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Research Article

A study on the effect of silver nitrate and 8-hydroxyquinoline citrate pulsing solutions on Lilium cut flowers

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Abstract
Lilium is one of the most important cut flowers in commercial markets, giving customers ornamental value. Fresh flowers, a highly perishable item, need more care and proper treatment for their longer post-harvest life and due to this, the end users face the post-harvest losses of cut flowers. Such losses can be minimized by using preservative chemical, which plays an important role in increasing the vase life of flowers. To increase the post-harvest life of lilium cut flowers cv. 'Pavia', the present investigation was aimed to study the effect of different combinations and concentrations of silver nitrate at 50, 75 and 100 ppm and 8-hydroquinoline citrate at 100, 150 and 200 ppm pulsing solutions with 20 % sucrose. Three replications were completely randomised with 16 treatments and one control. Silver nitrate showed better results in flower bud opening, flower bud opening to complete flowering, flower size, bloom life, dry weight and dry matter percentage. Among the treatment concentrations, $AgNO_3$ at 50 ppm with 20% sucrose showed the most effective result on enhancing the selected parameters and improved flower quality during post-harvest life. Among the treatment combinations, 8-HQC at 100 ppm + $AgNO_3$ at 75 ppm with 20 % sucrose showed better results. These findings will be useful to researchers, farmers, and end users to retain the ornamental value of lilium cut flowers for longer than usual.

Keywords: Lilium cut flowers, Vase life, $AgNO_3$, 8-HQC, Sucrose

INTRODUCTION

Lilium is the most vital bulbous flower, belongs family Liliaceae and commercially grown in India for cut flowers. The commercial ornamental market is growing and is creating an increasingly competitive market that requires higher quality products every day (Hummel and Miguel, 2017). Even though the production and commercial importance of this flower is increasing, an extensive portion of the flower product is lost due to post-harvest losses before reaching the retail market, which are escalated by its high perishability (Gupta and Dubey, 2018). Cultivation of lilium has been significant due to its response in the commercial markets (Fu *et al.*, 2020). Lilium cv. 'Pavia' is a particular cut flower that performs smooth production, stem length ranging from 60 cm to 90 cm on average and linear leave character makes it suitable for cut flower in Indian markets, highlighting its significance in post-harvest life. Above these, the cut flowers have an internal physiological system that changes after the harvest. Hence, water intake rate decreases, vascular tissue blockages by microbes, senescence accelerates, gain in ethylene biosynthesis and reduction of respiratory substrates (Sant'anna *et al.*, 2010). These types of complication can be reduced with the help of preservative chemicals which extend the cut flower's shelf life and subsequently increase the commercial life by improving the quality of flower (Zhao *et al.*, 2018). Out of these techniques, preservative chemicals are conspicuous as it can be utilised during production to end consumers (Menegaes *et al.*, 2019). Many factors influence the shelf life of cut flowers, like genetics, flower handling and growing conditions (Pizano, 2009), xylem blockage, ethylene, carbohydrate content, atmospheric composition, and preservative chemicals. Wilting determines the termination of the shelf life of many cut flowers and shortened water intake is generally caused by blockage of vessels at the base end of the stem (He *et al.*, 2006). The collective action of microbes causes blockage in the xylem vessels of the stem, which accumulates in the holding solution of vessels (Marandi *et al.*, 2011) and affect negatively for water uptake and transportation in cut flowers & stem tissues (Kazemi *et al.*, 2010) and by reducing water uptake, it reduces their shelf life (Kazemi *et al.*, 2011). Early wilting in leaves and flowers is caused by blockage of xylem vessels, leading to water stress (Marandi *et al.*, 2011).

