Comparison of Different Salicylic Acid Application Ways as a Preservative on Postharvest Life of Gerbera Cut Flowers

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ABSTRACT

Gerbera (Gerbera jamesonii) is valuable ornamental plant which is mostly used as cut flower. Salicylic acid (SA) is phenolic compound which can be used as a chemical preservative and therefore may affect postharvest life of cut flowers such as gerbera. The present study was carried out with the aim of finding side effects of SA application and also to find a better method of salicylic acid application. Hence, the effects of different concentrations of salicylic acid on postharvest vase life of gerbera cut flowers was studied in a completely randomized design. Salicylic acids were used in four different concentrations (0, 0.5, 1.5 and 2.5 mM) in three different ways. Different applied methods of salicylic acid application consisted of long term treatment (vase solution preservative) (M1), pulse treatment (twenty four hours) (M2) and spray application (three times with one day interval) (M3). Gerbera cut flowers were grouped in ten different treatment groups including control (C), SA0.5-M1, SA1.5-M1, SA2.5-M1, SA0.5-M2, SA1.5-M2, SA2.5-M2, SA0.5-M3, SA1.5-M3, SA2.5-M3. All salicylic acid application treatments increased vase life, vase solution uptake, cut flower fresh weight, soluble solid content and membrane stability of cut gerbera flowers. Besides that, SA improved stem texture and consequently decreased stem bending of gerbera cut flowers. Salicylic acid improvement of longevity could be resulted from its induced antioxidant effect, decreased transpiration of cut flower and its antimicrobial effects. The obtained results of present research indicated that the method of SA application is another important factor influencing the effectiveness rates of it. It was found that long term treatment (application as vase solution) and spray application of SA are more effective methods for vase life of gerbera than the pulse treatment method.

Keywords: Longevity, membrane stability, ornamental plants, soluble solid content, stem bending, vase life, vase solution preservative.

Abbreviations:
SA: Salicylic acid; TSS: Total soluble solid.

INTRODUCTION

Different chemical preservatives such as various plant growth regulators in vase solution could affect the postharvest life of various cut flowers (Kazemi et al., 2011). Salicylic acid (SA) has been proposed as a suitable preservative for cut flowers by some researchers such as Kazemi et al. (2011) and Ezhilmathi et al. (2007). SA is naturally produced by plants as secondary metabolite and is categorised a phenolic compound (Loutfy et al., 2012). SA plays various important roles in plant growth and development such as: ethylene biosynthesis, stomatal conductance, respiration and defence in different types of plants (Raskin, 1992; Loutfy et al., 2012). Beside the mentioned, SA has a vital role in plant defence and is implicated in the activation of defence systems against different pathogens (Grant and Lamb, 2006; Miura et al., 2010). Diverse plant reactions such as seed germination, cell growth, respiration, stomatal system, and senescence were influenced by the exogenous application of SA or its derivates (An and Mou, 2011). The antioxidant system and the nutritional worth of fruits and vegetables could be affected by the exogenous SA pre-treatment (Huang et al., 2008). Pre-harvest SA treatment could sustain fruit antioxidant activity and its nutritional values (Huanget al., 2008).

Gerbera, a member of Asteraceae family, is a valuable and important ornamental plant. Various variables, including genetic (Nazari deljou et al., 2011), plant growth regulators (Balestra et al., 2005), microbial contamination (Emongor, 2004) have been mentioned as the key reasons of postharvest longevity and neck bending in gerbera cut flowers (Wernett et al., 1996). The efficiencies
of various preservatives have been evaluated for improving longevity of gerbera cut flowers by various researchers such as Gerasopoulos and Chelbi (1999) and Nikbakht et al. (2008).

SA has been used by some researchers as a chemical preservative for elevating longevity of various cut flowers. However, the effects of different methods of its application on postharvest life of cut flowers have not been investigated specially on asteraceae cut flowers. The present study was carried out to indicate the best method of SA application on postharvest quality and longevity of cut gerbera flowers.

MATERIALS AND METHODS

Plant Material and Experimental Condition:

Cut gerbera flowers, Gerbera jamesonii cv. 'Dune', were obtained from commercial greenhouse producer. Experiments were performed in a postharvest room with an average temperature of 22 ± 1 °C, relative humidity of 60 ± 5% and 12 h light photoperiod.

