitrate : 180 and 270 ppm concentrations.
5. Control : Double Distilled water

Treatment combinations

Sr. No.	Treatments	Abbreviation
1.	Sucrose (2%)	S ₁
2.	Sucrose (3%)	S ₂
3.	8- hydroxy quinoline citrate (150 ppm) + Sucrose (2%)	8- HQC ₁ S ₁
4.	8- hydroxy quinoline citrate (150 ppm) + Sucrose (3%)	8- HQC ₁ S ₂
5.	8- hydroxy quinoline citrate (200 ppm) + Sucrose (2%)	8- HQC ₂ S ₁
6.	8- hydroxy quinoline citrate (200 ppm) + Sucrose (3%)	8- HQC ₂ S ₂
7.	Aluminium Sulphate (25 ppm) + Sucrose (2%)	Al ₁ S ₁
8.	Aluminium Sulphate (25 ppm) + Sucrose (3%)	Al ₁ S ₂
9.	Aluminium Sulphate (50 ppm) + Sucrose (2%)	Al ₂ S ₁
10.	Aluminium Sulphate (50 ppm) + Sucrose (3%)	Al ₂ S ₂
11.	Silver nitrate (15 ppm) + Sucrose (2%)	Ag ₁ S ₁
12.	Silver nitrate (15 ppm) + Sucrose (3%)	Ag ₁ S ₂
13.	Silver nitrate (25 ppm) + Sucrose (2%)	Ag ₂ S ₁
14.	Silver nitrate (25 ppm) + Sucrose (3%)	Ag ₂ S ₂
15.	Cobalt nitrate (180 ppm) + Sucrose (2%)	Co ₁ S ₁
16.	Cobalt nitrate (180 ppm) + Sucrose (3%)	Co ₁ S ₂
17.	Cobalt nitrate (270 ppm) + Sucrose (2%)	Co ₂ S ₁
18.	Cobalt nitrate (270 ppm) + Sucrose (3%)	Co ₂ S ₂
19.	Control (Double Distilled water)	C (D.D.W.)

The above-mentioned set of treatments (1 to 19) were repeated for both the varieties of roses.

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3.4.3 Application of the treatments :

Glass bottles having one litre capacity were used as vases for keeping the flowers. Four flowers were used for each replication which were kept in these bottles having 500 ml of the treatment solution. To reduce the experimental variability, all the solutions were prepared with distilled water and only freshly prepared solutions were used in the experiment. The rose buds were allowed to open under natural light conditions during day time and under cool white tubular fluorescent lamps placed 2 m above the flowers during night time.

3.4.4 Methodology adopted for the preparation of treatments :

3.4.4.1 Sucrose solution :

Sucrose solution of 2 and 3 per cent concentrations were prepared by dissolving 20 g and 30 g sucrose respectively, in one litre of distilled water.

3.4.4.2 8-hydroxy quinoline citrate solution :

8-hydroxy Quinoline Citrate Solution of 150 ppm and 200 ppm concentrations were prepared by dissolving 150 mg and 200 mg 8-HQC in one litre of distilled water.

3.4.4.3 Aluminium sulphate solution :

Solution of aluminium sulphate of 25 ppm and 50 ppm concentrations were prepared by dissolving 25 mg and 50 mg aluminium sulphate in one litre of distilled water.

3.4.4.4 Silver nitrate solution :

Silver nitrate solution of 15 ppm and 25 ppm concentrations were prepared by dissolving 15 mg and 25 mg silver nitrate in one litre of distilled water.

3.4.4.5 Cobalt nitrate solution :

Cobalt nitrate solution of 180 ppm and 270 ppm concentrations were prepared by dissolving 180 mg and 270 mg cobalt nitrate in one litre of distilled water.

3.5 DESCRIPTION OF THE VARIETIES :-

Rose (Rosa hybrida L.) belongs to the family of Rosaceae, consisting of 150 species (Gibson, 1984). Rose is an ornamental shrub with upright prickly stems, having solitary flow^ers. Rose cut flowers arranged in flower^s vases look extremely beautiful and they have a rightful place in the scheme of interior decoration. In general, cultivars with more petallage which open slowly and having long lasting quality are chosen as cut flowers.

The hybrid tea rose varieties used in the investigation were SuperStar (=Tropicana) and Gladiator.

3.5.1 Super Star :

SuperStar raised by Math.Tantau, Holstein, Germany was introduced in 1960. It has a hybrid parentage (Seedling x Peace) x (Seedling x Alphine Glow) and was adjudged as the finest hybrid tea rose after Peace, due to its luminous, clear vermilion-orange colour of the blooms which is unique to hybrid tea. Flowers are medium sized. It grows vigorously and is tall and bushy with high centre bud formed of iridescent, clear fresh petals having a sharp apple-like sweet fragrance, with plenty of glossy medium-green foliage. Called as "Tropicana" in America, it is the winner of many international awards, like " All America Rose selection" award for 1963 and also the "Royal National Rose Society's premier Award" of the United Kingdom.

3.5.2 Gladiator :

Gladiator is also an interesting hybrid tea variety, introduced in 1955 by Malandrone. It is one of the 8 modern roses and is a large-flowered climber. It has proved to be a boon commercially for the cut flower trade in Western India. Gladiator flowers are well shaped, deep red to crimson in colour and produce abundantly on long stems.

3.6 METHODOLOGY ADOPTED IN RECORDING THE POST HARVEST OBSERVATIONS :-

3.6.1 Opening of petals :

On the day when the flower stems were discarded, the total number of opened petals/flower buds were counted on percentage basis.

$$\text{per cent of opened petals/flower bud} = \frac{\text{No. of opened petals}}{\text{Total no. of petals per flower}} \times 100$$

3.6.2 Abscissing of petals :

The number of petals abscised from the flower from the day of placement in vase solution till the end of its vase life was counted and expressed on percentage basis.

$$\text{Per cent of abscised petals /flower bud} = \frac{\text{No. of abscised petals}}{\text{Total no. of petals per flower}} \times 100$$

3.6.3 Diameter of flowers :

Flower diameter was measured on two perpendicular axes and the average value was taken in cm.

3.6.4 Area of petal :

The area of the five petals of the first whorl from outside the flower was measured using an electronic leaf area meter (Licor 3000) and the average value was determined in cm².

3.6.5 Fresh weight of flower :

Initial weights of the cut flowers were measured before keeping them in the vase solution. Subsequently, the flowers were weighed at two days intervals and their fresh weights were expressed as the percentage of their initial weight as,

$$\text{per cent of fresh weight of flower} = \frac{\text{Flower weight at the time of periodical observations}}{\text{Initial weight of flower}} \times 100$$

3.6.6 Total water uptake :

The cut flowers were kept in equal volumes of vase solution. The glass bottles used for vases were covered with polyethylene film to reduce evaporation from the vase solution. At the end of 8th day in case of 'Gladiator' and 10th day in case of 'Super Star', the volume of the solution remaining in the vase was measured using a measuring cylinder. The total uptake of the solution by the flowers was recorded by subtracting the final volume from the initial volume.

3.6.7 Vase life :

The end of useful vase life of the flower was determined either with the appearance of bent-neck symptoms or wilting of the outer petals or blueing of the petals and was recorded in number of days.

3.7 STATISTICAL ANALYSIS :-

The data recorded during the experiment were subjected to statistical analyses. The design of analysis used was completely randomized design, as described by Panse and Sukhatme (1967). The significance of the treatment differences was tested by 'F' test on the basis of null hypothesis. The appropriate standard errors of mean (SEM \pm) were calculated in each case and the critical difference (C.D.) at 5 per cent level of probability was worked out to compare the two treatment means whenever the treatment effects were significant. Further, the treatment means were separated using Duncon's new multiple range test, as described by Gomez and Gomez (1976).

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The experimental results of the present investigation entitled "Studies on post harvest life of cut roses (*Rosa hybrida* L.) cv. Super Star and Gladiator" under the influence of sucrose alone and in combination with different chemicals namely, 8-hydroxy quinoline citrate, aluminium sulphate, silver nitrate and cobalt nitrate for determining the optimum concentration required for maximum vase life and for improving the keeping quality of cut rose flowers are presented in this chapter. The observations recorded on various aspects of vase life and keeping quality parameters were subjected to statistical analyses and tested for their significances using Duncon's new multiple range test.

4.1 Effect on opening^{of} petals :-

The data pertaining to the influence of various treatments on opening^{of} petals per flower are presented in Table 4.1. The results from the various treatments indicated that there was a significant effect on the opening of petals per flower in both cultivars of rose used in the present studies. In case of cv. 'Super Star' flowers kept in combination of preservative chemical treatments from T₃ to T₁₈ opened fully (100.0%) and they are statistically at par with each other but significantly superior over T₁, T₂ and T₁₉ at the end of their vase life. Further, T₁ and T₂ treatments are found to be significantly superior to the control (T₁₉) in terms of percentage of flowers with completely opened petals towards the end of their vase life. The control T₁₉ has recorded only 75.48 per cent flower opening.

In cv. 'Gladiator' T₆ and T₁₈ recorded significantly higher percentage (85.33%) of opened petals per flower over the remaining treatments followed by T₅ and T₁₇ (83.13 %), T₄ (82.86 %) , T₃ and T₁₆ (82.59 %), T₁₅ (81.84 %) and T₁₀ (81.30 %) which are statistically at par

Table 4.1. Effect of various preservative chemical substances on percentage of opened petals of cut roses cvs. 'Super Star' and 'Gladiator'.

Sr. No.	Treatment	Percentage of opened petals per flower *			
		Super Star (V ₁)	Test	Gladiator (V ₂)	Test
1	S ₁	89.21	b	64.39	b
2	S ₂	89.58	b	64.54	b
3	8-HQC ₁ S ₁	100.00	c	82.59	h
4	8-HQC ₁ S ₂	100.00	c	82.86	h
5	8-HQC ₂ S ₁	100.00	c	83.13	h
6	8-HQC ₂ S ₂	100.00	c	85.33	i
7	Al ₁ S ₁	100.00	c	77.56	cd
8	Al ₁ S ₂	100.00	c	79.66	ef
9	Al ₂ S ₁	100.00	c	80.21	efg
10	Al ₂ S ₂	100.00	c	81.30	fgh
11	Ag ₁ S ₁	100.00	c	75.63	c
12	Ag ₁ S ₂	100.00	c	75.87	c
13	Ag ₂ S ₁	100.00	c	77.56	cd
14	Ag ₂ S ₂	100.00	c	78.93	de
15	Co ₁ S ₁	100.00	c	81.84	gh
16	Co ₁ S ₂	100.00	c	82.59	h
17	Co ₂ S ₁	100.00	c	83.13	h
18	Co ₂ S ₂	100.00	c	85.33	i
19	Control	75.48	a	62.36	a
SEm ±		0.4977		0.6403	

* The treatment means are separated using Duncon's new multiple range test at 5% level.

with each other and they are significantly superior to rest of the treatments except T₁₀ which is at par with T₈ and T₉. In case of remaining treatments, T₁₉ (Control) had recorded the lowest percentage (62.36 %) of opened petals.

The percentage of opened petals was higher for Super star than Gladiator (Table 4.1).

4.2 Effect on abscissing^{of} petals :-

The data pertaining to the influence of various treatments on the abscised petals per flower are presented in Table 4.2. The various treatments significantly reduced the abscised petals per flower as compared to the control in both the cultivars of rose. However, no significant differences was observed between various treatments in either of the cultivars.

In general, the percentages of abscised petals are lower in Super Star as compared to Gladiator.

4.3 Effect on the diameter of flower :-

The data pertaining to the influence of various treatments on the diameter of flower are presented in Table 4.3. The various treatments significantly affected the diameters of flowers in both cultivars.

In case of cv. 'Super Star', T₁₈ was found to have significantly more diameter (9.79 cm) of flower as compared to other treatments. In the remaining treatments, the diameters of flowers are 9.60 cm (T₁₇), 9.58 cm (T₁₆) and 9.56 cm (T₆) all of which are statistically at par with each other but significantly superior to the rest of the treatments, except T₁₅ (9.51 cm) and T₅ (9.48 cm) which are in turn at par with T₄. The control had recorded significantly lowest diameter (8.27 cm) of flower.

Table 4.2. Effect of various preservative chemical substances on percentage of abscised petals of cut roses cvs. 'Super star' and 'Gladiator'.

