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TRANSFORMING CORMELS TO FLOWERING GRADE CORM THROUGH EFFICIENT FOLIAR NITROGEN MANAGEMENT IN GLADIOLUS

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ABSTRACT

Gladiolus is a bulbous crop that provides monetary benefits to farmers through sale of cut flowers as well as propagule production i.e. corms and cormels. The corms of 3-4 cm are required necessarily for better quality flower production, however cormels take long span of 3-4 years to reach flowering grade corm. Hence, the present study was conducted in gladiolus cv. ‘Punjab Glad 3’ to evaluate the effect of nitrogen foliar fertilization for improving qualitative and quantitative traits of cormels. The significant results after two seasons concluded that with foliar spray of 40 kg N/ acre in split doses leads to better growth and development of cormels with respect to plant height (58.67, 90.67 cm), no. of corms per plant (2, 2), no. of cormels/ plant (7.67, 15), corm size (2.23, 4.23 cm), corm weight (5.60, 25.33 g) and propagation coefficient (28.67). Higher doses of 50 kg N/ acre caused toxicity in plants by burning of leaves and resulting in poor growth and corm development. The application of 40 kg N/ acre increased the initial cormel size and weight by 47.54 % and 92.90 %, respectively thus transforming cormels into flowering grade corms within two growing seasons.
***Keywords* :** Gladiolus, nitrogen, fertilizer, foliar application, leaf nutrient analysis, geophytes.

Introduction

Gladiolus (*Gladiolus* spp.) is a prominent geophytic ornamental of the family Iridaceae. It is widely cultivated for its vibrant and long-lasting spikes, making it a preferred cut flower globally (Kentelky *et al.,* 2021). It thrives in well-drained soils and moderate climates, making it a popular choice for gardens, bouquets and floral arrangements (Abdel-Kader *et al*., 2020). Its economic significance is largely driven by the quality and availability of healthy propagules which influence both production cycles and market returns. However, the extended duration required for non-flowering grade cormels to mature into flowering-grade corms remains a key limitation in commercial propagation in floriculture. The floriculture industry, especially in developing regions, often suffers from a shortage of quality planting material due to limited propagation infrastructure and suboptimal agronomic practices. This creates a critical bottleneck in scaling up production to meet the increasing global demand for high-quality ornamental crops.

Efficient nutrient management, particularly nitrogen, plays a central role in accelerating vegetative development and cormel enlargement. Foliar application of nitrogen, especially in the form of urea, offers a rapid route for nutrient uptake by bypassing soil constraints such as leaching, fixation, or salinity-induced nutrient lock-up. This targeted approach enhances nitrogen use efficiency, promotes chlorophyll synthesis, and stimulates root and shoot growth leading to improved corm size, weight and overall plant vigor (Wani *et al*., 2016; Oliveira *et al*., 2020).

Foliar application of fertilizers allows rapid absorption of nutrients through the stomata and cuticle thus leading to quicker and more efficient nutrient utilization and improving physiological and biochemical parameters (Marital *et al.*, 2007; Bistgani *et al*., 2018; Oliveira *et al*., 2020).). This practice is used to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots (Ling and Silberbush, 2002). In gladiolus cultivation, foliar application is particularly beneficial as it can bypass soil-related issues such as nutrient lock-up, leaching and uneven distribution. Studies indicate that foliar sprays help in stimulating the absorption of soil-applied fertilizers, offering a potential solution to soil salt accumulation (Niu *et al*., 2021, Kentelky *et al*., 2021).

Understanding the effects of foliar nitrogen application on gladiolus cormel production is essential for optimizing fertilization strategies and achieving sustainable cultivation practices. This study investigates the effect of foliar-applied nitrogen on the qualitative and quantitative parameters of gladiolus, with emphasis on optimizing cormel development and reducing the transition period to flowering-grade corms. The goal is to establish a balanced nitrogen application regime that enhances yield, propagation efficiency and reduce propagule production time in gladiolus cultivation.

Materials and Methods

The experiment was carried out for two consecutive years (2021–22, 2022–23) at Department of Floriculture and Landscaping, Punjab Agricultural University (30°56’N, 75°52’E), located in north-western India. The region experiences a subtropical climate characterized by hot, humid summers from May to September and cool, dry winters from November to February. It receives an average annual rainfall of 760 mm, with nearly 80% of the precipitation occurring between July and September.

