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Membrane stability and postharvest keeping quality of cut Gladiolus flower spikes

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An experiment was conducted to assess the effect of different chemical solutions of preservatives on membrane stability and postharvest keeping quality of cut gladiolus flower spikes during winter season 2011. The uniform gladiolus flower spikes were harvested from the farm of the commercial grower at the usual stage of flowering when 1 to 2 florets of the spike at the bottom showed colour. The harvested spikes were transported to the laboratory on the day of harvest and trimmed at the lower end to obtain spikes of uniform size followed by recording of fresh weight. Non-significant variations were observed for fresh weight of flower spikes and ranged from 36.03 to 41.03 g. Membrane stability of petals was expressed as an electrolyte leakage percentage. Maximum electrolyte leakage (86.18%) of petals was observed in vase solution contained sucrose @ 5 g L^{-1} followed by control (81.97%). However, lowest leakage of electrolytes (56.97%) was recorded in vase solution having sucrose @ 5 g $L^{-1}$with malicacid @ 50 mg L^{-1}. Non-significant differences were observed for days to opening of the florets and ranged from 2.67 to 3.00 days. The highest fully opened florets (51%) per spike were obtained in vase solutions having sucrose @ 5/10 g L^{-1} in combination with malic acid @ 50 mg L^{-1}. No unopened/wilted florets observed in the same vase solution containing 5 or 10 g L^{-1} in combination with malic acid @ 50 mg L^{-1} The maximum cumulative solution uptake (459 ml), vase life (14.33 days) and weight loss (30.00 g) was observed at complete termination of flower spikes from the vase solution having sucrose and malic acid @ 10 g and 50 mg L^{-1}, respectively. However, the said maximum vase life (14.33 days) was also at par (14.00 days) with solution of sucrose and malic acid @ 5 g L^{-1} and 50 mg L^{-1}, respectively

Keywords:*Gladiolus*, vase life, chemical preservatives

Introduction

Cut flowers are highly delicate produce and susceptible to large postharvest losses. Once harvested from the plant, they are deprived of their natural source of water and nutrients and wilt rapidly (Singh and Sharma, 2003). Gladiolus is one of the potential cut flower for foreign exchange

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cultivated throughout the world for its attractive flower spikes bearing large number of florets per spike (Riaz *et al*., 2007; Islam and Haque, 2011; Memon *et al*., 2012). Generally, gladiolus flower spikes last for 7-8 days in tap water (Singh and Sharma, 2003; Singh *et al*., 2008). Wilting of the petals, senescence of half and full opened florets cause the early senescence of flower spikes and limit the acceptability of cut gladiolus flower spikes in the national and international trade. Many factors causing early senescence of fresh cut spikes, and the most common are inability of stems to absorb water due to the xylem vessels blockage (Loubaud and Van Doorn, 2004; Hassan, 2005) and the less supply of carbohydrates to support the process like respiration (Halevy and Mayak, 1979; Murali and Reddy, 1993). The xylem vessels blockage caused due to air or microorganisms accumulation in vase solution (Hardenburg, 1968; Hassan, 2005). The water conducting tubes in the stem (xylem vessels) become plugged by bacteria, yeast, and fungi, which are living in the water or on the flower, and proliferate in the containers holding the flowers (Van Doorn, 1997). These microorganisms and their chemical products plug the stem ends and restrict water absorption. They continue to multiply inside and eventually block the stem tubes (Van Doorn *et al.*, 1991; Van Doorn*et al.*, 1995). The xylem blockage is also caused by the plant self reactions at the actual cut area as certain type of enzymes are mobilized to the wounded area where chemicals are released in order to seal the wound (Loubaud and Van Doorn, 2004) and ultimately reduce the water uptake.

Less carbohydrate supply may be caused another early senescence of flower deterioration. Many flowers are harvested before they are fully developed, to ensure a long postharvest life and to minimize mechanical damage that might occur during handling. The development of these flower buds requires carbohydrates, which are stored in the leaves and stems. These stored carbohydrates can be mobilized to be used by lower bud but might be insufficient when the buds are harvested at the tight bud stage. The maintenance of the metabolic activities, including respiration, even for flowers that are harvested when fully developed, requires the adequate reserves which are provided in order to maintain a reasonable postharvest life. Due to less stored carbohydrates, the leaves and flower senesce rapidly and petals develop with less sugar have pale colour. Supplying cut flowers with carbohydrate sources could prolong flower vase life and improve flower quality.

