EFFECT OF FLOWER CLOLOUR AND PRESERVATIVE SOLUTIONS ON POSTHARVEST KEEPING QUALITY AND VASE LIFE OF GLADIOLUS

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Abstract

The research was carried out at the Postharvest Laboratory of Horticulture Division of Bangladesh Institute of Nuclear Agriculture (BINA) during the period from December 2021 to January 2022 to find out suitable vase solution(s) for longer vase life of gladiolus. The two-factor experiment comprised six vase solutions (tap water- control; distilled water; 4% sucrose solutions; 250 ppm citric acid; 3% sucrose + 150 ppm citric acid and 2% sucrose + 200 ppm citric acid) and four types of florets (pink, white, light pink and red), and was laid out in a completely randomized design with three replications. Gladiolus spikes were harvested at 1-2 floret color break stage. The harvested spikes having slanting cut at the base were individually kept in the prepared vase solutions as per experimental design. The vase solution comprising 3% sucrose and 150 ppm citric acid (CA) resulted in the maximum solution uptake (23.3%); longer duration for basal floret senescence (8 days) and maximum number of fully opened florets (95.1%) of the pink-coloured gladiolus at the 12th day after treatment. The same treatment also exerted the longest vase life (16.7 days) of the pink-coloured gladiolus. The shortest vase life of only 6.2 days was observed when the light pink gladiolus was held in tap water (control).

Key words: Gladiolus, Vase life, Sucrose, Citric Acid

Introduction

Gladiolus (*Gladiolus grandiflorus* L.) is one of the renowned commercial cut flowers in the world (Bai *et al.* 2009) as well as in Bangladesh. In Bangladesh, commercial cultivation of flowers actually started during 80s, and 1991, flowers were listed as exportable products from Bangladesh (Mukul, 2020). Gladiolus ranked the 1st in terms of production (9914 tons) with a market share of 31% (Hossen, 2018).

Short vase life is one of the most important limitations of cut flowers (Zamani *et al*., 2011), which is associated with wilting, ethylene-induced senescence, vascular blockage by air and microorganisms (Elgimabi, 2011) with reduced rate of water uptake, and continued transpiration through leaves (Hassan, 2005). Vase life of cut flowers is mainly affected by

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two main factors namely ethylene which accelerates the senescence of many flowers and microorganisms which cause vascular blockage thus reduce the vase life of cut flowers (Zencirkiran, 2010). Generally, life of florets spike placed in water as vase solution was reported as 4 to 6 days (Mayak *et al.*, 1973). Use of appropriate preservative(s) could help to extend vase life of the floret spikes for consumers' satisfaction and also for adequate marketing. A floral preservative usually is a complex mixture of sucrose, antimicrobial compound, and inhibitor of ethylene action. Sucrose that supplies the needed substrates for respiration and prolongs vase life, enables cut flowers harvested at the bud stage to open (Pun and Ichimura, 2003). Citric acid (CA) is a commonly used organic acid and makes a weak acid in water. CA is used to adjust water pH and to control the growth of microorganisms. The present experiment was designed to determine a suitable vase solution for optimal keeping quality and of longer vas life of gladiolus.

