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Studies on alternative holding solutions for improving vase life of cut carnation (*Dianthus caryophyllus* L.)

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Abstract
Studies were conducted to study the effect of different holding solutions on vase life and associated characteristics of cut carnation (*Dianthus caryophyllus* L.) flowers. Serotonin (300 uM) resulted in earliest flower opening, maximum flower diameter, maximum amount of holding solution consumption, maximum score for freshness of cut flowers, maximum RWC and maximum membrane stability. Cut flowers exhibited highest vase life of 27.37 days when placed in serotonin (300 uM) followed by 24.67 days in holding solution containing sucrose (2%) + 8HQC (150ppm) + BA (5ppm). Therefore, serotonin (300 uM) can be used as a noble environmental friendly alternative holding solution in floriculture industry to replace harmful chemical compounds which are being used to increase flower longevity of carnation cut flowers.

Keywords: holding solution, vase life, carnation

Introduction

The longevity of cut carnation flowers is one of the major aspects in floriculture industry and is the main characteristic determining the commercial value of the ornamental flowers (Nukuie *et al.*, 2004) [9]. The cut flowers are deprived of water and nutrients after being detached from the mother plant. Hence, addition of chemical preservatives to the cut flowers is recommended to continue its physiological processes so that the longevity of the flowers can be extended. The vase life of cut carnation flowers is mainly associated with ethylene which initiates senescence and microorganisms which is responsible for vascular blockage (Kader, 2003) [7]. STS protects the cut flowers from senescence caused by ethylene. The use of STS in extending the vase life has been discouraged because STS contains silver, which is seen as a potential environmental pollutant (Serek and Reid 1993) [10] and banned in several countries (Cross 1996) [2]. Microorganisms and their chemical products plug the stem ends and drastically reduce the water absorption. Many antimicrobial agents are being used in cut flowers vase solutions to extend the vase life by improving water uptake. Such important germicides include silver nitrate (Fujino *et al.*, 1983) [4], aluminium sulphate (Ichimura and Shimizu Yumoto, 2007) [5] and 8-hydroxyquinoline sulphate (Ichimura *et al.*, 1999) [6]. However, these chemicals are also hazards to environment.

Environmental and health limitations due to above chemicals used in vase solutions to improve vase life encourage the scientists to find safe alternatives with reduced toxicity in the preservative solutions for cut flower industry. Compounds recently considered for improving the postharvest longevity and quality of cut flowers included some plant essential oils and secondary messenger molecules like serotonin and melatonin. These molecules can delay the senescence process in different plants grown under diverse conditions by modulating the levels and activity of anti-oxidative enzymes and suppression of senescence genes (Wang *et al.*, 2012) [12]. Several reports showed that these molecules reduce the percentage of losses during postharvest storage among different fruits and vegetables (Sun *et al.*, 2015) [11]. However the role of these molecules to improve the post-harvest physiological process responsible for enhanced vase life of flowers has not been elucidated. The current studies were conducted to find out the effect of different holding solutions on the vase life of cut carnation flowers. The major aim of current studies was to find out the possible alternatives of hazardous chemicals which are being used in holding solutions to improve to improve the vase life of cut carnation flowers.

Material and Methods

The studies were carried out at Hi-Tech centre of Department of Floriculture and Landscaping, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan during 2019-2020. Experment was conducted using CRD design with three replications. A total on eleven treatments *viz*. T 1: Control (distilled water), T 2: As per university recommendations (Sucrose 2% +8HQC (150ppm) +BA (5ppm), T 3: Serotonin 150 µM, T 4: Serotonin 300 µM, T 5:Serotonin 450 µM, T 6: Melatonin 150 µM, T 7: Melatonin 300 µM, T 8:Melatonin 450 µM,T 9: Essential oil of Thyme 100 mg L^{-1}, T 10:Essential oil of Thyme 150 mg L^{-1},T 11: Essential oil of Thyme 200 mg L^{-1}.