To supply fresh cut flowers to the distant markets is a big deal for the growers as most of the cut flowers have short vase life. Unlike fruits and vegetables, prolong vase life of cut flowers is dependent on the continue supply of water and carbohydrates (Halevy and Mayak, 1979; Singh and Sharma, 2003). The addition of chemical preservatives to water is therefore

recommended to increase flower vase life. Realizing the role of extended vase life in the trade of cut flowers, the present research was therefore designed to explore maximum longevity of the gladiolus flower spikes by using various vase (preservative) solutions.

Material and methods

Plant material and procedure

The present research was carried out to study the effect of membrane stability and post harvest keeping quality of gladiolus cut spikes as influenced by chemical preservative solutions during winter season 2011. The gladiolus flower spikes were harvested from the farm of the commercial grower at the usual stage of flowering when 1 to 2 florets of the spike at the bottom showed colour. The harvested flower spikes were transported to the laboratory on the day of the harvest and trimmed at the lower end to obtain spikes of the uniform size. The trimmed flower spikes were kept at room temperature for the application of various chemical preservative solutions. Each vase solution treatment with 500 ml water contained three flower spikes. The experiment was conducted in completely randomized design (CRD) with three replications. The various sucrose levels i.e. 5, 10 and 15 g L^{-1} alone and in combination with malic acid @ 50 mg L^{-1} and sodium hypochlorite @ 1 ml L^{-1} were used as ten different vase solutions including control (without chemical preservative).

Traits measurement and analysis

The data were recorded on parameters viz; fresh weight of the flower spikes (Before immersion in vase solution), membrane stability of petals (electrolyte leakage %), days to opening the florets, percentage of fully opened florets per spike (at an interval of 24 hours), percentage of unopened florets per spike (at an interval of 24 hours), percentage of wilted florets per spike (at an interval of 24 hours), vase solution uptake (ml), vase life of flower spikes (days) and weight loss of flower spikes (g). Fresh weight of each flower spike was measured before immersion in vase solution and recorded separately using analytical weighing balance. Membrane stability of petals was determined on the basis of electrolyte leakage percentage of petals. The electrolyte leakage was measured by taking five petal discs (1 cm^2) of the third floret from the basal end of the spike. The petal discs were rinsed well in deionized water prior to incubation in 5 ml of deionized water for 3 h at room temperature. After incubation, the conductivity (value A) of the bathing solution was measured with the conductivity meter. The petal discs were boiled with bathing solution

for 15 min to kill the tissue. After cooling at room temperature, the conductivity (value B) of the bathing solution was again measured. The electrolyte leakage values were expressed in percentage according Murali (1990) and Singh *et al*. (2008).

$$Electrolyte\ Leakage\ (\%) = \frac{Value\,A}{Value\,B} \times 100$$

Total number of days was counted from starting of the experiment up to the initiation of the florets in chemical preservative solutions according to the prescribed treatments. Visual observations were made for the regularity/irregularity in flower opening. Total number of florets were counted at an interval of 24 hours and marked for the specific category. This practice was continued from 2nd day of the experiment and continued up to the complete termination of the flower spikes. The volume of holding solution absorbed by the flower spikes was calculated by measuring the volume of solution on a day of full termination of flower spikes particular day and subtracting it from the initial quantity of the vase solution kept in the flasks; taking into account the volume of solutions evaporated by using blank flasks in triplicate (containing particular vase solutions without buds) alongside the flasks with buds. The average vase life of the flowers was counted from the day of transfer of spikes to holding solutions and was assessed to be terminated when flowers lost their ornamental/display value (underwent color change; wilt and loose turgidity). Weight loss of each flower spike from each vase solution was noted at complete termination of florets per spike using analytical weighing balance (Khan *et al*., 2009; Singh and Sharma, 2003; Tiwari*et al*., 2010) The data were subjected to statistical analysis using fisher's analysis of variance technique and treatment means were compared using a duncan's multiple range test at the 5% level of probability (Steel *et al*., 1997).