Materials and Methods

The present investigation was carried out at the Postharvest Laboratory, Horticulture Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during the period from December, 2021 to January, 2022. Gladiolus of four colours (pink, white, light-pink and red) were grown at the BINA HQs farm, Mymensingh, through homogeneously maintained growing conditions. The experiment comprised two factors, namely colour (4 colours- pink, white, light-pink and red) and preservative solutions (6). The preservative solutions were control- tap water (T_o); distilled water (T_1); 4% sucrose (T_2); 250 ppm CA (T_3); 3% sucrose + 150 ppm CA (T_4) and 2% sucrose + 200 ppm CA (T_5). The experiment was laid out in a completely randomized design with three replicates of single spike per replication. Flowers were kept in graduated glass bottles containing the prepared preservative solutions (300 mL) as per the experimental treatments and design. The openings of the bottles were closed with aluminum foil and held at ambient condition (Temperature: 22.97^{0}C; Humidity: 75%; Light Intensity: 143 Lux), and the preservative vase solutions were not changed. Data were collected on spike diameter, rachis length, number of florets per spikes, flower diameter, fresh floret weight, floret opening, days to basal floret senescence, solution uptake, and vase life. For the measurement of the solution uptake the bottles containing preservative vase solutions were made air tight to protect the loss of solution through evaporation. The solution absorption was then measured by the difference between the initial and final volume of the solutions and converted into percentage. Reagent grade sucrose (SUCROSE Extra Pure) and CA (Citric acid crystals) were procured from Research-Lab Fine Chem Industry, Mumbai, India. Flowers on vase solutions were regularly examined during the entire period of investigation. Days to basal senescence, number of floret opening per spike, duration of basal floret senescence and rate of floret opening were carefully observed and data recorded. The spikes of gladiolus were harvested when 1-2 florets at the bottom showed colour. The spikes were trimmed in equal length and slanting cuts were made to provide more exposure of solution accumulation. Immediately after harvest, the spikes were placed in clean water and brought carefully to the laboratory without causing any damage. The collected data were statistically analyzed using Statistix10 computer package program. Means were calculated and analysis of variance for each of treatment was represented by F-test (variance ratio). Differences between treatments were evaluated by LSD test at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

Floral characteristics of the experimental coloured gladiolus

The floral characteristics of the experimental gladiolus genotypes are summarized in Table 1. Results revealed that the longest rachis (43.50 cm) was observed in the case of white gladiolus, while the shortest (39.67 cm) was found in the light pink gladiolus. The widest (8.46 cm diameter) and the heaviest floret (6.97 g) were recorded in the pink gladiolus, whereas the narrowest (6.06 cm) and the lightest (4.16 g) floret were found in light pink gladiolus (Table 1). Maximum number of florets (13.0 spike^{-1}) was found in light-pink gladiolus and the minimum number of florets (10.83 spike^{-1}) was found in the red gladiolus. Genotypic variation in floral characters in gladiolus is also observed by many workers (Marandi *et al.*, 2011; Mehraj *et al.*, 2013) that supported the present research results.

Table 1. Morphological characteristics (mean ± sd) of the experimental gladilolus

Colour of gladiolus	Rachis length (cm)	No. of florets plant^{-1}	Flower diameter (cm)	Flower weight (g)
Pink	39.33±4.60	10.05±0.08	8.46±0.62	6.97±0..48
White	43.50±7.48	12.33±2.31	7.80±0.88	4.33±0.63
Light pink	39.67±5.57	13.0±1.35	6.06±0.71	4.16±0.14
Red	42.17±4.09	10.83±1.03	8.08±1.10	5.68±0.22

Solution uptake

Colour of gladiolus significantly influenced the rate of uptake of vase solution. Results revealed that the pink gladiolus had higher level of solution uptake followed by white and red gladiolus (Table 2). Solution uptake also varied significantly due to the preservative vase solution at different days after treatment (DAT). Maximum solution uptake (23.3%) was recorded in the case of pink gladiolus when 3% sucrose + 150 ppm CA was used followed by 2% sucrose + 200 ppm CA (21.3%) at 12 DAT (Table 2). The minimum solution uptake (13.8%) was observed in light-pink gladiolus when preserved in tap water (control) at the same DAS. The maximum solution uptake with 3% sucrose + 100 ppm STS (silver thiosulphate) of gladiolus was reported by Jamal *et al.* (2016), and their findings were closely related to the present study. Results of the present study can be explained on basis of antimicrobial property of sucrose and citric acid that played an important role in improving the solution uptake by gladiolus cut flowers through preventing the growth of microorganism in the xylem vessels and thus maintained solution uptake by flower stems. Results of the present research showed that the rate of absorption of vase solution trended to increase up to the 6th day of observation, and there after the absorption rate decreased with advancement of time. The increased rate of absorption of vase solution might be due to the rapid increase in physiological activities like opening of florets and increase rachis length, and also might be attributed to the fact that sucrose provides necessary energy for continuing physiological activities needed for uptake of vase solution. Hutchinson *et al*. (2003) also studied pulsing of tuberose cut flower for 24 h in sucrose to prove their water relation. Similar result reported by Ali *et al*. (2008) in cut daffodil flower, who found that vase solution as distilled water uptake was first increased, and decreased afterwards sharply up to the 6^{th} day of observation. The interaction of gladiolus colour and vase solution was not found significant during the entire period of investigation (Table 2).

