Indian Journal of Agricultural Sciences **86** (4): 465–70, April 2016/Article
https://doi.org/10.56093/ijas.v86i4.57447

Potential of field grown sweet sultan (*Centaurea moschata*) as cut flower based on vase life

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Received: 14 December 2015; Accepted: 1 March 2016

ABSTRACT

The present study was conducted to evaluate the vase life of sweet sultan (*Centaurea moschata* L.) in different vase solutions with view to use it as cut flower. Various vase solutions such as sucrose @ 2% and in combination with 8-hydroxyquinoline citrate (8-HQC) @ 200ppm, ethanol @ 2% and plant bio-regulators like aminooxy acetic acid (AOA) @ 0.5 mM, salicylic acid (SA) 150 ppm and benzyl adenine (BA) 50 mg/l, ascorbic acid (200 ppm) were used. Vase life of flowers was found as 4.67 days in control and 6.0 days in treatment with sucrose (2%) alone. However, the vase life was significantly increased in treatments with plant bio regulators namely ascorbic acid, salicylic acid, benzyl adenine and AOA (9.67, 9.33 days and 9 days/respectively). Treatments with 8 HQC and ethanol along with sugar also increased the vase life of the flowers significantly than control. Maximum increase in flower weight (7.80 g) was observed in treatment with AOA on 8th day whereas, maximum flower diameter (71.80 mm) was observed in treatment with BA on 10th day. The maximum membrane stability index (57.50%) and total chlorophyll content of bract (1.22 mg/g) were recorded in treatment with ascorbic acid after 9 days of vase life.

Key words: 8-HQC, Cut flower, Plant bio-regulators, Sweet sultan, Vase life

Sweet sultan (*Centaurea moschata* L) is an important seasonal flower belonging to genera *Centaurea* and family *Asteraceae* and native of Middle East Asia and eastern parts of Mediterranean region. It is a winter annual and commonly grown in gardens and home landscapes for its delicate and sweet scented flowers.

Under normal conditions, cut flowers last only for a few days maintaining their beauty and attractiveness. However, their natural beauty and appearances should be retained for a longer period of time to increase socioeconomic value of flowers (Zamani *et al.* 2011). Many studies have been carried out to evaluate the appropriate preservatives to extend the vase life of the harvested flowers for consumer satisfaction and exploitation of cut flower business. Sucrose is the most commonly used energy source in vase solution to keep the plant cells turgid after harvest, (Han 2003). But adding sucrose in the vase solution favours the growth of microorganisms which block the xylem vessels and reduces the water uptake and cause stem bending (Ali and Hassan 2014). Hence, biocides like HQC are very much important to reduce the microbial growth in the vase solution. Apart from these two basic elements, ethylene produced during senescence of flowers accelerates the senescence process which makes petal wilting, permeability of petal cells and degrades the membrane lipids. The senescence effects can be reduced by inhibitors of ethylene biosynthesis (Kazemi *et al.* 2012). AOA has been reported as an inhibitor of ethylene synthesis in flowers during vase life (Zuliana *et al.* 2008, Chaturaphat *et al*. 2003, Sodi and Ferrante 2005). AOA along with sugars improved the vase life of *Dendrobium* flowers but had no significant effect on vase life when used alone. Further AOA reduced the bud drop and improved the bud opening in *Dendrobium* flowers (Chaturaphat *et al*. 2003). Salicylic acid (SA) is a well-known phenol that can extend the vase life of cut flowers by decreasing ethylene production. SA reduced the anthocyanin leakage and increased the chlorophyll content in highly ethylene sensitive carnation flowers (Kazemi *et al*. 2012). Increase in vase life by SA in vase solution is also reported in gladiolus and rose (Ezhilmathi *et al*. 2007). Use of ethanol to inhibit ethylene synthesis and to reduce sensitivity of flowers to ethylene was studied by Van Doorn (1998) in roses and tulips. Frokhzad *et al.* (2005) reported that adding 2% ethanol along with 2.5% sugar improved the vase life of lisianthus cut flowers. Vitamins such as ascorbic acid at low concentration are considered as plant bio-regulators (PBR) and they are involved in many of the plant growth processes

