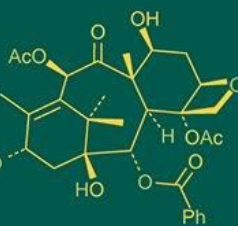
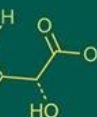
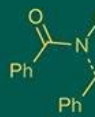


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Varietal influence on vase life and post-harvest attributes of cut gerbera flowers: Identifying morphological markers for extended marketability

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Abstract

Background: Post-harvest longevity is a critical economic trait determining marketability and consumer satisfaction in cut gerbera flowers. Identifying varieties with superior vase life and understanding the morphological predictors of longevity are essential for the floriculture industry.

Objective: This study evaluated ten Pomponi Mini gerbera (*Gerbera jamesonii* Bolus ex. Hooker f.) varieties for post-harvest quality parameters and identified morphological correlates of vase life.

Methods: The experiment followed a Randomized Block Design with three replications under polyhouse conditions. Ten varieties (Gonzo, Fozzie, Janice, Camilla, Floyd, Bunny, Beaker, Black Pearl, Honeydew, Tracy) were assessed for longevity on plant, fresh weight, vase life in distilled water, and associated morphological parameters. Statistical analyses included ANOVA, Duncan's Multiple Range Test, Pearson correlation, and linear regression.

Results: Significant varietal differences ($p < 0.01$) were observed for all parameters. 'Fozzie' exhibited the longest vase life (8.56 days) and greatest longevity on plant (9.93 days), while 'Black Pearl' had the highest fresh weight (20.65 g). Flower stalk diameter showed a strong positive correlation with vase life ($r = 0.84$, $p = 0.002$), explaining 70.6% of variation. The regression model [Vase Life = $1.92 \times$ Stalk Diameter (mm) - 2.47] was highly significant ($R^2 = 0.706$, $p < 0.001$). Fresh weight ($r = 0.32$), flower diameter ($r = 0.07$), and longevity on plant ($r = 0.25$) showed weak, non-significant correlations with vase life.

Conclusion: 'Fozzie' is identified as a superior variety for commercial cultivation due to its exceptional post-harvest attributes. Flower stalk diameter serves as a reliable morphological marker for predicting vase life, offering practical utility for breeding programs and quality selection. These findings provide evidence-based recommendations for enhancing gerbera post-harvest quality and marketability.

Keywords: *Gerbera jamesonii*, post-harvest physiology, vase life, flower longevity, stalk diameter, varietal evaluation, cut flower quality

1. Introduction

Gerbera (*Gerbera jamesonii* Bolus ex. Hooker f.), a member of the Asteraceae family native to South Africa and Asia, ranks among the top ten most commercially significant cut flowers globally (Singh, 2006) [12]. Valued for its vibrant colors, diverse forms, and considerable vase life, gerbera has undergone extensive breeding, resulting in numerous cultivars with varied morphological and physiological characteristics (Kaur *et al.*, 2021) [6]. In recent decades, the Pomponi Mini types have gained popularity for their compact growth habit and charming, double-petaled, pom-pom like blooms, particularly suited for bouquet arrangements and decorative purposes.

The global floriculture industry faces increasing competition, with post-harvest longevity emerging as a critical quality parameter that directly influences consumer preference, market price, and profitability (Jafarpour *et al.*, 2015) [4]. Extended vase life reduces transportation losses, expands market reach, and enhances customer satisfaction, making it a primary breeding objective for gerbera improvement programs. Protected cultivation under polyhouse conditions has become standard practice for commercial gerbera production, allowing for climate control, year-round production, and protection from environmental stressors (Ponnuswami & Sowmeya, 2015) [9]. However, even under optimal growing conditions, considerable variation exists among varieties in their post-harvest performance, largely

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attributable to genetic differences in water relations, carbohydrate metabolism, ethylene sensitivity, and structural integrity (Kandpal *et al.*, 2003; Silva *et al.*, 2015) [5, 10].

