



Effect of Sucrose, Salicylic Acid (SA), Sulfosalicylic Acid (SSA), Silver Nano and Ajwain E.O on Vase Life of Single Tuberose (*Polianthes tuberosa* L.)

Kumari Anjali ^{a++}, Sunil Kumar ^{a#*},
Devendra Kumar ^{b#}, Niranjana Singh ^{c#} and Hitesh Kumar ^{d#}

^a Department of Floriculture & Landscaping, College of Horticulture & Forestry, ANDUA&T, Kumarganj, Ayodhya (U.P.), India.

^b Department of Silviculture & Agroforestry, College of Horticulture & Forestry, ANDUA&T, Kumarganj, Ayodhya (U.P.), India.

^c Department of Fruit Science, College of Horticulture & Forestry, ANDUA&T, Kumarganj, Ayodhya (U.P.), India.

^d Department of Post Harvest Management, College of Horticulture & Forestry, ANDUA&T, Kumarganj, Ayodhya (U.P.), India.

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tuberose is a highly valued flower known for its vibrant colors, elegance, and captivating fragrance. It is prominent in floral arrangements, both as a cut flower and in the perfume industry. Despite its visual appeal, tuberose flowers have a relatively short shelf life. To address this, researchers have

⁺⁺ M.sc Student;

[#] Assistant Professor;

^{*}Corresponding author: Email: sunilfls13@gmail.com;

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explored various chemical treatments to enhance the longevity and quality of cut tuberose. An experiment was conducted at the Department of Floriculture and Landscaping, College of Horticulture & Forestry, Kumarganj, Ayodhya, during the 2023-24 period. The study, which followed a completely randomized design with sixteen treatments and three replications, aimed to determine the effects of different chemical solutions on the vase life of tuberose (*Polianthes tuberosa* L.). The results demonstrated significant differences among the treatments in various parameters, including changes in fresh weight, percentage change in spike length, longevity of the five basal florets (in days), vase solution uptake (in ml), vase life (in days), time taken for the first five florets to open, individual floret longevity, period of prime beauty, time taken for full spike opening, time for the first floret to fade, and time for the entire spike to fade. Among the treatments, the solution containing salicylic acid and sucrose proved to be the most effective in extending vase life. The combination of 2.5% sucrose, 50 ppm salicylic acid, and 150 ppm silver nanoparticles (T₁₂) achieved the highest longevity for the five basal florets, lasting 4.75 days. Additionally, the treatment with 2.5% sucrose and 150 ppm silver nanoparticles (T₈) resulted in 100% of florets opening. The longest vase life of 9.83 days was observed with the combination of 2.5% sucrose, 50 ppm salicylic acid, and 150 ppm silver nanoparticles (T₁₂). This study underscores the effectiveness of specific chemical treatments in significantly improving the vase life and overall quality of cut tuberose flowers.

Keywords: Cut flowers; nano particles; sucrose; salicylic acid; sulfosalicylic acid; vase life.

1. INTRODUCTION

Tuberose (*Polianthes tuberosa* L.), known by various names across India, is a highly valued ornamental bulbous plant famed for its long flower spikes, high cut flower yield, and enchanting fragrance. Originally native to Mexico, tuberose thrives in tropical and subtropical climates, particularly in regions like West Bengal, Karnataka, Tamil Nadu, and Maharashtra. The plant's visual appeal and significant role in the perfume industry make it a popular choice for cultivation. Various types of tuberose, including single, double, and semi-double forms, contribute to its versatility.

However, the production of ethylene can cause tuberose flowers to wilt more quickly, burn the florets, and bend the tips of their spikes, all of which reduce the flowers' vase life (Pérez-Arias et al., 2019). The terminal spike of tuberose flowers releases a unique fragrance (Jadhav et al., 2020). Flower longevity is significantly impacted by postharvest conditions. The postharvest quality and vase life of cut flowers are significantly influenced by variables like temperature, relative humidity, light, air velocity, and ethylene concentration. Water quality, microbial growth in preservative solutions, and holding solution composition are additional variables (Halevy and Mayak, 1981). Various chemical treatments, such as those containing calcium and silver, have been used to extend the vase life of cut flowers like roses (Capdeville et

al., 2003), gerberas (Geshnizjany et al., 2014), and tuberose (Bahrehmand et al., 2014). Silver nitrate and 8-HQC (8-hydroxyquinoline citrate) are effective antibacterial agents used in sucrose solutions to improve cut flower longevity (Nair et al., 2003; Meman and Dabhi, 2006). Ketsa et al. (1995) found that AgNO₃ was more effective than silver thiosulfate (STS) in controlling microbial growth and enhancing the vase life of Dendrobium 'Pompadour' flowers.

