International Journal of Plant & Soil Science

25(2): 1-7, 2018; Article no.IJPSS.43735
ISSN: 2320-7035

Effect of Postharvest Chemical Treatments on Quality and Longevity of Cut *Chrysanthemum*

F. U. Khan[1*], Nisar Ahmad Shah[1], Neelofar[1], Muneeb Ahmad Wani[1] and F. A. Khan[2]

[1]Division of Floriculture and Landscape Architecture, Faculty of Horticulture, SKUAST-K, Shalimar, Srinagar 190001, Jammu and Kashmir, India.
[2]Division of Basic Sciences and Humanities, Faculty of Horticulture, SKUAST-K, Shalimar, Srinagar 190001, Jammu and Kashmir, India.

Authors' contributions

This work was carried out in collaboration between all authors. Authors FUK, NAS and Neelofar designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MAW and FAK managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2018/43735
Editor(s):
(1) Dr. Abigail Ogbonna, Department of Plant Science and Technology, Faculty of Natural Sciences, University of Jos, Nigeria.
Reviewers:
(1) Miguel Aguilar Cortes, Universidad Autónoma del Estado de Morelos, Mexico.
(2) Ahmet Sivacioğlu, Kastamonu University, Turkey.
(3) Mohammad Shah Jahan, Sher-e-Bangla Agricultural University, Bangladesh.
Complete Peer review History: http://www.sciencedomain.org/review-history/26883

Original Research Article

Received 03 August 2018
Accepted 12 October 2018
Published 27 October 2018

ABSTRACT

The investigation was carried out to study the response of cut stem to sucrose and chemicals in terms of quality and vase life. The Experiment was comprised of 14 holding solutions containing sucrose 3 percent, biocide citric acid (200 and 400 ppm), aluminium sulphate (50 and 100 ppm) and growth regulator benzyl adenine (10 and 200 ppm). Sucrose and chemicals were used in isolation or in combination, and distilled water was used as a control. Results revealed that sucrose 3% + $Al_2(SO_4)_3$ 50 ppm helped stem to maintain favourable water relation, evaluated in terms of water uptake, water loss, water uptake/water loss ratio and water balance followed by sucrose 3 5% + $Al_2(SO_4)_3$ 50 ppm and citric acid 200 and 400 ppm exhibited less decline in fresh weight as compared to those in sucrose alone or control. Longest vase life of 14.64 days was recorded with sucrose 3% + $Al_2(SO_4)_3$ 50 ppm whereas, vase life in sucrose alone was 9.90 day only.

**Corresponding author: E-mail: fukhanskuastk@rediffmail.com;*

Keywords: Aluminium sulphate; benzyl adenine; Chrysanthemum; citric acid; sucrose; vase life.

ABBREVIATIONS

Su = Sucrose
CA = Citric acid
BA = Benzyl adenine
AS= Aluminium sulphate

1. INTRODUCTION

Chrysanthemum is grown throughout the world by amateurs and specialists both as cut flowers and potted plants. This plant has been studied intensively by scientists and growers with the result the crop can now be grown according to the precise schedule at any time by controlling the growing conditions. The name of *C. morifolium* Ramat has been changed to *Dendranthema grandiflora* Izevelev [1,2].

Chrysanthemum plant produces most showy flowers. It has a wide range of flower shape, size and colour. It is erect and tall growing cultivars are suitable for background planting in borders or as cut flowers. The dwarf and compact growing ones, on the other hand, are suitable for front row plantation or pot culture. The decorative and fluffy bloomed small flowered cultivars are ideal for garland making and hair decoration. The extra large bloomed cultivars are prized for their exhibition value.

Post harvest handling of cut *Chrysanthemum* stems to conserve their freshness for end users is of considerable commercial interest. However, little attention was paid in our country to extend vase life of these flowers. Only recently, some work has been conducted to extend vase life of cut *Chrysanthemum* flowers in eastern and southern parts of the country. Since, no systematic study has been conducted on this aspect under agro climatic conditions of Kashmir, the present investigations were undertaken to find out the effect of various post harvest chemical treatments on quality and longevity of cut *Chrysanthemum* stem. The results obtained from the investigation are discussed in this chapter.

