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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2021 18(3): 1958-1964. **OPEN ACCESS**

Influence of Citric acid ($C_6H_8O_7$) application on postharvest vase life of Tuberose (*Polianthes Tuberosa* L.)

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The rapid respiration and growth of tuberose inflorescence indicate the importance of temperature management and carbohydrate supply to long vase life. Under normal display conditions, many buds aborted, probably because of carbohydrate stress. Citric acid plays an important role in the reducing vascular blockage through anti-embolism traits of cut flowers. A research study was conducted to investigate the effect of citric acid on vase life and flower quality of tuberose. Tuberose cut flowers harvested early in the morning at bud opening stage were shifted to Directorate of Floriculture, National Agricultural Research Center Islamabad. The flowering spikes of tuberose were dipped in different combination of citric acid i.e. T_1-Control (Tape water), T_2 (2% sucrose solution), T_3 (100mg/l citric acid + 2% sucrose), T_4 (150mg/l citric acid + 2% sucrose), T_5 (200mg/l citric acid + 2% sucrose) and T_6 (250 mg/l citric acid + 2%). The analysis of data exhibited a significant difference for most of the studied attributes of tuberose. The highest value of fresh weight (12.5g), number of open florets spike^{-1} (6.54), spike diameter (8mm), florets diameter (5.75mm), water solution uptake (73%) and vase life of tuberose cut flower (11.75days) were recorded in treatment T_6 (250 mg/l citric acid + 2%) as compared to other treatments. It was concluded that T_6 (250 mg/l citric acid + 2%) was found an effective preservative solution for extending the vase life of tuberose cut flowers up to 12 days.

Keywords: Citric Acid, Cut Flower, *Polianthes tuberosa* L., Vase Life, Quality

INTRODUCTION

Cut flower longevity has also been associated with the concentration of carbohydrates in the cut flowers (van-Doorn, 2004). Cut flowers last only for a few days maintaining their beauty and attractiveness. However, most of the people would like to enjoy them for a longer period. Short vase life of cut flowers is related to wilting, ethylene production and vascular blockage by air or microorganisms. Flower senescence and shortening the vase life is influenced by several factors including endogenous ethylene. Preservative solutions are generally required to supply energy source, reduce microbial contamination, reduce vascular blockage, increase water uptake. Thus, using appropriate preservatives could extend the vase life of the harvested flowers. Motaghayer and Esna-Ashari (2009) reported that there are different flower

preservatives that provide water and energy which are required to improve flowers vase-life and to keep their quality over the period of presentation.

Tuberose (*Polianthes tuberosa* L.) is a perennial, bulbous flowering plant, belongs to family Amaryllidaceae which has traditionally been considered for the treasured scent. The tuberose is a very popular cut flower of Pakistan. It has white flowers, which are sweet scented. It usually flowers during summer and early autumn, when planted in spring. There are up to 30 flowers in one spike and the length of rachis varies between 14 and 28cm, depending upon the size of rhizome planted. Besides as a source of essential oils for perfume industry, it is commonly used in bouquets for presenting and in vases for interior decoration. The grading standard for the marketing of tuberose is a disease-free straight stem of about 70 cm and spike with a minimum of 10 pairs of pure white florets (Steenstra and Brundell, 1986)**.** The white, sweet scented flowers are valued as cut flower, used in bouquets for making garlands, veins and as a source of essential oils for perfumery industries. Tuberose actually, has delicate flowers where sellers and consumer are keen in extending its vase-life, this demands to improve its postharvest life. Keeping quality of the spikes is only 3 days per floret and vase**-**life of the flowers is only few days. Postharvest losses in many cut flowers are estimated to be as high as 40% in the absence of floral preservatives. Tuberose flowers are highly perishable in nature along with acropetal movement of the florets along the spike, when flower spikes are harvested from the plant, there will be deterioration in the internal carbohydrates and loss in turgidity is accelerated, therefore need to be treated with suitable chemicals, to enhance their vase life and improve quality. A major cause of deterioration in the cut flowers is the blockage of xylem vessels by air and microorganisms that cause xylem occlusion (Nowak and Rudnicki, 1990). Investigations pertaining to extend the vase-life of tuberose flowers by chemical treatments after harvest have been made with varying success. Several preservatives/chemicals i.e. citric acid, silver nitrate, aluminum sulphate, cobalt sulphate, 8-hydroxyquinoline sulphate, boric acid, ascorbic acid, sucrose etc. have been used in different formulations and combinations to enhance the vase life of tuberose (De and Barman, 1998).