Environmental and safety concerns regarding chemical use have driven research towards alternative substances. Essential oils (EOs) have emerged as promising antimicrobial agents. Studies show that EOs like carvacrol and thymol significantly extend vase life by inhibiting microbial growth and preventing bacterial blockage (Solgi et al., 2009). Reactive oxygen species (ROS) are also known to impact petal senescence, with antioxidants like 5-sulfosalicylic acid (5-SSA) proving beneficial in reducing ROS effects and extending vase life (Zoua et al., 2014; Ezhilmathi et al., 2007).

To improve the quality and durability of tuberose cut flowers, research has looked into a number of non-toxic materials, such as sucrose, salicylic acid, and nanoparticles. For instance, Mohibe et al. (2020) showed that 5% sucrose and 150 ppm salicylic acid enhanced gladiolus flower characteristics and vase life. Bahrehmand et al. (2014) discovered that the optimal combination for flower quality and longevity was 45 mg L⁻¹ nano-silver (NS) and 4% sucrose. According to

Naing et al. (2020), nanosilver helps cut flower vase life by preventing ethylene production and bacterial growth. The purpose of this research is to assess different chemical treatments in order to determine the best ways to extend the postharvest life of tuberose cut spikes. With the increasing demand for tuberoses and the need for eco-friendly preservation methods, identifying optimal treatments is crucial for enhancing flower quality and longevity.

2. MATERIALS AND METHODS

The present investigation was conducted in the Laboratory of the Department of Floriculture and Landscaping at the College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, U.P., during the 2023-2024 period. The study aimed to evaluate the effects of various preservative solutions on the postharvest life of tuberose cut spikes and to identify the most effective preservative solution for extending the vase life of tuberose cultivars, specifically the Prajwal (single) variety.

Harvesting of the tuberose spikes occurred early in the morning, with 1-2 basal florets just beginning to show color. The spikes were pre-cooled for one hour, recut underwater, adjusted to uniform length and shape, and selected to ensure they were injury-free. The experiment was designed using a Completely Randomized Design (CRD) with three replications, each containing 16 treatments, with two spikes per replication. The control treatment utilized only distilled water.

The spikes were placed in 750 ml conical flasks containing 600 ml of various holding solutions at different chemical concentrations. The flasks were covered with muslin cloths to prevent evaporation and microbial growth. Tap water was used for preparing the holding solutions, and this solution was not changed throughout the experiment. The spikes were harvested at the colored stage of the 1-2 basal florets and transported promptly to the laboratory in March 2024. All spike stems were trimmed to ensure an average spike length and 1-2 colored florets. The experiment was conducted at room temperature.

For the experiment, distilled water served as the control, while the holding solutions were consistently prepared with tap water and were not altered throughout the study. The treatments

applied were as follows: T₀ (control), T₁: Sucrose 2.5%, T₂: Sucrose 2.5% with Salicylic acid 50 ppm, T₃: Sucrose 2.5% with Salicylic acid 100 ppm, T₄: Sucrose 2.5% with Sulfosalicylic acid 100 ppm, T₅: Sucrose 2.5% with Sulfosalicylic acid 200 ppm, T₆: Sucrose 2.5% with Ajowan Essential Oil (E.O) 250 ppm, T₇: Sucrose 2.5% with Ajowan E.O 500 ppm, T₈: Sucrose 2.5% with Silver nanoparticles (nano) 150 ppm, T₉: Sucrose 2.5% with Silver nano 300 ppm, T₁₀: Sucrose 2.5% with Salicylic acid 50 ppm and Sulfosalicylic acid 100 ppm, T₁₁: Sucrose 2.5% with Salicylic acid 50 ppm and Ajowan E.O 250 ppm, T₁₂: Sucrose 2.5% with Salicylic acid 50 ppm and Silver nano 150 ppm, T₁₃: Sucrose 2.5% with Salicylic acid 100 ppm and Sulfosalicylic acid 200 ppm, T₁₄: Sucrose 2.5% with Salicylic acid 100 ppm and Ajowan E.O 500 ppm, and T₁₅: Sucrose 2.5% with Salicylic acid 100 ppm and Silver nano 300 ppm.