During the first year, cormels of gladiolus cv. ‘Punjab Glad 3’ of uniform size 0.5 cm, weighing 1-1.5g were treated with Bavistin (0.2 %) for half hour and were planted at 5 x 10 cm spacing and at 2-3 cm depth on flat beds during fortnight of October, 2021. The intercultural operations like irrigation, weeding and fungicides spray were performed as required in accordance with standard recommendations. The foliar application of nitrogen was applied through urea starting 45 days after planting till 1st week of April comprising of treatments as follows: 20kg N/acre, 30 kg N/acre, 40 kg N/acre, 50 kg N/acre. The dose for each treatment was calculated accordingly for the plot size of bed of 2.5 m^2 and divided into splits to be applied at 10 days’ interval. The cormels showed sign of maturity when leaves commenced yellowing and drying. The cormels were dug out of soil with the help of *khurpa*, cleaned and stored in cold storage for second year planting. During the second year, the cormels stored during previous year were removed from cold storage and planted in the month of October. The cultural practices and nitrogen application were repeated as during the first year.

The observation for vegetative growth and cormels traits were recorded during both years i.e. plant height (cm), number and width of leaf per plant, number of corms and cormels/plant, corm size (cm), corm weight (g), relative growth rate (RGR) at 90-105 days and 105-120 days after planting, propagation coefficient and percentage increase in corm size and corm weight.

Propagation Coefficient (%) = No. of corms per plant + No. of cormels per plant / No. of corm planted x 100

Percent increase in corm weight (%) = (Final increase in corm weight after harvest- Initial corm weight)/ Final increase in corm weight after harvest x 100

Percent increase in corm size (%) = (Final increase in corm size after harvest- Initial corm size)/ Final increase in corm size after harvest x 100

The conventional analysis of plant NPK content typically involves stoichiometric methods. Nitrogen content was estimated using the Kjeldahl method (Jackson, 1975), while total phosphorus in leaves was measured through phosphorus-vanadium-molybdenum yellow spectrophotometry (Jackson, 1975). Potassium content was determined using flame atomic absorption spectrophotometry (Jackson, 1975), with results expressed as a percentage on a dry weight basis, following the procedure described by Motsara *et al*. (2008).

The experiment was laid as per Randomized Block Design and statistical analysis was carried out in agreement as proposed by Gomez and Gomez (1984). The data was analysed using one-way analysis of variance (ANOVA) by using the statistical software General R-based Analysis Platform Empowered by Statistics 1.0.0 (Gopinath *et al.,* 2020).

Results

The foliar nitrogen fertilization for both the years showed significant difference ($p< 0.05$) on vegetative growth, corm and cormels growth and production along with relative growth rate and propagation coefficient as presented in Table 1, 2 and 3.

Vegetative Growth

The positive effect of nitrogen fertilization was observed on above ground plant growth during the continued two-year experiment (Table1.). As the nitrogen dose was increased from 20 to 40 kg/acre, there was significant proportional increase in plant height and leaf width during both the years; however, effect on leaf number was non-significant. The further increase in nitrogen dose beyond 40 kg/acre drastically reduced the vegetative growth. Nitrogen fertilization levels of 40 kg/acre resulted in maximum plant height (58.67 and 90.67 cm) and leaf width (1.60 and 4 cm), respectively during both the years.

Qualitative and Quantitative traits of cormel

The foliar nitrogen application was associated with significant change in qualitative and quantitative traits of cormels during both the year (Table 2.). The positive significant trend in number of corm and cormels/ plant, corm size and weight was observed with increase in nitrogen dose from 20 to 40 kg/acre. However, during first year, the effect on number of corms/plants was non-significant. Moreover, the nitrogen dose on higher side i.e. 50 kg/acre showed negative effect on qualitative and quantitative traits of cormels. After two seasons of cormel planting, 40 kg of N/acre resulted in significantly highest production of corms and cormels per plant (2.00 and 15) along with largest and heaviest corms (4.23 cm and 25.33 g) (Fig. 2) which was however at par with 30 kg N/ acre.

