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Impact of Pre- and Post-harvest Putrescine Applications on Water Relations and Vase Life of Cut Alstroemeria Flowers

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ABSTRACT

The goal of this study was to investigate and compare the effect of pre- and post-harvest putrescine applications on keeping quality and vase life of cut alstroemeria flowers during vase period. Aqueous solutions of putrescine 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 putrescine at 0.0 (with distilled water), 1, 2 and 3 mM. Sucrose at 4% was added to all treatments as a base solution. During vase period, the changes in relative fresh weight, water uptake, water loss, water balance, total chlorophyll content and vase life were estimated. The data indicated that 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 all treatments. Also, statistically significant differences were observed between control and putrescine treatments in all measured parameters. The putrescine treatments maintained significantly a more favourable relative fresh weight, water uptake, water balance, total chlorophyll content and supressed significantly water loss, as compared to control treatment during vase period. Also, the results showed that the using putrescine treatment increased significantly the vase life cut alstroemeria flowers, over control. In terms of overall performance, application of pre + post-harvest putrescine is found to be more effective than in the post-harvest putrescine application. It was concluded that treatment of cut alstroemeria flowers with putrescine were effective on keeping quality and can be used commercially to extend the vase life of cut alstroemeria flowers with acceptable quality.

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INTRODUCTION

The production of cut flowers is of big economic interest in the world and its production has been rapidly increasing in recent years. During the last two decades, alstroemeria has been one of the very important in global cut flowers production [13]. It is in considerable demand in both domestic and export markets because the flowers are available in numerous colours like yellow, orange, pink through scarlet to purple and violet [18]. One of the predominant postharvest problems of cut alstroemeria flowers is leaf yellowing associated with early senescence, which may occur within a few days and proceeds very rapidly [16]. Senescence of cut flowers is induced by several factors such as; water stress [20], carbohydrate depletion, microorganisms [24] and ethylene effects [4,25].

Keeping quality and length of vase life are important factors for evaluation of cut flowers quality, for both domestic and export markets. Little research has been done on maintaining good quality and extending the vase life of cut alstroemeria flowers. Recent works studied treatments with silver thiosulphate (STS) [19], gibberellins (GA), cytokinins (CK) [9,10,17], accel (BA+GA_{4+7}) [16], thidiazuron (TDZ) [5], ethanol, methanol and essential oils [15].

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. Recently, there is an increasing interest in the use of natural compounds for maintenance of quality and vase life extension of cut flowers. Polyamines (PAs) are known as a group of natural compounds with aliphatic nitrogen structure that are ubiquitous in plants, animals

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and microorganisms. The major polyamines are found in every plant cell such as; spermidine (Spd), spermine (Spm) and putrescine (Put) [6]. It is known that polyamines play important roles in many physiological processes in plants including; growth and development of cell and respond to environmental stresses. Treatment with exogenous putrescine has been reported that the increased vase life, flowers yield, inflorescence diameter, total carbohydrates, total chlorophyll and carotonoids in chrysanthemum [11].

It was assumed that polyamines treatment has the potential for maintenance of quality and vase life extension of cut flowers. However, little information exists on the use of putrescine 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 putrescine applications on keeping quality and vase life of cut alstroemeria flowers during vase period.

MATERIALS AND METHODS

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 putrescine 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 putrescine 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 temperature, 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 (o day) when cut flowers were placed in vase solutions, until they lost their ornamental value were investigation traits.

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 [8]. Relative fresh weight of stems (flowers+leafy) was calculated as: relative fresh weight (%) = $(W_t/W_{t-0}) \times 100$; where, W_t is weight of stem (g) at t = days 0, 2, 4, etc., and W_{t-0} is weight of the same stem (g) at t = day 0. Water uptake was calculated as: water uptake (g $stem^{-1}$ day^{-1}) = $(S_{t-1}-S_t)$; where, S_t is weight of vase solution (g) at t = days 0, 2, 4, etc., and S_{t-1} is weight of vase solution (g) on the previous day. Water loss was calculated as: water loss (g $stem^{-1}$ day^{-1}) = $(C_{t-1}-C_t)$; where, C_t is the combined weights of the cut stem and vase solution (g) at t = days 0, 2, 4, etc., and C_{t-1} is the combined weights of the stem and vase solution (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 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 [12]. Vase life was assessed as the number days to wilting of flowers. The flowers were checked once a day for signs of deterioration.