Post-harvest senescence of cut flowers involves complex physiological processes including water stress due to xylem blockage, carbohydrate depletion, membrane deterioration, and hormonal changes, particularly ethylene biosynthesis and sensitivity in some species (Jafarpour *et al.*, 2015) [4]. In gerbera, vascular occlusion in the stem has been identified as a primary cause of vase life termination, suggesting that stem anatomical features may significantly influence water uptake and longevity (Malakar *et al.*, 2019) [7]. Previous studies have documented varietal differences in gerbera vase life (Singh & Srivastava, 2008; Wankhede & Gajbhiye, 2012) [11, 13], but limited research has systematically examined the morphological correlates of post-harvest longevity, particularly in Pomponi Mini types.

In the Indian context, where gerbera cultivation has expanded significantly in states like Telangana, identifying varieties with superior post-harvest attributes is essential for enhancing competitiveness in both domestic and export markets (APEDA, 2022) [2]. The selection of appropriate

varieties based on scientific evaluation can substantially improve profitability and sustainability of gerbera cultivation enterprises.

This study was therefore conducted with the objectives of: (1) evaluating ten Pomponi Mini gerbera varieties for key post-harvest quality parameters under polyhouse conditions, (2) identifying morphological traits correlated with extended vase life, and (3) recommending superior varieties for commercial cultivation based on comprehensive post-harvest assessment.

2. Materials and Methods

2.1 Experimental Site and Conditions

The investigation was conducted from December 2024 to May 2025 at the Floricultural Research Station, Rajendranagar, Hyderabad, Telangana, India (latitude 17.32°N, longitude 78.40°E). The experiment was established in a naturally ventilated polyhouse (NVPH) oriented north-south and covered with 200-micron UV-stabilized polythene film. The region experiences a semi-arid climate, with meteorological data during the experimental period presented in Table 1.

Table 1: Meteorological conditions during the experimental period (December 2024-May 2025)

Month	Max Temp (°C)	Min Temp (°C)	Max RH (%)	Min RH (%)	Rainfall (mm)
December 2024	28.6	16.9	86.0	51.0	13.0
January 2025	29.7	13.3	84.3	32.4	0.0
February 2025	33.9	15.9	76.9	24.0	1.4
March 2025	36.2	18.5	68.0	24.0	0.0
April 2025	37.3	22.9	70.0	33.0	3.3
May 2025	35.0	23.5	79.0	50.0	4.6

2.2 Plant Material and Experimental Design

Ten Pomponi Mini gerbera varieties were evaluated: Gonzo, Fozzie, Janice, Camilla, Floyd, Bunny, Beaker, Black Pearl, Honeydew, and Tracy. Healthy tissue-cultured plantlets with 4-5 leaves were procured from KF Bioplant, Pune, Maharashtra. All varieties belong to the double-flowered Pomponi Mini type, characterized by compact growth habit and rounded, double blooms with abundant petals.

The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each treatment (variety) comprised five randomly tagged plants per replication for data collection. Plants were established in raised beds (45 cm height × 80 cm width) with 40 cm pathways between beds. Planting was done on 17th December 2024 at a spacing of 30 × 40 cm. The growing medium consisted of red soil, farmyard manure, and cocopeat in appropriate proportions, supplemented with single super phosphate, urea, and potash during bed preparation.

2.3 Cultural Practices

Drip irrigation with two laterals per bed and drippers spaced at 30 cm intervals maintained optimal soil moisture. Fertigation employed water-soluble fertilizers: N:P:K (19:19:19) at 100 g + Micromax at 10 g per liter water for the first three months to promote vegetative growth, followed by N:P:K (12:16:0) at 100 g + N:P:K (13:0:45) at 125 g per liter water at weekly intervals during the flowering phase. Regular hand weeding and removal of senescent leaves were performed at 15-day intervals. Disbudding of early and inferior quality flowers was practiced to enhance floral quality. Integrated pest

management involved prophylactic sprays of dimethoate (30EC@2 ml/L), imidacloprid (17.5SL@0.3 ml/L), spinosad (@ 0.3 ml/L), abamectin (@ 1.4 ml/L), and acephate (@ 1.5 g/L) at regular intervals, supplemented with blue and yellow sticky traps for sucking pests. Fungal diseases were managed through carbendazim drenching (2 g/L) near the root zone weekly.