Number of open florets

Floret opening was significantly varied among the treatments at 12 days after treatment. Maximum floret opening (95.1%) was recorded in the case of pink gladiolus when 3% sucrose + 150 ppm CA was used as vase solution, followed by 4% sucrose (93%) with white gladiolus. On the contrary, the minimum floret opening rate (80%) was found from control (tap water) with the pink gladiolus (Table 3). Jamal *et al.* (2016) also found that the maximum floret opening from 3% sucrose + 100 ppm SA (salicylic acid) and their finding was similar to the findings of the present study. Pulsing gladiolus spikes with sucrose resulted in increased glucose and fructose concentration and improved the maintenance of high starch concentration in the floret during flower opening. Floret opening rate continuously increased till the end of the experiment due to sucrose supplement was due to the favorable osmotic pressure and carbohydrate concentrations and water uptake. Sucrose increases the osmotic potential and improves their ability to maintain turgidity (Acock and Nichols, 1979). Kumar and Deen (2015) also reported that the opening of florets were maximum with 20% sucrose as a pulsing solution.

Time to basal floret senescence

Days to basal floret senescence differed significantly due to application of various preservative vase solutions. The longest duration (8.0 days) for basal senescence was required for the pink gladiolus when 3% sucrose + 150 ppm CA was used, which was followed by 2% sucrose + 200 ppm CA (7.8 days). On the other hand, the shortest duration for basal floret senescence was recorded in control (4.5 days) with the light pink gladiolus (Table 4). It is because treatment with anti-ethylene compounds and anti-microbial compounds increase the amount of carbohydrates to flower and water uptake by flower, and inhibit the ethylene production that cause early senescence. The longest duration to basal floret senescence was observed with 3% sucrose+150 ppm CA acid that might be because of the fact that sucrose acts as carbon source, maintains mitochondrial structure and provides longer energy for longer duration to delay the senescence of florets (Kaur *et al*., 2006). Similarly, increase in drooping of florets with advancement of time has been reported in tuberose (Kumar & Deen, 2015). These reported observations supported the present findings.

Table 2. Effects of gladiolus colour, preservative vase solution, and their combined effects on rate of solution uptake at different days after treatment (DAT)

