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Effect of Silicon Based Postharvest Treatments on the Longevity of Selected Cut Flowers

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ABSTRACT

Gerbera (*Gerbera jamesonii*), Alstroemeria (*Alstroemeria* spp.), Gladiolus (*Gladiolus communis*) and Roses (*Rosa* spp.) are popular cut flower species in the domestic market of Sri Lanka. However, lack of postharvest treatments during handling has limited their end user vase life. Silicon (Si) supplementation has proven benefits to crop plants. Therefore, the efficacy of a commercial Si formulation was assessed for these species. Cut flower stems were placed in vase solutions containing Si concentrations of 0 (Distilled water; Control), 25, 50, 100, 200, 250 and 300 mg L^{-1}. Experiments were arranged in completely randomized design with three to seven replicates. The Si treatments, in the form of given commercial formulation, did not significantly improve the vase life, relative fresh weight of stems or the rate of vase solution uptake in all species. Silicon itself or possibly the other compounds in the formulation exerted phytotoxicity on cut flowers. The increased solution pH (> 9.0) too was undesirable for cut flower holding solutions.

KEYWORDS: Cut flowers, Relative fresh weight, Silicon, Vase life, Vase solution uptake

INTRODUCTION

Floriculture industry significantly contributes to Sri Lanka's economy by foreign exchange earnings and employment generation (Anon, 2015a). Sri Lanka exports both tropical and temperate cut flowers and over 90% of cut flower exports are temperate flora including roses, chrysanthemum, gerbera and carnation (Anon, 2015b). Cut flowers have always been the main group within global floriculture trade, followed by living plants (Anon, 2015c).

Keeping quality and length of vase life are important factors for evaluation of cut flowers' quality for both domestic and export markets. Early termination of vase life is considered to be caused by vascular occlusion, which inhibits water supply to the flowers. Vascular occlusion is caused by multiplication of bacteria, air emboli or by unknown physiological responses (Ichimura *et al.*, 2002).

Due to high perishability of cut flowers under warm tropical conditions, their post-harvest losses are high in Sri Lanka. Senescence of cut flowers depend on factors such as water stress, carbohydrate depletion, microorganisms and ethylene effects. Ethylene is the major coordinator of senescence in many flowers. Ethylene promotes flower senescence, increase the production of oxygen free radicles, malondyaldehydes accumulation, respiratory activity and loss of cell membrane fluidity (Kazemi *et al.*, 2012a). Addition of chemical preservatives to the holding solution is recommended to prolong the vase life of cut flowers (Kader, 2002).

The potential benefits of silicon (Si) nutrition in plants have been extensively studied. Some of these include a decrease of transpiration, resistance to heavy metal toxicities and suppression of fungal and bacterial diseases (Weerahewa, 2013). Silicon deposition results in a Si double layer under the cuticle and this barrier is believed to reduce water loss and provide a mechanical defense against biotic stresses (Belanger *et al.*, 1995). Pre-harvest Si supplementation improved the post-harvest quality parameters of gerbera (Savvas *et al.*, 2002; Snyder *et al.*, 2007), roses (Ehret *et al.*, 2005), sunflower and zinnia (Kamenidou *et al.*, 2008; 2009).

A few research reports suggest on postharvest Si application at 300 mg L^{-1} (Jamali and Rahemi, 2011) and 2.5 mM (Kazemi *et al.*, 2012a) as beneficial for cut carnation flowers. Moreover, delayed senescence with Si was observed for cut gerbera (Kazemi *et al.*, 2012b) and cut lisianthus flowers (Kazemi *et al.*, 2012c).

Therefore, this study was carried out to investigate the effect of Si, provided as a postharvest vase treatment, on longevity of selected ethylene sensitive cut flower species popular in Sri Lanka.

