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Studies on the effect of commonly available acidifiers on extension of vase life of gladiolus (*Gladiolus grandiflorus* L.) cv. Swarnima

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Abstract
The experiment entitled Studies on the effect of commonly available acidifiers on extension of vase life of gladiolus (*Gladiolus grandiflorus* L.) cv. Swarnima was conducted at Floricultural Research station, Rajendranagar during 2020-2021. The treatments comprised of Citric acid (200, 300 ppm), Ascorbic acid (200, 300 ppm), Soda (300, 500 ml) and Control (Distilled water). Citric acid 200 ppm recorded maximum water uptake (25.34, 16.97, 11.52 g), transpirational loss of water (23.24, 15.56, 11.22 g), water balance (7.10, 6.41, 5.23 g), fresh weight change (104.09, 99.13, 88.17%), minimum optical density of vase solution (0.044, 0.049, 0.052 nm) during 2nd, 4th and 6th days of vase life and least days to first floret opening (1.78 day), maximum diameter of basal floret (10.16 cm), maximum longevity of basal floret (2.46 days), highest number of florets opened on spike when basal floret is fresh (2.50) and highest number of florets opened per spike at the end of the vase life (10.66) and recorded highest vase life (9.62 days) and floret opening percentage (92.69%) when compared to other treatments. The results suggest that citric acid 200 ppm can be used to enhance the vase life of cut gladiolus cv. Swarnima.

Keywords: Gladiolus, citric acid, vase life, acidifiers

Introduction
Gladiolus is acclaimed as “Queen of bulbous flowers”. Gladiolus L. is a Iridaceae member and the subfamily Ixoideae, with its origin in South Africa. In Latin the word gladius means “Sword” and is commonly referred to as ‘Sword Lily’ or ‘Corn Lily’. The gladioli inflorescence is called a spike. The erect spikes of flower’s measure 1 to 4 feet tall and grow through the sword like leaves from the corm, a modified stem planted underground.
It is cultivated in West Bengal, Sikkim, Himachal Pradesh, Punjab, Karnataka, Delhi, Tamil Nadu. There is much demand for gladiolus spikes in cities like Delhi, Chennai, Kolkata, Mumbai, Bangalore, Hyderabad, Pune. Due to its elegance of floret colour and shape, it has become a outstanding bulbous plant in ornamental gardens and commercial cultivation. The flower spikes are used in bouquets and for indoor decorations and suited for bedding and exhibition purpose.
Longevity of cut flowers is one of the main challenges of florists today. It has been shown that at low pH water travels faster in the water conducting system, thereby preventing wilting and improving longevity. Marousky (1971) [8] demonstrated that low pH retarded stem blockage of rose. Cut flowers exhibit longer vase life when acidifying compounds like citric acid, ascorbic acid are used as preservative compounds which act through adjusting water pH and decreasing the incidence of microorganisms in the vase solutions (Vahdati, 2012) [13].
To amend the longevity of cut flowers many commercial preservatives are well researched and efficient but not readily available for everyone, expensive and harmful for human causing irritation to skin, eyes, respiratory tract *etc.*, also few among them are carcinogenic. The locally available preservatives and organic natural substances are safe, environment friendly and cheap (Lambert, 2001) [6]. They are also easily available for retailers, florists and domestic purposes. However, limited information is available on their effectiveness in extending the vase life of cut flowers in general and gladiolus in particular. To contour this issue few locally available acidifiers has been studied to know their effect on vase life of cut gladiolus.

Material and Methods
The present investigation was carried out at Post harvest Laboratory, Floricultural Research

Station, ARI, Rajendranagar, Hyderabad during *Rabi* season of the year 2020-2021. The experiment location is situated at an altitude of 542.3 m above mean sea level on 780 29' East longitude and 170 19' North latitude. The experiment was laid out in Completely Randomized Design with 7 treatments and three replications *viz.*, T1: Citric acid - 200 ppm, T2: Citric acid - 300 ppm, T3: Ascorbic acid - 200 ppm, T4: Ascorbic acid - 300 ppm, T5: Soda - 300 ml/l, T6: Soda - 500 ml/l, T7: Control (Distilled water). The experiment flowers were held at ambient room temperature (average mean temperature of 260C, maximum relative humidity 89% and minimum of 42%), under 40 W cool white fluorescent tubes to maintain 12 hours photoperiod. Flower spikes of Gladiolus (*Gladiolus grandiflorus* L.) cv. Swarnima were procured from Floricultural Research Station, Rajendranagar. Water uptake(g/spike), transpirational loss of water (g/spike), water balance (g/spike), fresh weight change (%), optical density of vase solution(480 nm), days to first floret opening (days), diameter of basal floret (cm), longevity of basal floret (days), number of florets opened on spike when basal floret is fresh, number of florets opened per spike at the end of the vase life, vase life of spike (days), floret opening percentage (%) were observed and calculated.