Treatment:

Flowers were cut so that they reached a height of 40 centimetre, weighted and placed in 500 ml containers with 3% sucrose and/or four different concentrations (0, 0.5, 1.5 and 2.5 mM) of salicylic acid solutions in three methods of its application. Different applied methods of salicylic acid application consisted of long term treatment (as vase solution till the end of life) (M1), pulse treatment (24h) (M2) and spraying three times with one day interval (M3). Cut flowers were grouped in ten different treatment groups with three replications and five flowers in each replication: Control (C), SA0.5-M1, SA1.5-M1, SA2.5-M1, SA0.5-M2, SA1.5-M2, SA2.5-M2, SA0.5-M3, SA1.5-M3 and SA2.5-M3. Control samples consisted of flowers placed in vase solution of 3% sucrose in distilled water. Also vase solution of all treatments was prepared or consisted of 3% sucrose solved in distilled water.

Vase Life:

Vase lives of cut flowers were recorded based on their visual appearance and senescence flowers were recorded.

Fresh Weight and Solution Uptake:

Fresh weights of flowers were recorded every three days in grams using a balance. Solution uptake rates were estimated by measuring the remaining vase solution and were expressed in ml per vase (Jowkar, 2006).

Stem Bending:

The stem bending in gerbera was determined. Curvature was measured using a protractor and expressed in degrees.

Membrane Stability Index:

The membrane stability index was estimated on the basis of the electrolyte leakage of petals using an electrical conductivity meter as previously described by Danae et al. (2011). Briefly, the petal discs were rinsed in deionized water prior to incubation in 10 ml of deionized water for 3 h at room temperature. After incubation, the conductivity (EC1) of the bathing solution was measured with the conductivity meter. Petal discs were boiled with bathing solution for 15 min to kill tissues. After cooling to room temperature, the conductivity (EC2) of the bathing solution was again measured. The membrane stability index was expressed in percentages according to the formula given below.

$$\text{Membrane stability index (\%) } = \left[ 1 - \frac{EC1}{EC2} \right] \times 100$$

Total Soluble Solid:

Total soluble solid (TSS) of cut flower stems were measured by using digital refractometer and was expressed in Brixes.

Anthocyanin Content:

Flower pigmentation was quantified by measuring the amount of anthocyanins in fresh ray florets as described previously by Meng and Wang (2004). Briefly, Acidic methanol (1% HCl, v/v) was used as an extraction solvent and anthocyanin concentrations of petals were calculated according to the formula given below and were expressed as ∆A g⁻¹ FW.

$$\Delta A = A_{530} - \frac{1}{4} A_{657}$$

Statistical Analysis:

Analysis of variance was performed on all data sets using SPSS 18 software. Duncan test with probability of 0.05 was applied to assess any significant differences between treatments.

RESULTS AND DISCUSSION

Flower Longevity:

The application of different concentrations of SA using three various methods led to increased longevity of the cut flowers where the third and first methods of application were the most effective ones, as was shown in Fig. 1. SA has been suggested as an influential treatment for extending the vase life in varieties of cut flowers including gladiolus (Ezhilmathi et al., 2007; Hatamzadeh et al., 2012) rose (Zamani et al., 2011; Geralloo and Ghasemnezhad, 2011) and carnation (Kazemi et al., 2011). SA has been known as an inhibitor of ethylene production (Kazemi et al., 2011; Hatamzadeh et al., 2012). Therefore it is one of the various compounds applied in postharvest to delay senescence (Emongor, 2004).

Stem Bending:

SA treatments significantly alleviated stem bending as it was shown in Fig. 2. The application of SA, especially in first and third methods, caused declined stem bending of gerbera cut flowers. Improved solution uptake, higher water potential,
and declined loss of fresh weight observed in SA-treated cut flowers which lead to delayed stem bending. The longevity of cut flowers is often restricted by stem bending, a premature ageing symptom (Kazemi et al., 2011). Water potential and biochemical status of cut flowers are critical for stem bending reaction (Ferrante and Serra, 2009; Prashanth et al., 2010).

Fig. 1. The effects of different concentrations of SA in three various methods of its application on longevity of gerbera cut flowers. The vertical bars indicate standard error (SE) of three replications.

Fig. 2. The effects of different concentrations of SA in three various methods of its application on changes in stem bending of gerbera cut flowers during postharvest life stages. The vertical bars indicate standard error (SE) of three replications.

**Solution Uptake and Fresh Weight:**
Solution uptake amounts in all SA-treated plants were significantly more than control samples. Gradually, uptake rates decreased and the reduction rates of it were significantly alleviated with the application of SA, especially when it was used in the first and third method (Fig. 3). The results indicated that the decreasing rates of solution uptake and fresh weight during the postharvest life were significantly alleviated with the application of SA, especially when it is used in first and third methods (Fig. 4). This can be resulted from antimicrobial properties (especially in the case of first method) and decreasing effects of SA on tissue transcription and respiration (probably acting mechanism about the third one).