Lilies are very much susceptible to ethylene hormone, which causes an important role in the premature death of floral buds due to increasing of abscission and senescence leading to tissue damage & shortened post-harvest life of flowers (Sidhdharth and Nivethaa, 2020; Azuma *et al.*, 2020). Inhibitors of its biosynthesis or actions can reduce the physiological effects of ethylene. Silver (Ag^+) ion is an ethylene inhibitor chemical and can be applied as silver nitrate ($AgNO_3$). For the binding sites of ethylene receptors, it blocks the action of C_2H_4 (ethylene) by competing (Lima *et al.*, 2017). Due to its very effectiveness in hindering the effects on respiratory and transpiration rates and controlling senescence along with the production of ethylene, the utilization of these preservative chemicals has been greater than before in floriculture (Sedaghathoor *et al.*, 2020; Liu *et al.*, 2018). In the reduction of anthocyanin contents, the exposure to pulsing caused significant differences from the control, which demonstrated two days increased shelf life of cut *L. pumilum* flowers by using pulsing preservative solution (Marcelo *et al.*, 2021). Using the silver nitrate as a vase solution showed a significantly superior outcome concerning fresh weight, water intake, flower size and shelf life in rose cut flower cv. ‘First Red’ (Kumar *et al.*, 2020). Silver nitrate ($AgNO_3$) and sucrose extended the vase life, with the delayed head dropping and discoloration on gerbera-cut flowers in different concentrations (Nair *et al.*, 2003). Shiva and Bhattacharjee (2003) observed an initial increase in fresh weight until 3rd day after harvest. The total content of starch in petals was built by holding the solution as compared to the control since the content of starch was positively connected with the shelf life, as studied by Mwangi *et al.* (2003). Limited studies have been conducted to extend the shelf life of lilium cut flower cv. ‘Pavia’, therefore, more studies needs to be done to get better quality and shelf life of the cut flower due to its commercial and economic importance. The unique parameters studied will help the researchers to observe the impact of diverse preservative chemicals on the flower quality and shelf life of lilium cut flowers for commercial use. Workers have not suggested clear-cut recommendations about using preservative chemicals and concentrations to extend the lilium cut flower's shelf life. Considering the facts, the trial was conducted to study the impact of preservative chemicals on the longevity of lilium cut flowers cv ‘Pavia’

MATERIALS AND METHODS

The study was conducted between May 2019 and July 2021 at Amity Institute of Horticulture Studies and Research, Amity University, Noida, U. P. - 201313, India. Lilium flowers were cut in the early morning at one flower bud opening stage and instantly shifted to the laboratory and graded according to the required flower size and stem length. To study vase life, all flower spikes having 5 flower buds with one opened flower on the spike were selected and observations were recorded to study the 3rd flower quality since the 3rd flower bud was in the middle of the spike and acts as the focal point of attraction for the whole flower spike. Cut flower spikes were placed in 500 ml capacity cylinders individually filled with preservative solutions with maintaining at 24 ºC ± 2 temperature with 60 – 70% relative humidity. The flower spikes were re-cut at the base keeping 70 cm length and the fresh weight of the spike was recorded before placing it in holding solution. Holding solutions with distilled water (control), sucrose (20%), 8-HQC at 100, 150 and 200 ppm and silver nitrate ($AgNO_3$) at 50, 75 and 100 ppm in different concentrations were taken to observe the impact of these preservative chemicals on longevity and quality parameters of lilium cut flower cv. “Pavia”. Details of treatment combinations are given in Table 1.

To observe the longevity of lilium cut flower cv “Pavia”, data were recorded on time taken for third flower bud opening, third flower bud opening to complete flowering, third flower size, bloom life of the third flower, dry weight and dry matter percentage of the flower spike. Dry matter percentage of the flower spike was measured by using the equation:

$$\text{Dry Matter percentage} = \text{Dry weight}/\text{fresh weight} \times 100 \quad \text{Eq.1}$$

Experimental design

Completely Randomized Design was followed with 3 replicates. Each replicate consisted of 17 cylinders (glass), including one control (distilled water) and 16 treatments. Each cylinder having 500 ml size contained one cut flower spike in the holding solution.