Results and Discussion

Water uptake (g/spike): Water uptake by spikes decreased gradually from day one to last day of vase life, T1 - Citric acid 200 ppm recorded maximum water uptake (25.34, 16.97, 11.52 g) followed by T3 - Ascorbic acid 200 ppm (23.87, 13.23, 9.83 g) while, lowest water uptake was observed in T7 - Control (14.31, 6.32, 3.20 g) respectively on 2nd, 4th and 6th day of vase life period. Maximum water uptake by citric acid 200 ppm might be due to low pH created by it in vase solution. Choi and Roh (1980) [2] reported that citric acid helps in maintaining pH at 3.5 and increases water uptake. Similar findings were observed by Madhavi (2007) [7] in gerbera.

Transpirational loss of water (g/spike)

T1 - Citric acid 200 ppm significantly recorded maximum values (23.24, 15.56, 11.22 g) of transpirational loss of water followed by T3 - Ascorbic acid - 200 ppm (22.34, 12.22, 9.64 g). While, T7 - Control recorded minimum values (14.11, 6.19, 4.40 g) on day 2nd, 4th and 6th respectively. Maximum water uptake by citric acid 200 ppm might have resulted in maximum transpirational loss of water due to good conductivity in vascular tissue. Similar results were observed by Sravanthi (2019) [11] in gerbera.

Table 1: Effect of commonly available acidifiers on water uptake (g/spike) and transpirational loss of water (g/spike) during vase life period of gladiolus cv. Swarnima.

Treatments (T)	Water Uptake (g)				Transpirational loss of water (g)			
	Days							
	2	4	6	8	2	4	6	8
T1 - Citric acid 200 ppm	25.34	16.97	11.52	9.88	23.24	15.56	11.22	9.80
T2 - Citric acid 300 ppm	21.83	12.58	8.68	6.35	20.62	11.64	8.78	7.32
T3 - Ascorbic acid 200 ppm	23.87	13.23	9.83	7.24	22.34	12.22	9.64	7.65
T4 - Ascorbic acid 300 ppm	20.42	11.66	7.66	5.52	19.42	10.85	7.93	6.63
T5 - Soda 300 ml	19.31	8.16	5.40	4.90	18.21	7.45	6.21	6.09
T6 - Soda 500 ml	17.01	11.55	5.91	5.21	15.91	10.80	6.23	6.35
T7 - Control (DW)	14.31	06.32	3.20	-	4.11	6.19	4.40	-
Mean	20.29	11.49	7.00		19.12	10.67	7.77	
S.E (m)±	0.35	0.27	0.15	-	0.13	0.14	0.10	-
CD at 5%	1.07	0.85	0.48		0.42	0.43	0.32	

Water balance (g/spike)

Inclusion of Citric acid 200 ppm in vase solution improved the water balance of cut spikes and recorded maximum values on 2nd, 4th and 6th day (7.10, 6.41, 5.23 g), Whereas, T7 control (DW) recorded minimum values (5.20, 5.13, 3.80 g) on 2nd, 4th and 6th days of vase life respectively. The high amount of water uptake and maintained transpirational loss of water by Citric acid 200 ppm (T1) might have resulted in high water balance in the flower tissues of spike when compared to other treatments. These results are in accordance with reports of (Durkin, 1979) [3] where citric acid prevented the vascular blockage and improved water balance. Similar results were obtained by Madhavi (2007) [7] in gerbera.

Fresh weight change (%)

Results presented in Table 3 shows that, T1 - Citric acid 200 ppm significantly recorded maximum values of fresh weight change (104.09, 99.13, 88.17%) followed by T3 - Ascorbic acid 200 ppm (102.67, 95.36, 86.35%) respectively on 2nd, 4th and 6th day of vase life. The change in fresh weight of flower is directly influenced by the difference between the rates of water uptake and transpirational loss (Rogers, 1963). Good amount of water balance maintained by Citric acid 200 ppm (T1) might have helped in attaining maximum fresh weight change values in gladiolus spikes when compared to other treatments. Similar results were observed by Kashyap *et al*. (2017) [5].

Table 2: Effect of commonly available acidifiers on water balance (g/spike) during vase life period of gladiolus *(Gladiolus grandiflorus* L.) cv. Swarnima.

