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Full Length Research Paper

Studies on chemical solutions and storage duration on keeping quality of cut gladiolus (*Gladiolus grandiflorus* L.) spikes (‘White Prosperity’)

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The experiment was carried out to investigate the effect of different chemical solutions (C_1= sucrose (20%) + [$Al_2 (SO_4)_3$.-16H_2O 300 ppm], C_2= sucrose (20%) + [$Al_2 (SO_4)_3$.-16H_2O] 300 ppm + GA_3 50 ppm and C_3= Control (Distilled water)) and five storage durations viz., (S_0 = 0 days, S_1 = 7 days, S_2 = 14 days, S_3 = 21 days and S_4 = 28 days) on keeping quality of cut spikes of gladiolus ‘White Prosperity’. The results showed that chemical solutions as well as storage durations significantly influenced the studied parameters. Among the chemical solutions, C_2 was significantly superior with regard to days to open basal floret, vase life, number of florets opened, floret size, longevity of open florets and fresh weight gain/loss, while the lowest values of these parameters were recorded in control treatment. Similarly, shorter storage durations of 0 days (S_0) recorded higher vase life, longevity of open floret and total water absorption, while days to open the basal floret and floret size were superior in S_3 storage and rest of the parameters were significantly higher in S_2 storage duration. The spikes stored in S_4 treatment did not open either pulsed with chemical solutions or in control.

Key words: Aluminium sulphate, gladiolus, gibberellic acid, sucrose, storage duration, quality parameters.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is an important ornamental and commercial flower known as queen of the bulbous plants, belongs to *Iridaceae* family and is valued for its wide range of flower colours, attractive shapes, varying sizes, large number of florets per spike, excellent keeping quality and popular as cut flower in the domestic and international market. Gladiolus is grown under varying climatic conditions and its spikes possess good vase life with variously-coloured elegant florets, which open in an acropetal succession.

Keeping quality is an important parameter for the evaluation of cut flower quality, for both domestic and export markets. One of the greatest problems in postharvest flower physiology is the blockage of vascular

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system, due to air or bacterial growth, which reduces water uptake and this blocks xylem vessels leading to water stress (Van Meetern et al., 2001) that expresses in the form of early wilting of flowers (Henriette and Clerkx, 2001), as a result of premature loss of cell turgidity and might appear when water uptake and transpiration are out of balance during a lasting. Adding chemical preservatives to the holding solution is recommended to prolong the vase life of the cut flowers. All holding solutions must contain essentially two components; sugar and germicides. The sugar provides a respiratory substrate, while the germicides control harmful bacteria and prevent plugging of the conducting tissues. Among all the different types of sugars, sucrose has been found to be the most commonly used sugar in prolonging vase life of cut flowers. The exogenous application of the sucrose supplies the cut flowers with substrates needed for respiration, and enables cut flowers harvested at the bud stage to open, which otherwise could not occur naturally (Pun and Ichimura, 2003). Cut flowers should be free of any deterioration, as this is one of the principal entry points for decay organisms. A major form of deterioration in cut flowers is the blockage of xylem vessels by air and microorganisms that cause xylem occlusion (Hardenburg, 1968). The $Al_2(SO_4)_3$ is a very important germicide in preservatives used in floral industry and acts as an antimicrobial agent which can led to increase water uptake. Its application increases the vase life as well as the fresh weight (percentage of initial) of the cut flowers and prevent the growth of the microorganisms in xylem vessels of the cut flower stems and maintained water uptake and becomes more effective when sugars particularly sucrose are coupled with it (Pun and Ichimura, 2003). On the other hand, gibberellic acid (GA_3) helps in breaking dormancy, stimulates the synthesis of specific RNA for protein metabolism. Cut flowers are living actively metabolizing plant parts and petals are an excellent model system for the study of fundamental senescence processes. If flowers are to provide their longest possible decorative role, controlled rate of opening or their development is needed with colour stability. The objective of this work was to investigate the effect of storage duration and chemical solutions on keeping quality of cut gladiolus 'White Prosperity' spikes especially when used for flower arrangements and interior decorations.

