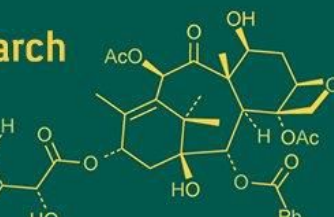
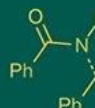


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(3): 819-823
www.biochemjournal.com
Received: 01-01-2025
Accepted: 04-02-2026

Sourav Sharma
Division of Floriculture and
Landscaping, SKUAST-J,
Jammu and Kashmir, India

Nomita Laishram
Division of Floriculture and
Landscaping, SKUAST-J,
Jammu and Kashmir, India

Arvinder Singh
Division of Floriculture and
Landscaping, SKUAST-J,
Jammu and Kashmir, India

Bhav Kumar Sinha
Division of Plant Physiology,
SKUAST-J, Jammu and
Kashmir, India

Rupali Thakur
Division of Floriculture and
Landscaping, SKUAST-J,
Jammu and Kashmir, India

Rajesh Kumar Pandey
Division of Floriculture and
Landscaping, SKUAST-J,
Jammu and Kashmir, India

Amit Jasrotia
Division of Fruit Science,
SKUAST-J, Jammu and
Kashmir, India

Corresponding Author:
Nomita Laishram
Division of Floriculture and
Landscaping, SKUAST-J,
Jammu and Kashmir, India

Effect of paclobutrazol on vegetative, floral and root parameters of a winter season annual: *Gazania*

Sourav Sharma, Nomita Laishram, Arvinder Singh, Bhav Kumar Sinha, Rupali Thakur, Rajesh Kumar Pandey and Amit Jasrotia

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i3Sj.7997>

Abstract

The morphological and floral characteristics of *Gazania* were assessed in this study in relation to several irrigation regimes (100%, 75%, 50%, and 25% Field Capacity) and foliar paclobutrazol (PBZ) sprays (0, 2.5, 5.0, 7.5, and 10 ppm). The 100% Field Capacity (FC) without PBZ produced the highest vegetative vigor (19.75 cm height; 22.45 cm spread), but it did not maximize floral productivity, according to statistical analysis. The most successful procedure was the combination of 5.0 ppm PBZ and 75% Field Capacity. Plants under this regime outperformed the absolute control (12 flowers) by achieving a desired, semi-compact architecture (10.23 cm height) and a robust floral production (14 flowers per plant). Furthermore, this combination improved the subterranean system, resulting in a root length of 27.40 cm and a dry weight of 1.07 g as opposed to the control's 22.70 cm and 0.67 g. Despite greatly enhancing root-to-shoot biomass partitioning, severe moisture stress (25% FC) and higher PBZ dosages (10 ppm) severely reduced blooming (4.00). According to the study's findings, 75% FC with 5.0 ppm PBZ provides a sustainable method of growing in *Gazania* that maximizes ornamental value while using 25% less watering.

Keywords: *Gazania*, irrigation regimes, paclobutrazol, flowering, growth, water-use efficiency

Introduction

Seasonal flowers have aesthetic appeal in a variety of locations, making them essential ornamental plants for landscape design (Fediw, 2015) ^[6]. However, because of their high-water requirements, these plants—including bedding plants like *Gazania*—are extremely vulnerable to water shortage stress. Plant morphology and physiology are adversely affected by drought stress, which results in decreased growth and marketability. Although plants have built-in antioxidant defense systems, severe water deprivation can overwhelm these systems, degrade photosynthetic pigments and stop structural growth.

A synthetic organic molecule called paclobutrazol (PBZ) has become a useful tool for reducing water stress since it is a strong plant growth suppressor (Fletcher *et al.*, 2000) ^[7]. According to Kondhare *et al.* (2014) ^[10], PBZ mainly inhibits gibberellic acid (GA), which limits cell elongation and produces stouter stems, better stem diameter, and increased lateral branching. Beyond its architectural advantages, PBZ stabilizes the plant's internal environment, shields cell membranes from degradation caused by reactive oxygen species (ROS), and improves osmotic control to promote systemic resistance to abiotic stress, especially drought (Gopi *et al.*, 2007) ^[8]. This enables plants to sustain blooming production and aesthetic qualities even in the face of extreme environmental restrictions by maintaining physiological hydration, boosting antioxidant defenses, and preserving photosynthetic capacity (Dwivedi *et al.*, 2018) ^[4].