Results

Data concerning fresh weight of the flower spikes noted before immersion in vase solutions are presented in Table 1. Non-significant differences were observed for fresh weight of flower spikes in various vase solution applications. However, fresh weight of the flower spikes per vase solution ranged from 36.03 g to 41.03 g. Most of the flower spikes for various solutions ranged below 40 g. Flower spikes of only three vase solutions exhibited more than 40 g fresh weight of the flower spikes.

Table 1. Fresh weight (g), days taken to initiate opening of the florets and percentage of fully opened florets as affected by various chemical solutions of preservatives

Vase solutions	Fresh weight flower spikes (g)	Days to opening of florets	Fully opened florets (%)
Control (Distilled water)	36.29	2.67	14.00 e
Sucrose 5 g L^{-1}	41.03	3.00	23.33 e
Sucrose 10 g L^{-1}	38.23	3.00	30.13 d
Sucrose 15 g L^{-1}	40.17	3.00	23.67 e
Sucrose 5 g L^{-1} + Malic acid -50 mg L^{-1}	36.03	2.67	51.00 a
Sucrose 10 g L^{-1} + Malic acid -50 mg L^{-1}	37.96	3.00	51.00 a
Sucrose 15 g L^{-1} + Malic acid -50 mg L^{-1}	38.90	3.00	35.67 c
Sucrose 5 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	38.11	3.00	42.00 b
Sucrose 10 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	37.81	3.00	40.53 b
Sucrose 15 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	40.59	3.00	34.80 c

Membrane stability expressed as percent leakage of total electrolytes of petal discs of the florets. Various vase solutions significantly affect the membrane stability of petals. The Fig. 1 depicts that maximum electrolyte leakage percentage of petals was recorded in control spikes (81.97) and the spikes of the solution having sucrose at 5 g L^{-1} (86.18). The lowest leakage of electrolytes (56.97%) was recorded with vase solution having sucrose at 5 g L^{-1} in combination with malic acid at 50 mg L^{-1}. Results were at par with the observations obtained from vase solution contained sucrose at 10 g L^{-1} and malic acid at 50 mg L^{-1}. Malic acid and sodium hypochlorite found better with sucrose in maintaining the stability of petals as compared to alone use of sucrose.

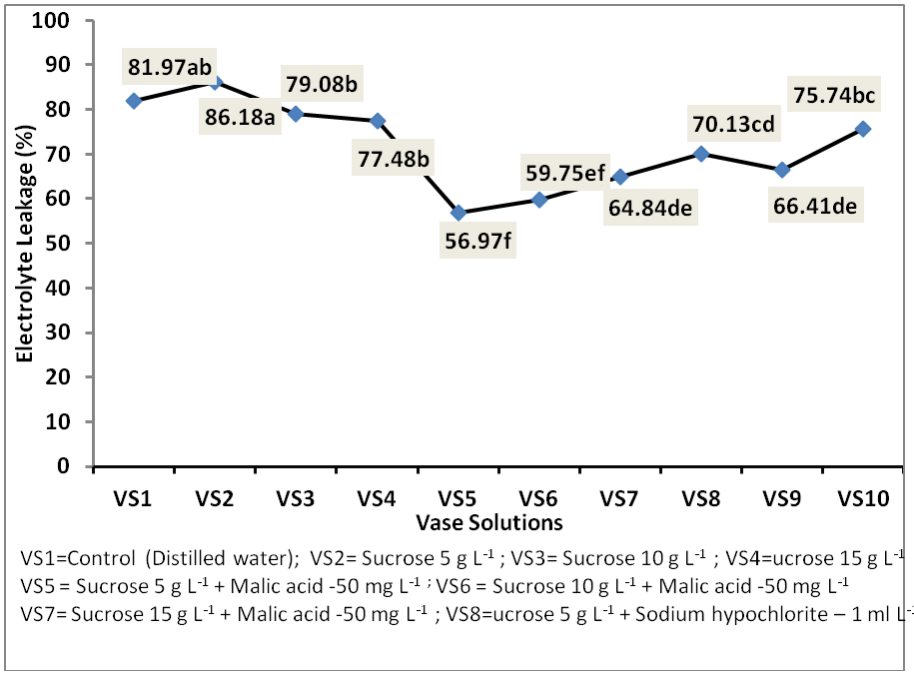

Fig. 1. Membrane stability of petals as expressed by electrolyte leakage (%) influenced by various preservative solutions.

