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Impact of Seed Priming on Germination, Growth, Flowering and Yield of *Gaillardia pulchella* var. Lorenziana

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ABSTRACT

The experiment was conducted during rainy season 2021–22 at the Department of Floriculture and Landscape Architecture, Junagadh Agricultural University, Gujarat, to evaluate the influence of different seed-priming treatments on germination, growth, and yield of Gaillardia. *Gaillardia pulchella* var. *Lorenziana* (blanket flower) is an important ornamental species valued for its vivid blooms and use in landscaping and cut flower arrangements, yet its cultivation has often been limited by poor germination and low yield. Seed priming is recognized as a simple and economical approach to overcoming poor seed performance, and the present study assessed the effects of potassium nitrate (KNO_3), gibberellic acid (GA_3), and *Trichoderma harzianum* under field conditions. Priming with 0.3% KNO_3 proved most effective, recording the earliest germination (5.58 days), the highest germination percentage (99.3%), and the greatest seedling vigor index (670.28). This treatment also significantly improved stem diameter, branching, floral traits, and yield (15.22 t ha^{-1}). Priming with GA_3 at 100 ppm enhanced plant height (81.68 cm) and leaf area (72.93 cm²), reflecting its promotive role in vegetative growth. Although *T. harzianum* showed moderate improvements, its effects were comparatively lower than chemical priming. Overall, 0.3% KNO_3 priming emerged as a practical and cost-effective technology for enhancing seed performance and productivity in Gaillardia, while GA_3 supplementation was beneficial for promoting vegetative development. These findings provide a scientifically validated strategy for improving Gaillardia cultivation and nursery management.

KEYWORDS: Gaillardia, seed priming, KNO_3, GA_3, germination, growth, hydropriming

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1. INTRODUCTION

Flowers represent some of the most exquisite creations of nature, symbolizing beauty, attraction, love, and tranquillity. Since ancient times, they have been closely associated with human social and cultural traditions. In India, flowers hold immense importance in religious rituals, cultural festivals, weddings, and various social ceremonies, and are widely used in garlands, bouquets, and decorative arrangements. The floriculture sector has gained substantial economic significance by contributing to employment generation, foreign exchange earnings, and strengthening rural livelihoods. At present, India cultivates approximately 305,000 ha of flower crops with a production of around 3,063,000 metric tons, positioning the country as the second-largest global producer after China (Anonymous, 2020). States such as Kerala, Tamil Nadu, and Madhya Pradesh lead in floriculture, whereas Andhra Pradesh is noted for the highest loose flower production, and West Bengal dominates in cut flower production. Gaillardia (*Gaillardia pulchella* L.), belonging to the family Asteraceae, is an attractive ornamental plant native to North America and widely cultivated throughout Asia and Africa. Commonly known as "Indian Blanket" or "Blanket Flower," it is valued for its vibrant and long-lasting blooms, bushy growth habit, and adaptability to diverse soil and climatic conditions. Of the twelve known species, *G. pulchella* Foug. and *G. aristata* are of major horticultural importance (Bose and Yadav, 1989). The cultivar 'Lorenziana' is particularly popular in the Junagadh region due to its double flowers, striking colour variations, and suitability for landscaping. In addition, Gaillardia is employed in roadside plantings, erosion control in coastal belts, and as a colourful alternative to chrysanthemums in floral decorations. Seed quality plays a crucial role in ensuring successful crop establishment in floriculture. Parameters such as germination percentage, seedling vigour, and uniform stand establishment greatly influence plant growth, flowering behaviour, and overall yield. However, seed viability and vigour tend to decline during storage and transportation due to fluctuations in moisture, temperature, and relative humidity. Seed priming, involving controlled hydration followed by drying, has emerged as an effective pre-sowing technique to enhance germination and promote uniform plant establishment. Significant progress in priming research over the past decade has demonstrated its potential across various ornamental and field crops (Cornea-Cipcigan et al., 2020; Biswas et al., 2023; Granata et al., 2024). Hydropriming, the simplest and most economical method, initiates early metabolic processes without radicle emergence. Studies have shown that optimizing soaking duration can maximize seedling vigour and improve field establishment (Priya Reddy and Nanja Reddy, 2024). Chemical priming using gibberellic acid (GA_3) has been reported to enhance germination, accelerate enzymatic activation, and improve root and shoot elongation in several ornamental species (Gueridi et al., 2024; Ma et al., 2018). Similarly, KNO_3 priming acts both as a nutrient source and a signalling molecule, improving early germination and seedling performance and helping maintain viability in aged seeds (Kaya et al., 2024). Biopriming, which incorporates beneficial fungi and bacteria, has gained prominence as a sustainable technique for enhancing seedling vigour, suppressing seed-borne pathogens, and improving crop productivity (Tarchoun et al., 2024). Recent reports have also demonstrated the effectiveness of priming specifically in Gaillardia for improving germination and maintaining seed quality during storage (Jhanji, 2022). Advances in seed packaging and post-priming handling further support long-term maintenance of primed ornamental seeds (Vidyashree, 2021). Considering these aspects, the present study was undertaken to evaluate the effect of different seed priming methods on Gaillardia (*Gaillardia pulchella* var. Lorenziana) with respect to seed germination, vegetative growth, flowering behaviour, and flower yield, to identify the most effective priming strategy for enhancing overall crop performance.

