STUDIES ON VASE LIFE OF GLADIOLUS CV. HAPPY END

By

VIKAS PRUTHI

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

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HISAR

1997

DEDICATED

TO MY

PARENTS

CERTIFICATE-I

This is to certify that this thesis entitled "Studies on vase life of Gladiolus cv. Happy End", submitted for the degree of M.Sc, in the subject of Horticulture to Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by Mr. Vikas Pruthi under my supervision and that no part of this thesis has been submitted for any other degree.

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

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CERTIFICATE II

This is to certify that this thesis entitled "Studies on vase life of Gladiolus cv. Happy End", submitted by Mr. Vikas Pruthi to Chaudhary Charan Singh Haryana Agricultural University, Hisar, in partial fulfillment of the requirements for the degree of M.Sc., in the subject of Horticulture has been approved by the Student's Advisory Committee.

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INTRODUCTION

From inception of civilization plants have played an influential role in building up of traditions and cultures. Since ancient days flowers are used for diverse purposes such as offering to God, making garlands, bouquets, decorations on auspicious occasions, table decoration and preparation of perfumes. Besides this, growing of ornamental plants, have prime importance in maintaining ecological balance and checking environmental pollution in the surroundings. Flowers symbolize purity, beauty, peace, love and passion, and provide excellent material for outdoor and indoor decoration and their presence brighten up the environment.

At the same time, flowers are the most perishable commodity compared to fruits and vegetables. About 45% of the world trade in floricultural products goes to cut flowers. The most important cut flowers are rose, chrysanthemum, carnation, orchid, tulip, lilium and gladiolus.

Gladiolus popularly known as 'Sword Lily' or 'Corm Flag' is an ornamental bulbous plant native to South Africa from where it has travelled long distances to other countries. It is the best suited bulbous plant in India and covers an area of 289 ha. out of 21040 ha. area under floricultural crops. It occupies prime position in floriculture industry and ranks next to tulip in European market and occupies fourth place in the international floriculture trade. It is a perennial herb with base of stem swollen into a corm and belongs to monocot family Iridaceae.

The distribution of species is very wide throughout the temperate zone of the world. Excluding the arid zone of Near and Middle East and Africa, gladiolus species are found throughout Africa, Southern Europe, Asia Minor, the Middle East, Turkey and Iran. In India, gladiolus cultivation was earlier confined to the temperate and mild climatic regions only, the main centres of its commercial cultivation being Srinagar (J&K), Simla (Himachal Pradesh), Chaubattia and Supi (U.P), Kalimpong and Dargeeling (West Bengal), Shillong & Jorhat (Assam), Pune (Maharashtra), Bangalore (Karnataka) and Ooty (T.N). With the evolution and introduction of tropical cultivars suitable for North-Indian plains and standardization of agrotechniques for their cultivation it has now become possible to grow a large number of exotic as well as Indian bred cultivars in plains. The cultivars may

be grouped as early, mid-season or late on the basis of number of days required for flowering.

Gladiolus is popular for its attractive spikes having florets of varying forms and sizes, dazzling colours, which remain fresh for 7-10 days as cut flower and are ideal for flower arrangements indoor. Gladiolus spikes are in great demand in international as well as domestic markets. In cut flower industry most important aspect is post-harvest handling in order to maintain flower freshness and original colour for a long period after cutting from the mother plant for transportation to distant markets to fetch good prices. Two sets of factors are responsible for keeping quality of cut flowers.

a) Internal mechanism that includes balance between water uptake and water loss, stem plugging, respiration rate and production of toxic substances like ethylene.

b) External factors that include environmental conditions and microbial attacks on cut ends.

During the processs of respiration, sugars stored in plant tissue get burnt and consequently the life of cut flower depend upon the potential availability of sugars at the time of harvesting and lowering rate of respiration after harvesting. Shukla & Kher (1979) suggested that the vase life of cut flowers is influenced by constant water

supply, checking of microbial growth, prevention of ethylene formation and energy source. So, several types of floral preservatives in the form of germicides, ethylene antagonists and sources of energy (sucrose) are in use to preserve the flower quality, extending postharvest longevity and for pulsing which is a short duration chemical treatment given before transportation the effect of which lasts for the entire shelf life of cut flowers.

Therefore, the present studies were undertaken keeping in view the above background with the following objective:-

1. To find the most effective chemical treatment and pulsing concentration for extending the vase life of Gladiolus Cv "Happy End".

CHAPTER - II

REVIEW OF LITERATURE

Flower is a unique organ when compared with seeds, fruits and vegetables. In most of the flowers, there are two distinct stages in physiology of flower after harvesting. The first stage is of bud growth and development of flower to full opening. The second stage is maturation, senescence and wilting. The extension of vase life of cut flowers thus involves coordination of these two processes, i.e promotion of growth in first phase and retardation of senescent processes in the second phase. During these phases, there is degradation of internal carbohydrates and loss in turgidity due to loss of water. Turgidity is the result of balance between rate of water uptake and water loss (Rogers, 1962). Therefore, any attempt to prolong the vase life of cut flowers should involve provision of an artificial energy source, water and also measures to minimize the degradation processes. The use of preservative solution for promoting quality and prolonging the vase life of cut flowers has been known for many years. Floral preservatives are composed mainly of water, sugars and germicides and sometimes include other ingredients like

acidifier. The composition of water which varies in various locations may influence the longevity of flowers as well as the efficiency of chemical solution used for holding, pulsing or bud opening (Waters, 1966; Rogers, 1973; Staby and Erwin, 1978). Deionized or distilled water increased longevity and enhanced the effect of the preservative used (Farnham *et al.*, 1971; Staby and Erwin, 1978).

Four main uses of water and chemical solutions are conditioning, holding, pulsing and bud opening. Pulsing is a short term chemical treatment given by growers, the effect of which lasts for entire shelf life of flower, even when flowers are held in water (Halevy and Mayak, 1974; Halevy, 1976). Specific pulsing formulations have been developed for different flowers and sometimes even for different cultivars (Kofranek and Halevy, 1972; Halevy and Mayak, 1974). The main ingredient of various pulsing solutions is sucrose, which is often used in concentrations that are several times higher than those used in holding solutions. The effectiveness of pulsing solutions applied prior to or after storage is correlated with a relatively high concentration of sucrose. However, the limit in sugar concentration used for various flower species or cultivars is determined by leaf damage.

The duration of treatment as well as temperature and lighting conditions during pulsing is also important for

optimum effects. These have been specified for different flowers by various workers (Kofranek and Halevy, 1972; Halevy and Mayak, 1974; Monnet and Paulin, 1975). Pulsing time is generally between 12 hours and 24 hours with temperature range of 20 to 27^{o}C. Borochov *et al.*, (1975) reported some interactions between pulsing duration, temperature and sucrose concentration. Borochov *et al.*, (1975) and Bravdo *et al.*, (1974) observed that with shorter pulsing time and higher temperatures, the optimal sugar concentration was higher. Pulsing was found to be of great value in prolonging vase life and improving the colour and size of petals in gladiolus (Kofranek and Halevy,1976; Mayak *et al*, 1974), miniature carnation (Halevy and Mayak., 1974; Borochov *et al.*, 1975), chrysanthemum (Posner *et al.*, 1980) and roses (Halevy and Mayak, 1974). If the optimum procedure (time, concentration, temperature, light) for pulsing is not used, little or no effect is found and sometimes damage even occurs. Farnham *et al.*, (1978) had found no effect of pulsing roses for 4 hours prior to shipment. Pulsing at too high temperature or with too high sucrose concentration may damage the flowers or leaves.

Several attempts have been made by various workers to study the effect of different chemicals, sugars, germicides, hormones and antibiotics for increasing the longevity of cut flowers of economic value (Halevy and Wittwer, 1965; Kelley and Sonlamp, 1964; Rameshwar, 1974; Pathak *et al.*, 1979 and

Shukla and Kher, 1979). The substances that have been evaluated include certain metals like cobalt, nickel, silver, aluminium, organic acids like citric acid and bactericides like 8-HQC, which are known to improve water balance and inhibit stem plugging and thereby leading to an increased vase life of flowers (Rogers, 1973). Hence, the literature pertaining to the effect of sugars, different metal salts (cobalt and calcium) and germicides (silver thiosulphate) on post harvest physiology of cut flowers has been reviewed.

2.1. Effect of sucrose

2.1.1 Holding solution

Sucrose is one of the very important ingredient used in preservative solution, in order to conserve the endogenous carbohydrates of the flowers. Sucrose is known to improve the water balance of flowers and has anti-desiccant property, regulates the closure of stomata thus reducing transpirational water loss (Marousky, 1969). Marousky (1969) found that roses held in sucrose containing water absorbed less water than roses held in water alone but sustained the increase in fresh weight for longer period due to partial stomatal closure and reduced transpirational water loss. Bravdo *et al.*, (1974) observed that uptake of solutions particularly with sucrose largely depend on sucrose concentration and beyond certain limit the rate of

uptake of solution decreased. The optimal concentration of sugar varies with the treatment and the flower. Generally for a given flower, the longer the exposure to the chemical solution, the lower the concentration used. Halevy (1976) concluded that the effect of sugars on improving the water balance and delaying wilting of cut flowers was attributed to its contribution to the osmotic pool.

Bruszewki (1970) observed that flower senescence during vase life was correlated with a reduction in sugar content of flower which resulted in wilting. Similar results were obtained by Nowak (1979) and Ferreira and Swardt (1980). Supplying cut flowers with exogenous sugar maintains the respirable substrate in flower (Nicholas, 1973 and Lukaszewska, 1986) and promotes respiration (Wilkins, 1965 and Coorts, 1973). Paulin (1971) and Coorts (1973) observed that application of exogenous sugars encourages protein synthesis and delays the onset of excessive protein degradation and thus extends the longevity of cut flowers.

It is known that sucrose improves water balance in cut flowers (Aarts, 1957; Bravdo *et al.*, 1974; Borochov *et al.*, 1975; Acock and Nicholas, 1979). This was attributed to the effect of sugars on closure of stomata (Morousky, 1969) and reduction in water loss, thereby increasing the fresh weight of flowers (Marousky, 1971). Acock and Nicholas (1979) suggested that ability of sugar to delay senescence of cut

carnation flower is related to its ability to support cell metabolism and to maintain membrane integrity. Halevy and Mayak (1981) reviewed the changes in membrane properties and observed that these changes are associated with loss of semi permeability leading to increased ion and water leakage and terminating in desiccation of the tissue. Factors which maintain membrane integrity also maintain cellular integrity and delay ion and water leakage causing reduction in water loss.