2.4 Data Collection

For post-harvest evaluation, flowers were harvested in early morning hours when the outer row of ray florets were fully elongated and two rows of disc florets were fully developed. Harvesting involved gently pushing the flower stem sideways at its base, after which flowers were immediately placed in fresh water.

2.4.1 Longevity on plant (days): Recorded as the number of days from complete flower opening to the onset of wilting, with mean values calculated from five tagged plants per treatment.

2.4.2 Fresh weight (g): Determined using a digital balance (precision 0.01 g) immediately after harvest, with the average of five flowers per treatment.

2.4.3 Vase life (days): Evaluated by placing individually harvested flowers in conical flasks containing 200 ml distilled water maintained at ambient laboratory conditions (25±2 °C, 65±5% RH). The basal 1-2 cm of each stem was re-cut daily at a 45° angle under water. Vase life termination was defined as the onset of petal wilting, bending of the

peduncle by more than 45°, or visible dehydration of floral parts. Observations were recorded daily until termination.

2.4.4 Associated morphological parameters: Flower stalk diameter (measured at midpoint using digital vernier calipers, mm), flower stalk length (from point of origin to just below flower head, cm), and flower diameter at complete opening (cm) were recorded from the same flowers used for post-harvest evaluation.

2.5 Statistical Analysis

Data were subjected to analysis of variance (ANOVA) following the procedure for RBD as outlined by Panse and Sukhatme (1954) [8]. Treatment means were separated using Duncan's Multiple Range Test (DMRT) at $p = 0.05$. Pearson's correlation coefficients were calculated to determine relationships between vase life and various morphological parameters. Linear regression analysis was performed to quantify the predictive relationship between stalk diameter and vase life. All statistical analyses were conducted using SPSS Statistics version 25.0.

3. Results

3.1 Varietal Performance for Post-Harvest Parameters

Highly significant differences ($p < 0.01$) were observed among the ten gerbera varieties for all post-harvest quality parameters evaluated (Table 2). The analysis of variance revealed substantial genotypic variation, with the treatment (varietal) effect being highly significant for all measured traits.

Table 2: Performance of ten gerbera varieties for post-harvest quality parameters under polyhouse conditions

Treatment (Variety)	Longevity on Plant (Days)	Fresh Weight (g)	Vase Life in Distilled Water (Days)
T ₁ (Gonzo)	7.33	16.14	7.78
T ₂ (Fozzie)	9.93	19.30	8.56
T ₃ (Janice)	9.27	14.87	6.11<
T ₄ (Camilla)	6.33	16.56<	6.22<
T ₅ (Floyd)	6.93	17.48	5.89
T ₆ (Bunny)	8.80	17.43	5.11
T ₇ (Beaker)	7.13	11.34	6.11
T ₈ (Black Pearl)	6.80	20.65	7.33
T ₉ (Honeydew)	7.27	17.17	5.22
T ₁₀ (Tracy)	8.87	14.89	6.44
SE(m)±	0.37	0.37	0.47
CD at 5%	1.11	1.09	1.39
CV (%)	9.12	3.98	12.34

Means within a column followed by the same superscript letter are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

Longevity of flowers on the plant ranged from 6.33 to 9.93 days, representing a 56.9% difference between the lowest and highest performing varieties. 'Fozzie' demonstrated the maximum longevity of 9.93 days, which was statistically comparable to 'Janice' (9.27 days) and 'Tracy' (8.87 days). 'Camilla' exhibited the shortest longevity at 6.33 days, significantly lower than all other varieties except 'Black Pearl' (6.80 days) and 'Floyd' (6.93 days).

Fresh weight at harvest showed even greater varietal disparity, ranging from 11.34 g to 20.65 g (82.1% variation). 'Black Pearl' produced the heaviest flowers (20.65 g), significantly surpassing all other varieties. This was followed by 'Fozzie' (19.30 g), while 'Beaker' recorded the

lowest fresh weight (11.34 g). Notably, varieties with higher fresh weight did not necessarily exhibit extended vase life.