Table 1. Treatment details of the present experiments

Treatment Code	Treatment details
T_0	Control (only distilled water)
T_1	Distilled Water + Sucrose (20%)
T_2	8-HQC (100 ppm) + Sucrose (20%)
T_3	8-HQC (150 ppm) + Sucrose (20%)
T_4	8-HQC (200 ppm) + Sucrose (20%)
T_5	$AgNO_3$ (50 ppm) + Sucrose (20%)
T_6	$AgNO_3$ (75 ppm) + Sucrose (20%)
T_7	$AgNO_3$ (100 ppm) + Sucrose (20%)
T_8	8-HQC (100 ppm) + $AgNO_3$ (50 ppm) + Sucrose (20%)
T_9	8-HQC (150 ppm) + $AgNO_3$ (50 ppm) + Sucrose (20%)
T_{10}	8-HQC (200 ppm) + $AgNO_3$ (50 ppm) + Sucrose (20%)
T_{11}	8-HQC (100 ppm) + $AgNO_3$ (75 ppm) + Sucrose (20%)
T_{12}	8-HQC (150 ppm) + $AgNO_3$ (75 ppm) + Sucrose (20%)
T_{13}	8-HQC (200 ppm) + $AgNO_3$ (75 ppm) + Sucrose (20%)
T_{14}	8-HQC (100 ppm) + $AgNO_3$ (100 ppm) + Sucrose (20%)
T_{15}	8-HQC (150 ppm) + $AgNO_3$ (100 ppm) + Sucrose (20%)
T_{16}	8-HQC (200 ppm) + $AgNO_3$ (100 ppm) + Sucrose (20%)

Statistical analysis

Statistical analysis of research data was carried out by using SPSS statistical software and analysis of variance (ANOVA), and means of comparison was calculated by Duncan's multiple range test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Third flower bud opening

The average days taken was counted from the first day till the third bud's opening on the spike. All the treatments have significantly influenced in delaying of the third flower bud opening (Fig. 1). Silver nitrate showed better results than 8-HQC. Among all treatment concentrations, $AgNO_3$ at 50 ppm with 20% sucrose (T_5) recorded the highest of 6.5 days, followed by the treatment combination of 8-HQC at 100 ppm + $AgNO_3$ at 75 ppm and sucrose (20%) (T_{11}) with 5.83 days while lowest was recorded in control (T_0) with 4 days. The average days for the third flower bud opening ranged from 4 to 6.5 days. The findings of the trial were in propinquity with Kumari et at. (2018) who reported that the silver nitrate at 30 ppm/L with a maximum of 4.46 days for opening upper florets in Asiatic hybrid lily cv. 'Arcachon'. Wani et. al. (2009) found that the 2^{nd} flower of lilium cut flower spike cv. 'Elite' took a maximum of 2.5 days to open in treatment with STS 2.0 mM and Sucrose 5%. During the vase life period, the opening of third flower bud was delayed by maximum 62.5 % more days than the control treatment which helped in prolonging the shelf life of the cut flower.

Third flower bud opening to complete flowering

The average days taken were counted from the day of the opening of the third flower bud to till maximum flower diameter. All the treatments significantly influenced the third flower bud from opening to the complete flowering stage. It was observed that the treatment concentration of $AgNO_3$ 50 ppm with 20% sucrose (T_5) took the highest of 5.5 days, followed by the treatment combination of 8-HQC at 100 ppm + $AgNO_3$ at 75 ppm and sucrose (20%) (T_{11}) with 5.17 days while lowest was recorded in T_2 with 3 days for third flower bud opening to complete flowering stage (Fig. 2). The average period of third flower bud opening to complete flowering stage was ranged from 3 to 5.5 days. The use of the preservative chemicals increased 73.5 % more days period than the control treatment for opening to complete flowering of third flower, which helped in extending the vase life.

Third flower diameter

Average diameter of third flower was recorded at its maximum flower opening stage on the spike. All the treatments influenced the third flower diameter significantly. Silver nitrate at 50 ppm concentration with 20% Sucrose (T_5) influenced maximum flower diameter of 17.37 cm which was followed by treatment combination of 8-HQC at 100 ppm + $AgNO_3$ at 75 ppm and Sucrose (20%) (T_{11}) with 17 cm while lowest was recorded in Control (T_0) with 14.59 cm diameter (Fig. 3). The average flower diameter ranged from 14.59 to 17.37 cm. Results corroborate with the reports of Wani et.

