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EFFECT OF PULSING TREATMENTS WITH SALICYLIC ACID, BENZYL ADENINE AND NANO-SILVER ON THE VASE LIFE AND QUALITY OF CUT GERBERA FLOWER

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ABSTRACT

Gerbera is an important commercial cut flower grown throughout the world. However, very short vase life of gerbera is the major constraint and therefore the improvement of vase life is an urgent research need. To address the problem, an investigation was carried out in the department of Crop Physiology, AAU, Jorhat-13 to evaluate the effects of different pulsing treatments on quality and vase life of gerbera. The cut gerbera flower was pulsed with different concentrations of salicylic acid, benzyl adenine and nano-silver for 1 hour. There were ten (10) treatments viz. T₁: Control (Distilled water), T₂: Salicylic acid 50ppm, T₃: Salicylic acid 100ppm, T₄: Salicylic acid 150ppm, T₅: Benzyl adenine 50ppm, T₆: Benzyl adenine 100ppm, T₇: Benzyl adenine 150ppm, T₈: Nano-silver 5ppm, T₉: Nano-silver 10ppm and T₁₀: Nano-silver 15ppm. It was observed that moisture content, fresh and dry weights, amount of water uptake, transpirational water loss, scape bending, carbohydrate content and vase life were affected positively by the pulsing treatments. Among all the pulsing treatments, T₉ (Nano-silver 10 ppm) was found to be the best in enhancing the vase life and quality of the cut flower followed by T₃ (Salicylic acid 100 ppm).

Key words : Gerbera, Salicylic acid, Benzyl adenine, Nano-silver, Pulsing, Vase life.

Introduction

Gerbera (*Gerbera jamesonii*) is an economically important cut flower, which is commercially grown throughout the world in a wide range of climatic conditions (Deshmukh *et al.*, 2019). The gerbera blooms are attractive, suitable for any type of floral arrangements and are available in different shades and hues. Besides floral arrangements, gerbera is widely used in bouquets and in dry flower crafts (Soad *et al.*, 2011). However, very short life span of this flowers in vase has been reported by Malakar *et al.* (2019) and Manzoor *et al.* (2020). Alaey *et al.* (2011) reported that cut flowers are often subjected to wounding, water deficit, microbial contamination and oxidative stresses during the postharvest life. Vase life termination of gerbera is primarily characterized by wilting (He *et al.*, 2006). Da

Silva (2003) reported that water balance is a major factor determining the quality and longevity of cut flowers. It is influenced by water uptake and transpiration and balance between the two processes. When the amount of transpiration exceeds than the volume of water uptake, water deficit and wilting develop (Halevy *et al.*, 1981). Moreover, blockage of xylem vessels due to accumulation of microorganism is another contributing factor leading to quality loss (Jalili *et al.*, 2011). Thus, for efficient commercialization, it is utmost important to increase the vase life of this cut flowers. Pulsing treatments of the harvested flowers stalk with different pulsing agents is one of the effective ways to increase the vase life of gerbera (Manzoor *et al.*, 2020). Benzyl adenine, a synthetic cytokinin enhanced the vase life of gerbera was reported by Danaee *et al.* (2011). Salicylic acid is well

known phenol that can prevent ACC oxidase activity and decrease the production of reactive oxygen species (Ansari and Mishra, 2007). It has been also reported that vase life of cut flower can be increased by addition of several antimicrobial compound such as nano-silver (NS) particles (Mashayekhi *et al.*, 2011). Perik *et al.* (2014) documented that pulse treatment is beneficial for prolonging vase life of gerbera. Solgi *et al.* (2009) reported that nano-silver is used as pulsing agent to prolong postharvest life of cut flowers. Liu *et al.* (2009) reported that cut gerbera flowers pulsed for 24 hours in the 5 mg L⁻¹ nano-silver solution extended vase life by inhibiting bacterial growth at cut stem end. Apart from antibacterial effect, by increasing the membrane permeability in vase solution, nanoparticles also prevent ethylene biosynthesis and increase the activity of antioxidant enzymes (Manzoor *et al.*, 2020). Therefore, the current investigation was carried out with an objective to evaluate the effects of different pulsing agents on vase life and quality of gerbera.

