Improving the Keeping Quality and Vase Life of Cut Alstroemeria Flowers by Pre and Post-harvest Salicylic Acid Treatments

Elnaz SOLEIMANY-FARD1,*, Khodayar HEMMATI1, Ahmad KHALIGHI1

1Department of Horticulture Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran; Elnazsoleimany@gmail.com (* corresponding author)
2Department of Horticulture Sciences, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

Abstract

Keeping quality and length of vase life are important factors for evaluation of cut flowers quality, for both domestic and export markets. Studding the effect of pre- and post-harvest salicylic acid applications on keeping quality and vase life of cut alstroemeria flowers during vase period is the approach taken. Aqueous solutions of salicylic acid at 0.0 (with distilled water), 1, 2 and 3 mM were sprayed to run-off (approximately 500 mL per plant), about two weeks before flowers harvest. The cut flowers were harvested in the early morning and both of cut flowers treated (sprayed) and untreated were kept in vase solutions containing salicylic acid at 0.0 (with distilled water), 1, 2 and 3 mM. Sucrose at 4% was added to all treatments as a base solution. The changes in relative fresh weight, water uptake, water loss, water balance, total chlorophyll content and vase life were estimated during vase period. The results showed that the relative fresh weight, water uptake, water balance, total chlorophyll content and vase life decreased significantly while the water loss increased significantly during experiment for all treatments. A significant difference between salicylic acid and control treatments in all measured parameters is observed. During vase period, the salicylic acid treatments maintained significantly a more favourable relative fresh weight, water uptake, water balance, total chlorophyll content and suppressed significantly water loss, as compared to control treatment. Also, the results showed that the using salicylic acid increased significantly the vase life cut alstroemeria flowers, over control. The highest values of measured parameters were found when plants were treated by pre + post-harvest application of salicylic acid at 3 mM. The result revealed that the quality attributes and vase life of cut alstroemeria flowers were improved by the use of salicylic acid treatment.

Keywords: alstroemeria, properties, total chlorophyll, vase period, water relations

Introduction

Alstroemeria is a member of the Alstroemeriaceae family and is one of the very important in global cut flowers production. It is widely used as cut flowers because the flowers are available in numerous colours like yellow, orange, pink through scarlet to purple and violet (Norbaek et al., 1996). Leaf yellowing associated with early senescence is a major problem in alstroemeria, which may occur within a few days and proceeds very rapidly (Mutui et al., 2001). Senescence of cut flowers may depend on many factors such as; water stress (Sankat and Mujaffar, 1994), carbohydrate depletion, microorganisms (Witte and Van Doom, 1991) and ethylene effects (Wu et al., 1991; Da Silva, 2003).

Short postharvest vase life is one of the most important problems on the cut flowers. The maintenance of vase life is an important quality attribute in these economically significant cut flowers. A suitable method for vase life extension, which easy to use, natural, safe and inexpensive compounds is always crucial in this respect for large-scale applications. A number of strategies have been used to maintaining good quality and extending the vase life of cut alstroemeria flowers such as; treatments with silver thiosulphate (STS) (Nowak and Rudnicki, 1990), gibberellins (GA) and cytokinins (CK) (Hickleton, 1991; Jordi et al., 1995; Mutui et al., 2003), acetyl (BA+GA20), (Mutui et al., 2001) and thidiazuron (TDZ) (Ferrante et al., 2002).