Sr. No.	Treatment	Percentage of abscised petals per flower *			
		Super star (V ₁)	Test	Gladiator (V ₂)	Test
1	S ₁	2.46	a	2.68	a
2	S ₂	2.37	a	2.68	a
3	8-HQC ₁ S ₁	2.08	a	2.45	a
4	8-HQC ₁ S ₂	2.08	a	2.37	a
5	8-HQC ₂ S ₁	1.78	a	2.45	a
6	8-HQC ₂ S ₂	1.78	a	2.13	a
7	Al ₁ S ₁	2.46	a	2.68	a
8	Al ₁ S ₂	2.37	a	2.56	a
9	Al ₂ S ₁	2.08	a	2.45	a
10	Al ₂ S ₂	1.78	a	2.37	a
11	Ag ₁ S ₁	2.46	a	2.68	a
12	Ag ₁ S ₂	2.46	a	2.68	a
13	Ag ₂ S ₁	2.46	a	2.56	a
14	Ag ₂ S ₂	2.37	a	2.56	a
15	Co ₁ S ₁	2.08	a	2.37	a
16	Co ₁ S ₂	2.08	a	2.37	a
17	Co ₂ S ₁	1.78	a	2.13	a
18	Co ₂ S ₂	1.78	a	2.13	a
19	Control	3.57	b	3.40	b
SEm ±		0.2504		0.1986	

* The treatment means are separated using Duncon's new multiple range test at 5% level.

Table 4.3. Effect of various preservative chemical substances on diameter of flower of cut roses cvs. 'Super Star' and 'Gladiator'.

Sr. No.	Treatment	Diameter of flower (cm) *			
		Super Star (V ₁)	Test	Gladiator (V ₂)	Test
1	S ₁	8.72	b	9.68	b
2	S ₂	8.78	bc	9.76	b
3	8-HQC ₁ S ₁	9.30	h	11.03	gh
4	8-HQC ₁ S ₂	9.36	hi	11.10	ghi
5	8-HQC ₂ S ₁	9.48	ij	11.24	ij
6	8-HQC ₂ S ₂	9.56	j	11.31	j
7	Al ₁ S ₁	9.08	efg	10.73	e
8	Al ₁ S ₂	9.11	efg	10.81	ef
9	Al ₂ S ₁	9.20	fgh	10.95	fg
10	Al ₂ S ₂	9.25	gh	11.02	gh
11	Ag ₁ S ₁	8.90	cd	10.46	c
12	Ag ₁ S ₂	8.94	cde	10.53	cd
13	Ag ₂ S ₁	9.00	de	10.68	de
14	Ag ₂ S ₂	9.05	def	10.76	e
15	Co ₁ S ₁	9.51	ij	11.20	hij
16	Co ₁ S ₂	9.58	j	11.28	ij
17	Co ₂ S ₁	9.60	j	11.33	j
18	Co ₂ S ₂	9.79	k	11.57	k
19	Control	8.27	a	9.16	a
SEm ±		0.0565		0.0641	

* The treatment means are separated using Duncon's new multiple range test at 5% level.

In cv. 'Gladiator', T₁₈ recorded significantly highest diameter (11.57cm) as compared to other treatments. In the remaining treatments, the diameter recorded were 11.33 cm (T₁₇) and 11.31 (T₆) which are statistically at par with each other but significantly superior to the rest of the treatments, except T₁₆ (11.28 cm), T₅ (11.24 cm) and T₁₅ (11.20 cm). T₁₅ was at par with T₄, T₃ and T₁₀. The control had recorded the lowest diameter (9.16 cm) of flower.

4.4 Effect on petal area of flower :-

The data pertaining to the influence of various treatments on petal area of flower (average of outer 5 petals) are presented in Table 4.4. The various treatments significantly affected petal area of flower in both the cultivars of rose.

In case of cv. 'Super Star', T₁₈ showed maximum petal area (18.32 cm²) as compared to the other treatments. The petal areas in T₁₇ and T₆ were 17.95 cm² and 17.89 cm², respectively, both being at par with each other but they were significantly superior to the rest of the treatments except T₁₆ (17.86 cm²), T₁₅ (17.78 cm²), T₅ (17.76 cm²) and T₄ (17.58 cm²), whereas the control (T₁₉) recorded only 16.10 cm² which was the lowest petal area of flower recorded.

In cv. 'Gladiator' T₁₈ had the maximum petal area (20.03 cm²) compared to the other treatments. The petal area in T₁₇, T₆, T₁₆, T₅ and T₁₅ were 19.63 cm², 19.45 cm², 19.40 cm², 19.36 cm² and 19.29 cm², respectively, which were statistically at par with each other. But T₆, T₁₆, T₅ and T₁₅ were significantly superior to the rest of the treatments except T₄, T₃ and T₁₀. The control (T₁₉) treatment recorded (16.83cm²) significantly lowest petal area of flower.

Table 4.4. Effect of various preservative chemicals on petal area of cut roses cvs. 'Super Star' and 'Gladiator'.

Sr. No.	Treatment	Petal area of flower (average of outer 5 petals) (cm ²) *			
		Super Star (V ₁)	Test	Gladiator (V ₂)	Test
1	S ₁	16.60	b	17.73	b
2	S ₂	16.67	b	17.82	bc
3	8-HQC ₁ S ₁	17.49	efgh	19.06	hijk
4	8-HQC ₁ S ₂	17.58	fghi	19.17	ijk
5	8-HQC ₂ S ₁	17.76	ghi	19.36	jkl
6	8-HQC ₂ S ₂	17.89	i	19.45	kl
7	Al ₁ S ₁	17.15	cde	18.59	efg
8	Al ₁ S ₂	17.20	cde	18.70	fgh
9	Al ₂ S ₁	17.35	def	18.88	ghi
10	Al ₂ S ₂	17.41	defg	19.00	hij
11	Ag ₁ S ₁	16.87	bc	18.15	cd
12	Ag ₁ S ₂	16.95	bc	18.24	de
13	Ag ₂ S ₁	17.04	cd	18.41	def
14	Ag ₂ S ₂	17.10	cd	18.52	defg
15	Co ₁ S ₁	17.78	ghi	19.29	jkl
16	Co ₁ S ₂	17.86	hi	19.40	jkl
17	Co ₂ S ₁	17.95	i	19.63	l
18	Co ₂ S ₂	18.32	j	20.03	m
19	Control	16.10	a	16.83	a
SEm ±		0.1185		0.1257	

* The treatment means are separated using Duncon's new multiple range test at 5% level.

4.5 Effect on fresh weight of flower :-

The data pertaining to the influence of various treatments on the fresh weight of cut roses are presented as percentage of their initial weight in Table 4.5 for Super Star and in Table 4.6 for Gladiator. They are also graphically depicted in Figs.1 and 2 respectively. The various preservative chemicals in combination with different concentrations of sucrose significantly affected the initial increase in the fresh weight of the flower and also its later decline. In both cultivars, the fresh weight of the flowers decreased more rapidly with time in control as compared to all other treatments.

