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Effects of Pre- and Postharvest Treatments of Silicon and Rice Hull Ash on Vase Life of Gerbera

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Abstract
This study was conducted to investigate the effects of different silicon supplements and postharvest treatments on growth and yield of gerbera in a greenhouse experiment. Silicon supplements were including potassium silicate at three concentrations (0, 140 and 200 mg L^{-1}), sodium silicate at three concentrations (0, 50 and 100 mg L^{-1}) and rice hull ash (RHA) at three concentrations (0, 50 and 100 mg L^{-1}). Also, postharvest treatments were including sucrose, salicylic acid (200 and 400 mg L^{-1}), methyl jasmonate (15 and 25 mg L^{-1}) and distilled water (as control). The application of potassium silicate, RHA and sodium silicate led to decrease in dry weight of flower. Shoot length and diameter were substantially higher in 140 mg L^{-1} potassium silicate than those in control treatment. The maximum inflorescence diameter was observed in rice husk ash (50 mg L^{-1}). Capitulum diameter was far greater in sodium silicate at 50 mg L^{-1} compared to other treatments. Vase life of gerbera flower was greater in 400 mg L^{-1} salicylic acid and 15 mg L^{-1} methyl jasmonate than in control treatment. The maximum inflorescence diameter was observed in 400 mg L^{-1} salicylic acid. This study confirmed that the studied sources of Si, salicylic acid and methyl jasmonate increased marketable quality of cut gerbera flowers.

Keywords: Methyl jasmonate, potassium silicate, rice hull ash, salicylic acid, sodium silicate.

Introduction

Gerbera (*Gerbera jamesonii* L.) is one of the herbaceous plants with colorful and fashionable flowers that are widely used as a decorative garden plant or cut flowers (Kanwar and Kumar, 2009). In horticulture, soilless substrates are employed for growing seedlings and ornamental plant production (Ahmad *et al*., 2012). Suitable growing substrates are necessary for gas exchange between roots and atmosphere, quality flower production, sufficient anchorage of plant as well as provision of nutrients and water (Abad *et al*., 2002).

In hydroponic system most plants are cultivated using soilless substrates where Si availability is limited (Voogt and Sonneveld, 2001). Many of studies focused on greenhouse produced horticultural crops have confirmed multiple useful effects of supplemental Si, such as high yields of greenhouse plants (Ma and Takahashi, 2002). However, in a hydroponic system for cut rose production, the application of Si improved most of the negative influence of recirculation, resulting in better stem quality (Ehret *et al*., 2005).

There are a few reports on rice husk hull as organic media (Karimi, 2014). However, the addition of rice husk to peat substrate decreased available water and porosity (Priyadharshini and Seran, 2009). Moreover husk rice is rich in K and Si and its using can supply these elements requirements and increase the quality of greenhouse crops (Kamenidou *et al*., 2008). Although Si is not considered an essential nutrient for plants, its advantageous impacts on plant growth and development have been

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investigated by numerous studies concerned with its role in plant nutrition (Epstein, 1994). Si-induced alleviation of abiotic stresses such as salinity, drought, high temperature, chilling, nutrient imbalance, and metal toxicity has been reported by many researchers. However, the beneficial impacts of Si on plant growth have been reported in many plants such as rice wheat, barley and cucumber (Hasanuzzaman and Fujita, 2011). Savvas *et al*. (2002) revealed that the increased supply of Si significantly enhanced the vegetative growth of roses. The effects of salinity on the flower vase life of gerbera can be reduced by foliar application of Si in case of using low-quality water (Torkashvand and Shirghani, 2015) and high-quality water (Oliveira *et al*., 2012).

Salicylic acid is a mono hydroxyl benzoic acid, a type of phenolic acid and a beta hydroxyacid (Gunes *et al.*, 2007). This plant growth regulator has been found to generate a wide range of physiological and metabolic responses in plants thereby affecting development and growth of plants (Hayat *et al.,* 2010). Salicylic acid is classified as a type of plant hormone which affects numerous plant physiological processes such as growth and development, flower induction, ethylene synthesis and respiration (Rajjou *et al.,* 2006) stomatal regulation, senescence and the activation of defense systems against different pathogens (Miura *et al.*, 2010; An *et al.*, 2011; Loutfy *et al.*, 2012). Jasmonic acid is an endogenous plant growth regulator widely distributed in higher plants (Tizio, 1996). Jasmonic acid is ubiquitous in plants and has hormone properties. This hormone is an important cellular regulator involved in diverse developmental processes, such as seed germination, root growth, fertility, fruit ripening, senescence and stomatal closure (Wasternack and Hause 2002; Hossain *et al.*, 2011) .