A positive correlation has been observed between vase life of cut flowers and solution uptake in gerbera cut flowers (Nazari deljou et al., 2011). Based on SEM observations, bacterial contamination has been proposed as the main reason of vascular blockage of cut
flowers (Su Dan et al., 2009). It has been reported that SA application negatively correlated with microbe population in vase solution of carnation cut flowers (Kazemi et al., 2011). SA-prevented loss of fresh weight in cut flowers has been attributed to decreasing effects of SA on tissue transpiration, evaporation and respiration (Hatamzadeh et al., 2012).

**Fig. 3.** The effects of different concentrations of SA in three various methods of its application on changes in solution uptake rates of gerbera cut flowers during postharvest life stages. The vertical bars indicate standard error (SE) of three replications.

**Fig. 4.** The effects of different concentrations of SA in three various methods of its application on changes in fresh weights of gerbera cut flowers during postharvest life stages. The vertical bars indicate standard error (SE) of three replications.

**Membrane Stability:**
Membrane stability indexes of SA-applied cut flowers were significantly more than controls. The application of SA in third and first methods retarded decrease in membrane stability rate during the postharvest life (Fig. 5). Various researchers have illustrated that during cut flowers ageing membrane stability level drops quickly (Ezhilmathi et al., 2007; Singh et al., 2008; Danaee et al., 2011). SA-reduced amounts of reactive oxygen species (arisen from stimulated antioxidant system) and ethylene are suggested as mechanisms
of SA-delayed senescence (Gerailoo and Ghasemnezhad, 2011). Lack of membrane integrity is a vital sign of irreversible phase of senescence (Paulin et al., 1986). Significantly lower rates of lipid peroxidation were recorded in SA-applied flowers during postharvest life stages (Hatamzadeh et al., 2012). SA could alleviate the damaged structure of chloroplast organelle (Kazemi et al., 2011). SA had preventing effects on lipoxigenase activity in SA-pulsed cut flowers (Gerailoo and Ghasemnezhad, 2011).

**Total Soluble Solid Content:**
Total soluble solids of SA-treated cut flowers in different ways were significantly more than control and the best results were found in SA1.5-M1, SA2.5-M1, SA0.5-M3, SA1.5-M3, SA2.5-M3 (Fig. 6). It means that the best results were obtained when SA were applied in first and third ways. Senescence and longevity of cut flowers were closely related to the carbohydrate contents of the petals (Van Doorn, 2004; Singh et al., 2008).

**Fig. 5.** The effects of different concentrations of SA in three various methods of its application on changes in membrane stability indexes of gerbera cut flowers during postharvest life stages. The vertical bars indicate standard error (SE) of three replications.

**Fig. 6.** The effects of different concentrations of SA in three various methods of its application on soluble solid content in gerbera cut flowers during postharvest life stages. The vertical bars indicate standard error (SE) of three replications.
Anthocyanin Content:
Anthocyanin contents decreased during postharvest life; however, their amounts in SA treated cut flowers, particularly when it was applied in first and third ways, were significantly more than controls (Fig. 7). The application of SA, especially when it is used in first and third methods, resulted in declined degradation rates of anthocyanin. SA has been proposed as a compound used in postharvest with the aim of retarding senescence (Hatamzadeh et al., 2012) and as an inhibitor of ethylene production (Kazemi et al., 2011; Hatamzadeh et al., 2012) therefore, its application could decrease anthocyanin degradation rates. Salicylic application reduced chlorophyll degradation (Zamani et al., 2011). Also, SA-induced antioxidant system has been found in SA-treated rose cut flowers (Geraliloo and Ghassemnejad, 2011) and its application therefore could reduce oxidative injuries during postharvest life of cut flowers. Thus it could be stated that stimulated antioxidant system and/or inhibited ethylene production caused alleviated anthocyanin degradation.

CONCLUSION
The obtained results of present research indicated that SA treatments could affect postharvest life of gerbera cut flowers; however, the methods of its application are another important factor influencing the effectiveness rates of this compound. According to our results it seems that long term treatment and spray of SA are more effective methods than pulse one to promote longevity of gerbera cut flowers. From the present research, it can be concluded that SA application, especially when it was used in long term treatments (as vase solution till the end of life) and spray, could promote the longevity of the cut flowers via increased solution uptake (probably, because of antimicrobial properties of SA), soluble solid, fresh weight (likely, due to enhanced solution uptake and reduced transpiration and respiration), membrane stability (likely, arisen from the SA inducing effects on antioxidant system and delayed senescence resulted from proposed inhibiting effects of SA on ethylene production and decreased accumulation of reactive oxygen species) and alleviated stem bending (via decreased microbial infection, increased solution uptake and membrane stability as well as delayed senescence).

REFERENCES