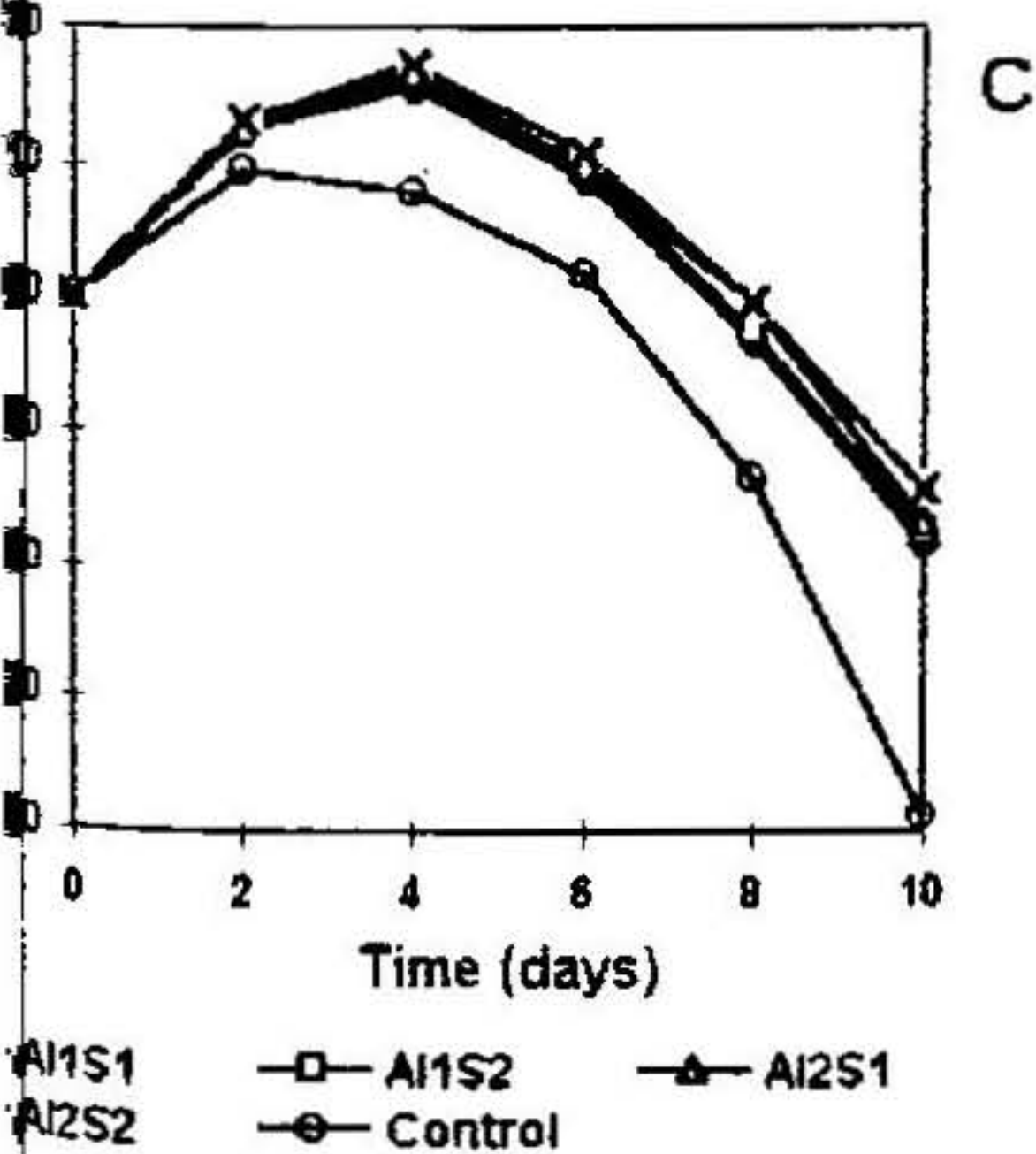
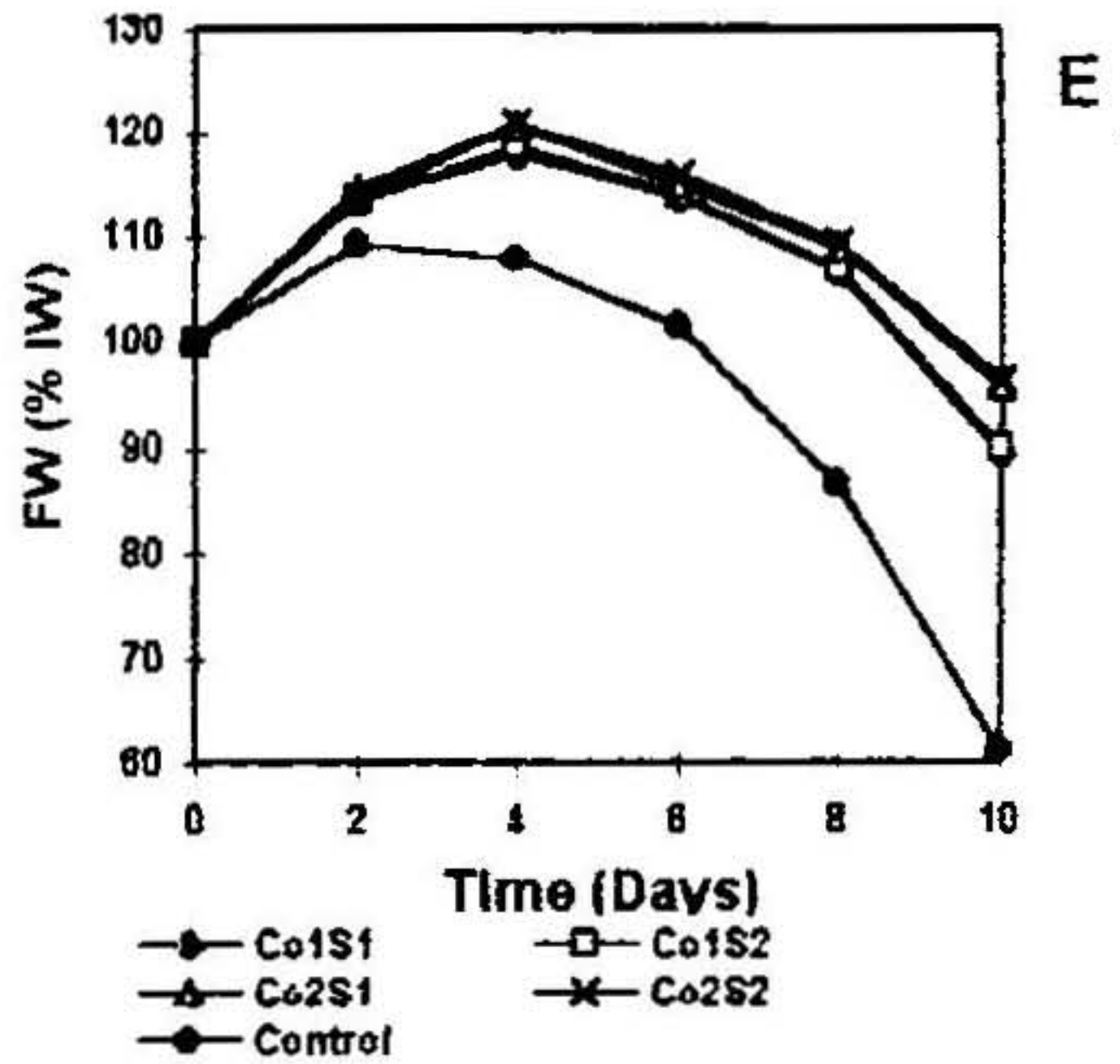
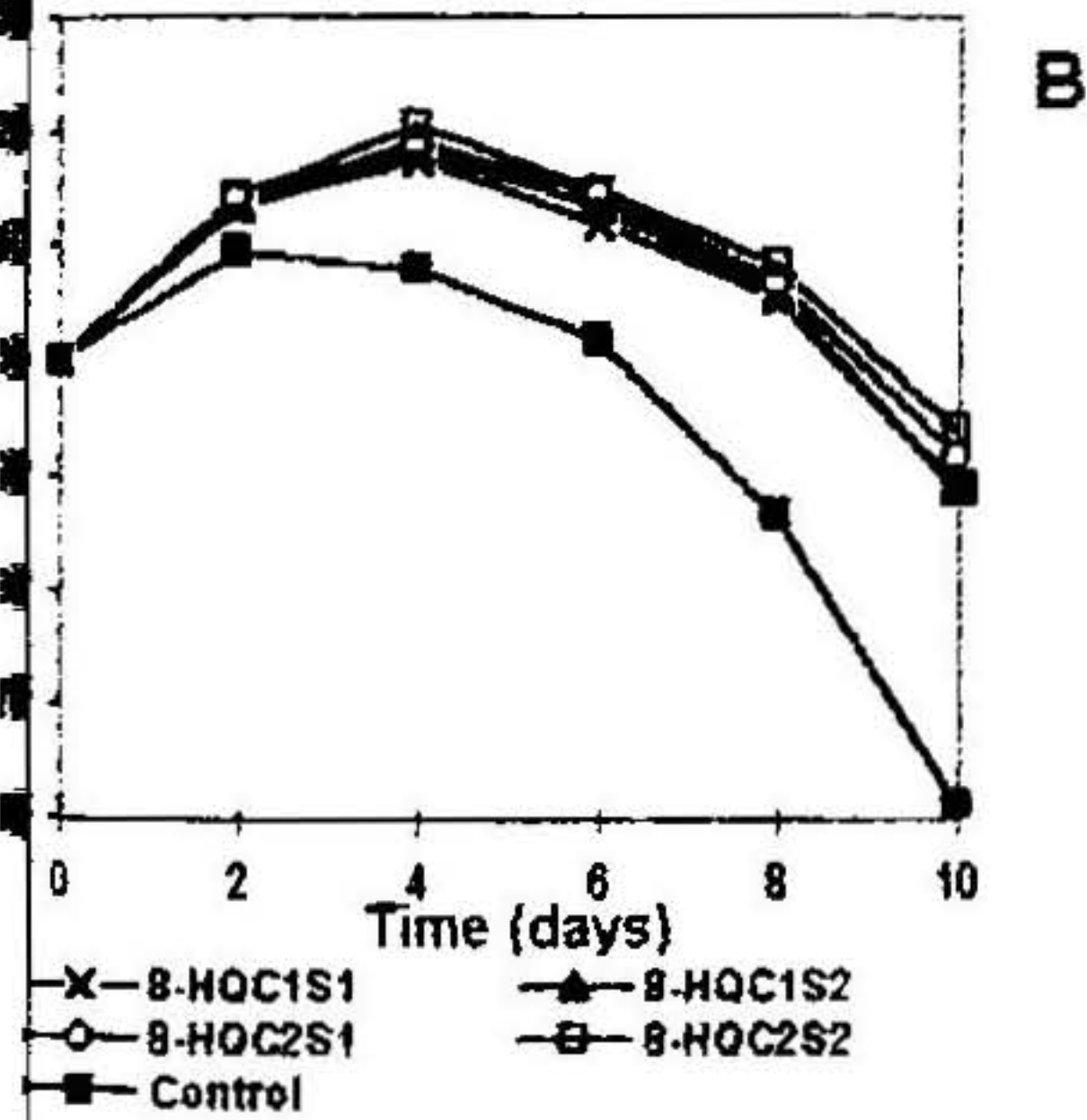
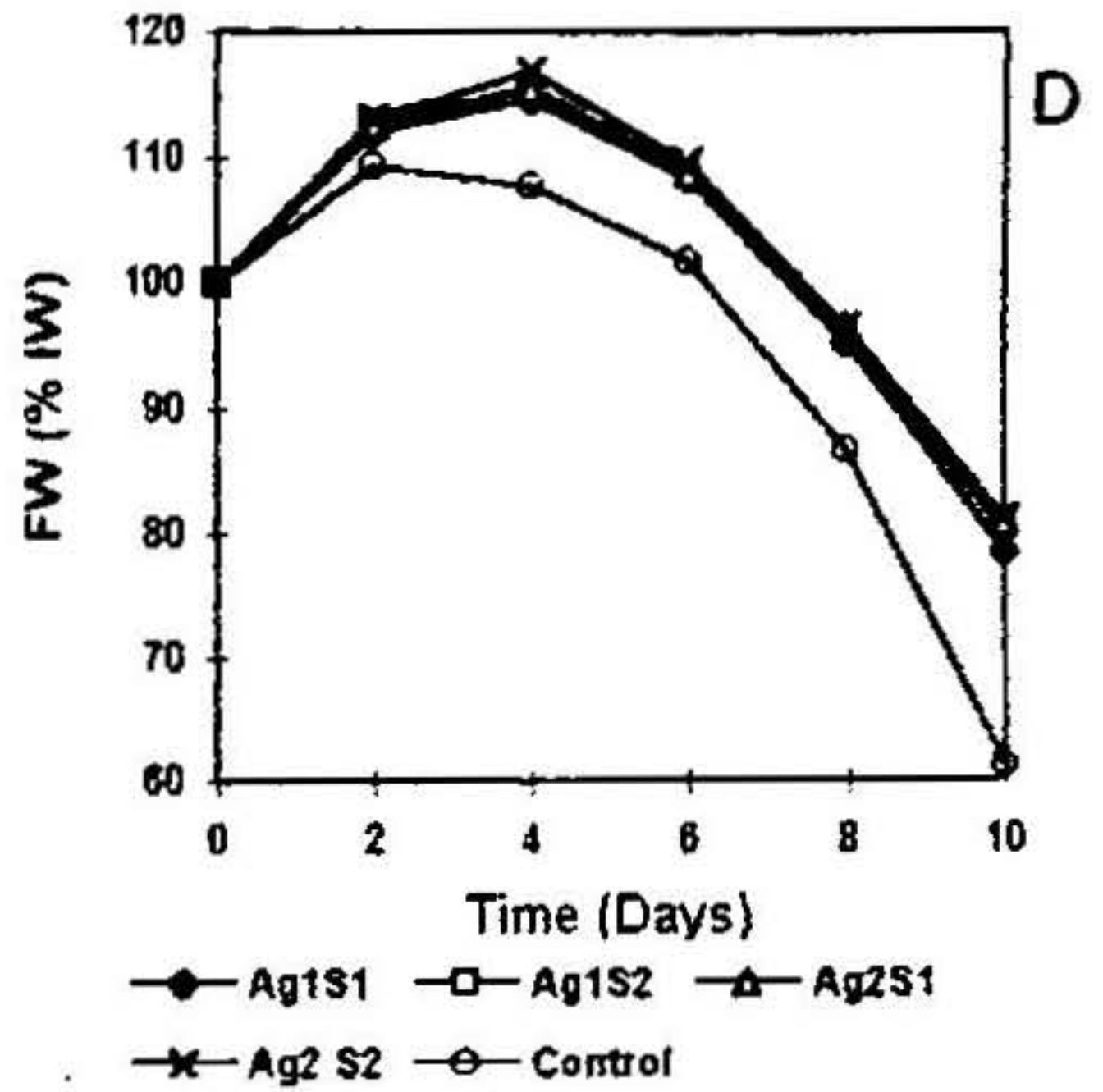
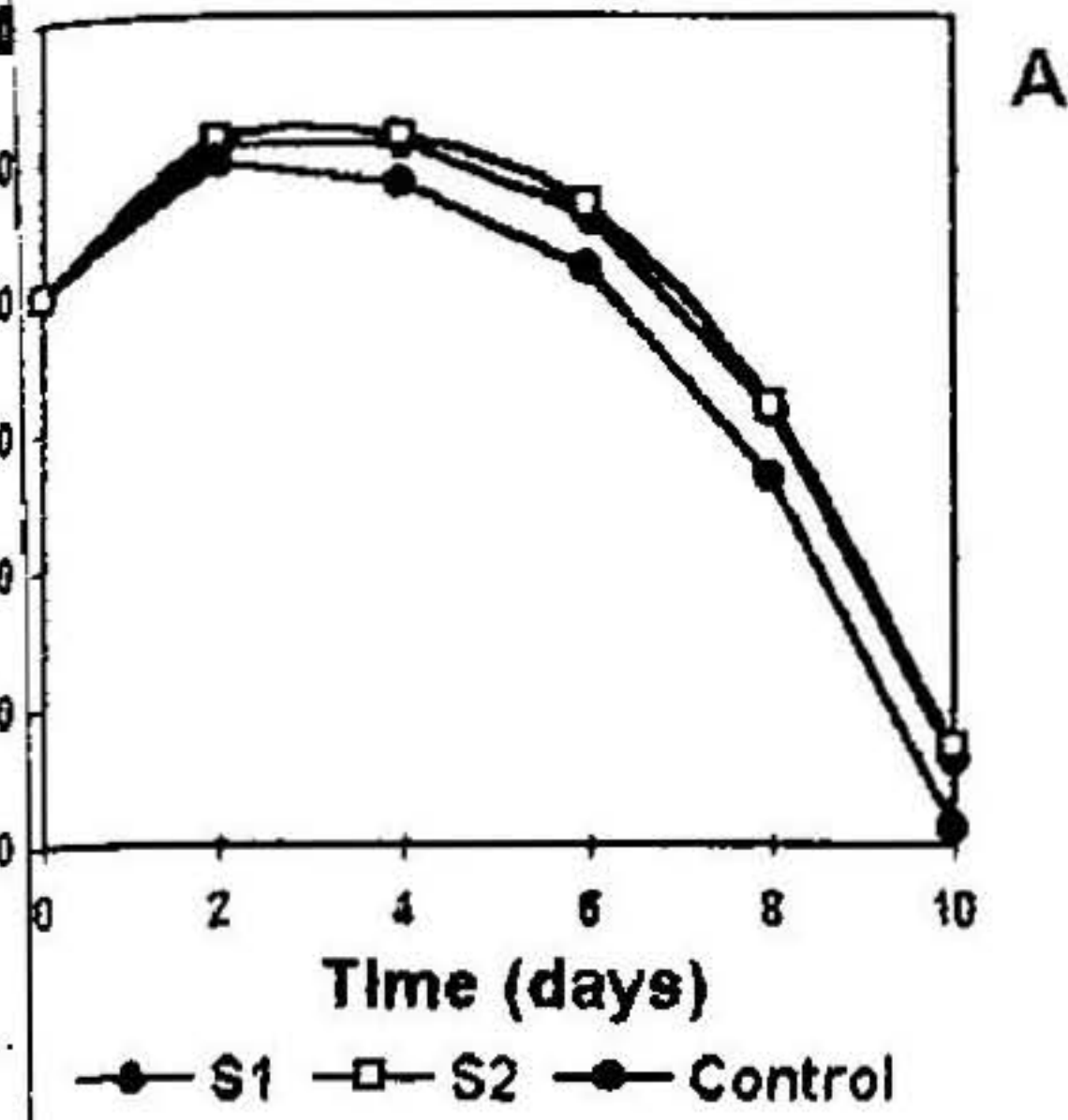
In case of 'Super Star', there was no significant difference between various treatments on the fresh weight of the flower. However, the fresh weight was significantly affected by the different combinations of preservative chemical concentrations (Fig .1). On any given day, the fresh weight of cut flowers in treatment solutions (T₁ to T₁₈) was found to be higher than in control (T₁₉). In general, the fresh weight of flowers held in different concentrations of preservative solution (T₁ to T₁₈) increased during first 4 days whereas in control (T₁₉) it increased during the first 2 days only.

