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Postharvest Life of Cut Lisianthus Flowers as Affected by Silicon, Malic Acid and Acetylsalicylic Acid

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ABSTRACT

Vase life is one of the most important problems on the cut flowers. Combinations of silicon, malic acid and acetylsalicylic acid were used as preservative mixture for cut lisianthus and their effect on regulation of senescence was examined. The vase were placed in chambers at 19°C, relative humidity about 70% and 14 h photoperiod that was maintained using fluorescent lamps (light intensity of 15 μmol m^{-2} sec^{-1}) at the top of the corolla. In this study, the recorded traits included vase life, total chlorophyll content (SPAD reading), anthocyanin leakage, malondialdehyde content and ACC-oxidase activity. The results showed that combination silicon, malic acid and acetylsalicylic acid treatments increased the vase life compared to the control. The vase solution containing 1.5 mM silicon and 2 mM malic acid with 1.5 mM acetylsalicylic acid significantly the malondialdehyde accumulation and ACC-oxidase activity reduced in the same solution while membrane stability was improved.

Key words: Silicon, malic acid, acetylsalicylic acid, lisianthus, cut flowers

INTRODUCTION

Short postharvest vase life and senescence are one of the most important problems on the cut flowers (Reid and Wu, 1992; Ichimura *et al.*, 2002; Kader, 2003; Da Silva, 2003; Farokhzad *et al.*, 2005; Reezi *et al.*, 2009). Ethylene reduced the postharvest quality cut flowers, increased respiratory activity and loss of cell membrane fluidity. Inhibitors of ethylene biosynthesis such as SA, Si and MA reduced the effects of senescence cut flowers with reduced ethylene production (Nowak and Rudnicki, 1990; Epstein, 1994; Eason and Webster, 1995; Ansari and Misra, 2007; Mahdavian *et al.*, 2007; Mba *et al.*, 2007; Canakci, 2008; Karlidag *et al.*, 2009; Kazemi *et al.*, 2011b). Kazemi *et al.* (2010) reported that SA and MA reduced effects ethylene with reduced the number of bacterial in the solution and with decrease ACC-oxidase activity cause delay in senescence. Janda *et al.* (1999), Ananieva *et al.* (2002) and Metwally *et al.* (2003) reported that SA could increased disease resistance in plants. SA treatment alleviates ACO activity and sensitivity (Kazemi *et al.*, 2011a). Therefore, In this study, the preservative effects of silicon, malic aid and acetylsalicylic acid and their interaction on the vase life of cut carnation flowers were studied.

MATERIALS AND METHODS

Plant material: The experiment was started on May 25, 2011 and chlorophyll content, Membrane stability, MDA content and ACO activity were measured. This study was on the effect of silicon, malic aid and acetylsalicylic acid treatments on vase life of lisianthus cut flowers, in a factorial test with complete randomized design with five replications. Cut flowers were harvested in half-open stage from local commercial greenhouses (Iran), in the morning and transported with appropriate covers immediately. Cut flower stems of lisianthus (*Eustoma grandiflorum* Mariachi. cv. blue (40 cm in length) were placed in solution containing silicon (0, 1.5 and 3 mM), acetylsalicylic acid (0, 1.5 and 3 mM) and malic aid (0, 1 and 2 mM) after cutting. Five cut flowers were placed in a 300 mL bottle with 250 mL of solution. Distilled water was used for the controls and placed in chambers at 19°C. The relative humidity was about 70% while 14 h photoperiod was maintained using fluorescent lamps with a light intensity of 15 μmol m^{-2} s^{-1} at the top of the corolla.

Vase life: The vase life of the inflorescence was considered terminated when 50% of the open flowers had wilted.

Chlorophyll content measurement: Total chlorophyll (a+b) content was measured by chlorophyll meter (SPAD-502, Minolta Co. Japan) which is presented by SPAD value. Average of 3 measurements from different spots of a single leaves was considered.

Determination of anthocyanin leakage: Anthocyanin leakage was measured based on the method of Poovaiah (1979).

Determination of ACC-oxidase activity: ACC-oxidase activity was measured based on the method of Moya-Leon *et al.* (2004).

