EFFECT OF SUCROSE,SALICYLIC ACID (SA), SULFOSALICYLIC ACID (SSA), SILVER NANO AND AJOWAN E.OON VASE LIFE OF SINGLE TUBEROSE (*POLIANTHES TUBEROSA* L.)

Abstract

Tuberose is a highly valued flower known for its vibrant colors, elegance, and captivating fragrance. It holds a prominent place 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 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 (T_{12}) 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 (T_8) 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 (T_{12}). This study underscores the effectiveness of specific chemical treatments in significantly improving the vase life and overall quality of cut tuberose flowers.

Key Words: Cut flowers, Nano particles, Sucrose, Salicylic acid, Sulfosalicylic acid, Vase life.

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 tuberoses, including single, double, and semi-double forms, contribute to its versatility.

However, tuberose flowers are susceptible to ethylene production, which accelerates wilting, causes floret burning, and bends the tips of flower spikes, ultimately shortening their vase life **(Pérez-Arias *et al*., 2019).** The distinctive fragrance of tuberose emanates from the terminal spike of its **flowers (Jadhav *et al*., 2020).**Postharvest conditions critically influence flower longevity. Factors such as temperature, relative humidity, light, air velocity, and ethylene concentration play vital roles in determining the postharvest quality and vase life of cut flowers. Additional factors include the composition of holding solutions, microbial proliferation in preservative solutions, and the quality of water (**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 tuberoses (**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 $AgNO_3$ 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**).

Research has explored various non-toxic substances, including salicylic acid, nanoparticles, and sucrose, to enhance the quality and longevity of tuberose cut flowers. For instance, **Mohibe*et al*. (2020)** demonstrated that a combination of 5% sucrose and 150 ppm salicylic acid improved flower characteristics and vase life in gladiolus. Similarly, **Bahrehmand*et al*. (2014)** found that combining 4% sucrose with 45 mg L^{-1} nano-silver (NS) optimized flower quality and longevity. **Naing *et al*. (2020)** highlighted the role of nano-silver in inhibiting ethylene production and bacterial growth, thus extending the vase life of cut flowers.This study aims to evaluate various chemical treatments to identify the most effective methods for prolonging 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.

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: T_0 (control), T_1: Sucrose 2.5%, T_2: Sucrose 2.5% with Salicylic acid 50 ppm, T_3: Sucrose 2.5% with Salicylic acid 100 ppm, T_4: Sucrose 2.5% with Sulfosalicylic acid 100 ppm, T_5: Sucrose 2.5% with Sulfosalicylic acid 200 ppm, T_6: Sucrose 2.5% with Ajowan Essential Oil (E.O) 250 ppm, T_7: Sucrose 2.5% with Ajowan E.O 500 ppm, T_8: Sucrose 2.5% with Silver nanoparticles (nano) 150 ppm, T_9: Sucrose 2.5% with Silver nano 300 ppm, T_{10}: Sucrose 2.5% with Salicylic acid 50 ppm and Sulfosalicylic acid 100 ppm, T_{11}: Sucrose 2.5% with Salicylic acid 50 ppm and Ajowan E.O 250 ppm, T_{12}: Sucrose 2.5% with Salicylic acid 50 ppm and Silver nano 150 ppm, T_{13}: Sucrose 2.5% with Salicylic acid 100 ppm and Sulfosalicylic acid 200 ppm, T_{14}: Sucrose 2.5% with Salicylic acid 100 ppm and Ajowan E.O 500 ppm, and T_{15}: 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 2^{nd} and 10^{th} 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:

Change in length (%) = Final Spike length – Initial spike length x 100
Final spike length

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.

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.

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 (T_3) 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 T_3 (Sucrose (2.5%) + Salicylic acid @ 50 ppm) with approximately 109.67 grams, followed by T_4 (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 T_8 (Sucrose (2.5%) + Silver nano @ 150 ppm), followed by 17.67% in T_3 (Sucrose (2.5%) + Salicylic acid @ 100 ppm). No change in spike length was observed in T_{14} (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 T_{12} (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.