The observations were fresh weight change of spike (g), length of spike change (%), vase solution uptake (ml), longevity of five basal florets/ spike, percent of opened florets/spike, vase life (days), days taken to open first five florets, longevity of individual florets, period of prime beauty, days taken to full spike opening, days taken to first floret fading and days taken to full spike fading at end of experiment using following given methods:

Fresh Weight Change of Spike (g): The change in fresh weight of the spikes was measured and recorded in grams on the 2nd and 10th days after placing them in the various holding solutions.

Length of spike change (%): The spike length was measured from the basal cut to the tip of the spike in centimeters. Measurements were taken on the first day and at the senescence stage. The percentage change in length was calculated relative to the initial length and at the senescence stage using the formula:

$$\text{Change in length (\%)} = \frac{\text{Final Spike length} - \text{Initial spike length}}{\text{Initial spike length}} \times 100$$

Vase solution uptake (ml): The uptake of vase solution was measured by subtracting the average volume of water evaporation from empty bottles from the volume reduction in bottles containing flowers, expressed as mL per gram of fresh weight. Total vase solution uptake was recorded throughout the vase life of the spikes.

Longevity of five basal florets/spike: The time from opening to fading of the five basal florets was recorded in days, and the average was calculated.

Percentage of opened florets/spike: The total number of florets on each spike at harvest was counted, along with the number of florets that opened during the vase life.

Vase life (days): The vase life was recorded by counting the number of days until 50% of the flowers on the spike had withered, as suggested by Padaganur et al. (2005).

Days taken to open first five florets: The number of days for the first five florets to open was recorded, starting from when the spikes were placed in the vase solutions until all five basal florets had opened.

Longevity of individual florets: The longevity of each individual floret was calculated as the number of days from harvest (day 0) until the florets showed signs of fading and bent neck.

Period of prime beauty: The period of prime beauty was recorded as the duration during which the flowers maintained their optimal appearance after being placed in the vase solution. A longer vase life indicated a longer period of prime beauty.

Days taken to full spike opening: The number of days from the opening of the first floret to the complete opening of the spike was recorded for each treatment.

Days taken to first floret fading: The number of days from the opening of the first floret to its fading was recorded for each treatment.

Days taken to full spike fading: The days until the entire spike faded were recorded, with the fading percentage calculated against the total number of florets on the spike.

Statistical analysis: The experiment was conducted using a Completely Randomized Design (CRD) with three replications. Data analysis was performed using OPSTAT software, and results were evaluated using the Least Significant Difference (LSD) test at 5% and 1% probability levels to compare treatment means.

3. RESULTS AND DISCUSSION

The study aimed to evaluate the effect of different chemical preservatives on the vase life of tuberose (*Polianthes tuberosa* L.) using various treatments. cut spikes are physiologically active enough to grow even harvested from the plants. In the stage of growing flower development, flower senescence is in progress resulting in dehydration of mature tissue leading to the change in the fresh weight.