Treatment/combination	Solution uptake (%) at different days after treatment (DAT)			
	3	6	9	12
Gladiolus colour (Main effect)				
Pink gladiolus (P_1)	6.8	13.7	17.6a	19.8a
White gladiolus (P_2)	6.5	12.6	15.3b	16.6b
Light pink gladiolus (P_3)	6.7	13.2	14.9b	14.9c
Red gladiolus (P_4)	7.4	13.1	15.9b	16.6b
L. of Significance	NS	NS	*	**
Vase solution (Main effect)				
Tap water (T_1)	7.1	12.8	15.3b	15.9b
Distilled water (T_2)	6.0	12.9	15.8b	16.5b
4% Sucrose (T_3)	6.6	12.8	15.5b	16.2b
250 ppm CA (T_4)	6.7	13.2	15.7b	16.4b
3% Sucrose + 150 ppm CA (T_5)	7.4	14.0	17.7a	19.3a
2% Sucrose + 200 ppm CA (T_6)	7.3	13.3	15.8b	17.3b
L. of Significance	NS	NS	*	**
Interaction effect between colour and vase solution				
$P_1 \times T_1$	7.3	14.2	17.3	18.9
$P_1 \times T_2$	6.7	12.2	17.1	18.4
$P_1 \times T_3$	6.9	14.0	17.1	19.0
$P_1 \times T_4$	6.1	13.7	16.3	17.8
$P_1 \times T_5$	7.2	15.4	20.8	23.3
$P_1 \times T_6$	6.6	12.7	17.1	21.3
$P_2 \times T_1$	6.3	11.2	14.4	15.2
$P_2 \times T_2$	5.8	12.3	14.2	15.4
$P_2 \times T_3$	5.2	12.3	15.2	15.9
$P_2 \times T_4$	7.2	12.2	15.0	16.2
$P_2 \times T_5$	6.8	13.3	16.9	19.0
$P_2 \times T_6$	7.4	14.3	16.2	17.6
$P_3 \times T_1$	6.7	11.6	13.8	13.8
$P_3 \times T_2$	6.1	14.2	15.2	15.1
$P_3 \times T_3$	6.9	12.9	14.6	14.3
$P_3 \times T_4$	5.6	14.0	15.6	15.6
$P_3 \times T_5$	7.2	12.8	15.6	16.0
$P_3 \times T_6$	7.6	14.0	14.6	14.6
$P_4 \times T_1$	8.0	14.1	15.6	15.8
$P_4 \times T_2$	5.6	12.7	16.4	17.0
$P_4 \times T_3$	7.3	11.8	15.0	15.6
$P_4 \times T_4$	7.8	13.1	15.8	16.1
$P_4 \times T_5$	8.3	14.4	17.6	1.0
$P_4 \times T_6$	7.7	12.4	15.2	15.7
L. of Significance	NS	NS	NS	NS
CV (%)	26.56	15.20	11.94	10.97

*= significance at 5% level of probability, **= significance at 1% level of probability, NS= Not significant.

Table 3. Effects of floret colour and preservative vase solution, and their interaction on open floret spike^{-1} (%) of gladiolus at different days after treatment (DAT)

Treatment	Open florets spike^{-1} (%)				
	1DAT	3DAT	6DAT	9DAT	12DAT
Main effect of gladiolus colour					
P_1	8.9a	37.7b	55.0b	79.6b	86.4
P_2	8.7a	40.4b	57.0b	76.7b	85.0
P_3	7.8b	55.2a	78.4a	86.2a	86.8
P_4	9.1a	52.1a	76.2a	87.1a	89.0
L. of Significance $_{(0.05)}$	**	**	**	**	NS
Main effect of vase solution					
T_1	8.7	49.3a	66.4	82.5ab	86.4bc
T_2	8.6	45.5ab	66.6	82.5ab	85.0c
T_3	8.6	46.1ab	68.4	82.7ab	88.5b
T_4	8.8	39.8b	62.8	80.4b	85.6c
T_5	8.5	46.9a	67.0	85.3a	91.9a
T_6	8.5	50.5a	68.6	80.8b	87.1bc
L. of Significance $_{(0.05)}$	NS	*	NS	*	**
Interaction effect between colour and vase solution					
$P_1 \times T_1$	9.1	33.2	51.2	77.4	80.6i
$P_1 \times T_2$	9.4	36.6	53.0	83.2	86.0d-h
$P_1 \times T_3$	8.6	40.5	57.3	83.9	90.9a-c
$P_1 \times T_4$	9.4	34.2	52.7	72.1	81.6hi
$P_1 \times T_5$	8.8	37.1	56.1	84.2	95.1a
$P_1 \times T_6$	8.0	44.8	59.4	76.5	85.7d-h
$P_2 \times T_1$	7.6	44.8	55.2	74.5	86.6c-g
$P_2 \times T_2$	8.7	31.0	52.2	74.4	81.6hi
$P_2 \times T_3$	9.0	44.1	55.7	71.5	85.3e-i
$P_2 \times T_4$	8.8	32.8	64.8	81.2	89.7b-e
$P_2 \times T_5$	9.1	44.1	55.8	82.2	93.0ab
$P_2 \times T_6$	9.1	45.4	58.1	76.2	87.6c-g
$P_3 \times T_1$	8.5	60.9	81.4	89.0	89.0b-f
$P_3 \times T_2$	7.7	59.9	84.9	86.7	86.7c-g
$P_3 \times T_3$	7.7	54.0	81.2	87.2	87.3c-g
$P_3 \times T_4$	7.2	48.8	64.8	84.2	84.2g-i
$P_3 \times T_5$	7.7	53.9	78.9	87.2	88.7b-g
$P_3 \times T_6$	7.7	53.9	79.2	82.6	85.0f-u
$P_4 \times T_1$	9.7	58.4	77.8	89.2	89.5b-f
$P_4 \times T_2$	8.6	54.3	76.4	85.9	85.9d-h
$P_4 \times T_3$	9.1	45.7	79.4	88.1	90.4a-d
$P_4 \times T_4$	9.8	43.5	68.7	84.0	86.7c-g
$P_4 \times T_5$	8.4	52.3	77.2	87.6	91.1a-c
$P_4 \times T_6$	9.1	57.9	77.7	88.1	90.1b-d
L. of Significance $_{(0.05)}$	NS	NS	NS	NS	**
CV	11.13	17.15	14.58	6.39	3.30

