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STANDARDIZATION OF VASE CHEMICALS FOR LONGEVITY AND QUALITY OF MULTIPLE CUT FLOWERS

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ABSTRACT

The present investigation entitled “Standardization of vase chemicals for longevity and quality of multiple cut flowers” was conducted in Department of Postharvest Management, College of Horticulture, Mudigere, during 2024-2025. The study aimed to standardize the vase chemicals for increase the vase life of multiple cut flowers (Rose, Carnation, Gerbera and Chrysanthemum). The experiment was laid out in a completely randomized design (CRD) with 15 treatments, including commercial preservatives (Floralife Crystal Clear and Chrysal Clear Universal) and combinations of sucrose (1.5, 2.0 and 2.5 %), aluminium sulphate (100 and 150 ppm) and benzyl adenine (75 and 100 ppm) were replicated thrice. Among fifteen treatments tested, the maximum cumulative water uptake (305.05, 290.98 and 263.55 g), cumulative transpiration loss of water (325.43, 313.15 and 288.00 g), the superior fresh weight (139.59, 133.92 and 128.97 g) with the lowest pH (3.68, 3.94 and 3.99), bacterial count (10.12, 11.76 and 12.28 CFU × 10⁴ ml⁻¹) and physiological weight loss (20.26, 22.95 and 25.94 %) and the highest vase life (15.09, 14.65 and 13.75 days) was recorded in the treatments T₂ (Floralife crystal clear, 5ml/L), T₉ (Sucrose 2.0 % + Al₂(SO₄)₃ 150 ppm + BA 75 ppm) and T₁₄ (Sucrose 2.5 % + Al₂(SO₄)₃ 100 ppm + BA 100 ppm) respectively, during fifteen days vase period. It has been concluded that multiple cut flowers treated with T₂, T₉ and T₁₄ prolong the vase life compared to other treatments.

Key words : Multiple cut flowers, Floral preservatives, Vase life, Sucrose, Aluminium sulphate, Benzyl adenine

Introduction

Cut flowers are valuable horticultural produce and maintaining their quality by extending the vase life, is considered important and practical for having acceptable products for the markets especially for sensitive species. Nowadays, cut flowers occupy an important position in both local and foreign markets due to their significance as a source of national income. The Indian floriculture industry includes a wide range of cut flowers that are in high demand globally such as rose, carnation, chrysanthemum, gladiolus, anthurium, gerbera, orchid, tulip

and lilly. India's total export of floriculture products was ` 717.83 crores (USD 86.63 million) in 2023–24 and produced 0.958 million metric tonnes (mMT) of cut flowers (Anonymous, 2024).

One of the major challenges in floriculture remains the limitation in postharvest longevity of cut flowers. Under normal conditions, cut flowers last only a few days and improper postharvest handling can result in 20 to 30 per cent loss during marketing (Jadhav *et al.*, 2014). The two primary factors influencing postharvest life are carbohydrate supply and water balance. Adequate water

relations are crucial for maintaining the quality and longevity of cut flowers after harvest (Van Doorn, 1997). Carbohydrates support respiration, maintenance and osmoregulation, while water balance ensures continuous hydration and prevents the wilting (Reid and Jiang, 2012).

Keeping quality is an important parameter for evaluation of cut flower quality, for both domestic and international markets. Addition of chemical preservatives to the holding solution is recommended to prolong the vase life of cut flowers. All holding solutions must essentially contain two components *viz.*, sugar and germicides. The sugars provide a respiratory substrate, while the germicides control harmful bacteria and prevent plugging of the vascular tissues (Nair *et al.*, 2003). In general, the four basic components required for enhancing vase life are a food source, water, a pH regulator and a biocide (Chakraborty *et al.*, 2008).

To address these challenges, modern floral preservatives often include additional agents such as acidifiers to enhance water uptake and slow microbial growth, anti-ethylene compounds to delay senescence and growth regulators like benzyl adenine (BA), a synthetic cytokinin that inhibits ethylene production and delay's petal senescence, particularly in ethylene-sensitive species like carnations and chrysanthemums (Tehranifar *et al.*, 2013; Armitage and Laushman, 2003).

