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Full Length Research Paper

Improvement of the vase life of cut gladiolus flowers by essential oils, salicylic acid and silver thiosulfate

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Effects of the application of salicylic acid (SA) (1.5 mMol), ajowan and summer savory essential oils (500 and 1000 ppm), silver thiosulphate (STS) (150 ppm) and combinations of these materials on vase life of cut gladiolus flowers were investigated. Results of this study showed that within all treatments, SA treatment showed the best effect on the fresh weight (%), water uptake (cm^3) and vase life of cut flowers. Moreover, it is showed that ajowan oil at 500 ppm concentration had benefit effect on fresh weight (%) and vase life of cut gladiolus and then STS treatment had positive effect on water uptake (cm^3) of cut flowers.

Key words: Cut gladiolus flower, essential oil, salicylic acid, silver thiosulphate, vase life.

INTRODUCTION

Gladiolus (*Gladiolus hybridus* Hort.) is one of the four famous cut flowers in the world (Bai et al., 2009). The longivity of cut flowers is one of the main challenges of florists today. Because, one the most important factors for consumers, apart from its external quality, is vase life of cut flower. The longivity of gladiolus cut flowers is very short. The typical vase life of individual florets is just 4 to 6 days and senescent florets remain at the bottom of the spikes after the opening of the upper florets (Yamada et al., 2003). It is well documented that one of the main causes for inferior cut flowers quality is the blockage of xylem vessels by microorganisms that accumulate in the vase solution or in the vessels themselves. When the vessels of stems blocked, continuing the water uptake and transpiration by the leaves of cut flowers results in net loss of water of flower and stem tissue (Hassan, 2005). It is reported that there was a positive correlation between the number of bacteria and water conductivity in the stem of cut flower (van Doorn et al., 1989). The vase life of cut flowers increased by addition of various antimicrobial compounds such as chlorine (Macnish et al., 2008), hydroxyquinoline sulfate (Beura et al., 2001) and silver nanoparticles (Solgi et al., 2009) in vase water for reduction of bacterial population in the vase water. High concentration of ethylene in the ambient atmosphere is one important factor in reduction of longevity of cut flowers. Because ethylene increased the rate of senescence and generally, bud, flower and leaf drop are known to be the result of ethylene action (Serek, 1993; Serek et al., 1994). Cut flowers are generally treated with anionic complex STS, as inhibitor of ethylene, for increase longevity of cut flowers. Because it is determined that STS could reduce the flower abscission of flowers when they subjected to ethylene. In addition, it is reported that STS provides some antimicrobial activity inside the plant tissues (Nowak and Rudnicki, 1990).

However, because STS contain a heavy metal, its application as a possible environment pollutant has been banned in several countries. Therefore, scientists trends to find an effective and safe alternatives for STS (Serek and Reid, 1993; Cross, 1996). Nowadays, trend to application of natural materials such as salicylic acid (SA) and plant essential oils as safe preservatives for maintenance of food and agricultural products increased.

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Abbreviations: SA, Salicylic acid; **STS,** silver thiosulphate; **SS,** sucrose solution; **CRD,** completely randomized design; **SAR,** systemic acquired resistance.

SA is a simple phenolic compound involved in the regulation of many processes in plant growth and development, including stomatal movement, seed germination, ion absorption, sex polarization, and induction of disease resistance (Raskin, 1992; Zhang et al., 2003). Essential oils are complex and highly variable mixtures of components that belong to two groups: terpenoids and aromatic compounds that accumulate in all types of vegetative organs (flowers, leaves, bark, woods, roots, rhizomes, fruits and seeds) (Aflatuni, 2005). The antimicrobial properties of essential oils have been known for a long time and have been documented in several studies (Bagamboula et al., 2004; Burt, 2004; Kotzekidou et al., 2008).

The reports in laboratory tests and field trials of a series of plant essential oils as antimicrobial agents have shown promising results (Abdolahi et al., 2010a, b; Jalili et al., 2010). Therefore, the main objective this work is the use of SA and plant essential oils for increase longevity gladiolus cut flower with low risk for environment.