Recently, there is an increasing interest in the use of natural compounds for maintenance of cut flowers quality and extension of vase life. Salicylic acid (SA), a widely distributed compound in plants, belongs to a group of phenolic compounds. Salicylic acid could be considered as an endogenous plant growth regulator involved in the regulation of plant growth, development and disease resistance mechanisms (Hayat et al., 2010; Luo et al., 2011). Also, salicylic acid has been found to suppress ACC-oxidase activity that is the direct precursor of ethylene and decrease ROS (Reactive Oxygen Species) with increasing antioxidant enzyme activity (Ansari and Misra, 2007; Mba et al., 2007; Mahdavian et al., 2007; Canakci, 2008; Kalidage, 2009). Numerous authors have reported the application of salicylic acid at different concentration extended vase life in cut flowers of rose (Zamani et al., 2011), gerbera and lily (Kazemi et al., 2011 a and b), carnation (Kazemi and Ameri, 2012) and chrysanthemum (Vahdati et al., 2012).
Salicylic acid treatment has the potential for maintenance of cut flowers quality and extension of vase life. However, little information exists on the use of salicylic acid on keeping quality and vase life improvement of cut alstroemeria flowers. Therefore, the objective of this research was to analyse and compare the effect of pre- and post-harvest salicylic acid applications on keeping quality and vase life of cut alstroemeria flowers during vase period.

Materials and methods

Plant material and treatments

Alstroemeria (cv. 'Tampa') flowers were obtained from local commercial greenhouses (Mashhad, Iran). Plants were grown in under standard greenhouse conditions with 22 and 16°C day and night temperatures, respectively. Solutions of salicylic acid at 0.0 (with distilled water), 1, 2 and 3 mM were sprayed to run-off (approximately 500 mL per plant), about two weeks before flowers harvest. The cut flowers were harvested in the early morning and transported with appropriate cover (in plastic packages) immediately to laboratory. Then cut flowers were re-cut under water to 30 cm length. The both of cut flowers treated (sprayed) and untreated were placed in the glass vials 300 ml solutions containing salicylic acid at 0.0 (with distilled water), 1, 2 and 3 mM. Sucrose at 4% was added to all treatments as a base solution. The flowers were kept in a controlled room at 19±2°C, 70±5% relative humidity and 12 μmol m⁻² s⁻¹ light intensity (cool-white fluorescence lamps) under a daily light period of 12 h. The period from the first day (0 day) when cut flowers were placed in vase solutions, until they lost their ornamental value were investigated traits.

Relative fresh weight, water uptake, water loss and water balance

Relative fresh weight, water uptake, water loss and water balance were recorded 2 days intervals by measuring weights of vases without flowers and of flowers separately (He et al., 2006). Relative fresh weight of stems (flowers+leafy) was calculated as: relative fresh weight (%) = (Wᵢ / Wᵢ₋₀) × 100; where, Wᵢ is weight of stem (g) at t = days 0, 2, 4, etc., and Wᵢ₋₀ is weight of the same stem (g) at t = day 0. Water uptake was calculated as: water uptake (g stem⁻¹ day⁻¹) = (Sᵢ₋₁ − Sᵢ); where, Sᵢ is weight of vase solution (g) at t = days 0, 2, 4, etc., and Sᵢ₋₁ is weight of vase solution (g) on the previous day. Water loss was calculated as: water loss (g stem⁻¹ day⁻¹) = (Cᵢ₋₁ − Cᵢ); where, Cᵢ is the combined weights of the cut stem and vase (g) at t = days 0, 2, 4, etc., and Cᵢ₋₁ is the combined weights of the stem and vase (g) on the previous day. Water balance (g stem⁻¹ day⁻¹) was calculated as water uptake from the vase minus water loss from the stem.

Total chlorophyll

Total chlorophyll content was determined (2 days intervals) by chlorophyll meter (SPAD-502 Konica, Minolta, Tokyo), which is presented by SPAD values. Average of 3 measurements from different spots of a single leave was considered (Kazemi and Ameri, 2012).

Vase life

Vase life was assessed as the number days to wilting of flowers. The flowers were checked once a day for signs of deterioration.