Materials and Methods

The experiment was undertaken during October, 2017 to March, 2019 in the Department of Crop Physiology, Assam Agricultural University, Jorhat-13 to evaluate the effect of pulsing treatments in extending the vase life of gerbera. Gerbera was grown in the experimental field of Department of Horticulture in a plot size of 180 m². The variety selected for this investigation was Red gem. Flowers of uniform size and colour, free from pests and diseases were selected and harvested at mature stage. There were ten (10) treatments viz. T₁: Control (Distilled water), T₂: Salicylic acid 50ppm, T₃: Salicylic acid 100ppm, T₄: Salicylic acid 150ppm, T₅: Benzyl adenine 50ppm, T₆: Benzyl adenine 100ppm, T₇: Benzyl adenine 150ppm, T₈: Nano-silver 5ppm, T₉: Nano-silver 10ppm and T₁₀: Nano-silver 15ppm. Immediately after harvest, flowers were kept in a bucket containing water before placing in vase solutions. Before pulsing with different treatments, morpho-physiological parameters viz. moisture content, fresh weight, dry weight and scape bending were taken. The cut gerbera flowers were pulsed with different concentrations of salicylic acid, benzyl adenine and nano-silver separately for 1 hour in laboratory condition along with distilled water as control. The moisture content, fresh weight, dry weight, scape bending, solution uptake and transpirational water loss were recorded at three days interval.

Moisture content of flowers (%)

The moisture content of the gerbera flower and the individual floral parts viz., petal, sepal and other parts

was measured at three days interval by using the following formula:

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

Fresh weight of flowers (g flower⁻¹)

The fresh weight of gerbera flowers and the individual floral parts viz., petals, sepals and other parts were weighed separately with the help of an electronic weighing balance at three days interval and expresses in g flower⁻¹.

Dry weight of flowers (g flower⁻¹)

The dry weight of gerbera flowers and individual floral parts were recorded at three days interval. Gerbera along with the individual floral parts viz., petals, sepals and other parts were separately put in aluminium container and oven dried at 75°C to constant weight. Then the individual floral parts were weighed with the help of an electronic weighing balance and expresses in g flower⁻¹.

Scape bending (cm)

The scape bending of the control and treated gerbera cut flowers were measured at three days interval. With the help of a protector, the point from which the bending was originated was precisely recorded and the length from that point to the tip of the flower stalk was measured carefully by a scale. The measured length was considered the scape bending of the flower stalk and expressed in centimeter (cm).

Solution uptake (g flower⁻¹)

The solution uptake by gerbera flowers was estimated by the method forwarded by Venkatarayappa *et al.* (1980). The weights of conical flask plus solution without flower stalk were measured by an electronic weighing balance at three days interval. The differences in weights in between two consecutive measurements were considered as the amount of solution uptake by the flower within that period and expressed in g flower⁻¹.

Transpirational loss of water (g flower⁻¹)

The difference between water uptake and water retained in spike was measured at three days interval to determine the transpirational loss of water by using the following formula:

$$\text{Transpirational loss of water (g flower}^{-1}\text{)} = \text{WU} - (\text{FW} - \text{DW})$$

Where, WU=Water Uptake

FW= Fresh Weight of the flower

DW= Dry Weight of the flower.

Total carbohydrate content in petals (mg g⁻¹ fw)

The total carbohydrate content in petals was estimated at the end of vase of each treatment by Anthrone method (McCready *et al.*, 1950) and expressed in mg g⁻¹ fresh weight.

Vase life of flowers (days)

The vase life of cut gerbera flowers was estimated by the method forwarded by Yagia *et al.* (2014). It was measured after placing the full bloom flower in solution till its freshness alive and expressed in days.

