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Effects of pre-and post-harvest putrescine applications on water relations and pot duration of cut alstroemeria flowers

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During this experiment, the researchers sought to determine and evaluate the effects of pre-and post-harvest putrescine treatments on preserving cut alstroemeria flowers' freshness and vase durability throughout the vase-holding interval. Approximately two weeks preceding flower collection, aqueous mixtures of Putrescine at 0.0 (containing distilled water), 1, 2, and 3 mM were sprinkled to springlet (about 500 mL per plant). In the early mornings, the cut flowers were collected, and both treated and untreated plants were maintained in pots-containing putrescine solutions with 0.0 (with distilled water), 1, 2, and 3 mM. Throughout all procedures, the Sucrose as a basic solution was given at 4 percent. The overall chlorophyll percentage, the proportional new mass, the water absorption, the water evaporation, the water equilibrium, and the variations in new mass throughout the pot duration were all measured. The results showed a considerable reduction in proportional new mass, water absorption, water equilibrium, overall chlorophyll percentage, and pot duration. In contrast, water evaporation rose substantially throughout all the interventions throughout the pot phase. In addition, all assessed indicators showed statistically significant changes between the control and putrescine intervention. Relative to the control treatment, the putrescine interventions substantially increased proportional new mass, water intake, water equilibrium, overall chlorophyll percentage, and greatly decreased moisture evaporation throughout the pot duration. Additional studies revealed that Putrescine positively affected the overall pot duration of cut alstroemeria flowers, whereas control groups exhibited no such impact. The treatment of putrescin before and after harvesting has shown to be more efficient than the treatment of putrescin after harvesting in terms of total effectiveness. Thus, this intervention was shown to have positive effects on the performance of alstroemeria flowers. It may also be used economically to maintain the length of pot lifespan of cut alstroemeria flowers.

Keywords: Alstroemeria, Cut flowers, Keeping quality, Polyamines, Water equilibrium, Pot duration

INTRODUCTION

Throughout past years, there has been a significant increase in the generation of cut flowers, which is of major commercial importance worldwide. One of the most significant worldwide cut flowers over the past two decades has mostly been alstroemeria (Kim 2005, Gholamin and Khayatnezhad 2020, Guo, She et al. 2021, Li, Mu et al. 2021, Sun and Khayatnezhad 2021). Since the flowers come in various color options, such as yellow, orange, pink, through scarlet to purple and violet, it is in great popularity in both local and international businesses (Nørbaek, Christensen et al. 1996, Si, Gao et al. 2020). However, cut alstroemeria flowers are susceptible to leaves discoloration connected with premature aging, which may manifest within a few days after collection and progress quickly (Aletor 2021, Barth

2021). Numerous factors, including water stress (Sankat and Mujaffar 1993), evacuation of carbohydrates, presence of microorganisms (Gholamin and Khayatnezhad 2020, Bi, Dan et al. 2021, Ma, Ji et al. 2021), and ethylene impacts (Kabir, Arefin et al. 2021, Radmanesh 2021)are effective in triggering the senescence of cut flowers.

One of the most significant variables to consider when evaluating cut flowers' excellence is the vase life. The pot duration influences both local and international businesses. Unfortunately, there has not been a lot of studies performed on prolonging the pot duration of cut alstroemeria flowers, and keeping their excellence intact Silver thiosulphate (STS) (Khayatnezhad and Gholamin 2021, Zhang, Khayatnezhad et al. 2021), gibberellins (GA), cytokinins (CK) (Mutui, Emongor et al. 2003), accel ($BA+GA_{4+7}$) (Gholamin and Khayatnezhad 2020), thidiazuron (TZD) (Ferrante, Hunter et al. 2002), ethanol, methanol, and essential oils (Bazaz and Tehranifar 2011) were some interventions that have been investigated during past investigations.