Citric acid is a weak organic tricarboxylic acid having the chemical formula $C_6H_8O_7$. It occurs naturally in citrus fruits and is an intermediate in the citric acid cycle, which occurs in the metabolism of all aerobic organisms. More than a million tons of citric acid are manufactured every year. It is used widely as an acidifier, as a flavoring and chelating agent. Citric acid seems to act by reducing the pH of water and, consequently, the proliferation of bacteria, which block the xylem vessels in the cut region and interfere with the normal flux of water through the stem (Nowak and Rudnicki, 1990). Improvement of keeping quality and extend of vase life of cut flowers are important areas in floricultural research. Senescence of cut flowers is induced by several factors e.g. water stress, carbohydrate depletion and microorganism etc. Chemical preservatives are known to be antibacterial agents, water uptake enhancers along with other properties, are used for extending vase life of cut flowers. Therefore, the present research was planned to determine the effect of citric acid treatment on the vase life and quality characteristics of tuberose cut flower.

MATERIALS AND METHODS

Site selection and Experimental Description

The present study was conducted at Directorate of Floriculture, National Agricultural Research Center, Islamabad, located at 33.6701° N latitude, 73.1261° E longitude (Basit et al., 2018), Pakistan. The experiment was laid out using Complete Randomize Design (CRD) with six treatments that was repeated four times. Tuberose cut flowers were harvested early in the morning at bud opening stage and were shifted to Floriculture Section, Horticultural Research Institute, NARC Islamabad-Pakistan. Flower stem ends were kept under water to remove air emboli and to prevent vascular blockage. The room temperature was 32-35º C and relative humidity was about 65%. The Citric Acid solution was used (100,150, 200, 250 mg/l) with combination of 2% sucrose. Sucrose was used as a nutrition source in preservation solution and as a perspiration material which prevents damages to proteins and increases the balance of water in cut-flowers. Tap water was used as control treatment. Flowering spikes were placed in 250 ml flasks. Conical flask mouths were covered with a sheet of polyethylene film, to minimize evaporation and to reduce further contamination. Citric acid treatment was used as a standard (continuous) treatment and flower stems were kept in solutions until the end of vase life.

The vase solution was prepared at the beginning of experiment and the details of the

treatments solution consisted of T_1-Control (Tape water), T_2 (2% sucrose solution), T_3 (100mg/l citric acid + 2% sucrose), T_4 (150mg/l citric acid + 2% sucrose), T_5 (200mg/l citric acid + 2% sucrose) and T_6 (250 mg/l citric acid + 2% sucrose).The observation was recorded on different postharvest attributes i.e. fresh weight of flower (Spike) (Spikes from tuberose plants were taken and weighted before putting in the citric acid solutions), Number of floret per spike (Florets were counted in a spike), No of open floret (Open florets were counted in spike), Spike and floret diameter (Diameter of spike and florets in mm was calculated with the help of Vernier caliper), Water solution uptake (Water was calculated on first day and last day for calculating water solution uptake and Vase life (It's the life span of flower from putting it in solution to the dying of all florets).

Data Analysis

Data collected was analyzed using analysis of variance (ANOVA) technique suitable for completely randomized design (CRD) with one factor. For this purpose, a statistical package Statistix 8.1 was used (Basit et al. 2018) to test the mean comparisons at least significant difference (LSD) at 5% probability level among various treatments (Jan et al. 2009).

RESULTS

Fresh weight of flower

It is obvious from Figure 1 that fresh weight of tuberose was significantly influenced by citric acid treatments. Among treatments, maximum fresh weights (12.5g) of tuberose cut flowers were recorded in T_6 (250 mg/l citric acid + 2% sucrose) followed by fresh weight of tuberose (11.75) cut flower in T_2 (2% sucrose solution).While the tuberose cut flowers dipped in T_5 (200mg/l citric acid + 2% sucrose) gained minimum value of fresh weight (9.25g).