al. (2009), who found maximum flower size of 16.74 cm in treatment with STS 2.0 mM and Sucrose 5% in lilium cut flower cv. Elite recorded. Verma et al. (2002) reported that flower diameter and petal area were increased by preservative solution compared to the lowest in control (distilled water) in cut carnation flowers. Bakhsh et al. (1999) reported that the flower diameter of tuberose was significantly affected and flowers treated with silver nitrate and silver thi-osulfate gave the maximum diameter as compared to the control. Chaudhary et al. (2016) reported Sucrose (2%) + HQC (200 ppm) + ABA (50 ppm) recorded a maximum of 12.77 cm in cut oriental lily. Vilas et al. (2017) reported that flower diameter in cut carnations was highly influenced by the treatment with 8-HQC 40 ppm. Chand et al. (2012) reported maximum flower size with $AgNO_3$ at 100 ppm in cv. 'Grand Gala' and 8-HQC at 100 ppm in cut rose flower cv. 'First Red' on 3rd day in the vase. Kombo and Sahare (2021) reported that stem treated 8-HQC at 200 ppm showed largest flower diameter of 13.63 cm in oriental hybrid cut lily. Kumar et al. (2020) reported that $AgNO_3$ at 125 ppm significantly impacted flower size and observed the highest flower size with $AgNO_3$ treatment in cut rose flower cv. First Red. Kshirsagar et al. (2021) reported maximum flower head diameter in cut rose flower cv. Top Secret at 30 ppm $AgNO_3$, boric acid 75 mg/l of water and 2% Sucrose. El-Attar and Sakr (2022) reported an increment in flower diameter and a decline in bacterial counts in vase solution. During the vase life period, it was observed that overall there was a maximum increase of 19.05 % in the third flower size over the control treatment.

Bloom life of third flower on the spike

Average days of bloom life of the third flower on the spike were counted from the day its bud opened and terminated when flowers lost its ornamental value. All treatments significantly influenced the bloom life of third flower. It was observed that the treatment combination with $AgNO_3$ 50 ppm and 20% Sucrose (T_5) has resulted in the highest no. of 9.17 days bloom life followed by 8-HQC (100 ppm) + $AgNO_3$ (75 ppm) + Sucrose (20%) combination treatment (T_{11}) with 8.50 days while T_0 (control) and T_1 treatments recorded the lowest bloom life of the third flower with 5.33 days on the flower spike (Fig. 4). The average of bloom life of the third flower ranged from 5.33 to 9.17 days. Wani et al. (2009) reported that the 1st flower of Lilium cut flower cv. Elite took a maximum of 5.08 days and 2nd flower took a maximum of 4.98 days in treatment with STS 2.0 mM and Sucrose 5%. It was observed that using the preservative solution, the bloom life of third flower was increased by a maximum of 72.05 % more days over the control treatment. The increase in bloom life might be due to the uptake of more water by the flower spike that helps maintain the physiological process and turgidity in flowers for a long time. Silver nitrate reduces microbial population in vase solution and improve water uptake by the cut stem. Sucrose, in combination with the pulsing solutions, showed significant increase in the bloom life of third flower by supplying the necessary energy requirements, while $AgNO_3$ is known to work as an anti-ethylene and biocide agent.

Dry weight

To determine the dry weight at the end of flower vase life, the flower spike of each treatment was weighed and then continuously dried under the sunlight for 20 days. It is observed that the pulsing solutions prominently increased the dry weight of the flower spike as compared to the control. It is also observed that $AgNO_3$ at 50 ppm concentration with 20% sucrose (T_5) has resulted in highest dry weight of 23.33 gm followed by treatment combination of 8-HQC (100 ppm) + $AgNO_3$ (75 ppm) and sucrose (20%) with 21.33 gm while the control (T_0) has resulted in lowest dry weight with 15.00 gm of the cut flower spike (Fig. 5). The average dry weight of the cut flower spike ranged from 15 to 23.33 gm. There was an increase of maximum of 55.53 % in dry weight of the flower spike over the control treatment.

Dry matter percentage

The dry weight of the flower spike was prominently increased over the control by the use of preservative

