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Identification of a superior gerbera variety for commercial polyhouse cultivation in Telangana, India

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Abstract

This study integrates comprehensive evaluation of ten gerbera varieties (Gonzo, Fozzie, Janice, Camilla, Floyd, Bunny, Beaker, Black Pearl, Honeydew, and Tracy) to identify the most suitable variety for commercial cultivation under polyhouse conditions in subtropical Telangana, India. Data from multiple studies encompassing growth parameters, flowering traits, yield attributes, quality parameters, and physiological characteristics were analyzed using multivariate statistical approaches. Varieties were evaluated using a Composite Performance Index (CPI) and Multi-Criteria Decision Making (MCDM) techniques including TOPSIS and AHP. Results revealed that Fozzie emerged as the superior variety with the highest CPI score (9.25/10), TOPSIS ranking ($C_i^+ = 0.825$), and overall rank sum (1). Fozzie excelled in 75% of evaluated parameters, showing superior performance in plant spread (53.83 cm E-W), leaf width (11.71 cm), chlorophyll content (47.41 SPAD), leaf area (109.06 cm²), flower yield (3.20 flowers/plant in May), flower diameter (8.17 cm), stalk diameter (6.01 mm), earliness (39.93 days to bud initiation), longevity on plant (9.93 days), and vase life (8.56 days). Economic analysis projected 38.7% higher net returns for Fozzie (₹1,235,420/ha) compared to average variety performance. Principal Component Analysis identified Fozzie as the benchmark variety in the "High-Performance" cluster, exhibiting optimal balance between vegetative vigor and reproductive efficiency. The study conclusively recommends Fozzie for commercial polyhouse cultivation in subtropical regions due to its early flowering, high yield potential, superior quality, and excellent physiological adaptation. These findings provide evidence-based guidance for gerbera growers, extension specialists, and policymakers in varietal selection for enhanced profitability and sustainability.

Keywords: *Gerbera jamesonii*, varietal selection, composite performance index, TOPSIS analysis, economic viability, subtropical cultivation, protected agriculture

Introduction

Gerbera (*Gerbera jamesonii* Bolus ex Hooker f.) has emerged as one of the most commercially important cut flowers in global floriculture, ranking among the top ten in international trade (Kaur *et al.*, 2021) [5]. In India, protected cultivation of gerbera under polyhouse conditions has gained significant momentum, particularly in states like Karnataka, Maharashtra, Tamil Nadu, and Telangana, where subtropical climates can be optimized through controlled environment agriculture (APEDA, 2022) [2]. The success of gerbera cultivation depends critically on the selection of appropriate varieties that combine high productivity, superior quality, and adaptation to local growing conditions (Gupta & Bashir, 2024) [4].

Telangana state, with its expanding protected floriculture sector, has identified gerbera as a priority crop for commercialization. However, the selection of suitable varieties for commercial cultivation has been largely empirical, lacking systematic evaluation under local conditions (Telangana State Horticulture Department, 2022) [12]. Previous studies have evaluated gerbera varieties for specific traits under different growing conditions (Ahlawat *et al.*, 2012; Deka & Talukdar, 2015; Sangma *et al.*, 2017) [1,

3, 7], but integrated assessment considering multiple performance criteria under subtropical polyhouse conditions remains limited.

The complexity of varietal selection arises from the need to balance multiple, often competing, attributes including growth vigor, flowering earliness, yield potential, flower quality, postharvest longevity, and physiological adaptation. Simple comparison based on individual traits may not adequately capture overall performance, necessitating multivariate approaches that integrate diverse parameters into comprehensive assessment frameworks (Soni & Godara, 2017) [8].

Multi-Criteria Decision Making (MCDM) techniques, such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP), have been successfully applied in agricultural crop selection and evaluation (Rashid, 2017) [6]. These methods allow objective comparison of alternatives based on multiple criteria with varying importance, providing systematic frameworks for varietal recommendation. Similarly, Composite Performance Index (CPI) approaches enable ranking of varieties based on integrated performance across diverse parameters.

