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Effect of pulsing, interval of stalk-end cutting and vase water renewal on the vase life of Heliconia

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Abstract
The present investigation, entitled *"*Effect of Pulsing, Interval of Stalk-End Cutting and Vase Water Renewal on the Vase Life of Heliconia,*"* was conducted at the Floricultural Research Station, SKLTGHU, Rajendranagar from June to September 2024 using a factorial completely randomized design with three replications per treatment. The parameters evaluated included Change in fresh weight after pulsing (g), water uptake (g/f), optical density (OD), Bract colour fading and vase life (days). Factor I comprised of five pulsing treatments including combinations of 3% or 6% sucrose with 150 or 300 ppm salicylic acid applied for either 6 or 12 hours. Among them, P_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid) significantly recorded the lowest fresh weight change (g), OD values, while P_2 (Pulsing for 12 hours in 3% Sucrose + 150 ppm of Salicylic Acid) recorded the maximum water uptake (g/f). The second factor involves stalk end cutting and renewal of vase water at intervals of 0 (no cutting/renewal), 2 and 4 days. Among them, I_1 (Stalk end cutting and renewal of water at every 2 days) significantly recorded the maximum water uptake (g/f). The interaction effect of factors significantly enhanced overall post-harvest performance with maximum water uptake (g/f), vase life (days), whereas the minimum OD value, change in bract colour fading was recorded in P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid with Stalk end cutting and renewal of water at every 2 days).

Keywords: Pulsing, salicylic acid, stalk end cutting, water renewal, vase life, Heliconia

Introduction
India's diverse agro-climatic zones support floriculture, with significant growth in exports and a shift to commercial production. In 2023-2024, 285 thousand hectares yielded 947 thousand tonnes of cut flowers and 2,284 thousand tonnes of loose flowers (NHB, 2023-2024). Heliconia, known for its vibrant bracts and durability, is highly valued in landscaping and floral decor. Thriving at 1000-1300 m elevation (Sheela, 2008) [20], it commands a premium price due to its exotic appeal and market demand. Heliconias are popular for landscaping and as cut flowers, with some varieties also used as cut greens. Native to tropical America (Berry & Kress, 1991) [4], Heliconia is known by names like "Lobster Claw" and "False Bird of Paradise." Renowned for vibrant bracts in red, pink, orange, yellow and green, the genus includes 89 species and 350+ varieties, with key species like *H. psittacorum*, *H. rostrata*, and *H. wagneriana* (Criley *et al*., 1997) [9].

Heliconias usually have a 6-8 days vase life, with senescence caused by stem stress, microbial contamination, air embolism, and nutrient deficiency (Gupta and Dubey, 2018) [11]. With Heliconia's growing global demand, addressing post-harvest issues like low water absorption, bract darkening, and senescence is crucial. Floral preservatives effectively extend vase life, enhancing its commercial value (Babarabie *et al*., 2015) [2]. Storing cut flowers in various preservatives has long been an effective method to enhance their longevity, a practice known as pulsing (Khan *et al*., 2007) [16].

Pulsing, a treatment with sucrose and chemicals for up to 2 days, maintains physiological processes by reducing microbial load, enhancing water absorption, and supplying respiration substrates (Pun and Ichimura, 2003) [18]. Pulsing solutions contain carbohydrates, growth regulators, ethylene inhibitors, biocides, and acidifiers along with sucrose as the primary energy source for petal growth (Han, 2003) [13].

Salicylic acid (SA), a natural growth regulator, extends cut flower longevity by regulating physiological processes and reducing membrane lipid peroxidation through its activation of

antioxidant enzymes, thereby neutralizing oxygen free radicals that accelerate senescence (Jamshidi *et al*., 2014). In *Anthurium andraeanum*, stem-end dipping (2mm) of SA minimized chilling injury and browning at 4±0.5 °C, delaying spathe senescence by lowering polyphenol oxidase activity and electrolyte leakage (Aghdam *et al*., 2016) [1]. Hatamzadeh *et al*. (2012) [14] and Iqbal *et al*. (2012) [15] reported improved vase life in *Gladiolus* and *Zinnia* with 150 mg/L and 50 mg/L SA, respectively.

Investigations into the practice of regularly renewing the maintenance solution, suggests that it enhances the post-harvest longevity of 'Golden Torch' stems by, interrupting the development cycle of possible microorganisms presented in the tap water used, especially since no germicidal substances were added to the solution (Carrera Alvarado *et al*., 2020) [6].

Heliconia stems face water imbalance during transport due to reduced uptake, causing leaf folding, bract discoloration, and deterioration. Xylem blockages from vascular occlusions, air embolisms, microbial contamination, and secondary metabolites hinder hydration, accelerating senescence (Van Doorn, 1997) [21]. Excessive transpiration worsens moisture loss. Recutting stems and using floral preservatives help restore water potential, improving absorption and hydration (Broschat & Donselmann, 1988) [4]. Effectiveness depends on recutting frequency, preservative composition, and storage conditions.