Methyl jasmonate and salicylic acid are naturally occurring phyto-hormones and known as secondary messengers, that are competent transducing normal developmental signals or adverse environmental stimuli to plant cells for initiating protective responses against oxidative stresses (Hayat *et al.*, 2005). It has been shown that methyl jasmonate affect invertase activity of rose petal discs. Previous works demonstrated that acid invertase activity is associated with petal growth and methyl jasmonate is effective in extending the vase life of cut flowers of rose (Horibe *et al.*, 2010).

The application of Si, salicylic acid and methyl jasmonate to promote plant growth is well documented in many plant species. There is little information on the influence of different sources of Si and postharvest treatments on traits and vase life of gerbera. Therefore, the objective of this study was to explore the effects of different sources of Si (rice hull ash, potassium and sodium silicate) and postharvest treatments (sucrose, salicylic acid and methyl jasmonate) on yield, flower quality and vase life of gerbera under greenhouse condition.

Materials and Methods

This experiment was carried out in Greenhouse Center and Horticulture Lab, Department of Horticulture, Faculty of Agriculture, Isfahan Branch, Islamic Azad University, Iran. Gerbera seedlings were transplanted and grown in 4 litters pots containing peat: perlite (1:1) (v/v). The following methods of application, concentrations of Si supplements inaugurating with the developmental stages, and sources as a postharvest treatment were used substrate incorporation of rice husk ash at 0, 50 and 100 mg L^{-1}, $KSiO_3$ solution at three concentrations (0, 140 and 200 mg L^{-1}) and $NaSiO_3$ solution (foliar application) at three concentrations (0, 50 and 100 mg L^{-1}). Also, postharvest treatments for vase life holding solution were containing sucrose, salicylic acid (200 and 400 mg L^{-1}), methyl jasmonate (15 and 25 mg L^{-1}) and distilled water (as control). During growth period, irrigation rate, humidity and temperature were conducted based on standard protocols. Average temperature of day and night were 29°C and 17°C, respectively during growth period. The growth characteristics of gerbera plant were determined at the end of growth period. The effects of different sources of Si (rice hull ash, potassium and sodium silicate) and postharvest treatments (sucrose, salicylic acid and methyl jasmonate) on yield, flower quality and vase life of gerbera were carried out by one-way analysis of variance (ANOVA). Statistical procedures were performed using the Statistical Analysis System (SAS), version 9.1 (SAS Institute, Cary, NC, USA). Differences between the treatments were determined using Least Significant Difference (LSD) test at $P<0.05$. Since the interaction effects of treatments were not statistically significant for the majority of investigated attributes in the current study, we analyzed and reported main effects only.

Results

The effects of silicon supplements on some traits of gerbera

As shown in Figures 1 and 2, there were no significant differences between applied treatments in length and diameter of flower shoot. Results showed that flower relative water content was greater in 100 mg L^{-1} RHA and sodium silicate compared to control treatment, although, in some cases, these differences were not significant (Fig. 3). The results showed that the application of potassium silicate, RHA and sodium silicate led to decrease in dry weight of flower, although the decreases were marginal. Dry weight of flower was greater in control and 50 mg L^{-1} RHA compared to other treatments (Fig. 4). As shown in Figure 5, flower water content was lower in 50 mg L^{-1} RHA compared to control treatment. However, the differences between other treatments were not significant at $P<0.05$ by LSD test. Shoot length was substantially higher in 140 mg L^{-1} potassium silicate than other treatments (Fig. 6). However, the differences between this treatment and both concentrations of sodium silicate and 50 mg L^{-1} RHA were not significant. The results indicated that, in most cases, silicon supplements resulted in an increase in shoot diameter. Shoot diameter was substantially higher in 140 mg L^{-1} potassium silicate than those in control treatment (Fig. 7). As shown in Figure 8, the maximum inflorescence diameter was observed in rice husk ash (50 mg L^{-1}). However, the differences between other treatments were not significant at $P<0.05$ by LSD test. The results showed that capitulum diameter was greater in sodium silicate at 50 and 100 mg L^{-1} compared to other treatments, although the differences were not significant (Fig. 9).