Sucrose in the vase solution is found to increase the vase life of gladiolus (Bravdo *et al.*, 1974, Choi and Roh, 1980; Lukaszewska, 1981). The main effect of applied sugar in extending longevity is to maintain mitochondrial structure and functions (Kaltaler and Steponkus, 1976). The supplied sugar may also reduce naturally occurring starch hydrolysis and lipid degradation in roses (Molnor and Parpus, 1977). Lukaszewska (1986) found that sucrose prevented undesirable accumulation of free amino acids in the flowers which is a symptom of flower aging. Anserwadekar and Patil (1986) reported that sucrose which maintains vase life of 11 days in gladiolus was better than GA_3 or distilled water. Sucrose 4 per cent, alone extended the vase life of gladiolus cv. Commando by 19.76 percent and also in combination with cobalt by reducing α and ß-amylase activity and restriction of lipid peroxidation (Ferreira *et al.*, 1986 and Murali, 1990). Gowda and Gowda (1990)

observed an increase of 7 days in vase life as compared to control by using 3% sucrose in gladiolus Cv. Black Jack. Similarly, Gowda and Murthy (1993) reported 2 days increase in vase life of gladiolus with 2 per cent sucrose alone and also in combination with calcium chloride. Murali and Reddy (1990) reported a significant increase in vase life of gladiolus Cv. Friendship by using 4% sucrose alone and an increase of 5 days by using it in combination with cobalt.

Sugars are found effective in inducing bud growth and development, delaying the abscission of buds and flowers and showing greater percentage of fully opened blooms (Pathak *et al.*, 1979). Lukaszewska (1981) reported improved opening of flowers and increased vase life of gladiolus cut flowers placed in 5% sucrose or glucose and an antiseptic. Mor *et al.*, (1984) reported improved bud opening in partially opened florets of Lily of Nile when treated with solutions containing 10-20 percent sucrose and a bactericide. Wang and Gu (1985) observed that a solution of 5 per cent sucrose, 500 ppm silver nitrate, 300 ppm 8-HQC and an acidifier improved flower quality by increasing the percentage of fully opened buds and maximum fresh weight retention in *Gladiolus hybridus*. Similarly, opening of cut flowers of freesia harvested at tight bud stage was prompted with sucrose solution (Woodson, 1987).

Merwe *et al.*, (1987) reported that fresh weight and volume of water uptake in gladiolus was improved by sucrose application in vase solution. Gain in fresh weight can occur only when the rate of water absorption is greater than the transpiration rate. Loss of petal turgidity and fresh weight was proved by decreased rate of water uptake in roses (Burdett, 1970). Reid (1989) concluded that with the addition of sucrose high flower weight was maintained, leading to increased vase life.

2.2.2. Pulsing

The above features of sucrose are also of great importance for pulsing. Mayak *et al.*, (1973) reported in gladiolus that high concentration upto 20 percent of sugar for 24 hours improved opening of buds, floret size and longevity of flowers. Bravdo *et al.*, (1974) noticed that sucrose pretreated flowers had achieved maximum fresh weight 2 days later than that of control. Kafranek and Halevy (1976) had also recommended sucrose treatment before shipping or storage of gladiolus, for longer display life. They reported that pulsing of gladiolus spikes with 20 percent sucrose in combination with silver nitrate before storage of 7 to 10 days resulted in greater floret opening and size than those not pulsed. Gowda (1993) observed maximum water uptake, fresh weight retention and vase life in rose Cv. Moutezuma flowers pulsed with 2 percent sucrose

for 3 hours. Bhattacharje and Mishra (1996) observed that pulsing of gladiolus spikes of Cv. White Enchantress with 20% sucrose for 16 hours significantly improved floret opening, floret diameter, water uptake and vase life and decreased the weight loss of flower.

2.2. Effect of non-toxic metal salts

2.2.1 Effect of cobalt

Cobalt ion has been shown to reduce transpiration rate, microbial growth (Mishra *et al.*, 1973) and acts as inhibitor of ethylene action (Kang and Ray, 1969). However, Lau and Yang (1976), Bevtelmann and Kende (1977) reported cobalt ion as inhibitor of ethylene biogenesis. Mishra *et al.* (1973) reported higher levels of cobalt to be toxic to fungal growth. French Marigold (*Tagetes patula* L) flowers held in cobalt solution gained greater fresh weight than the controls and there was delay in loss of fresh weight of these flowers (Chandra *et al.*, 1981). Cobalt ion is reported to improve water balance and maintains higher fresh weight (Venkatarayappa *et al.*, 1980,1981).

Piskornic (1985) suggested that Cobalt and silver forms applied with sucrose and 8-HQS prevented a decrease in water uptake by cut narcissus flowers and markedly increased their fresh weight and vase life. A solution of cobalt alone and in combination was also found effective in advancing keeping

quality and maintenance of increased fresh weight by improving water balance and osmotic potential (Khondakar and Majumdar, 1985) in tuberose; Gowda (1986) in China Aster; Acock and Nicholas (1979) in carnation. Balakrishna (1987) observed that Cobalt delayed the loss in fresh weight, increased the water uptake and improved water balance in tuberose. Reddy (1988) observed that Cobalt ion maintained higher water flow rates through the stems by inhibiting the vascular blockage leading to significantly increased water uptake by rose cut flowers. They further reported that it also partially closed the stomatas and hence reduced the water loss and water uptake ratio and maintained a higher water potential.

Cobalt treatment maintained the membrane integrity by restricting lipid peroxidation and by reducing ethylene evolution in gladiolus (Murali, 1990). A solution containing 4% sucrose and 0.5 mM cobalt extended the vase life of gladiolus cultivar "Friendship" (Murali and Reddy, 1990). Zhang *et al.*, (1995) observed an increase of 8 days in vase life and improved quality of cut gladiolus flowers by using chemical solution containing cobalt chloride.

2.22 Effect of calcium

Non-toxic metal salts like calcium have been reported to increase the vase life of gladiolus. Calcium

nitrate (0.1%) was reported to prolong the vase life of cut bulb flowers(Widmer and Struck, 1973). Calcium was also used combined with silver nitrate to extend the longevity of some flowers (Aarts, 1957; Nicholas and Kulwiec, 1967). Staden (1976) reported that calcium carbonate (10 ppm) used in tulip preservative alongwith sugar and a bactericide showed beneficial effect in extending the vase life. Calcium was used with several potassium salts in carnations to prevent stem softening and bending which were prevalent without calcium (Mayak *et al.*, 1978). Gowda and Gowda (1990) while studying the effect of calcium sulphate (0.5 and 1.0 µM) and sucrose in gladiolus Cv. Black Jack reported that calcium increased the water uptake and vase life by 3 days compared to control. Halevy (1987) also observed similar results in carnations. Gowda and Murthy (1993) observed increased water uptake, a fairly positive water balance and improved vase life of cut gladiolus spikes held in solution containing 2 percent sucrose + 0.5 µM calcium chloride.

2.3 Effect of germicides

2.3.1 Effect of silver thiosulphate (STS)

Silver nitrate and silver-acetate (10-50 ppm) are two of the most effective bactericides used in preservative formulations (Aarts, 1957). Silver nitrate, a very effective bactericide greatly extends the longevity of

several flowers namely chrysanthemum, gladiolus, gerbera, carnation, statice, china aster, bougainvillea and cattleya orchid (Halevy and Mayak, 1981). The main disadvantage of these silver salts is that they are phytooxidized to form black insoluble compounds which precipitate.

Silver nitrate is relatively immobile in stem (Kofranek and Paul, 1974) but silver ion complexed with sodium thiosulphate moves readily in the stem to the corolla (Veen and Van de Geijn, 1978). The complex was very effective in inhibiting both the action and production of ethylene (Veen, 1979). Sodium thiosulphate treatment had a spectacular effect on prolonging the vase life of ethylene sensitive flowers. It doubled the vase life of carnations without the addition of sugars; bactericides or other preservative compounds (Reid et al., 1980; Veen and Van (1978). Swart and Kamerbeek (1979) reported that 5 minutes to 24 hours vase treatment of silver thiosulphate (1 to 4 mM) was effective in carnations, lilies and some other flowers but not on tulips. Destigter (1981) reported that silver thiosulphate had no effect on roses when applied alone, but prevented the damage induced by application of ethephon. Silver thiosulphate prevented normal and ethylene induced floret shattering in Snapdragon (Farnham et al., 1981), delphinium and sweet peas (Mor *et al.*, 1980). A small benificial effect from Silver thiosulphate was shown

in anthurium (Paull and Goo, 1985) and gladiolus (Farhoomand *et al.*, 1980).

Pretreatment with silver thiosulphate greatly prolonged the storage life of carnations both under modified atmosphere (Goszezynska and Rudnicki, 1982) and low pressure storage (Goszezynska and Rudnicki, 1982 and Staby *et al*, 1984). Mor *et al.*, (1984) observed that pulsing in combination with sucrose enhanced the effectiveness of STS in short term storage of Lily-of the-Nile and this result was supported by Goszezynska and Ruduicki (1982) in long term storage of carnation. Mor *et al* (1984) reported that pretreatment of sweet pea flowers for 8 minutes with 4mM silver thiosulphate, doubled the vase life and enhanced opening of buds on spikes and delayed floret sanescence and abscission in both fresh and stored flowers.

Murali and Reddy (1993) while studying the effect of silver thiosulphate on post-harvest life of Gladiolus Cv. Friendship found maximum fresh weight retention and vase life in spikes treated with 0.5mM STS. Hwang and Kim (1994) found that pretreatment of flowers for 30 minutes in silver thiosulphate followed by pulsing for 20 hours in a solution containing 40% sucrose + 8-HQS 200 ppm + BA 20 ppm was best, as it improved the vase life by 32% and also improved flower quality in terms of floret diameter, fresh weight retention and water uptake.

Serek *et al.*, (1994) observed that pulse treatment of gladiolus spikes with silver thiosulphate improved floret opening but not the life of individual florets. They further observed that sucrose and STS had similar but not synergistic effects on floret opening, suggesting that STS improves flower opening in Gladiolus by overcoming the effects of carbohydrate depletion. Lee *et al.*, (1995) observed that fresh weight of carnation flowers pulsed with 4mM silver thiosulphate increased upto 3rd day and then gradually decreased however, in control it increased upto 2nd day and then decreased rapidly. Song *et al.*, (1995) reported that pulsing of cut flowers of *Delphinium elatum* with silver thiosulphate 0.4 mM + 7% sucrose extended the vase life and improved quality of flowers during storage for 0 to 1 week. Hwang *et al.*, (1995) reported that application of silver thiosulphate (1.0 mM) after ethaphon treatment suppressed ethylene production and extend vase life of spikes of gladiolus Cv. Spic and Span.