Data concerning days taken to opening of the florets are presented in Table 1. The days to opening of the florets were found with non-significant differences with various vase solution treatments, however, ranged from 2.67 to 3.00 days (Table 2). Flower spikes of only two vase solutions viz. control and the solution contained sucrose and malic acid at 5 g and 50 mg L^{-1}, respectively initiated opening of the florets within minimum days of 2.67. However, flower spikes from rest of the vase solutions took maximum of 3.00 days. Highly significant differences were observed among the various vase solutions for fully opened florets. Data in Table 1 revealed that 51% fully opened florets per spike obtained from the vase solutions where sucrose was used at 5 or 10 g L^{-1} in conjunction with malic acid at 50 mg L^{-1}. These observations were significantly reduced to 42% and 40.53%, respectively when same concentrations of sucrose used with sodium hypochlorite at 1 ml L^{-1}. However, minimum percentage of fully opened florets (14%) was recorded from control solution where no chemical preservative was added. Minimum observations (14%) of fully opened florets were followed by 23.33 and 30.13% obtained from vase solutions where sucrose was used alone at the concentration of 5 and 10 g L^{-1}, respectively.

Highly significant differences were observed for unopened florets per spike. Maximum unopened florets per spike (28.33%) were observed in control

vase solution where no chemical preservative was added followed by the 21% unopened florets per spike obtained from vase solution which had sucrose at 15 g L^{-1} (Table 2). No unopened floret was observed from the vase solutions contained sucrose 5 g L^{-1} supplemented with malic acid at 50 mg L^{-1} or sodium hypoclorite at 1 ml L^{-1}. Similar observations were also obtained when sucrose was used at 10 g L^{-1} in combination with malic acid at 50 mg L^{-1}. The differences for wilted florets per spike were found highly significant among various vase solutions. Results revealed that no wilted floret was observed from the vase solution contained sucrose at 5/10 g L^{-1} with malic acid at 50 mg L^{-1} (Table 2). However, when same concentration of malic acid was used with the highest concentration of sucrose (15 g L^{-1}), the percentage of wilted florets increased to 10.93%. These increased observations were at par with the results obtained from the vase solution contained sucrose at 5 or 10 g L^{-1} alone or sucrose at 5 g L^{-1} supplemented with sodium hypochorite at 1 ml L^{-1}.

Table 2. Percentage of un-opened/wilted florets and cumulative solution uptake by cut gladiolus flower spikes as affected by various chemical solutions of preservatives

Vase solutions	Un-opened florets (%)	Wilted florets (%)	Solution uptake (ml)
Control (Distilled water)	28.33 a	8.67 bc	305.33 cd
Sucrose 5 g L^{-1}	17.33 c	10.33 ab	283.13 d
Sucrose 10 g L^{-1}	10.00 d	10.87 ab	179.17 e
Sucrose 15 g L^{-1}	21.00 b	6.33 d	112.03 f
Sucrose 5 g L^{-1} + Malic acid -50 mg L^{-1}	0.00 f	0.00 e	411.80 b
Sucrose 10 g L^{-1} + Malic acid -50 mg L^{-1}	0.00 f	0.00 e	459.00 a
Sucrose 15 g L^{-1} + Malic acid -50 mg L^{-1}	4.40 e	10.93 a	283.33 d
Sucrose 5 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	0.00 f	9.00 abc	378.33 b
Sucrose 10 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	5.13 e	5.33 d	325.33 c
Sucrose 15 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	8.67 d	7.53 cd	390.77 b

Maximum cumulative solution uptake (459 ml) was observed from the vase solution where sucrose was used at 10 g L^{-1} with malic acid at 50 mg L^{-1} (Table 2). These observations were followed 411.80 ml and 390.77 ml obtained from the vase solutions contained sucrose at 5 g L^{-1} supplemented each with malic acid at 50 mg L^{-1} and sucrose at 15 g L^{-1} along with sodium hypochlorite

at 1 ml L^{-1}, respectively. These observations were at par with the results obtained from the vase solution where sucrose was reduced to 5 g L^{-1} in combination with sodium hypochlorite at 1 ml L^{-1}. Lesser uptake (112.03 ml) was recorded from the vase solution where sucrose was used alone at 15 g L^{-1}. This uptake increased up to 283.13 ml with decreasing levels of sucrose. The increased uptake of 283.13 ml was at par with the results obtained from control vase solution (305.33 ml).