An adequate technique for pot duration elongation that is simple to apply is generally important for large-scale implementations concerning organic, harmless, and cheap substances. The usage of organic substances for the preservation of excellence and the expansion of longevity of the cut flowers has recently been becoming more important Polyamines (PAs) are widespread in vegetation, animals, and microbes, all possessing aliphatic nitrogen structures. Spermidine (Spd), spermine (Spm), and Putrescine (Put) are the main polyamines observed in each plant cell (Gholamin and Khayatnezhad 2020, Karasakal, Khayatnezhad et al. 2020, Ma, Khayatnezhad et al. 2021, Xu, Ouyang et al. 2021). Polyamines are recognized to have a wide range of essential functions in plant physiology, involving the proliferation of cells and the ability to react to ecological stressors. Regarding chrysanthemum, administration of external Putrescine improved pot duration, flower output, inflorescence dimension, overall carbohydrates, overall chlorophyll, and carotenoid contents (Cheng, Hong et al. 2021, Huang, Wang et al. 2021, Rodríguez 2021, Wang, Shang et al. 2021, Zheng, Zhao et al. 2021, Zhu, Liu et al. 2021).

Since polyamine treatments are believed to have the ability to prolong cut flower freshness and improve their pot duration, it was thought that polyamine treatments would also increase the existence of flowers. Nevertheless, insufficient evidence is available on the effect of Putrescine on the preservation of cut alstroemeria flowers and the extension of their pot duration. Therefore, this study intended to analyze and evaluate the impact of putrescine treatments before and after collection on maintaining the freshness and longevity of alstroemeria cuts throughout the pot season.

MATERIALS AND METHODS

Regional commercial greenhouses (Mashhad, Iran) supplied Alstroemeria flowers (cv. 'Tampa'). Flowers were cultivated at 22°C and 16°C temperatures during day and night under normal greenhouse settings. Around two weeks preceding flower collection, putrescine formulations of 0.0 (containing distilled water), 1, 2, and 3 mM were sprinkled to run-off (almost 500 mL per plant). Early morning, cut flowers were gathered and promptly brought to the lab throughout plastic containers with adequate protection. The cut flowers (both treated and untreated) were situated throughout glass vials comprising 300 ml solutions of Putrescine, at the concentrations of 0.0 (with distilled water), 1.0, 2.0, and 3.0 mM. As a basic mixture, 4% sucrose was given to all regimens. Throughout a stabilized environment at 19±2°C, 70±5% percent relative moisture, and 12 μmol m^{-2} s^{-1} illumination intensity (cool-white fluorescence lamps) for 12 hours each day, the flowers were maintained. The study of when (first day) cut flowers are put in pot solutions and how their decorative potential diminishes is known as research into the properties of cut flowers.

Using pots with and without flowers, we calculated the proportional new mass, water absorption, water evaporation, and water equilibrium two days apart (He, Joyce et al. 2006, Yin, Khayatnezhad et al. 2021). First, the relatively new mass of stems (flowers+leafy) was determined as relative new mass (%) = $(W_t/W_{t-0}) \times 100$; where W_t is the weight of stalk (g) at t = days 0, 2, 4, etc., and W_{t-0} is the weight of the same stalk (g) at t = day 0. Next, water absorption was determined as water absorption (g $stem^{-1}$ day^{-1}) = $(S_{t-1}-S_t)$; where S_t is the weight of pot solution (g) at t = days 0, 2, 4, etc., and S_{t-1} is the weight of pot solution (g) on the previous day. Next, water evaporation was determined as follows: water evaporation (g $stem^{-1}$ day^{-1}) = $(C_{t-1}-C_t)$; where C_t is the mixed weights of the cut stalk and pot solution (g) at t = days 0, 2, 4, etc., and C_{t-1} is the mixed weights of the stalk and pot solution (g) on the previous day. Finally, water equilibrium (g $stem^{-1}$ day^{-1}) was determined as water absorption from the pot minus water evaporation from the stalk.

Overall chlorophyll frequency was calculated (2 days intervals) by chlorophyll meter (SPAD-502 Konica, Minolta, Tokyo), which is depicted by SPAD values. An average of 3 measurements from different spots of a single leave was considered (Khayatnezhad and Gholamin 2020). Pot duration was evaluated as the number of days of flower withering. Once a day, the flowers were examined for indications of degradation.

This trial was carried out factorially using a fully randomized block structure, with four iterations and three specimens for each iteration. Via Statistical Analysis System (SAS) software version 9.1 employing analysis of variance (ANOVA), the data were evaluated, and at $P < 0.05$ using Tukey's test, the disparities among averages were defined for significance.