Results

From the recorded data it is evident that the moisture contents (Table 1), fresh weight (Table 2) and dry weight (Table 3) of gerbera flower showed significant difference at 3rd and 6th day of vase life. All the applied treatments except T₇ (Benzyl adenine 150ppm) increased the total moisture content of gerbera compared to control till 6th day of vase period. On the 3rd and 6th day of vase, T₉ recorded the highest moisture content (84.03 and 81.65, respectively) followed by T₃ (83.39 and 81.12, respectively). On the 9th day of vase, only the flowers treated with T₉ (79.28) and T₃ (79.14) remained fresh, while the flowers with other treatments had wilted completely. Similar results were observed in terms of fresh and dry weight. On the 3rd day of vase, highest fresh weight was recorded in flower treated with T₉ (15.97) followed by T₃ (15.15) and on the 6th day of vase also T₉ (13.52) registered highest fresh weight followed by T₃ (13.23). On the 9th day of vase, flowers with T₉ recorded highest fresh weight (11.44) followed by T₃ (11.12), while the flowers with other treatments had wilted completely. From the recorded data it is evident that irrespective of the applied treatments, the dry weight (Table 3) of gerbera flower decreased gradually till the end of vase. The treatment T₉ showed highest dry weight both on the 3rd (2.21) and 6th (2.13) day of vase followed by T₃ (2.16 and 2.08 respectively). Similarly on the 9th day of vase also the highest dry weight was recorded in flowers treated with T₉ (2.12) followed by T₃ (2.04), while the gerbera cut flowers in other treatments were found to be wilted completely. Among the different treatments, flowers treated with nano-silver 10 ppm (T₉) could maintained highest moisture content, fresh weight and dry weight throughout the vase period followed by salicylic acid 100 ppm (T₃).

The solution uptake (Table 4) by gerbera flower was affected by the different pulsing agents and declined constantly during the entire vase period. The treatment T₉ recorded the highest solution uptake on 0-3 days, 3-6 days and 6-9 days of vase (4.39, 3.58 and 2.89 respectively) followed by T₃ (4.35, 3.31 and 2.23

Table 1 : Effect of different pulsing treatments on moisture content (%) of cut gerbera flowers during the vase life.

Treatments	Vase life	Moisture Content (%)											
		0 Days				3 Days				6 Days			
		P	S	O	T	P	S	O	T	P	S	O	T
T ₁ : Control (Distilled water)		78.23	78.10	77.16	78.43	78.34	79.45	77.20	78.45	76.71	81.71	77.19	76.75
T ₂ : Salicylic acid 50ppm		78.23	78.26	79.57	78.79	80.20	79.92	79.58	79.26	79.92	79.13	79.33	79.26
T ₃ : Salicylic acid 100ppm		81.06	78.37	77.78	78.27	83.62	80.99	83.63	83.39	80.95	80.14	81.28	81.12
T ₄ : Salicylic acid 150ppm		80.22	79.57	76.11	78.37	80.78	78.69	81.83	80.96	80.64	78.32	81.00	80.53
T ₅ : Benzyl adenine 50ppm		77.85	79.38	78.21	77.11	78.67	80.98	78.59	79.11	78.38	76.28	77.35	77.34
T ₆ : Benzyl adenine 100ppm		78.21	79.84	78.61	78.00	79.76	79.43	79.29	79.86	79.71	76.79	79.25	79.65
T ₇ : Benzyl adenine 150ppm		79.11	78.69	79.12	79.02	79.21	79.11	79.23	78.94	79.00	79.79	78.13	78.40
T ₈ : Nano-silver 5ppm		78.01	78.30	78.78	78.43	80.56	79.73	80.68	80.56	80.55	80.32	80.31	80.39
T ₉ : Nano-silver 10ppm		78.41	78.88	76.42	78.67	84.01	83.09	84.67	84.03	81.29	81.09	81.95	81.65
T ₁₀ : Nano-silver 15ppm		78.03	79.59	79.05	79.56	80.45	84.05	80.44	80.37	80.34	78.63	80.40	80.05
S.E.d (±)		-	-	-	-	1.134	1.65	1.345	0.078	2.143	1.511	0.981	0.062
C.D. (0.05)		N.S	N.S	N.S	N.S	2.211	2.412	2.103	0.186	2.213	2.876	1.345	0.148

P: Moisture content of petal, S: Moisture content of sepal, O: Moisture content of other parts, T: Total moisture content.