3.1 Change in Fresh Weight and Length of Spike

The data on the change in fresh weight of tuberose spikes, as detailed in Table 1, indicate that the vase solution containing Sucrose (2.5%) + Salicylic acid @ 100 ppm (T₃) resulted in the highest fresh weight change at 10 days, with an increase to 91.67 grams for single tuberose spikes compared to 43.67 grams in the control treatment. Significant variations in fresh weight were observed across different treatments. For the single cultivar, the maximum fresh weight change on the 2nd day was seen in T₃ (Sucrose (2.5%) + Salicylic acid @ 50 ppm) with approximately 109.67 grams, followed by T₄ (Sucrose (2.5%) + Sulfosalicylic acid @ 100 ppm) with about 108.33 grams. These results align with Tuna et al. (2007), who reported that improved water status in spikes helps retain fresh weight. Initially, there was a significant increase in fresh weight until the flowers fully opened, after which a notable reduction in fresh weight was observed in both single and double varieties of tuberose. Lu et al. (2010a) found that nano-silver application enhanced the fresh weight of cut roses (cv. 'Movie'), likely due to the increased energy supply from sucrose and water regulation by nano-silver (Lu et al., 2010b). The combination of sucrose 2.5% and Salicylic acid @ 100 ppm notably increased the fresh weight of cut tuberose flowers. The reduction in fresh weight could be attributed to decreased vase solution uptake and elevated respiration rates (Singh and Jagedheesen, 2003).

Significant differences were observed in the change in spike length across various treatments. The maximum percentage change in spike length for the single cultivar was 18.33% in T₈ (Sucrose (2.5%) + Silver nano @ 150 ppm), followed by 17.67% in T₃ (Sucrose (2.5%) + Salicylic acid @ 100 ppm). No change in spike length was observed in T₁₄ (Sucrose (2.5%) + Salicylic acid @ 100 ppm + Ajowan E.O @ 500

ppm). These results may be attributed to the effective role of salicylic acid and silver-nano at optimal concentrations. Salicylic acid's exogenous application may enhance the effects of naturally occurring hormones, thus promoting plant growth and increasing spike length (Pawar et al., 2018). The improvement in spike length could also be due to nitrogen's role in increasing the assimilates necessary for better spike quality, consistent with findings by Battacharjee et al. (1994) and Koley and Pal (2011).

The highest longevity of the five basal florets for the single cultivar was 4.75 days in T₁₂ (Sucrose (2.5%) + Salicylic acid @ 50 ppm + Silver nano @ 150 ppm), whereas the control had a minimum longevity of 2 days. Sucrose serves as both an energy source and osmotic regulator for cut flowers. Since cut flowers often experience a rapid decline in sugar levels, this may reduce their longevity. Thus, adding a supplemental sugar dose can extend their post-harvest life. Both sucrose and nano-silver applications increased the longevity of cut tuberose flowers, with the highest longevity recorded in treatments with 4% sucrose and 45 mg L⁻¹ nano-silver, as reported by Doi and Reid (1995) for the hybrid Limonium.

3.2 Vase Solution Uptake and Percent of Opened Florets/Spike

Analysis of the vase-hold data revealed significant differences among the treatments (Table 1). The highest vase solution absorption was observed in T₂ (Sucrose (2.5%) + Salicylic acid @ 50 ppm) with 600 ml, which was statistically comparable to T₁₂ (Sucrose (2.5%) + Salicylic acid @ 50 ppm + Silver nano @ 150 ppm) at approximately 550 ml, and T₁₄ (Sucrose (2.5%) + Salicylic acid @ 100 ppm + Ajowan E.O @ 500 ppm) with about 470 ml. In contrast, the lowest vase solution uptake was recorded in T₁ (Sucrose 2.5%) at 200 ml. The interaction effects were significant, with maximum water uptake observed in these combinations. Increased water uptake could be attributed to a larger xylem area and higher carbohydrate levels, which facilitate greater water absorption and retention in longer stems. Bhasker and Rao (1998) reported a gradual decrease in water uptake across all treatments until day 5, followed by fluctuations on the 6th and 7th days. Silver nitrate (AgNO₃) combined with citric acid has been noted for its effectiveness in improving water uptake by inhibiting microbial growth and enhancing water absorption.

The highest percentage of opened florets per spike was found in T₈ (Sucrose (2.5%) + Silver nano @ 150 ppm), reaching 100%, while the lowest percentage was seen in the control at 70%. These differences are likely due to the effects of adding sulfosalicylic acid at appropriate concentrations, which can enhance photosynthesis rates, increase photosynthetic pigments, and modify the activity of key enzymes (Yusuf et al., 2013). Additionally, spikes treated with silver nitrate showed the highest percentage of opened flowers (Allah Baksh et al., 1999).

