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Effect of corm priming on growth and development in gladiolus (*Gladiolus* (Tourn) L.)

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Abstract
The present investigation was conducted to evaluate the influence of corm priming on morphological, biochemical, and propagation traits of gladiolus cv. Arka Amar. Treatments included potassium nitrate (1.0%, 1.5%, 2.0%), thiourea (1.5%, 2.0%, 2.5%), Benzylaminopurine (BAP) (50, 100, 150 ppm), and a standard control (water-soaked corms stratified at 4-7 °C for 3 months). The experiment was carried out under field conditions during the *Rabi* season to identify effective priming methods for enhancing growth and propagation. Results revealed that 1.0% potassium nitrate induced the earliest sprouting (13.83 days), while 1.5% potassium nitrate promoted the earliest spike emergence (69.00 days), earliest floret opening (74.23 days), and higher spike production per plant. The standard control produced the maximum sprouting percentage (91.67%) and superior vegetative growth, including plant height (105.20 cm), spike length (93.60 cm), rachis length, internodal length, leaf length (61.97 cm), and leaf width (2.91 cm). BAP at 150 ppm recorded the highest tiller number (3.87) and corms per plant (3.73). The standard control also produced longer spikes, more florets per spike, maximum florets open simultaneously, and longest vase life. Furthermore, 1.5% potassium nitrate gave maximum corm diameter (6.91 cm) and corm weight (84.52 g), while 2.5% thiourea produced the highest number of cormels (30.03) and cormel weight (26.38 g).

Keywords: Gladiolus, corms priming, biochemical, dormancy

Introduction
Gladiolus (*Gladiolus* (Tourn.) L.) is a major ornamental bulbous crop belonging to the family Iridaceae and subfamily Ixiodeae, with a basic chromosome number of x = 15. Popularly known as the "Sword Lily," it is valued for its long floral spikes, large attractive florets, wide color spectrum, and extended vase life, which have earned it the title "Queen of Bulbous Flowers" (Roy *et al.*, 2017) [37]. The genus exhibits considerable morphological variation in traits such as spike length, number of florets per spike, floret diameter, flowering duration, leaf dimensions, corm size, and cormel production. These characteristics are influenced by both genetic makeup and external environmental factors including temperature, photoperiod, and soil fertility. Propagation occurs through corms, where a new daughter corm develops annually above the old one, which subsequently degenerates, while cormels are formed after flowering as photosynthates accumulate underground. In India, limited availability of quality planting material remains a major challenge (Janakiram & Prasad, 2010) [18], primarily due to the low multiplication rate of corms. Additionally, conventional cultivation provides limited control over vegetative and floral traits. Corm priming has emerged as a simple and cost-effective method to improve crop establishment, early vigor, sprouting, growth uniformity, flowering, and propagation efficiency in gladiolus. Among the different treatments, benzyladenine (BA), a synthetic cytokinin, is widely used to stimulate cell division and promote axillary bud sprouting, thereby enhancing propagation efficiency. Potassium nitrate (KNO_3), besides serving as a nutrient source, has been reported to improve sprouting, vegetative vigor, and flowering attributes, often showing effects comparable to those of GA_3 in gladiolus (Hoque *et al.*, 2021) [17]. Thiourea is recognized for its dormancy-breaking potential; pre-plant soaking of corms in thiourea has been shown to promote earlier sprouting, improve vegetative growth, and enhance floral performance (Padmalatha *et al.*, 2013) [32].

Hydropriming, an eco-friendly approach, has also been demonstrated to increase germination percentage, ensure uniform emergence, and enhance seedling vigor in *Gladiolus alatus*. Collectively, these priming treatments represent promising strategies to enhance corm performance, improve crop uniformity, and increase production efficiency in gladiolus cultivation.