The effects of postharvest treatments on some traits and vase life of gerbera flower

Data on vase life of gerbera under postharvest treatments are reported in Figure 10. The results indicated that vase life of gerbera flowers was more in 400 mg L^{-1} salicylic acid and 15 mg L^{-1} methyl jasmonate than in control treatment. The application of postharvest treatments delayed petal wilting. The petal wilting was lower in salicylic acid and methyl jasmonate than in control treatment (Fig. 11). As shown in Figure 12, ovary diameter of gerbera flower was significantly greater in salicylic acid and methyl jasmonate than in control treatment. The results showed that stem height was greater in salicylic acid and methyl jasmonate compared to control treatments (Fig. 13), although the differences were not significant at $P<0.05$ by LSD test. The maximum inflorescence diameter was observed in 400 mg L^{-1} salicylic acid (Fig. 14). However, the differences between other treatments were not significant at $P<0.05$ by LSD test (Fig. 14).

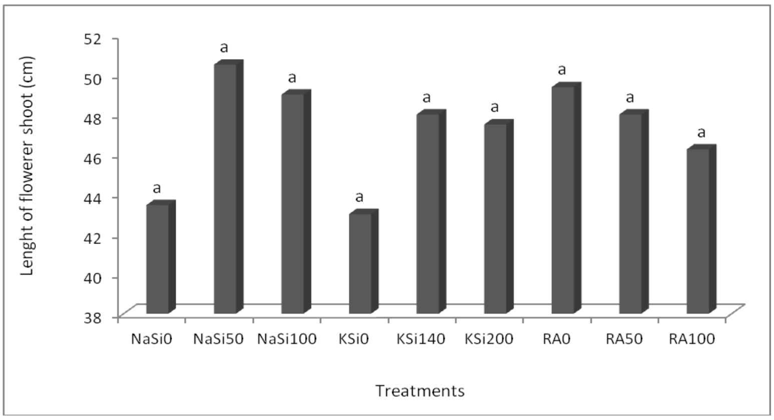

Fig. 1. Effects of silicon supplements on length of flower shoot of gerbera. Means followed by the same letter are not significantly different at P<0.05 by LSD.

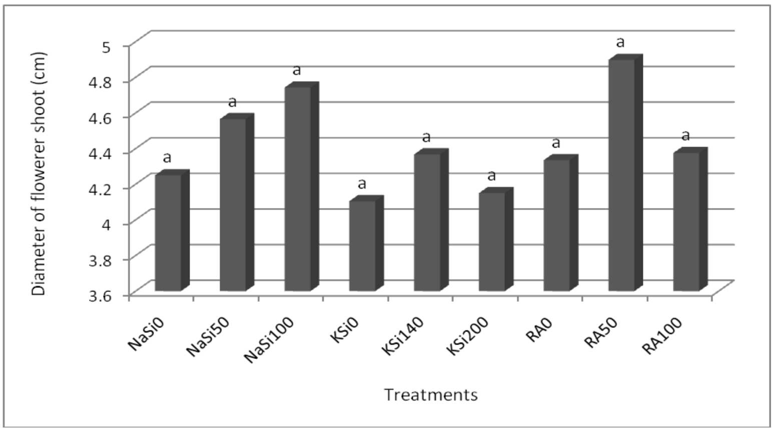

Fig. 2. Effects of silicon supplements on diameter of flower shoot of gerbera. Means followed by the same letter are not significantly different at P<0.05 by LSD.

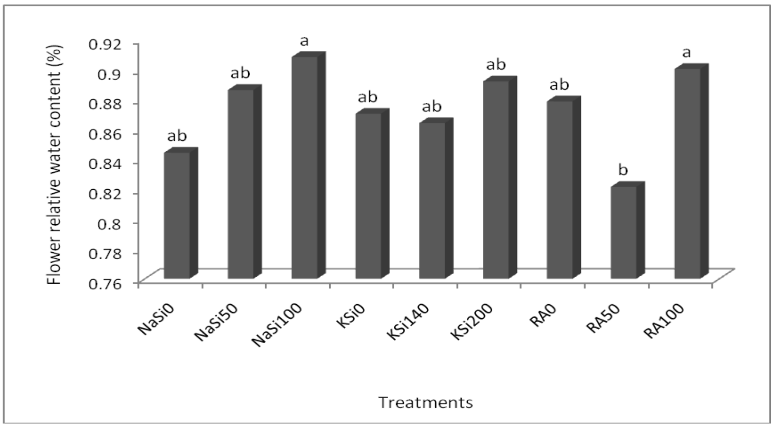

Fig. 3. Effects of silicon supplements on RWC of gerbera flower. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