3.3 Vase Life and Longevity of Individual Florets

In the current study, the treatment T₁₂ (Sucrose 2.5% + Salicylic acid @ 50 ppm + Silver nano @ 150 ppm) resulted in the longest vase life for single tuberose flowers, lasting 9.83 days (Table 1). Conversely, the shortest vase life of 5.17 days was observed in T₇ (Sucrose 2.5% + Ajowan E.O @ 500 ppm). This finding aligns with Jokar et al. (2006), who reported that silver thiosulfate and silver nitrate led to severe burning and wilting of florets early in the experiment. The combination of nano-silver with sucrose improved flower vase life compared to the control. Nano-silver enhances flower resistance to microbial contamination, likely due to its interaction with sucrose, which contributes to improved vase life. Additionally, nano-silver's effects on flower longevity may stem from its ability to inhibit ethylene production (Ried et al., 1989). As flowers are detached from the plant, they continue to lose water through transpiration, making an ideal preservative one that supports water absorption in the flower tissues.

The study also found that using chemical treatments at various concentrations significantly increased the percentage of fully opened florets per spike compared to the control. Specifically, T₁₂ (Sucrose 2.5% + Salicylic acid @ 50 ppm + Silver nano @ 150 ppm) achieved the highest percentage of fully opened florets in single tuberose flowers. This improvement may be attributed to the combined effects of salicylic acid and nano-silver, which enhance photosynthetic pigment levels, photosynthesis rates, and the activity of key enzymes. This leads to increased production and accumulation of biosynthetic materials, resulting in more florets developing and opening. Similar results were observed by Ezilmathi et al. (2007) for Gladiolus, Rasul et al. (2011) for Gladiolus, and Nasibi et al. (2014) for tuberose.

Table 1. Effect of different chemicals treatment on fresh weight change of spike (g) change in length of spike (%) longevity of five basal florets (days) vase solution uptake (ml) percent of the opened florets/spike and vase life (days)

Treatment notation	Fresh weight change of spike (g)		Change in length of spike (%)	Longevity of five basal florets (days)	Vase solution uptake (ml)	Per cent of the opened florets /spike	Vase life(days)
	2 nd day	10 th day					
T ₀	65.33	43.67	13.00	2.00	250.00	70.00	5.50
T ₁	72.67	52.00	14.00	2.50	200.00	80.00	5.33
T ₂	90.67	71.00	14.67	3.00	600.00	81.67	7.67
T ₃	109.67	91.67	17.67	3.33	400.00	97.00	7.00
T ₄	108.33	88.33	14.67	3.00	200.00	91.00	5.50
T ₅	102.33	83.00	14.17	3.50	370.00	75.33	5.83
T ₆	99.67	72.00	17.00	2.50	350.00	93.33	5.00
T ₇	95.33	80.00	15.00	2.67	200.00	94.33	5.17
T ₈	102.00	85.00	18.33	3.25	200.00	100.00	8.50
T ₉	98.33	85.00	17.33	4.00	366.67	98.00	7.92
T ₁₀	104.00	87.00	8.67	3.17	406.67	97.67	6.67
T ₁₁	105.00	89.00	10.67	4.17	440.00	93.67	7.00
T ₁₂	97.33	79.33	9.33	4.75	550.00	100.00	9.83
T ₁₃	101.00	83.00	6.33	4.08	355.00	98.00	6.83
T ₁₄	86.33	71.00	0.00	3.33	470.00	96.67	7.00
T ₁₅	85.33	69.00	3.00	3.83	450.00	99.67	8.50
SE(m)±	2.08	0.60	0.51	0.37	19.02	1.47	0.44
CD@ 5%	6.01	1.74	1.48	1.08	54.04	4.25	1.26