2. MATERIALS AND METHODS

The present investigation entitled “Effect of post harvest chemical treatments on quality and longevity of cut *Chrysanthemum* cv. Punjab Anuradha” was carried out in the Division of Floriculture and Landscape Architecture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar.

2.1 Treatment Details

Treatments	***Notation***
Su (3%)	T_1
CA (200 ppm)	T_2
CA (400 ppm)	T_3
BA (10 ppm)	T_4
BA (20 ppm)	T_5
AS (50 ppm)	T_6
AS (100 ppm)	T_7
Su (3%) + CA (200 ppm)	T_8
Su (3%) + CA (400 ppm)	T_9
Su (3%) + BA (10 ppm)	T_{10}
Su (3%) + BA (20 ppm)	T_{11}
Su (3%) + AS (50 ppm)	T_{12}
Su (3%) + AS (100 ppm)	T_{13}
Distilled water (control)	T_{14}
No. of Treatments:	**14**

2.2 Preparation of Field, Planting of Cuttings and after Care

The land was dug three times with a garden spade followed by clod breaking and the removal of weeds etc. The field was levelled and well rotten farmyard manure @ 5 kg m^{-2} was applied and thoroughly mixed into the soil. A basal dose of nitrogen, phosphorus and potassium @ 150: 150: 75 kg ha^{-1}, respectively in the form of urea, diamonium phosphate and muriate of potash was applied uniformly a week before planting of rooted cuttings.

Rooted cuttings were dipped in 0.2 per cent Bavistin for 15 min. one day before planting as a protective measure. Uniform size of healthy rooted cuttings were selected and planted at a spacing of 25 x 25 cm (row x plant) in spring 2004.

The cultural practices like weeding-cum-hoeing, irrigation and plant protection measures were carried out as and when needed as per the package of practices.

2.3 Preparation of Chemical Solutions

The required number of conical flasks were washed, weighed and labelled as per schedule of treatments. Then a calculated quantity of each chemical *viz.*, citric acid, benzyladenine and aluminium sulphate were weighed and then dissolved in known quantity of distilled water to make the required concentrations as per plan. Similarly, the sucrose solution of 3 per cent was prepared by dissolving their known quantity of sucrose in distilled water. In addition, one set of flasks containing chemicals were kept as blanks (without stem) for recording the evaporational loss. The latter was negligible, hence no correction factor was incorporated.

2.4 Harvesting, Selection of Cutting of Stems

Fifty cm long sprays of *Chrysanthemum* cv. 'Punjab Anuradha' were harvested in the morning at a stage when the flowers were fully expanded but had not yet shed the pollens. The stems were brought to laboratory with their basal ends dipped in water. The stems were cut to a uniform length of 45 cm under distilled water to remove any surface imbolism. The leaves from the lower part of the stem were removed and five leaves were maintained on each stem. To maintain uniformity, only five flowers were kept on each stem. The stems were immediately transferred to vases containing solutions of sucrose (3%), citric acid (200 and 400 ppm). Benzyleadenine (10 and 20 ppm) and aluminium sulphate (50 and 100 ppm).

The data were recorded for vase life at alternate day. Vase life of the cut stem was considered to be terminated when florets on any three flowers on the stem started showing signs of wilting. Data presented are a mean of 15 stems each representing a replication.

Water uptake (g/stem): The difference between consecutive measurements of the flask + solutions (without the stem) represented the water up take.

$$Wu = [C+S] - [C+S]_2$$

Water loss (transpirational, g/stem): The difference between consecutive measurements of flask + solution + stem represented the water loss

$$W_L \text{ (transp.)} = [C+S+F]_1 – [C+S+F]_2$$

Water loss/water uptake ratio: Transpirational loss of water divided by uptake represented the water loss/water uptake ratio

$$\text{Ratio} = W_L/W_U$$

2.5 Statistical Analysis

Experimental data were subject to statistical analyses and the variation among the treatment means was tested for significance by analyses of variance techniques as described by Gomez and Gomez [3] for CRD. Levels of significance used for 'F' and 't' tests were P=0.05 and P=0.01 from the tables given by Fisher [4]. The standard error of the difference between any two-treatment means and critical difference have been worked out.