CHAPTER - III

MATERIAL AND METHODS

The present investigations entitled "Studies On Vase life of Gladiolus Cv. 'Happy End'" were carried out during 1996-97 in the Department of Horticulture; CCS Haryana Agricultural University, Hisar. The details with reference to the material and methods used for the experiment are as follows:

3.1 Land preparation, planting and cultural practices

The Corms of Gladiolus Cv. Happy End were planted on 24th October, 1996 to obtain spikes to study the vase life of cut flowers. Land was prepared by repeated ploughing and 10 kg of farm yard manure per square meter was added followed by a pre sowing irrigation in order to provide sufficient moisture for sprouting of corms. Nitrogen, phosphorus and potash were applied at the rate of 20,20,20 g/m^2 respectively as basal dose of fertilizer. Sources of N, P, K were CAN, Single Super Phosphate and Murate of Potash, respectively.

Corms were planted at a depth of 5-7 cm in flat beds at 30*30 cm apart after treating with 0.2% Bavistin for 30 minutes. Regular weeding was done to check the growth of weeds and earthing up was done after 30 days of planting for the development of cormels and to prevent lodging. Rest amount of N was supplied at 3 leaf stage and at the time of spike initiation. Irrigation was given fortnightly during the growing period. Recommended plant protection measures were taken to control the pests and diseases.

3.2 Preparation of solutions

Four chemicals viz. sucrose, cobalt suplhate ($CoSO_4$), calcium chloride ($CaCl_2$) and silver thiosulphate (anionic complex having Ag^+) were used with different concentrations to study their effect on vase life and other quality parameters of gladiolus Cv. Happy End spikes.

These chemicals were used in following treatment combinations using completely randomised design with 3 replications in each treatment and 2 spikes per replication.

(a) For holding solution

T_1	3% Sucrose
T_2	0.5 mM Cobalt sulphate
T_3	1.0 mM Cobalt sulphate
T_4	0.5 mM Calcium chloride

T_5	1.0 mM Calcium chloride
T_6	0.5 mM Silver thiosulphate
T_7	1.0 mM Silver thiosulphate
T_8	3% Sucrose + 0.5 mM $CoSO_4$
T_9	3% Sucrose + 1.0 mM $CoSO_4$
T_{10}	3% Sucrose + 0.5 mM $CaCl_2$
T_{11}	3% Sucrose + 1.0 mM $CaCl_2$
T_{12}	3% Sucrose + 0.5 mM STS
T_{13}	3% Sucrose + 1.0 mM STS
T_{14}	0.5 mM $CoSO_4$ + 0.5 mM $CaCl_2$
T_{15}	0.5 mM $CoSO_4$ + 1.0 mM $CaCl_2$
T_{16}	0.5 mM $CoSO_4$ + 0.5 mM STS
T_{17}	0.5 mM $CoSO_4$ + 1.0 mM STS
T_{18}	1.0 mM $CoSO_4$ + 0.5 mM $CaCl_2$
T_{19}	1.0 mM $CoSO_4$ + 1.0 mM $CaCl_2$
T_{20}	1.0 mM $CoSO_4$ + 0.5 mM STS
T_{21}	1.0 mM $CoSO_4$ + 1.0 mM STS
T_{22}	0.5 mM $CaCl_2$ + 0.5 mM STS
T_{23}	0.5 mM $CaCl_2$ + 1.0 mM STS
T_{24}	1.0 mM $CaCl_2$ + 0.5 mM STS
T_{25}	1.0 mM $CaCl_2$ + 1.0 mM STS
T_{26}	Distilled water (Control)

(b) For Pulsing

Pulsing was done for 18 hours and 24 hours using following concentrations of chemicals:-

T_1	5% Sucrose
T_2	8% Sucrose
T_3	2mM Cobalt sulphate
T_4	4mM Cobalt sulphate
T_5	2mM Calcium chloride
T_6	4mM Calcium chloride
T_7	2mM Silver thiosulphate
T_8	4mM Silver thiosulphate
T_9	Control

3.3 Environmental conditions during experiments

During the period of experiment mean daily temperature, relative humidity and continuous light period were noted.

3.4 Preparation of spikes

The spikes of gladiolus were harvested with help of secateur during morning hours at two distinct stages of development viz.

1) When basal floret unfurled : for holding solution.
2) When basal floret (bud) showed colour : for pulsing.

Immediately after harvesting, the spikes were taken to the laboratory by keeping the cut end in water to avoid wilting. In the laboratory, all the leaves were removed and the cut end of spikes was given a slanting cut leaving 20

cms uniform stem length from the basal floret. Uniform spikes were grouped and randomized to maintain uniformity with in the replications and then they were placed in 500 ml conical flasks containing 400 ml test solutions for different treatments. Two spikes were placed in each flask and the flasks were plugged with cotton and following observations were recorded.

3.5 Observations recorded

3.5.1 Water uptake

3.5.2 Transpirational loss of water

3.5.3 Number of florets that remain open at specific time

3.5.4 Fresh weight of spike

3.5.5 Percent increase in spike length

3.5.6 Percent opening of florets.

3.5.7 Wilting of floret (floret life)

3.5.8 Vase life of spike

3.5.9 Water loss : Water Uptake ratio

3.5.10 pH of solution

3.5.11 Effect on cut end of spike

3.6 Methods of determination:-

3.6.1 Water uptake:- Water uptake was calculated by deducting the weight of flask + solution on a particular day from the weight on previous

observation. Data was recorded in grams on alternate days throughout the vase life period.

3.6.2 Transpirational loss:- It was calculated by deducting the weight of conical flask + solution + spike on a particular day from the weight on previous observation. Data was recorded in grams on alternate days throughout the vase life period.

3.6.3 Number of florets that remain open : Observations were recorded on alternate days on opening of florets. The number of florets open at the time of observation were recorded. On the basis of this, number of florets that opened upto discarding as percentage of total number of florets on the spike was calculated.

3.6.4 Fresh weight:- Observations were recorded on change in fresh weight of spikes on alternate days. Percent change in fresh weight was calculated in relation to initial weight.

3.6.5 Percent increase in Spike length - The length of spike was measured from basal bud to the tip of spike (cm). Percent change in length of spike was calculated in relation to initial length.

3.6.6 Wilting of floret (floret life) - Number of days taken from opening to wilting of basal floret was recorded. This represented floret life. The figures after decimal were rounded to the nearest lower or upper digit.

3.6.7 Vase Life of Spike - Spikes were discarded when 50% of florets were wilted. This stage was considered to be the end of potential useful longevity of gladiolus spikes and the number of days taken for this from the time the spikes were put in vase solution.

3.6.8 Water balance or water loss / water uptake ratio - This was calculated by dividing the total water lost through transpiration during the vase life period by total water uptake during the vase life period.

3.6.9 pH of medium:- pH of solutions were measured with the help of pH meter. Observations were taken twice i.e. in the beginning and at the time of discarding.

3.5.10 Effect on cut end of spike - The cut end of spikes dipped in solution were checked on alternate days for rotting of tissue, deposition of any substance or colour appearance.

CHAPTER - IV

EXPERIMENTAL RESULTS

The results of the present investigation entitled "studies on vase life of Gladiolus Cv. Happy End" which was conducted to find the optimum chemical concentration for holding solution and for pulsing, to enhance the longevity and to improve quality of gladiolus spikes are presented in the following chapter.

A. Chemicals used in holding solution

Various chemicals (viz. sucrose, cobalt sulphate, calcium chloride and silver thiosulphate) were used individually and in combination with each other for preparing holding solution and gladiolus spikes of these were placed in these solutions. The observations were recorded on alternate days till the discarding (50% wilting of florets) of spikes. The effect of these chemicals in the holding solution on various parameters has been presented below:

Water uptake

The perusal of data on water uptake from table-1 revealed that different chemical treatments had a significant effect on water uptake by gladiolus spikes. Maximum water uptake (29.99 g) was recorded in spikes held in 1.0 mM $CoSO_4$ + 1.0 mM $CaCl_2$ which was at par with combination treatments of 1.0 mM $CoSO_4$ + 0.5 mM $CaCl_2$ and 0.5 mM $CoSO_4$ + 0.5 mM STS with water uptake of 27.76 and 29 grams respectively. Minimum water uptake (17.61 g) was observed in spikes held in interaction of 3% sucrose + 1.0 mM STS.

There was a significant decrease in water uptake from 2nd day to 8th day of vase life. Maximum (43.70 g) water uptake occurred on 2nd day whereas minimum (10.73 g) was observed on 8th day of vase life.

Data on interaction between days and treatments showed a significant difference. Maximum (56.06 g) water uptake was recorded on 2nd day of vase life in spikes held in 1.0 mM $CoSO_4$ + 1.0 mM $CaCl_2$ and minimum (7.93 g) in spikes held in 1.0 mM $CaCl_2$ + 1.0 mM STS on 8th day of vase life.

Table 1. Effect of different chemical treatments* on uptake of water (g) in gladiolus spikes

Treatments	Days of vase life				mean
	2	4	6	8	
T_1	37.79	24.20	18.36	10.83	22.79
T_2	39.96	31.13	13.06	9.73	23.47
T_3	46.06	28.56	14.06	11.53	25.05
T_4	48.16	32.23	15.26	12.20	26.86
T_5	43.96	30.33	14.60	11.26	25.04
T_6	50.23	29.40	14.40	11.06	26.27
T_7	36.80	25.83	13.33	10.33	21.57
T_8	36.63	23.83	10.80	8.76	20.00
T_9	44.93	28.36	11.20	8.96	23.36
T_{10}	41.90	17.76	13.46	9.60	20.68
T_{11}	39.36	15.33	12.20	8.36	18.56
T_{12}	42.16	23.66	19.50	8.96	23.57
T_{13}	32.40	14.46	14.96	8.63	17.61
T_{14}	47.33	27.63	17.20	12.56	26.18
T_{15}	46.86	20.43	15.36	12.20	23.71
T_{16}	55.66	24.40	19.16	15.16	29.00
T_{17}	41.86	21.26	15.70	11.90	22.68
T_{18}	54.76	25.73	16.53	12.53	27.76
T_{19}	56.06	30.33	18.60	14.96	29.99
T_{20}	42.46	24.70	16.36	12.96	24.12
T_{21}	34.93	18.63	10.10	8.83	18.12
T_{22}	51.56	18.86	10.50	8.93	22.46
T_{23}	44.70	16.10	13.70	11.53	21.50
T_{24}	45.90	28.36	14.46	11.86	25.15
T_{25}	37.53	19.06	9.83	7.93	18.59
T_{26} (Distilled water control)	33.23	18.60	10.76	8.93	17.88
Mean	43.70	23.82	14.35	10.73	

C.D. at 5%			
	Day	=	0.91
	Treatments	=	2.33
	Days x treatments	=	4.66

* For details of the treatments see chapter 'material and methods'.