Treatments (T)	Water Balance (g)			
	Day 2	Day 4	Day 6	Day 8
T1 - Citric acid 200 ppm	7.10 (2.10)	6.41 (1.41)	5.23 (0.23)	5.08 (0.08)
T2 - Citric acid 300 ppm	6.21 (1.21)	5.94 (0.94)	4.90 (-0.10)	4.03 (-0.97)
T3 - Ascorbic acid 200 ppm	6.53 (1.53)	6.01 (1.01)	5.19 (0.19)	4.59 (-0.41)

T4 - Ascorbic acid 300 ppm	6.00 (1.00)	5.81 (0.81)	4.73 (-0.27)	3.89 (-1.11)
T5 - Soda 300 ml	6.10 (1.10)	5.71 (0.71)	4.21 (-0.79)	3.81 (-1.19)
T6 - Soda 500 ml	6.10 (1.10)	5.75 (0.75)	4.68 (-0.32)	3.86 (-1.14)
T7 - Control (DW)	5.20 (0.20)	5.13 (0.13)	3.80 (-1.20)	
Mean	6.17 (1.17)	5.82 (0.82)	4.62 (-0.26)	
S.E (m)±	0.03	0.05	0.05	
CD at 5%	0.10	0.16	0.16	

Parenthesis represents original values. The data were analyzed statistically after uniform addition of a base value 5.0.

Optical density of vase solution (480 nm)

The lowest optical density on 2nd, 4th and 6th day was recorded with T1 - Citric acid 200 ppm (0.044, 0.049, 0.052 nm) followed by T3 - Ascorbic acid 200 ppm (0.049, 0.058, 0.069 nm), highest optical density (0.080, 0.099, 0.119 nm) was recorded with T7 - Control (DW) on 2nd, 4th and 6th day of vase life. Reduction in pH of vase solution on effect of citric acid outcomes in reduced number of microorganisms in vase solution and leads to reduction in turbidity. Citric acid reduces bacterial population in vase solution (Van Doorn, 1997) [14]. Similar findings were recorded by Mehdikhan *et al.* (2016) [9] where, citric acid retarded the bacterial population in the vase solution of gerbera.

Days to first floret opening (days)

T1 - Citric acid 200 ppm recorded least number of days to first floret opening (1.78 days) which was at par with T3 - Ascorbic acid 200 ppm (1.82 days) and T2 - Citric acid 300 ppm (1.83 days). Citric acid 200 ppm (T1) enabled continuous flow of water without interruption, and recorded maximum water uptake and water balance which leads to turgidity in flower tissue, resulting in early opening of the floret of gladiolus spikes when compared to other treatments.

Diameter of basal floret (cm)

The diameter of the basal floret varied from 7.23 cm to 10.16 cm. The effect of different treatments on the diameter of the basal floret was significant. T1 - Citric acid 200 ppm was superior and recorded maximum diameter (10.16 cm). Low pH created by Citric acid 200 ppm (T1) in vase solution has led to high uptake of solution by xylem and this might have increased the diameter of the floret in present study. Whereas, minimum diameter (7.23 cm) was recorded with T7 – Control. According to Tomar *et al*. (2021) [12] high uptake of solution helped in more opening of disc florets and enlargement of ray florets contributing to increased flower size in gerbera.

Table 3: Effect of commonly available acidifiers on Fresh weight change (%) and optical density of vase solution (480 nm) during vase life period of gladiolus (*Gladiolus grandiflorus* L.) cv. Swarnima.

Treatments (T)	Fresh weight change (%)				Optical density of vase solution (nm)			
	Days				Days			
	2	4	6	8	2	4	6	8
T1 - Citric acid 200 ppm	104.09	99.13	88.17	80.17	0.044	0.049	0.052	0.060
T2 - Citric acid 300 ppm	100.89	94.19	79.69	73.16	0.056	0.069	0.073	0.076
T3 - Ascorbic acid 200 ppm	102.67	95.36	86.35	75.17	0.049	0.058	0.069	0.070
T4 - Ascorbic acid 300 ppm	100.09	90.11	76.43	70.12	0.066	0.074	0.079	0.081
T5 - Soda 300 ml	97.49	87.12	73.12	62.17	0.076	0.095	0.102	0.109
T6 - Soda 500 ml	99.35	89.04	74.21	68.91	0.070	0.083	0.097	0.099
T7 - Control (DW)	92.30	79.91	69.03	-	0.080	0.099	0.119	-
Mean	99.50	90.69	78.14		0.063	0.075	0.084	
S.E (m)±	0.19	0.44	0.35	-	0.001	0.003	0.001	-
CD at 5%	0.60	1.35	0.17		0.004	0.009	0.003	

Longevity of basal floret

Citric acid 200 ppm (T1) was most effective in prolonging the longevity (2.46 days) of basal floret of cut gladiolus this might be due to the reduction of microbial population in vase solution and enhanced water conductivity, these findings can be justified by reports of Van Doorn (1997) [14] and lowest longevity of basal floret (1.08 days) was recorded in T7 - Control.