Results and discussion

Relative fresh weight

As shown in Fig. 1, relative fresh weight increased significantly during the first 4 days of experiment and from this time until end of the experiment decreased significantly. Similar patterns of changes were also reported for cut rose flowers (Lu et al., 2010; Alaey et al., 2011). A variation in terms of relative fresh weight was observed among the treatments and the differences were statistically significant (p < 0.05). The relative fresh weight was affected by salicylic acid treatments, since control cut flowers had significantly lower relative fresh weight during experiment, while the highest levels were obtained with 3 mM salicylic acid treatment (Fig. 1). Kazemi and Ameri (2012) showed that the treated cut gerbera flowers with salicylic acid had the highest levels of relative fresh weight during vase period. Also, the data indicates that among the presently tested treatments, pre + post-harvest application of salicylic acid is found to be more effective in increasing relative fresh weight of cut alstroemeria flowers during vase period than in the post-harvest application of salicylic acid (Fig. 1).

The decrease in relative fresh weight of cut flowers during the days of after harvest could be due to the decrease in water uptake (Biesleski and Reid, 1992; Serek et al., 1995). Alaey et al. (2011) reported that the highest relative fresh weight of cut rose flowers was observed in vase solutions which showed the greatest water uptake. In this experiment, all treatments showed decreases in relative fresh weight, although these decreases were significantly lower in treatments of salicylic acid than in the control treatment. This effect can be attributed to the acidifying and stress alleviating properties of salicylic acid, thereby enhancing
water uptake and relative fresh weight of cut flowers (Vahdati et al., 2012).

**Water uptake**

The results showed that the water uptake increased significantly during the first 4 days of after harvest and from this time until end of the experiment decreased significantly (Fig. 2). The results were in agreement with the findings reported by Lu et al. (2010) on cut rose flowers (cv. ‘Movie Star’). Significant differences ($p < 0.05$) were revealed among the treatments for water uptake. The treatments of salicylic acid showed significantly highest water uptake than in the control treatment during experiment. The higher the salicylic acid concentration applied, the greater the improvement in water uptake, that highest water uptake values were observed in 3 mM salicylic acid treatment (Fig. 2). Similar results were also reported for cut flowers of rose (Alaey et al., 2011; Zamani et al., 2011) and gerbera (Kazemi et al., 2011a). In relation to water uptake, pre + post-harvest salicylic acid application was more effective on increasing water uptake of cut alstroemeria flowers during experiment, as compared to application of post-harvest salicylic acid (Fig. 2).

Previous study had revealed that the pathogens affect water uptake due to vascular blockage (Vahdati et al., 2012). The decrease in water uptake of cut flowers during vase period was probably due to growth of microbes and vascular blockage. Anjum et al. (2001) suggested adding a suitable germicide in vase solution can prevent the growth of microbes and increased water uptake. During vase period, the salicylic acid treatments maintained significantly a more favourable water uptake than in the control treatment. Salicylic acid can be decreased pH of vase solution and consequently, the growth and proliferation of bacteria was reduced, which led to increase water uptake (Raskin, 1992).

**Water loss**

The water loss increased significantly during experiment, that the water loss levels at the initial of the after harvest were higher than the end ones just (Fig. 3). Our results were in agreement is in agreement with Lu et al. (2010) who reported that the water loss of cut rose flowers increased significantly after harvest. As shown in Fig. 3, a significant variation in water loss was found among the studied treatments. The lowest levels of water loss was observed for 3 mM salicylic acid treatment during vase period.

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**Fig. 1.** Effect of pre + post-harvest and post-harvest applications of different concentrations of salicylic acid on relative fresh weight (% of initial) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

**Fig. 2.** Effect of pre + post-harvest and post-harvest applications of different concentrations of salicylic acid on water uptake (g stem$^{-1}$ day$^{-1}$) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.
Their effects on water balance levels. Among the studied treatments, 3 mM salicylic acid treatment had the highest amount of water balance and control treatment had the lowest water balance content during experiment (Fig. 4). Also, the data indicated that the application of pre + post-harvest salicylic acid was more effective than in the post-harvest salicylic acid application in change of water balance values during vase period (Fig. 4).

During vase period, the decrease in water balance of cut flowers in association with a lower water uptake and high water loss. In the current research, salicylic acid treatments maintained a more favourable water uptake and suppressed water loss than in the control treatment. This effect salicylic acid may be due to antimicrobial activity (inhibiting vascular blockage), increases the water uptake (Mori et al., 2001) and decrease in transpiration rate (Mei-hua et al., 2008).