2. MATERIALS AND METHODS

The current study was carried out at the Jambuvadi Farm, Department of Horticulture, Junagadh Agricultural University, located in Junagadh, Gujarat, during the rainy season of 2021–22. The experimental location is situated at an altitude of 60m above mean sea level, positioned between 21.52°N latitude and 70.47°E longitude. The experimental design was structured in a factorial manner, employing a Completely Randomized Design (CRD) for laboratory germination assessments and a Randomized Block Design (RBD) for field experiments. A total of eight seed priming treatments were tested; each was replicated three times. Each replication included 100 seeds; 50 were designated for germination analysis and 50 for field experimentation, culminating in an overall plant population of 600. The field was maintained with a spacing of 30×30 cm^2. The seed priming treatments included a control group (non-primed seeds) (T_1), hydropriming with distilled water (T_2), hormonal priming with GA_3 at 50 ppm (T_3), GA_3 at 100 ppm (T_4), osmopriming with KNO_3 at 0.1% (T_5), KNO_3 at 0.3% (T_6), biopriming with Trichoderma harzianum at 4 g kg^{-1} (T_7), and *Trichoderma harzianum* at 8 g kg^{-1} (T_8). Seeds were immersed in the respective solutions for a duration of 24 hours in sterilized petri dishes at ambient temperature. Following the soaking period, seeds were rinsed with distilled water 2–3 times and subsequently dried on blotting paper under room conditions to restore their original moisture content. Seedlings were cultivated in trays utilizing a sterilized growing medium composed of coco peat, FYM, and soil in a 2:1:1 (v/v) ratio. Sowing occurred in late September and early October. Healthy and uniform seedlings, aged forty-five days, were selected and transplanted into raised beds measuring 1.5×1.5 m^2 on November 10, 2021. Observations recorded during the germination studies included days to germination, germination percentage, seedling length (shoot+root), and seedling vigor index I (Abdul-Baki and Anderson, 1973). Growth and yield parameters recorded during the field trial included plant height (cm), leaf area (cm^2), stem diameter (mm), number of branches per plant, days to first flower, flower diameter (cm), fresh flower weight (g), number of flowers per plant, and flower yield (g $plant^{-1}$, kg $plot^{-1}$, t ha^{-1}). The experimental data were statistically analyzed using the technique of analysis of variance (ANOVA) under RBD. The level of significance for the t-test was kept at 5% (p=0.05). "Statistical analysis of the experimental data was performed using OPSTAT (CCSHAU, Hisar) and Windowstat Ver. 9.1 (Indostat Services, Hyderabad, India).