The house hold user decorates the vase by using multiple flowers instead of individual flowers. Several attempts have been made and developed to prolong the vase life of cut flowers by using commercial floral preservatives *viz.* Florissant, Chrysal, Bloomlife, Petallife, Roselife (Thwala *et al.*, 2013).

Hence, in the present study the emphasis was given to find out the economical and effective preservatives to facilitate easy usage for consumers and household user. Therefore, the efforts have been made to standardize different combination of chemical preservatives, growth regulator and mineral salts for extending the vase life of multiple flowers *viz.*, rose, carnation, gerbera and chrysanthemum. The outcome of the investigation will certainly help in maintaining the freshness of cut flowers benefiting both the floriculture industry and household users.

Materials and Methods

The present investigation was carried out at the Department of Postharvest Management, College of Horticulture, Mudigere, Chikkamagaluru (District), Karnataka. Experiment was conducted in the laboratory

Table 1 : Treatment details.

Treatments	
T ₁	Control (Distilled water)
T ₂	Floralife crystal clear (5ml/L)
T ₃	Chrysal clear universal (5ml/L)
T ₄	Sucrose (1.5%) + Aluminium sulphate (100 ppm) + Benzyl adenine (75 ppm)
T ₅	Sucrose (1.5%) + Aluminium sulphate (150 ppm) + Benzyl adenine (75 ppm)
T ₆	Sucrose (1.5%) + Aluminium sulphate (100 ppm) + Benzyl adenine (100 ppm)
T ₇	Sucrose (1.5%) + Aluminium sulphate (150 ppm) + Benzyl adenine (100 ppm)
T ₈	Sucrose (2.0%) + Aluminium sulphate (100 ppm) + Benzyl adenine (75 ppm)
T ₉	Sucrose (2.0%) + Aluminium sulphate (150 ppm) + Benzyl adenine (75 ppm)
T ₁₀	Sucrose (2.0%) + Aluminium sulphate (100 ppm) + Benzyl adenine (100 ppm)
T ₁₁	Sucrose (2.0%) + Aluminium sulphate (150 ppm) + Benzyl adenine (100 ppm)
T ₁₂	Sucrose (2.5%) + Aluminium sulphate (100 ppm) + Benzyl adenine (75 ppm)
T ₁₃	Sucrose (2.5%) + Aluminium sulphate (150 ppm) + Benzyl adenine (75 ppm)
T ₁₄	Sucrose (2.5%) + Aluminium sulphate (100 ppm) + Benzyl adenine (100 ppm)
T ₁₅	Sucrose (2.5%) + Aluminium sulphate (150 ppm) + Benzyl adenine (100 ppm)

with a relative humidity of 75 to 80 per cent and temperature of 24 to 28°C, with total eight flower per vase such as rose (Taj mahal and gold strike), carnation (Rosso Augustus and Soto), gerbera (Petali and Livia) and chrysanthemum (Lollipop purple and Champagne yellow) procured from farmer's field near Chikkamagalur. The rose flowers were harvested at tight bud stage, carnation flowers were harvested at paint brush stage, gerbera flowers when two outer rows of disc florets begin to open and chrysanthemum flowers when the blooms are one-third to one-half open. Immediately after harvesting, the flowers were pre-cooled by dipping the basal portions of the stalks in a bucket containing water and brought immediately to the laboratory for imposing the treatments. Uniform sized flower stems were trimmed to 30 cm to maintain uniform length within the replications. Flowers were placed in conical flasks containing 500 ml distilled water or vase solution.

Observations were recorded on Cumulative water uptake, Cumulative transpiration loss of water, Cumulative water balance, Fresh Weight, pH of vase solution, Bacterial count, Physiological loss in weight (PLW), Vase life in the experiment during fifteen days of vase period. The analysis of the data obtained in experiment was analyzed by completely randomized design with three replications.