RESULTS

Proportional New Mass

The findings indicated that proportional new mass enhanced substantially throughout the first four days following collection and then dropped dramatically before the conclusion of the trial (Fig. 1). There was a substantial difference in proportional new mass across the interventions examined ($p < 0.05$). Under 3 mM, 2 mM, and 1 mM putrescine treatment throughout the pot interval, the maximum degrees of proportional new mass were found. In contrast, the minimum level was seen in the control group (Fig. 1). According to the findings, pre-and post-harvest putrescine administrations are more successful at raising the proportional new mass of cut alstroemeria flowers than post-harvest putrescine treatments (Fig. 1).

Water Absorption

Water consumption continued to rise substantially over the first four days of the test, as indicated in Fig 2, and dropped dramatically before the research conclusion. The consequences of the putrescine administration on water absorption quantities differed from those of the controls significantly ($p < 0.05$). The most water absorption was seen for 3 mM putrescin interventions, while the minimum water absorption percentage throughout experiments was recorded in the control group (Fig. 2). Furthermore, the results showed that pre-and post-harvest Putrescine more effectively increases water absorption throughout pot duration than applying post-harvest Putrescine (Fig. 2).

Water Evaporation

According to the information presented, water evaporation enhanced substantially throughout the trial (Fig. 3). Between interventions, there was a statistically significant difference in water evaporation ($p < 0.05$). Putrescine interventions impacted water evaporation because the cut flowers had much more water decrease in the control group, whereas, throughout the administration of 3 mM putrescine, minimal rates were achieved (Fig. 3). The results additionally show that the therapies currently studied show greater effectiveness in preventing water evaporation in cut alstroemeria flowers throughout pot intervals before and after harvesting putrescin rather than after the harvesting period. (Fig. 3).

Water equilibrium

The water equilibrium dropped substantially throughout the trial, according to findings presented in Figure 4. Results show an apparent variation between the various interventions in terms of water equilibrium ($p < 0.05$). While carrying out the investigation, the putrescine administrations demonstrated substantially greater water equilibrium than the controls. As putrescine levels increase, better water equilibrium is obtained; nevertheless, with 3 mM putrescine administration, higher water equilibrium scores were found (Fig. 4). Compared with the post-harvest putrescin administration, the pre-and post-gathering intervention increased the water equilibrium of the cut alstroemeria flowers throughout the trial (Fig. 4).

Overall Chlorophyll

During the trial, the overall chlorophyll concentration dropped considerably. Overall chlorophyll contents were likewise greater than final values during the first post-harvest period (Fig. 5). There was a significant change in the overall chlorophyll percentage between control and putrescine administrations, as illustrated in Figure 5 ($p < 0.05$). Throughout controls and 3 mM putrescine interventions, respectively, the minimum and maximum overall chlorophyll levels have been found. The findings show that before and after harvest, administration of Putrescine is more efficacious than post-harvest Putrescine in preserving the overall chlorophyll of alstroemeria flowers (Fig. 5).

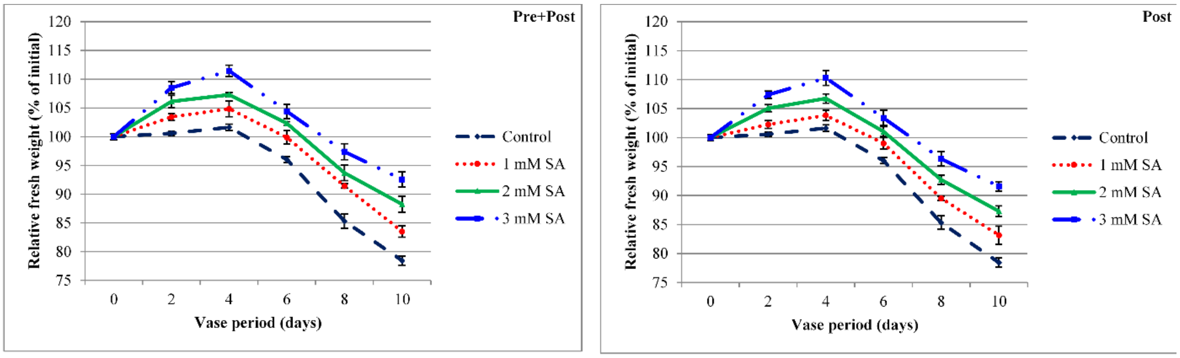

Figure 1: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on relative fresh weight (% of initial) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