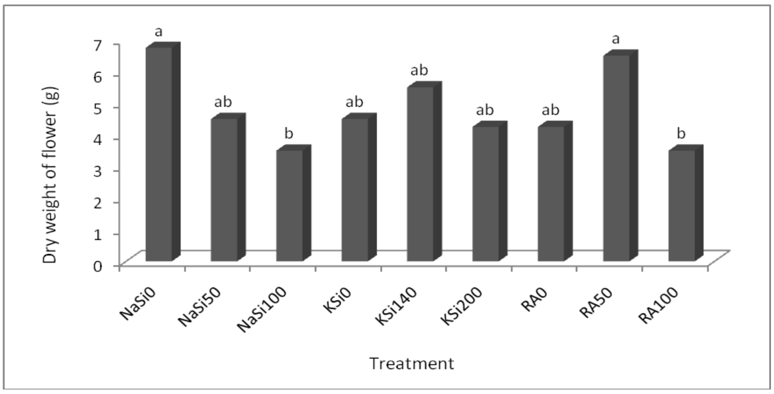

Fig. 4. Effects of silicon supplements on dry weight of flower. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

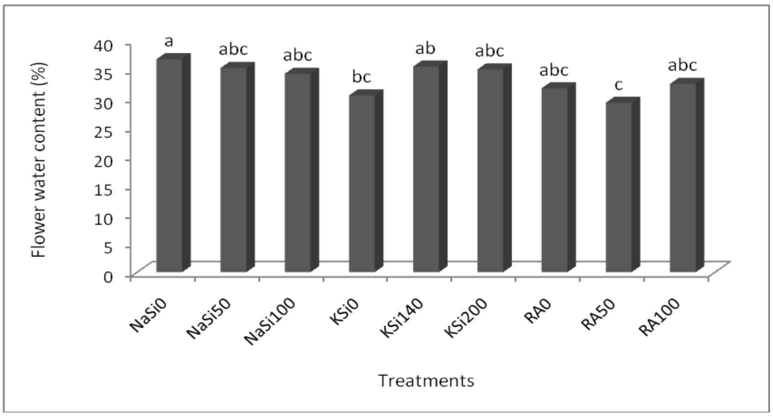

Fig. 5. Effects of silicon supplements on flower water content. Means followed by the same letter are not significantly different at P<0.05 by LSD.

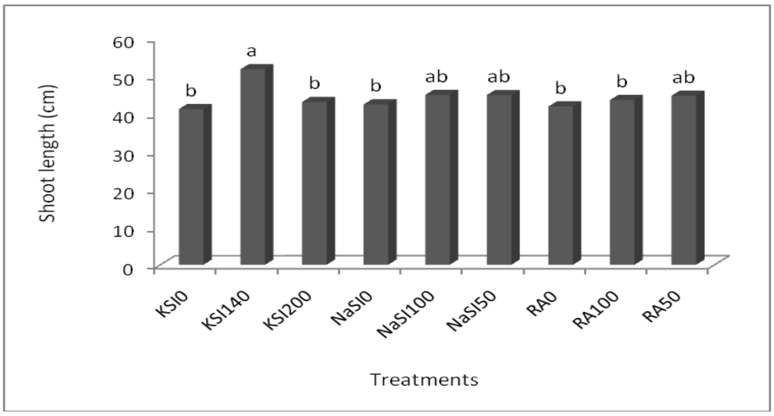

Fig. 6. The effect of silicon supplements on shoot length. Means followed by the same letter are not significantly different at p<0.05 by LSD.