3. RESULTS AND DISCUSSION

3.1 Water Uptake (g/stem)

A cursory view of the Table 1 reveals two types of trends in water uptake one is that in the initial day of vase life evaluation water uptake in the treatments involving sucrose is significantly less. The other is the steady decline in uptake by stems in formulations not containing sucrose. Infact 0-2 day interval water uptake in distilled water is at par with treatments involving citric acid only (T_2 and T_3). A similar trend continues for 2-4 and 4-6 day intervals. Sucrose reduces the water potential of the holding solution which accounts for reduced water uptake of stem held in sucrose containing solutions.

Over the period of evaluation, water uptake tapers off steadily in stems held in formulations containing sucrose plus biocide (either citric acid or aluminium sulphate). This is in comparison to the stems held in solutions lacking sucrose where a sudden drop in uptake occurred after day 10. However, uptake in stems held in biocide laced solutions was better than those held in solutions containing sucrose only. In the latter case (T_1) water uptake dropped by more than 50 per cent in between 8-12 day interval. This drop can be attributed to the rapid microbial growth in sucrose solutions lacking biocide.

Comparison among the treatments where sucrose was used in combination with biocide reveals that aluminium sulphate helped to maintain higher water uptake upto the end of the experiment (14-16 day). Aluminium sulphate being an acidifier prevents microbial growth and also prevents vascular blockage. The results are in close agreement with those of Iqbal et al. [5] and Dixit and Shukla [6].

Overall results in Table 1 also indicates that the usefulness of using a biocide in combination with sucrose rather than biocide alone. While sucrose acts as an energy source to power respiration in cut stems biocide checks microbial growth in the holding solution. This could be a reason for higher water uptake in solutions laced with sucrose plus biocide.

Cumulative data revealed that comparatively less uptake by stems dipped in sucrose containing solutions. This could be due to lower water potential in sucrose containing vase solutions. The lowest cumulative uptake was recorded in T_1 (sucrose 3%). This could be because of increased microbial growth at the cut end in presence of sucrose which resulted in vascular blockage. Higher uptake in sucrose less formulations was because of higher water potential.

3.2 Water Loss (g/stem)

Water loss calculated over successive two day interval is presented in Table 3. Overviews of the Table 3 reveal an increase in water loss in the stems upto day 8 in treatments involving sucrose alone or biocide or in control. In treatments where sucrose is used with biocide (citric acid or aluminium sulphate) increasing trend in water loss lasts upto day 10. These trends are in correspondence to the trends in water uptake in the stems (Table 1). A solution, xylem (vessels of stem) and atmosphere continuum exists along the water potential gradient (from solution through xylem vessels in the stem to atmosphere). This means that corresponding to higher water uptake upto day 10 the water loss from the stem was also high. The decline in water loss after 8 or 10 day also corresponds to lower water uptake through stems for the same period.

In T_1 (sucrose 3%) where sucrose was used alone water loss from stems drops approximately by 50 per cent between 6-8 and 8-10 day interval. This corresponds to 50 per cent drop in water uptake in stems (Table 1) for the same period. In treatments where solution contains biocide alone reduction in water loss from stems was steady and evenless dramatic in stems held in solution laced with sucrose in addition to biocide.

Water loss in treatments involving sucrose plus biocide (aluminium sulphate and citric acid) was 3 to 4 fold higher in magnitude than that recorded under control (distilled water) or where biocide was used alone. Aluminium sulphate and citric acid maintain a low solution pH thus reducing microbial blockage of vessels. In addition to this the increased energy from added sucrose which helps stems to maintain a steady metabolism over a longer period. The result was an increased water uptake and corresponding water loss. These results are in close association with Iqbal et al. [5] and Mantur and Nalawadi [7].

Cumulative water loss figures under different treatments vary significantly. Water loss from stems in sucrose containing solutions was significantly less than that from stems held in sucrose less solutions. This can be explained on the basis of less water uptake over the duration of the experiment by the stems held in sucrose containing solutions. Lowest water loss occurs under T_1 (sucrose 3%) which corresponds to lowest water uptake under the same treatment.