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as regulating factors (Tiwari *et al.* 2010a). Tiwari *et al.* (2010b) reported increase in vase life of China aster and gladiolus in vase solutions containing citric acid. Ascorbic acid along with sugar significantly increased the vase life of antirrhinum flowers (Abdulrahman *et al.* 2012). Flower quality parameters where improved and maintained in gladiolus with ascorbic acid (Nahed *et al.* 2009). It is also reported by Bedour and Rawia (2011) that improved growth, delayed flower opening and increased carbohydrate accumulation in gladiolus was found in ascorbic acid treatment. Vase life and membrane stability of the cut spikes of gladiolus were increased by using benzyl adenine (BA) (Singh *et al.* 2008). Danaee *et al*. (2011) reported that, BA along with sucrose increased the vase life of gerbera in terms of solution uptake, fresh weight, flower diameter, and anthocyanin content, therefore enhancing flower quality and delaying senescence.

Adding new potential novel flowers as cut flower will improve the floriculture trade and widen the scope of flower cultivation. Sweet sultan plants can be grown in open fields and does not need protected cultivation practices as in the case of other cut flowers. Apart from this, they can have better market value due to its unique flower head and mild fragrance. Despite these favourable qualities only limited literatures are available on postharvest performance evaluation of sweet sultan flowers. Hence, this work was carried out with the objective of evaluating field grown sweet sultan flowers for its suitability as cut flower based on its vase life in different vase solutions.

MATERIALS AND METHODS

Sweet sultan was cultivated in the research field of Directorate of Floricultural Research, IARI, New Delhi. From the preliminary study it was found that sweet sultan was having 5 days vase life in tap water without any preservatives. Further it was also noticed that stems harvested with tight bud stage did not open during the vase life. Therefore, the flowers were harvested at "paint brush stage" to determine the vase life. Each stem was trimmed at 40 cm from the flower head. Flower stems were held in centrifuge tubes filled with 50 ml deionized water (control) or other appropriate vase solutions according to the treatments. All the chemicals used were dissolved in deionized water and used as vase solution in different combinations (Table 1). The centrifuge tubes were covered with cotton plug and aluminium foil to avoid evaporative losses and kept in a room with natural light. The average room temperature and humidity during the study was maintained as 25±2ºC and 80±5%, respectively. Each experiment was replicated four times with five flowers per replication.

Weight of each flower stem was measured at 2 days interval for 10 consecutive days. The relative fresh weight of flowers was calculated as:

$$\text{Relative fresh weight (\%)} = \frac{\text{weight of flower at day t}}{\text{initial flower weight}} \times 100;$$

where t = 0,2,4,6,8,10. (He *et al*. 2006). Flower head diameter was measured using vernier calliper in mm. Change in volume of solution and weight of tubes without spikes was recorded at 2 days interval. Following formula were used to find the water relations.

Water balance (ml): $s_{t-2} - s_t$; where s_t= solution level and t = 0,2,4,6,8,10.

$$\text{VSUR (ml/g Intial Fresh weight (IFW)/day)} = \frac{(S_{t-2}) - (S_t)}{(IFW \times 2)};$$

(He *et al*. 2006).

Membrane Stability Index (MSI) of petals was analysed at 3 days interval. It was calculated on the basis of the electrolyte leakage of petals. 1 g of petal was rinsed well in deionised water prior to incubation in 10 ml of deionised water for 3 h at room temperature. After incubation, the conductivity (C_1) of the solution was measured with the conductivity meter. Petals were boiled along with solution for 15 min to kill the tissue. After cooling to room temperature, the conductivity (C_2) of the solution was measured. The MSI was expressed as percent value from the formula:

$$\text{Membrane Stability Index (\%)} = \left[1 - \left(\frac{C_1}{C_2}\right)\right] \times 100$$