Number of florets per spike

The application of citric acid treatment significantly influenced number of florets per spike of tuberose cut flower (Figure 1). The highest number of florets per spike were recorded in treatment T_6 (250 mg/l citric acid + 2% sucrose), while the minimum number of florets per spike (13.50) were observed in treatment T_5 (200mg/l citric acid + 2% sucrose).

Number of open florets

The analysis of data revealed that application of citric acid treatment significantly influenced the number of open florets per spike of tuberose cut flower (Figure 1). A significant increase in number of open florets per spike from day 1 to day 6 in different citric acid treatments. The highest number of open florets per spike (5.5) at 1st day was recorded in treatment T_4 (150mg/l citric acid + 2% sucrose) after harvesting that showed an increase in number of open florets per spike (49.63%) when noticed on day 6 in the T_4 (150mg/l citric acid + 2% sucrose),while the lowest number of open florets per spike were observed in T_5 (200mg/l citric acid + 2% sucrose) which was at par with T_6 (250 mg/l citric acid + 2% sucrose) that exhibited increase in number of open florets per spike (49.17 and 53.88%) on day 6 in the same treatments i.e. T_5 and T_6.

Spike diameter (mm)

The analysis of data revealed that higher value of spike diameter (6.60 mm) was observed in treatment T_5 (200mg/l citric acid + 2% sucrose), while the lower value of spike diameter (5.47cm was recorded in T_1-Control (Tape water). The increasing concentration of citric acid observed increase in spike diameter (6.60 mm to 8 mm) from day 1 to day 6. Similarly, T_1-Control (Tape water) also observed (7.31%) increase in spike diameter.

Floret diameter (mm)

Floret diameter of tuberose was recorded on day 1 and day 6 which also shows a significant increase in floret diameter when dipped in different treatments of citric acid (Figure 2). The maximum value of flower diameter was noted in treatment T_6 (5.5mm) on day1 which observed an increase of (9.25%) in floret diameter when measured on day 6, while the minimum value of diameter of flower was recorded in T_1 (5mm) that recorded 5% increase in floret diameter on day 6 as compared to day 1.

Water Solution uptake

The analysis of data presented in Figure 2 revealed the highest value for water solution uptake (73%) that was recorded in T_6 (250 mg/l citric acid + 2% sucrose).While, the lowest value of water solution uptake (51.75%) was noted in T_2 (2% sucrose solution).

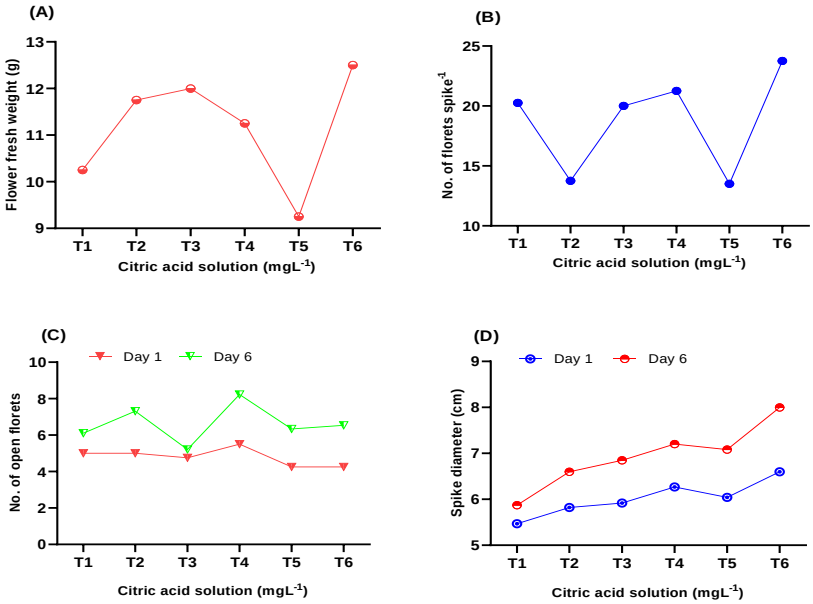

Figure 1: Flower fresh weight, No. of florets spike^{-1}, No. of open florets and spike diameter of tuberose cut flower as influenced by citric acid treatments

T_1-Control (Tape water) T_2 (2% sucrose solution), T_3 (100mg/l citric acid + 2% sucrose), T_4 (150mg/l citric acid + 2% sucrose), T_5 (200mg/l citric acid + 2% sucrose) and T_6 (250 mg/l citric acid + 2% sucrose).