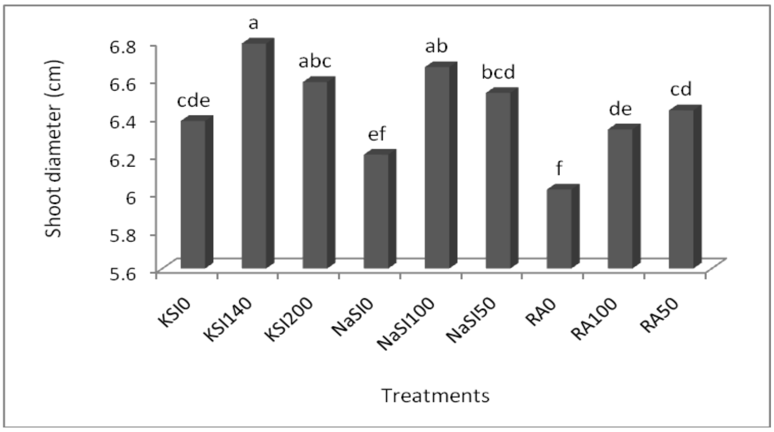

Fig. 7. Effects of silicon supplements on shoot diameter. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

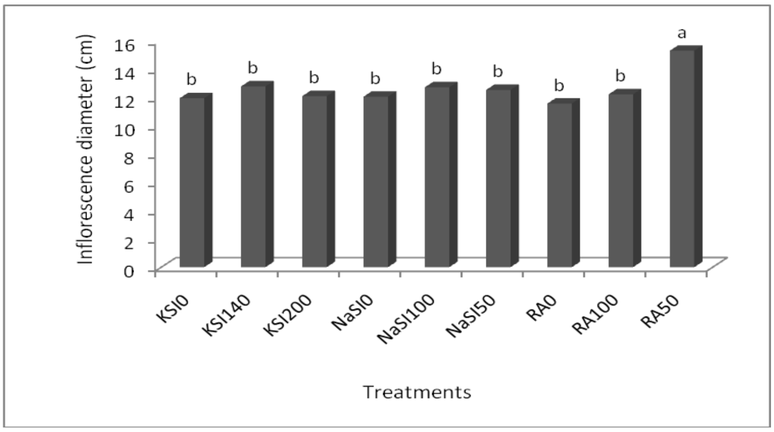

Fig. 8. Effects of silicon supplements on inflorescence diameter. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

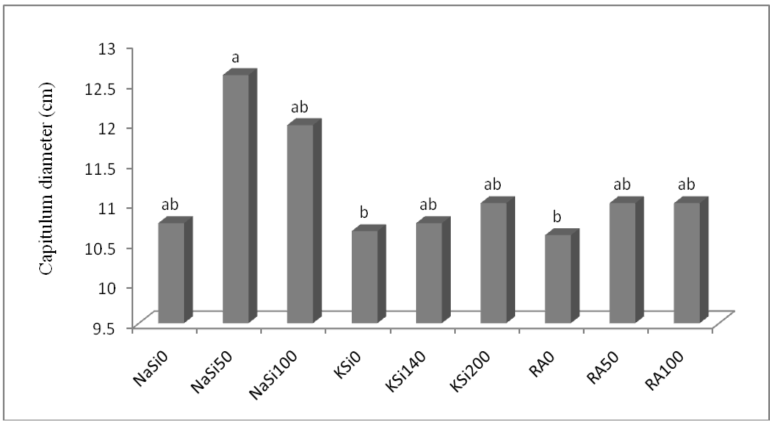

Fig. 9. Effects of silicon supplements on capitulum diameter. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

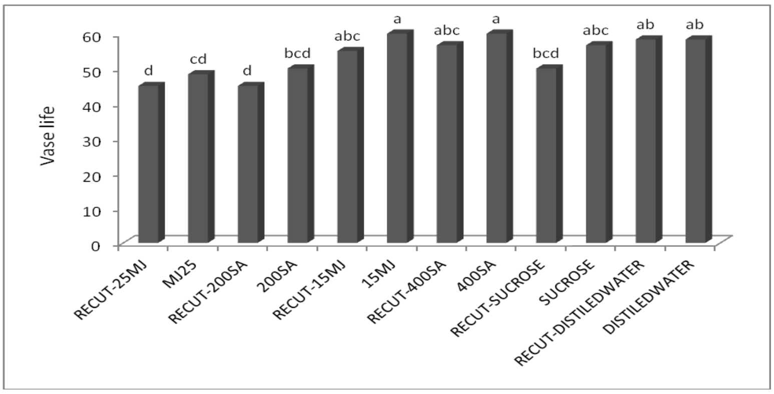

Fig. 10. Effects of postharvest treatments on vase life of flower. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

