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Response of post-harvest treatment in maintaining quality and reducing waste in cut spike gladiolus (*Gladiolus grandiflorus* L.) cv. (Saffron)

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Abstract

A lab study on “Response of post-harvest treatment in maintaining quality and reducing waste in cut spike gladiolus (*Gladiolus grandiflorus* L.) cv. (Saffron)” was conducted at the K.D. College of Horticulture and Research Station, Jagdalpur, Bastar (C.G.) during 2024–25. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. A total of nine post-harvest management treatments were evaluated, consisting of T₀ - Distil water, T₁ - Sucrose 2%, T₂ - Boric acid 2%, T₃ - Citric acid (200) ppm + Sucrose 2%, T₄ - Boric acid 4%, T₅ - GA₃ (200 ppm) + Sucrose 4%, T₆ - Salicylic acid (150) ppm, T₇ - Citric acid (200) ppm and T₈ - Salicylic acid (200) ppm. Observations on quality parameters of cut spike gladiolus such as fresh weight of spikes (g.), final weight of spikes (g.), physiological weight loss, water uptakes ratio, drooping of spike, florets remained open at a time, day taken to florets deterioration, diameter of florets (mm), floret opening (%), initial volume of water (ml), final volume of water (ml), longevity of spikes (days) and average vase life of spikes (days) were recorded and statistically analyzed. The study resulted that the post-harvest treatment T₅ – GA₃ (200 ppm) + Sucrose 4% consistently outperformed all other treatments in maintaining the quality of gladiolus cut spikes. This treatment recorded the highest fresh and final spike weights (45.41 g and 17.69 g), the lowest physiological weight loss (58.79%), the greatest water uptake ratio (0.94), the maximum number of florets opened (12.66), the longest duration for floret deterioration (5.22 days), the largest floret diameter (59.96 mm), the highest floret opening percentage (88.65%), the maximum water consumption (124.75 ml), the longest fifth spike longevity (10.57 days) and the highest average vase life (13.05 days). These findings suggest that GA₃ combined with higher sucrose concentration enhances water absorption, delays senescence, promotes floret expansion, and significantly extends vase life. In contrast, the control treatment T₀ – Distilled water showed the poorest performance, exhibiting the lowest spike weights, highest physiological weight loss, minimal water uptake, fewer florets opened, shortest floret longevity, smallest floret diameter, lowest floret opening percentage, least water consumption, shortest spike longevity and minimum vase life. Overall, T₅ – GA₃ (200 ppm) + Sucrose 4% proved to be the most effective post-harvest treatment, followed closely by T₃ – Citric acid 200 ppm + Sucrose 2%, both ensuring superior spike quality, prolonged freshness and enhanced market value.

Keywords: Gladiolus, citric acid, boric acid, salicylic acid, sucrose and GA₃.

Introduction

Gladiolus (*Gladiolus grandiflorus* L.) is an herbaceous perennial and an important ornamental bulbous flowering crop. It ranks among the most widely cultivated cut flowers across the world and in India (Kazemi *et al.*, 2011) ^[14]. Floriculture, a major component of ornamental horticulture, is steadily gaining importance among small and commercial farmers in India due to its growing market demand. The genus name “Gladiolus” originates from the Latin word gladius, meaning “sword” referring to the plant’s sword-shaped leaves. Because of its striking floral spikes and foliage, gladiolus is commonly referred to as the “Queen of Bulbous Flowers” or “Sword Lily”. Gladiolus was introduced to India between the 16th and 17th centuries by the British. In the country, it is cultivated over an area of about 12.85 thousand hectares, producing approximately 319.12 thousand metric tonnes of flowers for both loose and cut flower purposes (Anonymous, 2022) ^[4]. In Chhattisgarh, gladiolus occupies an area of 2,224 hectares with a total