Materials and Methods

Healthy, uniform-sized corms were selected, cleaned, and prepared for the experiment. The corms were soaked for 24 hours in different dormancy-breaking solutions i.e. Potassium nitrate (KNO_3) (1%, 1.5%, 2%), Thiourea (1.5%, 2%, 2.5%), Benzylaminopurine (BAP) (50ppm, 100ppm, 150 ppm) or water, according to the treatment plan. After soaking, the corms were removed from the solution, shade-dried for 6 hours. The corms were placed in cold storage at 4-7 °C for three months in the DFR, Keshavnagar facility. Primed corms were planted in the field as per the FRBD layout, at a spacing of 20 cm × 20 cm and a depth of 5-6 cm. Light irrigation was applied immediately after planting, and the crop was managed following standard cultural practices. Various morphological observations were recorded including corm sprouting parameters (Days required for corms sprouting, Sprouting percentage), vegetative growth parameters (plant height, internodal length, number of leaves per spike, leaf width, leaf length, rachis length, number of spikes per plant, number of tillers per plant), floral growth parameters (days taken to spike emergence, days taken to first floret opening. spike length, diameter of second floret, number of florets remained open at a time, number of florets per spike, fresh weight of spike, spike diameter, vase life), corms and cormels production parameters (number of corms per plant, number of cormels per plant, fresh weight of corm, fresh weight of cormels per plant, diameter of corm).

Statistical analysis

The experiment was laid out in Factorial randomized block design (FRBD) layout with three replications. Collected data was statistically analyzed through Analysis of Variance (ANOVA), and treatment means were further compared through least significant difference (LSD) test. All the statistical analyses were performed using OPSTAT software at a significance level of $p \leq 0.05$.