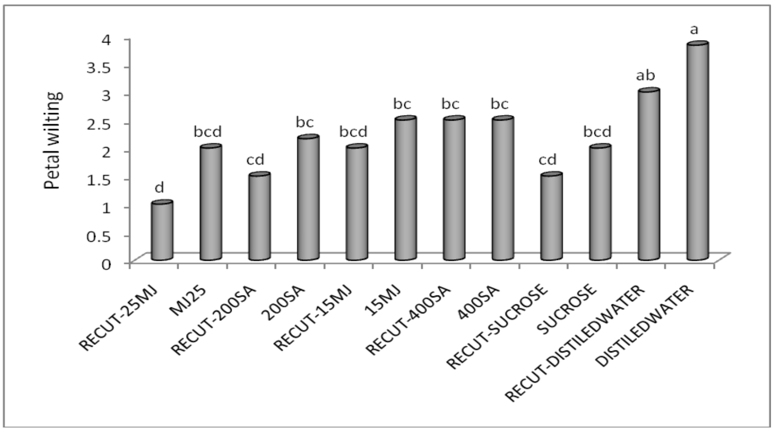

Fig. 11. Effects of postharvest treatments on petal wilting. Means followed by the same letter are not significantly different at P<0.05 by LSD.

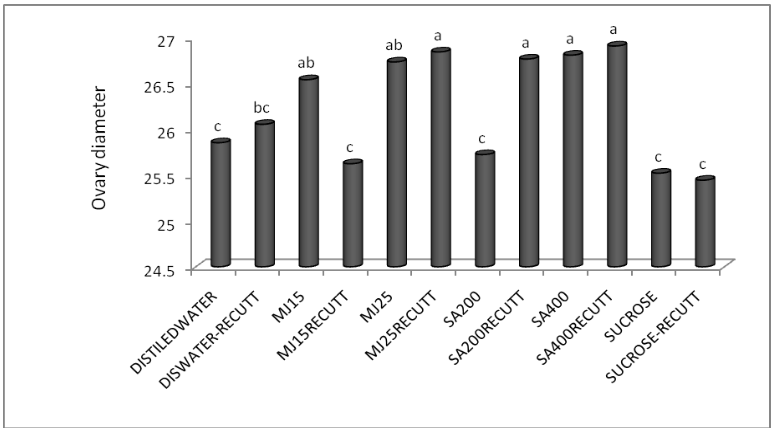

Fig. 12. Effects of postharvest treatments on ovary diameter. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

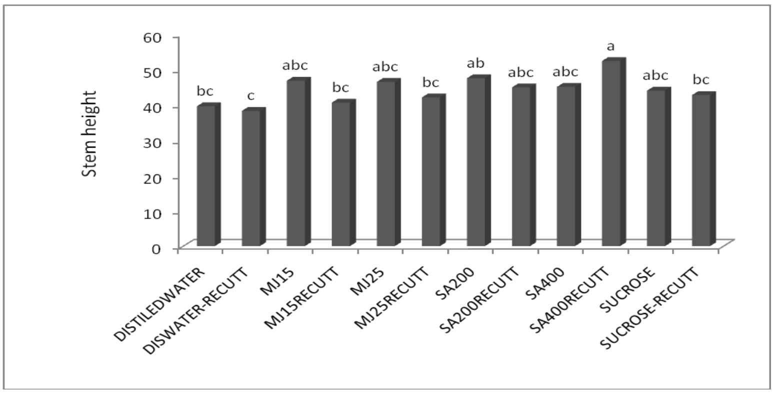

Fig. 13. Effects of postharvest treatments on stem height. Means followed by the same letter(s) are not significantly different at P<0.05 by LSD.

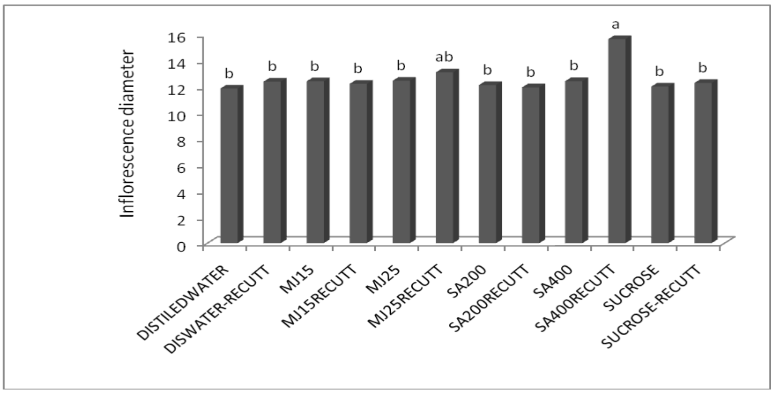

Fig. 14. Effects of postharvest treatments on inflorescence diameter. Means followed by the same letter are not significantly different at P<0.05 by LSD.