Materials and Methods

The experiment was conducted from June to September, 2024 at Floricultural Research Station, Agricultural Research Institute, Sri Konda Laxman Telangana Horticultural University, Rajendranagar, Hyderabad (17.90°N, 78.23°E, 542.3 m AMSL). The study was performed in the station's research laboratory, maintained at an ambient temperature of 25±5°C and relative humidity of 70-80%, under white, fluorescent lighting. The experiment was laid out in a factorial completely randomized design (FCRD) with two factors, replicated thrice. The first factor consists of five pulsing treatments *viz*., P_0-Control (Distilled water + 12 hours), P_1-Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, P_2-Pulsing for 12 hours in 3% Sucrose + 150 ppm of Salicylic Acid, P_3-Pulsing for 6 hours in 6% Sucrose + 300 ppm of Salicylic Acid, P_4-Pulsing for 12 hours in 6% Sucrose + 300 ppm of Salicylic Acid. The second factor consists of three intervals of stem end cuttings and renewal of water treatments: I_0-control, I_1-Stalk end cutting and renewal of water at every 2 days, I_2-Stalk end cutting and renewal of water at every 4 days. Data on Change in fresh weight after pulsing (g), Water uptake (WU, g/f) at an interval of 2 days, OD value of vase solution at an interval of 2 days, Bract colour fading (chromometer) and Vase life (days) were recorded at the end of observation period and subjected to statistical analysis, as described by (Gomez and Gomez, 1984) [10]. Standard Error of Mean (S.Em±), Critical Difference (CD) at 5% probability and Co-efficient of Variance (CV%) was worked out for the interpretation of the results.

Results and Discussion

1. Change in fresh weight after pulsing (g)

The effect of pulsing treatments on change in fresh weight (g) during the vase life of heliconia cut spike was recorded immediately after completion of pulsing and the analysed data presented in Table 1 and graphically depicted in Fig. 1. Among the pulsing treatments, the minimum fresh weight loss was observed in cut spikes placed in P_1 (0.57 g). However, the maximum fresh weight loss (g) was recorded in cut spikes placed in P_4 (1.88 g). The minimal fresh weight change in P_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid) could be attributed to the role of sucrose, which acted as a building block and supplied the essential energy needed, thereby slowing down the rate of respiration (Costa *et al*., 2012) [8]. Additionally, salicylic acid served as an efficient antimicrobial agent.

2. Water uptake (WU, g/f)

The effect of pulsing treatments, interval of stem end cut and water renewal on water uptake of heliconia cut spikes was recorded every alternate day until the end of their vase life and the analysed data is presented in Table 2 and graphically depicted in Fig. 2. It is evident from the data that there was a significant difference between the treatments that influence water uptake in heliconia cut spikes.

Among the pulsing treatments, the highest water uptake was observed in cut spikes under P_2 (Pulsing for 12 hours in 3% Sucrose + 150 ppm of Salicylic Acid) (11.71 g/f and 13.34 g/f) which is at par with P_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid) (11.52 g/f and 13.21 g/f) on 2nd and 4th day respectively. Similarly highest water uptake was observed in cut spikes in P_1 (14.70 g/f and 13.84 g/f) which is at par with P_2 (14.47 g/f and 13.25 g/f) on 6th and 8th day respectively. However, lowest water uptake was observed in P_0 (control) on 2nd (10.16), 4th (11.77 g/f) and 6th day (13.24 g/f) respectively. In contrast, the lowest water uptake on the 8th day (11.91 g/f) was observed in P_4 (Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 12 hours).

Interval of stem end cutting and water renewal had significant effect on water uptake of heliconia cut spike. Among the various treatments, significantly highest water uptake was observed in I_1 (Stalk end cutting and renewal of water at every 2 days) on 2nd (13.43 g/f), 4th (14.46 g/f), 6th (16.42 g/f) and 8th (16.51 g/f) day respectively, whereas lowest quantity of water was taken up by cut spikes placed in I_0 treatment (No stem end cut and no renewal of water) on 2nd, 4th, 6th and 8th day (9.19 g/f, 11.14 g/f, 12.12 g/f and 10.49 g/f) respectively.