Harvesting of cut flower stems was done in the morning hours (7-8 A.M.) with the help of secateurs. Harvesting of flowers was done at the paint bush stage. Harvested cut flower stems of carnation were reduced to a uniform length of 30 cm by giving a slanting cut at the basal portion. The basal leaves of these stems were detached up to a length of 15 cm before placing them in vase solutions. One cut flower was placed in one test tube containing 25 ml vase solution. Observations on Days taken to flower opening, Flower diameter, appearance (freshness and color) of cut bloom, vase life (days), amount of holding solution consumed (ml/stem), petal Relative Water Content (%) and membrane stability index (%) was recorded in all treatments.

Results and Discussion

The experiment was conducted to evaluate the different concentrations of serotonin, melatonin and thyme essential oil to find out the suitable holding solution along with its concentration for improving the vase life of carnation cut flowers.

The data revealed that various holding solution treatments have influenced number of days for full flower opening significantly. Results showed that cut flowers opened earliest (3.94 days) in T_4 i.e holding solution containing serotonin (300 um) which was found to be at par with T_3 (4.01 days), T_5 (4.07 days), T_2 (4.28 days) and T_{10} (4.33 days), respectively. In contrast, maximum time taken for flower opening (5.88 days) was recorded with thyme oil (200 mgL^{-1}) i.e. T_{11} and found to be at par with control i.e distilled water (5.56 days).

The earliest opening of flowers in serotonin (300 um) may be due to the reason that serotonin blocks ethylene biosynthesis in cut carnation flowers, leading in increase in the potassium ions in petals of cut flowers. Such higher level of potassium ions might have helped in cell expansion of petals which is ultimately reflecting in early flower opening (Wong *et al.*, 1989) [13]. Cut flowers took maximum time to open the flowers (5.56 days) when placed in holding solution containing distilled water i.e. control. Such a delay in flower opening may be due to the accumulation of various micro-organisms in distilled water which might have reduce the water conductivity resulting in slow down the process of flower opening (Accati *et al.*,1981) [1].

The maximum flower diameter (8.58 cm) was measured for the cut flowers placed in the holding solution comprising of serotonin @300 um i.e. Treatment T_4, which was found to be statistically similar withT_{10} (8.27 cm), T_9 (8.10 cm), T_2 (8.07cm) and T_3 (8.04 cm) respectively. However, minimum flower diameter (7.02 cm) was noted in the solution of thyme oil (200 mgL^{-1}) i.e. T_{11} and found to be statistically at par with control i.e T_1 (7.31 cm).

Serotonin can be responsible for the enhanced antimicrobial activities of serotonin (Erland *et al.*, 2016) [3]. Such antimicrobial activity may be responsible for the prevention of physiological vascular blockage that helped in better vase solution conductivity and ultimately manifested in term of higher flower diameter.

The highest score (4.38) for appearance of cut blooms was recorded when the cut flowers were put in the holding solution containing serotonin @300 µm (T_4) and observed to be at par with score of appearance of cut blooms in T_2 (4.27). However, least appearance score of cut blooms (3.37) was noticed with thyme oil (200 mgL^{-1}) i.e. $T_{11}$and it was found to be at par with control i.e, T_1 (3.38). The higher score for freshness of appearance of cut blooms in holding solution containing Serotonin @ 300µM may be as consequence of higher relative water content (88.22%) observed in cut blooms in the said treatment. Accordingly the petals could maintain maximum turgidity hence, recorded better appearance of cut blooms for longer duration in comparisons to other holding solutions.

Results revealed that different holding solutions significantly increase in the vase life of carnation as compared to control (17.22 days) except T_7, T_8 and T_{11} (18.34, 18.09 and 17.44 days respectively). Maximum vase life of 27.37 days was recorded with T_4 i.e. Serotonin (300 uM) and it was observed significantly higher compare to all other treatments. In comparison Serotonin, holding solution containing recommended holding solution i.e. Sucrose (2%) +8HQC (150ppm) +BA (5ppm) recorded vase life of 24.67 days. All three concentrations of serotonin significantly increases the vase life of carnation cv. 'Bizet' over control. Such an increase in vase life can be associated with serotonin ability to delay senescence (Kang *et al.*, 2009) [8] and anti-microbial ability (Erland *et al.*, 2016) [3] which improves uptake of holding solution in the vase. The dual effect of serotonin in delaying the senescence through blocking ethylene biosynthesis and antimicrobial activity might have helped in achieving maximum vase life.