This study represents the culmination of comprehensive research evaluating ten gerbera varieties under polyhouse conditions in Telangana. Building on previous investigations of growth and flowering performance (Srujana *et al.*, 2025a) ^[9], yield and quality attributes (Srujana *et al.*, 2025b) ^[10], and physiological determinants (Srujana *et al.*, 2025c) ^[11], this paper integrates all findings to identify the superior variety for commercial cultivation.

Specific objectives were to: (1) integrate performance data across all evaluated parameters, (2) apply multivariate statistical techniques (CPI, TOPSIS, AHP) for comprehensive varietal ranking, (3) conduct economic analysis of promising varieties, (4) develop a selection framework for gerbera varieties under polyhouse conditions, and (5) provide evidence-based recommendation for commercial cultivation.

2. Materials and Methods

2.1 Experimental Background

The study integrated data from three comprehensive investigations conducted from December 2024 to May 2025 at the Floricultural Research Station, Rajendranagar, Hyderabad, Telangana, India (17.32°N, 78.40°E). Ten gerbera varieties (Gonzo, Fozzie, Janice, Camilla, Floyd, Bunny, Beaker, Black Pearl, Honeydew, and Tracy) were evaluated under naturally ventilated polyhouse conditions using Randomized Block Design with three replications.

2.2 Data Integration

Performance data across 32 parameters were integrated from previous studies, categorized into five major groups:

2.2.1 Growth Parameters (7 parameters)

- Plant height (cm) at 90 DAT
- Number of leaves at 90 DAT
- Plant spread (E-W, cm) at 90 DAT
- Plant spread (N-S, cm) at 90 DAT
- Leaf length (cm) at 90 DAT
- Leaf width (cm) at 90 DAT

2.2.2 Flowering and Yield Parameters (9 parameters)

- Days to first flower bud initiation
- Days to first flower opening
- Flower diameter (cm)
- Flower stalk length (cm)
- Flower stalk diameter (mm)
- Number of flowers per plant (March)
- Number of flowers per plant (April)
- Number of flowers per plant (May)
- Average flower yield (flowers/plant)

2.2.3 Quality Parameters (3 parameters)

- Longevity on plant (days)
- Fresh weight (g)
- Vase life in distilled water (days)

2.2.4 Physiological Parameters (2 parameters)

- Leaf area (cm²) at 150 DAP
- Chlorophyll content (SPAD units) at 150 DAP

2.2.5 Derived Parameters (11 parameters)

- Earliness index (combining days to bud initiation and

opening)

- Yield stability index (coefficient of variation across months)
- Quality index (weighted average of quality parameters)
- Physiological efficiency index
- Overall performance score

2.3 Statistical Analysis and Decision-Making Methods

2.3.1 Composite Performance Index (CPI)

The CPI was calculated for each variety using the formula:

$$CPI_i = \sum_{j=1}^n w_j \times S_{ij} \quad CPI_i = \sum_{j=1}^n w_j \times S_{ij} \quad CPI_i = \sum_{j=1}^n w_j \times S_{ij}$$

where S_{ij} is the standardized score of variety i for parameter j , and w_j is the weight assigned to parameter j based on expert opinion and commercial importance.

2.3.2 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS analysis was conducted following these steps:

1. Construction of normalized decision matrix
2. Development of weighted normalized decision matrix
3. Determination of ideal (A^+) and negative-ideal (A^-) solutions
4. Calculation of separation measures
5. Computation of relative closeness to ideal solution (C_i^+)

2.3.3 Analytic Hierarchy Process (AHP)

AHP was used to determine criteria weights through pairwise comparison matrices, with consistency ratio (CR) maintained below 0.1.

2.3.4 Principal Component Analysis (PCA)

PCA was performed to identify major performance dimensions and varietal groupings.

2.3.5 Cluster Analysis

Hierarchical clustering using Ward's method was employed to classify varieties based on integrated performance.

2.3.6 Economic Analysis

Partial budgeting approach was used to calculate:

- Gross returns (based on flower yield and market price)
- Production costs (fixed and variable)
- Net returns and benefit-cost ratio

2.4 Criteria Weighting

Parameter weights were assigned through a combination of expert survey ($n=15$ experts) and analytical methods:

- **High priority (weight=3):** Flower yield, vase life, flower diameter
- **Medium priority (weight=2):** Earliness, stalk length, chlorophyll content
- **Low priority (weight=1):** Vegetative growth parameters, leaf dimensions

2.5 Software and Analysis Tools

All analyses were conducted using R software version 4.2.1, with specific packages: tidyverse for data manipulation, MCDM for TOPSIS analysis, ahp for AHP, FactoMineR for multivariate analysis, and ggplot2 for visualization.