3.3 Water Loss/Water Uptake Ratio

Data regarding water loss/water uptake ratio (Table 5) calculated for successive two day intervals reflects the true dynamics of water relation of the stems. An overall view of the Table 5 reveal that ratio for most of the treatments crosses unity or approaches close to it by day 12^{th} of experiment. However, water loss/water uptake ratio in treatments involving sucrose plus biocide remained below unity. This means water budgeting in such stems remains slightly tilted towards water uptake. In other words, water uptake was more than water loss thus reflecting a positive water balance. This favourable water balance in stems was reflected in the overall vase life of the stems. At the end of the experiment ratio for treatments T_{12} and T_{13} (Su 3% + $Al_2(SO_4)$ 50 and 100 ppm) remains less than unity. This can be attributed to the effect of sucrose in maintaining the metabolism and that of aluminium sulphate in keeping down bacteria in solution and consequently preventing xylem blockage. In addition effect of aluminium sulphate in partial stomatal closure also improve water balance in cut stem. The results are in accordance to those found by Iqbal et al. [5]; Murali and Reddy [8].

Table 1. Effect of sucrose and various chemical treatments on daily water uptake (g/stem) of cut *Chrysanthemum*

Treatments		Day							
		(0-2)	**(2-4)**	**(4-6)**	**(6-8)**	**(8-10)**	**(10-12)**	**(12-14)**	**(14-16)**
T_1	Sucrose (3%)	7.43	7.56	7.62	6.63	3.25	1.83	0.53	0.29
T_2	Citric acid (200 ppm)	10.83	10.95	11.13	10.15	7.75	3.65	1.00	0.45
T_3	Citric acid (400 ppm)	10.95	11.15	11.24	10.23	7.93	3.82	1.10	0.52
T_4	Benzyl adenine (10 ppm)	10.46	10.53	10.62	8.21	3.75	2.37	0.75	0.30
T_5	Benzyl adenine (20 ppm)	10.75	10.85	10.87	8.43	5.83	2.50	0.73	0.38
T_6	$Al_2(SO_4)_3$ (50 ppm)	10.68	10.92	11.10	10.15	8.35	4.87	1.15	0.57
T_7	$Al_2(SO_4)_3$ (100 ppm)	10.56	10.72	10.77	9.92	8.14	4.95	1.21	0.62
T_8	Sucrose(3%) + CA (200 ppm)	7.74	7.83	7.91	7.79	7.00	6.10	2.67	0.83
T_9	Sucrose(3%) + CA (400 ppm)	7.83	7.92	8.13	7.85	7.34	6.45	2.83	0.87
T_{10}	Sucrose(3%) + BA (10 ppm)	7.43	7.54	7.57	6.93	6.12	3.65	1.41	0.49
T_{11}	Sucrose(3%) + BA (20 ppm)	7.62	7.65	7.68	7.10	6.15	3.87	1.33	0.55
T_{12}	Sucrose(3%) + $Al_2(SO_4)_3$ (50 ppm)	7.53	7.86	7.91	7.68	7.53	6.63	3.14	1.25
T_{13}	Sucrose(3%) + $Al_2(SO_4)_3$ (100 ppm)	7.45	7.83	7.87	7.43	7.21	6.44	3.00	1.20
T_{14}	Distilled water (control)	10.91	11.24	11.32	9.47	7.13	2.12	0.87	0.38
SE.diff		**0.096**	**0.057**	**0.037**	**1.149**	**0.076**	**0.057**	**0.025**	**0.064**
CD (p=0.05)		**0.197**	**0.118**	**0.076**	**2.354**	**0.156**	**0.118**	**0.052**	**0.132**

Table 2. Effect of sucrose and various chemical treatments on cumulative water uptake (g/stem) of cut *Chrysanthemum* (0-16 day)

Treatment		Water uptake (g/ stem)
T_1	Sucrose (3%)	35.14
T_2	Citric acid (200 ppm)	55.91
T_3	Citric acid (400 ppm)	56.95
T_4	Benzyl adenine (10 ppm)	46.99
T_5	Benzyl adenine (20 ppm)	50.31
T_6	$Al_2(SO_4)_3$ (50 ppm)	57.79
T_7	$Al_2(SO_4)_3$ (100 ppm)	56.89
T_8	Sucrose(3%) + C.A. (200 ppm)	47.87
T_9	Sucrose(3%) + C.A. (400 ppm)	49.25
T_{10}	Sucrose(3%) + B.A. (10 ppm)	41.14
T_{11}	Sucrose (3%) + B.A. (20 ppm)	41.95
T_{12}	Sucrose (3%) + $Al_2(SO_4)_3$ (50 ppm)	49.53
T_{13}	Sucrose (3%) + $Al_2(SO_4)_3$ (100 ppm)	48.43
T_{14}	Distilled water (control)	53.44
S.E. diff		**2.41**
CD (p=0.05)		**4.94**