Growth Index and Propagation Coefficient

The relative growth rates at 90-105 days as well as 105-120 days after planting and propagation coefficient were significantly enhanced as nitrogen fertilization was increased from 20 to 40 kg /acre (Table 3.). However, when comparing the relative growth rate and propagation coefficient during both the years, it could be concluded that during second year the growth rate and propagule production were more pronounced than first year. Moreover, the effect of fertilization on relative growth rates were more during 105-120 days with maximum (2.80) at foliar spray of nitrogen @ 40 kg/acre. Higher RGR at these stages indicates that foliar-applied nitrogen facilitated sustained growth during critical developmental phases of gladiolus. The propagation coefficient was observed maximum (28.67) in plants treated with 40 kg N/ acre which was statistically at par with 20 kg N/ acre (25.33) and 30 kg N/ acre (23.33). The dose higher than 40 kg/acre resulted in leaf burn and toxicity which further reduced plant growth, corm development and overall propagation efficiency.

Percent increase in corm size and weight

The response of cormel growth traits specifically percent increase in corm size and weight to different nitrogen levels (20, 30, 40 and 50 kg N/acre) is presented in Figure 1 and its effect can be observed in Fig. 2. The data clearly illustrate a quadratic relationship between nitrogen application and percent increase in corm size, as described by the polynomial regression equation: $y = -16.887x^2 + 86.44x - 59.514$ with $R^2 = 0.9998$ which indicates a very strong fit of the model. A marked increase in both corm size (47.54 %) and weight (92.90 %) were observed up to 40 kg N/acre. Beyond this level (i.e., at 50 kg N/acre), a decline in corm size was noted, although corm weight remained relatively stable and high across all nitrogen levels tested. The 40 kg N/acre represents an optimal level of fertilization by 37.6 % increase in morphological size and 6.04 % in weight gain in cormels as compared to lower doses of nitrogen i.e. 20 kg/acre.

Leaf nutrient analysis

The results from different nitrogen application rates (20, 30, 40, and 50 kg N/acre) show a clear trend in nitrogen (N), phosphorus (P) and potassium (K) accumulation in the leaves, reflecting the plant's response to increasing nitrogen fertilization (Fig. 3.). Leaf N content increased progressively with higher nitrogen application, reaching a maximum of 1.40 % at 50 kg N/acre. The phosphorus content showed an increasing trend up to 40 kg N/acre (0.22%) as compared to 20 kg N/acre. The potassium content increased from 0.38% (20 kg N/acre) to a peak of 0.62% (40 kg N/acre), followed by a slight reduction (0.60% at 50 kg N/acre), respectively.

Discussion

The present findings highlight the significant role of foliar nitrogen fertilization in enhancing cormel traits especially turning them into flowering grade corms. Foliar application of nitrogen, particularly in the form of urea, proved effective in promoting vegetative growth, root development and metabolic functions like amino acid and protein synthesis, which collectively contribute to improved cormel development. The foliar fertilization also allowed direct nitrogen absorption by leaf tissues, reducing nutrient losses due to leaching or immobilization in soil and ensuring efficient nitrogen translocation to critical growth sites.

From the data it was observed that 40 kg N/acre represents the optimum application level for maximizing cormel enlargement and weight gain. At this rate, the percent increase in cormel size and weight was higher, demonstrating that foliar nitrogen can transform substandard propagules (initially ~0.5 cm in diameter and 1–1.5 g in weight) into near flowering-grade corms. The observed increase of over 45% in size and nearly 90% in weight suggests final dimensions approaching 4 cm in size and 2.0–2.8 g in weight, which meet the criteria for marketable or transplant-grade cormels. This reduces the production cycle of cormels turning into flowering grade corms from 3-4 years to two growing seasons.