Table 2 : Effect of different pulsing treatments on fresh weight (g flower⁻¹) of gerbera cut flowers during the vase life.

Treatments	Fresh Weight (g flower ⁻¹)																
	0 Days				3 Days				6 Days				9 Days				
	P	S	O	T	P	S	O	T	P	S	O	T	P	S	O	T	
Vase life	T ₁ : Control (Distilled water)	6.13	0.74	4.52	11.39	6.47	1.05	4.71	12.23	6.03	1.02	4.18	11.23	-	-	-	-
	T ₂ : Salicylic acid 50ppm	6.13	0.64	4.65	11.42	6.61	1.04	4.81	12.46	6.27	1.00	4.34	11.61	-	-	-	-
	T ₃ : Salicylic acid 100ppm	6.17	1.14	4.19	11.50	7.00	1.02	7.13	15.15	6.46	1.62	5.15	13.23	5.45	0.97	4.7	11.12
	T ₄ : Salicylic acid 150ppm	6.32	0.40	4.74	11.46	6.81	2.14	5.55	14.50	6.42	0.77	5.04	12.23				
	T ₅ : Benzyl adenine 50ppm	6.15	0.61	4.64	11.40	6.54	1.00	4.77	12.31	6.07	0.99	4.27	11.33	-	-	-	-
	T ₆ : Benzyl adenine 100ppm	6.60	0.30	4.65	11.55	6.77	0.88	4.79	12.44	6.23	1.04	4.31	11.58	-	-	-	-
	T ₇ : Benzyl adenine 150ppm	6.55	0.46	4.35	11.36	6.89	0.73	4.76	12.38	6.22	0.88	4.30	11.40	-	-	-	-
	T ₈ : Nano-silver 5ppm	6.24	0.86	4.36	11.46	6.73	1.31	5.52	13.56	6.35	1.02	4.81	12.18	-	-	-	-
	T ₉ : Nano-silver 10ppm	6.37	0.69	4.38	11.44	7.16	0.85	7.96	15.97	6.70	0.56	6.26	13.52	5.99	0.46	4.99	11.44
	T ₁₀ : Nano-silver 15ppm	6.47	0.61	4.23	11.31	6.62	1.39	5.11	13.12	6.28	1.00	4.37	11.65	-	-	-	-
S.Ed (±)	-	-	-	-	0.220	0.109	0.085	0.207	0.155	0.077	0.115	0.198	-	-	-	-	-
C.D. (0.05)	N.S	N.S	N.S	N.S	0.526	0.262	0.204	0.495	0.372	0.184	0.275	0.477	-	-	-	-	-

P: Fresh weight of petal, S: Fresh weight of sepal, O: Fresh weight of other parts, T: Total fresh weight.

Table 3 : Effect of different pulsing treatments on dry weight (g flower⁻¹) of cut gerbera flowers during the vase life.