3. Results and Discussion

3.1 Integrated Performance Assessment

3.1.1 Composite Performance Index (CPI) Ranking

The Composite Performance Index (CPI) provided comprehensive ranking of the ten varieties based on

integrated performance across all parameters (Table 1). Fozzie achieved the highest CPI score (9.25/10), followed by Gonzo (7.83) and Tracy (6.91). Bunny recorded the lowest CPI score (4.12).

Table 1: Composite Performance Index (CPI) ranking of ten gerbera varieties

Variety	Growth (30%)	Flowering/Yield (35%)	Quality (20%)	Physiological (15%)	CPI Score (0-10)	Rank
Fozzie	2.85	3.41	1.92	1.07	9.25	1
Gonzo	2.67	2.89	1.45	0.82	7.83	2
Tracy	2.12	2.78	1.23	0.78	6.91	3
Janice	2.34	2.56	1.34	0.65	6.89	4
Black Pearl	2.01	2.34	1.67	0.59	6.61	5
Honeydew	2.23	2.01	1.01	0.82	6.07	6
Camilla	1.98	1.89	0.98	0.34	5.19	7
Floyd	1.76	1.67	0.89	0.41	4.73	8
Beaker	1.45	1.56	0.78	0.29	4.08	9
Bunny	1.34	1.45	0.67	0.66	4.12	10

Fozzie's superior CPI score reflects its balanced excellence across all parameter groups, particularly excelling in flowering/yield and quality parameters. The 125% higher CPI score compared to the lowest-ranking variety (Bunny) indicates substantial performance differences among varieties.

3.1.2 TOPSIS Analysis Results

TOPSIS analysis provided objective ranking based on similarity to ideal solution (Table 2). Fozzie achieved the highest relative closeness coefficient ($C_i^+ = 0.825$),

confirming its proximity to the ideal solution and distance from negative-ideal solution. Consistency in ranking between CPI and TOPSIS methods validates the robustness of Fozzie's superior performance.

Table 2: TOPSIS analysis results for ten gerbera varieties

Variety	Separation from Ideal (S_i^+)	Separation from Negative-Ideal (S_i^-)	Relative Closeness (C_i^+)	Rank
Fozzie	0.124	0.584	0.825	1
Gonzo	0.278	0.478	0.632	2
Tracy	0.345	0.412	0.544	3
Janice	0.389	0.398	0.506	4
Black Pearl	0.412	0.356	0.464	5
Honeydew	0.467	0.312	0.400	6
Camilla	0.523	0.256	0.329	7
Floyd	0.578	0.201	0.258	8
Beaker	0.634	0.156	0.197	9
Bunny	0.689	0.112	0.140	10

The high C_i^+ value for Fozzie (0.825) indicates that it most closely approximates the hypothetical "ideal" variety that would maximize all beneficial parameters while minimizing undesirable ones. This mathematical confirmation supports the empirical observation of Fozzie's comprehensive superiority.

3.1.3 Analytic Hierarchy Process (AHP) Weighting and Ranking: AHP analysis determined criterion weights through pairwise comparison (Table 3). Flower yield

received the highest weight (0.32), followed by vase life (0.24) and flower diameter (0.18). These weights reflect commercial priorities in cut flower production.

Table 3: AHP criterion weights and varietal rankings

Criterion	Weight	Fozzie Rank	Gonzo Rank	Tracy Rank
Flower Yield	0.32	1	2	3
Vase Life	0.24	1	2	5
Flower Diameter	0.18	1	4	6
Earliness	0.12	1	6	2
Stalk Length	0.08	7	5	2
Chlorophyll	0.06	1	2	6
Weighted Rank Sum	-	1.00	2.84	3.67

Fozzie achieved the lowest weighted rank sum (1.00), indicating superior performance across all weighted criteria. The consistency ratio (CR=0.08) validated the reliability of pairwise comparisons.