(Treatment detail: T₀ (control), T₁: Sucrose 2.5%, T₂: Sucrose 2.5% with Salicylic acid 50 ppm, T₃: Sucrose 2.5% with Salicylic acid 100 ppm, T₄: Sucrose 2.5% with Sulfosalicylic acid 100 ppm, T₅: Sucrose 2.5% with Sulfosalicylic acid 200 ppm, T₆: Sucrose 2.5% with Ajowan Essential Oil (E.O) 250 ppm, T₇: Sucrose 2.5% with Ajowan E.O 500 ppm, T₈: Sucrose 2.5% with Silver nanoparticles (nano) 150 ppm, T₉: Sucrose 2.5% with Silver nano 300 ppm, T₁₀: Sucrose 2.5% with Salicylic acid 50 ppm and Sulfosalicylic acid 100 ppm, T₁₁: Sucrose 2.5% with Salicylic acid 50 ppm and Ajowan E.O 250 ppm, T₁₂: Sucrose 2.5% with Salicylic acid 50 ppm and Silver nano 150 ppm, T₁₃: Sucrose 2.5% with Salicylic acid 100 ppm and Sulfosalicylic acid 200 ppm, T₁₄: Sucrose 2.5% with Salicylic acid 100 ppm and Ajowan E.O 500 ppm, and T₁₅: Sucrose 2.5% with Salicylic acid 100 ppm and Silver nano 300 ppm)

Table 2. Effect of different chemicals treatment on days taken to open first five florets (days), longevity of individual florets (days), period of prime beauty, days taken to full spike opening, day taken to first floret fading and day taken to full spike fading

Treatments notation	Days taken to open first five florets (days)	Longevity of individual florets (days)	Period of prime beauty	Days taken to full spike opening	Day taken to first floret fading	Day taken to full spike fading
T ₀	1.67	2.17	3.00	5.33	1.67	8.67
T ₁	2.33	2.33	3.00	6.00	2.67	9.00
T ₂	2.67	2.33	4.00	9.67	3.17	14.00
T ₃	3.33	3.33	4.33	9.33	3.50	14.00
T ₄	3.50	3.00	4.00	9.67	3.50	14.33
T ₅	2.67	3.33	3.67	9.67	2.50	13.00
T ₆	4.00	3.00	4.00	9.00	2.33	12.33
T ₇	3.67	2.33	4.67	9.33	2.67	13.00
T ₈	3.00	3.83	6.33	11.67	3.67	16.00
T ₉	3.00	4.67	6.00	13.00	3.50	15.33
T ₁₀	3.83	4.17	4.67	12.50	3.67	13.00
T ₁₁	4.17	3.33	5.00	11.33	3.50	14.67
T ₁₂	5.00	5.00	6.00	13.33	3.33	15.00
T ₁₃	3.67	3.33	4.33	11.00	3.83	13.67
T ₁₄	2.67	3.17	4.67	10.33	2.83	11.67
T ₁₅	3.50	4.50	6.67	13.00	4.33	15.67
SE(m) ±	0.50	0.37	0.55	0.59	0.39	0.77
CD @5 %	1.44	1.07	1.60	1.70	1.14	2.24

(Treatment detail: T₀ (control), T₁: Sucrose 2.5%, T₂: Sucrose 2.5% with Salicylic acid 50 ppm, T₃: Sucrose 2.5% with Salicylic acid 100 ppm, T₄: Sucrose 2.5% with Sulfosalicylic acid 100 ppm, T₅: Sucrose 2.5% with Sulfosalicylic acid 200 ppm, T₆: Sucrose 2.5% with Ajowan Essential Oil (E.O) 250 ppm, T₇: Sucrose 2.5% with Ajowan E.O 500 ppm, T₈: Sucrose 2.5% with Silver nanoparticles (nano) 150 ppm, T₉: Sucrose 2.5% with Silver nano 300 ppm, T₁₀: Sucrose 2.5% with Salicylic acid 50 ppm and Sulfosalicylic acid 100 ppm, T₁₁: Sucrose 2.5% with Salicylic acid 50 ppm and Ajowan E.O 250 ppm, T₁₂: Sucrose 2.5% with Salicylic acid 50 ppm and Silver nano 150 ppm, T₁₃: Sucrose 2.5% with Salicylic acid 100 ppm and Sulfosalicylic acid 200 ppm, T₁₄: Sucrose 2.5% with Salicylic acid 100 ppm and Ajowan E.O 500 ppm, and T₁₅: Sucrose 2.5% with Salicylic acid 100 ppm and Silver nano 300 ppm)

Longevity of individual florets ranged from 2.17 days to 5.00 days, with the control having the shortest longevity of 2.17 days. The longest longevity of 5.00 days was recorded for T₁₂ (Sucrose 2.5% + Salicylic acid @ 50 ppm + Silver nano @ 150 ppm). Hutchinson et al. (2003) similarly found that silver thiosulphate and accel treatments extended flower longevity and floret opening in cut tuberose flowers, while sucrose pulsing improved longevity and floret opening by enhancing substrate utilization and mobilization along the spikes.