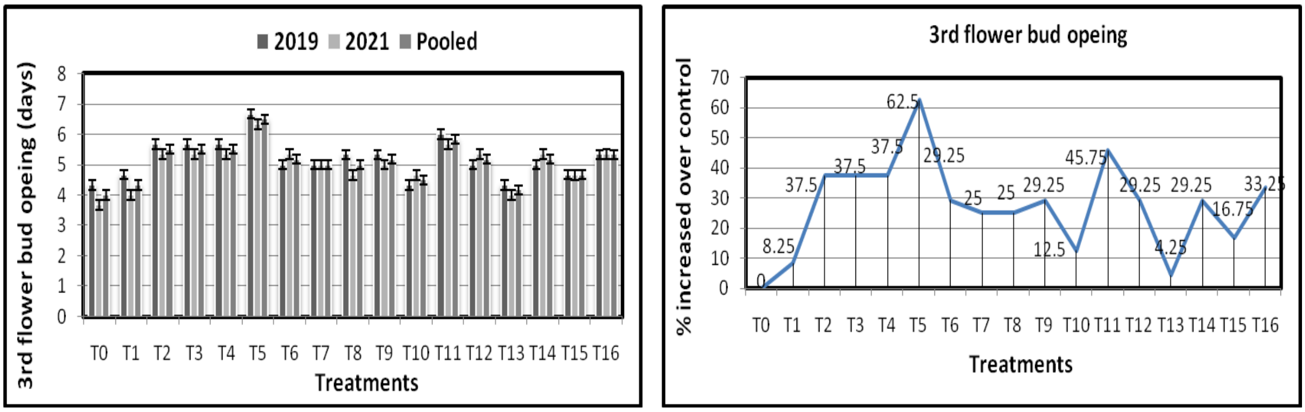


Fig. 1. *Third flower bud opening on spike (days)*

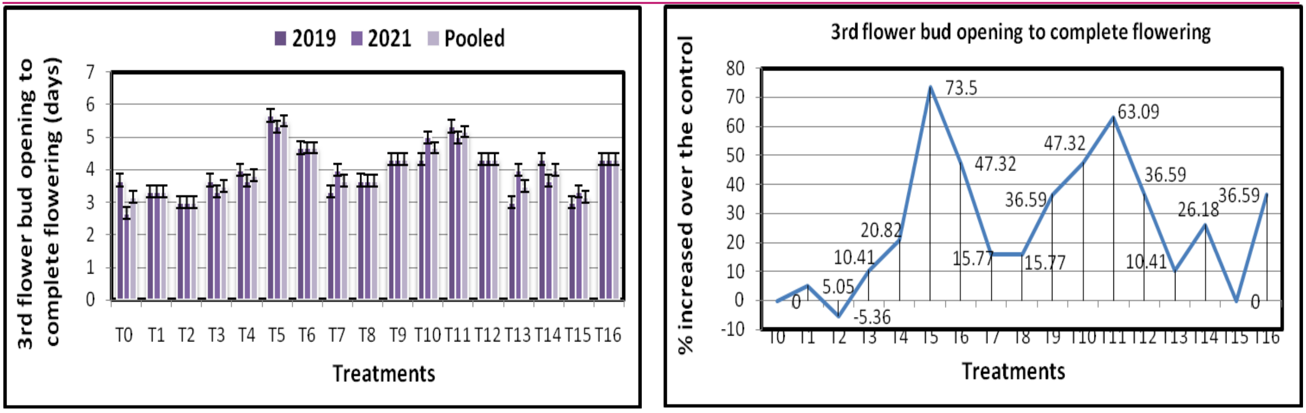


Fig. 2. *Third flower bud opening to complete flowering (days)*

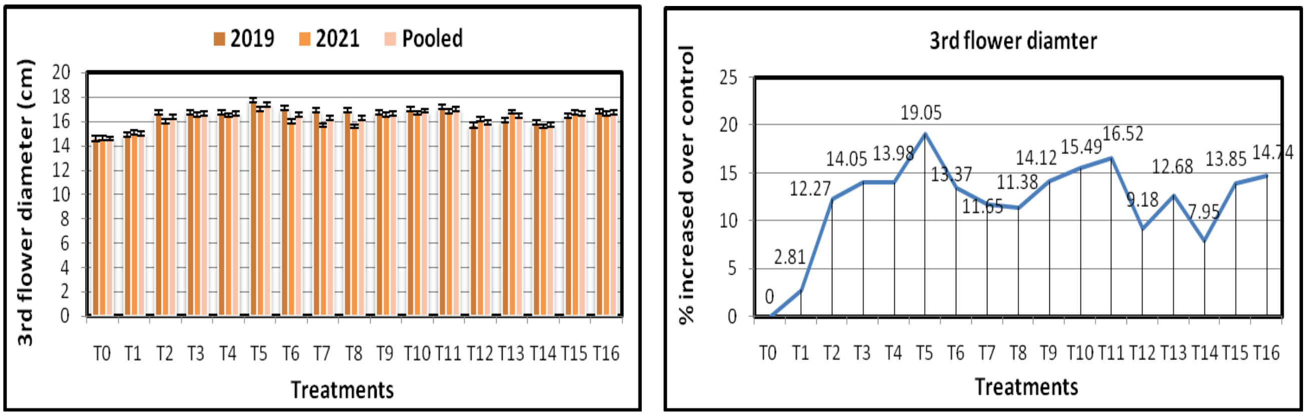