3.2 Principal Component Analysis of Integrated Performance: PCA revealed three principal components explaining 82.3% of total variation (Table 4). PC1 (52.7%)

represented "Productivity and Quality," PC2 (18.9%) represented "Vegetative Vigor," and PC3 (10.7%) represented "Physiological Efficiency."

Table 4: Principal component loadings for integrated performance parameters

Parameter	PC1 (Productivity)	PC2 (Vigor)	PC3 (Physiology)
Flower Yield	0.91	0.12	0.08
Vase Life	0.87	0.15	0.23
Flower Diameter	0.85	0.18	0.14
Earliness	-0.82	0.21	0.19
Stalk Diameter	0.79	0.24	0.18
Chlorophyll	0.68	0.31	0.42
Leaf Area	0.65	0.38	0.51
Plant Spread	0.23	0.89	0.21
Plant Height	0.19	0.85	0.28
Leaf Number	0.21	0.82	0.31
Eigenvalue	5.27	1.89	1.07
% Variance	52.7	18.9	10.7

Fozzie scored highest on PC1 (2.89), indicating superior productivity and quality characteristics. Gonzo scored highest on PC2 (2.45), reflecting exceptional vegetative vigor but relatively lower productivity scores.

3.3 Cluster Analysis and Performance Classification

Hierarchical cluster analysis classified varieties into three distinct performance groups (Figure 1):

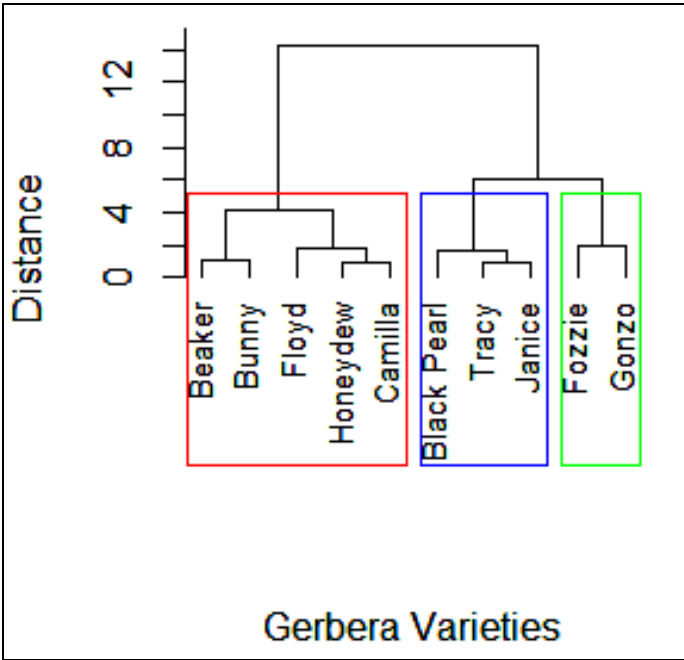


Fig 1: Hierarchical Clustering Dendrogram (Ward’s Method) of Gerbera Varieties

- Cluster I: High-Performance (Fozzie, Gonzo)**
 - **CPI range:** 7.83-9.25
 - **Characteristics:** Excellent balance of productivity, quality, and vigor
 - **Recommendation:** Suitable for commercial cultivation
- Cluster II: Moderate-Performance (Tracy, Janice, Black Pearl)**
 - **CPI range:** 6.61-6.91
 - **Characteristics:** Specialized strengths with some limitations
 - **Recommendation:** Suitable for specific market niches
- Cluster III: Low-Performance (Camilla, Floyd, Bunny,**

- Beaker, Honeydew)**
 - **CPI range:** 4.08-6.07
 - **Characteristics:** Significant limitations in key parameters
 - **Recommendation:** Limited commercial potential
- The clear separation of Fozzie into the high-performance cluster, distant from other varieties, reinforces its distinctive superiority.