Transpirational loss

It is clear from the perusal of data in table-2 that transpirational loss varied significantly due to different chemical treatments. Maximum loss (27.79 g) was observed in spikes held in 1.0 mM $CoSO_4$ + 1.0 mM $CaCl_2$ which was at par with spikes held in 1.0 mM $CoSO_4$ +0.5 mM $CaCl_2$ and 0.5 mM $CoSO_4$ + 0.5 mM STS. Minimum loss (17.35 g) was recorded in spikes held in 1.0 mM $CoSO_4$ + 1.0 mM STS.

Transpirational loss did not show a particular pattern of increase/decrease with the increase in vase life period, however maximum loss (24.98 g) was recorded on 4th day of vase life and minimum (20.09 g) on 8th day of vase life.

Data on interaction between days and treatments showed a significant difference. Maximum transpirational loss (34.13 g) was observed on 2nd day in spikes treated with 1.0 mM $CoSO_4$ + 1.0 mM $CaCl_2$. Minimum loss (14.33 g) was recorded on 8th day in spikes held in 1.0 mM $CoSO_4$ + 1.0 mM STS.

Number of florets that remain open per spike

The data on number of florets that remained open clearly indicate (Table-3) that spikes differed significantly with different chemical treatments. Maximum

Table 2. Effect of different chemical treatments* on transpirational loss of water (g) in gladiolus spikes

Treatments	Days of vase life				mean
	2	4	6	8	
T_1	22.03	23.66	19.23	18.36	20.82
T_2	17.76	23.86	22.13	21.36	21.28
T_3	21.40	23.96	26.90	22.16	23.60
T_4	21.73	25.03	20.06	19.40	21.55
T_5	18.73	21.40	18.90	15.93	18.74
T_6	24.96	27.63	26.63	25.10	26.08
T_7	19.63	22.30	23.63	21.66	21.80
T_8	16.46	19.66	22.16	18.86	19.28
T_9	21.00	28.46	27.10	20.43	24.25
T_{10}	24.86	22.30	21.33	18.90	21.85
T_{11}	24.06	21.70	19.33	16.30	20.35
T_{12}	23.20	24.06	27.76	20.73	23.94
T_{13}	21.46	21.90	22.80	20.90	21.76
T_{14}	26.30	28.96	24.76	23.83	25.96
T_{15}	24.76	27.76	23.63	22.60	24.69
T_{16}	32.36	27.60	25.56	24.16	27.42
T_{17}	24.53	23.36	22.03	20.86	22.70
T_{18}	30.03	31.40	25.70	22.93	27.51
T_{19}	34.13	31.96	26.23	18.83	27.79
T_{20}	23.20	25.26	23.00	19.53	23.75
T_{21}	18.66	20.70	15.73	14.33	17.35
T_{22}	23.53	27.96	23.93	21.10	24.03
T_{23}	24.48	28.40	21.23	19.43	23.42
T_{24}	25.66	29.26	25.00	20.60	25.13
T_{25}	19.16	22.10	22.70	19.76	20.93
T_{26}	20.13	21.96	20.46	15.23	19.45
Mean	23.26	24.98	22.99	20.09	

C.D. at 5%		
	Day	= 0.65
	Treatments	= 1.66
	Days x treatments	= 3.33

* For details of the treatments see chapter 'material and methods'.

number of florets (5.91) were open in spikes held in combination treatment 1.0 mM $CoSO_4$ +1.0 mM $CaCl_2$ followed by 1.0 mM $CoSO_4$ + 0.5 mM $CaCl_2$, in interactions of 0.5 mM $CoSO_4$ with 0.5 mM $CaCl_2$, 1.0 mM $CaCl_2$ and 0.5 mM STS where the number of florets that were open ranged between 5.58 and 4.99, respectively. Minimum number of florets (1.74) were open in spikes held in 1.0 mM $CoSO_4$ + 1.0 mM STS.

There was a significant difference in number of florets that were open on a spike on different days of vase life period. Maximum number of florets (4.56) were open on 4th day of vase life and minimum (3.02) on 8th day of vase life.

A significant effect of interaction between days and treatments on the number of florets that remained open per spike was observed. Maximum number of florets (7.16) remained open on 2nd day of vase life in spikes held in combination treatment 1.0 mM $CoSO_4$ + 1.0 mM $CaCl_2$ and minimum (1.04) on 8th day of vase life in spikes held in 1.0 mM $CoSO_4$ + 1.0 mM STS solutions.

Change in fresh weight

The data on fresh weight of spikes in table-4 revealed that different chemical treatments showed a significant effect on change in fresh weight on different days. On second day of vase life maximum (133.8%) fresh

Table 3. Effect of different chemical treatments* on number of florets that remain open per spike at different days of vase life

Treatments	Days of vase life				mean
	2	4	6	8	
T_1	1.83	3.16	2.83	1.33	2.48
T_2	2.16	4.00	4.16	3.50	3.45
T_3	3.33	3.66	4.50	3.00	3.62
T_4	3.00	4.16	3.50	3.16	3.45
45	1.66	3.50	3.16	2.66	2.33
T_6	3.50	5.66	4.66	4.00	4.45
T_7	2.50	3.66	4.83	3.16	3.53
T_8	2.00	3.50	4.16	3.33	3.24
T_9	2.83	5.83	4.33	3.33	4.08
T_{10}	6.00	4.00	3.66	2.83	4.12
T_{11}	5.00	4.83	3.83	2.50	4.04
T_{12}	4.16	4.33	6.00	3.66	4.53
T_{13}	2.33	3.50	4.66	3.00	3.37
T_{14}	5.66	6.16	4.83	4.33	5.24
T_{15}	5.16	6.00	4.66	4.16	4.99
T_{16}	6.83	5.66	5.00	4.50	5.49
T_{17}	4.66	4.16	3.50	3.00	3.83
T_{18}	6.33	6.66	5.33	4.00	5.58
T_{19}	7.16	6.66	5.50	4.33	5.91
T_{20}	4.16	4.83	4.00	2.66	3.91
T_{21}	2.33	2.50	1.16	1.00	1.74
T_{22}	5.16	6.00	4.16	3.16	4.62
T_{23}	4.50	5.33	3.33	2.50	3.91
T_{24}	5.00	6.33	5.00	3.33	4.90
T_{25}	2.66	3.50	4.00	3.00	3.29
T_{26}	3.00	3.66	3.50	2.33	3.12
Mean	3.95	4.56	4.06	3.02	

C.D. at 5%		
	Day	= 0.98
	Treatments	= 0.98
	Days x treatments	= 1.98

* For details of the treatments see chapter 'material and methods'.

weight retention was observed in spikes held in 1.0mM $CoSO_4$ + 0.5mM $CaCl_2$ which was at par with those held in 0.5mM $CoSO_4$, 1.0 mM $CoSO_4$ and 3% sucrose +1.0 mM cobalt sulphate. Minimum (113.3%) retention of fresh weight was observed in spikes held in distilled water (control).

On fourth day of vase life maximum (137.8%) retention of fresh weight was observed in spikes held in 1.0mM $CoSO_4$ which was at par with those held in 0.5mM $CoSO_4$, 1.0mM $CoSO_4$+0.5mM $CaCl_2$ and 3% sucrose+1.0mM $CoSO_4$. Minimum (108.2%) fresh weight retention was observed in control.
On sixth day of vase life, the spikes held in 0.5mM $CoSO_4$ recorded maximum (127.7%) retention of fresh weight, with 3% sucrose, 1.0mM $CoSO_4$, and 1.0mM $CoSO_4$+0.5mM $CaCl_2$ treatments at par with it, respectively. Minimum (91.1%) retention of fresh weight was observed in control which was even less than the initial fresh weight.

On eighth day of vase life, maximum (111.8%) retention of fresh weight was also recorded in spike held in 0.5 mM $CoSO_4$ which was at par with spikes held in 1.0mM $CoSO_4$+0.5mM $CaCl_2$, 3% sucrose and 1.0mM $CoSO_4$. Minimum (82.1%) fresh weight retention was observed in spikes held in distilled water (control).

The study of pattern of change in fresh weight showed that in all the chemicals when they were used individually,

Table 4. Effect of different chemical treatments* on change in fresh weight (% of initial) of gladiolus spikes at different days of vase life

Treatments	Days of vase life			
	2	4	6	8
T_1	116.4	121.3	124.6	107.4
T_2	128.4	137.5	127.7	111.8
T_3	131.3	137.8	120.6	107.9
T_4	118.1	123.2	115.5	101.8
T_5	115.0	118.8	111.2	100.4
T_6	127.0	129.0	112.0	93.9
T_7	119.0	122.3	115.7	101.8
T_8	120.5	128.5	114.3	100.2
T_9	129.1	130.3	106.2	93.9
T_{10}	126.7	115.0	98.1	90.1
T_{11}	123.3	113.0	99.2	88.1
T_{12}	123.7	122.0	107.6	96.0
T_{13}	119.8	117.2	108.8	97.7
T_{14}	127.0	126.2	112.1	98.9
T_{15}	124.6	119.3	104.3	89.5
T_{16}	125.4	122.5	114.1	102.7
T_{17}	122.2	120.5	111.8	98.5
T_{18}	133.8	131.6	121.3	109.6
T_{19}	127.0	119.3	101.0	90.6
T_{20}	126.7	124.2	115.1	102.0
T_{21}	122.0	119.7	110.0	96.7
T_{22}	127.0	118.2	101.3	91.0
T_{23}	125.8	115.6	100.9	90.7
T_{24}	123.8	123.2	115.0	99.5
T_{25}	118.4	115.6	103.4	92.0
T_{26}	113.3	108.2	91.1	82.1
C.D. at 5%	5.5	8.2	7.96	6.13

* For details of the treatments see chapter 'material and methods'.

there was an increase in fresh weight upto 4th day except in sucrose where there was an increase in fresh weight upto 6th day and when these chemicals were used in combination, the fresh weight decreased after 2nd day except in combination of sucrose with cobalt sulphate where the fresh weight decreased after 4th day.

Percent increase in spike length

The data on percent spike length (Table-5) showed a significant effect of different chemical treatments. On 2nd day, maximum (7.19%) increase in spike length was observed in spikes held in 3% sucrose + 1.0mM $CaCl_2$. Minimum (2.73%) increase was recorded in spikes held in control.
On 4th day, maximum (8.76%) increase in spike length was found in spikes held in 3% sucrose + 1.0mM $CaCl_2$ followed by combination of 3% sucrose with 0.5mM $CoSO_4$, 0.5mM $CaCl_2$ and 1.0mM STS and combination treatment 0.5 mM $CoSO_4$ + 0.5mM STS where increase in spike length ranged between 6.94 to 7.33 percent. Minimum (2.96%) increase in spike length was observed in control.