Fig. 3. *Third flower diameter (cm)*

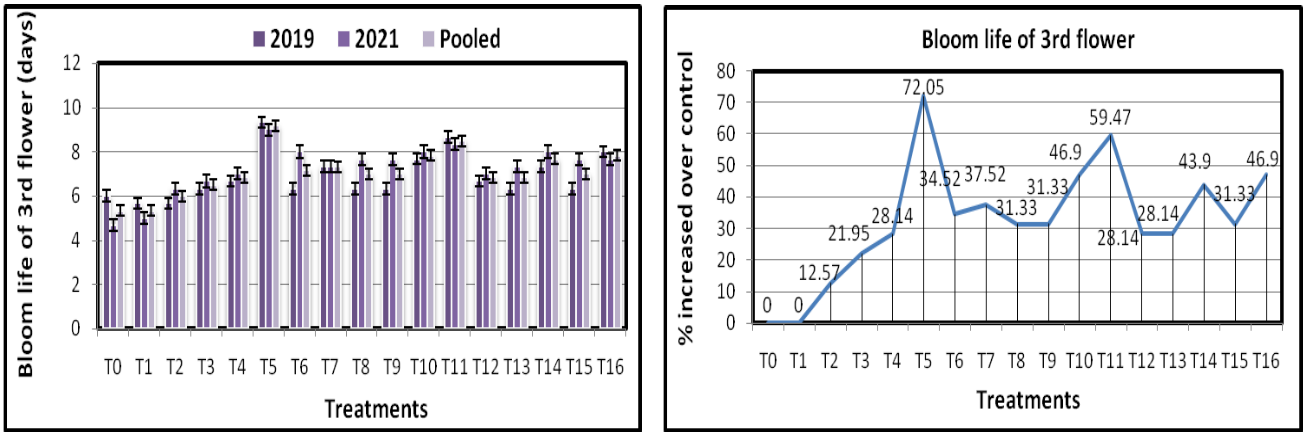


Fig. 4. *Bloom life of third flower on the spike (days)*

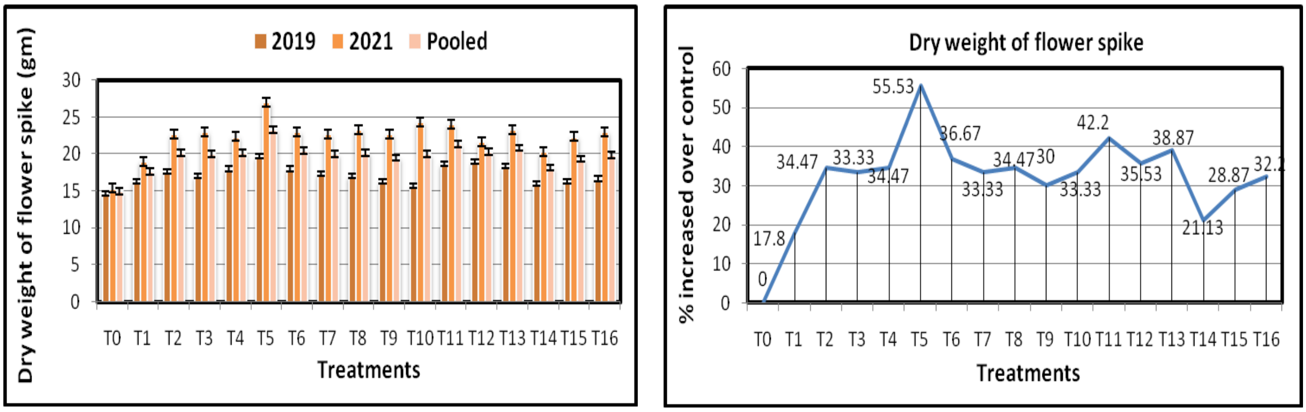
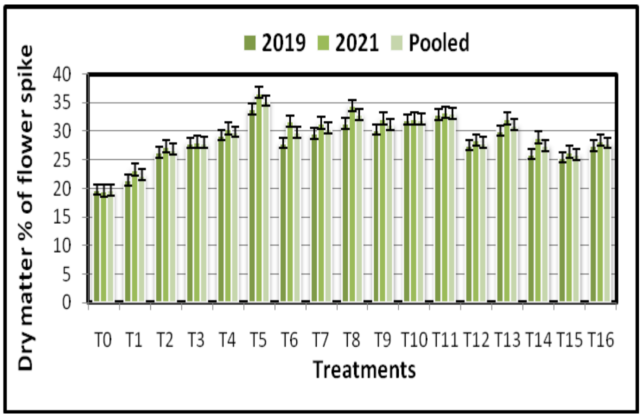