EXPERIMENTAL

Chemicals, plant material and treatment

Sucrose (Scharlua, Spain), SA (Scharlua, Spain) and silver thiosulphate (Merk, Germany) were purchased, respectively. The aerial parts of summer savory (*Satureja hortensis* L.) at flowering stage and ajowan (*Carum copticum* L.) fruits at ripening stage were harvested, air dried and then submitted to hydrodistillation in a Clevenger-type apparatus for 3 h. The extracted essential oils dried over anhydrous sodium sulfate. Cut gladiolus (*G. hybridus* Hort.) flowers were purchased from a commercial grower at normal harvest maturity and immediately transported to laboratory of Department of Horticulture, Faculty of Agriculture, Urmia University and used for experiments.

Treatment of cut flowers

Flower stems were trimmed to 40 cm, all leaves except for the upper three were removed and the end of cut flowers disinfected with solution of 1% sodium hypochlorite for 2 min. Different treatment solutions were prepared and then cut flowers treated with and different solutions. 15 treatments carried out in this study on cut flowers: (1) sucrose solution 4% (SS) as control; (2) SA 1.5 mMol + SS; (3) STS 150 ppm + SS; (4) ajowan EO (500 ppm) + SS; (5) ajowan EO (1000 ppm) + SS; (6) *S. hortensis* EO (500 ppm) + SS; (7) *S. hortensis* EO (1000 ppm) + SS; (8) ajowan EO (500 ppm) + SA 1.5 mMol + SS; (9) ajowan EO (1000 ppm) + SA 1.5 mMol + SS; (10) *S. hortensis* EO (500 ppm) + SA 1.5 mMol + SS; (11) *S. hortensis* EO (1000 ppm) + SA 1.5 mMol + SS; (12) ajowan EO (500 ppm) + STS 150 ppm + SS; (13) ajowan EO (1000 ppm) + STS 150 ppm + SS; (14) *S. hortensis* EO (500 ppm) + STS 150 ppm + SS; (15) *S. hortensis* EO (1000 ppm) + STS 150 ppm + SS. Three cut flowers were placed in a glass vessel with 10 ml treatment solution. Three flowers were used for each treatment. The cut flowers were maintained at 22 ±1°C, 60 to 70% relative humidity, and a 16 h photoperiod less than 10 µmol m^{-2} s^{-1} irradiance from cool-white fluorescence lamps.

Determination of quality sensors

Vase life was the period from the time of harvest to the time when 50% of the petals lost turgor and wilted. The fresh weight of cut flowers and the amount of water uptake were measured daily. The amount of water loss was calculated by subtracting the increase in fresh weight from the amount of water uptake. The stem diameter of flower at harvest and in the end of storage (when 50% of flowers welted) measured.

Statistical analysis

Statistical analyses of the data were performed with SPSS statistical software using completely randomized design (CRD) with 3 replicates. Data were subjected to ANOVA but no formulae, bar graphs, statistical parameters, data tables have been provided. Mean differences were established by Duncan's test ($P < 0.05$).

RESULTS

Assessment of stem diameter, fresh weight (%), solution uptake (cm^3) and vase life of treated gladiolus cut flowers showed that none of treatments had not significant effect on stem diameter of cut flowers in comparison with sucrose 4% (control). Results of this study showed that with in all treatments SA had the best effect on the fresh weight (%), solution uptake (cm^3) and vase life of cut flowers. Also, it is showed that ajowan oil at 500 ppm concentration had benefit effect on fresh weight (%) and vase life of cut gladiolus and then STS treatment had positive effect on water uptake (%) of cut flowers.

Moreover followed by SA and STS treatment had the highest efficacy in enhancement of water uptake (%) collation with control (Table 1). On other hand, it is determined that treatment of cut gladiolus flowers with ajowan oil at 500 ppm concentration in combination with SA and sucrose 4% had the best effect on fresh weight (%) followed by ajowan at 500 ppm concentration in combination with STS in the vase solution, respectively (Figure 1).