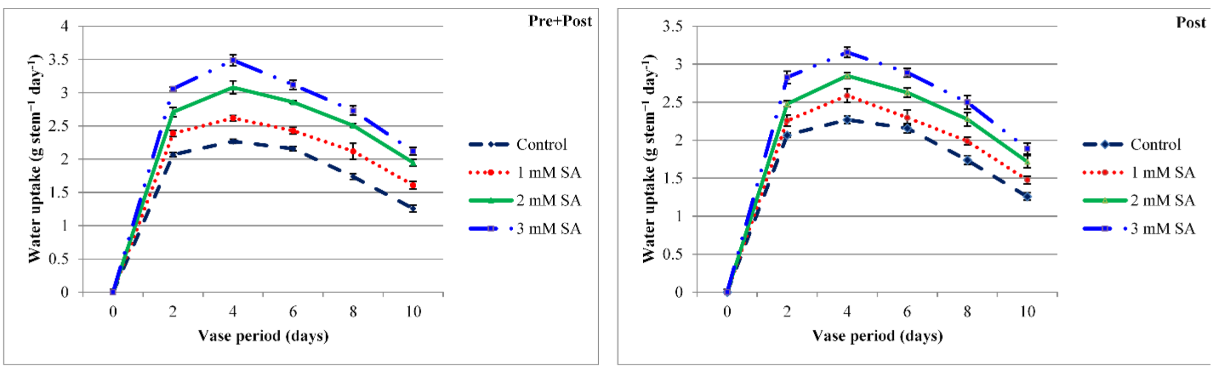

Figure 2: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on water uptake (g stem^{-1} day^{-1}) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

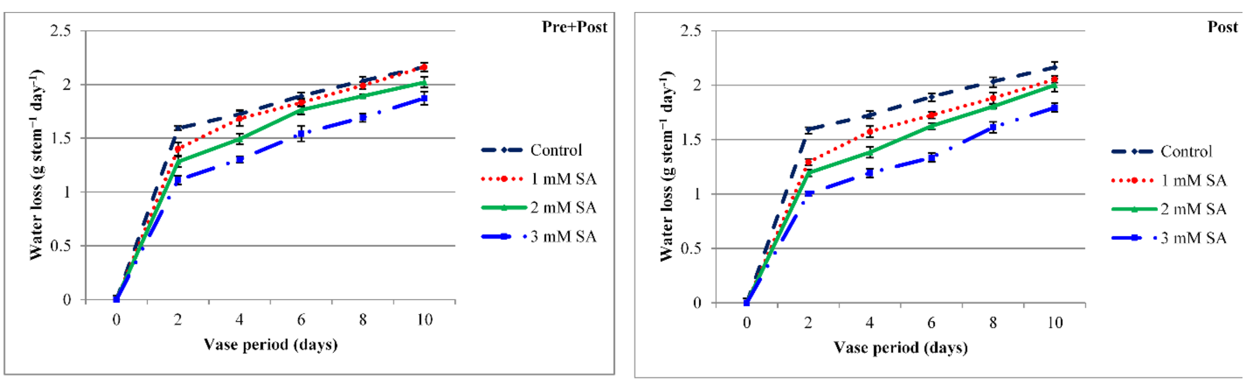

Figure 3: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on water loss (g stem^{-1} day^{-1}) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

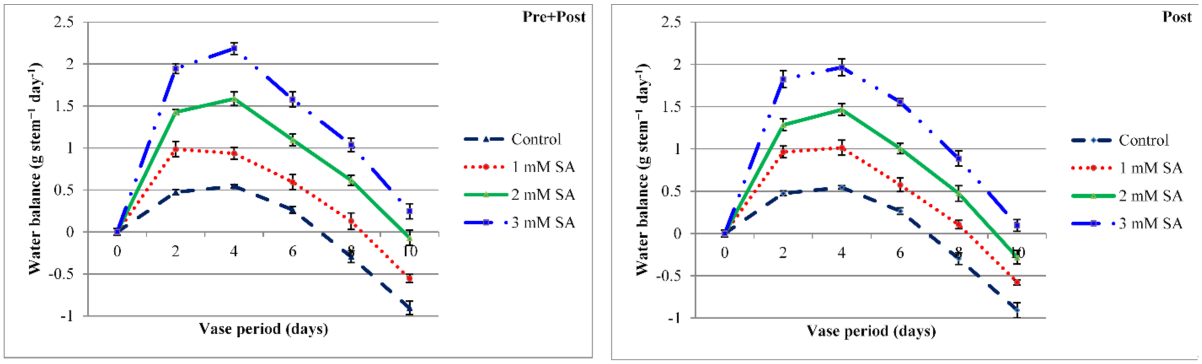

Figure 4: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on water balance (g stem^{-1} day^{-1}) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