The interaction between pulsing treatment, Interval of stem end cuttings and water renewal had a significant effect on water uptake of heliconia cut spike. Among the various treatments, significantly highest water uptake was observed in P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) on 2nd (14.45 g/f), 4th (15.20 g/f), 6th (17.49 g/f) and 8th (18.59 g/f) day which is at par with P_3I_1 (Pulsing for 6 hours in 6% Sucrose + 300 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) on 2nd (14.18 g/f), 4th (14.99 g/f), and 6th (17.16 g/f) day respectively. However, lowest water uptake was observed in treatment P_0I_0 (Control with No stalk end cut and no renewal of water) on 2nd, 4th, 6th and 8th day respectively (8.35 g/f, 10.03 g/f, 11.17 g/f and 9.64 g/f). Water uptake increased steadily, peaking on the 6th day before declining. This uptake is vital for maintaining hydration, reducing wilting, and slowing senescence (Costa *et al*., 2021) [7]. Disruptions due to cavitation or microbial blockages hinder absorption (Wang *et al*., 2014) [22]. Water renewal, as in P_1I_1, disrupts microbial growth and improves uptake. The synergy between sucrose and salicylic acid at lower concentrations enhances xylem function and osmotic

balance, facilitating better water transport and flower hydration (Seyed Hajizadeh *et al*., 2024) [19].

3. Optical density (OD)

The effect of pulsing treatments, interval of stem end cut and water renewal on OD value of vase water was recorded at every alternate day up to the end of vase life and the analysed data is presented in Table 3 and graphically depicted in Fig. 3.

Among the pulsing treatments, significantly lowest OD value of vase water was observed in cut spikes placed in P_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid) on 2nd, 4th, 6th and 8th day (0.006, 0.011, 0.012 and 0.014 respectively) which was on par with P_2 (Pulsing for 12 hours in 3% Sucrose + 150 ppm of Salicylic Acid) on 2nd, 4th, 6th and 8th day (0.006, 0.011, 0.012 and 0.015) respectively. Whereas, the highest OD value of the vase water was observed in P_0 (Control) on 2nd, 4th, 6th and 8th day (0.010, 0.016, 0.021 and 0.024 respectively).

Interval of stem end cutting and water renewal had a significant effect on OD value of vase water of heliconia cut spikes. Among the various treatments, significantly lowest OD value of vase water was observed in I_1 (Stalk end cutting and renewal of water at every 2 days) on 2nd, 4th, 6th and 8th day (0.004, 0.006, 0.010 and 0.012) respectively. Whereas, the highest OD value of vase water was observed in I_0 treatment (No stem end cut and no renewal of water) on 2nd, 4th, 6th and 8th day (0.012, 0.018, 0.022 and 0.025) respectively.

The interaction between pulsing treatment, Interval of stem end cutting and water renewal had a significant effect on OD value of vase water during vase life of heliconia cut spikes. Among the various treatments, significantly lowest OD value of vase water was observed in P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) on the 2nd, 4th and 6th day (0.001, 0.004 and 0.007) respectively. In contrast, P_4I_2 (Pulsing for 12 hours in 6% Sucrose + 300 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) recorded the lowest OD value on 8th day (0.009). However, highest OD values were recorded in P_0I_0 (Control with No stalk end cut and no renewal of water) on 2nd, 4th, 6th and 8th day (0.015, 0.027, 0.031 and 0.034) respectively. The OD values of solution represent the turbidity of vase solution which might be due to vascular leakages or microbial growth. The lowest OD value of vase water in treatment P_1I_1 might be due to low bacterial count as this treatment registered maximum water up take and transpirational loss of water than other treatments.

4. Bract colour fading

The effect of pulsing treatments, interval of stem end cut and water renewal on change in bract colour of cut spike was recorded on the initial day and final day of vase life. The analysed data is presented in Table 4.

Luminosity (L*): Luminosity indicates the brightness of the bract colour. Minimum bract colour fading, indicated by the smallest reduction in L* values from initial to final day, was observed in treatments P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) (50.35 to 49.97), P_3I_1 (48.62 to 48.08) and P_2I_2 (49.02 to 48.35), showing better colour retention. In contrast, the highest bract colour loss occurred in the control treatment P_0I_0 (49.55 to 47.17), indicating accelerated senescence.

a* (red-green axis) value Indicates the position of the colour on the green-to-red spectrum. On initial day, a* axis value ranged from (15.53 to 19.77) which falls under the positive side of Reddish orange colour. In all the treatments the colour retained on the positive side i.e, reddish orange colour range. However, there was a shift in the colour from brighter to darker hue. Very minimum bract colour loss was observed in P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) (19.77 to 19.22), which shows that there was barely any colour fading and the bracts retained their original colour till the end of the vase life.

b* value (yellow-blue axis) represents yellow to bluish colour. On the initial day, all the treatments recorded positive range, representing yellow colour with a range from 34.22 to 39.88. There was a shift of colour fading in all the treatments at the end of vase life. The minimal bract colour fading was observed in P_3I_1 (Pulsing for 6 hours in 6% Sucrose + 300 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) (37.18 to 37.5), followed by P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) (39.88 to 40.25).