Among the various treatments, T₁₈ showed significantly higher gain in fresh weight upto 4 days (120.87 %) followed by T₁₇ (120.52 %) and T₆ (120.48 %). It maintained a higher fresh weight than the initial weight upto day 8 and thereafter it declined below its initial weight on day 10. A similar pattern was observed in T₅, T₁₆, T₁₅ and T₃ treatments while the rest of the treatments, T₁, T₂ and T₇ to T₁₄ showed significant increase in fresh weight for the first 4 days and there after it declined gradually, but the higher fresh weight was retained upto 6 days. By 8 to 10 days the fresh weight declined below its initial weight. In control (T₁₉), the treated flowers increased ⁱⁿ the fresh weight during the first 2 days and

Table 4.5. Effect of various preservative chemical substances on fresh weight (% I.W.) of cut roses cv.

'Super Star'

Sr. No.	Treatment	Fresh weight (% of I.W.) per flower *										
		Days of display										
		0	2	Test	4	Test	6	Test	8	Test	10	Test
1	S ₁	100	110.70	ab	110.84	b	105.53	b	91.44	b	66.25	b
2	S ₂	100	110.98	abc	111.36	b	106.10	bc	91.70	bc	67.10	b
3	8-HQC ₁ S ₁	100	113.31	bcd	117.52	cdefgh	111.72	defg	105.43	e	88.66	ef
4	8-HQC ₁ S ₂	100	113.57	bcd	118.22	defgh	113.36	defgh	105.93	e	88.86	ef
5	8-HQC ₂ S ₁	100	113.81	cd	118.94	fgh	114.29	fgh	106.91	e	91.71	fgh
6	8-HQC ₂ S ₂	100	114.38	d	120.48	gh	114.81	gh	108.28	e	93.97	gh
7	Al ₁ S ₁	100	112.47	bcd	115.67	cde	108.93	bcd	96.84	cd	81.54	cd
8	Al ₁ S ₂	100	112.52	bcd	116.49	cdef	109.56	cd	97.30	d	82.40	cd
9	Al ₂ S ₁	100	113.18	bcd	116.61	cdef	109.72	cde	99.56	d	83.16	cd
10	Al ₂ S ₂	100	113.26	bcd	117.28	cdef	110.66	def	99.67	d	85.63	de
11	Ag ₁ S ₁	100	112.13	abcd	114.67	c	108.33	bcd	95.33	bcd	78.45	c
12	Ag ₁ S ₂	100	112.47	bcd	115.33	cd	108.54	bcd	95.74	bcd	80.27	c
13	Ag ₂ S ₁	100	112.66	bcd	115.59	cde	108.82	bcd	96.50	bcd	80.72	cd
14	Ag ₂ S ₂	100	113.21	bcd	116.81	cdef	109.57	cd	96.61	bcd	81.13	cd
15	Co ₁ S ₁	100	113.43	bcd	117.74	cdefgh	113.67	fgh	106.56	e	89.33	efg
16	Co ₁ S ₂	100	113.59	bcd	118.65	efgh	114.04	fgh	106.89	e	89.94	efg
17	Co ₂ S ₁	100	113.88	cd	120.52	gh	114.98	gh	108.74	e	95.82	h
18	Co ₂ S ₂	100	114.62	d	120.87	h	115.92	h	109.33	e	96.53	h
19	Control	100	109.43	a	107.83	a	101.67	a	86.51	a	61.33	a
SEm ±			0.8702		0.9213		1.1745		1.6137		1.5694	



Effect of various preservative chemical substances on fresh weight (% of I.W.) of cut roses cv. 'Super Star'.