3.4 Prime Beauty and Days to Full Spike Opening

The longest period of prime beauty for single tuberose flowers was observed in T₁₅ (Sucrose 2.5% + Salicylic acid @ 100 ppm + Silver nano @ 300 ppm) (Table 2). This can be attributed to sucrose providing essential energy for cut flowers, acting as a readily available carbohydrate for respiration and metabolic processes, which helps maintain flower vitality. Additionally, Salicylic acid improves vase life by boosting antioxidant defences, reducing oxidative stress, and inhibiting microbial growth. Nano-silver enhances these effects with its antimicrobial properties, further prolonging the vase life of cut flowers.

The time required for full spike opening ranged from 5.33 days to 13.33 days, with the shortest duration occurring in the control treatment at 5.33 days. The longest time to full spike opening was observed in T₁₂ (Sucrose 2.5% + Salicylic acid @ 50 ppm + Silver nano @ 150 ppm), which took 13.33 days. This extended period may be due to the influence of sulfosalicylic acid, which at optimal concentrations reduces respiration rates (Ezhilmathi et al., 2007), delays senescence (Mackay et al., 2000), and improves vase solution uptake. These factors contribute to increased synthesis of essential materials in cut flowers, leading to a greater number of fully opened florets per spike.

3.5 Days Taken to First Floret Fading and Full Spike Fading

The time taken for the first floret to start fading ranged from 1.67 days to 4.33 days (Table 2). The control treatment exhibited the shortest fading time of approximately 1.67 days, while the longest fading time was observed in treatment T₁₅ (Sucrose 2.5% + Salicylic acid @ 100 ppm +

Silver nano @ 300 ppm), which lasted about 4.33 days. Similarly, the time required for the full spike to fade ranged from 8.67 days to 16.00 days. The shortest fading time was recorded in the control treatment at around 8.67 days, while the longest time was noted in treatment T₈ (Sucrose 2.5% + Silver nano @ 150 ppm), extending up to 16.00 days. This variation in fading time can be attributed to senescence, which is a common phenomenon in cut flowers. The minimal floret drop observed with 15% sucrose, where fading was around 29.15% by the 12th day, is likely due to sucrose acting as a carbon source that supports mitochondrial function and provides sustained energy, thereby delaying the senescence process of the florets (Halevy and Mayank, 1981; Kaur et al., 2006).

4. CONCLUSION

To address issues affecting cut tuberose flowers, researchers have explored various treatments, including silver nanoparticles, salicylic acid, sulfosalicylic acid, and ajwain essential oil, due to concerns about public health and environmental impact. This study evaluated these treatments and reached the following conclusions: The most effective treatment for extending the vase life of tuberose flowers was a chemical solution combining salicylic acid with sucrose. This was followed by a solution containing 100 ppm sulfosalicylic acid and 2.5% sucrose, which was particularly effective for prolonging the life of basal florets. For a single cultivar of tuberose, the treatment yielding the longest longevity of five basal florets was T₁₂ (Sucrose 2.5% + Salicylic acid 50 ppm + Silver nano 150 ppm), which lasted 4.75 days. The highest percentage of florets opening per spike was observed with T₈ (Sucrose 2.5% + Silver nano 150 ppm). The longest overall vase life was achieved with the combination of sucrose 2.5%, salicylic acid 50 ppm, and silver nano 150 ppm (T₁₂), lasting approximately 9.83 days. Overall, the study suggests that specific combinations of sucrose, salicylic acid, and silver nanoparticles significantly enhance the vase life and quality of cut tuberose flowers, providing effective solutions for their commercial use.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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