Discussion

Results of the current study showed the positive influences that silicon supplements might have on quality and quantity traits of cut-flower gerbera. In greenhouse production most crops are planted in soilless substrates with limited concentrations of the useful elements such as silicon (Si). This element in greenhouse production is reported to influence the quality of different plants that accumulate Si in their tissues (Kamenidou *et al.*, 2010). Kamenidou *et al.* (2010) revealed that foliar application of potassium silicate ($KSiO_3$), sodium silicate ($NaSiO_3$) and rice husk ash caused thicker flower peduncles, increased flower diameters, increased height, and flowered earlier than control. The application of Si in hydroponic system for gerbera cultivation resulted in markedly thicker flower stems (Savvas *et al.*, 2002). According to finding of Savvas *et al*. (2002), Si influenced inflorescence production in gerbera. In many works, rice hulls were applied as substitute either for pine bark or vermiculite and perlite. Laiche *et al*. (1990) suggested composted rice hulls as a component of container growth media for growing different plants. Dueitt *et al*. (1993) also reported that rice hull, produced *Impatiens walleriana* plants with height similar to those of peat: vermiculite. Lee *et al*. (1999) found that greater marketable yield of cucumber were observed on the perlite with rice hull or with carbonized rice hull as compared to the pure perlite.

The short vase life of cut gerbera flowers, leads to difficulties with long-distance transportation and subsequent marketing. In present work, the application of postharvest treatments resulted in an increase in vase life. These findings are in accordance with the observations of Alaey *et al*. (2011) who concluded that postharvest salicylic acid application prolonged vase life in cut rose flowers by improving the reactive oxygen species scavenging capacity related to Catalase activity and by better regulation of the water balance. In rose, Alaey *et al*. (2011) reported that maximum vase-life was obtained in solutions contained 50µM and 100 µM salicylic acid. However, in this study, maximum vase-life of gerbera was observed in solutions contained 400 mg L^{-1} salicylic acid and 15 mg L^{-1} methyl jasmonate. Vase-life was improved by using salicylic acid in vase solutions. Salicylic acid extended vase-life of flowers by regulating water uptake. Improved water balance may be because of possible germicidal activity of salicylic acid as an anti-microbial compound acting by prohibitive vascular blockage and/or positive regulatory role of salicylic acid on stomatal closure which regulates the rates of transpiration and increases the water-retaining capacity of leaf and petal (Mori *et al*., 2001).

Results of present study confirm the positive influences that salicylic acid and methyl jasmonate might have on quality and quantity traits of gerbera cut-flower. Horibe *et al*. (2013) observed that fresh weight of petals did not decrease after the application of methyl jasmonate, and flower senescence seemed to be delayed. The activation of invertase by methyl jasmonate promotes sucrose translocation from leaves to petals during growth of petal and resulted in accumulation of hexose in petals and cut flower senescence delayed by methyl jasmonate (Horibe *et al*., 2013). Alaey *et al*. (2011) found that leaf area, stem height, stem fresh weight and dry weight were higher in salicylic acid sprayed plants. They found that leaf area, and stem height increased consistently with increasing salicylic acid concentration (50 µM to 200 µM).

Conclusions

In this study an attempt was made to investigate the potential role of sources of Si, sucrose, salicylic acid and methyl jasmonate in maintaining good marketable quality of cut gerbera flowers. A substantially higher shoot length and diameter were was observed using potassium silicate pre-harvest treatment. In addition, rice husk ash pre-harvest supplementation maximized the inflorescence diameter. More importantly, vase life of gerbera flower was prolonged following salicylic acid and methyl jasmonate treatments. In conclusion, this study revealed that different sources of Si as pre-harvest treatment as well as salicylic acid and methyl jasmonate as postharvest treatment can significantly affect on marketability of cut gerbera flowers.

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