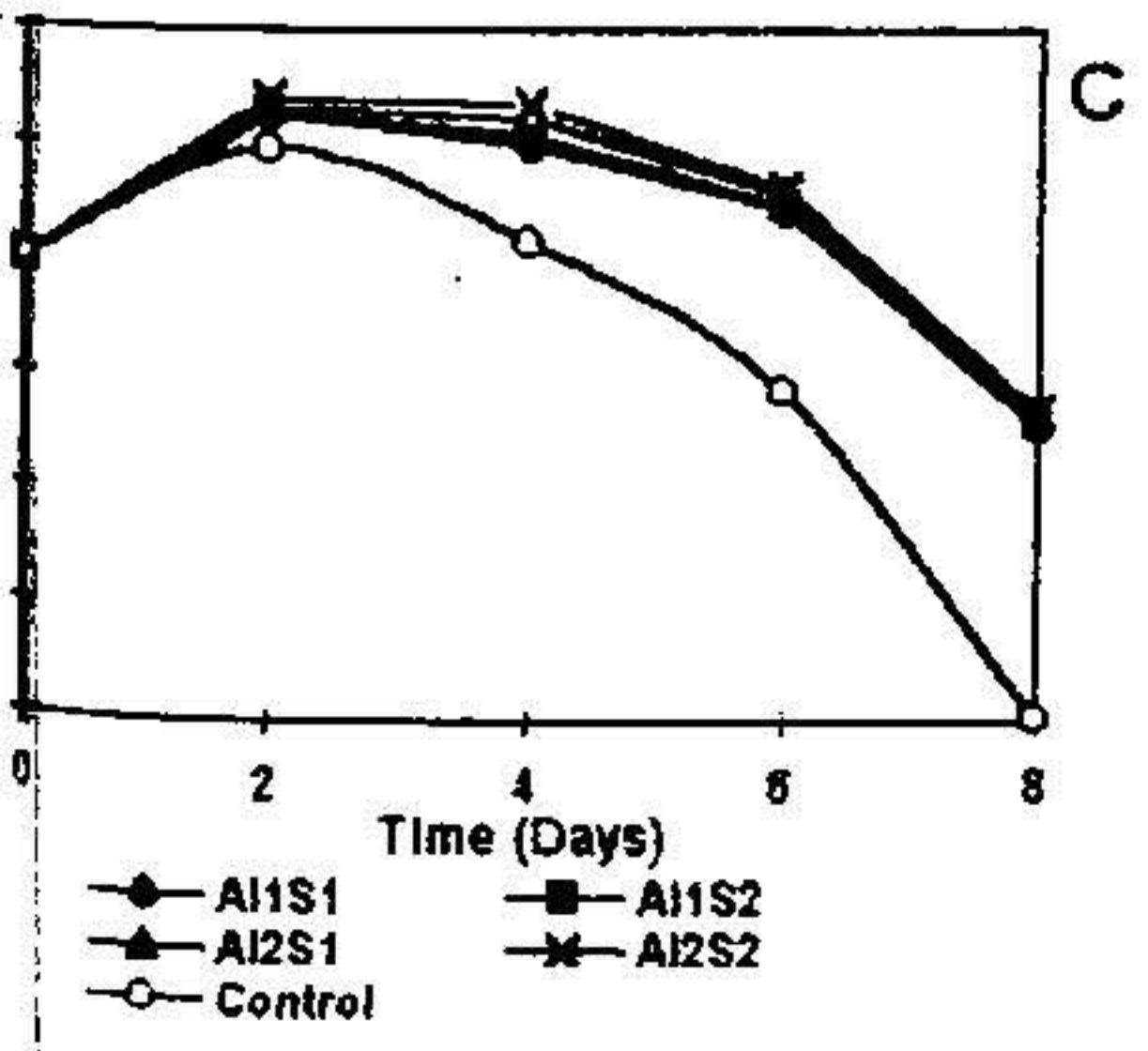
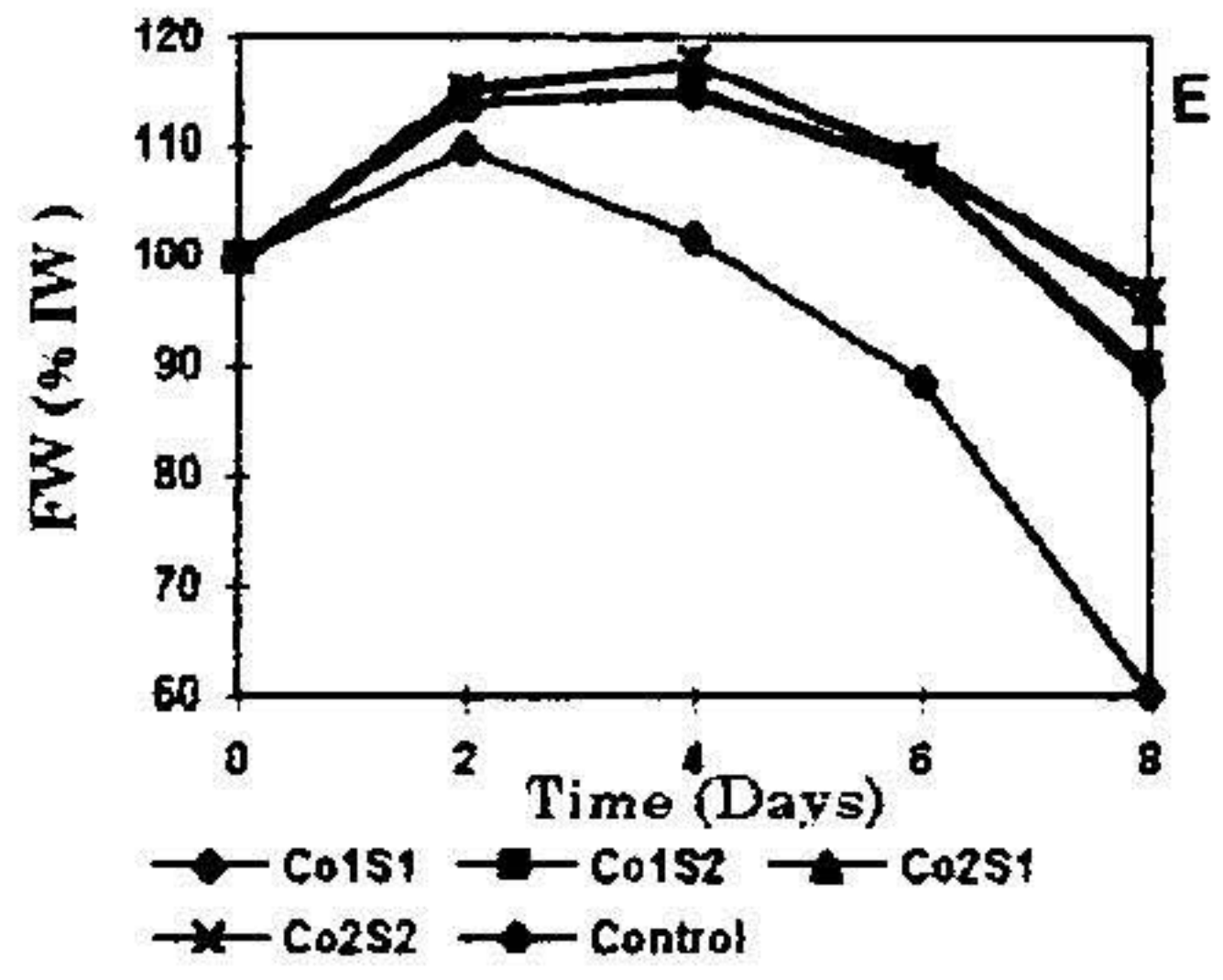
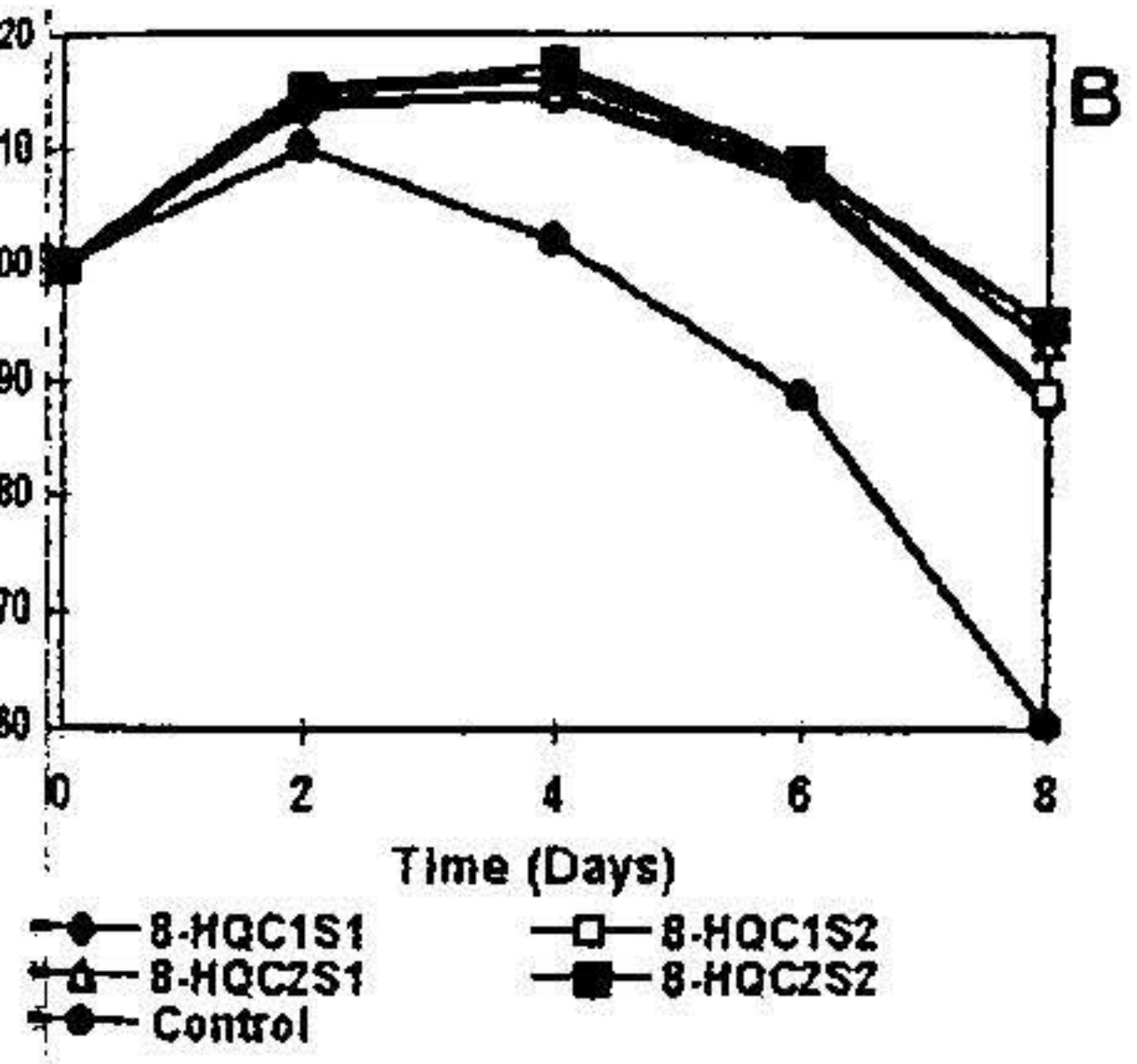
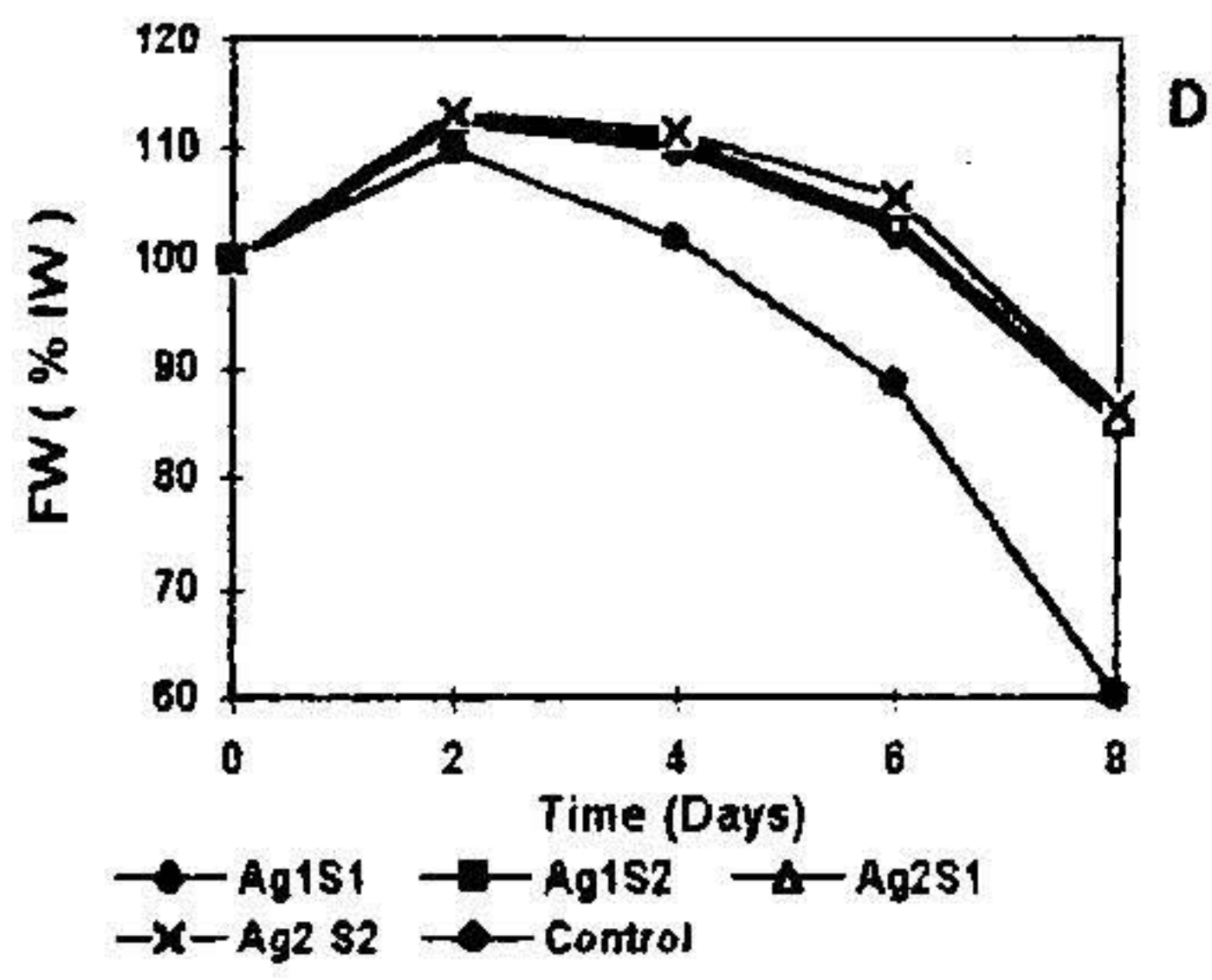
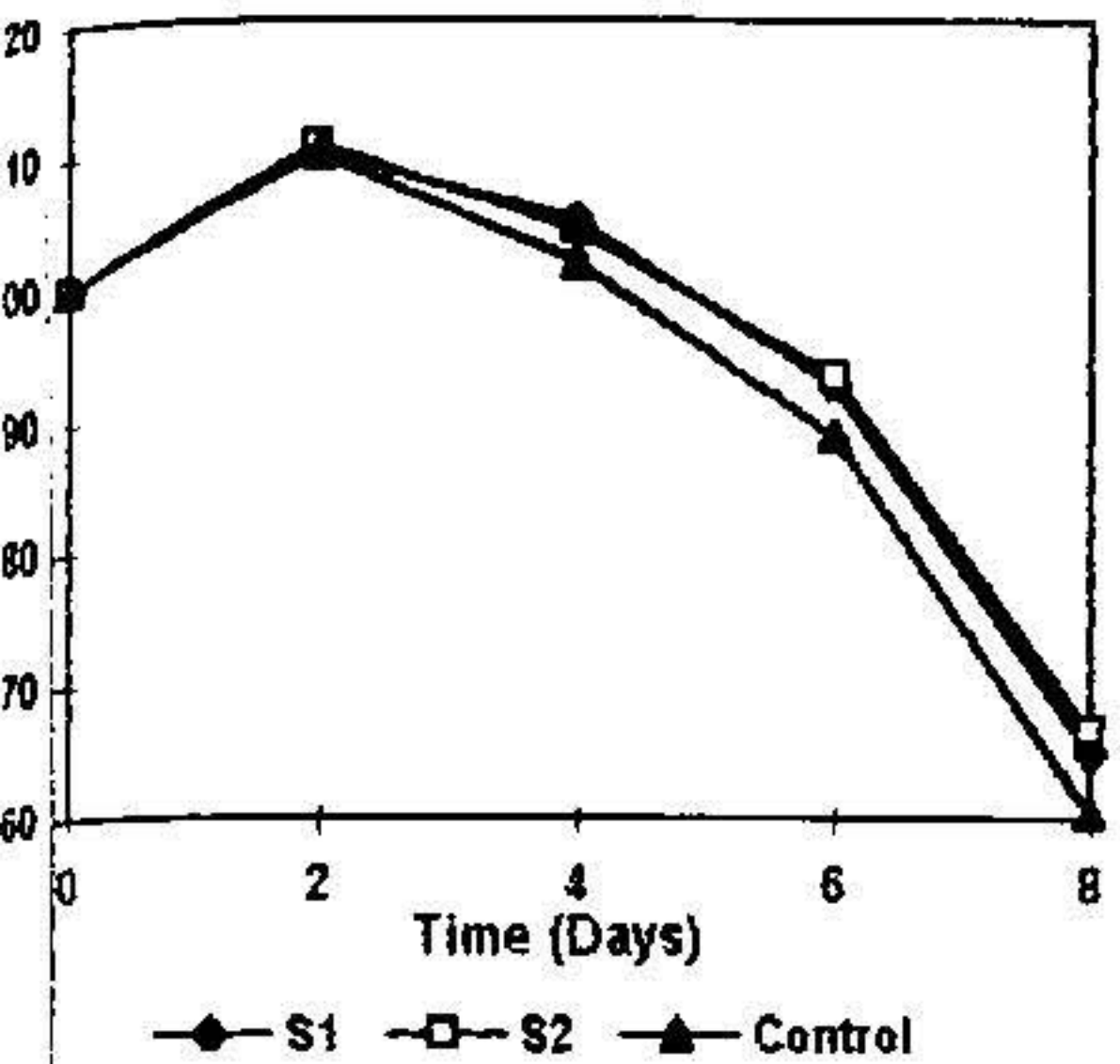
then decreased slowly up to 6 days, although it has retained a higher fresh weight than its initial weight. Afterwards, the fresh weight declined rapidly reaching a value much lower than its initial weight by 6 to 10th day.

In cv. 'Gladiator', there were no significant differences between various chemical treatments on the fresh weight of the flower. However, the fresh weight was significantly affected over control (Fig. 2) as in the case of 'Super Star'. On any given day, the fresh weight of cut flower placed in preservative solutions (T_1 to T_{18}) was higher than the one placed in distilled water (T_{19}). In general, the fresh weight of flowers showed different behaviour in different treatments. In T_3 to T_6 and T_{15} to T_{18} the fresh weight increased during the first 4 days and in the remaining treatments (T_1 , T_2 and T_7 to T_{14}) the fresh weight increased only during the first 2 days. In control (T_{19}) the gain in fresh weight was marginal and was confined to the first 2 days only.

Among the various treatments, T_{18} recorded significantly higher fresh weight upto 4 days (118.02 %) followed by T_{17} (117.60 %) and T_6 (117.21 %) and later the fresh weight declined gradually. Even though they maintained higher fresh weight than the initial on day 6, it declined below its initial weight of flower on day 8. A similar trend was observed in case of T_5 , T_{16} , T_{15} , T_4 and T_3 while in the rest of the treatments T_1 , T_2 and T_7 to T_{14} the fresh weight increased significantly for the first 2 days and thereafter it declined gradually, but the fresh weight was retained only upto 6 days. However, by 8th day the fresh weight decreased below its initial weight whereas, in control (T_{19}) the fresh weight increased during the first 2 days and then decreased slowly upto 4th day. Although it has retained a higher fresh weight upto 4 days the fresh weight declined rapidly thereafter.