production 6,693 metric tonnes (Anonymous, 2018) ^[5]. Commercial cultivation of gladiolus in India is mainly concentrated in states such as West Bengal, Himachal Pradesh, Sikkim, Karnataka, Uttar Pradesh, Tamil Nadu, Punjab, Delhi, Tripura, Assam, Manipur, Meghalaya, and Nagaland. The most important aspect of the flower industry is post-harvest handling, which allows flowers to keep their freshness and colour after being cut from the mother plant for a longer period of time. Various factors are responsible for maintaining good quality and prolonging vase life of cut flowers viz. internal mechanism that includes maintenance of optimum water balance between water uptake and water loss, respiration rate, stem plugging and production ethylene and external factors such as climatic conditions and microbial attack on the cut end of the spike (Anonymous, 2022) ^[4]. Cut flowers are living tissues with an active metabolism, subject to the same basic ageing phenomenon as that of other plant parts. The post-harvest longevity of flower has a critical importance in determining the value of crop. This is particularly true with cut flower and it is a necessity for extended handling and transportation. The flowers are highly perishable and therefore need to be treated with suitable chemicals, to enhance their vase life and improve quality. There are reports that improper post-harvest handling accounts to 20 to 30% of cut flower loss during marketing (Singh and Singh, 2023) ^[24]. Keeping quality is an important parameter for evaluation of cut flower quality for both domestic and export markets. Most floral preservatives contain germicides, ethylene synthesis inhibitors, growth regulators, mineral compounds and carbohydrates that are essential to extend the vase life of cut flowers.

Sucrose is widely used in floral preservatives, which acts as a food source of respiratory substrate and delays the degradation of proteins, improves the water balance of cut flower. Treatment of flowers with solutions containing sucrose improves the vase life of gladiolus. Sucrose provides readily available energy for respiration and metabolic activities, supporting continued flower opening and spike elongation. It maintains turgidity and freshness of florets and slows down wilting, fading and abscission by supplying food reserves. Encourages uniform opening of upper florets that might otherwise remain closed due to lack of assimilates. Boric acid is often included in vase solutions for cut gladiolus spikes because it helps improve their post-harvest life. It suppresses bacterial and fungal growth in vase water. This prevents xylem blockage, allowing continuous water uptake by the stem. By keeping vascular tissues free from microbial plugs, it helps maintain turgidity and prevents premature wilting of florets. It results in prolonged freshness, delayed senescence and improved opening of upper florets in gladiolus spikes.

Citric acid is commonly used in vase solutions for gladiolus spikes because it helps in maintaining water uptake and delaying senescence. It lowers the pH of vase water, which enhances water absorption through the stem and reduces vascular blockage. Citric acid inhibits growth of bacteria and fungi in vase solutions, keeping the xylem vessels clear for continuous water uptake. It reduces deposition of microbial slime and inorganic salts in stem vessels, preventing early wilting, ensures sufficient water reaches florets, helping upper florets open properly and stay fresh longer. When combined with sucrose, citric acid prevents microbial growth that sucrose alone would encourage, thereby improving vase life and spike quality. Gibberellic acid is used in vase solutions or as a pretreatment to improve the post-harvest life of gladiolus spikes. GA₃ slows down physiological aging processes in florets, thereby extending vase life. Promotes elongation of pedicels and helps in uniform

opening of florets, including the upper ones that often remain unopened. By delaying degradation of chlorophyll and proteins, it helps preserve the green color of spikes and freshness of florets. It enhances cell elongation and keeps tissue hydrated, reducing floret wilting. When combined with sucrose and antimicrobial agents, GA₃ further improves spike longevity and ornamental value. Salicylic acid (SA) is widely studied as a postharvest treatment for cut flowers, including gladiolus, because of its growth regulator and anti-senescence properties. SA slows down natural aging by inhibiting ethylene production and action, which is a key hormone that accelerates floret wilting. It reduces lipid per-oxidation and oxidative damage, thereby keeping cell membranes intact and delaying tissue collapse. Promotes the activity of antioxidant enzymes (like superoxide dismutase, Catalase and polyphenol oxidase), which help in scavenging reactive oxygen species and prolong freshness. Salicylic acid keeps xylem vessels free from blockage, ensuring steady water uptake and preventing premature wilting. It supports proper and uniform opening of upper florets, enhancing ornamental value (Uddin *et al.*, 2016).