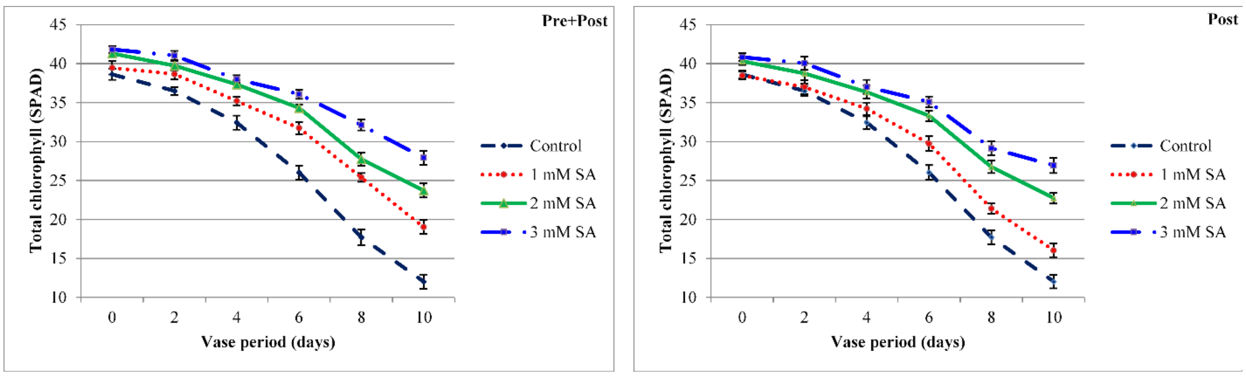

Figure 5: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on total chlorophyll (SAPD) of cut alstroemeria flowers during vase period. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

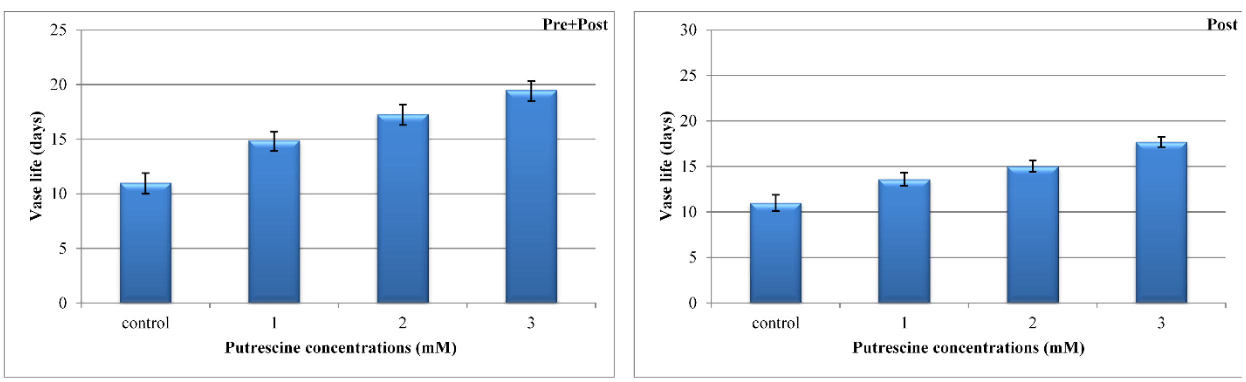

Figure 6: Effect of pre + post-harvest and post-harvest applications of different concentrations of putrescine on vase life (days) of cut alstroemeria flowers. The results represent the means of 12 cut flowers in 4 replicates ± standard errors.

Pot Duration

Relative to the control group, Fig 6 demonstrates that the administration of Putrescine substantially improved the pot duration of cut alstroemeria flowers throughout the trial. A study on vase life discovered that the interventions varied considerably concerning their ability to prolong vase life; however, the control treatment produced the minimum vase life, while 3 mM putrescine produced the maximum pot duration ($p < 0.05$). When applied before and after collection, Putrescine has been shown to increase the pot duration of the alstroemeria flowers compared to after harvesting (Fig. 6).