MATERIALS AND METHODS

Location, Experimental Material and Set Up

Experiments were conducted at the Horticulture Laboratory, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura from January to May 2016. Cut flowers of gerbera

(*Gerbera jamesonii* var. Candela, Camel and Entourage), roses (*Rosa* spp. var. Prestige and Akito), alstroemeria (*Alstroemeria* spp. var. Tiesto and Elysee) and gladiolus (*Gladiolus communis*) grown in Nuwara Eliya (Up Country Wet Zone), harvested at the correct maturity and transported under cool condition (7-10 °C) were obtained from a retail centre in Negombo immediately upon arrival. Flowers were selected for uniformity and quality. Stems were re-cut to 35-40 cm immediately before they were putting into 600 mL plastic bottles which were filled with 400 mL of distilled water for the control treatment and 400 mL of treatment solutions. A commercial Si formulation [50% Potassium bicarbonate, 10% Sodium silicate (Na_2SiO_3) and 40% Citric acid] was used as the source of Si. Solutions were prepared using distilled water (Table 1). Mouths of the bottles were covered using Parafilm.

Temperature, relative humidity (RH; Data logger DTM-322, TECPEL Co. Ltd., Taiwan) and light intensity (Light meter, Cleator Moor Cumbria, UK) of the environment were recorded. pH of fresh treatment solutions (Table 1) was measured (pH meter, Model:2100, OHAUS Corporation, USA). The mean temperature (day/night), RH (day/night) and light level during 12 h photoperiod were 31.4 °C/29.3 °C, 68.8%/76.6% and 15 µmol m^{-2} s^{-1}, respectively.

Table 1. Silicon (Si) level and pH of treatment solutions

Treatment	Si concentration ($mg\ L^{-1}$)	Solution pH
T_1 (Distilled water)	0	5.41
T_2	10	9.94
T_3	25	9.88
T_4	50	9.71
T_5	100	9.76
T_6	200	9.73
T_7	250	10.17
T_8	300	10.01
T_9	350	10.06

Determination of Vase Life

Overall appearance and the quality of flowers and leaves were recorded daily using a scale developed for their quality (Table 2).

Relative Fresh Weight (RFW) and Vase Solution Uptake Rate (VSUR) Measurements

Individual vases with and without flowers were weighted daily using an electronic top loading balance. For weighing, flowers were taken out from water as short a time as possible (20-30 s). Relative Fresh Weight of stems were calculated using the formula: RFW (%) = (W_t / $W_{t=0}$) * 100% where, W_t is the current day's weight of stem (g) at t=day 0, 1, 2, 3, *etc.* and $W_{t=0}$ is the weight of same stem (g) at t=day 0 (He *et al.*, 2006).

Average daily vase solution uptake (g g^{-1} initial Fresh Weight) was calculated by the formula: VSUR = (S_{t-1} – S_t) / FW. Where, S_t is the current day's weight of vase solution (g) at t = day 1, 2, 3, *etc.*, S_{t-1} is the weight of vase solution (g) on the previous day and FW is initial stem fresh weight at day 0 (He *et al.*, 2006).

Table 2. Methods of determining the vase life termination in cut flowers

Species	Symptoms
Gerbera	≥45⁰ scape bending
	Stem breakage
	≥25% wilting
	≥25% petal discolouration
Roses	≥90⁰ bent neck
	≥25% flower wilting
	≥50% petal discolouration
	≥50% petal abscission
	Failure to open buds
	≥50% wilting of leaves
Alstroemeria	≥50% petal abscission
	≥75% leaf yellowing
Gladiolus	≥50% flower wilting

Experimental Design and Statistical Analysis

Experiments were arranged in Completely Randomized Design (CRD) with 3-7 replicates consisting of individual flowers as experimental units. Data analysis was done by ANOVA using Statistical Analysis System (SAS) Version 9.2 (SAS Institute Inc., USA).

RESULTS AND DISCUSSION

Si Effect on Vase Life Parameters

The cut flowers used in the current study are considered as ethylene sensitive species. Vase solution Si at 25–300 mgL^{-1} did not significantly improve the longevity of cut gerbera cultivars (Table 3). Rather, in var. Candela and Camel, they slightly advanced the senescence by accelerating bent neck symptoms. For alstroemeria var. Elysee, a slightly higher vase life was given by Si at 100 – 350 mgL^{-1}, while it slightly shortened the vase life of var. Tiesto. However, non of these effects were significant at P=0.05 level (Table 3). Leaf longevity of alstroemeria var. Tiesto was slightly increased by Si due to delayed yellowing possible caused by chlorophyll retention by Si treatment (Kazemi *et al.*, 2012a). For roses, Si did not have a significant effect on flower or leaf longevity while at higher concentrations, it appeared toxic. Vase life of gladiolus too was not influenced by Si treatments (Table 3). Previous research with carnation showed just one-day extension of vase when Si (K_2SiO_3) was provided at 300 mgL[-1] in vase solution (Jamali and Rahemi, 2011).