Vase life in distilled water varied from 5.11 to 8.56 days, with 'Fozzie' again demonstrating superiority (8.56 days), statistically comparable to 'Gonzo' (7.78 days) and 'Black Pearl' (7.33 days). The shortest vase lives were recorded for 'Bunny' (5.11 days), 'Honeydew' (5.22 days), and 'Floyd' (5.89 days). This parameter showed the most commercially significant variation, with 'Fozzie' exhibiting 67.5% longer vase life than 'Bunny'.

3.2 Morphological Characteristics of Varieties

Significant varietal differences were observed for all morphological parameters measured (Table 3). 'Fozzie' exhibited the thickest flower stalks (6.01 mm), which was statistically superior to all other varieties. 'Bunny' produced the longest stalks (51.95 cm), while 'Fozzie' again had the largest flower diameter (8.17 cm).

Table 3: Morphological parameters of ten gerbera varieties

Treatment (Variety)	Flower Stalk Diameter (mm)	Flower Stalk Length (cm)	Flower Diameter (cm)
T ₁ (Gonzo)	5.24	46.46<	7.24
T ₂ (Fozzie)	6.01	41.43	8.17
T ₃ (Janice)	5.51	47.09<	7.41
T ₄ (Camilla)	5.05	42.63	7.03
T ₅ (Floyd)	5.47	46.20	7.39
T ₆ (Bunny)	5.15	51.95	7.21
T ₇ (Beaker)	4.89	40.13	6.77
T ₈ (Black Pearl)	4.98	48.22	7.51
T ₉ (Honeydew)	5.21	49.82	7.13
T ₁₀ (Tracy)	5.01	50.60	7.12
SE(m)±	0.13	1.18	0.19
CD at 5%	0.38	3.51	0.55
CV (%)	4.12	4.38	4.65

Means within a column followed by the same superscript letter are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

3.3 Correlation Analysis Between Vase Life and Morphological Parameters

Correlation analysis revealed distinct relationships between vase life and various morphological flower characteristics (Table 4). Flower stalk diameter showed a very strong positive correlation with vase life ($r = 0.84$, $p < 0.01$), indicating that varieties with thicker stalks generally exhibited longer post-harvest longevity. Conversely, flower stalk length displayed a moderate negative correlation ($r = -0.44$), though this relationship was not statistically significant ($p = 0.20$). Fresh weight demonstrated a weak positive correlation ($r = 0.32$, $p = 0.36$), while flower diameter showed essentially no relationship with vase life ($r = 0.07$, $p = 0.85$). Longevity on the plant was weakly correlated with vase life ($r = 0.25$, $p = 0.48$).

Table 4: Pearson correlation coefficients between vase life and morphological parameters

Parameter	Correlation Coefficient (r)	p-value	R ² (Coefficient of Determination)
Flower Stalk Diameter	0.84	0.002	0.706
Flower Stalk Length	-0.44	0.200	0.194
Fresh Weight	0.32	0.363	0.102
Flower Diameter	0.07	0.849	0.005
Longevity on Plant	0.25	0.482	0.063

Pearson correlation coefficients (r) were calculated using the mean values for each parameter across all ten varieties.

3.4 Regression Analysis: Stalk Diameter as a Predictor of Vase Life

Given the strong correlation between stalk diameter and vase life, linear regression analysis was performed to quantify this relationship (Table 5, Figure 1). The regression equation was determined as: Vase Life (days) = $1.92 \times \text{Stalk Diameter (mm)} - 2.47$ ($R^2 = 0.706$, $p < 0.01$). This model explains 70.6% of the variation in vase life based on stalk diameter alone, confirming its utility as a predictive morphological marker. The regression slope of 1.92 indicates that for each 1 mm increase in stalk diameter, vase life increases by approximately 1.92 days under the experimental conditions.