(Danaee *et al*. 2011)

Chlorophyll from the bracts was estimated by Dimethtyl Sulphoxide (DMSO) method (Hiscox and Israelstam 1979). Chlorophyll solution was prepared by incubating the 50 mg sample tissues in 10 ml DMSO at 65ºC for 4 hr. After 4 hr the absorbance of the chlorophyll solution is read at 663 and 645 nm using DMSO as blank in UV-Vis spectrophotometer. Chlorophyll (chl) content (chl a, chl b and total chlorophyll) was calculated using the following formulae:

Chlorophyll a (mg/g of fw) =

$$\frac{[12.7(OD_{663}) - 2.69\ (OD_{645})] \times Volume \times dilution\ factor}{1000 \times wt.\ of\ sample}$$

Chlorophyll b (mg/g of fw) =

$$\frac{[22.9(OD_{645}) - 2.69\ (OD_{663})] \times Volume \times dilution\ factor}{1000 \times wt.\ of\ sample}$$

Table 1 Sweet sultan vase solution treatment details

	Treatment	Codes
T0	Control (Deionized water)	Control
T1	Sucrose (2%)	Suc
T2	Sucrose (2%) + 8HQC (200 ppm)	Suc+HQC
T3	Sucrose (2%) + 8HQC (200 ppm) + 0.5 mM AOA	Suc+AOA
T4	Sucrose (2%) + 8HQC (200 ppm) + Salicylic acid (150 ppm)	Suc+SA
T5	Sucrose (2%) + Ethanol (2%)	Suc+Eth
T6	Sucrose (2%) + 8HQC (200 ppm) + Ascorbic acid (200 ppm)	Suc+AsA
T7	Sucrose (2%) + 8HQC (200 ppm) + Benzyl adenine (50 mg/l)	Suc+BA

Total Chlorophyll (mg/g of fw) =

$$\frac{[20.2(OD_{645}) + 8.02\ (OD_{663})] \times Volume \times dilution\ factor}{1000 \times wt.\ of\ sample}$$

(Lichtenthaler and Wellburn 1983)

Vase life of the sweet sultan flowers was characterised based on physical evaluation of senescence based on petal wilting, petal drying, stem bending and stem rotting. The average vase life of spikes was considered as completed when 50% of the flowers in a spike were senesced.

Experiment was carried out in completely randomized block design (CRBD). Data were analyzed by Generalized Linear Model (GLM) procedure and means were compared using Duncan's multiple range test at ≤ 0.05 in SAS® 9.3 (SAS Institute, Cary NC).

RESULTS AND DISCUSSION

Effect on Relative fresh weight (RFW), Flower diameter and Vase solution uptake

Change in flower weight was observed in all treatments and there was a significant increase in the flower weight during first 4 days of the experiment (Fig 1a). The maximum increase in relative weight was observed in Suc+AOA (130.7%) followed by Suc+AsA (123.1%) on 8th day. Minimum RFW of 78.3% was observed in control after 10 days of vase life. An increasing trend in flower diameter was found in all treatments up to 4 days. Flower diameter was reduced in control (45.8 mm) and Suc+Eth (49.7 mm) on 6th day (Fig 1b). Increase in flower diameter till 10th day of vase life was observed in Suc+SA (62.6 mm), Suc+AsA (68.8 mm) and Suc+BA (71.8 mm). After 10 days minimum flower diameter was observed in control (34.7 mm) followed by Suc+Eth (42.0 mm) (Table 2) .