This experiment was conducted according to factorial based on completely randomized block design with 4 replicates and 3 samples (individual flowers) for each replication. Data were analyzed by Statistical Analysis System (SAS) software version 9.1 using analysis of variance (ANOVA) and differences among means were determined for significance at $P < 0.05$ using Tukey's test.

Results:

Relative fresh weight:

The results showed that the relative fresh weight increased significantly during the first 4 days of after harvest and from this time until end of the experiment decreased significantly (Fig. 1). A significant variation ($p < 0.05$) in relative fresh weight was found among the studied treatments. The highest levels of relative fresh weight was observed for 3 mM putrescine treatment during vase period, followed by 2 mM and 1 mM putrescine treatments while the lowest was in control treatment (Fig. 1). With respect to the results, the application of pre + post-harvest putrescine is found to be more effective than in the post-harvest putrescine application in increasing relative fresh weight of cut alstroemeria flowers after harvest (Fig. 1).

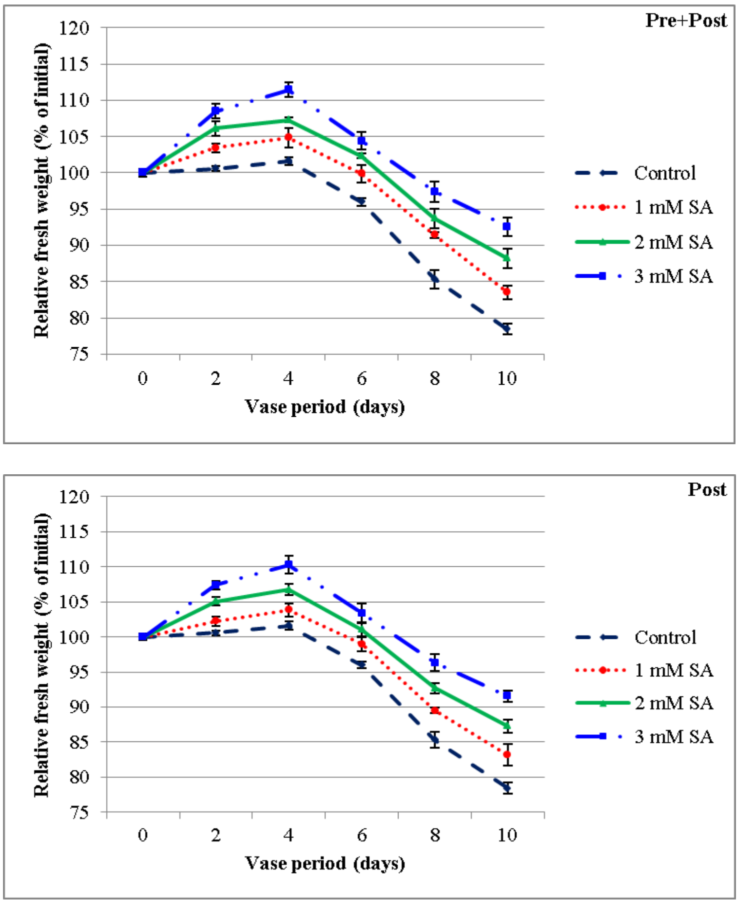
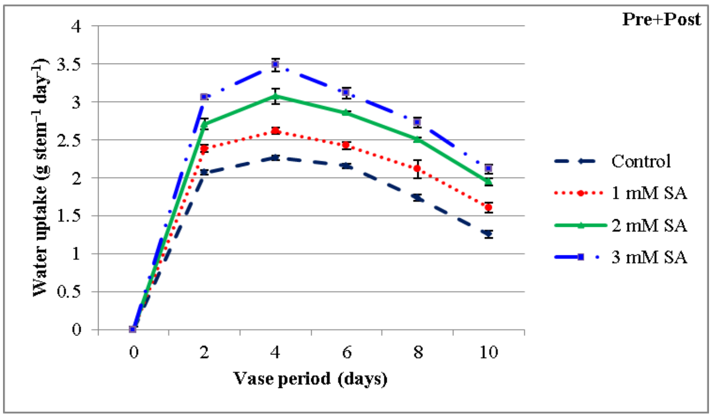