This study intends to optimize specific dosages for commercially significant seasonal flowers like *Gazania* under varied irrigation regimes, given the strong evidence of PBZ's effectiveness in a variety of crops. This study especially examines the impact of paclobutrazol treatment on vegetative and root parameters in order to mitigate water deficit stress in *Gazania*.

Materials and Methods

The experiment was carried out inside protected structure at experimental farm, division of floriculture and landscaping, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha (J&K) during December, 2023-March, 2024. Meteorological data for the year in which study was conducted is given in Figure 1. The study utilized a factorial design with two main factors: Field Capacity (FC) at 4 levels and Paclobutrazol (PBZ) application at 5 levels comprising of 20 treatment combinations viz. T₁-At Field Capacity + 0 ppm Paclobutrazol, T₂-At Field Capacity + 2.5 ppm Paclobutrazol, T₃-At Field Capacity + 5.0 ppm Paclobutrazol, T₄-At Field Capacity + 7.5 ppm Paclobutrazol, T₅-At Field Capacity + 10 ppm Paclobutrazol, T₆-75% Field Capacity + 0 ppm Paclobutrazol, T₇-75% Field Capacity + 2.5 ppm Paclobutrazol, T₈-75% Field Capacity + 5.0 ppm Paclobutrazol, T₉-75% Field Capacity + 7.5 ppm Paclobutrazol, T₁₀-75% Field Capacity + 10 ppm Paclobutrazol, T₁₁-50% Field Capacity + 0 ppm

Paclobutrazol, T₁₂-50% Field Capacity + 2.5 ppm Paclobutrazol, T₁₃-50% Field Capacity + 5.0 ppm Paclobutrazol, T₁₄-50% Field Capacity + 7.5 ppm Paclobutrazol, T₁₅-50% Field Capacity + 10 ppm Paclobutrazol, T₁₆-25% Field Capacity + 0 ppm Paclobutrazol, T₁₇-25% Field Capacity + 2.5 ppm Paclobutrazol, T₁₈-25% Field Capacity + 5.0 ppm Paclobutrazol, T₁₉-25% Field Capacity + 7.5 ppm Paclobutrazol and T₂₀-25% Field Capacity + 10 ppm Paclobutrazol. Each treatment combination was replicated three times (R₁, R₂, R₃). Gazania plants were grown under controlled conditions and transplanted in 8-inch plants filled with potting mixture containing sand, vermicompost, soil and cocopeat.

Paclobutrazol was applied in the form of foliar application at the specified concentrations (0, 2.5, 5.0, 7.5, and 10 ppm) and irrigation was applied at different levels of field capacity at 20 days interval. The following vegetative and root parameters were measured: Plant Height (cm), Plant Spread (cm), Number of flowers per plant (NoFP), Root Length (cm) and dry weight of root (g).