Number of florets opened on spike when basal floret is fresh

Observations on the number of florets opened on spike when basal floret is fresh have differed significantly with different treatments. T1 - Citric acid 200 ppm recorded maximum number of florets opened when basal floret is fresh (2.50) followed by Ascorbic acid 200 ppm (2.16). These results are in accordance with reports of (Blecksma and Van Doorn, 2003) [1] disruption of water relations cause lack of flower opening. Citric acid - 200 ppm has led to continuity in water follow which might have helped in a greater number of florets opening when basal floret is fresh. Least number of florets opened was recorded in control (0.63).

Number of florets opened per spike at the end of the vase life: Maximum number of florets opened at the end of vase life (10.66) was recorded in citric acid – 200 ppm (T1) followed by T2 - Citric acid 300 ppm (9.73). Good water conductivity maintained by the Citric acid 200 ppm (T1) might have resulted in more number of floret opening. Similar results were noticed by Jowkar and Salehi (2003) in tuberose where citric acid has increased the number of opened florets. Lowest florets opened was observed in control (6.90).

Vase life: Vase life of gladiolus spikes varied from 6.21 days to 9.62 days. Placement of spikes of gladiolus in 200 ppm of citric acid markedly improved the vase life and recorded maximum number of days *i.e.*, 9.62 days when compared to control (6.21 days). Citric acid improves the water conductivity and reduces microbial occlusion in the vase solution, resulting in enhanced vase life of cut flowers. Similar findings were observed by Madhavi (2007) [7] where citric acid 200 ppm has recorded the highest vase life in gerbera and also by Mehdikhan *et al.* (2016) [9] in gerbera.

Table 4: Effect of commonly available acidifiers on flowering parameters during vase life period of gladiolus (*Gladiolus grandiflorus* L.) cv Swarnima.

Treatments (T)	Days to first floret opening (days)	Diameter of basal floret (cm)	Longevity of basal floret (days)	Number of florets opened on spike when basal floret is fresh	Number of florets opened per spike at the end of vase life	Vase life of the spike (days)	Floret opening percentage (%)
T1 - Citric acid 200 ppm	1.78	10.16	2.46	2.50	10.66	9.62	92.69
T2 - Citric acid 300 ppm	1.83	9.29	1.94	1.56	9.73	8.79	84.52
T3 - Ascorbic acid 200 ppm	1.82	9.66	2.11	2.16	9.72	9.05	84.60
T4 - Ascorbic acid 300 ppm	2.09	8.52	1.40	1.33	9.18	8.23	79.82
T5 - Soda 300 ml	2.29	7.99	1.26	1.06	7.86	7.79	68.34
T6 - Soda 500 ml	2.12	8.18	1.10	1.20	8.35	8.03	72.62
T7 - Control (DW)	2.78	7.23	1.08	0.63	6.90	6.21	60.00
Mean	2.10	8.71	1.62	1.49	8.91	8.24	77.51
S.E (m)±	0.02	0.08	0.05	0.15	0.08	0.08	0.03
CD at 5%	0.07	0.27	0.15	0.16	0.26	0.26	0.10

Floret opening percentage (%)

Significantly highest (92.69%) floret opening was recorded in T1 - Citric acid 200 ppm. Whereas significantly lowest floret opening percentage was recorded in T7 - Control (60%).the highest floret opening in citric acid 200 ppm might be due to high water uptake and low microbial growth.

Conclusion

It can be concluded from the present study that among all the locally available acidifiers studied, citric acid 200 ppm maintained good water conductivity and recorded highest vase life of 9.62 days with high water uptake (25.34, 16.97, 11.52 g), transpirational loss of water (23.24, 15.56, 11.22 g), water balance (7.10, 6.41, 5.23 g), Fresh weight change (104.09, 99.13, 88.17%), least optical density of vase solution (0.044, 0.049, 0.052 g), and least days to first floret opening (1.78 days), maximum diameter (10.16 cm) and longevity of basal floret (2.46 days), maximum number of florets opened on spike when basal floret is fresh (2.50) and number of florets opened per spike at the end of vase life (10.66), and floret opening percentage (92.69%) when compared to other treatments. Hence this treatment can be used as an acidifier in vase solution, alternative to chemical preservatives.

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