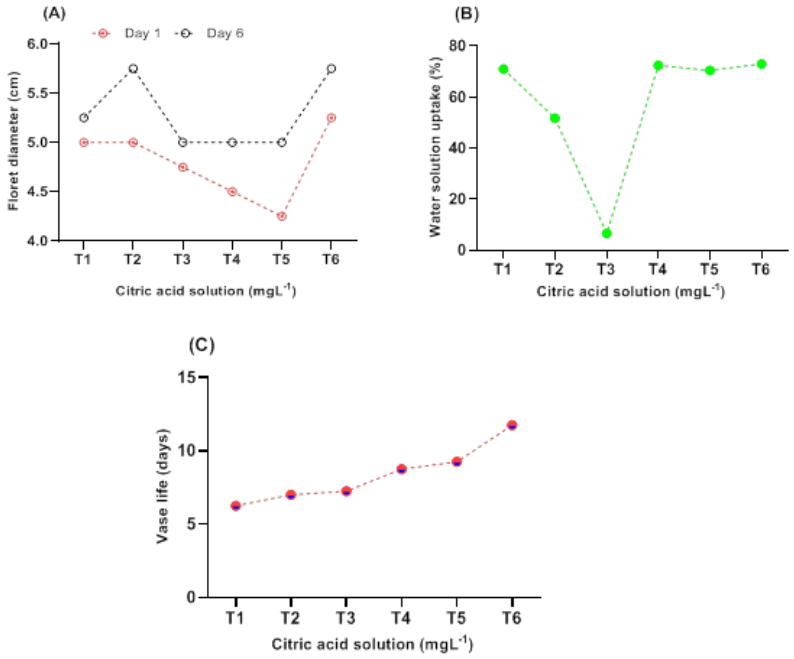

Figure 2: Floret diameter, water solution uptake and vase life of tuberose cut flower as influenced by citric acid treatments

T_1-Control (Tape water), T_2 (2% sucrose solution), T_3 (100mg/l citric acid + 2% sucrose), T_4 (150mg/l citric acid + 2% sucrose), T_5 (200mg/l citric acid + 2% sucrose) and T_6 (250 mg/l citric acid + 2% sucrose)

Vase life

Vase life of cut flowers tuberose extended significantly by application of citric acid treatments (Figure 2). The analysis of data revealed that vase life of T_6 (250 mg/l citric acid + 2% sucrose) treated flowers (11.75 days) were higher compared to other treatments of citric acid (9.25, 8.75, 7.25, 7days).

DISCUSSION

The analysis of results indicated that application of preservative vase solutions resulted in higher daily fresh weight, which increases the percentage of the flower weight, which expressed the flower freshness, flower longevity and senescence (Taha and Soad, 2010). Steinitz (1982) pointed out that addition of sucrose to the solution increased the mechanical turgidity of stem by inducing cell wall thickening and lignification of vascular tissues. Moreover, Juang et al. (2001) on "Snapdragon Mar wall" found that sucrose was apparently to be effective in increasing the fresh weight. Microbial contamination is a main limiting factor in postharvest life of carnation cut flowers (Kazemi et al. 2011). Sucrose or its combination with biocides, improved postharvest performance in tuberose Gul and Tahir (2013) on *Narcissus pseudonarcissus* cv. Emperor. This might be explained that Silver thiosulphate (STS) significantly decreased ethylene production by all cut flowers tested in comparison with the control. It also provides some antimicrobial activity inside the plant tissues, and it is beneficial for ethylene-sensitive flowers such as carnation, this might explain the effective role of STS in prolonging the vase life of these cut flowers (Nowak and Rudnicki, 1990). Concerning the role of sucrose with hydroxyquinoline sulphate (8-HQS) or STS, the previous results showed that adding sucrose extended the vase life and improved the quality of carnation cut flowers. Similar results were also studied by Joyce and Jones (1992) that fresh weight of the flowers was determined just before the immersion of the flowers into the solutions. Eidyan (2010) also concluded that fresh weight of cut flowers was measured every day. Similar results were reported by Adarsh et al., (2010) on Vase life studies in tuberose (*Polianthes tuberosa*) cv. Shringar as affected by post-harvest handling treatments.