Results and Discussion

The earliest corm sprouting was observed in treatment T_1 (KNO_3 - 1.0%) with an average of 13.83 days, which can be attributed to improved osmotic regulation, water uptake, and cell elongation; several studies (Powar *et al.* 2015 [34]; Sunilrao *et al.* 2014 [42]; Lakshminarayana *et al.* 2015 [25]; Kaur *et al.* 2018 [21]; Anjum *et al.*, 2020) [5] consistently reported that 1-1.5% KNO_3 significantly reduced sprouting days in gladiolus. The highest corm sprouting percentage (91.67%) was recorded in T_0 (standard control-soaked in water after stratification), where superior sprouting was linked to uniform hydration, hormonal balance, and inhibitor removal, findings that align with the promotive effects of hydro-priming reported by Mushtaq *et al.* (2012) [28], Ramzan *et al.* (2010) [35], Harris *et al.* (2001) [15] and Sung & Chang (1993) [41]. The earliest spike emergence (69.00 days) and earliest floret opening (74.23 days) both occurred in T2 (KNO_3 - 1.5%), as KNO_3 acted as both nutrient and stimulant, enhancing photosynthesis, metabolism, and floral initiation, with similar promotive effects reported at 1-3% by Anjum *et al.* (2020) [5], Reshma *et al.* (2017) [36], Lakshminarayana (2015) [25], Hoque *et al.* (2021) [17], and Memon *et al.* (2013) [27]. The tallest plants (105.20 cm) were recorded in T_0 (Standard control), while the shortest (91.23 cm) were observed in T_7 (BAP-50 ppm), where stratification supported elongation and BA reduced height by promoting lateral shoots, as also reported by Anjum *et al.* (2020) [5], Kaur *et al.* (2018) [21]. The number of leaves per plant (7.00) showed no significant variation, suggesting genetic control, in agreement with Varun (2011) [44], Lakshminarayana (2015) [25], and Hoque *et al.* (2021) [17]. Maximum leaf width (2.91 cm) and leaf length (61.93 cm) were observed in T_0 (Standard control-soaked in water after stratification), where greater width was attributed to hydration and stratification, while BAP (100-125 ppm) reduced it (Kaur *et al.*, 2018) [21]; KNO_3 also enhanced leaf length via improved stomatal conductance and nutrient use, as reported by Hoque *et al.* (2021) [17], Memon *et al.* (2013) [27], and Khan *et al.* (2012) [23]. Similarly, the longest internodes (3.11 cm) were recorded in T_0 (standard control-soaked in water after stratification), attributed to cold stratification and hydration, with similar findings by Sharma *et al.* (2021) [40]. Rachis length showed no significant variation, though Anjum *et al.* (2020) [5] noted longer rachis with 1% KNO_3 and shorter with 100 ppm BAP. The highest number of tillers per plant (3.87) was recorded in T_9 (BAP-150 ppm), as BA enhanced tillering by breaking apical dominance and stimulating axillary buds, consistent with findings by Baskaran & Misra (2007) [8], Kumar (2008) [24], Khan *et al.* (2011) [22], Padmalatha *et al.* (2013) [32], Manasa *et al.* (2017) [26], Anjum *et al.* (2020) [5], Sharma *et al.* (2021) [40], Nandania *et al.* (2023) [30], and Wankhede *et al.* (2024) [45]. The highest number of spikes per plant (2.60) was obtained in T2 (KNO_3 - 1.5%) due to the synergistic effect of nitrate and potassium, as also reported by Anjum *et al.* (2020) [5], Nagamani *et al.* (2017) [29], Karagüzel *et al.* (1999) [20], and Padmalatha *et al.* (2013) [32]. In the standard control treatment (T_0), superior floral performance was observed, including the largest second floret diameter (9.80 cm), the highest number of florets open at a time (6.03), the greatest number of florets per spike (15.10), the longest spike length (93.60 cm), the maximum spike girth (9.13 mm), the heaviest fresh spike weight (62.48 g), and the longest vase life (13.10 days), attributed to hydration, cold storage, balanced metabolism, and hormonal stability. Larger floret diameter under control conditions aligned with findings by Lakshminarayana (2015) [25], Sharma *et al.* (2003) [39], and Bhattacharjee (2001) [9]. More florets per spike in control were consistent with hydration and stratification effects, while higher floret numbers with 1-3% KNO_3 were also noted by Abbasi *et al.* (2005) [1], Memon *et al.* (2013) [27], Lakshminarayana (2015) [25], Anjum *et al.* (2020) [5], and Hoque *et al.* (2021) [17]. Greater spike length in control was attributed to stratification and hormonal balance, with similar enhancements under KNO_3 and N-K treatments (Lakshminarayana, 2015 [25]; Hoque *et al.*, 2021 [17]; Anjum *et al.*, 2020 [5]; Amir, 2006), while spike diameter and fresh weight were also enhanced under control, though KNO_3 (1-3%) increased girth and weight of spike, whereas BA reduced them by diverting assimilates to corms Anjum *et al.*, 2020 [5]; Baskaran, 2007 [8]; Tawar *et al.*, 2007 [43]; Lakshminarayana, 2015 [25]; Baskaran *et al.*, 2009 [7]. Vase life averaged 13.00 days across treatments, with slight prolongation in control due to hydration, turgidity, and reduced oxidative stress, while cytokinins and gibberellins also improved longevity by delaying senescence (Sajid *et al.*, 2015; Franco & Han, 1997; Jaroenkit & Paull, 2003; Padhye *et al.*, 2008; Faraji *et al.*, 2011) [38, 13, 19, 31, 12]. The highest number of corms per plant (3.73) was observed in T_9 (BAP-150 ppm), where BA promoted cell division, axillary bud initiation, and sink activity, with similar results at 75-300 ppm reported by Baskaran *et al.* (2014) [6], Aier *et al.* (2015) [2], Chopde *et al.* (2015) [11], Roy *et al.* (2017) [37], Holkar *et al.* (2018) [16], Nandania *et al.* (2023) [30], and Wankhede *et al.* (2024) [45]. The maximum number of cormels per plant (30.03) and highest cormel fresh weight (26.38 g) were recorded in T6 (Thiourea-2.5%), as thiourea enhanced meristem activity, water uptake, metabolism, sink strength, and carbohydrate allocation, corroborated by Padmalatha *et al.* (2013) [32], Chahal *et al.* (2013) [10], Lakshminarayana (2015) [25], Anjum *et al.* (2020) [5], Hadiya *et al.* (2020) [14], Pawar *et al.* (2023) [33], and Kaur *et al.* (2018) [21]. The maximum corm weight (84.52 g) and corm diameter (6.91 cm) were also obtained in T2 (KNO_3 - 1.5%), consistent with earlier reports that nitrate and potassium synergistically enhance vegetative growth, cell division, assimilate translocation, and corm enlargement (Ramzan *et al.*, 2010 [35]; Mushtaq *et al.* 2012 [28]; Lakshminarayana, 2015 [25]; El-Naggar *et al.* 2016 [3]; Anjum *et al.* 2020 [5]; Wankhede *et al.* 2024) [45].