Sr. No.	Treatment	Fresh weight (% of I.W.) per flower *								
		Days of display			Days of display			Days of display		
		0	2	Test	4	Test	6	Test	8	Test
1	S ₁	100	110.20	ab	104.13	b	92.52	b	65.17	b
2	S ₂	100	110.63	abc	104.83	b	93.23	b	66.75	b
3	8-HQC ₁ S ₁	100	113.52	defg	114.47	fg	106.88	defg	88.05	c
4	8-HQC ₁ S ₂	100	113.77	defg	114.66	fg	107.97	efg	88.54	cd
5	8-HQC ₂ S ₁	100	114.57	defg	116.01	ghij	108.66	efg	93.11	de
6	8-HQC ₂ S ₂	100	115.05	fg	117.21	hij	108.77	fg	94.85	c
7	Al ₁ S ₁	100	112.56	cde	110.18	cd	104.57	cde	85.76	c
8	Al ₁ S ₂	100	112.82	cdef	110.83	cd	104.66	cdef	85.90	c
9	Al ₂ S ₁	100	113.45	defg	112.43	def	105.86	cdegf	86.58	c
10	Al ₂ S ₂	100	114.10	defg	113.67	efg	106.25	cdefg	86.94	c
11	Ag ₁ S ₁	100	112.28	bcd	109.77	c	102.46	c	85.08	c
12	Ag ₁ S ₂	100	112.53	cde	110.38	cd	102.92	cd	85.33	c
13	Ag ₂ S ₁	100	112.78	cdef	110.83	cd	103.44	cd	85.41	c
14	Ag ₂ S ₂	100	113.33	defg	111.55	cde	105.73	cdefgh	86.30	c
15	Co ₁ S ₁	100	113.73	defg	114.91	gh	108.03	efg	88.66	cd
16	Co ₁ S ₂	100	113.91	defg	115.31	ghi	108.30	efg	89.98	cd
17	Co ₂ S ₁	100	114.86	efg	117.60	ij	108.89	g	95.52	e
18	Co ₂ S ₂	100	115.34	g	118.02	j	109.04	g	96.75	e
19	Control	100	109.92	a	101.81	a	88.71	a	60.34	a
SEm ±			0.7115		0.7570		1.2244		1.50	

* The treatment means are separated using Duncon's new multiple range test at 5% level.



Effect of various preservative chemical substances on fresh weight (% of I.W.) of cut rose cv. 'Gladiator'.

From the above, it can be seen that, in general, all the treatments maintained a higher fresh weight throughout the post harvest life the cut flower as compared to the control.

4.6 Effect on water uptake by cut flower :-

The data pertaining to the influence of various treatments on the total water uptake by cut flower are presented in Table 4.7. The data very clearly indicated that the various preservatives had significantly enhanced the water uptake in both the varieties of rose. All the eighteen treatments were more effective in cut flower Super Star as compared to Gladiator.

In case of cv. 'Super Star', T₁₈ had recorded maximum uptake of water (63.54 ml) as compared to other treatments and this was significantly superior over all the other treatments. In the remaining treatments, the water uptake by the cut flower was maximum in T₁₇ (61.46 ml) closely followed by T₆ (61.17 ml), T₅ (60.96 ml), T₁₆ (60.33 ml), T₅ (59.76 ml) and T₄ (59.60 ml) which are statistically at par with each other. The remaining treatments also maintained significantly higher water uptake as compared to control (45.05 ml). The water uptake in T₂ was significantly lower than that in T₁ which indicates that lower concentration of sucrose is more preferable. However, both the treatments maintained significantly higher water uptake as compared to control.

In cv. 'Gladiator', T₁₈ significantly enhanced the uptake of water (58.26 ml) as compared to all the other treatments. Treatment T₁₇ with 56.31 ml water uptake, eventhough significantly less than T₁₈, was at the same time showed significant superiority over all the other treatments. Other effective treatments include T₆ (56.02 ml), T₅ (55.33ml) and T₁₆ (54.83 ml) which are statistically at par with each other. The remaining treatments also maintained significantly higher water uptake as compared to T₁₉ or control (43.16 ml).

Table 4.7. Effect of various preservative chemical substances on water uptake of cut roses cv. 'SuperStar' and 'Gladiator'.

Sr. No.	Treatment	Total water uptake per flower (ml) *			
		Super Star ¹ (V ₁)	Test	Gladiator ² (V ₂)	Test
1	S ₁	49.85	c	47.29	bc
2	S ₂	47.67	b	46.94	b
3	8-HQC ₁ S ₁	59.21	hij	53.25	g
4	8-HQC ₁ S ₂	59.60	ijk	53.98	gh
5	8-HQC ₂ S ₁	60.96	jk	55.33	hij
6	8-HQC ₂ S ₂	61.17	jk	56.02	ij
7	Al ₁ S ₁	54.18	d	48.35	bcd
8	Al ₁ S ₂	55.66	def	49.26	def
9	Al ₂ S ₁	57.32	fgh	49.98	def
10	Al ₂ S ₂	58.68	ghi	50.77	f
11	Ag ₁ S ₁	54.26	d	48.15	bcd
12	Ag ₁ S ₂	54.98	de	48.75	bcde
13	Ag ₂ S ₁	56.81	efg	48.92	cdef
14	Ag ₂ S ₂	58.34	ghi	50.58	ef
15	Co ₁ S ₁	59.76	ijk	54.33	ghi
16	Co ₁ S ₂	60.33	ijk	54.83	ghij
17	Co ₂ S ₁	61.46	k	56.31	j
18	Co ₂ S ₂	63.54	l	58.27	k
19	Control	45.05	a	43.16	a
SEm ±		0.6671		0.6133	

* The treatment means are separated using Duncon's new multiple range test at 5% level.

1 Water uptake for 10 days

2 Water uptake for 8 days

4.7 Effect on vase life :-

The data pertaining to the influence of various treatments on extending the vase life of cut roses are presented in Table 4.8. All the chemical treatments, significantly helped in prolonging the period of post harvest life in both the cultivars of cut roses.

In cv. 'Super Star', T₁₈ gave the maximum vase life (9.51 days) followed by T₁₇ (9.23 days). The remaining treatments were also found to increase the longevity of flower. Treatment T₆ (9.00 days) was followed by T₅ (8.88 days) which were statistically at par with each other but they were significantly superior to the rest of the treatments. T₅ was at par with T₁₆ and T₁₅. The rest of the treatments significantly improved the vase life as compared to control (6.28 days).

In cv. 'Gladiator' also T₁₈ was found to be the best treatment with a vase life of 7.66 days followed by T₁₇ (7.28 days). These two treatments showed significantly better results as compared to other treatments. This was followed by T₆ (7.15 days), T₅ (7.06 days) which were statistically at par with each other but they were significantly superior to the rest of the treatments. The rest of the treatments also played significant role in influencing greater vase life as compared to those held in control (T₁₉) which recorded a vase life of 4.92 days only.

Table 4.8. Effect of various preservative chemical substances on vase life of cut roses cvs. 'Super Star' and 'Gladiator'.

Sr. No.	Treatment	Vase life (days) *			
		Super Star (V ₁)	Test	Gladiator (V ₂)	Test
1	S ₁	7.02	b	5.38	b
2	S ₂	7.11	b	5.45	b
3	8-HQC ₁ S ₁	8.51	h	6.78	f
4	8-HQC ₁ S ₂	8.60	h	6.84	f
5	8-HQC ₂ S ₁	8.88	ij	7.06	g
6	8-HQC ₂ S ₂	9.00	j	7.15	g
7	Al ₁ S ₁	7.90	f	6.36	d
8	Al ₁ S ₂	7.98	f	6.43	d
9	Al ₂ S ₁	8.15	g	6.60	e
10	Al ₂ S ₂	8.26	g	6.65	e
11	Ag ₁ S ₁	7.52	cd	6.10	c
12	Ag ₁ S ₂	7.59	cd	6.18	c
13	Ag ₂ S ₁	7.68	de	6.33	d
14	Ag ₂ S ₂	7.76	e	6.40	d
15	Co ₁ S ₁	8.76	i	6.80	f
16	Co ₁ S ₂	8.83	i	6.86	f
17	Co ₂ S ₁	9.23	k	7.28	h
18	Co ₂ S ₂	9.51	l	7.66	i
19	Control	6.28	a	4.92	a
SEm ±		0.0482		0.0400	

* The treatment means are separated using Duncon's new multiple range test at 5% level.

DISCUSSION

V. DISCUSSION

An extended vase life and keeping quality of cut flower depend on its water relations and in retarding the rate of senescence which can be achieved by using certain chemicals. With this idea in view, sucrose alone and in combination with different preservative chemicals were tried and the results obtained are discussed in this chapter.

5.1 Effect on opened petals :-

It can be seen from the Table 4.1 that significantly higher percentage of the opened petals per flower was observed in the flowers kept in chemical solutions than control. Further, from the table, it is evident that in case of Super Star, petals opened completely (100.0%) where sucrose (2 and 3 per cent) was used in combination with four different preservative chemicals, namely 8-hydroxy quinoline citrate (150 and 200 ppm); aluminium sulphate (25 and 50 ppm); silver nitrate (15 and 25 ppm) and cobalt nitrate (180 and 270 ppm). In case of Gladiator; cobalt nitrate 270 ppm + sucrose 3 per cent and 8-hydroxy quinoline citrate 200 ppm + sucrose 3 per cent showed significantly higher percentage of opened petals per flower (85.33%). The remaining treatment combinations of chemicals and sucrose also showed higher percentage of opened petals per flower than the control. Ferreira and De Swardt (1980) also reported complete opening of cut rose petals in different concentrations of 8-HQS and AgNO_3 alone and in combination with sucrose and alongwith other chemicals. Goszczynska and Reid (1985) and Goszczynska *et al.*, (1989) also reported that when tight buds of cut roses were treated with various concentrations of 8-HQC, in combination with sucrose, the petals were completely opened.

Aluminium sulphate also proved to be effective in showing greater percentage of bloomed flowers in cut roses by Gowda and Langans, (1988); in tuberose by Mukhopadhyay (1980) and Gowda, (1990) and in gladiolus by Rameswar (1974). Besemer and Hasek, (1973) and Accati and Sulis (1980) also reported that aluminium sulphate and sucrose combinations were best for normal opening of the even most tightly closed buds of carnations. Kesta and Boonrote, (1990) found that the bud opening of dendrobium flowers was increased by glucose or sucrose, 8-HQS and AgNO_3 treatments, whereas in cut gladiolus, S.T.S. (0.2 mM) CoSO_4 (0.5 mM) and $\text{Al}_2(\text{SO}_4)_3$ (0.5 mM) chemical combinations with sucrose (4 per cent) were reported to be better for opening of florets over control by Murali, (1990) and Murali and Reddy (1993). Similar results were observed in marigold and chrysanthemum by Chandra *et al.*, (1981). They have attributed to prevention of plugging of the stems in solutions containing chemicals such as 8-HQC which are very good bactericides and fungicides (Marousky, 1969, 1971 and Rogers, 1973). Similarly, $\text{Al}_2(\text{SO}_4)_3$ acidifies the holding solutions and reduces bacterial growth (Halevy and Mayak, 1981; Gowda, 1986, 1987), whereas AgNO_3 exhibits antimicrobial and antiethylene properties (Aarts, 1957 ; Beyer, 1976; Kofranek and Paul, 1975; Mayak *et al.*, 1973; Rogers, 1973). $\text{Co}(\text{NO}_3)_2$ acts as an inhibitor of ethylene biogenesis (Lau and Yang, 1976; Paul and Good; 1985) and is toxic to microbial and fungal growth (Saradhi *et al.*, 1989).

Halevy and Mayak (1974), Bhattacharjee, (1995) and Daankupieret *et al.*, (1995) reported that addition of sucrose in the holding solution helped in the continuation of normal metabolic activity of the flower buds after harvest which resulted in the complete development and opening of the cut rose buds. Mukhopadhyay, (1993) also reported that the sucrose showed greater percentage of full bloomed flowers per spike. He stated that the increased floral development in cut

tuberose spikes due to sucrose treatment may be explained in two ways; firstly, it is a source of energy since it acts as a good respiratory substrate and secondly, increases the osmotic potential of the flower spikes thus maintaining turgidity (Acock and Nichols, 1979; Gowda, 1986; Halevy, 1976; Halevy and Mayak, 1974; Larsen and Frolich, 1969; Lukaszewska, 1986; Nichols, 1975; Rogers, 1973). Similar beneficial effects of sucrose were reported in tuberose by Pathak *et al.* (1979).