Foliar application of citric acid significantly increases the vegetative growth, spike length and number of flowers per plant. It was observed that the citric acid performed better and produced the maximum number of florets/spike which might be due to availability of more nutrients uptake. Statistically significant variation was found for number of floret/spike. Similar results were in conformity with Kumar et al. in (2003) on postharvest quality of tuberose spikes as affected by coloring agents and storage. Our results are also in accordance with the observation of Talukdar et al. (2011) who reported that flower quality and vase life of tuberose (*Polianthes tuberosa* L.) cv. Calcutta Double had significantly influenced by pulsing and different holding solutions. When flowers are detached from the plant, water loss occur continuously from these through transpiration. It is well known that sugars supply increases the longevity of cut flowers, through acting as nutrition for tissues approaching carbohydrate starvation, it may also osmotically active molecule, thereby having a role of flower opening and subsequence water relation (Kuiper et al. 1995). The dissolved sugars in cells of the petals are osmotically active substance that draws water into the corolla cells making the cell turgid and hydrolyzing the sucrose of respiration. Similar finding was obtained by Erin et al. (2002) who found that vase solution containing sugar could improve the vase life of many cut flowers. The ideal flower preservative is that which allows water absorption in flower tissues (Salunkhe et al. 1990). Adding a suitable germicide in vase water can prevent the growth of microbes and increased water uptake (Anjum et al. 2001).

It seems that antimicrobial effect of the applied beneficial treatments led to the declined vascular blockage, higher solution uptake and the fresh weight in the treated cut flowers by which the senescence process was delayed, (Kazemi et al. 2011).Sucrose or its combination with biocides, improved postharvest performance in tuberose (Gul and Tahir, 2013) on *Narcissus pseudonarcissus* cv. Emperor. Adding sucrose to the vase solution in order to prolong the vase life of most flowers, also improve quality after cutting, as reported that sugars are delaying senescence, sugars improve the water balance in cut flowers and this was attributed to the effect of sucrose on the closure of stomata and reduction of water loss (Halevy and Mayak, 1981). The improvement of water balance was also associated with a reduced endogenous level of Abscisic acid that is typical response to reduction of water stress. The sugars accumulate in the flowers, increasing their osmotic concentration and improving their ability to absorb water and maintain their turgidity. This is due to carbohydrates, which are considered the main source of nutrition and energy necessary for

maintaining all biochemical and physiological process after separation from mother plant. The longest vase life of cut tuberose 'Double' was recorded by using 250 ppm citric acid + 3% sucrose + 0.01% calcium nitrate (Bhaskar et al. 2000).Bhattacharjee and Palanikumar (2001) observed that water uptake of cut roses 'Raktagandha' flowers was maximum in sucrose + citric acid treatment. +Citric acid increased the vase life by enhancing the water uptake and maintain better water balance and fresh weight of *Solidago Canadensis* L. (Patil and Reddy, 2001). The vase life of cut flowers increased from a minimum of 7.07 days in distilled water to 13.25 days in solution containing 2% sucrose and 1.00 mM citric acid. Solutions containing 2% glucose + 0.015% citric acid increased the vase life of *Gerbera* and *Gladiolus* (Dumitraş et al. 2002). Kushal (2002) showed that, Citric acid at 300 mg/liter in vase solution extended the longevity of fronds of *Asparagus myrie*.

CONCLUSION

It is concluded from the above discussion that citric acid has a positive effect on the vase life and other studied attributes of tuberose. It was observed that vase life of tuberose increased up to almost 12 days when T_6 (250 mg/l citric acid + 2% sucrose) was used as preservative material.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

We are very thankful to Mr. Noor Alam Khan-Late (Principal Scientific Officer) Founder Director Floriculture, DHRD, National Agricultural Research Center Islamabad, for providing all possible resources and their valuable suggestions in completing the research project successfully.

AUTHOR CONTRIBUTIONS

Conceived and designed the experiments: A. Basit; performed the experiments: A Basit; Analyzed the data: A. Basit & I. Ullah. Contributed materials/ analysis/ tools: I. Ullah, A. Basit, I Ullah, S.T. Shah, N. Ahmad, I. Ahmad. Wrote the original paper: A. Basit. Edited and reviewed the final draft: I. Ullah & A. Basit. All authors read and approved the final version.

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