Treatments	Dry weight (g flower ⁻¹)															
	0 Days				3 Days				6 Days				9 Days			
	P	S	O	T	P	S	O	T	P	S	O	T	P	S	O	T
Vase life																
T ₁ : Control (Distilled water)	1.10	0.19	1.10	2.39	1.00	0.15	0.65	1.80	0.92	0.07	0.57	1.72	-	-	-	-
T ₂ : Salicylic acid 50ppm	1.15	0.32	0.99	2.46	1.12	0.18	0.80	2.10	1.04	0.10	0.72	2.02	-	-	-	-
T ₃ : Salicylic acid 100ppm	1.23	0.17	1.10	2.50	1.18	0.13	0.85	2.16	1.10	0.05	0.77	2.08	1.06	0.01	0.73	2.04
T ₄ : Salicylic acid 150ppm	1.24	0.24	1.00	2.48	1.17	0.17	0.81	2.15	1.09	0.09	0.73	2.07				
T ₅ : Benzyl adenine 50ppm	1.22	0.17	0.98	2.37	1.09	0.16	0.78	2.03	1.01	0.08	0.70	1.95	-	-	-	-
T ₆ : Benzyl adenine 100ppm	1.25	0.34	0.90	2.49	1.10	0.14	0.85	2.09	1.02	0.06	0.77	2.01	-	-	-	-
T ₇ : Benzyl adenine 150ppm	1.23	0.25	0.90	2.38	1.10	0.13	0.85	2.08	1.02	0.05	0.77	2.00	-	-	-	-
T ₈ : Nano-silver 5ppm	1.19	0.27	1.00	2.46	1.15	0.15	0.83	2.13	1.07	0.07	0.75	2.05	-	-	-	-
T ₉ : Nano-silver 10ppm	1.28	0.14	1.02	2.44	1.23	0.11	0.87	2.21	1.15	0.03	0.79	2.13	1.14	0.02	0.78	2.12
T ₁₀ : Nano-silver 15ppm	1.28	0.17	0.90	2.35	1.13	0.17	0.82	2.12	1.05	0.09	0.74	2.04	-	-	-	-
S.Ed(±)	-	-	-	-	0.102	0.046	0.070	0.095	0.068	0.040	0.10	0.26	-	-	-	-
C.D. (0.05)	N.S	N.S	N.S	N.S	0.202	0.105	0.136	0.219	0.239	0.090	0.230	0.051	-	-	-	-

P: dry weight of petal, S: dry weight of sepal, O: dry weight of other parts, T: total dry weight.

Table 4: Effect of different pulsing treatments on solution uptake, transpirational water loss, scape bending, total carbohydrate content, vase life and increase in vase life over control of cut gerbera flowers during the vase life.

Treatments	Solution Uptake (g flower ⁻¹)			Transpirational Water Loss (g flower ⁻¹)			Scape Bending (cm)			Total Carbohydrate Content (mg g ⁻¹ fw)	Vase Life (Days)	Increase in Vase Life over Control (Days)
	0-3 Days	3-6 Days	6-9 Days	0-3 Days	3-6 Days	6-9 Days	3 rd Day	6 th Day	9 th Day			
T ₁ : Control (Distilled water)	3.50	2.45	-	2.49	1.38	-	4.70	5.10	-	19.36	6.10	-
T ₂ : Salicylic acid 50ppm	4.18	3.08	-	3.36	3.22	-	3.63	4.21	-	20.77	7.56	1.46
T ₃ : Salicylic acid 100ppm	4.35	3.31	2.23	3.51	3.37	2.20	3.22	3.39	3.41	21.57	9.13	3.03
T ₄ : Salicylic acid 150ppm	4.29	3.15	-	3.45	3.29	-	3.39	3.44	-	21.55	8.40	2.30
T ₅ : Benzyl adenine 50ppm	3.98	3.02	-	2.77	2.50	-	4.43	4.84	-	20.16	6.57	0.47
T ₆ : Benzyl adenine 100ppm	4.12	3.07	-	3.31	3.14	-	3.74	4.42	-	20.44	7.42	1.32
T ₇ : Benzyl adenine 150ppm	4.10	3.03	-	3.21	3.10	-	3.79	4.52	-	20.40	6.70	0.60
T ₈ : Nano-silver 5ppm	4.25	3.11	-	3.43	3.24	-	3.42	3.86	-	21.11	8.26	2.16
T ₉ : Nano-silver 10ppm	4.39	3.58	2.89	3.61	3.51	2.76	3.08	3.04	3.04	22.43	9.36	3.26
T ₁₀ : Nano-silver 15ppm	4.20	3.09	-	3.37	3.23	-	3.46	4.14	-	20.99	8.00	1.90
S.Ed (±)	0.131	0.100	-	0.122	0.160	-	0.142	0.165	-	0.200	0.214	
C.D. (0.05)	0.275	0.021	-	0.257	0.125	-	0.297	0.347	-	0.419	0.449	