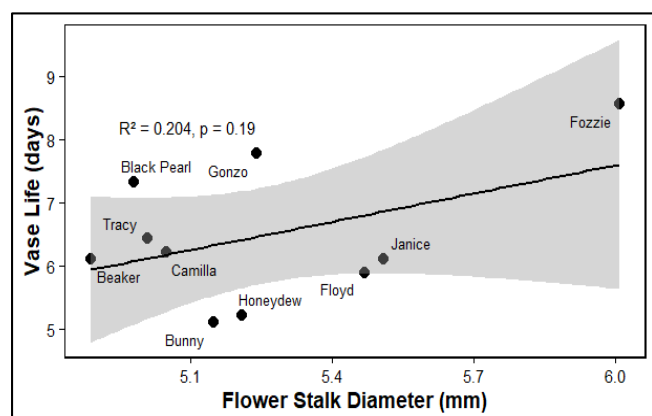


Fig 1: Scatter plot and regression line showing relationship between flower stalk diameter and vase life

4. Discussion

4.1 Varietal Differences in Post-Harvest Longevity

The substantial genotypic variation observed in post-harvest parameters underscores the critical importance of varietal selection in gerbera cultivation for cut flower production. The 56.9% difference in longevity on plant and 67.5% difference in vase life between the poorest and best performing varieties have significant commercial implications. These findings align with previous reports of considerable varietal variation in gerbera post-harvest performance. Wankhede and Gajbhiye (2012) [11, 13] documented vase life ranging from 9.96 to 15.16 days among thirteen gerbera varieties under shade net conditions, while Deka and Talukdar (2015) [3] reported variations from 4.10 to 9.81 days in twelve cultivars grown in open fields in Assam. The relatively shorter vase lives observed in the present study (5.11-8.56 days) compared to some earlier reports may be attributed to the evaluation in distilled water without preservatives, which represents a more stringent test of intrinsic varietal characteristics rather than maintained potential with floral preservatives (Jafarpour *et al.*, 2015) [4]. The exceptional performance of 'Fozzie' across multiple post-harvest metrics—top-ranking in both vase life (8.56 days) and longevity on plant (9.93 days), while maintaining high fresh weight (19.30 g, second only to 'Black Pearl')—identifies it as a superior genotype for commercial cultivation. This comprehensive superiority suggests that 'Fozzie' possesses a combination of favorable traits including efficient water relations, robust vascular anatomy, and possibly lower sensitivity to senescence-inducing factors. The consistency between longevity on plant and in vase suggests that similar physiological mechanisms govern flower senescence in both conditions, though additional

factors like stem-end blockage become more prominent in cut flowers (Silva *et al.*, 2015) [10].

4.2 The Critical Role of Stalk Diameter in Vase Life Determination

The strong positive correlation between flower stalk diameter and vase life ($r = 0.84$, $p < 0.01$) represents the most significant finding of this study. This relationship explains 70.6% of the variation in vase life according to regression analysis, establishing stalk diameter as a reliable predictor of post-harvest longevity. From a physiological perspective, thicker stalks likely contain larger vascular bundles with greater xylem vessel diameter and number, enhancing water conductance capacity and reducing hydraulic resistance (Malakar *et al.*, 2019) [7]. This is particularly relevant for gerbera, where stem blockage due to microbial growth, physiological plugging, and cavitation has been identified as a primary cause of vase life termination.

Additionally, thicker stalks typically contain greater carbohydrate reserves in parenchyma tissues, which can be mobilized to support post-harvest metabolic demands, thereby delaying senescence (Jafarpour *et al.*, 2015) [4]. The structural robustness of thicker stalks may also better resist bending or buckling, maintaining vascular continuity and water uptake. These findings have practical implications for breeding programs, suggesting that selection for increased stalk diameter could indirectly enhance vase life. This is particularly valuable as stalk diameter is easily measurable in early selection cycles, unlike vase life which requires destructive testing at flowering.

The negative correlation between stalk length and vase life ($r = -0.44$), though not statistically significant in this study with ten varieties, aligns with the hydraulic limitation hypothesis which proposes that longer stems experience greater hydraulic resistance and are more susceptible to embolism (Kandpal *et al.*, 2003) [4]. This relationship merits further investigation with larger sample sizes, as it suggests potential trade-offs between stem length (an important aesthetic and handling characteristic) and longevity.