The primary function of sucrose as explained earlier is to supply a source of energy for metabolic processes, secondary function to prevent osmotic moisture stress. Further, since sugar serves as building blocks, the growth processes will continue even after the flower stalks are severed from the parent plant (Gowda, 1986). Addition of preservative chemicals has an additive effect on sugars since these chemicals help in the better maintenance of water balance in the flower tissues. Results obtained by Shobha and Gowda (1992) in China aster also supported this view point.

5.2 Effect on abscission of petals :-

Due to the influence of the preservative chemical substances, the percentage of abscised petals per flower was found to reduce drastically. From Table 4.2, it can be seen that the percentages of abscised petals were significantly much lower in both the rose cultivars, Super star and Gladiator in sucrose alone or in combination with the four different preservative chemicals, namely, 8-HQC, $Al_2(SO_4)_3$, $AgNO_3$ and $Co(NO_3)_2$ as compared to control.

According to Mayak and Dilley (1976) sucrose enhances the effect of cytokinin in delaying senescence of flowers and also reduces the effect of ethylene in promoting it, thereby increasing the vase life of cut flowers. Pathak *et al.* (1979) also found that sucrose was effective in

inducing bud growth and development, as well as in delaying abscission of the buds and flowers. Addition of sucrose in holding solutions helps in the continuation of normal metabolic activities after the flower was harvested and also inhibits the processes associated with senescence (Bhattacharjee, 1995). Inhibition of senescence due to sucrose is mainly attributed to the decrease in moisture stress or improving the water status of flower. The translocated sugar was found accumulate in the flower buds increasing their osmotic concentration, these maintaining turgidity (Acock and Nichols; Halevy, 1976; Halevy and Mayak 1994; Gowda, 1986). Halevy *et al.*, (1974) pointed out that water deficit has a direct effect on wilting of cut flowers and would accelerate the senescence if the flowers were kept under continued water stress. Further, according to Borochoy *et al.*, (1976) changes in the water status of plant organs may affect the ABA content of these organs which plays an important role in the senescence. Improved water balance, therefore, reduces the ABA levels in the organs and delays senescence. Better water uptake by cut rose flowers held in metal salts and sucrose solutions might have prevented the increase in endogenous ABA level and therefore, delayed senescence.

Metalic salts like cobalt nitrate, silver nitrate are known to be inhibitors of ethylene biogenesis and action (Aarts, 1957; Beyer, 1976; Lau and Yang, 1976) which was to retard senescence of cut rose blooms. They are also reported to be toxic to microbial and fungal growth which cause vascular blockage in cut flowers (Chandra *et al.*, 1981; Saradhi *et al.*, 1989).

Aluminium sulphate acts as an acidifier of the holding solution and has a similar antimicrobial property (Halevy and Mayak, 1981; Gowda, 1986). In addition, it lowers petal P^H and stabilizes anthocyanins (Halevy and Mayak, 1979) improving the colour of the petals. 8-HQC also

has a similar effect in presenting the vascular blockage due to bacterial and fungal growth, improving the water uptake and delaying the senescence of the cut rose flowers (Halevy and Mayak, 1981; Marousky, 1969, 1971; Rogers, 1973).

Therefore, the improved water uptake and delayed senescence observed in sucrose alone and in combination with chemicals might be responsible for the reduction of the percentage of the abscised petals over the control.

5.3 Effect on diameter of flowers :-

From Table 4.3 it can be seen that all the chemical treatments significantly influenced the diameter of the flowers over the control in both the rose cultivars. Although severed from the parent plant, the cut flower continued to grow in diameter as pointed out earlier due to growth expansion of the petals on the stored substrates so long as water relations are maintained in the cut flowers. When exogenous sugars in the form of sucrose were supplied to the vase solutions, growth of the flowers diameter could be seen to increase significantly (8.72 cm in T₁ and 8.78 cm in T₂) over the control (8.27 cm in T₁₉) in 'Super Star'. In 'Gladiator', the corresponding figures for the flower diameter were 9.68 cm in sucrose 2 per cent and 9.76 cm in sucrose 3 per cent as compared to 9.16 cm in control.

Addition of other chemicals with sucrose in the vase solution can be seen (Table 4.3) to increase the flower diameter significantly over the treatments containing only the sucrose. These chemicals are known to have bactericidal and fungicidal properties and therefore, the stem blockage due to bacterial growth is prevented and thereby maintain the water flow to the flower stem (Aarts, 1957; Chandra *et al.*, 1981; Halevy and Mayak, 1981; Johnes and Hills, 1993; Marousky, 1969, 1971;

Rogers, 1973; Saradhi *et al.*, 1989; VanDoorn and Perik, 1990). In Super Star, the treatment, T₁₈ with 270 ppm cobalt nitrate and 3 per cent sucrose showed the highest flower diameter (9.79 cm) followed by the other Co (NO₃)₂ treatments T₁₇ and T₁₆ and the 8-hydroxy quinoline citrate treatment, T₆ with 200 ppm of 8-HQC + 3 per cent sucrose which were at par with each other. As compared to the other Co(NO₃)₂ and 8-HQC treatments, the Al₂ (SO₄)₃ and AgNO₃ showed significantly lower influence on the increase of flower diameter with AgNO₃ treatment showing the least influence.

In Gladiator also, the cobalt nitrate treatment, T₁₈ with Co(NO₃)₂ 270 ppm + sucrose 3 per cent showed the maximum effect on the flower diameter (11.57 cm) as compared to other treatments. This was closely followed by T₁₇ with 270 ppm Co(NO₃)₂ + 2 per cent and T₆ with 200 ppm 8-HQC+3 per cent sucrose which were statistically at par with each other.

In contrast to Super Star, the Gladiator showed a higher response to Al₂ (SO₄)₃ and with higher concentration of sucrose as compared the AgNO₃ treatments.

From the above discussion it can be seen that in both cultivars of rose the cobalt nitrate treatment with 270 ppm Co(NO₃)₂ + sucrose 3 per cent had the maximum effect in increasing the diameter of the flowers followed by the 8-HQC treatments. The Al₂ (SO₄)₃ and AgNO₃ treatments showed significantly lower influence as compared to the Co(NO₃)₂ + or 8-HQC treatments.

Few investigators have studied the influence of Co(NO₃)₂ in increasing the diameter of cut flowers. However, many workers reported that 8-HQC in combination with sucrose had beneficial effect in increasing the flower diameter. Goszczynska *et al.*, (1989) found in cut roses cv.

Sonia, 8-HQC of 200ppm+ sucrose 2 per cent had maximum effect in increasing diameter as compared to 8-HQC + S + $\text{Ca}(\text{NO}_3)_2$. Bhattacharjee (1993) investigated the influence of 8-HQC, $\text{Al}_2(\text{SO}_4)_3$, AgNO_3 and sucrose in various combinations and found that 8-HQC of 250 ppm concentration had maximum influence on the flower diameter as well as the quality parameters in cut rose cv., 'Priyadharshini'. Michalczuk *et al.*, (1989) also reported that 200 ppm of 8-HQC + 2 per cent sucrose had maximum effect on the flower diameter in cut 'Sonia' roses. Bhattacharjee (1994) studied a number of rose varieties including 'Super star' and found that 300 ppm of 8-HQC + 1% sucrose showed maximum effect on the flower diameter, whereas, Murali and Reddy (1993) found that 0.5mM concentration of CoSO_4 had more influence than 0.5 mM concentration of $\text{Al}_2(\text{SO}_4)_3$ in increasing diameter of cut gladiolus flower.

5.4 Effect on petal area of flower :-

From the results presented in section 4.4, it is clear that all the chemical treatments had significantly increased the petal area of the flower over control in both varieties of roses, Super Star and Gladiator.

In cut flowers, the petal area continued to grow due to cellular expansion initially on the stored substrates with the petals and cut stems, if the water balance or turgidity could be maintained against transpirational loss. External supply of sugars in vase solutions is known to provide^e the necessary respiratory as well as osmotic substances when only sugar was added to the vase solution. The growth of the petal area in Super Star could be seen to increase significantly (16.60 cm² in T₁ and 16.67 cm² in T₂) over the control (16.10 cm²). In Gladiator also the petal area increased in T₁ (17.73 cm² in T₁) and T₂ (17.82 cm²) as compared to the control (16,83 cm²).

The other preservative chemicals added to the vase solution also helped to increase the petal area of the flowers significantly over the treatments containing only the sucrose. In Super Star, the treatment T₁₈ with 270 ppm cobalt nitrate + 3 per cent sucrose showed the highest petal area (18.32 cm²). The 8-HQC treatments, showed higher influence as compared to the Al₂(SO₄)₃ and AgNO₃ treatments, with the AgNO₃ treatments showing the least effect. In Gladiator also the Co (NO₃)₂ treatment T₁₈ 270 ppm gave maximum effect on the petal area as compared to the rest of the treatments. 8-HQC treatments with different concentrations of sucrose followed closely. Bhattacharjee (1994) observed that in a mixture of 300 ppm 8-HQC +1% sucrose, the petal area of 'Priyadarshini' and 'Super Star', varieties of cut roses increased significantly over the distilled water control. In another study, Bhattacharjee (1993) compared the influence of various chemical solutions on the petal area of cut roses cv. 'Priyadarshini' and found that 8-HQC 250 ppm had maximum influence in comparison to Al₂ (SO₄)₃ 50 ppm and AgNO₃ 25 ppm solutions. Goszczynska and Reid (1985) also found that 8-HQC + sucrose combination had the most beneficial affect in increasing the petal area of the cut roses cv. 'Sonia'.

5.5 Effect on fresh weight of flower :-

The fresh weight of the cut flowers was determined at two days intervals in each of the treatment solutions and was expressed as the per cent of initial fresh weight of the flowers. The results obtained are given in Table 4.5 and 4.6 for Super Star and Gladiator respectively. They are also shown graphically in Fig.1 for Super Star and Fig.2 for Gladiator. It can also be seen from these tables that in all the treatments the cut flowers maintained higher fresh weight as compared to the distilled water control. In general, in both the cultivars, the fresh weight increased initially upto 2 to 4 days and thereafter, the fresh weight declined gradually. The fresh weight could be maintained upto 6 to 8 days in case

gradually. The fresh weight could be maintained upto 6 to 8 days in case of Super Star and 4-6 days in case of Gladiator depending upon the chemical treatments used.

As compared to sucrose alone the cobalt nitrate + sucrose and the 8-hydroxy quinoline citrate + sucrose treatments showed a higher gain in the fresh weight of cut flowers, 'Super star' as well as 'Gladiator'. Both these treatments also retained the fresh weight for longer duration as compared to $Al_2(SO_4)_3$ and $AgNO_3$ treatments.

The longevity of cut flower is related to the maintainance of fresh weight which is dependent on the rate of reduction of fresh weight. Sucrose is known to help in increasing the levels of moisture retention in cut flowers thus increasing their fresh weight as a consequence of improved water balance. Sucrose also reduces the transpiration loss due to increased osmotic potential of the cytoplasm. Further, it is also known to act as an oxidisable respiratory substrate and as an anti desiccant, the result of which is to increase the fresh weight of the cut flowers. (Marousky, 1969)

It is observed that the influence of sucrose in the present study confirms the results of other researchers who reported that sucrose had a beneficial effect in the gain of fresh weight of cut flowers (Aarts, 1957; Marousky, 1969, 1971; Nagarajaiah et al., 1989).

The beneficial effect of 8-HQC and metallic salts such as $Co(NO_3)_2$, $Al_2(SO_4)_3$, $AgNO_3$ etc was thought to be mainly due to their antimicrobial properties in reducing xylem blockage and maintenance of water flow to the cut flowers (Aarts, 1957; Chandra et al., 1981; Halevy and Mayak, 1981; Johnes and Hills, 1993; Marousky, 1969, 1971; Mohanthy et al., 1993; Rogers, 1973; Saradhi et al., 1989; Van Doorn and Perik, 1990; Venkatarayappa et al., 1980, 1981). As a consequence of the

improved water balance, the cut flowers are believed to maintain their fresh weight for longer duration. The present investigation clearly support their view point. In addition, the $\text{Co}(\text{NO}_3)_2$, is known to reduce transpirational loss of water and increase the fresh weight by partially closing the stomates (Marousky, 1969). Similar effects of 8-HQC on roses have been reported by Marousky, (1969). Ferreira and De Swardt (1980) reported that in case of cut 'Sonia', 8-HQS was more effective than AgNO_3 in the gain of fresh weight. Beneficial effects of 8-HQC in increasing the fresh weight of different varieties of cut roses were also reported by Goszczynska *et al.*, (1989); Johnes and Hills (1993).