MATERIALS AND METHODS

The present work was conducted at the Laboratory of Floriculture, Medicinal and Aromatic Plants, Faculty of Horticulture, S. K. University of Agricultural Sciences and technology of Kashmir, Srinagar, J&K, India during 2014. Experiment was arranged in a complete randomized design with four replications. Five spikes were used per replication. Spikes of gladiolus 'White Prosperity' were harvested from the field-grown crop, at tight bud stage (when colour was visible in basal 1-2 florets) and stored under wet refrigerated conditions (3.5 to 4.0°C temperature; 85 to 90% R.H.) for 0, 7, 14, 21 and 28 days. The spikes were subjected to three treatments with chemical solution. In treatment 1 (C_1) the spikes were subjected to pre-storage treatment with pulsing solution containing sucrose (20%) + $Al_2(SO_4)_3$.-$16H_2O$ (300 ppm) for 20 h at 23±2°C temperature, 60 to 70% relative humidity and 24 h illumination (1000 lux intensity) provided by white fluorescent tubes, in an air-conditioned laboratory, held in water during storage. In treatment 2 (C_2), the spikes were treated with chemical solution containing sucrose (20%) + $Al_2(SO_4)_3$.-$16H_2O$ (300 ppm) + GA_3 50 ppm and in treatment 3 (C_3) the spikes were subjected to distilled water i.e. control treatment. The treatments were given by dipping basal 5 to 7 cm portions of the spikes in the respective solution.

The observations were recorded on days for basal floret to open, vase life (days), florets opened (%), floret size (cm), longevity of open floret (days) and per cent change in fresh weight after storage. The results were interpreted according to Steel and Torrie (1980) and the differences between the means of the treatments were considered significant when they were equal or more than the least significant difference (L.S.D.) at the 5% level.

RESULTS AND DISCUSSION

Effect of chemical solution

The results of the experiment revealed that pre-storage pulse treatment recorded superior keeping quality characters of gladiolus cut spikes as compared to control treatment. Perusal of data (Table 1) showed that C_2 treatment took significantly less days to open basal florets which was followed by C_1 and maximum days were taken by C_3 (control). It has earlier been reported that pulsing treatment with 20% sucrose as well as vase solution containing 4% sucrose took significantly less days to open basal florets of cut gladiolus spikes (Singh et al., 2007). Sucrose is reported to promote microbial growth in vase solution but when applied in combination with $Al_2(SO_4)_3$.-$16H_2O$ (400 mg l^{-l}), it significantly improved vase life and opening of florets in gladiolus due to inhibition of microbial contamination of vase solution (Singh et al., 2000). Among the treatments vase life was enhanced significantly more than double by C_1 (8.57 days) as compared to 4.06 days recorded by control (C_3), while C_2 recorded 7.53 days vase life. Significantly highest percentage of florets opened and floret size was recorded in C_2, whereas minimum values of these parameters were exhibited by control treatment. These results might be due to the presence of sucrose in the solution that had acted as a food source or respiratory substrate and delayed the degradation of proteins and improved water balance of cut flowers. Steinitz (1982) opined that addition of sucrose to the solution increased the mechanical rigidity of the stem inducing cell wall thickening and lignifications of vascular tissues. Sucrose antagonized the effect of ABA, which promoted senescence. Sugars alone, however, tend to promote microbial growth, therefore, the combination of $Al_2(SO_4)_3$ improved the vase life of cut flowers as $Al_2(SO_4)_3$ is a very effective biocide, which completely inhibited the microbial growth. However, dilute solution of sucrose

Table 1. Effect of dry refrigerated storage of cut gladiolus 'White Prosperity' spikes with pre-storage pulsing treatment for 24 h).