Table 3. Vase life and weight loss of gladiolus cut flower spikes as affected by various chemical solutions of preservatives

Vase solutions	Vase life (50% termination)	Vase life (complete termination)	Weight loss flower spikes (g)
Control (Distilled water)	3.33 d	7.33 e	21.12 de
Sucrose 5 g L^{-1}	5.00 c	9.67 cd	21.67 cd
Sucrose 10 g L^{-1}	5.00 c	8.67 de	20.67 de
Sucrose 15 g L^{-1}	4.67 c	7.33 e	19.33 e
Sucrose 5 g L^{-1}+ Malic acid -50 mg L^{-1}	9.00 a	14.00 a	26.00 b
Sucrose 10 g L^{-1} + Malic acid -50 mg L^{-1}	9.00 a	14.33 a	30.00 a
Sucrose 15 g L^{-1} + Malic acid -50 mg L^{-1}	7.33 b	10.33 bc	22.33 cd
Sucrose 5 g L^{-1}+ Sodium hypochlorite 1 ml L^{-1}	7.00 b	8.67 de	20.67 de
Sucrose 10 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	6.67 b	11.67 b	23.67 c
Sucrose 15 g L^{-1} + Sodium hypochlorite 1 ml L^{-1}	7.33 b	10.33 bc	22.00 cd

Highly significant differences were observed among various vase solutions for vase life recorded at 50% termination of the flower spikes. On the basis of data presented in Table 3, more vase life (9.00 days) was observed in vase solutions where sucrose was used at 5 or 10 g L^{-1} in combination with malic acid at 50 mg L^{-1}. Non-significant variations were observed when sucrose was used alone at various concentrations i.e. 5 (5 days), 10 (5 days) and 15 g L^{-1} (4.67 days). However, these results were significantly different from observations obtained from treatment having sucrose supplemented with sodium hypochlorite at 1 ml L^{-1} or malic acid at 50 mg L^{-1}. Minimum vase life of 3.33 days was observed from the control treatment where no chemical preservative was added. On the basis of complete termination presented in Table 3, maximum vase life of 14.33 days was observed from the vase solution contained sucrose (10 g L^{-1}) and malic acid (50 mg L^{-1}). These results were at

par with the observations when sucrose was reduced from 10 to 5 g L^{-1} and supplemented with same concentration of malic acid. Better result (11.67 days) was also obtained from the vase solution that had sucrose (10 g L^{-1}) with sodium hypochlorite (1 ml L^{-1}). However, vase solutions viz. control and the solution contained sucrose at its maximum level of 15 g L^{-1} alone exhibited similar and minimum days (7.33).

Results further revealed that maximum weight loss per spike (30.00 g) was observed under the vase solution where sucrose was used at 10 g L^{-1} supplemented with malic acid at 50 mg L^{-1}. In contrast, minimum weight loss (19.33 g) noted where sucrose was used alone at 15 g L^{-1}. These minimum observations were non-significantly different to control where no chemical preservative was added. However, minimum weight loss (19.33 g) increased up to 21.67 g with decreased level of sucrose (5 g L^{-1}).

Discussion

Enhancement of vase life of cut flowers is an important area in the field of horticulture. Early senescence of fresh cut flowers is the big deal for the growers as most of the cut flowers are highly perishable due to high respiration rate and excessive weight loss (Khan *et al*., 2009). The rate of senescence in cut flowers is based on the acceptable amount of sugars and status of the carbohydrates (Chandran *et al*., 2006). Since gladiolus has many florets which open sequentially, extension of vase life of the flower can help the flower industry and also the end user (Khan *et al.*, 2009).

Results revealed that opening of the florets was not significantly influenced by various vase solutions contained different concentrations of various chemicals. Contradictory findings were reported by Mutui *et al*. (2001) and stated that cut flowers of Alstroemeria held in Accel at 25 or 50 mg L^{-1} BA equivalent consistently increased the number of days to full opening of primary florets. This variation in observations might be due to genotypic and chemical preservative differences.