Table 3. Effect of sucrose and various chemical treatments on daily water loss (g/stem) of cut *Chrysanthemum*

Treatments		Day							
		(0-2)	**(2-4)**	**(4-6)**	**(6-8)**	**(8-10)**	**(10-12)**	**(12-14)**	**(14-16)**
T_1	Sucrose (3%)	5.13	4.97	5.15	5.21	2.86	1.99	0.58	0.35
T_2	Citric acid (200 ppm)	8.28	8.36	8.70	8.70	7.13	3.48	1.00	0.51
T_3	Citric acid (400 ppm)	8.16	8.30	8.44	8.76	7.20	3.57	1.07	0.58
T_4	Benzyl adenine (10 ppm)	7.83	7.81	8.15	6.94	3.42	2.60	0.84	0.38
T_5	Benzyl adenine (20 ppm)	8.00	8.24	8.42	7.08	5.47	2.67	0.81	0.45
T_6	$Al_2(SO_4)_3$ (50 ppm)	8.12	8.20	8.50	8.61	7.45	4.79	1.21	0.65
T_7	$Al_2(SO_4)_3$ (100 ppm)	7.87	7.80	7.87	5.79	7.21	4.79	1.26	0.69
T_8	Sucrose(3%) + CA (200 ppm)	5.41	5.34	5.26	5.68	5.53	5.55	2.67	0.89

Treatments		Day							
		(0-2)	(2-4)	(4-6)	(6-8)	(8-10)	(10-12)	(12-14)	(14-16)
T_9	Sucrose(3%) + CA (400 ppm)	5.53	5.59	5.60	5.68	5.81	5.82	2.78	0.92
T_{10}	Sucrose(3%) + BA (10 ppm)	5.23	5.29	5.45	5.29	5.00	3.48	1.50	0.53
T_{11}	Sucrose (3%) + BA (20 ppm)	5.23	5.20	5.35	5.35	5.03	3.60	1.40	0.60
T_{12}	Sucrose (3%) + $Al_2(SO_4)_3$ (50 ppm)	5.12	5.29	5.10	5.25	5.60	5.76	2.97	1.15
T_{13}	Sucrose (3%) + $Al_2(SO_4)_3$ (100 ppm)	5.17	5.37	5.15	5.07	5.34	5.69	2.88	1.12
T_{14}	Distilled water (control)	8.14	8.47	8.72	8.22	6.88	2.48	1.03	0.48
SE.diff		**0.027**	**0.030**	**0.028**	**0.029**	**0.024**	**0.029**	**0.027**	**0.027**
CD (p=0.05)		**0.055**	**0.062**	**0.057**	**0.060**	**0.050**	**0.060**	**0.055**	**0.055**

Table 4. Effect of sucrose and various chemical treatments on cumulative water loss (g/stem) of cut *Chrysanthemum* (0-16 day)

Treatment		Cumulative water loss (g/stem)
T_1	Sucrose (3%)	26.32
T_2	Citric acid (200 ppm)	46.16
T_3	Citric acid (400 ppm)	46.08
T_4	Benzyl adenine (10 ppm)	37.97
T_5	Benzyl adenine (20 ppm)	41.14
T_6	$Al_2(SO_4)_3$ (50 ppm)	47.53
T_7	$Al_2(SO_4)_3$ (100 ppm)	45.67
T_8	Sucrose (3%) + C.A. (200 ppm)	36.44
T_9	Sucrose (3%) + C.A. (400 ppm)	37.73
T_{10}	Sucrose (3%) + B.A. (10 ppm)	31.77
T_{11}	Sucrose (3%) + B.A. (20 ppm)	31.76
T_{12}	Sucrose (3%) + $Al_2(SO_4)_3$ (50 ppm)	36.24
T_{13}	Sucrose (3%) + $Al_2(SO_4)_3$ (100 ppm)	35.79
T_{14}	Distilled water (control)	44.42
SE.diff		**1.53**
CD (p=0.05)		**3.13**