Assays of MDA content (lipid peroxidation): Oxidative damage to lipids was measured based on the method of Heath and Packer (1968).

Superoxide dismutase (SOD) activity: The activity of superoxide dismutase was measured based on the method of Beauchamp and Fridovich (1971).

Carbohydrates determination: Carbohydrates were measured based on the method of Hassan (2005).

Determination of proline: Proline was quantified by using ninhydrin reagent and measured according to Bates *et al.* (1973).

Experimental design and statistical analysis: Experiment was arranged in a factorial test with complete randomized design with five replications. Analysis of variance was performed on the data collected using the General Linear Model (GLM) procedure of the SPSS software (Version 16, IBM Inc.). The mean separation was conducted by Tukey analysis in the same software ($p = 0.05$).

RESULTS AND DISCUSSION

Treatment with Si, ASA and MA showed remarkable decreases in Anthocyanin leakage and ACO activity as compared with the control ($p = 0.05$). The remarkable decreases in Anthocyanin leakage and ACO activity is compared as indicators of the reduction of membrane damage and increased membranes stability. Treatment with 1.5 mM silicon+1.5 mM acetylsalicylic acid+2 mM MA higher delayed the climacteric ethylene production, anthocyanin leakage and extended vase life of the carnation (Table 1), while treatment with Silicon 3 and 3 mM acetylsalicylic acid increased anthocyanin leakage and ACO activity and senescence ($p = 0.05$). In agreement with our result, Kazemi *et al*. (2011a) reported that treatment with salicylic acid significantly extends the vase life with reduced the anthocyanin leakage and ACO activity. Also, Kazemi *et al*. (2010) reported that treatment with malic acid significantly extends the vase life with decrease ACC-oxidase activity. Table 1 show that significant increases in chlorophyll content were recorded in MA treatments followed by the low concentration of Si and ASA (1.5 and 1.5 mM, respectively) ($p = 0.05$). Chlorophyll content decreased rapidly in present cut flower in solutions containing 3 mM silicon and 3 mM acetylsalicylic acid while flowers in the solutions containing 1.5 mM Si+2 mM MA+1.5 mM ASA showed the minimum decrease in chlorophyll content from day 18 ($p = 0.05$). The application of different Si, ASA and MA concentrations delayed the

Table 1: Mean comparisons of chlorophyll content, vase life, MDA, SOD activity, membrane stability and ACC-oxidase activity in Si, ASA and MA treatments and their interaction

Silicon (mM)	Acetyl salicylic acid (mM)	Malic acid (mM)	Vase life (day)	Chlorophyll total (a+b) content (SPAD reading)	ACC-oxidase activity (nmol/g FW/h)	Membrane stability (anthocyanin leakage OD 525)	MDA (μmol mg^{-1} protein)	SOD (U g^{-1} protein)	Proline (μmol g^{-1} FW)
0	0.0	0	6	1.880	78.030	341.210	231.000	61.14	100.00
		1	6	3.000	48.110	141.140	110.230	70.00	61.40
		2	8	4.410	40.150	137.180	100.000	87.11	60.00
	1.5	0	8	2.000	35.110	60.230	55.120	147.31	38.10
		1	8	2.000	34.230	57.640	53.000	150.00	36.00
		2	10	3.010	33.000	57.030	52.890	161.14	36.14
	3.0	0	6	1.700	55.110	111.360	200.120	36.40	97.14
		1	6	1.840	52.310	89.150	175.600	38.00	90.00
		2	6	1.760	50.140	70.100	161.000	38.90	87.14
1.5	0.0	0	8	2.000	30.110	60.180	45.590	100.00	55.41
		1	8	2.010	30.000	56.110	45.110	103.30	51.14
		2	9	3.680	30.020	50.130	40.310	103.00	51.00
	1.5	0	13	4.700	26.140	45.890	31.140	201.30	30.12
		1	14	5.420	16.000	44.170	31.000	213.00	29.91
		2	18	7.000	16.780	30.180	24.980	239.00	24.59
	3.0	0	8	2.000	33.140	64.170	44.150	87.00	49.80
		1	9	2.000	31.140	60.000	43.900	87.14	49.31
		2	9	2.000	32.000	60.370	43.000	90.00	49.02
3	0.0	0	10	2.300	36.000	70.110	118.910	65.70	66.20
		1	11	2.460	35.470	70.000	110.320	66.00	60.20
		2	11	2.090	35.110	69.110	101.000	66.09	60.01
	1.5	0	10	2.000	30.090	60.170	97.690	68.70	58.36
		1	11	1.900	30.140	60.000	97.560	68.49	56.00
		2	12	2.450	30.000	60.050	97.000	68.93	54.86
	3.0	0	6	1.700	82.140	89.130	203.100	43.18	109.08
		1	7	2.000	60.410	80.790	169.450	50.36	89.11
		2	9	2.000	55.110	80.000	116.000	54.00	86.00
F-test probabilities	Silicon		0	0.001	0.001	0.004	0.001	0.00	0.001
	Acetyl salicylic acid		0	0.001	0.001	0.001	0.010	0.00	0.001
	Malic acid		0	0.01	0.002	0.000	0.000	0.03	0.001