Fig. 1: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on relative fresh weight (% of initial) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

Water uptake:

As shown in Fig. 2, water uptake increased significantly during the first 4 days of experiment and from this time until end of the experiment decreased significantly. There was a significant difference ($p < 0.05$) between control and putrescine treatments in terms of their effects on water uptake levels. Among the studied treatments, 3 mM putrescine treatment had the highest amount of water uptake and control treatment had the lowest water uptake content during experiment (Fig. 2). Also, the data indicated that the application of pre + post-harvest putrescine was more effective than in the post-harvest putrescine application in increasing of water uptake during vase period (Fig. 2).



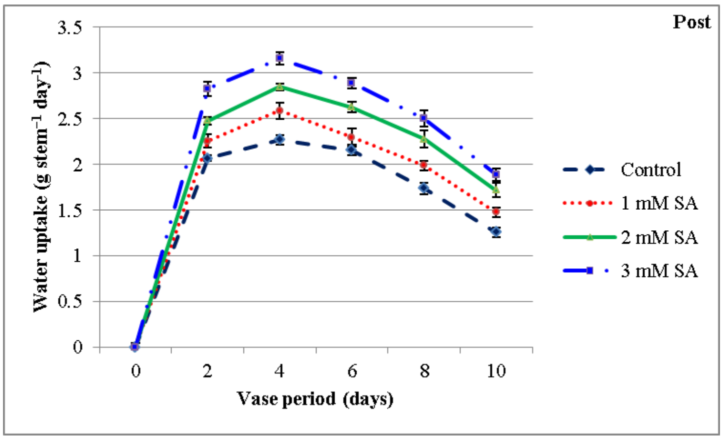
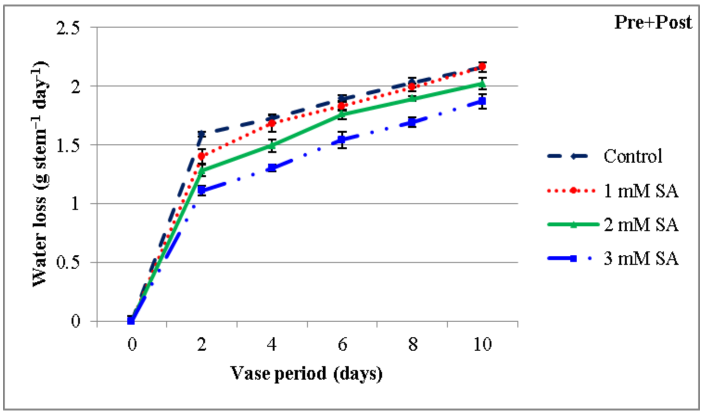


Fig. 2: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on water uptake (g stem^{-1} day^{-1}) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

Water loss:

The based on the present data, the water loss increased significantly during experiment (Fig. 3). A variation in terms of water loss was observed among the treatments and the differences were statistically significant ($p < 0.05$). The water loss was affected by putrescine treatments, since control cut flowers had significantly higher water loss during experiment, while the lowest levels were obtained in 3 mM putrescine treatment (Fig. 3). Also, the data indicates that among the presently tested treatments, pre + post-harvest application of putrescine is found to be more effective in reducing water loss of cut alstroemeria flowers during vase period than in the post-harvest application of putrescine (Fig. 3).