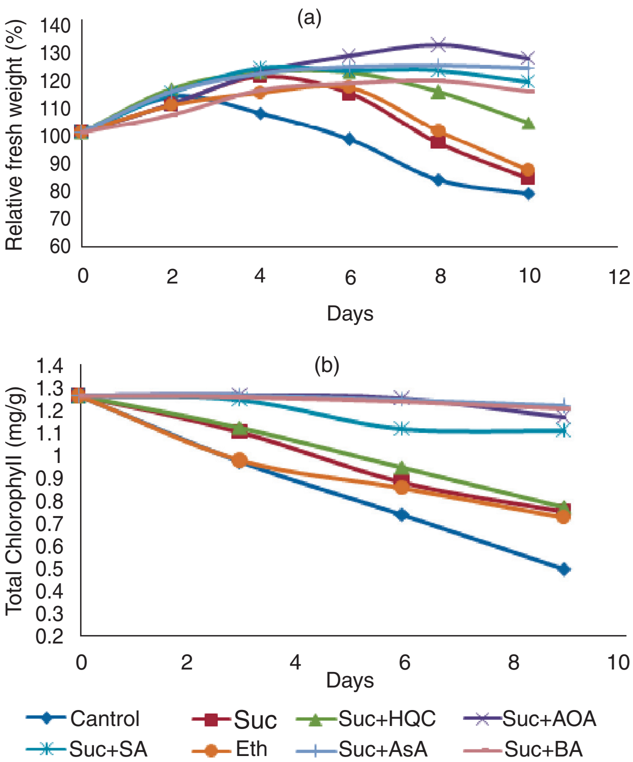

Fig 1 Effect of treatments on (a) relative fresh weight and (b) total chlorophyll content of sweet sultan flowers.

Table 2 Effect of treatments on flower parameters on 10th day of experiment and vase life

Treatment	Flower diameter (mm)	Vase solution uptake rate (ml/g/day)	chl a/b ratio*	Vase life (day)
Control	34.73 e	0.03 a	0.89 e	4.67 d
Suc	43.87 d	0.03 a	0.79 g	6.00 c
Suc+HQC	55.83 c	0.03 a	0.84 f	7.67 b
Suc+AOA	62.53 b	0.11 a	1.05 a	9.00 a
Suc+SA	62.60 b	0.14 a	1.02 b	9.33 a
Suc+Eth	42.02 f	0.03 a	0.97 c	6.33 c
Suc+AsA	68.80 a	0.11 a	0.92 d	9.67 a
Suc+BA	71.80 a	0.12 a	0.98 c	9.00 a

* chl a/b ratio- after 9 days of experiment (Means followed by the same letter are not significantly different at $P \leq 0.05$ using Duncan)

The water holding capacity of sweet sultan flower was found less in all treatments. The difference in water balance and VSUR among treatments was found insignificant throughout the period under. Maximum VSUR after 10 days of vase life was found in Suc+ SA (0.14 ml/g/day) and minimum of 0.03 ml/g/day was found in control, Suc, Suc+HQC and Suc+Eth (Table 2).

From the results it is evident that the RFW increased drastically in sucrose (2%) treatment during the first 2 days, but the same was reduced on 6th day (Fig 1a). This may be due to the microbial growth in the vase solution which caused physical plugging in the stems and blockage of xylem vessels (Danaee *et al.* 2011). HQC acted as a bactericide which reduces the growth of stem plugging microorganisms and the carbohydrate source provide energy to the stem which increased RFW of the flowers in treatment with HQC during vase life. In all treatments with plant bio regulators including AsA increased the flower weight of the flowers during vase life (Fig 1a) (Keramat *et al.* 2012). This may also be due to the negative correlation between plant bio-regulators like Salicylic acid and microbial population as reported by Kazemi *et al.* (2012) in carnation flowers. The results of present study are in harmony with these findings. Flower diameter increased in all treatments during vase life but in treatments with plant bio-regulators including AsA the flower diameter was maintained till 10th day. Sakine *et al.* (2011) reported the delay in flower opening in treatment with BA in roses as cytokinin reported for its negative effect on flower senescence. It was reported by Nahed *et al.* (2009) that the flowering parameters of gladiolus flowers were improved by AsA. The overall VSUR in all treatments was less when compared to other cut flowers .This could be due to the hard and thin stems of sweet sultan flowers. Reduction in vase solution uptake rate during vase life is in agreement with Lu *et al*. (2010). In the present study adding ethanol in the vase solution did not improve the vase life and other quality parameters of the sweet sultan flowers when compared to PBR treatments. The finding is in agreement with Bayat *et al.* (2011) who reported that treatment with ethanol did not improve the vase life of carnation flowers.