Results and Discussion

Cumulative water uptake (CWU) (g)

The data on effect of different vase chemical concentrations on cumulative water uptake of multiple cut flowers during the vase period were presented in Fig. 1. The physiological process of water uptake continues throughout the vase period reflects the flower's ability to maintain freshness and turgidity, thereby enhancing its longevity. Different vase solutions had a significant effect on the cumulative water uptake (CWU) by multiple cut flowers. The maximum CWU was recorded in the cut flowers treated with T_2 (Floralife crystal clear, 5ml/L), resulting in a total uptake of 305.05 g. This was followed by T_9 (Sucrose 2.0% + $Al_2(SO_4)_3$ 150 ppm + BA 75 ppm), which recorded 290.98 g and

T_{14} (Sucrose 2.5 % + $Al_2(SO_4)_3$ 100 ppm + BA 100 ppm) with 263.55 g. The minimum cumulative water uptake of 121.66 g was observed in the control (T_1) (Distilled water) by the fifteen days vase period. This was might be due to the balanced formulation of commercial preservative floralife crystal clear contains sugars, acidifying agents and biocides that provide the nutrient availability to the flower. These findings were accordance with by Ranwala (2013) in rose, chrysanthemum, alstroemeria and aster. Similarly, the increased water uptake observed in treatments T_9 and T_{14} might be due to the fact that translocation and accumulation of sugar in the floral tissues, which raises the osmotic concentration and enhances the ability of flower to absorb water, similar findings were also recorded in gerbera by Prashanth and Chandrasekhar (2007). Aluminium sulphate acts as a germicide, preventing vascular blockage by inhibiting microbial growth and maintaining membrane integrity, thus allowing continuous water transport through the cut stems, as accordance with Jamil *et al.* (2016) in *Hippeastrum*. Additionally, benzyl adenine, a anti ethylene agent, induces the physiological changes that modify source-sink metabolism, promote nutrient mobilization, acidify the vase solution, suppress microbial growth and

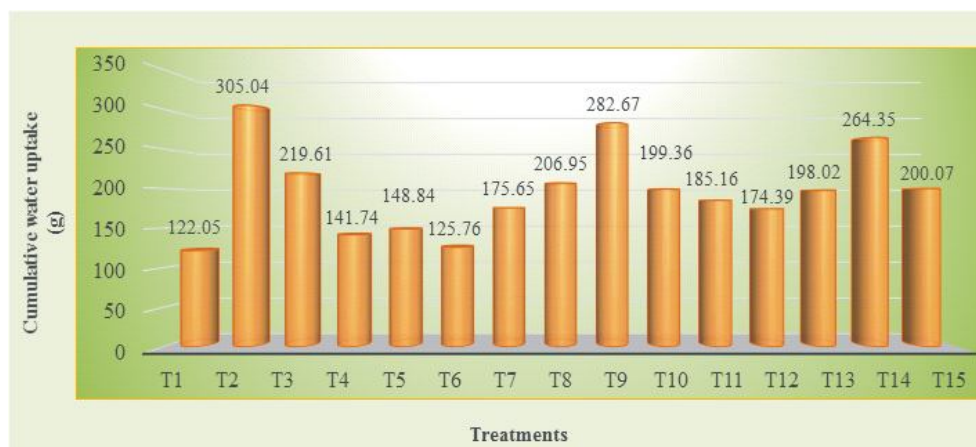


Fig. 1 : Effect of different vase chemical concentrations on cumulative water uptake (CWU) of multiple cut flowers during the vase period.

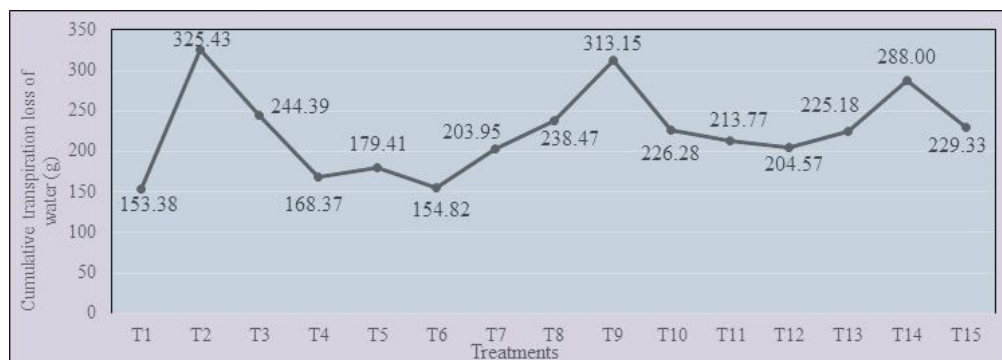


Fig. 2 : Effect of different vase chemical concentrations on cumulative transpiration loss of water (CTLW) of multiple cut flowers during the vase period.