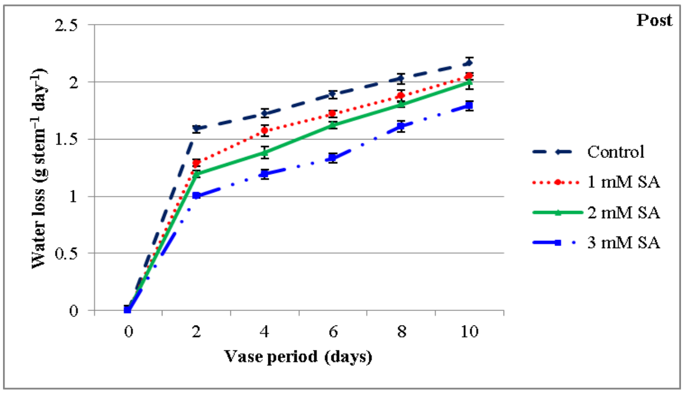


Fig. 3: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on water loss (g stem^{-1} day^{-1}) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

Water balance:

According to results shown in Fig. 4, the water balance decreased significantly during experiment. Significant differences ($p < 0.05$) were revealed among the treatments for water balance.

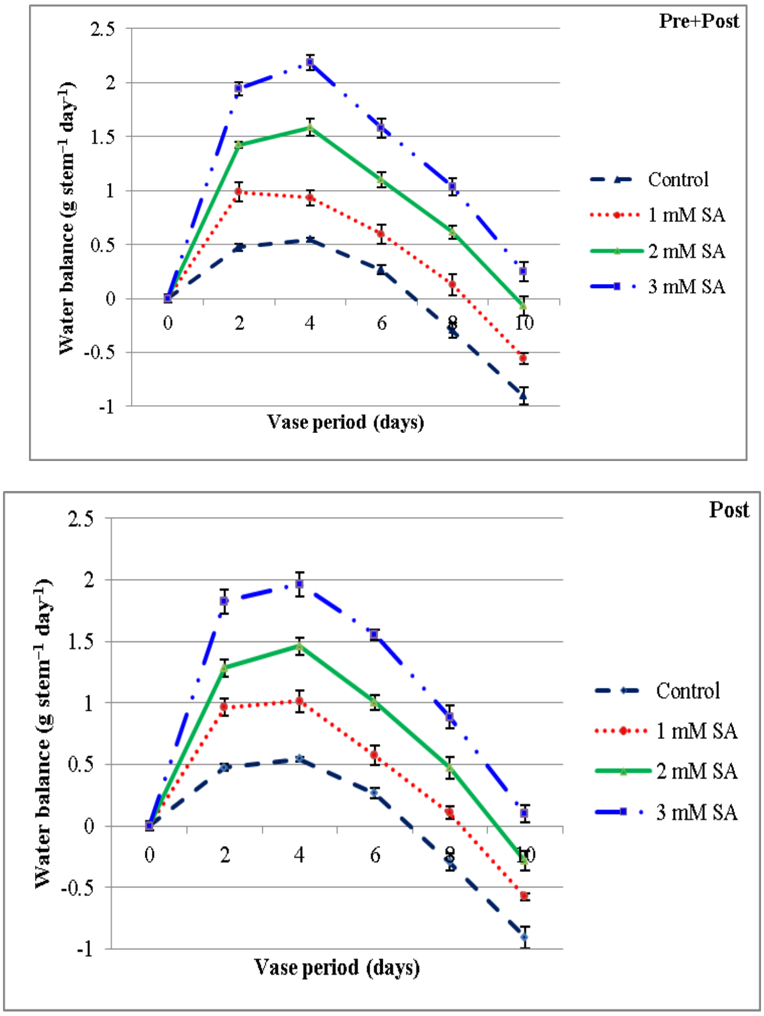


Fig. 4: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on water balance (g stem^{-1} day^{-1}) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

The treatments of putrescine showed significantly highest water balance than in the control treatment during experiment. The higher the putrescine concentration applied, the greater the improvement in water balance, that highest water balance values were observed in 3 mM putrescine treatment (Fig. 4). In relation to water balance, pre + post-harvest putrescine application was more effective on increasing water balance of cut alstroemeria flowers during experiment, as compared to application of post-harvest putrescine (Fig. 4).