The percentage of fully opened florets was significantly improved by the vase solution having sucrose with malic acid. Singh *et al*. (2008) reported maximum number of open florets in the cut spikes placed in sucrose plus GA_3. Singh and Sharma (2003) reported maximum number of fully opened florets from the gladiolus cut flower spikes when treated with sucrose in combination with 8-HQC. Murali (1990) reported 16-17 fully opened florets in case of flower spikes placed in the metallic salt solutions plus sucrose compared to 8.67 in the case of those held in distilled water. The enhanced number of open florets per spike might be due to sucrose and higher solution uptake. That's why higher petal sugar status and water balance in flowers is suggested to improve

bud opening (Halevy and Mayak, 1981). Similarly Han (2001) reported that bud opening improved in lilies due to sucrose with GA_3. In contrast, Waithaka *et al*. (2001) reported that bud opening of gladiolus florets was accompanied by an increase in fresh weight, dry weight and carbohydrate concentration in the perianth.

In the present study more percentage of unopened florets was recorded from control treatment (distilled water) and these findings were in accordance with observations of Murali (1990) as reported more percentage of unopened florets from cut gladiolus flower spikes in control treatment (distilled water) as compared to the solution contained sucrose. Ezhilmathi *et al*. (2007) reported also more percentage of unopened florets of cut gladiolus flower spikes in water while only fifty % of florets remained unopened in 5-Sulfosalicylic acid. This more percentage of unopened florets in control solution might be due to the inability of the stems to absorb water due to the blockage of xylem vessels (Loub and Van Doorn, 2004; Hassan, 2005) and the less supply of carbohydrates to support respiration (Murali& Reddy 1993). However, the blockage of xylem vessels is caused due to air or microorganisms accumulation in vase solution (Hardenburg, 1968; Hassan, 2005). Higher floret wilting was recorded from the vase solution when sucrose was used at its maximum level with malic acid. Normally the vase solutions resulting in less wilting percentage of florets are considered good because these might result in longer vase life compared to those showing more wilting (Anjum, 2001).

The vase solution containing sucrose plus malic acid increased cumulative uptake of vase solution compared to the control and solution where sucrose was used alone resulting fifty % increase over control and over sucrose alone. Similar results were reported by Ezhilmathi *et al*. (2007) as they observed that vase solution containing 5-SSA significantly increased cumulative uptake of vase solution compared to the control resulting in 156% increase in vase solution uptake

The vase life of gladiolus is about 6-7 days under normal conditions (Reddy and Murali, 1994). Present results revealed that maximum vase life of 14.33 days was recorded in vase solution having sucrose with malic acid. Almost similar results were obtained by Tiwari*et al*. (2010) as reported different types of chemical preservatives. They reported maximum vase life of 14.66 and 14.00 days in cultivar Nova Lux and White Friendship, respectively in response to the solution contained sucrose (4%), citric acid (200 ppm), Tween-20 (0.02%) and $AgNo_3$ (200 ppm). Singh *et al*. (2008) observed more days with maximum vase life of 18.5 days in response to 50 g L^{-1} (18.5 days) plus GA_3 (50 mg L^{-1}) in cultivar Peter pears. Ezhilmathi*et al*. (2007) obtained vase life of 11.27 days in gladiolus flower spikes in solution contained 5-

sulfosalicylic acid (5 SSA) as compared to 8.3 days in control. In present study, almost similar results were obtained in control treatment. Khan *et al*. (2009) reported maximum vase life of 8.47 days from the solution contained sucrose at 3% and their results were in accordance with present findings (minimum vase life of 7.33 days was obtained in solution contained 15 g L^{-1}).

Ezhilmathi*et al*. (2007) reported more stability of petals in 5-sulfosalicylic acid 5 SSA as compared to control. Singh *et al*. (2008) reported maximum petal membrane stability index (80%) from cut spikes of gladiolus treated with 50 g L^{-1} GA_3 + 50 mg L^{-1} vase solution while the control was at lowest (67.2%). An increase in membrane permeability as indicated by either ion leakage or Malondialdehyde (a degradative product of lipid peroxidation) was found to be delayed or reduced by the use of sucrose and metals.

Conclusion

Gladiolus vase life could be successfully extended by collective use of sucrose and malic acid at 5 g and 50 mg L^{-1}, respectively.

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