Effect on Membrane Stability Index (MSI) and chlorophyll content

Membrane stability which is expressed as leakage of electrolytes of petals varies drastically after harvest in cut flowers (Memon *et al*. 2012). The MSI of fresh flower petal was estimated as 56.31%. There was a significant differ rence in MSI of petals among all treatments during vase life (Table 3). The MSI of the flower petal increased in all treatments except in treatments control and Suc+Eth. Maximum increase in MSI was observed in Suc+ AOA (60.78%) on day 3 but it was reduced to 56.6% on day 9. The membrane stability Index of control (33.81%) and Suc+Eth (52.78%) were reduced from day 3 onwards and the minimum of 25.22% was observed in control after 9 days. The maximum MSI after 9 days of vase life was observed in Suc+AsA (57.5%) followed by Suc+AOA (56.6%) and this value was higher than the initial MSI (56.31%) of sweet sultan flower petal. It was reported by Bartoli *et al*. (1996) that in carnation that petal electrolytic leakage by membrane disruption is due ethylene and by controlling ethylene production membrane stability of the petals can be improved. They also reported that adding PBR like AOA reduces the electrolytic leakage in carnation flowers. Danaee *et al.* (2011) and Sellam *et al.* (2015) reported that adding BA in the vase solution increased the membrane stability of gerbera and snap dragon flowers during vase life. Adding exogenous SA to vase solution to decrease the permeability of the plasma membrane and membrane lipid per oxidation and to maintain the membrane integrity was reported by (Kazemi & Shokri, 2011). Ali and Hassan (2014) reported that 8-HQS treatments retained the MSI at higher levels and it was also reported that 8-HQS may reduce the plasmolysis of cells which occur when the rate of cellular water loss is too rapid or excessive then the inner plasma membrane.

Chlorophyll a, b (Table 3) and total chlorophyll content (Fig 1b) of bract of sweet sultan flower head evaluated at 3 days interval. The initial chl a and chl b of fresh flower bracts was recorded as 0.92 mg/g and 1.25 mg/g, respectively. The initial total chlorophyll content and chl a/b ratio were recorded as 1.26 mg/g and 0.74 mg/g, respectively. Maximum retention in chlorophyll content during vase life was observed in Suc+ AsA followed by Suc+ BA in respect of chl a (0.92 mg/g and 0.90 mg/g), chl b (0.99 mg/g and 0.93 mg/g) and total chl (1.22mg/g and 1.21 mg/g) after 9 days of vase life. But maximum chl a/b ratio was found in Suc+HQC (1.05) and Suc+AOA (1.02), respectively, (Table 2). It is evident from the results that the higher chlorophyll content after 9 days of vase life in AsA treatment could be due to its antioxidant property. Further, all PBR treatments significantly maintained the chlorophyll content during vase life when compared to the control (Table 3 and Fig 1b). It was reported that cytokinins such as BA prevented the leaf senescence by arresting degradation of protein and chlorophyll by Sakine *et al.* (2011) in gladiolus. Better chlorophyll content in SA treatment was reported in alstroemeria and snap dragon flowers (Fard *et al.* 2010 and Sellam *et al.* 2015) Ali and Hassan (2014) reported that HQC significantly retarded the reduction of chlorophyll content in *Strelitzia reginae*. It was reported by Asrar (2012) that pulse treatment with sucrose+ 8-HQS was most effective in retarding chlorophyll degradation compared to control in snap dragon flowers. The concentration of chlorophyll a was higher than chlorophyll b at any point of time throughout the vase life. It is reported by Karimi *et al.* (2012), AOA and BA significantly reduced the petal and bract discoloration of carnation during vase life. The results are in agreement with the above findings.