The relative fresh weight (RFW) showed a declining trend from day three onwards in the vase period (Figure 1). The highest RFW for a longer compared to other treatments (Figure 1).

The rate of solution uptake increased up to day one and thereafter had a decreasing trend (Figure 2). Many previous studies have also shown that the solution uptake rate tended to increase initially and then decreased (Knee, 2000). The higher fresh weight retention was associated with increased solution uptake rate of the control treatment as shown in Figure 2. Thus, the relatively better, *albeit* slightly, vase life in the control was due to improved solution uptake rate and fresh weight retention of those stems. Silicon treatment has caused phytotoxicity which retarded the water uptake and thereby, advanced the senescence.

Table 3. Effect of vase solution silicon (Si) concentration on the vase life of selected cut flower species

Si (mg L^{-1})	*Gerbera jamesonii*			*Alstroemeria* spp.				*Rosa* spp.				*Gladiolus communis*
				Tiesto		Elysee		Prestige		Akito		
	1	2	3	Fl	Lv	Fl	Lv	Fl	Lv	Fl	Lv	Fl
0	7.4	6.0	4.3	6.0	2.6	2.8	2.6	2.0	2.0	1.8	2.0	2.8
10	-	-	-	-	-	-	-	2.0	2.0	1.6	2.0	-
25	-	7.0	4.3	-	-	-	-	2.0	2.0	1.4	1.0	-
50	-	3.0	4.0	5.6	4.3	-	-	2.0	2.0	1.0	2.0	2.6
100	5.4	5.0	4.0	5.3	3.6	3.2	1.6	1.0	2.0	1.4	1.0	2.2
200	5.4	-	4.0	5.6	4.3	3.0	1.2	1.4	1.0	1.6	2.0	2.4
250	5.8	-	4.3	5.3	3.0	2.2	1.4	1.6	2.0	1.0	1.0	2.4
300	5.0	-	-	-	-	3.2	1.4	-	-	-	-	2.2
350	-	-	-	-	-	3.2	1.4	-	-	-	-	-

Fl -Flower vase life; Lv - Foliage vase life 1-Candela; 2- Camel; 3 - Entourage. Within each column, treatment means were not significant at P = 0.05

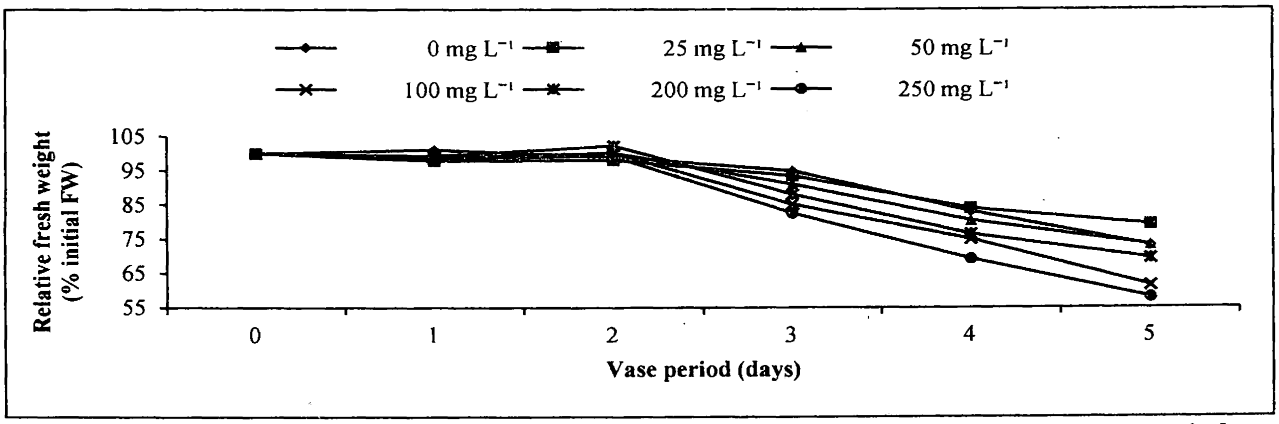

Figure 1. Change of relative fresh weight in cut gerbera variety Entourage during vase period