There is a negative correlation between a* and b* axis and storage duration, physiological stress on flowers. As the stress on the flower stalk and the duration increased, there was a corresponding reduction in the red and yellow colouration. Similarly, the fresh weight change, also showed negative correlation with luminosity, a and b axis. The results are in conformity with the research work of Bañuelos-Hernández *et al*. (2016) [3] in storage studies of *Heliconia psittacorum* L. cv. Tropica.

5. Vase life (days)

The effect of pulsing treatments, interval of stem end cut and water renewal on vase life of cut spike was recorded at every alternate day up to the end of vase life and the analyzed data is presented in Table 5 and graphically depicted in Fig. 4.

Among the pulsing treatments, significantly highest vase life of cut spike was observed in P_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid) (8.17 days) and P_2 (Pulsing for 12 hours in 3% Sucrose + 150 ppm of Salicylic Acid) (8.00 days) which was on par with P_3 (Pulsing for 6 hours in 6% Sucrose + 300 ppm of Salicylic Acid) (7.44 days) and lowest vase life of cut spike was observed in spikes of P_0 (Control (Distilled water + 12 hours) (6.89 days).

Interval of stem end cutting and water renewal had a significant effect on vase life of heliconia cut spikes. Among the various treatments, significantly maximum vase life of cut spike was observed in I_1 (Stalk end cutting and renewal of water at every 2 days) (9.53 days), whereas the minimum vase life of cut spike was observed in I_0 (No Stalk end cut and no renewal of water) (6.17 days).

The interaction between pulsing treatment, Interval of stem end cutting and water renewal had a significant effect on vase life of heliconia cut spikes. Among the various treatments, significantly highest vase life of cut spike was recorded in P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) (10.83 days) and P_3I_1 (Pulsing for 6 hours in 6% Sucrose + 300 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) (10.33 days) which was at par with P_2I_1 (Pulsing for 12 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and

renewal of water at every 2 days) (10.17 days), On the other hand, the lowest vase life of cut spike was recorded in P_0I_0 (Control with No stalk end cutting and no renewal of water) and P_3I_0 (Pulsing for 6 hours in 6% Sucrose + 300 ppm of Salicylic Acid, No stalk end cutting and no renewal of water) (5.33 days). The longest vase life in the P_1I_1 was due to the fact that this treatment also registered the highest water uptake, minimal physiological weight loss, lowest OD values and minimal change in bract colour resulting in a longer vase life compared to other treatments. Another reason might be the synergistic effect of pulsing with sucrose and salicylic acid, stem end cutting and water renewal which led to a higher vase life compared to the other treatments. Similar findings were reported by Hatamzadeh *et al*. (2012) [14] in Alstroemeria.

Table 1: Effect of pulsing treatments on Heliconia cv. Alan Carle cut spike (lowest change in weight should be given 'a' followed by 'b')

Pulsing Treatments	Change in fresh weight (g) after pulsing
P_0-Control (Distilled water+12 hours)	0.84^{b}
P_1-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 6 hours	0.57^{b}
P_2-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 12 hours	0.99^{b}
P_3-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 6 hours	0.77^{b}
P_4-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 12 hours	1.88^{a}
SE(m)±	0.240
CD (5%)	0.692

Table 2: Effect of pulsing treatment, interval of stalk end cutting and renewal of vase water on water uptake (g/f) of Heliconia cv. Alan Carle cut spike.