DISCUSSION

In line with an experiment conducted by Lu et al. (2010) on cut rose flowers (cv. 'Movie Star'), we found that the proportional new mass, water absorption, and water equilibrium dropped. In contrast, water evaporation has been enhanced (Fig. 1, 2, 3, and 4). Thanks to the reduced water absorption, cut flowers have lost some of their proportional new mass over the periods of the following collection (Serek, Tamari et al. 1995). Among pot mixtures that exhibited maximum water intake, Alaey, Babalar et al. (2011) found that the largest proportional new mass of rose flowers occurred. Microbial development and vascular obstruction likely impeded water absorption throughout this time, which would account for the decline in water absorption (Karasakal, Khayatnezhad et al. 2020, Gholamin and Khayatnezhad 2021, Peng, Khayatnezhad et al. 2021, Tao, Cui et al. 2021). An appropriate germicide may be added to the pots mixture, according to Anjum, Naveed et al. (2001), which can inhibit the development of germs and improve water absorption.

Putrescine administration had a smaller overall reduction in proportional new mass and water absorption than the control treatment, but this difference was more prominent compared to all treatments(Fig. 1 and 2). Water absorption and the new mass of cut alstroemeria flowers were presumably affected by Putrescine's anti-growth and reproduction properties, reducing microorganisms.

Whenever the incidence of water absorption is less than the rate of transpiration in a cut stalk standing in pot solution, an aqueous deficit will occur, according to Van Doorn (1997). Throughout the pot phase, cut flowers have a smaller water absorption and higher water evaporation than other flowers. Therefore, water equilibrium is better preserved during the putrescine administration, whereas water evaporation is prevented in the control-treated members (Fig. 3 and 4). Putrescine's impacts were hypothesized to be related to an increase in water absorption and a reduction in transpiration frequency, thus reducing water evaporation and improving the water equilibrium among alstroemeria flowers.

In accordance with the results published by Ferrante et al. (2002), the overall chlorophyll level was decreased considerably throughout the pot duration, as indicated in Fig.5. Among these commercially significant ornamental flowers, preserving green color in their leaves is an essential qualitative element) Khayatnezhad and Gholamin 2020(. It had been shown in earlier research that the xanthosis of the leaves of cut alstroemeria flowers is linked with chlorophyll degradation and depletion, thus resulting in a significant reduction in pot duration (Hou, Li et al. 2021, Huang, Wang et al. 2021, Khayatnezhad and Gholamin 2021, Zhu, Saadati et al. 2021). All treatments exhibited reductions in the overall chlorophyll composition according to Fig. 5; in putrescine treatments, these drops were considerably smaller than that of the control group. Restricting ethylene activity in comparison to control groups may be the origin of this putrescine activity (Khayatnezhad and Nasehi 2021, Ren and Khayatnezhad 2021, Sun, Lin et al. 2021).

Fig. 6 indicates that the putrescin administration substantially enhanced the pot duration of alstroemeria flowers in accordance with chrysanthemum-related findings published in Kandil et al. (2011). Owing to a limited water intake presumably attributed to growing bacteria and vascular blockages, a high sweat percentage, and water losses, the short life span of the cut flowers was due to inadequate water levels. Compared to the controls, the putrescine interventions substantially extended the pot duration of cut alstroemeria flowers, according to the research findings (Fig. 6). Decreased vascular blocking and development of microorganisms, better water absorption, water drainage reduction, inhibition of ethylene effects, and lower transpiration incidence are effective factors mediating putrescine impact (Galston and Kaur-Sawhney 1995, Jia, Khayatnezhad et al. 2020).

Therefore, it can be concluded that external putrescine administration can extend the alstroemeria flowers duration by helping to regulate the plant moisture and raising the overall chlorophyll composition. Therefore, when applied to cut alstroemeria flowers, Putrescine may be commercialized to prolong the pot duration.

CONCLUSION

Therefore, it can be concluded that external putrescine administration can extend the alstroemeria flowers duration by helping to regulate the plant moisture and raising the overall chlorophyll composition. Therefore, when applied to cut alstroemeria flowers, Putrescine may be commercialized to prolong the pot duration. It is recommended to repeat the experiment in the following years to achieve more reliable results**.**

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Arda Karasakal conducted, planned, Analyzed the data, wrote manuscript and interpreted the results and involved in manuscript preparation. All authors read and approved the final version.

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