Table 2 : Effect of different vase chemical concentrations on fresh weight of multiple cut flowers during the vase period.

Treatments	Fresh Weight (g / multiple cut flower)														
	1 st day	2 nd day	3 rd day	4 th day	5 th day	6 th day	7 th day	8 th day	9 th day	10 th day	11 th day	12 th day	13 th day	14 th day	15 th day
T ₁	167.27 ^{hi}	168.29 ^h	168.79 ^f	168.91 ^g	166.55 ^g	133.81 ⁱ	101.25 ^o	68.26 ^m	-	-	-	-	-	-	-
T ₂	175.28 ^a	177.12 ^a	178.23 ^a	178.42 ^a	177.64 ^a	177.78 ^a	176.94 ^a	175.47 ^a	171.19 ^a	169.41 ^a	162.36 ^a	151.82 ^a	148.53 ^a	146.47 ^a	139.59 ^a
T ₃	172.52 ^c	173.21 ^c	174.52 ^c	174.76 ^b	174.89 ^b	172.29 ^f	169.82 ^d	163.77 ^c	159.63 ^d	143.17 ^d	114.73 ^e	83.56 ^f	-	-	-
T ₄	168.94 ^{ig}	169.85 ^g	169.28 ^f	169.62 ^{ef}	165.97 ^g	154.42 ⁱ	129.83 ^k	104.28 ^k	70.82 ^m	-	-	-	-	-	-
T ₅	168.42 ^g	169.92 ^g	169.73 ^{ef}	169.76 ^{ef}	168.48 ^g	139.76 ⁱ	117.54 ⁱ	108.97 ⁱ	71.43 ⁱ	-	-	-	-	-	-
T ₆	166.72 ⁱ	167.24 ⁱ	167.16 ^g	166.23 ^g	166.78 ^g	135.15 ^k	108.42 ^m	71.56 ⁱ	-	-	-	-	-	-	-
T ₇	167.78 ^h	168.21 ^h	168.86 ^g	168.92 ^f	168.94 ^f	163.76 ⁱ	158.38 ^g	146.75 ^e	137.59 ^f	104.58 ⁱ	81.42 ⁱ	-	-	-	-
T ₈	169.36 ^f	170.87 ^{ef}	170.55 ^e	170.26 ^e	170.64 ^e	159.52 ^g	152.37 ^h	141.22 ^h	138.39 ^e	131.66 ^e	125.15 ^d	108.84 ^d	83.72 ^e	-	-
T ₉	173.82 ^b	175.23 ^b	175.61 ^b	175.75 ^b	175.86 ^b	175.94 ^b	172.53 ^b	171.62 ^b	169.13 ^b	164.46 ^b	157.16 ^b	149.32 ^b	138.13 ^b	135.47 ^b	133.92 ^b
T ₁₀	171.41 ^d	171.23 ^c	171.65 ^d	171.87 ^{cd}	170.99 ^{de}	169.62 ^d	150.44 ⁱ	143.39 ^g	136.43 ^g	129.77 ^f	103.25 ^g	83.45 ^f	-	-	-
T ₁₁	170.12 ^e	170.37 ^{fg}	170.52 ^e	170.72 ^{de}	170.83 ^{de}	165.72 ^e	153.25 ^h	145.47 ⁱ	122.37 ⁱ	108.72 ^h	83.73 ^h	-	-	-	-
T ₁₂	170.16 ^e	170.25 ^{fg}	170.31 ^e	170.32 ^e	170.93 ^{de}	156.17 ^h	148.64 ⁱ	135.93 ⁱ	109.43 ^o	79.38 ⁱ	-	-	-	-	-
T ₁₃	170.55 ^e	171.34 ^e	171.59 ^d	171.72 ^{cd}	171.82 ^d	169.47 ^d	159.67 ⁱ	145.39 ⁱ	132.61 ⁱ	109.85 ^g	81.97 ⁱ	-	-	-	-
T ₁₄	174.16 ^b	175.14 ^b	175.23 ^{bc}	175.59 ^b	175.71 ^b	175.83 ^b	171.28 ^c	170.93 ^b	166.82 ^c	159.96 ^c	144.21 ^c	142.76 ^c	132.47 ^c	128.97 ^c	-
T ₁₅	171.71 ^d	172.13 ^d	172.37 ^d	172.46 ^c	172.96 ^c	168.84 ^d	168.73 ^c	159.66 ^d	135.71 ^h	129.48 ^f	122.58 ^e	106.26 ^e	87.17 ^d	-	-
S. Emt	0.22	0.22	0.32	0.38	0.36	0.33	0.37	0.28	0.21	0.32	0.24	0.27	0.47	0.40	0.12
CD @ 1%	0.66	0.66	1.12	1.14	1.08	0.99	1.11	0.84	0.63	0.96	0.72	0.81	1.41	1.20	0.36