Table 1: Effect of different corm priming treatments on sprouting, vegetative growth, and morphological traits of gladiolus cv. Arka Amar

Treatments	Corms sprouting (%)	Days required for corms sprouting	Days taken to spike emergence	Days taken to first floret opening	Plant height (cm)	No of leaves per stalk	Leaf width (cm)	Leaf length (cm)	Internodal length (cm)	Rachis length (cm)	No of spikes per plant	No of tillers per plant
b_0 - (T_0- Standard Control x stratification)	91.67^c (74.32)	15.23^b	69.73^a	74.83^a	105.20^d	7.23 (2.87)	2.91^e	61.97^e	3.11^e	43.63	2.20^c (1.79)	2.63^b (1.91)
b_1 - (T_1 - KNO_3 1.0 %)	87.50^c (70.28)	13.83^a	70.23^a	75.07^a	99.30^{bcd}	7.07 (2.84)	2.51^a	59.17^{cde}	2.82^a	40.17	2.50^e (1.87)	2.67^b (1.91)
b_2 - (T_2- KNO_3 1.5 %)	89.17^c (71.77)	14.10^a	69.00^a	74.23^a	101.73^{cd}	7.13 (2.85)	2.70^{bcd}	60.13^e	2.97^{bcd}	42.87	2.60^f (1.89)	2.60^b (1.90)
b_3 - (T_3- KNO_3 2.0 %)	85.83^c (69.11)	14.53^{ab}	69.53^a	74.73^a	100.00^{bcd}	7.03 (2.83)	2.78^{cde}	59.43^{de}	2.95^{bc}	41.63	2.33^d (1.82)	2.60^b (1.90)
b_4 - (T_4- TU 1.5 %)	76.67^{ab} (61.47)	21.07^c	73.50^b	78.73^b	95.03^{ab}	7.17 (2.86)	2.61^{ab}	54.93^{ab}	2.87^{ab}	40.2	2.13^{bc} (1.77)	2.43^a (1.85)
b_5 - (T_5- TU 2.0 %)	73.33^{ab} (59.29)	21.57^c	$74.23b^c$	79.63^b	96.53^{abc}	6.90 (2.81)	2.64^{abcd}	56.07^{ab}	2.90^{ab}	41.37	2.13^{bc} (1.77)	2.67^b (1.91)
b_6 - (T_6- TU 2.5 %)	70.83^a (57.43)	21.87^c	$74.13b^c$	79.93^b	97.70^{bc}	6.90 (2.81)	2.66^{abcd}	56.43^{bc}	2.94^{bc}	41.17	2.07^b (1.75)	2.80^c (1.95)
b_7 - (T_7- BAP 50 ppm)	77.50^b (62.04)	22.97^d	75.20^c	81.53^c	91.23^a	7.00 (2.83)	2.52^a	53.30^a	2.88^{ab}	39.37	1.97^a (1.72)	2.93^d (1.98)
b_8 - (T_8- BAP 100 ppm)	75.00^{ab} (60.15)	23.37^{de}	78.90^d	86.87^d	94.33^{ab}	6.93 (2.82)	2.62^{abc}	55.17^{ab}	3.05^{cde}	39.97	2.07^b (1.75)	3.57^e (2.14)
b_9 - (T_9- BAP 150 ppm)	75.00^{ab} (60.23)	23.93^e	82.53^e	91.90^e	95.90^{abc}	7.00 (2.83)	2.80^{de}	57.10^{bcd}	3.08^{de}	40.2	2.17^c (1.78)	3.87^f (2.21)
SE(m)±	2.15	0.3	0.49	0.45	2.11	0.02	0.06	0.99	0.04	1.19	0.03	0.03
CD (@5%)	6.17	0.85	1.39	1.31	6.07	NS	0.16	2.84	0.11	NS	0.09	0.09
Result	Sign.	Sign.	Sign.	Sign.	Sign.	NS	Sign.	Sign.	Sign.	NS	Sign.	Sign.