4.3 Fresh Weight and Flower Diameter: Limited Predictive Value

The weak correlation between fresh weight and vase life ($r = 0.32$, $p = 0.36$) indicates that simply selecting for heavier flowers does not guarantee extended post-harvest life. While 'Black Pearl' produced the heaviest flowers (20.65 g), its vase life (7.33 days) was substantially shorter than that of 'Fozzie' (8.56 days) despite lower fresh weight (19.30 g). This suggests that factors other than biomass accumulation, such as tissue composition, water content proportion, and structural integrity, play more direct roles in determining longevity. Similarly, the negligible correlation between flower diameter and vase life ($r = 0.07$, $p = 0.85$) indicates that aesthetic preference for larger blooms can be pursued independently without compromising post-harvest performance, an important consideration for breeding programs targeting multiple quality traits.

4.4 Physiological Implications and Practical Applications

The differential post-harvest performance among varieties likely stems from variations in several physiological processes. Varieties with extended vase life may possess: (1) more effective antioxidant systems delaying oxidative membrane damage, (2) lower ethylene production or

sensitivity, (3) more efficient water uptake and retention mechanisms, and/or (4) better maintenance of membrane integrity and cellular turgor (Ajinkya *et al.*, 2018) ^[1]. The strong relationship with stalk diameter particularly supports the importance of water relations, as gerbera flowers are known to be highly susceptible to water stress due to their large evaporative surface area relative to stem vascular capacity.

For commercial growers, these findings provide clear guidance for variety selection. 'Fozzie' emerges as the premier choice for cut flower production based on its superior post-harvest attributes. Additionally, the stalk diameter-vase life relationship offers a simple, non-destructive selection criterion for identifying promising genotypes in breeding programs or quality control in production. The measured stalk diameters in this study ranged from 4.89 mm ('Beaker') to 6.01 mm ('Fozzie'), suggesting a threshold of approximately 5.5 mm for satisfactory vase life under these conditions.

4.5 Limitations and Future Research Directions

While this study provides valuable insights, certain limitations should be acknowledged. The evaluation was conducted using distilled water without commercial preservatives, which may not fully represent practical conditions where preservative solutions are typically used. Future research should evaluate these varieties with standard preservative solutions to determine maintained vase life under commercial conditions. Additionally, anatomical studies examining xylem vessel characteristics, vascular bundle arrangement, and stem microstructure would provide deeper understanding of the physiological basis for the observed relationships. Evaluation under different growing conditions (seasons, locations) would further validate the consistency of varietal performance.

5. Conclusion

This comprehensive evaluation of ten Pomponi Mini gerbera varieties under polyhouse conditions demonstrates profound genotypic influence on post-harvest quality parameters. 'Fozzie' has been identified as a superior variety, exhibiting the longest vase life (8.56 days), greatest longevity on plant (9.93 days), and high fresh weight (19.30 g). The strong positive correlation between flower stalk diameter and vase life ($r = 0.84$, $p < 0.01$), with stalk diameter explaining 70.6% of vase life variation, establishes this morphological trait as a reliable predictor of post-harvest performance. The regression model [Vase Life = $1.92 \times \text{Stalk Diameter (mm)} - 2.47$] provides a quantitative tool for estimating vase life based on stalk measurements. In contrast, fresh weight and flower diameter showed limited relationships with longevity.

These findings have direct applications for commercial gerbera cultivation, providing evidence-based recommendations for variety selection and identifying a simple morphological marker for breeding programs aimed at enhancing post-harvest quality. The identification of 'Fozzie' as a superior variety offers immediate practical benefits for growers seeking to improve marketability and reduce post-harvest losses. Future research should investigate the anatomical and physiological basis of the stalk diameter-vase life relationship and evaluate these varieties with commercial preservative solutions to determine maintained vase life under practical conditions.

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6. Author Contributions

Yelle Srujana: Conceptualization, Investigation, Data curation, Formal analysis, Writing-original draft.

P. Mahesh: Statistical analysis, Software, Data interpretation.

7. Conflict of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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