Fig. 5. *Dry weight of flower spike (gram)*



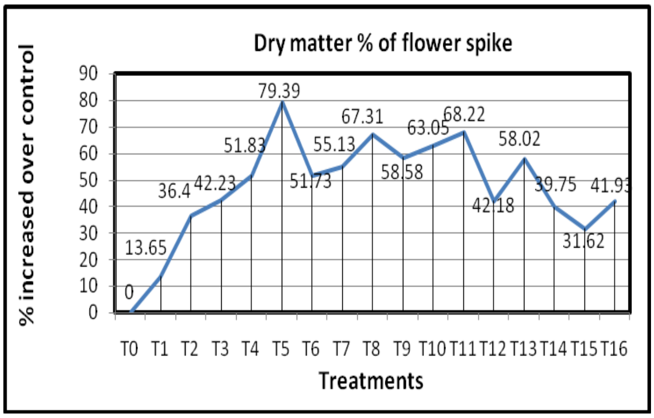


Fig. 6. *Dry matter percentage of cut flower spike (%)*

chemicals. It was observed that the treatment combination with $AgNO_3$ at 50 ppm and 20% Sucrose (T_5) resulted in the highest dry matter percentage of 35.34%, followed by 8-HQC (100 ppm) + $AgNO_3$ (75 ppm) + sucrose (20%) treatment combination (T_{11}) treatment with 33.14% while the control (T_0) has resulted in the lowest dry matter percentage with 19.7% (Fig. 6). The average dry matter percentage of the cut flower spike with the different treatment combinations ranged from 19.7 to 35.34%. The highest positive correlation coefficient was recorded between vase life and the dry weight of the flower spike. Silver nitrate ($AgNO_3$) increased the dry weight by increasing the solution intake, sustaining water balance and fresh weight of flower spike which resulted in increased shelf life over other treatments. Kazemi et al. (2011) reported beneficial impacts on the shelf life of carnation cut flowers by using different concentrations of $AgNO_3$. During the present study, the dry matter percentage was observed by a maximum of 79.39 % over the control treatment.

Conclusion

Silver nitrate and 8-hydroquinoline citrate pulsing solutions affected lilium cut fower cv. 'Pavia' at different concentrations with different combinations. Based on the results, it was concluded that silver nitrate with 20 % sucrose as a pulsing solution showed better results than the 8-hydroquinoline citrate pulsing solution in flower bud opening, flower bud opening to complete flowering, flower diameter, bloom life, dry weight and dry matter percentage. Among all the treatment concentrations, Silver nitrate at 50 ppm with 20% sucrose showed the most effective result in enhancing the selected parameters and hence improved the flower quality during the post-harvest life of lilium cut flower. 8-HQC at 100 ppm + AgNO3 at 75 ppm with 20 % sucrose showed better results among all the treatment combinations. This suggests that the specific pulsing solution, along with particular concentration and combination, could be useful to researchers, commercial producers, wholesalers, retailers, consumers or anyone considering utilising a pulsing solution to enhance lilium cut flowers' post-harvest life. This will help the end users retain the ornamental value of lilium cut flowers for longer than usual.

Conflict of interest

The authors declare that they have no conflict of interest.

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