improve water absorption, findings supported by Elham *et al.* (2013).

Cumulative transpiration loss of water (CTLW) (g)

Data regarding effect of different vase chemical concentrations on transpiration loss of water of multiple cut flowers during the vase period were enumerated in Fig. 2. The physiological process of water loss through transpiration is balanced by water uptake, enabling the flower to maintain cellular turgidity and overall water balance thereby enhance the vase life. Transpirational loss of water showed an increasing trend during the study period following a steady decline in the trend in all the treatments. Cumulative transpiration loss of water (CTLW) was significantly influenced by the different vase chemical treatments. T₂ (Floralife crystal clear, 5ml/L) showed the highest CTLW of 325.43 g, whereas T₉ (Sucrose 2.0% + Al₂(SO₄)₃ 150 ppm + BA 75 ppm) recorded 313.15 g and followed T₁₄ (Sucrose 2.5% + Al₂(SO₄)₃ 100 ppm + BA 100 ppm) (288.06 g). The control (T₁) (Distilled water) had the lowest CTLW of 153.38 g by fifteen days vase period. The elevated water loss in T₂ may be associated with the formulation of the commercial preservative, which likely promotes greater water uptake and greater loss, these were accordance with Ranwala., 2013. In the sucrose-containing treatments (T₉ and T₁₄), sugar may have helped to reduce the moisture stress by regulating stomatal opening, which limited the excessive water loss through transpiration, accordance with Halevy *et al.* (1974) in cut flowers and Gowda, 1986 in china aster. The presence of aluminium sulphate in the vase solution may have also has influenced the transpiration and maintenance of tissue water content by accumulating in the tissues, findings were similar to Shobha and Gowda (1994) in calendula flowers. Additionally, benzyl adenine decreases the stomatal opening thereby reduced the transpiration loss and promoting water retention in floral tissues, which contributes to higher fresh weight, Bhattacharjee, 1998 observed similar results in roses and button flower. Together, these chemicals-maintained water balance, minimized moisture stress and support for prolonged vase life.

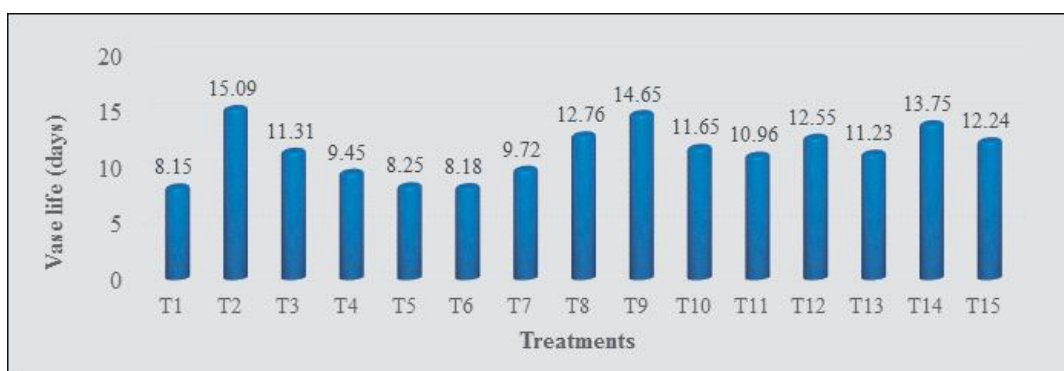


Fig. 3 : Effect of different vase chemical concentrations on vase life (days) of multiple cut flowers during the vase period.