3. RESULTS AND DISCUSSION

3.1. *Germination parameters*

Seed germination in *Gaillardia* was significantly influenced by KNO_3 priming. Seeds treated with 0.3% KNO_3 germinated earliest (5.58 days) and showed the highest germination percentage (99.30%), which may be attributed to enhanced pre-germination metabolic activity and increased permeability of potassium through the seed coat, promoting radicle protrusion and early seedling establishment (Basra et al., 2005; Abdi and Arefi, 2001; Gao et al., 2011; Bian et al., 2013). Seedling length was also maximum (6.75 cm) under this treatment, indicating that potassium plays a crucial role in sugar translocation, cell enlargement, and meristematic growth, thereby enhancing early vegetative development (Mengel and Kirkby, 1987; Afkari, 2010; Jagharghi et al., 2014; Farhoudi, 2012; Karimi and Varyani, 2016). The combined effect of improved germination and enhanced seedling growth resulted in the highest seedling vigor index-I (670.28) in 0.3% KNO_3-treated seeds, demonstrating that potassium priming not only accelerates germination but also strengthens overall seedling performance (Vimala et al., 2014; Dayeswari et al., 2018; Millaku et al., 2012; Ramzan et al., 2010). These results indicate that KNO_3 priming can be effectively used in nursery practices to achieve uniform, vigorous, and early seedling establishment in *Gaillardia*, which could enhance transplant success and overall crop performance. Adoption of this simple seed treatment can therefore improve productivity and reduce the time required for raising quality seedlings in commercial cultivation (Table 1).

3.2. *Plant growth and yield parameters*

Plant growth and yield parameters of *Gaillardia* were significantly influenced by different priming treatments. The plants primed with 100 ppm GA_3 recorded maximum height (81.68 cm) as compared to the control (65.23 cm), which may be attributed to improved root and shoot development, enabling greater water and nutrient uptake and consequently luxuriant growth. Similar positive effects of GA_3 on plant height have been reported in tulip (Ramzan et al., 2014), China aster (Pangtu et al., 2018), peas (Sharma, 2012), lentil (Toklu, 2015), and recent studies confirming enhanced vegetative growth due to GA_3 application (Khan et al., 2021). Leaf area was also highest in GA_3-primed plants (72.93 cm^2), likely due to enhanced cell division and expansion, as well as prolonged photosynthetic activity that ensured greater carbohydrate production (Khan et al., 2021). These findings corroborate earlier reports in tulip and China aster (Ramzan et al., 2014; Pangtu et al., 2018). Stem diameter was maximized in 0.3% KNO_3 (14.23 mm)

Table 1: Impact of priming treatments on germination percentage, seedling growth and vigor index in gaillardia

Treatments	Days taken for seed germination	Germination	Seedling length	Seedling vigour index-I
T_1: Control	9.56	89.30	3.73	333.089
T_2: Hydropriming	8.86	92.00	4.62	425.04
T_3: GA_3 (50 ppm)	6.74	97.30	5.28	513.744
T_4: GA_3 (100 ppm)	6.53	98.00	6.03	590.94
T_5: KNO_3 (0.1%)	5.92	96.60	6.67	640.32
T_6: KNO_3 (0.3%)	5.58	99.30	6.75	670.275
T_7: *Trichoderma harzianum* (4 g kg^{-1})	8.24	92.00	6.27	576.84
T_8 - *Trichoderma harzianum* (8 g kg^{-1})	7.18	96.00	6.48	622.08
SEm±	0.131	0.84	0.09	4.154
CD (p=0.01)	0.394	2.51	0.28	12.455

Table 2: Impact of priming treatments on growth, flowering and yield of gaillardia