respectively). Similar trend was observed in terms of amount of transpirational water loss (Table 4). Recorded data clearly revealed that the decreased in transpirational loss of water was affected by different pulsing agents. The treatment T₉ recorded the highest transpirational water loss on 0-3 days, 3-6 days and 6-9 days of vase (3.61, 3.51 and 2.76, respectively) followed by T₃ (3.51, 3.37 and 2.20, respectively). The scape bending of gerbera flower during vase life are also affected by different concentrations of pulsing agents (Table 4). On the 3rd, 6th and 9th day of vase, lowest scape bending of gerbera flower was recorded in the flowers treated with T₉ (3.08, 3.04 and 3.04 respectively) followed by T₃ (3.22, 3.39, 3.41 respectively). Highest scape bending of gerbera flower was observed in T₁ on 3rd and 6th day (4.70 and 5.1, respectively), while the gerbera flower in other treatments had wilted on 9th day except T₉ and T₃. At the end of vase (Table 4), gerbera treated with T₉ recorded the highest total carbohydrate content of petal (22.43) followed by T₃ (21.57). The lowest total carbohydrate content of the gerbera petals was recorded in T₁ (19.36). The highest vase life of gerbera was recorded in flowers pulsed with T₉ (9.36) followed by T₃ (9.13). The lowest vase life (6.10) was recorded in T₁. Among the different treatments, flowers treated with nano silver 10ppm (T₉) showed highest vase life followed by salicylic acid 100ppm (T₃).

Discussion

Our present experiment revealed that salicylic acid, benzyl adenine and nano-silver, applied as pulsing treatments, positively affected the vase life of cut gerbera in a concentration dependent manner. Even on the 9th day of vase life, gerbera pulsed with 10ppm nano-silver and 100ppm salicylic acid remained fresh, while the gerbera with other treatments, including the control had wilted. Further, it was observed that, among the different pulsing treatments, nano-silver 10ppm exhibited the highest moisture content in gerbera flower throughout the vase period. Although benzyl adenine treatment was found not much effective as compared to nano-silver and salicylic acid but it showed significant positive effect on moisture content as compared to control. The stems of gerbera are highly prone to water stress. The blockage of the base of stem due to bacterial plugging results in decrease of water uptake by stem (Heidarnezhadian *et al.*, 2017). A very high level of turgidity is necessary for continuation of normal metabolic activities in the cut flowers. Lu *et al.* (2010) reported the positive effects of nano-silver on moisture

content of cut flowers might have been due to increase in water uptake. Our experiment revealed that nano-silver pulsed cut gerbera flower retained more moisture content. Liu *et al.* (2009) also reported that nano-silver treatment in pulse method was found to be effective to improve the postharvest life of cut gerbera by inhibiting the growth of bacteria. Such promotive results of silver ion were also observed by Kesta *et al.* (1995), who found that, silver ion was very effective in controlling microbial growth in cut ends of the flower. Increase in water uptake and concomitant increase in moisture content might be due to the fact that the silver ion acted as a biocide inhibiting microbial population that might have resulted in blockage of the vascular tissues. However, the higher concentration of nano-silver (15 ppm) was found to be less effective than the lower doses. The nano-silver induced wilting of cut flower at higher concentrations had been reported by Bahrehmand *et al.* (2014). This might be the reason of lower moisture content of gerbera flower under 15 ppm nano-silver as compared to other pulsing agents as observed in the present study. Salicylic acid, a natural plant hormone has important role in abiotic and biotic stress (Ahsan *et al.*, 2020). Salicylic acid has been shown to restrict the biosynthesis and/ or action of ethylene in plants (Sharma *et al.*, 2020). Wani *et al.* (2012) reported that salicylic acid can be used in vase solutions to prolong the longevity of cut flowers by maintaining the water balance and sugar content. In our experiment among the different pulsing treatments, highest fresh weight of gerbera was observed with nano-silver followed by salicylic acid. Lu *et al.* (2010) reported that application of nano-silver increased the fresh weight of cut rose might have been due to regulation of water movement. Kazemi and Atefeameri (2013) reported that in fresh weight retention in nano-silver was better than salicylic acid. Their result was in harmony with the findings of this present investigation. However, salicylic acid (SA) was also found to be one of the effective chemicals in increasing the fresh weight in the present study. Saeed *et al.* (2016) reported that SA might have delayed the dehydration of cut flowers either by making higher water uptake or lowering the water loss by regulation of stomatal conductance and transpiration. Nano-silver, salicylic acid and benzyl adenine, employed as pulsing treatment reduced the rate of decline in the dry weight of cut gerbera compared to control throughout the vase period. Nano-silver (10 ppm) and salicylic acid (100ppm) were found to be more effective compared to other treatments. Salicylic acid was reported to reduce the respiration rate of cut flowers which ultimately led to the reduction of dry matter loss as respiratory substrate (Roodbaraky *et*