Note: Parentheses show arcsine or square-root transformed means. Same superscripts=non-significant; different superscripts=significant

Table 2: Effect of different corm priming treatments on floral quality attributes and corm/cormel production of gladiolus cv. Arka Amar

Treatments	Diameter of second floret (cm)	No of florets remained open at a time	No. of florets per spike	Spike length (cm)	Spike diameter (mm)	Fresh weight of spike (g)	Vase life (days)	No of corms per plant	No of cormels per plant	Weight of corm (g)	Weight of cormels per plant (g)	Diameter of a corm (cm)
b_0 - (T_0- Standard Control x stratification)	9.80^c	6.03^f (2.65)	15.10^g (4.01)	93.60^d	9.13^e	62.48^d	13.10^d	2.47^c (1.86)	20.80^e (4.66)	79.97^{cd}	18.58^{bc}	6.78^{de}
b_1 - (T_1 - KNO_3 1.0 %)	9.17^a	5.83^{de} (2.61)	14.50^d (3.94)	85.60^{abc}	8.81^{cde}	54.24^{bc}	13.00^{cd}	3.17^e (2.04)	18.03^b (4.36)	82.27^d	15.89^a	6.82^e
b_2 - (T_2- KNO_3 1.5 %)	9.18^a	5.90^{ef} (2.63)	14.80^f (3.98)	89.27^{cd}	9.00^e	55.22^{bcd}	12.63^{ab}	2.50^{cd} (1.87)	17.70^a (4.32)	84.52^d	15.72^a	6.91^e
b_3 - (T_3- KNO_3 2.0 %)	9.30^{ab}	5.60^c (2.57)	14.67^e (3.96)	86.83^{bc}	8.90^{de}	59.89^{cd}	12.60^{ab}	2.53^{cd} (1.88)	19.80^c (4.56)	83.29^d	17.52^{ab}	6.86^e
b_4 - (T_4- TU 1.5 %)	9.30^{ab}	5.13^a (2.48)	14.07^a (3.88)	83.50^{ab}	8.22^{ab}	51.30^{ab}	12.57^{ab}	2.57^d (1.89)	24.43^g (5.03)	73.47^{bc}	20.80^{cd}	6.60^{de}
b_5 - (T_5- TU 2.0 %)	9.56^{bc}	5.20^a (2.49)	14.07^a (3.88)	84.40^{abc}	8.70^{bcde}	56.27^{bcd}	12.70^{abc}	2.17^a (1.78)	26.80^h (5.27)	71.71^b	23.51^e	6.45^{cd}
b_6 - (T_6- TU 2.5 %)	9.65^c	5.30^b (2.51)	14.37^c (3.92)	85.90^{bc}	8.65^{abcde}	52.86^{abc}	12.60^{ab}	2.37^b (1.83)	30.03^i (5.57)	69.58^b	26.38^f	6.45^{cd}
b_7 - (T_7- BAP 50 ppm)	9.03^a	5.37^b (2.52)	14.33^b (3.92)	80.10^a	8.13^a	45.38^a	12.53^a	3.27^f (2.06)	20.40^d (4.62)	58.47^a	18.54^{bc}	6.14^{bc}
b_8 - (T_8- BAP 100 ppm)	9.05^a	5.60^c (2.57)	14.37^c (3.92)	82.73^{ab}	8.33^{abc}	51.12^{ab}	12.73^{abc}	3.50^g (2.12)	20.20^d (4.60)	52.68^a	18.85^{bcd}	5.74^a
b_9 - (T_9- BAP 150 ppm)	9.12^a	5.77^d (2.60)	14.50^d (3.94)	84.37^{abc}	8.45^{abcd}	52.08^{abc}	12.87^{bcd}	3.73^h (2.17)	24.00^f (4.99)	54.66^a	21.15^{de}	5.82^{ab}
SE(m)±	0.12	0.02	0.06	1.98	0.19	2.8	0.11	0.03	0.11	2.45	0.88	0.11
CD (@5%)	0.34	0.07	0.02	5.7	0.54	8.04	0.32	0.07	0.31	7.05	2.54	0.33
Result	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.

Note: Parentheses show arcsine or square-root transformed means, same superscripts=non-significant; different superscripts=significant

Conclusion

Based on the above results, it can be concluded that potassium nitrate treatments were most effective for promoting early corm sprouting and spike emergence. In terms of vegetative growth and floral traits, the standard control treatment (water x stratification at 4-7 °C for 3 month) proved to be the most beneficial, followed closely by potassium nitrate. Corms treated with potassium nitrate also produced the largest and heaviest corms, indicating improved storage organ development. In contrast, treatments with BAP resulted in a greater number of corms, though these were generally smaller to medium in size. For cormel production, both in terms of number and weight, thiourea treated corms showed the best performance, suggesting its effectiveness in stimulating axillary bud activity and assimilate partitioning toward cormel formation.

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