Consumption of holding solution showed that cut flowers consumed maximum amount of holding solution (42.46 ml/stem) when cut flowers were placed in T_4 i.e. Serotonin (300 uM). However, cut flowers stems consumed minimum amount of holding solution in T_{11} (24.26ml/stem) and it was found to be at par with T_1 (25.20ml/stem) and T_7 (27.27ml/stem). Anti microbial activity during pathogen attack (Erland *et al.*, 2016) [3] may also be associated with prevention of stem blockage and enhanced holding solution uptake by cut stem ends. The dual effect of serotonin in delaying the senescence through blocking ethylene biosynthesis and antimicrobial activity might have helped in higher solution uptake.

RWC was recorded maximum (88.22%) in T_4 i.e. Serotonin (300 uM) which was found to be at par with T_2 (84.38%). In contrast, minimum RWC was recorded with T_{11} (68.39%) and it was found to be at par with control i.e. T_1(70.22%). The cut flowers of carnation consumed highest amount of holding solution (42.46 ml /stem) when placed in serotonin (300µM) might have helped the cut flowers to maintains maximum turgidity of petals. Membrane stability was maximum (69.78%) in serotonin (300 um) which was found to be at par withT_2 (67.43%). In contrast lowest membrane stability (50.88%) recorded with thyme oil (200 mgL^{-1}) which was found to be at par with control treatment with distilled water i.e.T_1 (53.95%).The cut flowers of carnation consumed highest amount of holding solution (42.46 ml /stem) when placed in serotonin (300µM). Higher consumption of holding solution helps the cut flowers of carnation cv. "Bizet" to maintain highest membrane stability.

Correlation among different traits (Fig 1-4) revealed that vase life was governed by water status of the flowers. A strong correlation (R^2= 0.92) was observed between vase life and consumption of holding solution by the cut flowers. Consumption of higher holding solution was responsible for maintaining higher petal relative water content (R^2= 0.82). Higher petal water status maintains the better appearance (R^2= 0.95) and resulted in higher flower diameter of cut flowers in vase solution (R^2= 0.82).

Table 1: Effect of holding solutions on days taken to flower opening, flower diameter and appearance of cut carnation flowers cv. 'Bizet'

Treatment No.	Holding solutions	Days taken to flower opening	Flower diameter (cm)	Appearance of cut bloom (Score out of 5.00)	Vase life (days)	Holding solution consumed (ml/stem)	Relative Water Content (%)	Membrane stability (%)
T_1	Control	5.56	7.31	3.38	17.22	25.20	70.22	53.95
T_2	*Sucrose (2%) +8HQC (150ppm) +BA (5ppm)	4.28	8.07	4.27	24.67	38.27	84.38	67.43
T_3	Serotonin (150 µM)	4.01	8.04	4.09	22.55	37.43	82.33	63.77
T_4	Serotonin (300 µM)	3.94	8.58	4.38	27.37	42.46	88.22	69.78
T_5	Serotonin (450 µM)	4.07	7.78	4.03	22.64	34.13	79.22	65.28
T_6	Melatonin (150 µM)	5.19	7.84	3.77	19.55	32.79	78.25	62.58
T_7	Melatonin (300 µM)	5.38	7.73	3.69	18.34	27.27	76.23	60.41
T_8	Melatonin (450 µM)	5.44	7.43	3.81	18.09	28.80	78.22	63.22
T_9	Thyme oil (100 mgL^{-1})	4.55	8.10	3.87	20.22	32.87	77.88	64.87
T_{10}	Thyme oil (150 mgL^{-1})	4.33	8.27	3.99	22.68	36.40	81.99	67.87
T_{11}	Thyme oil (200 mgL^{-1})	5.88	7.02	3.37	17.44	24.26	68.39	50.88
$CD_{0.05}$		0.42	0.64	0.25	1.92	3.03	4.17	4.09