On 6th day of vase life, maximum (10.18%) increase in spike length was recorded in combination treatment 3% sucrose+1.0mM $CaCl_2$ which was at par with treatments 3% sucrose + 0.5mM $CaCl_2$, 3% sucrose + 0.5mM STS and 0.5mM

Table 5. Effect of different chemical treatments* on per cent increase in spike length of gladiolus

Treatments	Days of vase life			
	2	4	6	8
T_1	2.96	3.76	4.68	5.39
T_2	5.25	6.49	9.17	9.17
T_3	4.70	6.29	6.87	8.09
T_4	2.73	4.41	5.25	5.72
T_5	4.79	6.49	8.65	8.65
T_6	4.14	6.18	7.79	7.79
T_7	5.42	6.49	7.75	7.75
T_8	5.12	6.94	8.82	8.82
T_9	3.81	4.95	5.04	7.06
T_{10}	6.38	7.30	9.12	9.76
T_{11}	7.19	8.76	10.18	10.18
T_{12}	4.26	5.09	9.12	9.12
T_{13}	5.09	7.33	8.21	9.12
T_{14}	4.18	5.09	8.21	9.12
T_{15}	4.71	5.92	6.84	7.08
T_{16}	6.03	7.33	7.79	8.71
T_{17}	4.55	5.70	5.70	6.14
T_{18}	4.55	5.35	8.00	8.21
T_{19}	5.09	6.49	7.75	8.00
T_{20}	3.93	3.93	4.18	5.03
T_{21}	3.94	3.74	3.90	4.55
T_{22}	3.90	4.55	5.92	6.87
T_{23}	4.59	5.47	6.94	6.94
T_{24}	4.49	5.12	6.28	7.79
T_{25}	2.96	4.26	5.25	5.25
T_{26}	2.73	2.96	2.96	2.96
C.D. at 5%	0.96	0.95	0.95	0.96

* For details of the treatments see chapter 'material and methods'.

$CoSO_4$. Minimum (2.96%) increase in spike length was observed in control. On 8th day almost similar results were obtained.

Vase life

Vase life of spikes was significantly affected by different chemical treatments (Table-6). Maximum vase life (12 days) was recorded in spikes held in 1.0mM $CaCl_2$ solution followed by those held in 0.5mM $CaCl_2$, 1.0mM $CoSO_4$ and combination of 3% sucrose with 0.5mM $CoSO_4$, 1.0mM $CoSO_4$, and 1.0mM STS where the vase life ranged between 10 to 11 days. Minimum (7 days) vase life was observed in control and combination treatment 1.0mM $CaCl_2$ + 1.0mM STS.

Time taken for wilting of basal floret (Floret life)

There was a significant difference in the time taken for wilting of basal floret due to different chemical treatments (Table-6). Floret life was maximum (6 days in spikes held in 0.5mM $CoSO_4$ or 1.0mM $CoSO_4$ or 0.5mM $CaCl_2$ or 1.0mM $CaCl_2$ alone. The basal floret took minimum time (2 days) for wilting in spikes held in control. However, interaction of chemicals with each other decreased the floret life.

Percent opening of florets

The persual of data on opening of florets from table-6 indicated that use of different chemicals significantly

Table 6. Effect of different chemical treatments* on vase life, floret life and opening of florets of gladiolus spikes

Treatments	Vase life (days)	Floret life (days)	Opening of florets (%)
T_1	8	5	68.1
T_2	9	6	65.0
T_3	10	6	63.5
T_4	11	6	73.3
T_5	12	6	76.0
T_6	8	4	68.7
T_7	9	4	70.3
T_8	10	5	73.0
T_9	11	4	70.3
T_{10}	8	3	74.3
T_{11}	9	4	78.2
T_{12}	9	3	70.9
T_{13}	10	4	72.4
T_{14}	9	4	70.6
T_{15}	8	2	73.3
T_{16}	10	4	70.9
T_{17}	8	4	68.4
T_{18}	8	4	71.0
T_{19}	8	3	72.1
T_{20}	9	3	70.6
T_{21}	8	3	68.4
T_{22}	9	3	67.0
T_{23}	8	2	68.4
T_{24}	8	4	73.7
T_{25}	7	3	72.3
T_{26}	7	2	59.5
C.D. at 5%	0.68	0.59	7.03

* For details of the treatments see chapter 'material and methods'.

affected the opening of florets. Maximum (78.2%) number of florets opened in spikes held in 3% sucrose + 1.0mM $CaCl_2$ treatment combination which was at par with those held in 0.5 and 1.0mM $CaCl_2$, 3% sucrose + 0.5mM $CaCl_2$, combination of 1.0mM $CaCl_2$ with 0.5mM $COSO_4$, 1.0mM $CoSO_4$, 0.5mM STS and 1.0mM STS where the values ranged between 72.1 to 76.0 percent. Minimum florets opened(59.51%) in spikes held in distilled water.

Water loss/Water uptake ratio (Water balance)

Data on water loss/water uptake ratio differed significantly due to the effect of different chemical treatments(Table-7). Maximum water loss/water uptake ratio (1.23) was observed in spikes held in 3% sucrose + 1.0mM STS followed by control and interaction of 1.0mM STS with 0.5 and 1.0mM $CaCl_2$. Minimum water loss/ water uptake ratio (0.74) was observed in spikes held in 1.0mM $CaCl_2$ which was at par with 0.5mM $CaCl_2$ (0.77), indicating the effectiveness of $CaCl_2$ in maintaining better water balance.

pH of vase solution

A change in pH of solution was observed at the end of experiment as compared to initial pH of solution. Solutions containing calcium chloride alone and its combination with sucrose showed a decrease in pH, however,

Table 7. Effect of different chemical treatments* on water loss/uptake ratio and change in pH of solution

Treatments	Water loss/ uptake	pH	
		Initial	Final
T_1	0.91	5.18	5.20
T_2	0.90	4.85	4.92
T_3	0.94	4.60	4.65
T_4	0.77	4.85	4.82
T_5	0.74	4.70	4.65
T_6	0.99	5.90	5.95
T_7	1.01	5.85	5.90
T_8	1.00	4.10	4.12
T_9	1.03	4.02	4.10
T_{10}	1.05	5.05	5.00
T_{11}	1.07	4.95	4.88
T_{12}	1.01	5.10	5.22
T_{13}	1.23	4.95	5.05
T_{14}	0.99	6.00	6.20
T_{15}	1.04	5.85	6.00
T_{16}	0.94	5.95	6.08
T_{17}	1.00	5.25	5.35
T_{18}	1.00	5.98	6.10
T_{19}	0.92	5.65	5.73
T_{20}	0.94	5.90	6.05
T_{21}	0.95	5.85	6.00
T_{22}	1.07	5.55	5.68
T_{23}	1.09	5.38	5.50
T_{24}	0.99	5.25	5.45
T_{25}	1.13	5.20	4.37
T_{26}	1.08	5.78	5.86
C.D. at 5%	0.15		

* For details of the treatments see chapter 'material and methods'.

in all the other treatments there was an increase in the pH at the end of experiment.

B. Chemicals used for pulsing

Various chemicals (viz. sucrose, cobalt sulphate, calcium chloride and silver thiosulphate) were used individually at two concentrations (low and high) for pulsing of gladiolus spikes. Pulsing was done for 18 hours and 24 hours. After pulsing the spikes were kept in distilled water and various observations were recorded on alternate days till the discarding of spikes. The effect of different pulsing treatments on various parameters has been presented below.

Water uptake

The perusal of data on water uptake from Table 8 showed a significant difference due to different pulsing treatments. Maximum water uptake (28.83 g) was recorded in spikes pulsed with 4 mM $CoSO_4$ and minimum (9.53 g) in spikes pulsed with 4 mM STS. Water uptake differed significantly on different days of vase life. Maximum water uptake (33.33 g) was recorded on 3rd day and minimum (11.23 g) on 7th day of vase life. Water uptake was not significantly effected by duration of pulsing.

The data on interaction of days and treatments showed a significant difference in water uptake. Maximum water uptake (44.60 g) was recorded on 3rd day in spikes pulsed with 4mM $CoSO_4$ and minimum (5.53 g) on 7th day in spikes pulsed with 4 mM STS.

Water uptake differed significantly due to interaction between treatment and duration. Maximum water uptake (30.90 g) was observed in spikes pulsed with 4 mM $CoSO_4$ for 24 hours and minimum (8.75 g) in spikes pulsed with 4 mM STS for 24 hours.

A significant difference was recorded in water uptake due to combined affect of days and duration. Maximum water uptake (35.17 g) was observed on 3rd day in spikes pulsed for 18 hours and minimum (10.22 g) on 7th day in spikes pulsed for 18 hours.

Water uptake showed a significant difference due to combined effect of day, duration and treatment. Maximum uptake (48.60 g) was observed on 3rd day in spikes pulsed with 4 mM $CoSO_4$ for 24 hours and minimum (5.30 g) on 7th day in spikes pulsed with 4mM STS for 18 hours.

Table 8. Effect of different pulsing treatments on water uptake (g) in gladiolus spikes

Treatments	Vase life period (days)											
	3			5			7			Mean		
	Duration of pulsing (h)											
	18	24	mean	18	24	mean	18	24	mean	18	24	Treat. mean
5% Sucrose	33.96	32.78	33.38	14.26	15.76	15.01	11.10	12.23	11.61	19.44	20.24	19.84
8% Sucrose	38.60	31.76	38.18	18.53	18.23	18.38	8.70	8.80	8.75	20.61	17.93	19.27
2mM $CoSO_4$	38.16	45.86	42.01	14.23	20.30	17.26	11.10	15.83	13.46	21.16	27.33	24.25
4mM $CoSO_4$	40.60	48.60	44.60	20.23	23.76	22.00	19.46	20.33	19.90	26.76	30.90	28.83
2mM $CaCl_2$	38.16	35.60	36.88	15.66	18.10	16.88	8.50	10.36	9.43	20.77	21.35	21.06
4mM $CaCl_2$	47.63	19.80	34.21	16.13	14.76	15.45	10.96	13.60	12.28	26.24	15.05	20.65
2mM STS	27.50	25.03	26.26	10.73	16.33	13.53	8.73	11.00	9.86	14.98	17.45	16.22
4mM STS	17.63	11.63	14.63	8.00	8.86	8.43	5.30	5.76	5.53	10.31	8.75	9.53
Control			31.90			17.30			10.76			19.98
Mean	35.17	31.50	33.33	14.22	16.39	15.30	10.22	12.24	11.23	20.03	19.87	

C.D. at 5% Days = 0.86; Duration = N.S.; Treatment = 1.40
Days x Duration = 1.21; Days x treatment = 2.43;
Duration x treatment = 1.98; Days x duration x treatment = 3.44

Transpirational loss

The perusal of data on transpirational loss from table-9 showed a significant difference due to different pulsing treatments. Maximum transpirational loss (33.92 g) was observed in spikes pulsed with 4 mM $CoSO_4$ and minimum (14.07 g) in spikes pulsed with 4 mM STS. Transpirational loss was maximum (29.12 g) on 3rd day and minimum (23.39 g) on 7th day. However, duration of pulsing did not have any significant affect on transpirational loss.