Materials and Methods

A lab experiment entitled “Response of post-harvest treatment in maintaining quality and reducing waste in cut spike gladiolus (*Gladiolus grandifloras* L.) cv. (Saffron)” was conducted at the K.D. College of Horticulture and Research Station, Jagdalpur, Bastar (C.G.) during 2024-25. The experiment was conducted using a Completely Randomized Design (CRD) with three replications. A total of nine post-harvest management treatments were evaluated, consisting of T₀ - Distil water, T₁ - Sucrose 2%, T₂ - Boric acid 2%, T₃ - Citric acid (200) ppm + Sucrose 2%, T₄ - Boric acid 4%, T₅ - GA₃ (200 ppm) + Sucrose 4%, T₆ - Salicylic acid (150) ppm, T₇ - Citric acid (200) ppm and T₈ - Salicylic acid (200) ppm. Observations on quality parameters of cut spike gladiolus such as fresh weight of spikes (g.), final weight of spikes (g.), physiological weight loss, water uptakes ratio, drooping of spike, florets remained open at a time, day taken to florets deterioration, diameter of florets (mm), floret opening (%), initial volume of water (ml), final volume of water (ml), longevity of spikes (days) and average vase life of spikes (days) were recorded and statistically analyzed.

Results and Discussion

Growth Parameters

1. Fresh weight of spikes (g)

The fresh weight of cut gladiolus spikes was significantly influenced by post-harvest treatments. The maximum fresh weight was recorded in T₅ - GA₃ (200 ppm) + sucrose 4% (45.41 g), which was statistically at par with T₃ - citric acid (200 ppm) + sucrose 2% (44.79 g). The lowest fresh weight was recorded in the control, T₀ - distilled water (25.61 g). The higher fresh weight under combined treatments may be attributed to improved carbohydrate supply, enhanced water uptake, and delayed senescence.

2. Final weight of spikes (g)

The final weight of cut gladiolus spikes was significantly affected by different post-harvest treatments. The highest final spike weight was recorded in T₅ - GA₃ (200 ppm) + sucrose 4% (17.69 g), which was statistically at par with T₃ - citric acid (200 ppm) + sucrose 2% (17.44 g) and superior to all other treatments. Moderate final weights were observed in T₄ - boric acid 4% (16.18 g) and T₈ - salicylic acid 200 ppm (16.04 g), whereas the lowest final spike weight was recorded in the control, T₀ - distilled water (10.98 g).

3. Physiological weight loss (%)

The minimum physiological weight loss was recorded in T₅ – GA₃ (200 ppm) + sucrose 4% (58.79%), which was found to be significantly superior over all other treatments. This treatment was statistically at par with T₃ – citric acid (200 ppm) + sucrose 2% (59.68%), both of which effectively minimized post-harvest weight loss. The maximum physiological weight loss was consistently observed in T₀ – distilled water (80.39%), indicating rapid moisture loss and advanced senescence in untreated spikes.

4. Water uptakes ratio

The highest water uptake ratio was recorded in T₅ – GA₃ (200 ppm) + sucrose 4% (0.94), followed closely by T₃ – citric acid (200 ppm) + sucrose 2% (0.93). These treatments exhibited comparatively higher water uptake over the rest of the treatments. Slightly lower but comparable values were observed in T₄ – boric acid 4% (0.89) and T₈ – salicylic acid 200 ppm (0.88). The lowest water uptake ratio was observed in T₀ – distilled water (0.76).

5. Drooping of spike

The longest duration before floret drooping in cut gladiolus was observed under T₅ – GA₃ (200 ppm) + sucrose 4%, with the 1st and 5th florets drooping at 5.74 days and 9.39 days, respectively. This was statistically at par with T₃ – citric acid (200 ppm) + sucrose 2% (5.66 days and 9.29 days). Intermediate delays were seen in T₄ – boric acid 4%, T₈ – salicylic acid 200 ppm and T₇ – citric acid 200 ppm, while T₆ – salicylic acid 150 ppm, T₂ – boric acid 2%, and T₁ – sucrose 2% showed lesser effects. The earliest drooping occurred in T₀ – distilled water (3.34 days and 6.55 days).

6. Florets remained open at a time

The maximum number of florets remained open at a time in cut gladiolus was recorded under T₅ – GA₃ (200 ppm) + sucrose 4% (12.66), which was statistically at par with T₃ – citric acid (200 ppm) + sucrose 2% (12.48). The lowest number of florets open was in T₀ – distilled water (7.14). Treatments with GA₃ combined with sucrose or citric acid improved floret opening by enhancing carbohydrate supply, water balance, delaying senescence and promoting cell elongation.

7. Day taken to florets deterioration

The maximum delay in floret deterioration of cut gladiolus was observed under T₅ – GA₃ (200 ppm) + sucrose 4% (5.22 days), which was statistically at par with T₃ – citric acid (200 ppm) + sucrose 2% (5.15 days). These treatments were significantly superior to other treatments. The earliest floret deterioration occurred in T₀ – distilled water (3.04 days), indicating rapid senescence without post-harvest preservatives.