P_1= Pink gladiolus, P_2= White gladiolus, P_3= Light pink gladiolus, and P_4= Red gladiolus. T_1= Tap water (control), T_2 = Distilled water, T_3 = 4% Sucrose, T_4= 250 ppm CA, T_5= 3% Sucrose + 150 ppm CA, and T_6= 2% Sucrose + 200 ppm CA. *= Level of significance at 5%, **= Level of significance at 1%, NS= Not significant.

Table 4. Effects of gladiolus colour, preservative vase solution, and their combined effects on time to basal floret senescence

Treatment/Combination	Time to basal floret senescence (days)	Combination	Time to basal floret senescence
Main effect of gladiolus colour		Combined effect (contd.)	
P_1	7.1a	$P_2 \times T_1$	6.5b-f
P_2	7.0a	$P_2 \times T_2$	7.0a-e
P_3	5.6b	$P_2 \times T_3$	7.2a-e
P_4	5.3b	$P_2 \times T_4$	6.8a-e
		$P_2 \times T_5$	7.5a-d
Level of significance	**	$P_2 \times T_6$	7.0a-e
Main effect of vase solution		$P_3 \times T_1$	4.7i
T_1	5.6c	$P_3 \times T_2$	4.5i
T_2	5.7c	$P_3 \times T_3$	6.2d-h
T_3	6.3bc	$P_3 \times T_4$	4.8a-e
T_4	6.1bc	$P_1 \times T_5$	7.2a-e
T_5	7.3a	$P_1 \times T_6$	6.3c-g
T_6	6.6ab	$P_4 \times T_1$	5.0g-i
LSD	0.74	$P_4 \times T_2$	5.3f-i
Level of significance	**	$P_4 \times T_4$	5.0g-i
Interaction effect between gladiolus colour and vase solution		$P_1 \times T_6$	5.2f-i
$P_1 \times T_1$	6.3		
$P_1 \times T_2$	5.9	Level of significance	NS
$P_1 \times T_3$	7.0		
$P_1 \times T_4$	7.7		
$P_1 \times T_5$	8.0		
$P_1 \times T_6$	7.8		

P_1 = Pink gladiolus, P_2 = White gladiolus, P_3 = Light pink gladiolus, and P_4= Red gladiolus. T_1 = Tap water (control), T_2 = Distilled water, T_3 = 4% Sucrose, T_4 = 250 ppm CA, T_5 = 3% Sucrose + 150 ppm CA, and T_6 = 2% Sucrose + 200 ppm CA. * = Level of significance at 5%, ** = Level of significance at 1%, NS= Not significant.