Table 2: Effect of MA with or without Si and SA on carbohydrate content (in mg^{-1} DW) for petals and stems of lisianthus cut flowers

	Days of determination of carbohydrate content								
	1st day			6th day			16th day		
Treatment	Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose
Petals									
Control	0.42	1.74	1.81	0.20	0.54	0.50	---------	---------	--------
MA 1 mM	0.36	2.00	1.91	2.70	4.11	3.89	--------	---------	--------
MA 2 mM	0.43	2.14	2.00	3.11	6.14	4.01	--------	---------	--------
1.5 mM Si+1.5 mM SA+2 mM MA	0.90	2.00	2.10	0.89	4.00	2.91	0.59	3.47	1.70
Stems									
Control	0.49	2.21	2.60	0.11	1.30	2.00	--------	---------	--------
MA 1 mM	1.10	2.00	1.74	0.91	3.46	3.68	--------	---------	--------
MA 2 mM	1.07	2.00	2.45	1.88	4.63	3.00	--------	---------	--------
1.5 mM Si+1.5 mM SA+2 mM MA	0.98	1.89	2.31	1.90	3.90	4.00	0.87	2.10	2.60

senescence with increase SOD activity and decreased accumulation MDA and proline significantly as compared to control (p = 0.05). The best treatment in this regards was 1.5 mM Si+2 mM MA+1.5 mM ASA. There were no significant difference between 1 mM MA and control (p = 0.05). These findings are in agreement with those reported by Jamali and Rahemi (2011), Kazemi *et al.* (2010) and Kazemi *et al.* (2011a, d) they reported that treatment with Si, SA and MA significantly extends the vase life with reduced the MDA, proline content and increasing chlorophyll content and superoxide dismutase activity. According to Table 1, fructose, glucose and sucrose were the main soluble carbohydrates in petals and stems of cut lisianthus (Table 2). The results indicate that the carbohydrate content significantly increased as a result of using MA (p = 0.05). Flowers treated with 2 mM MA solution significantly increased carbohydrate content in cut flowers (p = 0.05). Glucose was the major component in the petals as well as in stems but generally, its value was higher than in stems (Table 2). In agreement with our result, Kazemi *et al.* (2011c) reported that treatment with MA and SA significantly extends the vase life with reduced the anthocyanin leakage and ACO activity. According to Table 1, significant differences were observed among the different treatments in term vase life (p = 0.05). Among the different Si, ASA and MA concentrations, 1.5 mM Si+1.5 mM ASA+2 mM MA with average vaselife of 18 days was better than other treatments and as compared to the control treatment it increased the vaselife more than 12 days (Table 1). These findings are in agreement with those reported by Jamali and Rahemi (2011), Kazemi *et al.* (2010) and Kazemi *et al.* (2011a, c, d). They reported that treatment with Si, SA and MA significantly extends the vase life. These findings are similar to previous results reported by Jamali and Rahemi (2011) and Kazemi *et al.* (2011a, b, c, d).

CONCLUSION

In the present study, results our showed that treatment with Si, MA and ASA extends the vase life of cut carnation flowers. Also, Si, MA and ASA reduced chlorophyll total degradation and preserved chlorophyll total content.

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