DISCUSSION

Significant toxic properties of chemical preservatives such as STS on environment trends researchers intend to find a novel way to enhancement longevity of cut flowers. Results of present study showed that treatment of cut gladiolus flowers with plant essential oils, as safe and natural compounds, especially ajowan oil at 500 ppm concentration had a noticeable effect on improvement of quality parameters of oil-treated flowers. This preservative efficacy of essential oils could be related to their antibacterial properties that reduce bacterial proliferation in the stem vessels of cut gladiolus flowers. Antimicrobial property of variety of essential oil bearing plants have been recognized through history but the exact mechanism(s) of their antimicrobial activities not

Table 1. The effect of essential oils, SA and STS treatments on stem diameter, fresh weight (%), solution absorption (cm^3) and vase life of gladiolus cut flowers.

Treatments	Stem diameter	Fresh weight (%)	Solution uptake (cm^3)	Vase life (day)
Sucrose (4%)	83.6 ^{a}	83.2 ^{ab}	1.5 ^{b}	18 ^{b}
Summer savory (500 ppm)	82.9 ^{a}	71.6 ^{c}	0.9 ^{d}	16 ^{c}
Summer savory (1000 ppm)	82.3 ^{a}	73.6 ^{b}	1.2 ^{c}	18 ^{b}
Ajowan (500 ppm)	81.2 ^{a}	85.1 ^{a}	2.7 ^{a}	20 ^{a}
Ajowan (1000 ppm)	83.1 ^{a}	75.6 ^{b}	1 ^{d}	17 ^{c}
SA	83.8 ^{a}	109.4 ^{a}	9.9 ^{a}	21 ^{a}
STS	82.1 ^{a}	93.2 ^{b}	4.4 ^{b}	19 ^{b}

The means followed by same symbol in each column are not significantly different according to Duncan's multiple comparison tests ($P < 0.05$).

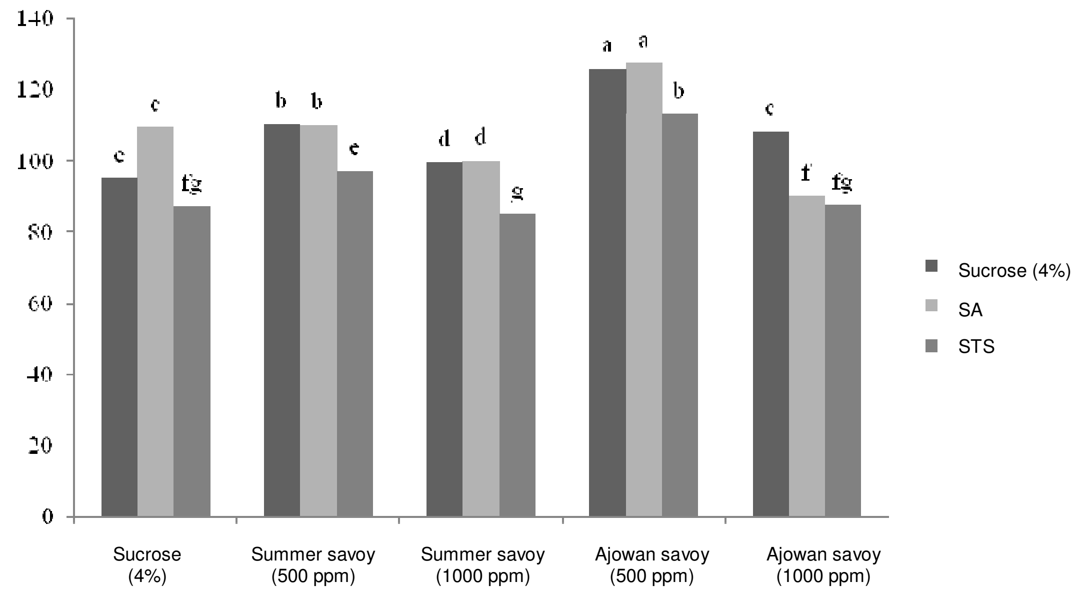

Figure 1. The effect of different essential oil, sucrose (4%), SA and STS treatments on fresh weigh (%) in the cut gladiolus flowers. Means of treatments with the same letter are not significantly different according to Duncan's multiple ($P < 0.05$).