Fresh weight (g)

The influence of various vase chemical concentrations on the fresh weight of multiple cut flowers during the vase period were represented in Table 2. Among the treatments, T₂ (Floralife crystal clear, 5ml/L) and T₉ (Sucrose 2.0% + Al₂(SO₄)₃ 150 ppm + BA 75 ppm) maintained the maximum fresh weight upto fifteenth day of period of values 139.59 g per day and 133.92 g per day per flower followed by T₁₄ (Sucrose 2.5% + Al₂(SO₄)₃ 100 ppm + BA 100 ppm) which maintained the fresh weight of 128.97 g per day by fourteenth day of vase period, while in the control (T₁, Distilled water) it declined sharply to 68.26 g per day by the 8th day of the vase period. According to Floralife (2013), the solution floralife clear crystal hydrates and nourishes the flowers by promoting increased water uptake, blooming and enhancing the vibrancy of their colours. Fresh weight is maintained when solution uptake balances for transpiration loss, which in turn supports the longer vase life. In T₉ and T₁₄ maintenance of increased fresh weight of cut flowers might be due to the presence of sucrose in vase solution, which acted as a respiratory substance in flowers and ultimately avoids the consumption of internal carbohydrates, similar findings reported by Harish (2012) in anthurium and aluminium sulphate in the vase solution has been observed to decrease the aperture size of stomata which resulted a decrease in the transpiration loss of water thereby retention of more water in the floral tissue, thus contributing an increased fresh weight. Similar findings were also reported by Atiqullah and Gopinath (2012) in goldenrod and Madhavi, 2007 in gerbera flower. The positive effect of kinetin increases when combined with sucrose that enhances the flowers sink strength, improving its ability to utilize the nutrients and water effectively, was accordance with observations made by Jain *et al.* (2009) in chrysanthemum.

pH of the solution

The data presented in Table 3 elucidated the effect

of various vase chemical concentrations on the pH dynamics of multiple cut flowers during the vase period. The final pH values of the vase solutions varied significantly, ranging from 3.68 to 7.49 in treatments, the minimum pH of 3.68 was recorded in T₂ (Floralife crystal clear, 5ml/L), whereas the treatment T₉ (Sucrose 2.0% + Al₂(SO₄)₃ 150 ppm + BA 75 ppm) (3.94) was on par with T₁₄ (Sucrose 2.5 % + Al₂(SO₄)₃ 100 ppm + BA 100 ppm) (3.99). In contrast, the control treatment, T₁ (Distilled water), exhibited the maximum pH of 7.49. The effectiveness of Floralife Crystal Clear may be due to its ability to lower the pH of the vase solution, creating a slightly acidic environment that enhances water uptake by preventing microbial growth and reducing vascular blockage. Similar effects have been reported by Ranwala (2013) in rose, chrysanthemum, alstroemeria, and aster. Additionally, the antimicrobial action of aluminium sulphate acidifies the solution, keeps it microorganism-free, and promotes better flower bud opening, maintaining freshness, as observed by Singh *et al.* (2001).

Bacterial count (CFU × 10⁴ ml⁻¹)

The data pertaining to various vase chemical concentrations on the bacterial count (CFU × 10⁴ / ml) of multiple cut flowers during the vase period were analysed in Table 3. Lower bacterial count in the vase solution helps maintain stem conductivity, ensuring better water absorption and sustained freshness of cut flowers. The lowest bacterial count of 10.12 × 10⁴ CFU ml⁻¹ was recorded in the T₂ (Floralife crystal clear, 5ml/L) by followed T₉ (Sucrose 2.0 % + Al₂(SO₄)₃ 150 ppm + BA 75 ppm) (11.76 × 10⁴), which is on par with T₁₄ (Sucrose 2.5 % + Al₂(SO₄)₃ 100 ppm + BA 100 ppm) which had the bacterial counts of 12.28 × 10⁴ CFU ml⁻¹, respectively during vase period. The addition of aluminium sulphate decreased the bacterial population in cut flowers, since aluminium sulphate acidifies vase solutions, thus reduces the bacterial growth and improves water uptake, this was accordance with Schanbl (1976) in roses and carnation.



Plate 1 : Effect of different vase chemical concentrations on fifteenth day vase period of multiple cut flowers.