Water Uptake (g/f) on 2nd day					Water Uptake (g/f) on 4th day				Water Uptake (g/f) on 6th day				Water Uptake (g/f) on 8th day			
Treatments	**I_0**	**I_1**	**I_2**	**Mean**	**I_0**	**I_1**	**I_2**	**Mean**	**I_0**	**I_1**	**I_2**	**Mean**	**I_0**	**I_1**	**I_2**	**Mean**
P_0	8.35^{h}	12.90^{c}	9.23^{g}	10.16^{d}	10.03^{g}	13.97^{b}	11.32^{e}	11.77^{c}	11.17^{g}	16.11^{b}	12.42^{f}	13.24^{c}	9.64^{j}	16.02^{d}	10.43^{hi}	12.03^{c}
P_1	9.32^{g}	14.45^{a}	10.78^{ef}	11.52^{a}	11.37^{e}	15.20^{a}	13.07^{c}	13.21^{a}	12.57^{ef}	17.49^{a}	14.03^{d}	14.70^{a}	10.76^{h}	18.59^{a}	12.19^{fg}	13.84^{a}
P_2	11.05^{e}	13.58^{b}	10.52^{f}	11.71^{a}	13.29^{c}	14.75^{a}	11.97^{d}	13.34^{a}	14.16^{d}	16.35^{b}	12.91^{ef}	14.47^{a}	12.30^{f}	16.62^{c}	10.85^{h}	13.25^{b}
P_3	8.55^{h}	14.18^{a}	10.67^{ef}	11.13^{b}	10.29^{fg}	14.99^{a}	12.42^{d}	12.56^{b}	11.24^{g}	17.16^{a}	13.20^{e}	13.87^{b}	9.82^{j}	17.95^{b}	11.73^{g}	13.17^{b}
P_4	8.65^{h}	12.05^{d}	11.68^{d}	10.80^{c}	10.74^{f}	13.37^{c}	13.35^{c}	12.49^{b}	11.47^{g}	15.01^{c}	14.33^{cd}	13.60^{bc}	9.94^{ij}	13.36^{e}	12.44^{f}	11.91^{c}
Mean	9.19^{c}	13.43^{a}	10.58^{b}		11.14^{c}	14.46^{a}	12.43^{b}		12.12^{c}	16.42^{a}	13.38^{b}		10.49^{c}	16.51^{a}	11.53^{b}	
Factors	SE(m)±		CD (5%)		SE(m)±		CD (5%)		SE(m)±		CD (5%)		SE(m)±		CD (5%)	
(P)	0.098		0.424		0.111		0.481		0.142		0.614		0.104		0.450	
(I)	0.076		0.219		0.086		0.248		0.11		0.317		0.081		0.233	
(P × I)	0.17		0.489		0.193		0.556		0.246		0.709		0.180		0.520	

P_0-Control (Distilled water + 12 hours)	**I_0-No Stalk end cut and no renewal of water**
P_1-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 6 hours	I_1-Stalk end cutting and renewal of water at every 2 days
P_2-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 12 hours	I_2-Stalk end cutting and renewal of water at every 4 days
P_3-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 6 hours	
P_4-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 12 hours	

Table 3: Effect of pulsing treatment, interval of stalk end cutting and renewal of vase water on the OD value of vase water (at 480 nm) of Heliconia cv. Alan Carle cut spike. (lowest OD value should be given 'a' followed by 'b' and 'c')

OD value of vase water on 2nd day					OD value of vase water on 4th day				OD value of vase water on 6th day				OD value of vase water on 8th day			
Treatments	**I_0**	**I_1**	**I_2**	**Mean**	**I_0**	**I_1**	**I_2**	**Mean**	**I_0**	**I_1**	**I_2**	**Mean**	**I_0**	**I_1**	**I_2**	**Mean**
P_0	0.015^{a}	0.005^{h}	0.010^{c}	0.010^{a}	0.027^{a}	0.006^{j}	0.016^{d}	0.016^{a}	0.031^{a}	0.011^{hi}	0.022^{d}	0.021^{a}	0.034^{a}	0.031^{b}	0.026^{c}	0.024^{a}
P_1	0.009^{d}	0.001^{k}	0.007^{f}	0.006^{e}	0.015^{de}	0.004^{l}	0.013^{f}	0.011^{d}	0.015^{e}	0.007^{j}	0.012^{g}	0.012^{e}	0.023^{d}	0.018^{e}	0.017^{f}	0.014^{e}
P_2	0.007^{f}	0.004^{i}	0.008^{e}	0.006^{d}	0.012^{g}	0.006^{jk}	0.015^{e}	0.011^{d}	0.012^{g}	0.011^{i}	0.014^{f}	0.012^{d}	0.016^{g}	0.016^{g}	0.016^{g}	0.015^{d}
P_3	0.015^{a}	0.003^{j}	0.008^{e}	0.009^{b}	0.020^{b}	0.005^{k}	0.014^{f}	0.013^{b}	0.029^{b}	0.011^{i}	0.012^{g}	0.017^{b}	0.015^{g}	0.013^{h}	0.013^{hi}	0.019^{b}
P_4	0.013^{b}	0.005^{h}	0.006^{g}	0.008^{c}	0.017^{c}	0.009^{i}	0.010^{h}	0.012^{c}	0.023^{c}	0.011^{hi}	0.012^{gh}	0.015^{c}	0.012^{i}	0.011^{j}	0.009^{k}	0.018^{c}
Mean	0.012^{a}	0.004^{c}	0.008^{b}		0.018^{a}	0.006^{c}	0.013^{b}		0.022^{a}	0.010^{c}	0.014^{b}		0.025^{a}	0.012^{c}	0.018^{b}	
Factors	SE(m)±		CD (5%)		SE(m)±		CD (5%)		SE(m)±		CD (5%)		SE(m)±		CD (5%)	
(P)	0.0001		0.0003		0.0001		0.0005		0.0001		0.0006		0.0001		0.0006	
(I)	0.0001		0.0002		0.0001		0.0002		0.0001		0.0003		0.0001		0.0003	
(P × I)	0.0001		0.0004		0.0002		0.0005		0.0002		0.0007		0.0003		0.0007	

Table 4: Effect of pulsing treatment, interval of stalk end cutting and renewal of vase water on bract colour fading of Heliconia cv. Alan Carle cut spike.