recognized. Some researchers reported that essential oil components attack to cell well and react with enzymes responsible for synthesis of cell wall and as a result causing pathogen death (Sharma and Tripathi, 2008). Moreover, antibacterial properties of essential oils assigned to their lipophilic character that accumulate in bacterial membranes causing energy depletion (Conner, 1993). Totally, the mechanism of action is considered to be the disturbance of the cytoplasmic membrane, disrupting the proton motive force, electron flow, active transport, and coagulation of cell contents (Kotzekidou et al., 2008). In an earlier work, reported that thymol (63.18%) and carvacrol (54.14%), as phenolic compounds, were the major constituents of essential oils of ajowan and summer savory, respectively (Abdolahi et al., 2010a, b). The essential oils had inhibitory effect on oxygen uptake and oxidative phosphorylation of microbial pathogens. Especially phenolic and non-phenolic compounds showed strongest inhibitory effects, followed by aldehydes and ketones. The monoterpene hydrocarbons were less active and it has been suggested that this behavior depends on the free hydroxyl group from the alcohols (Oliveira et al., 2007). Also, in several papers antimicrobial properties of plant essential oils related to their phenolic constituents. This components affect cell membrane permeability, and able to disintegrate the outer membrane of gram-negative bacteria, releasing lipopolysaccharides and increasing the permeability of the cytoplasmic membrane to ATP (Bagamboula et al., 2004; Burt, 2004; Didry et al., 1994).

Therefore, in agreement to previous studies, it could be speculated that good preservative efficacy of ajowan and summer savory oils are attributed to its phenolic constituents.

In this study, STS, ethylene production inhibitor, was added to sucrose solutions 4% to improvement the vase life of gladiolus cut flowers, which enhanced the longevity of cut flowers. Previously, Beura et al. (2001) reported that treatment of gladiolus cut flowers with sucrose in combination with STS increased the vase life of cut flowers. In addition, Zemin et al. (2001) showed that the pulsing treatment with sucrose and STS prolonged the vase life of gentian flowers compared with the water control. They suggest that sucrose and STS act similarly at least on soluble sugar changes and ethylene production that are associated with inhibiting flower senescence. It is distinguished that pulsing gladiolus spikes with sucrose resulted in increased glucose and fructose concentration and improved the maintenance of high starch concentration in the floret during flower opening. Also, adding STS to the holding solution increased the concentrations of glucose and fructose in florets this data suggested that STS may improve sucrose uptake and its subsequent hydrolysis (Meir et al., 1995). It is well documented that the production of ethylene after cutting the plant tissues increased (van Doorn et al., 1989). Burzo and Dobrescu (1995) indicated that pulsing cut carnation flowers with STS + 10% sucrose inhibited the ethylene synthesis and improved the postharvest quality of cut flowers. In addition, treatment of chrysanthemum cut flowers with STS inhibited chlorophyll, soluble protein and sugar losses during flower senescence (WeiMing et al., 1997). One other reason for beneficial effects of STS related to their antimicrobial activity and it is showed that STS decreased the bacterial population in cut flowers (Torre and Fjeld, 2001). Results of present study showed that adding SA in holding solution had positive effect on quality sensors of cut gladiolus flowers. SA is one of the endogenous signals which play an important role in plant defense. SA required for basal resistance against pathogens as well as for the inducible defense mechanism, systemic acquired resistance (SAR), which confers resistance against a broad-spectrum of pathogens (Chaturvedi and Shah, 2007). Also, SA inhibited the ethylene biosynthesis and delayed senescence progress in plant tissues (Leslie and Romani, 1986). Therefore, we can speculate that SA with induction SAR and/or with inhibition of ethylene biosynthesis could prolong the vase life of gladiolus cut flowers.

Conclusion

In conclusion, our results show that SA and essential oils alone cannot provide very good preservative to increase of vase life of cut gladiolus flowers and for best efficacy this substances should be combined with chemical components such as STS.

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