8. Diameter of florets (mm)

The maximum floret diameter in cut gladiolus was observed under T₅ – GA₃ (200 ppm) + sucrose 4% (59.96 mm), which was statistically at par with T₃ – citric acid (200 ppm) + sucrose 2% (59.40 mm). The lowest diameter occurred in T₀ – distilled water (44.33 mm), indicating poor floret development without post-harvest treatments.

9. Floret opening (%)

The highest floret opening in cut gladiolus was recorded under T₅ – GA₃ (200 ppm) + sucrose 4% (88.65%), which was statistically at par with T₃ – citric acid (200 ppm) + sucrose 2% (87.92%). Intermediate opening was observed in T₄, T₆, T₇, and T₈ (84.64–85.83%), while the lowest opening occurred in T₀ – distilled water (76.94%).

10. Volume of water

The lowest final water volume in cut gladiolus spikes, indicating highest water uptake, was recorded under T₅ – GA₃ (200 ppm) + sucrose 4% (124.75 ml), which was statistically at par with T₃ – citric acid (200 ppm) + sucrose 2% (127.59 ml). Moderate water uptake was observed in T₁ – sucrose 2% (146.07 ml) and T₂ – boric acid 2% (142.26 ml), while the highest final water volume was in T₀ – distilled water (163.16 ml), indicating the least water absorption.

11. Longevity of spikes (days)

The highest longevity of the 5th spike (10.57 days) was achieved with T₅ – GA₃ (200 ppm) + sucrose 4%, indicating its effectiveness in prolonging vase life. This treatment was closely followed by T₃ – citric acid (200 ppm) + sucrose 2%, which recorded 10.42 days of longevity and was statistically at par with T₅. Both treatments outperformed the rest of the treatments as well as the control. The shortest longevity was noted in T₀ – distilled water (5.96 days), reflecting rapid senescence under untreated conditions.

12. vase life of spikes (days)

The average vase life of cut gladiolus spikes was significantly influenced by post-harvest treatments. The longest vase life was observed in T₅ – GA₃ (200 ppm) + sucrose 4% (13.05 days), closely followed by T₃ – citric acid (200 ppm) + sucrose 2% (12.87 days), both being statistically superior to other treatments. The shortest vase life was recorded in T₀ – distilled water (7.36 days). Treatments combining sucrose with growth regulators or organic acids (T₃ and T₅) enhanced vase life by improving carbohydrate supply, water uptake and delaying senescence.

Table 1: Response of post-harvest treatment in weight of cut spike gladiolus (*Gladiolus grandiflorus* L.)

Treatment details	Fresh weight of spikes (g.)	Final weight of spikes (g.)
T ₀ - Distilled water	25.61	10.98
T ₁ - Sucrose 2%	34.59	13.47
T ₂ - Boric acid 2%	35.74	13.92
T ₃ - Citric acid (200) ppm + Sucrose 2%	44.79	17.44
T ₄ - Boric acid 4%	41.55	16.18
T ₅ - GA ₃ (200 ppm) + Sucrose 4%	45.41	17.69
T ₆ - Salicylic acid (150) ppm	39.43	15.36
T ₇ - Citric acid (200) ppm	40.26	15.68
T ₈ - Salicylic acid (200) ppm	41.17	16.04
SEm (±)	1.05	0.30
CD (5%)	3.12	0.88
CV (5%)	4.70	3.37

Table 2: Response of post-harvest treatment in physiological loss and water uptake ratio of cut spike gladiolus (*Gladiolus grandiflorus* L.)

Treatment details	Physiological weight loss (%)	Water uptake ratio
T ₀ - Distilled water	80.39	0.76
T ₁ - Sucrose 2%	74.10	0.80
T ₂ - Boric acid 2%	72.47	0.81
T ₃ - Citric acid (200) ppm + Sucrose 2%	59.68	0.93
T ₄ - Boric acid 4%	64.26	0.89
T ₅ - GA ₃ (200 ppm) + Sucrose 4%	58.79	0.94
T ₆ - Salicylic acid (150) ppm	67.26	0.85
T ₇ - Citric acid (200) ppm	66.08	0.86
T ₈ - Salicylic acid (200) ppm	64.80	0.88
SEm (±)	1.05	0.04
CD (5%)	3.11	NS
CV (5%)	4.68	7.74

Table 3: Response of post-harvest treatment in florets open, floret deterioration and floret diameter of cut spike gladiolus (*Gladiolus grandiflorus* L.)