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 T_2 (Sucrose (2.5%) + Salicylic acid @ 50 ppm) with 600 ml, which was statistically comparable to T_{12} (Sucrose (2.5%) + Salicylic acid @ 50 ppm + Silver nano @ 150 ppm) at approximately 550 ml, and T_{14} (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 T_1 (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. **Bhaskar *et al.* (1999**) reported a gradual decrease in water uptake across all treatments until day 5, followed by fluctuations on the 6^{th} and 7^{th} days. Silver nitrate ($AgNO_3$) 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 T_8 (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).**

Vase life and longevity of individual florets

In the current study, the treatment T_{12} (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 T_7 (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 *etal.*, 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, T_{12} (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.

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 T_{12} (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.

Prime beauty and days to full spike opening

The longest period of prime beauty for single tuberose flowers was observed in T_{15} (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 T_{12} (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.

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 T_{15} (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 T_8 (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 12^{th} 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 andMayank, 1981; Kaur *et al.*, 2006**).

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)		Changeinlengthofspike (%)	Longevity of five basalflorets(days)	Vasesolutionuptake (ml)	*Per cent* of the openedflorets/spike	Vaselife(days)
	2nd day	10th 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: T_0 (control), T_1: Sucrose 2.5%, T_2: Sucrose 2.5% with Salicylic acid 50 ppm, T_3: Sucrose 2.5% with Salicylic acid 100 ppm, T_4: Sucrose 2.5% with Sulfosalicylic acid 100 ppm, T_5: Sucrose 2.5% with Sulfosalicylic acid 200 ppm, T_6: Sucrose 2.5% with Ajowan Essential Oil (E.O) 250 ppm, T_7: Sucrose 2.5% with Ajowan E.O 500 ppm, T_8: Sucrose 2.5% with Silver nanoparticles (nano) 150 ppm, T_9: Sucrose 2.5% with Silver nano 300 ppm, T_{10}: Sucrose 2.5% with Salicylic acid 50 ppm and Sulfosalicylic acid 100 ppm, T_{11}: Sucrose 2.5% with Salicylic acid 50 ppm and Ajowan E.O 250 ppm, T_{12}: Sucrose 2.5% with Salicylic acid 50 ppm and Silver nano 150 ppm, T_{13}: Sucrose 2.5% with Salicylic acid 100 ppm and Sulfosalicylic acid 200 ppm, T_{14}: Sucrose 2.5% with Salicylic acid 100 ppm and Ajowan E.O 500 ppm, and T_{15}: 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	Daystakentoopen first five florets (days)	Longevity of individualflorets (days)	Periodof primebeauty	Daystakentofull spike opening	Daytakentofirst floret fading	Daytakentofull 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: T_0 (control), T_1: Sucrose 2.5%, T_2: Sucrose 2.5% with Salicylic acid 50 ppm, T_3: Sucrose 2.5% with Salicylic acid 100 ppm, T_4: Sucrose 2.5% with Sulfosalicylic acid 100 ppm, T_5: Sucrose 2.5% with Sulfosalicylic acid 200 ppm, T_6: Sucrose 2.5% with Ajowan Essential Oil (E.O) 250 ppm, T_7: Sucrose 2.5% with Ajowan E.O 500 ppm, T_8: Sucrose 2.5% with Silver nanoparticles (nano) 150 ppm, T_9: Sucrose 2.5% with Silver nano 300 ppm, T_{10}: Sucrose 2.5% with Salicylic acid 50 ppm and Sulfosalicylic acid 100 ppm, T_{11}: Sucrose 2.5% with Salicylic acid 50 ppm and Ajowan E.O 250 ppm, T_{12}: Sucrose 2.5% with Salicylic acid 50 ppm and Silver nano 150 ppm, T_{13}: Sucrose 2.5% with Salicylic acid 100 ppm and Sulfosalicylic acid 200 ppm, T_{14}: Sucrose 2.5% with Salicylic acid 100 ppm and Ajowan E.O 500 ppm, and T_{15}: Sucrose 2.5% with Salicylic acid 100 ppm and Silver nano 300 ppm**)**

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 T_{12} (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 T_8 (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 (T_{12}), 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.

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