These physiological responses can be attributed to nitrogen's pivotal role in promoting vigorous vegetative growth, enhancing chlorophyll content and increasing the rate of photosynthesis that lead to higher assimilate partitioning towards cormel development. The deleterious effect of higher dose of nitrogen (50 kg/acre) suggests the onset of nitrogen saturation point, beyond which the marginal benefits of additional nitrogen are minimal and may even reduce plant quality (Ahmed *et al*., 2015). Moreover, surplus nitrogen has been associated with disruption of osmotic balance, increased susceptibility to physiological stress and impaired metabolic functions (Swaroop *et al*., 2017; Verma *et al.,* 2015). Similar results were reported by in gladiolus (Verma *et al.,* 2015), in pelargonium (Cınar and Koksal, 2025) where in high concentrations of nitrogen resulted in depleted growth. The minimal increase in cormel growth under 20 kg N/acre reflected the insufficient nitrogen for optimal growth. Similar findings are corroborated in hydrangea (Li *et al.,* 2020), azalea (Li *et al.,* 2018) and gaillardia (Dedhia *et al*., 2023).

In support of these physiological outcomes, the nutrient profile of the leaf tissue (Fig. 3) reveals a progressive increase in nitrogen (N) and potassium (K) concentrations, with a modest rise in phosphorus (P) content across increasing N levels. This increase is consistent with nitrogen's critical role in protein synthesis, enzyme activation, and chlorophyll formation (Raven *et al.,* 2004), all of which contribute to improved plant vigor and cormel bulking in gladiolus. Potassium (K) content also showed a steady increase with nitrogen application, reaching a peak at 40 kg N/acre before plateauing. This pattern suggests a synergistic interaction between nitrogen and potassium, where nitrogen improves root development and nutrient uptake, facilitating greater potassium assimilation. It plays a crucial role in osmoregulation, carbohydrate transport and enzyme activation, thereby supporting overall physiological performance and storage organ development (Barzegar *et al.,* 2020).

Phosphorus, though essential for energy transfer and root development, exhibited only modest increases with the highest values observed at 40 kg N/acre, possibly due to its strong fixation in soil or dilution effects from increased biomass.

These nutrient dynamics, particularly the improved N and K levels at 40 kg N/acre, further support the physiological observations of enhanced cormel vegetative growth, as nutrient-rich foliage directly supports active photosynthesis and assimilate allocation of carbohydrates to developing cormels.

The findings of this study have important implications for optimizing the nutrient management strategies in gladiolus cultivation, particularly for enhancing the efficiency of propagule multiplication. The demonstrated success of foliar nitrogen application at 40 kg/acre in improving key vegetative and cormel parameters such as plant height, corm size, corm weight and the number of cormels while maintaining high relative growth rates (RGR) and propagation coefficients, opens avenues for rapid upgradation of non-flowering grade cormels to flowering-grade standards within a shortened cropping cycle. This could significantly reduce the traditional propagation duration, which is often a bottleneck in commercial gladiolus production. The work highlights the importance of precision fertilization, particularly using foliar delivery to minimize nutrient losses and enhance uptake efficiency. The evidence of physiological damage at higher nitrogen levels (50 kg/acre) emphasizes the need for correct dose of nutrient application to avoid negative trade-offs in plant health and flower quality. Therefore, the ability to upgrade cormel classes with foliar application of nitrogen at 40 kg/acre in split doses with almost 47.54 % increase from initial cormel size within two seasons has the potential to transform propagule supply chains and support round-the-year cultivation cycles in commercial floriculture.

Table 1 : Effect of foliar nitrogen fertilization on vegetative growth and corm production in gladiolus

Treatment	**Plant height (cm)**		**Number of leaves per plant**		**Width of leaves (cm)**	
	1st yr	**2nd yr**	**1st yr**	**2nd yr**	**1st yr**	**2nd yr**
20 kg N/ acre	49.00	83.67	5.33	5.67	1.81	2.67
30 kg N/ acre	52.67	85.67	4.33	6.33	1.53	3.50
40 kg N/ acre	58.67	90.67	5.67	6.90	1.60	4.00
50 kg N/ acre	56.00	88.33	5.07	6.33	1.67	3.70
C.D.	3.825	4.84	NS	NS	NS	0.567
SE(m)	1.084	1.374	0.347	0.347	0.093	0.161
SE(d)	1.534	1.944	0.491	0.491	0.132	0.227

Table 2 : Effect of foliar nitrogen fertilization on qualitative and quantitative traits of corm and cormels