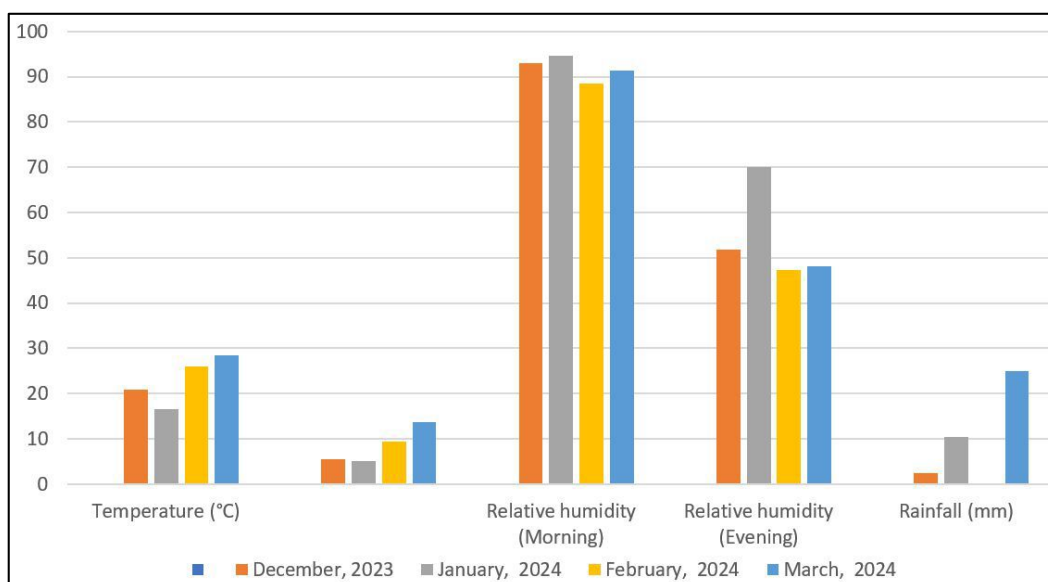


Fig 1: Meteorological data for Dec, 2023-March, 2024

Results

The results for plant height, plant spread, number of flowers (NoFP), root length, and dry weight of root, across different field capacities and paclobutrazol concentrations are presented in the table 1 and the comparison between different treatment combinations is shown in Plate 1.

Throughout the experiment, an inverse association between shoot growth and Paclobutrazol (PBZ) concentration was noted. The largest plants (Height: 19.75 cm, Spread: 22.45 cm) were produced at Full Field Capacity with 0 ppm PBZ. This occurred because the high moisture content without PBZ allowed for unconstrained development. Both height and spread sharply decline when PBZ rises from 0 to 10 ppm. Regardless of the irrigation schedule, height decreases to about 8 cm at 10 ppm PBZ. The lowest irrigation level (25% FC) results in the least plant spread (11.50 cm to 12.25 cm), demonstrating how PBZ and water stress

cooperate to limit lateral expansion.

It was observed that PBZ sometimes acts as a floral stimulant rather than decreasing flower count. Increasing PBZ actually increased floral production at Field Capacity. At 0 ppm, the count was 12 flowers; at 5 ppm, it peaked at 15 blooms. The count remains comparatively high after 5 ppm, although it starts to plateau or gradually decline. Only four flowers were produced as a result of severe water stress (25% FC) and high PBZ (10 ppm), indicating that the plant's metabolic energy was too low to sustain reproduction.

We also observed that PBZ greatly encourages root development while suppressing the top of the plant. Higher PBZ concentrations resulted in longer and heavier roots at all irrigation levels. At the greatest stress level (25% FC + 10 ppm PBZ), the longest root (49.20 cm) and highest dry weight (1.83 g) were noted.

Table 1: Effect of irrigation at different regimes and PBZ concentrations on vegetative, floral and root parameters of *Gazania*

	Plant Height (cm)	Plant spread (cm)	NoFP	Root Length (cm)	Dry weight of root (g)
At Field Capacity + 0 ppm Paclobutrazol	19.75	22.45	12	22.70	0.67
At Field Capacity + 2.5 ppm Paclobutrazol	17.22	21.59	13	23.80	0.78
At Field Capacity + 5.0 ppm Paclobutrazol	15.76	20.33	15	25.60	0.89
At Field Capacity + 7.5 ppm Paclobutrazol	11.72	19.67	14	28.30	1.11
At Field Capacity + 10 ppm Paclobutrazol	8.37	16.58	14	30.40	1.27
75% Field Capacity + 0 ppm Paclobutrazol	16.13	20.50	11	23.30	0.73
75% Field Capacity + 2.5 ppm Paclobutrazol	14.26	18.67	12	24.50	0.91
75% Field Capacity + 5.0 ppm Paclobutrazol	10.23	18.03	14	27.40	1.07
75% Field Capacity + 7.5 ppm Paclobutrazol	9.10	17.17	12	30.70	1.13
75% Field Capacity + 10 ppm Paclobutrazol	8.44	15.83	11	32.60	1.38
50% Field Capacity + 0 ppm Paclobutrazol	15.75	18.76	9	26.80	0.87
50% Field Capacity + 2.5 ppm Paclobutrazol	14.25	19.33	11	29.30	0.99
50% Field Capacity + 5.0 ppm Paclobutrazol	11.50	17.08	12	32.80	1.18
50% Field Capacity + 7.5 ppm Paclobutrazol	9.50	16.33	10	35.70	1.43
50% Field Capacity + 10 ppm Paclobutrazol	8.42	13.58	11	41.40	1.70
25% Field Capacity + 0 ppm Paclobutrazol	14.43	11.50	7	20.60	0.65
25% Field Capacity + 2.5 ppm Paclobutrazol	11.98	14.78	11	24.70	0.81
25% Field Capacity + 5.0 ppm Paclobutrazol	10.33	15.33	11	29.30	0.96
25% Field Capacity + 7.5 ppm Paclobutrazol	9.03	14.67	9	40.60	1.61
25% Field Capacity + 10 ppm Paclobutrazol	8.11	12.25	4	49.20	1.83
CD _{0.05}	1.5722	2.1416	1.6225	4.1481	0.1535
SE(m)	0.5501	0.7493	0.5676	1.4513	0.0537