*As per university recommendations

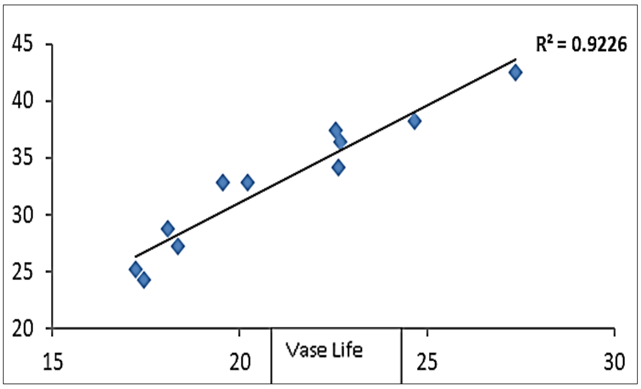

Fig 1: Relationship between vase life (days) and consumption of hoding solution (ml/stem) by cut stem

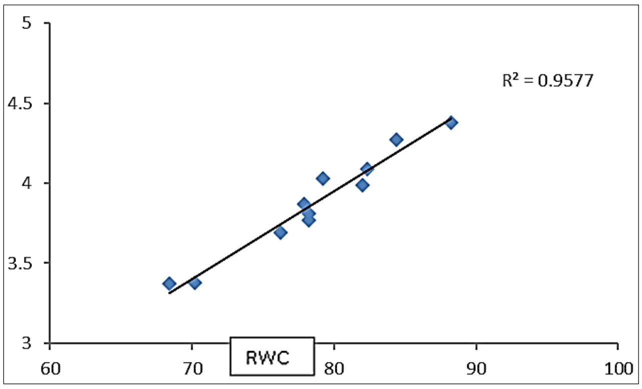

Fig 3: Relationship between relative water content (%) and appearance (1-5 score) of cut carnation flowers

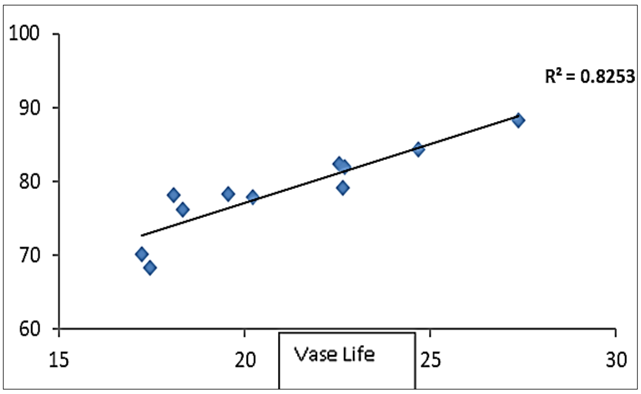

Fig 2: Relationship between vase life (days) and relative water content (%) of petals of cut flowers

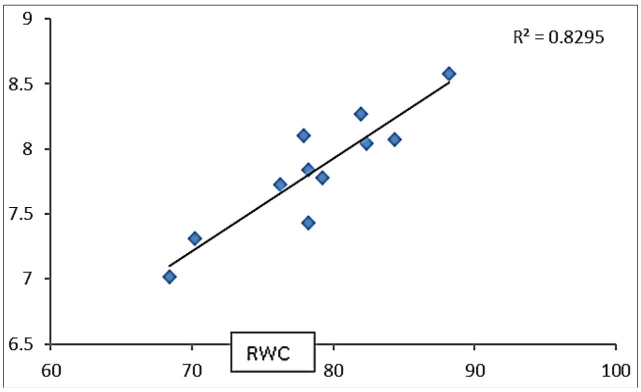

Fig 4: Relationship between relative water content (%) and flower diameter (cm) of cut carnation flowers

Conclusion

It is evident from the results that serotonin (300µM) improves petal water status of the cut flowers through higher holding solution uptake. It also maintains the flower appearance for longer time in vase solution and resulted in higher flower diameter. Serotonin (300µM) shows maximum vase life compared to all treatments. It can be concluded that serotonin (300µM) can be used as alternative holding solution for improvement of vase life in cut carnation flowers.

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