The present investigation have shown that the cobalt nitrate as well as 8-hydroxy quinoline citrate are more effective in increasing the fresh weight of the cut flowers as compared to other chemical treatments, as was observed by Ferreira and Swardt (1980) in 'Sonia' variety of cut rose.

5.6 Effect on water uptake :-

The data on the total water uptake in different treatment solutions at the end of 10 days in case of 'Super Star' and 8 days in case of 'Gladiator' is presented in Table 4.7. It can be seen from this table that maximum solution uptake occurred in cobalt nitrate treatment with 270 ppm + sucrose 3 per cent in both Super Star and Gladiator. The other cobalt nitrate treatments fared better in the total water uptake than the 8-HQC + sucrose treatments all at par with each other. Both the $\text{Al}_2(\text{SO}_4)_3$ and AgNO_3 treatments should more or less the same response in either of the cultivars.

The water uptake also increased significantly in sucrose treated cut flowers as compared to the distilled water control in both varieties of

the cut flowers studied. With the increase in the sucrose concentration, the water uptake was observed to decrease in both cases.

Water uptake in cut flowers takes place mainly because of the need to maintain the water balance in the cut flower against transpiration loss of water. The addition of sucrose to the vase solution decreases the water potential in the tissues thereby improving the water uptake by the cut stem (Kofranek and Halevy, 1976). It was also shown that sucrose limits transpiration by stomatal closure (Aarts, 1957). Sucrose at higher concentration can be seen to decrease the water uptake in both varieties of cut roses as was observed by Venkatarayappa *et al.*, (1981).

Increase in water uptake due to various chemicals in the vase solutions was mainly attributed to reduction in the vascular blockage of the stem by preventing bacterial and fungal growth (Aarts, 1957; Gowda, 1986, 1987; Halevy and Mayak, 1981; Johnes and Hills, 1993; Kofranek and Paul, 1975; Marousky, 1969, 1971; Mohanthy *et al.*, 1993; Murr *et al.*, 1979; Nagarajaiah *et al.*, 1989; Reddy, 1988; VanDoorn and Parek, 1990; Venkatarayappa, 1980,1981). In this, metal salts and sucrose appeared to have opposite effect on water uptake and water loss, while sucrose at high concentrations reduced water uptake and water loss while the metal salts are known increase both. (Halvey, 1976; Nagarajaiah *et al.*, 1989; Venkatarayappa, 1983).

5.7 Effect on vase life :

From the data presented in Table 4.8 it can be clearly seen that all the chemical treatments had significantly enhanced the vase life of the cut flowers over the distilled water control.

In 'Super Star', the maximum vase life of 9.51 days was obtained with cobalt nitrate 270 ppm + sucrose 3 per cent combination

closely, followed by cobalt nitrate 270 ppm + sucrose 2 per cent (9.23 days) combination. The 8-hydroxy quinoline citrate treatment, T₆ gave 9.00 days of vase life followed by T₅ with 8-HQC 200ppm + sucrose 2 per cent which gave 8.88 days as compared to 6.28 days in the distilled water control. Similarly, in case of 'Gladiator', the cobalt nitrate treatment T₁₈ gave 7.66 days of vase life, while T₁₇ gave 7.28 days. Both these cobalt nitrate treatments showed significantly better results as compared to all other chemical treatments. The 8-HQC treatment, T₆ gave 7.15 days and T₅, 7.06 days as compared to 4.92 days of vase life obtained in control.

The end of useful vase life of cut flowers was either marked by the appearance of bent-neck symptoms or wilting of the outer petals or blueing of petals. Bent-neck symptoms occur under conditions of water stress (Burdett, 1970) when maturation and lignification of peduncle is incomplete (Murr *et al.*, 1979). In some rose cultivars, secondary thickening of vascular system is found to occur after normal harvest stage and therefore, the cell turgor contributes to the erectness of peduncle during bloom opening. Thus a water deficit in a cut flower induced either by the excess of leaf transpiration or reduction of water uptake or transport through stem blockage is known to result in bent-neck. Marousky, (1969,1971) found that incorporation of 8-HQC into opening solutions improved the water balance with in cut roses by reducing water loss and increasing water uptake. However, in none of the chemical treatments bent-neck symptoms were noticed even at the end of the vase life in either of the cultivars. Murr *et al.*, (1979) found that the addition of cobalt nitrate in the opening solution not only inhibited ethylene synthesis and action which accelerate the senescence of the blooms but also counteract neck-bending by preventing stem blockage and improving water uptake. Thus extending vase life.

The present results have shown that $\text{Co}(\text{NO}_3)_2$ treatments were more effective in extending the vase life as compared to the 8-HQC treatments. Venkatrayappa *et al.*, (1981) pointed out the synergistic effect of Co^{+2} ion and sugar in improving the water balance of the cut flowers and thus extending their vase life. Nagarjaiah *et al.* (1989) also found that inclusion of CoSO_4 in the vase solution increased the water uptake and reduce the transpirational loss of water by the cut roses as a result of which higher balance of water was maintained for longer time, prolonging the vase life. Reddy, (1988) observed that the higher concentrations of cobalt upto 1.5 mM were more effective in increasing the life of cut roses cv. 'Samantha'.

Blueing of the petals of red roses is attributed to the accumulation of ammonia due to proteolytic break down of protein caused by the gradual decline of readily respirable substrates, mainly sugars. Scholes, (1963) was the first to elucidate the need for sugars to maintain the red colour of rose petals. Exogenous supply of sucrose or glucose was shown to reduce the change in the petal colour by Kofranek and Halevy (1976). The present results also showed that the addition of sucrose to vase solutions had greatly improved the vase life over the double distilled water control.

The influence of sucrose observed in the present study confirms the results obtained by other research workers who reported that sucrose reduced moisture stress in cut flowers by decreasing transpiration loss due to partial closure of leaf stomata coupled with the moisture retention in petal (Aarts, 1957; Marousky, 1969; 1971).

As pointed out earlier, metallic salts, because of their anti-microbial properties, reduce the stem blockage and maintain water uptake reducing water stress in the petal cells, prolonging the vase life of

cut flowers. In additions to cobalt, other chemicals like 8-HQC (Goszczyńska *et al.*, 1989; Johnes and Hills, 1993; Marousky, 1969; 1971;), $\text{Al}_2(\text{SO}_4)_3$ (Barman *et al.*, 1996; Gowda and Langans, 1988; Mohanthy, *et al.*, 1993; Mukhopadhyay, 1980, 1990; Rameswar, 1974; Rath *et al.*, 1991), AgNO_3 (Kesta and Boonrote, 1990; Mohanthy *et al.*, 1993; Rath *et al.*, 1991; Reddy and Nagarajaiah, 1988) were also reported to increase the vase life of cut flowers. Bhattacharjee (1993) reported that a combination of 8-HQC, $\text{Al}_2(\text{SO}_4)_3$, AgNO_3 , citric acid along with sucrose was more effective in increasing the longevity of cut roses cv., 'Priyadarshini' as compared to the individual chemicals. Among 8-HQC, $\text{Al}_2(\text{SO}_4)_3$, AgNO_3 solutions 8-HQC was found to be more effective in prolonging the vase life. Patil and Singh (1995) also observed that 8-HQC + sucrose combination gave higher vase life as compared to $\text{Al}_2(\text{SO}_4)_3$, + sucrose combination in cv. 'Gladiator' roses. The present investigation support their earlier observation.

From the above discussion it can be concluded that the addition of chemicals such as, 8-HQC, $\text{Al}_2(\text{SO}_4)_3$, AgNO_3 and $\text{Co}(\text{NO}_3)_2$ in combination with sucrose in vase solution are effective in the various quality improving parameters, including fresh weight as well as the vase life of the cut rose varieties studied. Among all the chemicals, cobalt nitrate and 8-hydroxy quinoline citrate appeared to be very promising in extending the post harvest life of the rose cultivars Super Star and Gladiator.

**SUMMARY
AND
CONCLUSION**

VI . SUMMARY AND CONCLUSION

Rose (*Rosa hybrida* L.) is one of the most important commercial flower crops in India and is grown on a large scale in the states of Rajasthan, Maharashtra, Karnataka, Utter Pradesh and West Bengal. In Gujarat, the commercial cultivation of rose is confined to Ahmedabad, Vadodara, Anand, Surat, Navsari and Valsad. There is a great demand for cut roses ⁱⁿ European markets especially during the winter months. India with its diverse agro-climatic conditions is ideally suited for commercial production of roses for both export and to meet the internal demand. Farmers often face problems of storage and preservation of cut roses due to their shorter vase life and poor keeping quality. Looking to these problems, an investigation was taken up to study the means of extending the vase life and to improve keeping quality of two important commercial varieties cut roses cv. 'Super Star' and 'Gladiator' grown widely in Western India.

The present investigation was carried out to study the influence of sucrose alone and in combination with various chemical preservatives in extending the vase life and improving the keeping quality of cut roses cvs. 'Super Star' and 'Gladiator' at the P.G. Research Laboratory, Department of Horticulture, N.M. College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari; during the winter season of the year 1995-96. The chemical combinations used in the present study were sucrose alone at 2 per cent and 3 per cent concentrations and the preservative chemicals. 8-hydroxy quinoline citrate 150 and 200 ppm; aluminium sulphate 25 and 50 ppm; silver nitrate 15 and 25 ppm and cobalt nitrate 180 and 270 ppm concentrations alongwith sucrose at 2 per cent and 3 per cent

concentrations. The experiment was laid out in a completely randomized design (C.R.D.) with nineteen treatments each with three replications.

Experimental observations on some of the important attributes related to the vase life and the keeping quality of the cut roses such as the percentage of opened petals, percentage of abscised petal, flower diameter, area of the outer five petals, fresh weight, total water uptake and useful vase life were recorded and the results were subjected to statistical analysis for their significance.

The present studies have shown that all the chemical combinations, in general, increased the percentage of opened petals, reduced abscission of petals, improved petal area, flower diameter, fresh weight, water uptake and vase life in both cultivars of roses studied. The cobalt nitrate treatment with 270 ppm $\text{Co}(\text{NO}_3)_2$ + sucrose 3% showed maximum influence on all the quality parameters including the fresh weight and water uptake as well as in extending the vase life. It was observed that the vase life with this treatment could be extended up to 9.51 days in Super Star and 7.66 days in Gladiator. The next best chemical preservative which showed a substantial improvement in quality and in extending the vase life was 8-hydroxy quinoline citrate, which with 200 ppm of 8-HQC + sucrose 3 per cent, gave a vase life of 9.00 days in case of Super Star and 7.15 days in case of Gladiator. With aluminium sulphate 50 ppm + sucrose 3 per cent, a vase life 8.25 days and 6.65 days could be achieved in Super star and Gladiator respectively. Using silver nitrate 25 ppm + sucrose 3 per cent, a vase life of 7.76 days and 6.40 days could be obtained in the above rose varieties. In comparison, the sucrose 3 per cent treatment gave 7.11 days for Super Star and 5.45 days for Gladiator, while the distilled water control gave 6.28 and 4.92 days respectively.

The fresh weight and the water uptake could be maintained for longer duration thus improving the vase life when cobalt nitrate and 8-hydroxy quinoline citrate treatments were tried. The aluminium sulphate and silver nitrate solution combinations fared better than the sucrose alone or the distilled water control but their influence was less as compared to the above chemical combinations. The quality parameters such as percentage of opened petals, percentage of abscised petals, flower diameter and petal area also showed a similar trend in various chemical combinations of sucrose. Cobalt nitrate showed maximum influence as compared to the 8-hydroxy quinoline citrate or other metallic salts like aluminium sulphate, silver nitrate.

From the present studies conducted on two rose cultivars, namely, Super Star and Gladiator, it can be concluded that holding solutions containing 270 ppm of cobalt nitrate + 2 to 3 per cent sucrose, followed by 8-hydroxy quinoline citrate 200 ppm + sucrose 3 per cent combination can be profitably employed by the crop growers for extending the vase life and for improving the keeping quality of the above cut roses.

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