Table 5. Effect of sucrose and various chemical treatments on daily water loss/water uptake ratio of cut *Chrysanthemum*

Treatments		Day							
		(0-2)	(2-4)	(4-6)	(6-8)	(8-10)	(10-12)	(12-14)	(14-16)
T_1	Sucrose (3%)	0.69	0.66	0.67	0.78	0.88	1.08	1.09	1.20
T_2	Citric acid (200 ppm)	0.76	0.76	0.78	0.86	0.92	0.95	1.00	1.13
T_3	Citric acid (400 ppm)	0.74	0.74	0.75	0.85	0.91	0.93	0.97	1.11
T_4	Benzyl adenine (10 ppm)	0.75	0.71	0.77	0.84	0.91	1.09	1.12	1.26
T_5	Benzyl adenine (20 ppm)	0.74	0.76	0.77	0.84	0.94	1.07	1.11	1.18
T_6	$Al_2(SO_4)_3$ (50 ppm)	0.76	0.75	0.76	0.85	0.89	0.98	1.05	1.14
T_7	$Al_2(SO_4)_3$ (100 ppm)	0.74	0.73	0.73	0.58	0.88	0.97	1.04	1.11
T_8	Sucrose (3%) + CA (200 ppm)	0.69	0.68	0.66	0.73	0.79	0.91	1.00	1.07
T_9	Sucrose (3%) + CA (400 ppm)	0.70	0.70	0.69	0.72	0.79	0.90	0.98	1.06
T_{10}	Sucrose (3%) + BA (10 ppm)	0.70	0.70	0.72	0.76	0.82	0.95	1.06	1.08
T_{11}	Sucrose (3%) + BA (20 ppm)	0.69	0.68	0.69	0.75	0.82	0.93	1.05	1.09
T_{12}	Sucrose (3%) + $Al_2(SO_4)_3$ (50 ppm)	0.68	0.67	0.64	0.68	0.74	0.86	0.95	0.92
T_{13}	Sucrose (3%) + $Al_2(SO_4)_3$ (100 ppm)	0.69	0.68	0.65	0.68	0.74	0.88	0.96	0.93
T_{14}	Distilled water (control)	0.74	0.75	0.77	0.86	0.96	1.17	1.18	1.26

4. CONCLUSION

$Al_2(SO_4)_3$ in combination with sucrose 3 % improved water uptake, reduced water loss, maintain water balance, better water relations, increased fresh weight gain thereby increased vase life by delaying senescence of cut *Chrysanthemum* stems. Also maintained greater chlorophyll content and relative content at the end of vase life. $Al_2(SO_4)_3$ 50 ppm + sucrose 3 % and $Al_2(SO_4)_3$ 100 ppm proved the best combination compared to other treatments.

ACKNOWLEDGEMENTS

Authors wish to thanks SKUAST-Kashmir for providing the necessary facilities during the course of investigation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anderson NO. Reclassification of the genus *Chrysanthemum* L. HortScience. 1987;22(2):313.
2. Kitamura S. *Dendranthemaat nipponanthema*. Acta Phytotaxonomica et Geobotanica. 1978;29:165-170.
3. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2nd Ed.). John Wiley and Sons, Inc., New York; 1984.
4. Fisher RA. Statistical methods for research workers (14th Ed.). Oliver and Boyd Ltd., London; 1970.
5. Iqbal S, Siddique MAA, Masoodi N, Masoodi M, Wani MA, Din A. Differential cultivar response to chemical preservative treatment for better shelf life in Narcissus (Daffodil). Res. on Crops. 2016;17(3):584-589.
6. Dixit AK, Shukla PK. Effect of chemicals on vase life of gladiolus and annual *Chrysanthemum*. Orissa Journal of Horticulture. 2005;33(1):106-107.
7. Mantur SM, Nalawadi UG. Effect of chemical preservatives on vase life of China aster cut flowers. South Indian Horticulture. 1989;37(6):361-363.
8. Murali TP, Reddy TV. Post harvest life of gladiolus as influenced by sucrose and metal salts. Acta Horticulturae. 1993;343: 313-320.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26883