Treatment details	Florets remained open at a time	Day taken to florets deterioration	Diameter of florets (mm)
T ₀ - Distilled water	7.14	5.89	44.33
T ₁ - Sucrose 2%	9.64	7.95	49.63
T ₂ - Boric acid 2%	9.96	8.22	50.73
T ₃ - Citric acid (200) ppm + Sucrose 2%	12.48	10.30	59.40
T ₄ - Boric acid 4%	11.58	9.55	56.30
T ₅ - GA ₃ (200 ppm) + Sucrose 4%	12.66	10.44	59.96
T ₆ - Salicylic acid (150) ppm	10.99	9.06	54.26
T ₇ - Citric acid (200) ppm	11.22	9.26	55.06
T ₈ - Salicylic acid (200) ppm	11.48	9.46	55.93
SEm (±)	0.28	0.21	1.16
CD (5%)	0.82	0.63	3.44
CV (5%)	4.43	4.13	5.72

Table 4: Response of post-harvest treatment in florets opening (%) and volume of water of cut spike gladiolus (*Gladiolus grandiflorus* L.)

Treatment details	Floret opening (%)	Initial volume of water (ml)	Final volume of water (ml)
T ₀ - Distilled water	76.94	200.00	163.16
T ₁ - Sucrose 2%	80.71	200.00	146.07
T ₂ - Boric acid 2%	81.58	200.00	142.26
T ₃ - Citric acid (200) ppm + Sucrose 2%	87.92	200.00	127.59
T ₄ - Boric acid 4%	85.83	200.00	131.36
T ₅ - GA ₃ (200 ppm) + Sucrose 4%	88.65	200.00	124.75
T ₆ - Salicylic acid (150) ppm	84.64	200.00	138.05
T ₇ - Citric acid (200) ppm	84.96	200.00	135.47
T ₈ - Salicylic acid (200) ppm	85.42	200.00	133.98
SEm (±)	0.42		2.56
CD (5%)	1.26		4.62
CV (5%)	4.87		4.22

Table 5: Response of post-harvest treatment in longevity and average vase life of cut spike gladiolus (*Gladiolus grandiflorus* L.)

Treatment details	Longevity of 5 th floret (days)	vase life of spikes (days)
T ₀ - Distilled water	2.59	7.36
T ₁ - Sucrose 2%	3.50	9.94
T ₂ - Boric acid 2%	3.62	10.27
T ₃ - Citric acid (200) ppm + Sucrose 2%	4.53	12.87
T ₄ - Boric acid 4%	4.20	11.94
T ₅ - GA ₃ (200 ppm) + Sucrose 4%	4.59	13.05
T ₆ - Salicylic acid (150) ppm	3.99	11.33
T ₇ - Citric acid (200) ppm	4.07	11.57
T ₈ - Salicylic acid (200) ppm	4.16	11.83
SEm (±)	0.07	0.26
CD (5%)	0.22	0.78
CV (5%)	4.27	4.09

Conclusion

The study revealed that the post-harvest treatment T₅ – GA₃ (200 ppm) + Sucrose 4% consistently produced the best results across all quality parameters of cut spikes of gladiolus. This treatment

recorded the maximum fresh and final spike weight (45.41 g and 17.69 g), lowest physiological weight loss (58.79%), highest water uptake ratio (0.94), maximum florets opened (12.66), longest time to floret deterioration (5.22 days), largest floret

diameter (59.96 mm), highest floret opening percentage (88.65%), maximum water consumption (124.75 ml), longest 5th spike longevity (10.57 days) and the highest average vase life (13.05 days). These results demonstrate that GA₃ combined with a higher sucrose concentration effectively enhances water absorption, delays senescence, improves floret expansion and significantly extends vase life. In contrast, the control T₀ – Distilled water exhibited the poorest performance, with the lowest spike weights, highest physiological weight loss, minimum water uptake, fewer florets open, shortest deterioration period, smallest floret diameter, lowest floret opening percentage, least water use, shortest spike longevity and minimum vase life.

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