Treatment	Days for basal floret to open	Vase life (days)	No. of florets opened (%)	Floret size (cm)	Longevity of open floret (days)	Per cent gain/loss in FW after storage	Total water absorbed (ml spike^{-1})
Chemical solution (C)							
*Su (20%)+ **AS 300 ppm - (C_1)	1.19	8.57	63.66	9.02	3.88	1.12	42.40
Su (20%)+AS 300 ppm+ GA_3 50 ppm - (C_2)	1.02	7.53	66.86	9.28	4.30	1.23	45.09
Control (Distilled water) - (C_3)	1.58	4.06	57.37	7.87	2.79	0.38	28.90
CD (P = 0.05)	**0.06**	**0.14**	**0.61**	**0.13**	**0.07**	**0.09**	**1.23**
Storage duration (S)							
0 days (S_0)	2.36	10.16	84.66	11.61	6.03	0.00	69.11
7 days (S_1)	1.80	9.66	89.22	11.97	5.28	2.98	55.64
14 days (S_2)	1.30	8.33	77.88	10.64	4.13	2.00	44.61
21 days (S_3)	0.86	5.33	61.38	9.39	2.85	0.94	19.63
28 days (S_4)	0.00	0.00	0.00	0.00	0.00	-1.35	5.00
CD (P = 0.05)	**0.10**	**0.21**	**1.07**	**0.27**	**0.17**	**0.15**	**2.13**

*Su = Sucrose, ** AS = Aluminum Sulphate = $Al_2(SO_4)_3$.

provided ideal media for microbial growth. The microbes entered into the vascular bundles and might block the water uptake, thus affecting the keeping quality of cut spikes in vase solution. Further, Grover (2001) reported that maximum floret opening might be due to the higher soluble sugars in the buds and cell division and cell elongation by GA_3 by promoting DNA synthesis in the cell. The present findings are in close agreement with the earlier reports of Namita and Singh (2006); Nelofar and Paul (2008); Marandi et al. (2011); Mehraj et al. (2013) and Mahawar et al. (2015).

Longevity of the open floret was significantly higher in C_2 over other treatments. Such increase in longevity might be attributed that aluminum sulfate inhibited the action of ethylene and leading to a decrease in lipoxygenase (Lox) activity as well as served as an antibacterial component and prevented the growth of microorganism in the xylem and thus maintained water uptake by flower stems (Sarkka, 2005), while sucrose reduced the initial water uptake due to the decrease in osmotic potential of sucrose solution. In addition, sucrose inhibited ethylene synthesis as well as promoting bud opening and inhibiting flower senescence (Ichimura and Hisamatsu, 1999). The present findings are in conformity with the earlier reports of Singh et al. (2007), Nelofar and Paul (2008) and Seyf et al. (2012).

Treatment C_2 exhibited significantly higher gain in fresh weight over other treatments. Similarly, the same treatment recorded the highest total water absorption, while the lowest water absorption was recorded in C_3 (control) treatment. Nelofar and Paul (2008) also reported gain in fresh weight of gladiolus 'White Prosperity' spikes in combined treatment of sucrose and aluminum sulphate. These results might be due to maximum uptake of water by the flowers as influenced by pulsing and germicidal properties of aluminum sulphate in addition to inhibition of ethylene biosynthesis which resulted in gain in fresh weight.

Effect of storage duration

Pulsed spikes of gladiolus held in different dry storage durations varied significantly for keeping quality characters, however, cut spikes kept for 28 days long duration (S_4) did not open florets, hence data on most of the floret quality parameters wasn't recorded for this treatment. The data presented in Table 1 revealed that S_3 storage took minimum 0.86 days to open the basal floret which was closely followed by S_2, whereas, S_4 spikes did not open either pulsed with chemical solutions or in control. It has earlier been reported that the florets of gladiolus lose the ability to open with advancement in the duration of storage (Arora et al., 2001). Significantly maximum vase life was exhibited by S_0 (10.16 days), followed by S_1, S_2

and S_3 recording 9.66, 8.33 and 5.33 days, respectively. Highest percentage of florets opened was recorded in S_1 (89.22%) treatment and the same treatment exhibited significantly highest floret size (11.97 cm), whereas the lowest floret size was measured in S_3 treatment (9.39 cm). The storage duration of S_0 was significantly superior with regard to the longevity of open floret (6.03 days) over other treatments which was closely followed by S_1, S_2 and S_3 with 5.28, 4.13 and 2.85 days, respectively. Percent gain in fresh weight was observed maximum by S_1 (2.98%) while S_4 spikes recorded loss in fresh weight (-1.35%) after storage. Similarly, total water absorbed was measured significantly highest by S_0 (69.11 ml spike^{-1}). The present findings are in agreement with the earlier reports of Nelofar and Paul (2008).

Conflict of Interest

The authors have not declared any conflict of interest.

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