Vase life

Main effect of gladiolus in terms of colour was found significant (Figure 1). The longest vase life (13.83 days) was recorded in pink gladiolus. The preservative vase solution caused significant effects to influence vase life of gladiolus (Figure 2). The longest vase life was recorded when 3% sucrose + 150 ppm CA was used as vase solution followed by 2% sucrose + 200 ppm CA. Highly significant variation was found on flower longevity i.e. vase life as influenced by the combined effects of gladiolus type (in terms of color) and preservative vase solution (Figure 3). The pink gladiolus stayed for the longest duration (16.7 days) in flower vase when treated with 3% sucrose + 150 ppm CA followed by 2% sucrose + 200 ppm CA (14.3 day), while the shortest vase life (only 6.2 days) was observed in control (tap water) with light pink gladiolus.

It is due to the fact that short vase life of cut flowers is generally related to wilting, ethylene production and vascular blockage by air and microorganisms (Elgimabi, 2011). But when sucrose in combination with antimicrobial agent (example CA, HQS, $AgNO_3$) and ethylene inhibitor is used a synergistic effect, which improves the water balance and osmotic potential, inhibits the microbial growth, arrest the negative effect of ethylene (Nigussie, 2005). Acidic water with pH (3.0-3.5) is used to decreases microbial growth (Mehraj *et al*., 2013) whereas, sugar is used as artificial source of additional food after harvest helping in opening of flower buds *viz*., carnation, rose and gladiolus, improves water balance (Pun and Ichimura, 2003) and also decreases sensitivity towards ethylene as in case of carnation (Mayak *et al*., 1973). Sucrose was observed to reduce moisture stress in cut flowers by affecting stomatal closure, preventing transpiration and water loss as well as it provides energy required by flower thus resulting in longer vase life of flowers. Cut flowers' vase life is affected by several factors such as: cell programmed death (Eason *et al*., 2002), ethylene induced senescence (Liao *et al*., 2000), dehydration (Lu *et al*., 2010), or loss of assimilates and substrates (Ichimura *et al*., 2005). Among the above mentioned, water relation and balance play a major role in postharvest quality and longevity of cut flowers (Lu *et al*., 2010) and water stress during this period is often the reason for short vase life for cut flowers (Van Doorn, 1997). Water relation interruption is mostly due to proliferation of microorganism in the vase solution and occlusion in the basal end of the cut flower stem by microbes (Van Doorn, 1997; 2003; He *et al*., 2006; Liu *et al*., 2009). Besides vessel blockage (Van Doorn, 1997; He *et al*., 2006; Liu *et al*., 2009), bacteria secrete pectinases and toxic compounds and produce ethylene (Williamson *et al*., 2002), and ultimately accelerate senescence. In order to prevent vase solution microbial count and proliferation, most preservatives incorporate acidifying agents. One of the most widely and commercially used acidifying agent has been the citric acid. Muhammad *et al*. (2012) reported that application of citric acid (300 mg L^{-1}) increased vase life (12.44 days) of 'Cherry Brandy' roses. Mehraj *et al*. (2013) suggested that cut gladiolus stayed for the 18.3 days in flower vase when treated with 100 ppm sucrose + lemon juice. Gowda and Gowda (1990) also found 18.3 days vase life of cut gladioli treated with 1.0 µM aluminium sulphate; also 3% sucrose (17.0 days) and 2% sucrose (15.3 days) that justify the current findings.

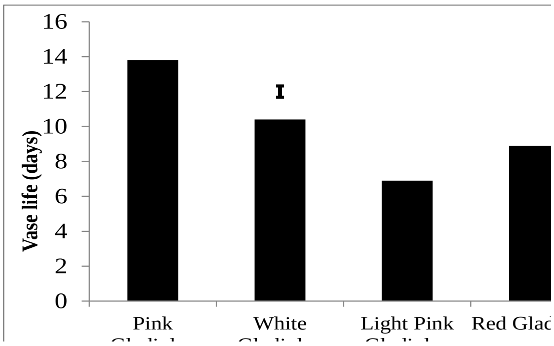

Figure 1. Graph showing effect of flower colours on vase life (days) of gladiolus flowers. Vertical bar represents LSD (0.05).