Treatments	Plant height at final harvest (cm)	Leaf area (cm^2)	Stem diameter (mm)	Branches plant^{-1} (Final harvest)	Days to first flower	Flower diameter (cm)	Fresh flower weight (g)	Flowers plant^{-1}	Flower yield plant^{-1} (g)	Flower yield plot^{-1} (kg)	Flower yield (t ha^{-1})
T_1: Control	65.23	34.84	10.16	38.54	78.77	4.23	3.54	51.52	253.54	2.31	10.3
T_2: Hydropriming	68.13	43.18	11.35	41.33	77.49	4.94	3.82	59.19	272.81	2.49	11.06
T_3: GA_3 (50 ppm)	76.31	69.12	13.26	45.91	72.53	5.35	4.23	69.45	331.98	3.04	13.51
T_4: GA_3 (100 ppm)	81.68	72.93	13.5	50.43	69.45	5.8	4.92	72.82	345.68	3.16	14.08
T_5: KNO_3 (0.1%)	72.3	67.18	13.91		71.67	5.47	4.53	71.59	365.35	3.34	14.85
T_6: KNO_3 (0.3%)	77.32	70.52	14.23	51.23	63.84	5.9	5.2	78.15	372.86	3.42	15.22
T_7: *Trichoderma harzianum* (4 g kg^{-1})	70.37	62.97	11.96	42.25	75.93	5.17	4.29	63.34	309.52	2.83	12.6
T_8: *Trichoderma harzianum* (8 g kg^{-1})	72.04	65.19	12.33	43.56	74.63	5.45	4.31	65.23	311.82	2.85	12.69
SEm±	3.13	2.47	0.58	2.21	2.89	0.23	0.18	3.31	12.97	0.39	1.65
CD (p=0.01)	9.52	7.51	1.76	6.71	8.77	0.68	0.56	10.04	39.34	7.76	7.22

compared with the lowest value in the control (10.16 mm), in line with results in gladiolus (Karaguzel et al., 1999), and supported by recent findings demonstrating that nitrate priming enhances stem growth and vigor (Alharbi and Farouk, 2020). The number of branches per plant was also significantly higher in KNO_3 (51.23 at final harvest), followed by GA_3, which may be attributed to the role of potassium in improving photosynthetic CO_3 fixation, chlorophyll content, and cellular metabolism, thereby supporting branching and canopy spread (Vijayakumar et al., 2017; Singh et al., 2018; Alharbi and Farouk, 2020). Priming also influenced flowering behavior, with the earliest flowering recorded in 0.3% KNO_3 (63.84 days), followed by GA_3 (69.43 days), while the control took the maximum days (78.77). The earliness may be due to enhanced bud initiation promoted by hormonal and metabolic stimulation under GA_3 and KNO_3 priming, a trend recently confirmed in ornamentals (Singh et al., 2022). Similar findings were observed in lisianthus (Shah et al., 2018), chrysanthemum (Sajid et al., 2016), and China aster (Vijayakumar et al., 2017) (Table 2).

Flower diameter was also greatest in 0.3% KNO_3 (5.90 cm), followed by GA_3 (5.80 cm), which could be due to the influence of potassium ions on petal cell expansion (Wong, 1989). Comparable effects of mineral priming on flower size have been recently reported in ornamentals (Patel et al., 2020). Reproductive performance was further improved by priming, with the highest fresh weight of flowers in 0.3% KNO_3 (5.20 g) and GA_3 (4.92 g), against only 3.54 g in the control. Potassium is known to strengthen plant tissues through energy metabolism and enzyme activation, thereby increasing flower weight (Shah et al., 2014). The number of flowers plant^{-1} was also significantly higher in KNO_3 (78.15), likely due to enhanced branching and bud development, a trend consistent with earlier reports in China aster and zinnia (Vijayakumar et al., 2017; Shah et al., 2014) and supported by recent findings (Reddy et al., 2021). Consequently, flower yield was highest in 0.3% KNO_3, recording 372.86 g plant^{-1}, 3.42 kg plot^{-1}, and 15.22 t ha^{-1}, whereas the control showed the lowest yield (10.30 t ha^{-1}). The improvement in yield is a cumulative effect of better vegetative growth, more branches, larger flower size, and higher flower number, in agreement with studies in zinnia (Shah et al., 2014) and supported by recent evidence (Reddy et al., 2021).

4. CONCLUSION

Seed priming with 0.3% KNO_3 emerged as the most effective treatment, leading to significant enhancements in germination behaviour, seedling vigor, stem diameter, branching, early flowering, flower diameter, fresh flower weight, and overall yield. Conversely, GA_3 priming exhibited a notable impact on increasing plant height and leaf area.

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