Effect on flower vase life

Maximum vase life of 9.67 days was recorded in Suc+AsA followed by Suc+AOA (9.33 days), Suc+SA (9.00) and Suc+BA (9.00) were also had better vase life when compared to control (Table 2). The minimum vase life was recorded in control (4.67 days). Back curl and petal withering was observed in Suc and Suc+HQC treatments where as

Table 3 Effect of treatments on Membrane stability index and chlorophyll content of sweet sultan flower

Treatment	Membrane Stability Index (%)				Chlorophyll a (mg/g)				Chlorophyll b (mg/g)			
	0	3	6	9	0	3	6	9	0	3	6	9
Control	56.31 a	33.81 c	28.21 e	25.22 f	0.92 a	0.66 f	0.43 h	0.34 h	1.25 a	0.81 f	0.49 h	0.39 g
Suc	56.31 a	57.55 a	53.88 c	51.23 d	0.92 a	0.91 c	0.74 e	0.58 f	1.25 a	1.04 e	0.86 f	0.73 e
Suc+HQC	56.31 a	59.75 b	54.44 c	52.53d	0.92 a	0.91 c	0.85 d	0.64 e	1.25 a	1.15 c	0.89 e	0.76 d
Suc+AOA	56.31 a	60.36 ba	57.85 ba	55.86 b	0.92 a	0.93 a	0.90 b	0.85 c	1.25 a	1.18 b	1.08 c	0.81 c
Suc+SA	56.31 a	60.78 a	58.26 ba	56.60 ba	0.92 a	0.91 d	0.87 c	0.84 d	1.25 a	1.11 d	1.05 d	0.82 c
Suc+Eth	56.31 a	52.78 c	50.53 d	49.85 e	0.92 a	0.70 e	0.52 g	0.44 g	1.25 a	0.76 g	0.53 g	0.45 f
Suc+AsA	56.31 a	60.08 a	58.85 a	57.50 a	0.92 a	0.93 a	0.93 a	0.92 a	1.25 a	1.22 a	1.18 a	0.99 a
Suc+BA	56.31 a	59.14 a	56.83 b	54.38 c	0.92 a	0.92 b	0.91 b	0.90 b	1.25 a	1.19 b	1.11 b	0.93 a

Means followed by the same letter are not significantly different at P≤0.05 using Duncan.

drying of petals was observed in control and Suc+Eth treatments. Suc+AsA followed by Suc+AOA, Suc+BA and Suc+SA maintained the optimum flower head diameter and petal turgor up to 10 days. In the present study, it was demonstrated that ascorbic acid and other plant bio-regulators along with sucrose found better for enhancing the vase life of sweet sultan cut flowers significantly (Table 2). As treatment significantly extends vase life in cut lisianthus flowers reported by (Sheikh *et al*. 2015). It was also reported that AsA due to its antioxidant property protected plant cells and involved in a wide range of important functions as antioxidant defence, photo protection, regulation of photosynthesis and growth. As reported by Zuliana *et al.* (2008), the increase in vase life and other parameters in Suc+AOA treatment, clearly indicates the effect of AOA on senescence. The effect of PBRs on improving the flower quality and vase life was reported by Fard *et al.* (2010), Danaee *et al.* (2011), Zamani *et al.* (2011) and Sellam *et al.* (2015).

Sweet sultan is one of the versatile flower crops which can be grown under open field condition during winter season in India. The unique flower head and mild fragrance make it highly attractive. The vase life of flowers is one of the determining factors for making it commercially successful cut flower and introducing new novel flowers will improve the floriculture trade. From the present study it was found that sweet sultan flowers are having better vase life as any other cut flower and it could be used as commercial cut flower. Further, adding preservatives like plant growth regulators and ascorbic acid significantly improved the vase life and other quality parameters of sweet sultan flowers.

ACKNOWLEDGEMENT

We acknowledge Directorate of Floricultural Research, Pune for providing opportunity to carry out the experiment. We also express our sincere gratitude to Dr Ramesh Kumar (Former Director, Directorate of Floricultural Research) for the support rendered.

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