**Water balance**

The results in this experiment showed that the water balance decreased significantly during experiment (Fig. 4). Reduction in the water balance during vase period is in agreement with Lu et al. (2010) who reported that the water balance of cut rose flowers declined almost linearly with vase time. There was a significant difference \( p < 0.05 \) between control and salicylic acid treatments in terms of their effects on water balance levels. Among the studied treatments, 3 mM salicylic acid treatment had the highest amount of water balance and control treatment had the lowest water balance content during experiment (Fig. 4).

According to Van Doorn (1997), water deficit in a cut stem standing in vase solution will develop when the rate of water uptake is lower than the rate of transpiration. In our experiment, salicylic acid treatments supressed significantly water loss than in the control treatment. It was assumed that the effect of salicylic acid treatment on lower of water loss could be due to the increasing water uptake (Raskin, 1992) as well as decrease in transpiration rate (Mei-hua et al., 2008).

**Total chlorophyll**

According to results shown in Fig. 5, the total chlorophyll content decreased significantly during experiment, that the levels of total chlorophyll at the initial of the after harvest were higher than the end ones just. The results...
The significant differences \((p < 0.05)\) were revealed among the treatments for vase life, that the control treatment had the lowest vase life and 3 mM salicylic acid treatment had the highest vase life after harvest (Fig. 6). With respect to the results, using salicylic acid treatment increased significantly the vase life cut alstroemeria flowers, as compared to control treatment during experiment. Previous researches had revealed that the salicylic acid treatments significantly extend the vase life of cut flowers (Mei-hua et al., 2008; Yuting, 2009; Kazemi et al., 2011a and b; Zamani et al., 2011; Vahdati et al., 2012), that is in agreement with our results. As shown in Fig. 6, application of pre + post-harvest salicylic acid is found to be more effective in extending vase life of cut alstroemeria flowers after harvest than in the post-harvest salicylic acid application.

The short vase life of cut flowers was caused by poor water relations in association with a lower water uptake (probably due to growth of microbes and vascular blockage), high rate of transpiration and water loss. The data indicated that the salicylic acid treatments increased significantly vase life of cut alstroemeria flowers than in the control treatment. This effect of salicylic acid is might be due to inhibited ethylene action, as compared to control treatment.

![Fig. 5. Effect of pre + post-harvest and post-harvest applications of different concentrations of salicylic acid on total chlorophyll (SAPD) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors](image)

**Vase life**

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![Fig. 6. Effect of pre + post-harvest and post-harvest applications of different concentrations of salicylic acid on vase life (days) of cut alstroemeria flowers in experiment. The results represent the means of 12 cut flowers in 4 replicates ± standard errors](image)
water loss (Raskin, 1992; Mori et al., 2001), inhibiting ethylene action (Zamani et al., 2010) and decrease in transpiration rate (Mei-hua et al., 2008).

Conclusions

The naturally short vase life of the cut flowers is one of the most important problems. The using of different treatments is recommended to keeping quality and extending the vase life of cut flowers. In this study, influence of salicylic acid pre and post-harvest applications on keeping quality and vase life of cut alstroemia flowers during vase period were investigated. This research showed that the same behaviour in all measured factors after harvest for all treatments. The relative fresh weight, water uptake, water balance, total chlorophyll content and vase life decreased significantly while water loss increased significantly during vase period. In addition, statistically significant differences were observed between control and salicylic acid treatments in all measured parameters. In terms of overall performance, application of pre + post-harvest salicylic acid is found to be more effective than in the post-harvest salicylic acid application. Exogenous salicylic acid treatment is able to increase vase life of cut alstroemia flowers by regulating the plant water and increasing total chlorophyll content. Thus, the data suggest that salicylic acid treatment has the potential to be used commercially to extend the vase life of cut alstroemia flowers.

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