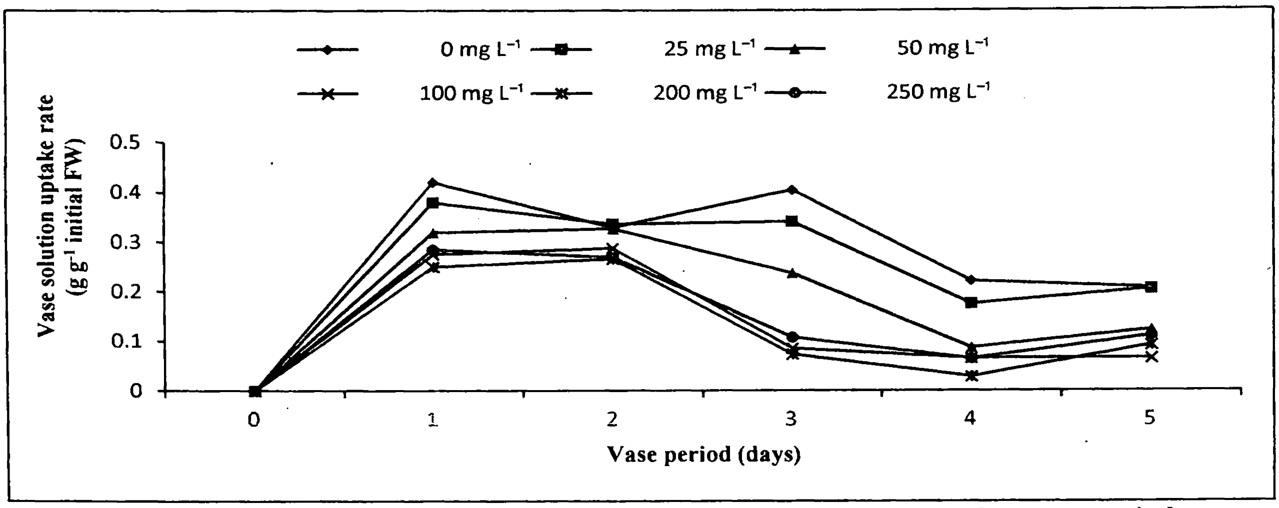

Figure 2. The rate of solution uptake in cut gerbera variety Entourage during vase period

As depicted in Figures 1 and 2, the tendency was to decrease RFW and VSUR with increasing Si concentration. The decrease in water uptake leads to water deficit stress and reduced turgidity in cut flowers (Burdett, 1970).

Possible Issues with Si Formulation

In the current study, instead of a pure Si source, a commercial formulation reported to contain potassium bicarbonate (50%), sodium silicate (Na_2SiO_3; 10%) and citric acid (40%) was used. Although citric acid is expected to reduce solution pH to a favourable level (*i.e.* pH 3-4) for cut flowers, the solutions were found alkali (Table 1; Jowkar *et al.,* 2012). While basic solutions are undesirable as cut flower holding solutions, a compound in the formulation exerted phytotoxicity on cut flowers.

CONCLUSIONS

Incorporation of Si in vase water using the given commercial formulation is ineffective for cut gerbera, roses, alstroemeria and gladiolus due to its apparent phytotoxicity and/or increased solution pH. Therefore, further research is recommended with different Si sources (e.g. Na_2SiO_3) to find out the potential benefits of Si. Because the pre-harvest application of given commercial formulation has been beneficial for other crops, its effect on cut flower crops, especially on their postharvest quality attributes, should also be investigated.

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