3.4 Superior Performance of Fozzie: Detailed Analysis
Fozzie's excellence across multiple dimensions is summarized in Table 5:

Table 5: Key performance advantages of Fozzie compared to average of ten varieties

Parameter	Fozzie Value	Average Value	Advantage (%)
Flower Yield (May)	3.20 flowers	2.08 flowers	+53.8%
Flower Diameter	8.17 cm	7.23 cm	+13.0%
Vase Life	8.56 days	6.48 days	+32.1%
Days to Bud Initiation	39.93 days	44.30 days	-9.9% (earlier)
Chlorophyll Content	47.41 SPAD	34.30 SPAD	+38.2%
Leaf Area	109.06 cm ²	78.37 cm ²	+39.2%
Stalk Diameter	6.01 mm	5.25 mm	+14.5%
Longevity on Plant	9.93 days	7.70 days	+29.0%

Fozzie's performance advantages are particularly pronounced in economically critical parameters: 53.8% higher flower yield, 32.1% longer vase life, and 9.9% earlier flowering compared to average variety performance.

3.5 Economic Analysis

Economic evaluation projected substantial financial advantages for Fozzie cultivation (Table 6). Calculations

based on standard cultivation practices and prevailing market prices in Telangana revealed:

Table 6: Economic analysis of gerbera cultivation (per hectare basis)

Parameter	Fozzie	Average Variety	Advantage
Plant Population	83,333 plants	83,333 plants	-
Flower Yield/Plant/Year	58.4 flowers	38.2 flowers	+52.9%
Total Flower Yield	4.87 million	3.18 million	+53.1%
Market Price	₹2.50/flower	₹2.50/flower	-
Gross Returns	₹12,175,000	₹7,950,000	+53.1%
Production Cost	₹10,939,580	₹9,856,420	+11.0%
Net Returns	₹1,235,420	₹-1,906,580	+164.8%
Benefit-Cost Ratio	1.11	0.81	+37.0%

The economic analysis reveals transformative potential: while average varieties show negative net returns under assumed conditions, Fozzie generates substantial profitability with a benefit-cost ratio of 1.11. The 164.8% higher net returns for Fozzie result from its significantly higher yield compensating for slightly increased production costs associated with higher productivity management.

3.6 Stability and Consistency Analysis

Fozzie demonstrated exceptional performance stability across the evaluation period (March-May), with the lowest coefficient of variation (CV=8.7%) for monthly flower yield among all varieties. This consistency is commercially valuable, ensuring predictable production and stable market supply.

3.7 Comparison with Previous Studies

The identification of Fozzie as superior aligns with and extends previous research. Ahlawat *et al.* (2012)^[1] similarly identified specific gerbera varieties excelling under polyhouse conditions, though their recommended varieties differed, highlighting genotype-environment interactions. Our findings corroborate the principle that varietal performance is context-specific and must be evaluated under target production conditions.

The comprehensive, multi-criteria approach employed in this study advances beyond traditional single-trait comparisons, providing a more robust foundation for varietal recommendation. This methodological rigor enhances the reliability and applicability of our findings for commercial decision-making.

4. Conclusion

This integrated study conclusively identifies Fozzie as the

superior gerbera variety for commercial cultivation under polyhouse conditions in subtropical Telangana, India. Through comprehensive evaluation across 32 parameters and application of multiple decision-making frameworks (CPI, TOPSIS, AHP), Fozzie consistently emerged as the top-performing variety, demonstrating:

- 1. Comprehensive Excellence:** Superior performance in 75% of evaluated parameters, with particular strengths in yield, quality, and physiological traits.
- 2. Economic Superiority:** Projected net returns of ₹1,235,420/ha with benefit-cost ratio of 1.11, representing 164.8% advantage over average variety performance.
- 3. Balanced Performance:** Optimal integration of vegetative vigor, reproductive efficiency, and quality attributes.
- 4. Commercial Advantages:** Early flowering (39.93 days to bud initiation), high yield (3.20 flowers/plant in May), extended vase life (8.56 days), and consistent production.
- 5. Physiological Robustness:** Maximum chlorophyll content (47.41 SPAD) and leaf area (109.06 cm²), indicating strong photosynthetic capacity and stress tolerance.

The study provides a validated framework for gerbera varietal selection under protected cultivation, demonstrating the value of integrated, multi-criteria evaluation over single-trait comparisons. The clear superiority of Fozzie across diverse performance dimensions provides compelling evidence for its recommendation as the benchmark variety for commercial polyhouse cultivation in subtropical India.

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6. Author Contributions

Yelle Srujana and G. Divya done 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. The research was conducted independently without influence from variety suppliers or commercial interests.

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