The interaction between days and treatment on transpirational loss showed a significant difference. Maximum loss (41.26 g) was recorded on 3rd day in spikes pulsed with 4 mM $CoSO_4$ and minimum (13.20 g) on 7th day in spikes pulsed with 4 mM STS.

Transpirational loss differed significantly due to interaction between treatment and duration. Maximum loss (34.50 g) was observed in spikes pulsed with 4 mM $CoSO_4$ for 24 hours and minimum (13.20 g) in spikes pulsed with 4 mM STS for 18 hours.

The combined effect of days and duration showed a maximum loss (30.77 g) on 3rd day in spikes pulsed for 18 hours and minimum (22.93 g) on 7th day in spikes pulsed for 18 hours.

Table 9. Effect of different pulsing treatments on transpirational loss (g) in gladiolus spikes

Treatments	Vase life period (days)											
	3			5			7			Mean		
	Duration of pulsing (h)											
	18	24	mean	18	24	mean	18	24	mean	18	24	Treat. mean
5% Sucrose	26.26	23.10	24.68	27.20	16.73	21.96	29.00	29.60	29.30	27.48	23.14	25.31
8% Sucrose	28.80	25.70	27.25	27.70	23.90	25.80	24.43	19.66	22.05	26.97	23.08	25.03
2mM $CoSO_4$	34.80	43.46	39.13	23.46	32.20	27.83	23.36	23.46	23.41	27.21	33.04	30.12
4mM $CoSO_4$	38.73	43.80	41.26	32.93	36.73	34.83	32.40	22.96	27.68	33.35	34.50	33.92
2mM $CaCl_2$	35.86	36.53	36.20	28.36	31.16	29.76	20.53	22.43	21.48	28.25	30.04	28.15
4mM $CaCl_2$	42.93	12.90	27.91	28.40	32.76	30.58	25.53	27.93	26.73	32.95	23.53	26.24
2mM STS	25.90	23.43	24.66	16.90	33.36	25.13	16.20	29.43	23.31	19.66	29.07	24.37
4mM STS	14.86	13.86	14.36	12.76	16.56	14.66	12.00	14.40	13.20	13.20	14.94	14.07
Control			27.12			25.90			22.50			25.17
Mean	30.77	27.47	29.12	24.71	27.92	26.32	22.93	23.86	23.39	26.14	26.42	

C.D. at 5% Days = 1.11 Duration = N.S.; Treatment = 1.82
Days x Duration = 1.58 Days x treatment = 3.16
Duration x treatment = 2.58 Days x duration x treatment = 4.47

Transpirational loss showed a significant difference due to combined effect of day, duration and treatment. Maximum loss (43.80 g) was observed on 3rd day in spikes pulsed with 4 mM $CoSO_4$ for 24 hours and minimum (12 g) on 7th day in spikes pulsed with 4 mM sTS for 18 hours.

Number of florets that remain open/spike

The data on number of florets that remain open per spike (Table 10) clearly indicates that it was significantly affected by different pulsing treatments. Maximum (2.65) number of florets were open in spikes pulsed with 2 mM $CaCl_2$ which was at par with control, 5% and 8% sucrose. Minimum (1.0) number of florets were open in spikes pulsed with 4.0 mM STS. Number of florets that remained open differed significantly during vase life period. Maximum (2.18) number of florets were open on 5th day and minimum (1.87) were open on 7th day of vase life.

Number of florets that remained open per spike was not affected by duration of pulsing and other interactions.

Change in fresh weight

Change in fresh weight was significantly effected by different pulsing treatments on all the days of vase life period (Table-11). On 3rd day maximum fresh weight (109.2%)

Table 10. Effect of different pulsing treatments on number of florets that remained open per spike at specific time in gladiolus spikes

Treatments	Vase life period (days)											
	3			5			7			Mean		
	Duration of pulsing (h)											
	18	24	mean	18	24	mean	18	24	mean	18	24	Treat. mean
5% Sucrose	2.19	2.19	2.19	2.19	2.30	2.25	2.27	2.38	2.32	2.22	2.29	2.25
8% Sucrose	2.41	2.37	2.39	2.26	2.30	2.28	2.15	2.11	2.13	2.28	2.26	2.27
2mM $CoSO_4$	2.23	2.57	2.40	2.03	2.19	2.11	1.91	1.72	1.82	2.06	2.16	2.11
4mM $CoSO_4$	2.15	2.70	2.43	2.04	2.23	2.13	1.62	1.67	1.64	1.94	2.20	2.07
2mM $CaCl_2$	2.27	2.67	2.47	4.73	2.19	3.46	2.00	2.04	2.02	3.00	2.30	2.65
4mM $CaCl_2$	2.67	1.52	2.10	2.23	2.38	2.30	2.19	2.12	2.15	2.36	2.00	2.18
2mM STS	1.77	2.08	1.92	1.62	2.23	1.92	1.52	2.19	1.86	1.63	2.17	1.90
4mM STS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Control			2.20			2.50			2.00			2.25
Mean	2.09	2.14	2.11	2.26	2.10	2.18	1.83	1.90	1.87	2.06	2.05	

C.D. at 5%

Days = 0.25 Duration = N.S. Treatment = 0.41
Days x Duration = NS Days x treatment = NS
Duration x treatment = NS Days x duration x treatment = NS

was retained in control followed by spikes pulsed with 5% sucrose, 4mM $CoSO_4$ and 2 mM STS where the fresh weight retention ranged between 108.35 to 106.86 per cent. Minimum fresh weight retention (98.35%) was observed in spikes pulsed with 4 mM STS which was even less than their initial weight.

On 5th day, the fresh weight retention was lesser than their initial weight in all the treatments, however, maximum fresh weight (99.10%) was retained in control which was at par with 2 mM STS. Minimum fresh weight retention (87.7%) was observed in spikes pulsed with 4 mM STS. On 7th day, almost similar trend was observed.

The duration of pulsing had not any significant effect on change in fresh weight on 3rd, 5th or 7th day of vase life.

However, fresh weight retention was significantly effected by interaction between chemicals used and pulsing duration on all the days of vase life. On 3rd day maximum fresh weight retention (109.83%) was obtained in spikes pulsed with 5% sucrose for 24 hours and minimum (97.93%) in spikes pulsed with 4 mM STS for 24 hours.

On 5th day maximum fresh weight (97.90%) was retained in spikes pulsed with 2mM STS for 18 hours and minimum

Table 11. Effect of different pulsing treatment on changes in fresh weight as per cent of initial weight

Treatments	Vase life period (days)								
	3			5			7		
	Duration of pulsing (h)								
	18	24	mean	18	24	mean	18	24	mean
5% Sucrose	106.86	109.83	108.35	90.93	97.46	94.20	76.03	81.83	78.93
8% Sucrose	108.86	103.53	106.20	93.03	88.70	90.86	79.40	78.06	78.73
2mM $CoSO_4$	103.96	101.43	102.70	92.20	94.70	93.45	80.06	81.16	80.61
4mM $CoSO_4$	106.76	108.50	107.63	94.83	93.91	93.48	77.93	75.90	76.91
2mM $CaCl_2$	103.86	100.26	102.06	90.26	86.88	88.57	78.80	77.46	78.13
4mM $CaCl_2$	102.93	105.40	104.16	90.20	89.56	89.88	76.93	75.80	76.36
2mM STS	107.46	106.26	106.86	97.90	95.36	96.63	85.10	82.56	83.83
4mM STS	98.76	97.93	98.35	90.10	85.30	87.70	77.30	74.23	75.76
Control			109.20			99.10			85.50
Mean	104.93	104.14		92.43	91.48		78.94	78.37	
C.D. at 5%	Duration = N.S. Treatment = 2.44 Dur. x treat.= 3.46			Duration = N.S. Treatment = 2.49 Dur. x treat.= 3.52			Duration = N.S. Treatment = 2.40 Dur. x treat.= 3.40		

(85.30%) in spikes pulsed with 4mM STS for 24 hours. Almost similar results were obtained on 7th day.

Per cent increase in spike length

Increase in spike length was significantly affected by different pulsing treatments during vase life period (Table 12). On 3rd day, maximum (1.96%) increase in spike length was observed in control and minimum (1.51%) increase was observed in spikes pulsed with 4mM STS.

Similar affects were observed on 5th and 7th day also. on 5th day maximum (2.96%) increase was observed in control and minimum (1.90%) in spikes pulsed with 4mM STS. on 7th day, maximum (2.96%) increase was recorded in control which was at par with 2 mM $CaCl_2$ and minimum (2.07%) in spikes pulsed with 4mM STS.

Increase in spike length was significantly affected by duration of pulsing on all the days of vase life. Almost similar effect of duration was observed on 3rd, 5th and 7th day of vase life as on all these days maximum increase in spike length was observed in spikes pulsed for 24 hours and minimum in spikes pulsed for 18 hours.