Total chlorophyll:

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 (Fig. 5). As shown in Fig. 5, there was a significant difference ($p < 0.05$) between control and putrescine treatments in terms of total chlorophyll content. The lowest and highest the total chlorophyll values were observed in control and 3 mM putrescine treatments, respectively. With respect to the results, pre + post-harvest application of putrescine is found to be more effective in maintaining total chlorophyll of cut alstroemeria flowers after harvest, as compared to application of post-harvest putrescine (Fig. 5).

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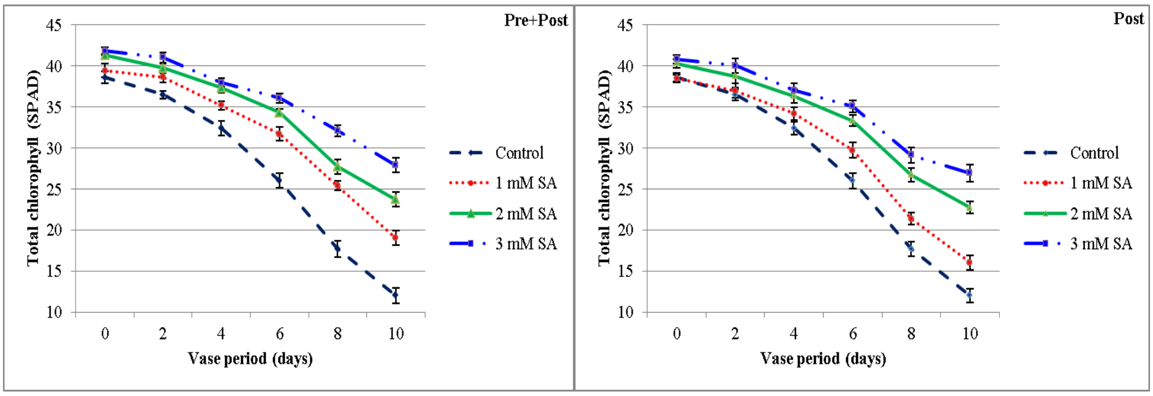
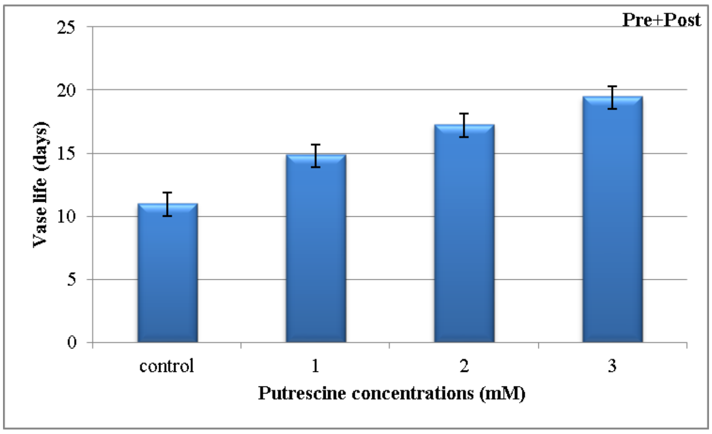


Fig. 5: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on total chlorophyll (SAPD) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

Vase life:

As shown in Fig. 6, the using putrescine treatment increased significantly the vase life cut alstroemeria flowers, as compared to control treatment during experiment (Fig. 6). The results showed that 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 putrescine treatment had the highest vase life. With respect to the results, application of pre + post-harvest putrescine is found to be more effective in extending vase life of cut alstroemeria flowers after harvest than in the post-harvest putrescine application (Fig. 6).