Treatments	L*		a*		b*	
	Initial day	End of Vase life	Initial day	End of Vase life	Initial day	End of Vase life
P_0I_0	49.55	47.17	17.55	14.25	35.03	39.15
P_0I_1	48.98	48.17	15.53	14.93	35.78	37.67
P_0I_2	48.65	47.87	17.87	14.87	35.70	38.82
P_1I_0	49.15	47.22	18.03	16.35	34.22	39.47
P_1I_1	50.35	49.97	19.77	19.22	39.88	40.25
P_1I_2	48.87	47.47	17.18	15.25	35.43	39.02
P_2I_0	50.50	49.10	19.62	18.00	36.10	41.22
P_2I_1	49.18	48.48	15.62	14.58	37.62	37.05
P_2I_2	49.02	48.35	18.67	14.93	37.43	37.88
P_3I_0	49.98	47.62	19.30	18.02	35.35	40.23
P_3I_1	48.62	48.08	15.95	14.87	37.18	37.50
P_3I_2	48.75	47.85	17.48	16.35	36.87	37.85
P_4I_0	49.28	48.07	17.13	15.60	36.57	37.65
P_4I_1	49.27	48.40	16.42	14.73	35.75	38.50
P_4I_2	49.65	48.68	19.32	17.05	37.88	38.63

Table 5: Effect of pulsing treatment, interval of stalk end cutting and renewal of vase water on vase life (days) of Heliconia cv. Alan Carle cut spike.

Vase life (days)				
Treatments	**Interval of stem end cutting and water renewal**			**Mean**
Pulsing	**I_0**	**I_1**	**I_2**	
P_0-Control (Distilled water+12 hours)	5.33^{e}	8.83^{bc}	6.50^{de}	6.89^{b}
P_1-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 6 hours	6.50^{de}	10.83^{a}	7.17^{d}	8.17^{a}
P_2-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 12 hours	7.33^{d}	10.17^{ab}	6.50^{de}	8.00^{a}
P_3-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 6 hours	5.33^{e}	10.33^{a}	6.67^{de}	7.44^{ab}
P_4-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 12 hours	6.33^{de}	7.50^{cd}	7.33^{d}	7.06^{b}
Mean	6.17^{c}	9.53^{a}	6.83^{b}	
Factors	SE(m)±		CD (5%)	
(P)	0.283		1.224	
(I)	0.219		0.632	
(P × I)	0.490		1.413	

P_0-Control (Distilled water + 12 hours)	I_0-No Stalk end cut and no renewal of water
P_1-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 6 hours	I_1-Stalk end cutting and renewal of water at every 2 days
P_2-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 12 hours	I_2-Stalk end cutting and renewal of water at every 4 days
P_3-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 6 hours	
P_4-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 12 hours	