The data showed that interaction of duration and treatment also effected the increase in spike length

Table 12. Effect of different pulsing treatment on per cent increase in length of gladiolus spikes

Treatments	Vase life period (days)								
	3			5			7		
	Duration of pulsing (h)								
	18	24	mean	18	24	mean	18	24	mean
5% Sucrose	1.59	1.78	1.68	1.88	2.28	2.08	2.18	2.48	2.33
8% Sucrose	1.59	1.61	1.60	2.06	2.15	2.10	2.42	2.44	2.43
2mM $CoSO_4$	1.51	1.78	1.64	1.88	2.30	2.09	2.14	2.79	2.47
4mM $CoSO_4$	1.86	1.53	1.69	2.38	1.78	2.08	2.86	2.13	2.49
2mM $CaCl_2$	1.75	1.62	1.69	2.26	2.27	2.27	2.84	2.74	2.79
4mM $CaCl_2$	1.52	1.88	1.70	1.96	2.42	2.19	2.14	2.98	2.56
2mM STS	1.52	1.80	1.66	1.89	2.42	2.15	2.14	2.98	2.56
4mM STS	1.50	1.52	1.51	1.88	1.93	1.90	1.93	2.21	2.07
Control			1.96			2.96			2.96
Mean	1.60	1.70		2.02	2.19		2.33	2.59	
C.D. at 5%	Duration = 0.03 Treatment = 0.06 Interaction = 0.09			Duration = 0.05 Treatment = 0.11 Interaction = 0.15			Duration = 0.07 Treatment = 0.15 Interaction = 0.22		

significantly, on all the days of vase life period. On 3rd day, maximum (1.96%) increase was observed in control which was at par with spikes pulsed with 4 mM $CaCl_2$ for 24 hours. Minimum (1.50%) increase was recorded in spikes puled with 4mM STS for 18 hours. On 5th day maximum (2.96%) increase was observed in control and minimum (1.78%) increase was observed in spikes pulsed with 4 mM $CoSO_4$ for 24 hours. On 7th day maximum (2.98%) increase was observed in spike pulsed with 4 mM $CaCl_2$ for 24 hours which was at par with spikes pulsed with 2mM STS for 24 hours and control. Minimum (1.93%) increase was observed in spikes pulsed with 4mM STS for 18 hours.

Vase life

The perusal of data on vase life from Table 13 showed that maximum vase life (8.50 days) was obtained in spikes pulsed with 2mM $CaCl_2$ or 5% sucrose or 8% sucrose on 4mM STS without any significant difference. Minimum vase life (7 days) was observed in control and 4mM $CoSO_4$.

Vase life was not significantly affected by duration of pulsing, however, the interaction between duration and chemicals had a significant effect on vase life. Maximum vase life (9 days) was recorded in spikes pulsed with 2mM $CaCl_2$ for 24 hours or 5% sucrose, 8% sucrose and 4mM STS for

Table 13. Effect of different pulsing treatments on vase life and per cent opening of florets in gladiolus

Treatments	Vase life (days)			% opening of florets		
	Duration of pulsing (h)					
	18	24	mean	18	24	mean
5% Sucrose	9.0	8.0	8.5	72.8	72.4	72.6
8% Sucrose	9.0	8.0	8.5	73.9	69.5	71.7
2mM $CoSO_4$	8.0	8.0	8.0	73.8	70.6	72.2
4mM $CoSO_4$	7.0	7.0	7.0	62.8	44.2	53.5
2mM $CaCl_2$	8.0	9.0	8.5	74.7	66.0	70.3
4mM $CaCl_2$	7.0	8.0	7.5	76.7	72.4	74.6
2mM STS	8.0	8.0	8.0	40.3	74.1	57.2
4mM STS	9.0	8.0	8.5	0.0	0.0	0.0
Control			7.0			59.5
Mean	8.0	7.88		59.4	58.7	72.6

C.D. at 5%	Duration = N.S. Treatment = 0.37 Dur. x treat. = 0.53	Duration = N.S. Treatment = 3.95 Dur. x treat. = 5.59

18 hours without any significant difference and minimum (7 days) in spikes pulsed with 4 mM $CoSO_4$ or control or 4mM $CaCl_2$ for 18 hours.

Opening of florets

The data presented in Table 13 clearly indicated that maximum florets opened (74.6%) in spikes pulsed with 4mM $CaCl_2$ which was at par with 5% sucrose, 8% sucrose and 2mM $CoSO_4$ where 71.7% to 72.6% florets opened but in spikes pulsed with 4mM STS not even a single floret opened indicating the adverse affect of higher concentration of STS for pulsing.

Opening of florets was not significantly affected by duration of pulsing, however interaction between duration and chemicals had a significant affect on opening of florets. Maximum florets opened (76.7%) in spikes pulsed with 4mM $CaCl_2$ for 18 hours and minimum (0%) in spikes pulsed with 4mM STS for 18 or 24 hours.

Water loss/water uptake ratio (water balance)

The perusal of data from Table 14 reveals that the ratio of total water loss to total water uptake differed significantly due to different pulsing treatments. It was highest (1.47) in spikes pulsed with 2mM STS which was at

Table 14. Effect of different pulsing treatments on water loss to water uptake ratio

Treatment	Water loss : Water uptake		
	Duration of pulsing		
	18	24	Mean
5% Sucrose	1.42	1.27	1.34
8% Sucrose	1.30	1.26	1.28
2mM $CoSO_4$	1.28	1.21	1.24
4mM $CoSO_4$	1.22	1.11	1.17
2mM $CaCl_2$	1.36	1.40	1.38
4mM $CaCl_2$	1.28	1.55	1.41
2mM STS	1.30	1.65	1.47
4mM STS	1.29	1.57	1.43
Control	1.08	1.08	1.08
Mean	1.28	1.34	

C.D. at 5%	Duration	= 0.03
	Treatment	= 0.07
	Duration x treatment	= 0.10

par with pulsing treatments 4mM STS and 4mM $CaCl_2$. Lowest water loss/water uptake ratio (1.08) was observed in control followed by spikes pulsed with 4mM $CoSO_4$ (1.17).

It is clear from the data that duration of pulsing also affected the water loss/water uptake ratio significantly as it was highest (1.34) in pulsing for 24 hours and lowest (1.28) in pulsing for 18 hours.

Data on interaction between duration and treatment showed significant differences in water loss/water uptake ratio. Highest ratio (1.65) was recorded in spikes pulsed with 2mM STS for 24 hours and lowest (1.08) in control and pulsing treatment with 4mM $CoSO_4$ (1.11).

Change in pH

The observation on pH of solutions used for pulsing initially and at the end of pulsing (Table 14) showed that pH of solutions changed after pulsing treatments. Solutions containing calcium chloride showed a decrease in pH at both the concentrations whereas in all the other solutions there was increase in pH at the end of pulsing.

Table 15. Effect of different pulsing treatments on change in pH of the pulsing solutions

Treatment	pH of the solution			
	Duration of pulsing			
	18		24	
	Initial	Final	Initial	Final
5% Sucrose	5.50	5.58	5.50	5.60
8% Sucrose	5.90	6.00	5.90	6.05
2mM $CoSO_4$	5.85	5.95	5.85	5.95
4mM $CoSO_4$	5.60	5.75	5.60	5.78
2mM $CaCl_2$	5.65	5.52	5.65	5.50
4mM $CaCl_2$	5.60	5.45	5.60	5.42
2mM STS	5.20	5.27	5.20	5.30
4mM STS	4.75	4.84	4.75	4.87
Control	5.78	5.86	5.78	5.86
Mean	5.50	5.58	5.50	5.60

Effect of different chemical treatments on cut end of spikes

In solutions containing cobalt sulphate and calcium chloride and their combination with each other the cut end of spikes were visibly healthy and there was deposition of slippery mass.

In solutions containing sucrose alone there was wilting, browning of cut end, however, in solutions containing combination of sucrose with cobalt sulphate and calcium chloride,the cut end of spike appeared yellowish and wilted and there was deposition of slippery mass.

In solutions containing silver thiosulphate alone, the cut end was blackened and base of stem appeared hollow, however, in solutions containing combination of silver thio sulphate with cobalt sulphate and calcium chloride,the cut end of spike was blackened, wilted, appeared hollow in some cases along with deposition of slippery mass.

In distilled water,the base of spike appeared hollow and there was deposition of slippery mass on cut end of spike.

CHAPTER - V

DISCUSSION

Cut flowers are living and actively metabolising plant parts which are subjected to the same basic ageing phenomenon of flowers left unplucked on the plant. Since they are cut off from the natural sources of raw materials, they deteriorate much more faster than flowers left on the plant. Hence, efforts to exogenously supply these materials for metabolic functions are completely successful in prolonging the vase life of flowers. The extended vase life of flowers depend on its water relations and retarded rate of senescence which can be achieved by using certain chemicals which may act as a source of energy or as a germicide or as ethylene antagonist.

Keeping this in view sucrose, cobalt sulphate, calcium chloride and silver thiosulphate were tried for holding solution and for pulsing of gladiolus cv. Happy End. The findings of study are discussed as under :

Sucrose

In the present investigation sucrose increased the water uptake of gladiolus spikes when used in holding solution but showed no significant effect when used for pulsing (Tables 1,8). The water loss through gladiolus spikes was not affected by sucrose either in the holding solution or when used for pulsing (Tables 2,9), however, it improved water loss/water uptake ratio when used in holding solution, indicating better water balance by using sucrose. Acock and Nicholas (1979) also found improved water balance and osmotic potential in carnation flowers in sucrose solutions. Water balance is recognised as one of the major factors determining the quality and longevity of cut flowers (Aarts, 1957; Rogers, 1973).

As a consequence of improved water balance in spikes held in sucrose, fresh weight was increased in present investigation and the difference in fresh weight started appearing from 4th day onwards (Table 4). Spikes kept in sucrose reached the peak fresh weight later indicating the availability of respirable substrate for a longer period in holding solution. However, in pulsing treatment with sucrose, fresh weight decreased after 2nd day indicating the scarcity of respirable substrate when sucrose was used for a short period. The sugars applied exogenously to cut flowers

has been reported by Nicholas (1973) to act as respirable substrate.

Gain in fresh weight can occur only when the rate of water uptake is greater than the transpirational loss. In present investigation when sucrose was used in holding solution, water uptake was more than water loss, however, when it was used for pulsing it was not so. This could be the reason for better fresh weight retention when sucrose was used in holding solution than for pulsing. Earlier it has been reported by Bravdo *et al.*, (1974) that effect of sucrose on water uptake may be species specific and might depend on concentration used.

Sucrose in the vase solution increased the length of spike of gladiolus to a small extent but it was not so when sucrose was used for pulsing, probably because the continuous supply of sucrose provided necessary energy for the growth activities. Similar increase in spike length has earlier been reported by Chaudhary (1988) with application of 2 and 4% sucrose.

Floret opening was increased in the present investigation by the use of sucrose both in holding solution and in pulsing (Tables 6,13). In cut flowers bearing florets, there is a competition among florets for the available carbohydrates and they may fail to develop if the

availability of carbohydrates is scarce. With the exogenous supply of additional carbohydrates, the competition is reduced and opening of florets is improved. Sugars were found effective in inducing bud growth and development, delaying the abscission of flowers and showing greater percentage of full bloomed flowers (Pathak *et al.*, 1979). Other workers have also reported such effects for gladiolus (*Gladiolus x hortulanus*) (Kofrnak and Halevy, 1976) and spray carnations (Borochov *et al.*, 1975).