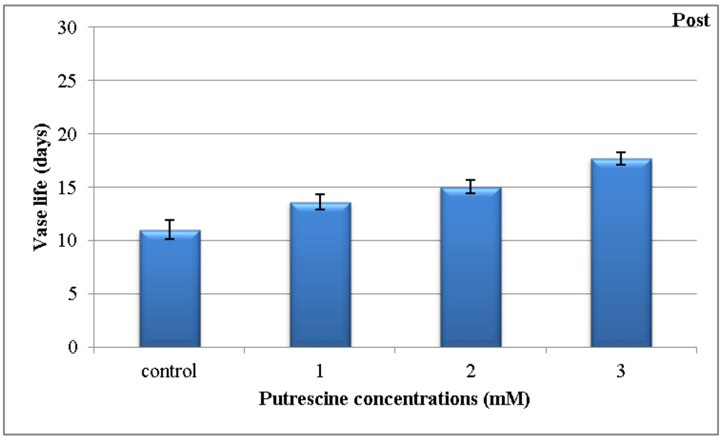


Fig. 6: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on vase life (days) of cut alstroemeria flowers. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

Discussion:

The results showed that the relative fresh weight, water uptake and water balance decreased significantly while water loss increased significantly during experiment (Fig. 1, 2, 3 and 4), which is in agreement with the findings reported by Lu *et al*. [14] on cut rose flowers (cv. 'Movie Star').

The decrease in relative fresh weight of cut flowers during the days of after harvest could be due to the decrease in water uptake [3,21]. Alaey *et al.* [1] reported that the highest relative fresh weight of cut rose flowers was observed in vase solutions which showed the greatest water uptake. The decrease in water uptake of cut flowers during vase period was probably due to growth of microbes and vascular blockage [22]. Anjum *et al.* [2] suggested adding a suitable germicide in vase solution can prevent the growth of microbes and increased water uptake.

In this experiment, all treatments showed decreases in relative fresh weight and water uptake, although this decreases were significantly lower in treatments of putrescine than in the control treatment (Fig. 1 and 2). These effects of putrescine were probably due to decreasing the growth and proliferation of bacteria, which led to water uptake and relative fresh weight of cut alstroemeria flowers.

According to Van Doorn [23] 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 this sense, the decrease in water balance of cut flowers in association with a lower water uptake and high water loss during vase period. In the current research, putrescine treatments maintained a more favourable water balance and suppressed water loss than in the control treatment (Fig. 3 and 4). It was assumed that the effects of putrescine may be due to the increasing water uptake as well as decrease in transpiration rate consequently, decreasing water loss and enhancing water balance of cut alstroemeria flowers.

As shown in Fig. 5, the total chlorophyll content reduced significantly during vase period, which is in agreement with the findings reported by Ferrante *et al.* [5]. The maintenance of green colour in the leaves is an important quality properties in these economically significant ornamental plants. Previous study had revealed that the leaf yellowing of cut alstroemeria flowers is associated with chlorophyll breakdown and loss, thereby decreasing significant vase life [5]. According to Fig. 5, all treatments showed decreases in total chlorophyll content, although this decreases were significantly lower in treatments of putrescine than in the control treatment. This effect of putrescine is might be due to inhibiting ethylene action [7], as compared to control treatment.

Application of putrescine treatment improved significantly the vase life of cut alstroemeria flowers (Fig. 6), which is in agreement with results reported by Kandil *et al*. [11] on chrysanthemum. 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 putrescine treatments increased significantly vase life of cut alstroemeria flowers than in the control treatment (Fig. 6). This effect of putrescine is might be due to reduced the bacteria growth and vascular blockage, maintained a more favourable water uptake, suppressed water loss, inhibiting ethylene action [7] and decrease in transpiration rate.

In conclusion, exogenous putrescine treatment is able to increase vase life of cut alstroemeria flowers by regulating the plant water and increasing total chlorophyll content. Thus, the data suggest that putrescine treatment has the potential to be used commercially to extend the vase life of cut alstroemeria flowers.

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