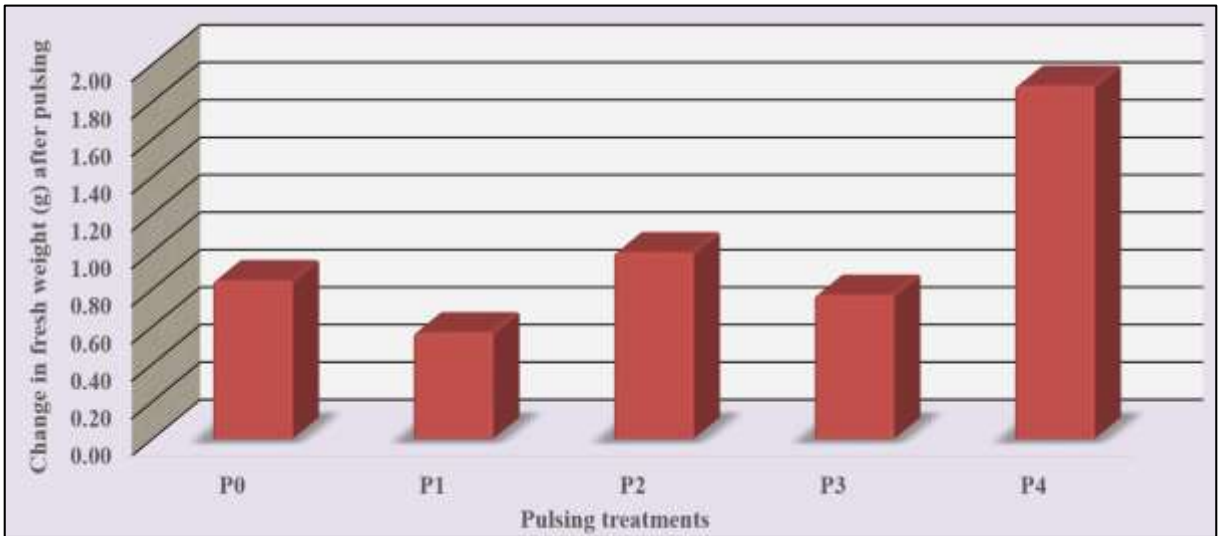

Fig 1: Effect of pulsing treatments on change in fresh weight (g) after pulsing of Heliconia cv. Alan Carle cut spikes

P_0-Control (Distilled water+ 12 hours)
P_1-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 6 hours
P_2-Pulsing with 3% Sucrose + 150 ppm of Salicylic Acid for 12 hours
P_3-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 6 hours
P_4-Pulsing with 6% Sucrose + 300 ppm of Salicylic Acid for 12 hours

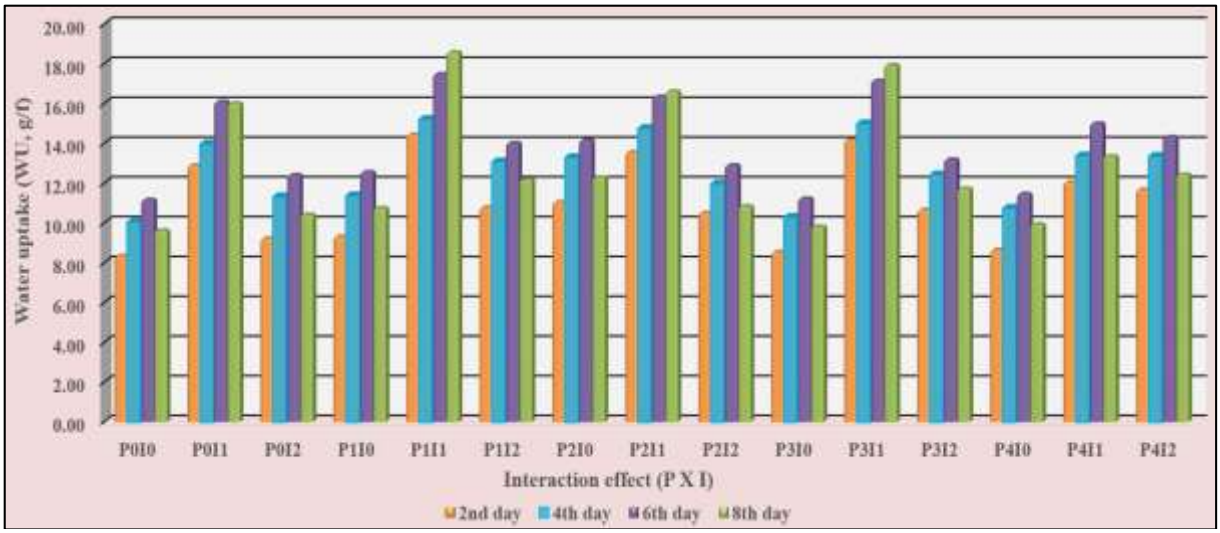

Fig 2: Effect of pulsing treatment, interval of stalk end cutting and renewal of vase water on water uptake (g/f) of Heliconia cv. Alan Carle cut spikes.