Discussion

The study's findings are consistent with previous research on paclobutrazol's (PBZ) effects on plant growth and drought stress reduction. PBZ's well-established function as a plant growth suppressor is consistent with the observed decrease in plant height and spread with increasing PBZ concentrations. Its capacity to prevent gibberellic acid (GA) biosynthesis, which limits cell elongation and internodal development, is the main cause of this impact (Desta & Amare, 2021; Fletcher *et al.*, 2000) [2, 7]. For decorative bedding plants like *Gazania*, this results in more compact plants, which improves their visual appeal and marketability.

The harmful effects of dryness on growth and flowering in *Gazania* are confirmed by the overall decrease in plant height, plant spread, and number of flowers under reduced field capacity (water deficit stress). Water scarcity is a major environmental limitation that restricts plant growth and productivity globally, resulting in detrimental physiological and morphological reactions (Farooq *et al.*, 2009) [5]. The use of paclobutrazol, however, seems to lessen some of these detrimental effects, indicating its potential as a drought-mitigating medication.

One noteworthy discovery is the rise in root length and dry weight with increasing PBZ concentrations, especially in water-stressed situations. This implies that PBZ encourages the growth of roots, which is an essential adaptation strategy for plants to deal with drought. A larger root system improves the plant's capacity to absorb nutrients and water from the soil, increasing its capacity to endure and flourish in situations when water availability is restricted (Berova & Zlatev, 2003) [1]. Other ornamental species have also shown

increased root growth following PBZ treatment, which helps to enhance water relations under stress (Hatamifar & Babadaei Samani, 2017) [9].

There may be an ideal PBZ dosage for maximizing flowering under particular water stress levels, according to the intricate relationship between field capacity and paclobutrazol concentration for the number of flowers. Higher PBZ concentrations may assist sustain blooming under mild stress by reallocating resources or enhancing stress tolerance, even though they typically decrease vegetative growth. This supports the theory that PBZ enables ornamental plants to maintain their vital aesthetic qualities, flowering production, and structural development even in the face of extreme environmental restrictions (Dwivedi *et al.*, 2018) [4]. Sustained flowering may be facilitated by PBZ's capacity to increase water use efficiency and shield photosynthetic pigments from stress (Dwivedi *et al.*, 2017) [3].

The necessity of adjusting PBZ doses according to the particular irrigation regime is shown by the strong interaction effects found across all parameters. Understanding these relationships is essential for sustainable floriculture, particularly in areas where water constraint is a problem. According to the data, PBZ can be a useful instrument for controlling the growth of *Gazania* and strengthening its resistance to drought, which would increase its marketability. PBZ's promise in horticulture operations is further supported by prior research demonstrating the effectiveness of PBZ treatment techniques, especially soil drench, in influencing plant development and stress tolerance (Nasr, 1995) [11].



Plate 1: Effect of different treatment combinations on growth and development of Gazania

Summary and Conclusion

The 75% Field Capacity + 5.0 ppm PBZ treatment appears to be ideal for a commercial grower. In comparison to the control, it actually increases the number of blooms (14) and strengthens the root system (27.40 cm) while producing a little more manageable, compact plant (10.23 cm).

The physiological and biochemical processes that underlie these effects in Gazania, such as variations in relative water content, antioxidant enzyme activity, and osmolyte buildup, as covered in the introduction, might be investigated further. A more thorough understanding would also be obtained by examining the long-term consequences of PBZ application and its influence on following blooming cycles.

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