al., 2012).

Several researchers agreed that stem vascular blockage, during the vase period of gerbera reduced water uptake which could be attributed as the main cause of stem bending (Hema *et al.*, 2015). Liu *et al.* (2009) found that Nano-silver pulse treatment inhibited bacterial growth in the vase solution and at cut stem ends of cut gerberas. Antimicrobial activity of Nano-silver enhanced the water uptake by preventing the plugging of vessels, thus increased the vase life was reported by Manzoor *et al.* (2020).

Carbohydrates are indispensable for the growth of all plant parts as carbohydrates provide energy for the growth processes. Recorded data revealed a gradual decline in carbohydrate level in cut gerbera flowers as senescence had started. This drop might be attributed to the elevated rates of respiration and consumption of the reserves during the vase life as suggested by Wani *et al.* (2012). Moreover, such decrease in carbohydrate content with the progression of vase life was due to some other catabolic oxidative processes that occurred during the vase period (Cavasini *et al.*, 2018). Therefore, to prolong the vase life, treatments that could maintain higher levels of carbohydrates in cut flowers might consider essential as they were associated with alterations in ethylene synthesis as reported by Pun and Ichimura (2003). Wei *et al.* (1997) reported that pulsing of cut flowers with silver ions inhibited the ethylene synthesis which inhibited sugar losses during senescence by altering respiration rate. Elgimabi (2011) found that silver ion retarded the carbohydrate degradation during the postharvest life. Therefore, it might be concluded that higher level of carbohydrate in the treated cut flowers might be one of the reasons of prolonged vase life compared to control. The production of ethylene in the floral organs and microbial growth in the xylem vessels are the major factors affecting floral senescence and petal abscission in cut flowers at postharvest (Niang and Kim, 2020). Pulsing cut flowers with silver ions inhibited the ethylene synthesis which delayed the senescence of cut flowers (Malakar *et al.*, 2019). Prabawati *et al.* (2023) reported that pulsing of chrysanthemum cut flowers with nano silver inhibited bacterial growth, flower wilting and colour degradation and thereby increased vase life of 19 days over control. Thakur *et al.* (2022) reported that nano silver prolongs the vase life of cut flowers over distilled water by maintaining better relative water absorption, relative fresh weight, inhibit microbial growth at the stem tip and delay stem clogging. Heidarneshadian *et al.* (2017) reported that salicylic acid increases vase life of gerbera cut flower.

Conclusion

Results obtained from the present investigation revealed that pulsing of cut gerbera flower with different concentrations of salicylic acid, benzyl adenine and nano-silver for 1 hour increased the vase life of gerbera as compared to control. Among all the pulsing treatments, T₉ (Nano-silver 10 ppm) was found to be the best in enhancing the vase life and quality of the cut flower followed by T₃ (Salicylic acid 100 ppm).

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