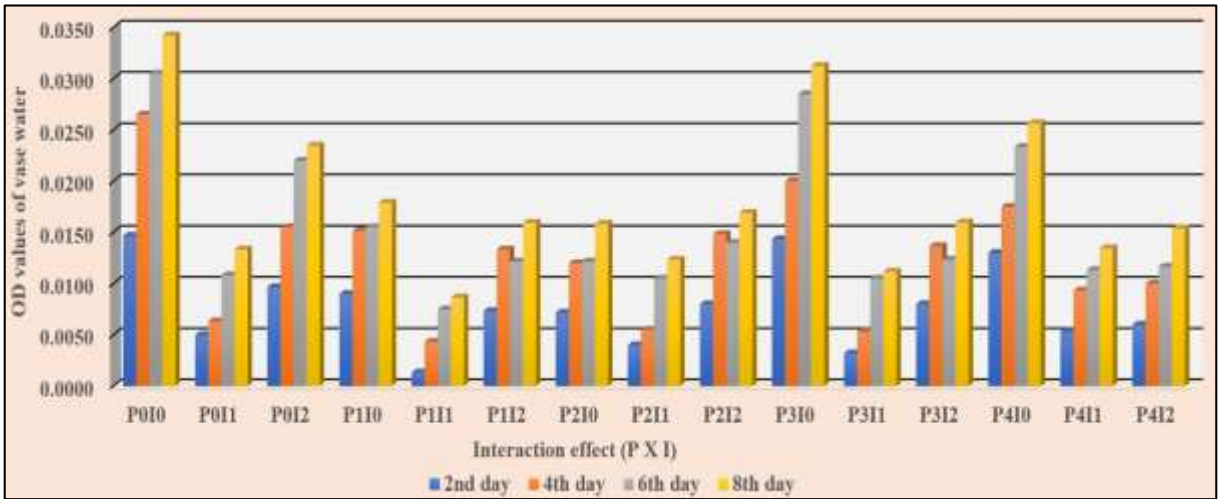

Fig 3: Effect of pulsing treatment, interval of stalk end cutting and renewal of vase water on OD values of vase water (at 460 nm) of Heliconia cv. Alan Carle cut spikes.

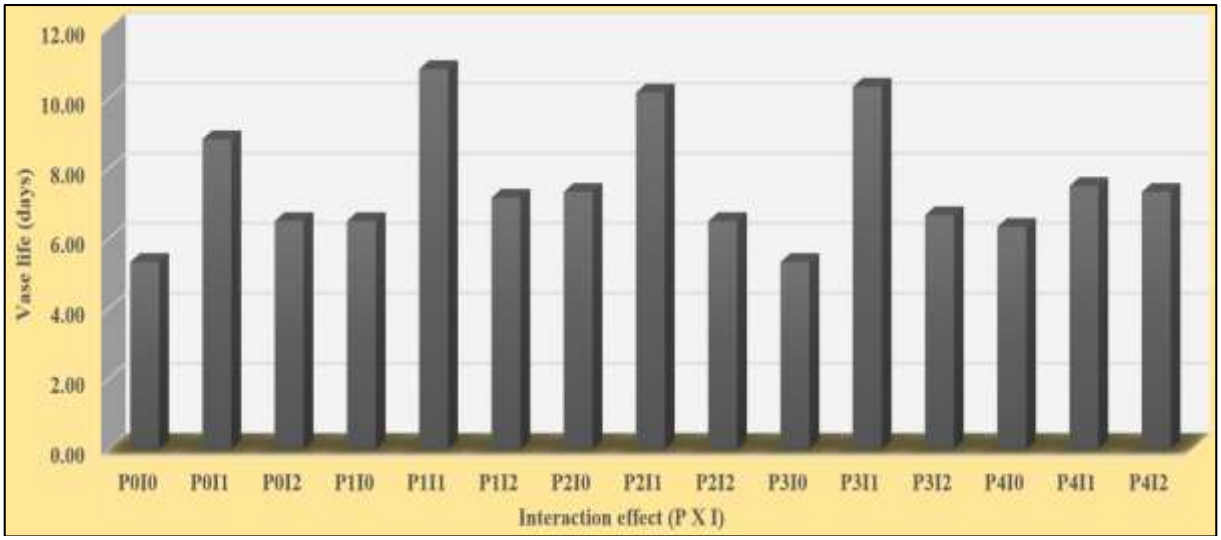

Fig 4: Effect of pulsing treatment, interval of stalk end cutting and renewal of vase water on vase life (days) of Heliconia cv. Alan Carle cut spikes.

Conclusion

The present investigation revealed that P_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid) recorded optimal to maximum water uptake, minimum fresh weight change and lowest OD value of water, indicating lower microbial contamination.

Among the interval of stem end cuttings and vase water renewal I_1 (Stalk end cutting and renewal of water at every 2 days) reported highest water uptake, vase life, OD values of vase water. Periodic recutting of stalk ends, and renewal of vase water removes occluded xylem vessels caused by microbial growth, air embolisms, and accumulation of secondary metabolites, thereby restoring hydraulic continuity and enhancing water uptake efficiency. The elevated OD values (optical density) are likely due to the transient accumulation of microbial or organic matter in the vase solution prior to each water renewal. Periodic flushing at 2-day intervals effectively balances hydration and preservative uptake while preventing long-term vascular blockage by limiting excessive microbial colonization.

Among all the combinations, P_1I_1 (Pulsing for 6 hours in 3% Sucrose + 150 ppm of Salicylic Acid, Stalk end cutting and renewal of water at every 2 days) proved to best as it recorded the best values for most of the parameters *i.e*., water uptake (g/f), vase life (days) and lowest optical density of vase water, fresh weight change (g) and bract colour change as compared to other treatment combinations. As a result, the vase life of the flower was significantly increased and the colour fading was minimized, enhancing the aesthetic appeal and freshness. This improvement in postharvest quality allows the flowers to fetch a premium price in the marke.

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