Treatment details:

- T₁: Control (Distilled water)
 T₂: Floralife Crystal Clear (5ml/L)
 T₃: Chrysal clear universal (5ml/L)
 T₄: Sucrose (1.5%) + Al₂(SO₄)₃ (100 ppm) + BA (75 ppm)
 T₅: Sucrose (1.5%) + Al₂(SO₄)₃ (150 ppm) + BA (75 ppm)
 T₆: Sucrose (1.5%) + Al₂(SO₄)₃ (100 ppm) + BA (100 ppm)
 T₇: Sucrose (1.5%) + Al₂(SO₄)₃ (150 ppm) + BA (100 ppm)
 T₈: Sucrose (2.0%) + Al₂(SO₄)₃ (100 ppm) + BA (75 ppm)
 T₉: Sucrose (2.0%) + Al₂(SO₄)₃ (150 ppm) + BA (75 ppm)
 T₁₀: Sucrose (2.0%) + Al₂(SO₄)₃ (100 ppm) + BA (100 ppm)
 T₁₁: Sucrose (2.0%) + Al₂(SO₄)₃ (150 ppm) + BA (100 ppm)
 T₁₂: Sucrose (2.5%) + Al₂(SO₄)₃ (100 ppm) + BA (75 ppm)
 T₁₃: Sucrose (2.5%) + Al₂(SO₄)₃ (150 ppm) + BA (75 ppm)
 T₁₄: Sucrose (2.5%) + Al₂(SO₄)₃ (100 ppm) + BA (100 ppm)
 T₁₅: Sucrose (2.5%) + Al₂(SO₄)₃ (150 ppm) + BA (100 ppm)

Table 3 : Effect of different vase chemical concentrations on pH, bacterial count (CFU × 10⁴ ml⁻¹) and physiological loss in weight (PLW %) of multiple cut flowers during the vase period.

Treatments	pH of the solution	Bacterial count (CFU × 10 ⁴ ml ⁻¹)	PLW (%)
T ₁ : Control (Distilled water)	7.49 ^a	45.54 ^a	59.19 ^a
T ₂ : Floralife crystal clear (5ml/L)	3.68 ⁱ	10.12 ⁿ	20.36 ^o
T ₃ : Chrysal clear universal (5ml/L)	4.36 ^g	23.12 ^h	50.41 ^k
T ₄ : Sucrose (1.5 %) + Al ₂ (SO ₄) ₃ (100 ppm) + BA (75 ppm)	5.62 ^b	43.65 ^b	58.08 ^b
T ₅ : Sucrose (1.5 %) + Al ₂ (SO ₄) ₃ (150 ppm) + BA (75 ppm)	5.43 ^{bc}	39.76 ^d	57.59 ^c
T ₆ : Sucrose (1.5 %) + Al ₂ (SO ₄) ₃ (100 ppm) + BA (100 ppm)	5.15 ^{de}	40.97 ^c	57.08 ^d
T ₇ : Sucrose (1.5 %) + Al ₂ (SO ₄) ₃ (150 ppm) + BA (100 ppm)	5.24 ^{cd}	29.28 ^f	51.47 ^g
T ₈ : Sucrose (2.0 %) + Al ₂ (SO ₄) ₃ (100 ppm) + BA (75 ppm)	4.93 ^{ef}	21.16 ^j	50.63 ^j
T ₉ : Sucrose (2.0 %) + Al ₂ (SO ₄) ₃ (150 ppm) + BA (75 ppm)	3.94 ^h	11.76 ^m	22.95 ⁿ
T ₁₀ : Sucrose (2.0 %) + Al ₂ (SO ₄) ₃ (100 ppm) + BA (100 ppm)	5.03 ^{de}	24.78 ^g	51.32 ^h
T ₁₁ : Sucrose (2.0 %) + Al ₂ (SO ₄) ₃ (150 ppm) + BA (100 ppm)	4.99 ^{de}	31.62 ^e	50.78 ⁱ
T ₁₂ : Sucrose (2.5 %) + Al ₂ (SO ₄) ₃ (100 ppm) + BA (75 ppm)	4.97 ^e	24.75 ^g	53.35 ^e
T ₁₃ : Sucrose (2.5 %) + Al ₂ (SO ₄) ₃ (150 ppm) + BA (75 ppm)	5.09 ^{de}	20.45 ^k	51.94 ^f
T ₁₄ : Sucrose (2.5 %) + Al ₂ (SO ₄) ₃ (100 ppm) + BA (100 ppm)	3.99 ^h	12.28 ^l	25.94 ^m
T ₁₅ : Sucrose (2.5 %) + Al ₂ (SO ₄) ₃ (150 ppm) + BA (100 ppm)	4.72 ^f	22.47 ⁱ	49.23 ^l
S. Em±	0.08	0.12	0.04
CD @ 1%	0.24	0.36	0.12