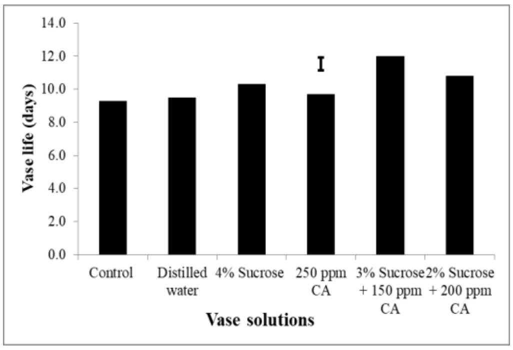

Figure 2. Graph showing effect of flower colours on vase life (days) of gladiolus flowers. Vertical bar represents LSD (0.05).

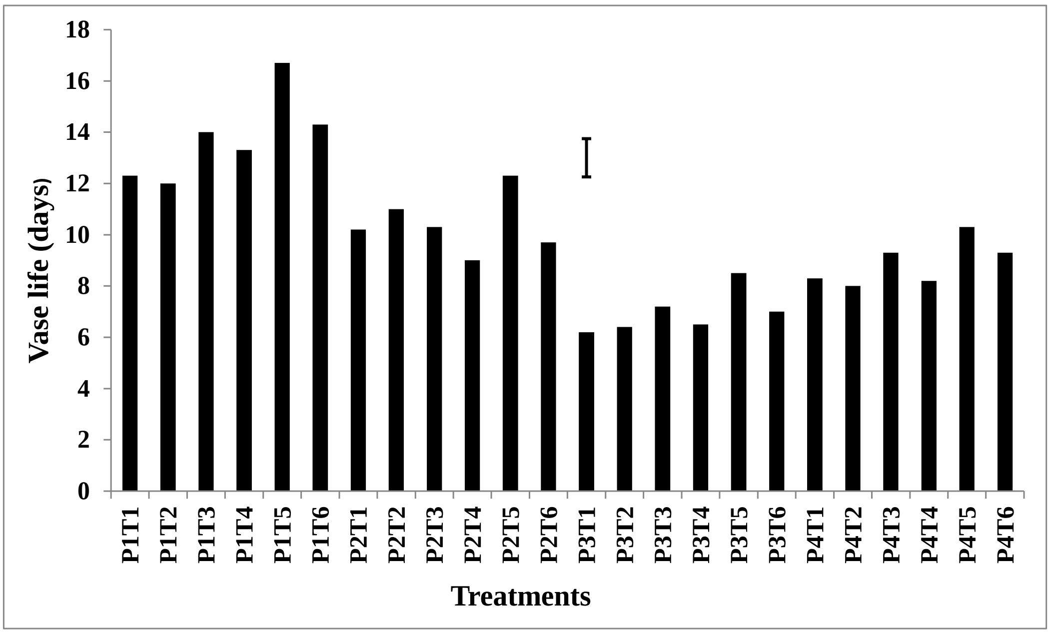

Figure 1. Graph showing interaction effect of vase solution and flowers colours on vase life (days) of gladiolus flowers (P_1= Pink gladiolus, P_2= White gladiolus, P_3= Light pink gladiolus, and P_4= Red gladiolus. T_1= Tap water (control), T_2 = Distilled water, T_3 = 4% Sucrose, T_4= 250 ppm CA, T_5= 3% Sucrose + 150 ppm CA, and T_6= 2% Sucrose + 200 ppm CA).

Conclusion

From the present study it can be concluded that 3% sucrose + 150 ppm CA was the best preservative vase solution in terms of retention of keeping quality and vase life. Among the varieties examined, the pink gladiolus performed the best in respect of all the parameters.

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