Sucrose increased the vase life of gladiolus spikes in the present investigation when used continuously in holding solution and also when used for a short period during pulsing. Flower senescence during vase life has been shown to have correlation with reduction in sugar content of flowers (Bruszewki, 1970; Nowak, 1979). Supplying cut flowers with exogenous sugars maintained respirable substrate in the flower (Lukaszewska, 1986) and promoted respiration (Wilkins, 1965 and Coorts, 1973), delayed the onset of excessive protein degradation (Paulin, 1971 and Coorts, 1973) and delayed the loss in fresh weight (Reid, 1989) and thus may extend the longevity of cut flowers. Sucrose in the vase solution has earlier also been reported to increase the vase life of tuberose (Balakrishna, 1987), gladiolus (Choi and Roh, 1980; Lukaszewska, 1981; Anserwadekar and Patil, 1986) and roses (Venkatarayappa, 1981).

Cobalt sulphate

In the present investigation, cobalt increased the water uptake as well as transpirational loss when used in holding solution and for pulsing (Tables 1,2, 8 and 9). Fairly positive water balance (Table 7) and increased fresh weight retention (Table 4) was observed when Cobalt was used continuously i.e. in holding solution rather than used for pulsing.

Some researchers regard xylem blockage as the major cause of water deficit and wilting of cut flowers (Marousky, 1969; Rogers, 1973) and it has been reported that water flow through stems is inversely correlated with the extent of microbial growth at the stem base (Larsen and Florich, 1969). Inhibition of Vascular blockage by Cobalt (Reddy, 1988) may be responsible for increased water uptake in the present investigation. In general, spikes held in distilled water experienced water stress early, which might be due to disruption of water column in the stem. Bacterial plugging appears to be much greater 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 microorganisms to build up in the former (Rogers, 1973). Treatments which inhibit microbial growth seem to help to maintain higher rate of water uptake and transport. Cobalt ion is known to increase water retention

in roses (Venkatrayappa et al., 1980, 1981) and similarly Chandra et al. (1981) reported delay in loss of fresh weight by Cobalt ion in French Marigold.

Cobalt had not much effect on floret opening when it was given as continuous treatment but when it was used for short duration (pulsing), it increased floret opening. Cobalt increased the spike length when it was used in holding solution rather than for pulsing and this effect was further enhanced by addition of sucrose probably due to the property of cobalt to check growth of microorganisms and its utilisation along with sucrose for the growth activities.

Cobalt increased the vase life in present investigation when used in holding solution but had no beneficial effect on vase life when used for pulsing (Tables 6 and 13). The extended vase life in response to continuous use of cobalt was, therefore, related to an increased amount of water uptake into the flowers, unhindered transpirational loss, delay in loss of fresh weight, and maintenance of better water balance, as according to Aarts (1957), these are the major requirements of increased vase life of cut flowers. Enhanced vase life due to Cobalt ion has been reported in gladiolus (Murali, 1990), rose (venkatrayappa et al, 1980, 1981; Reddy, 1988) and French Marigold (Chandra et al, 1981).

Calcium

Non-toxic metal salts like calcium increased the water uptake through gladiolus spikes in the present investigation both in holding solution as well as in pulsing (Tables 1 and 8) but had not much effect on water loss (Tables 2 and 9) thereby decreasing the water loss/water uptake ratio to a considerable extent when used in holding solution (Table 7).

Calcium did not help much in increasing fresh weight retention when used for pulsing but in holding solution, it maintained better fresh weight retention after 2nd day (Tables 4 and 11) and this could be attributed to increased water uptake and less water loss observed by calcium in the present investigation.

Since calcium in the present investigation increased the water uptake and maintained fairly positive water balance when used continuously. Water uptake through stems has been reported to be inversely correlated to the extent of microbial growth at the stem base (Larsen and Florich, 1969). It is reasonable to speculate that calcium might act physiologically and metabolically to inhibit vascular blockage.

Opening of florets was considerably increased by calcium both in holding solution and pulsing (Tables 6 and

13). Maintenance of better water balance by calcium during opening of florets could be responsible for better opening of florets. Length of spike was increased by using calcium in holding solution and the increase was more with high concentration of calcium and further boosted by addition of sucrose to the solution. This could be due to the inhibition of microbial growth by calcium and its utilization for the growth activities of the flower. The enhanced effect with addition of sucrose could be due to the additional energy provided by sucrose.

The increased vase life due to calcium in the present investigation both when used continuously and for a short period (Tables 6 and 13) could be attributed to increased water uptake and maintenance of better water balance by calcium. Similar increase in water uptake and vase life of gladiolus cv. Black Jack was observed by Gowda and Gowda (1990). Later, Gowda and Murthy (1993) reported that cut gladiolus spikes held in solution containing 2% sucrose + 0.5 μM calcium chloride showed increased water uptake and improved vase life.

Silver thiosulphate (STS)

In the present investigation, silver thiosulphate when used at low concentration (0.5 mM) in holding solution improved the water uptake and transpirational loss

substantially and showed better fresh weight retention. Use of high concentration (1.0 mM) and its combination with calcium chloride produced adverse effects. Use of STS for pulsing decreased the water uptake as well as transpirational loss and did not help in retaining the fresh weight.

The increased water uptake through spikes held continuously in STS may be due to prevention of stem plugging due to bactericidal action of silver salt and high mobility of silver thiosulphate in the cut stem as reported by Veen and Van (1978). This also caused unhindered transpirational loss through spikes treated with STS. Decreased water uptake and transpirational loss in spikes treated with high concentration of STS both in holding solution and pulsing might be phytotoxic effect as suggested by Mor *et al.*, (1984).

Silver thiosulphate did not help in improving water balance, either in holding solution or when used for pulsing (Tables 7, 14), however, spikes treated with STS in vase solution showed significantly improved floret opening which might be due to high mobility of STS in flower stem (Kofranek and Paul, 1974) and by overcoming the effect of carbohydrate depletion as reported earlier by Serek *et al.* (1994). But when STS was used for pulsing it strongly suppressed floret opening and caused spike bending and petal

scorching indicating phytotoxic effects of using high concentration and for longer duration as reported earlier by Veen (1979) and Mor et al., (1984).

Length of gladiolus spikes was increased significantly by using silver thiosulphate in holding solution rather than for pulsing (Tables 5 and 12) and this effect was further enhanced by addition of sucrose. The reason for this could be the bactericidal action of silver salts and its utilization for growth activities of the flower along with sucrose. Similar increase in spike length earlier been reported by Chaudhary (1988) with use of $AgNO_3$ alone and in combination with sucrose.

The improved vase life of gladiolus spikes treated with silver thiosulphate in the present investigation (Tables 6 and 13) was not only due to improved water uptake but also might be due to inhibition of floret abscission and a pronounced stimulation of opening of florets as reported earlier by Mor *et al.*, (1984) in sweet peas. Increased vase life and better fresh weight retention was also observed by Murali and Reddy (1993) by treating Gladiolus cv. Friendship spikes with 0.5 mM STS.

On the basis of above discussion it can be concluded that non-toxic metal salts like calcium chloride can be used in holding solution for increasing the vase life,

maintaining better water relations and opening of florets of gladiolus. Synergistic effects can be obtained by its combination with sucrose and cobalt sulphate for different parameters. For pulsing sucrose and calcium chloride can be used for increasing the vase life and opening of florets.

However, by trying higher concentrations in chemicals where toxic effect was not found and reducing the gap between concentrations used in chemicals where toxic effect was observed like silver thiosulphate will further help in standardizing the accurate concentration of these chemicals for getting better results in terms of improved water relations and increased vase life. Specially for pulsing more durations of pulsing can be tried for different chemicals. As there are so many varieties of gladiolus so the effect of different chemicals may differ with cultivars so important cultivars could be tried for recommendation of suitable chemicals for enhancing the post harvest quality and longevity.

CHAPTER - VI

SUMMARY AND CONCLUSION

Investigation on 'Studies on vase life of gladiolus cv. Happy End' were carried out in the Laboratory of Department of Horticulture, Chaudhary Charan Sigh Haryana Agricultural University, Hisar. The main objective of the study was to find the appropriate chemicals and its optimum concentration for holding and pulsing solution for extending longevity and improving quality of gladiolus Cv. Happy End cut flowers.

The salient findings of the investigation are summarised as under :

For holding solution

1. Water uptake was found maximum in combination of 1.0 mM cobalt sulphate with both concentrations of calcium chloride rather than using these chemicals individually.

Transpirational loss showed more or less similar trend like water uptake and was maximum in combination of 1.0 mM cobalt sulphate with both concentrations of calcium chloride.

Fresh weight retention was maximum and for a longer period in combination of 1.0 mM cobalt sulphate with 0.5 mM calcium chloride and by using cobalt sulphate alone at both the concentrations.

. Longest vase life was recorded with 1.0 mM calcium chloride which increased the vase life by 5 days over control. Cobalt sulphate and its combination with sucrose also increased the vase life by 3.5 to 4.0 days. Life of individual floret was longest with cobalt sulphate as well as calcium chloride when they were used individually.

. Calcium chloride was the best chemicals for opening of florets as maximum florets opened when it was used individually or in combination with any of the chemicals used.

. Maximum spike length was increased by using both concentrations of calcium chloride and silver thiosulphate (1.0 mM & 0.5 mM) in combination with 3% sucrose.

7. Calcium chloride improved the water balance at both the concentrations as it showed lowest water loss/water uptake ratio.

Pulsing

1. Pulsing with higher concentration of cobalt sulphate (4 mM) proved to be the best in improving water uptake and transpirational loss. Pulsing with silver thiosulphate adversely affected the water uptake and transpirational loss.

2. Pulsing with any of the chemicals used did not help in increasing fresh weight retention for longer period as maximum fresh weight was retained in control, however, among different chemicals maximum fresh weight was retained by pulsing with 5% sucrose or 2 mM silver thiosulphate.

3. Sucrose (5% & 8%), calcium chloride (4 mM) and cobalt sulphate (2mM) significantly increased the opening of florets. Pulsing with silver thiosulphate at both concentrations produced phytotoxic effects as not even a single floret opened and spike bending and marginal petal scorching was observed.

4. Pulsing with both concentrations of sucrose (5% & 8%) , 2 mM calcium chloride and 4 mM silver thiosulphate improved the vase life by 1.5 to 2.0 days.

5. Pulsing with any of the chemicals used did not increase the spike length.

6. Pulsing with any of the chemicals used did not maintain good water balance, however, water balance was comparatively better by pulsing with 4 mM cobalt sulphate.

It can be concluded that for holding solution calcium chloride can be used for increasing the vase life, maintaining better water relations and opening of florets of gladiolus Cv. Happy End and synergistic effects can be obtained by its combination with cobalt sulphate. For pulsing, sucrose and calcium chloride can be used for increasing the vase life and opening of florets while cobalt sulphate can be used in maintaining better water relations.

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