Means in the column followed by same letters are not statistically significant as Duncan multiple range test at P = 0.01%.

Aluminium sulphate acted as a potent antimicrobial agent by suppressing the growth of microorganisms, thereby preventing blockage of the xylem vessels. In contrast, the highest bacterial count of 45.54 × 10⁴ CFU mL⁻¹ was recorded with samples obtained from the treatment control

(T₁) this is due to without preservatives the bacteria multiply rapidly in the water, leading to clogging in the stem vessels, which restricts the water uptake and accelerates wilting.

Physiological loss in weight (PLW) (%)

The cut flowers held in treatments T₂ (Floralife crystal clear, 5ml/L) and T₉ (Sucrose 2.0% + Al₂(SO₄)₃ 150 ppm + BA 75 ppm) showed the lowest physiological weight loss of 20.36 and 22.95 per cent, respectively, followed by T₁₄ (Sucrose 2.5 % + Al₂(SO₄)₃ 100 ppm + BA 100 ppm) (25.94 %) and in contrast the highest physiological weight loss was recorded in T₁ (Distilled water) (59.19%). Floralife crystal clear is a commercial nutrient solution designed to maintain optimal nutrition, stem flow and flower hydration (Floralife, 2010). In T₉ and T₁₄, due to increased water uptake and cumulative water uptake with reduced microbial load in the pulsing solution and presence of sucrose provides an energy source, aluminium sulphate acts as an antibacterial agent reducing microbial blockage in xylem vessels and benzyl adenine (BA) acts as anti-ethylene agent thus improving water retention and vase life, Rakesh *et al.* (2004) reported similar findings in carnation flowers.

Vase life (days)

Good water uptake, low transpiration loss and optimal water balance results in increased vase life of cut flowers (Halevy and Mayak, 1981) in roses. Vase life termination for many cut flowers is characterized by wilting similar findings was observed by Budiarto *et al.* (2022) in chrysanthemum. Most of the treatments maintained the vase life of flower up to eight days, possibly due to higher microbial population and toxic effect of chemical concentration. However, the best water retention values and flower freshness were observed in the treatments T₂ (Floralife crystal clear, 5ml/L), T₉ (Sucrose 2.0% + Al₂(SO₄)₃ 150 ppm + BA 75 ppm) and T₁₄ (Sucrose 2.5% + Al₂(SO₄)₃ 100 ppm + BA 100 ppm), which recorded the vase lives of 15.09 days, 14.65 days and 13.75 days, respectively and minimum was recorded in control (T₁) of 8.15 days. This extended vase life might be due combined effect of vase chemicals that contributed to continuous water uptake, reduced transpiration loss and maintained freshness over a longer duration, acidic pH along with lower bacterial counts with minimum physiological loss of weight per cent. Similar observations were reported by Singh *et al.* (2001) in cut flowers, who found that aluminium sulphate enhanced vase life, mainly due to its bactericidal properties. These findings were also in agreement with the earlier work of Gowda (1986) in china aster.

Conclusion

Among different concentration of vase solution studied for vase life parameters like cumulative water uptake, cumulative transpiration loss, cumulative water

balance, fresh weight, pH, bacterial count and physiological loss of weight. The treatments Floralife crystal clear, 5ml/L, Sucrose 2.0 per cent + Al₂(SO₄)₃ 150 ppm + BA 75 ppm and Sucrose 2.5 per cent + Al₂(SO₄)₃ 100 ppm + BA 100 ppm found to be effective and economical vase chemicals for extending the life of multiple cut flowers. Hence, this standardized chemical facilitates easy usage for floriculture industry and household users for extending the longevity and quality of multiple cut flowers.

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