Treatment	Number of corms per plant		Number of cormels per plant		Corm size (cm)		Corm fresh weight (g)	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
20 kg N/ acre	1.00	1.00	6.67	11.67	1.25	1.95	0.87	1.43
30 kg N/ acre	1.00	1.63	5.33	10.33	1.84	3.62	1.07	2.02
40 kg N/ acre	1.50	2.00	7.67	15.00	2.23	4.23	0.77	2.80
50 kg N/ acre	1.00	1.33	3.67	5.00	1.77	3.30	0.90	2.17
C.D.	NS	0.56	1.20	5.215	0.48	0.50	NS	0.63
SE(m)	0.167	0.319	0.898	1.478	0.14	0.14	0.08	0.18
SE(d)	0.236	0.451	1.269	2.091	0.19	0.20	0.12	0.25

Table 3 : Effect of foliar nitrogen fertilization on growth index and propagation coefficient in gladiolus

Treatment	RGR at 90-105		RGR at 105-120		Propagation coefficient	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
20 kg N/ acre	0.98	1.13	0.87	1.43	15.33	25.33
30 kg N/ acre	0.74	1.67	1.07	2.02	12.67	23.33
40 kg N/ acre	1.16	2.67	0.77	2.80	17.33	28.67
50 kg N/ acre	0.94	1.33	0.90	2.17	10.00	14.07
C.D.	0.12	0.56	NS	0.63	NS	9.58
SE(m)	0.18	0.18	0.08	0.18	1.93	3.00
SE(d)	0.25	0.25	0.12	0.25	2.74	4.24

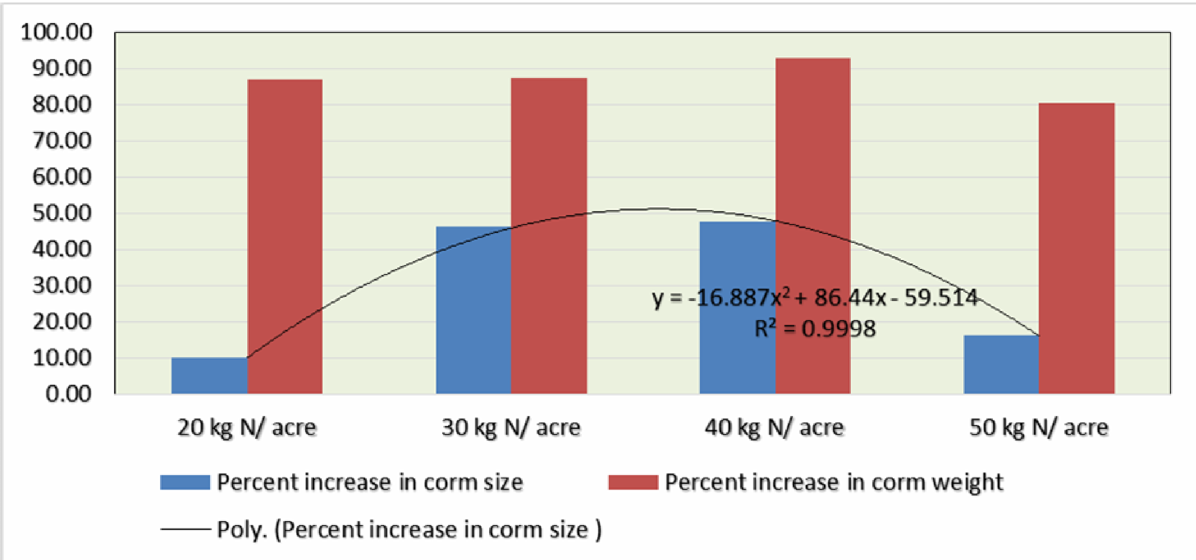

Fig. 1 : Effect of different doses of nitrogen on percent increase in corm size and corm weight during the two years.

Fig. 2 : Percent increase in corm size during the two years from initial to final with the application of foliar spray of urea 40 kg N/acre. (The first cormel in the left is the initial size (0.5 cm) taken for experiment. The middle cormel was the result of the first year urea treatment developed from initial size (0.5 cm). The third corm on the right is the result of second year treatment of urea.)

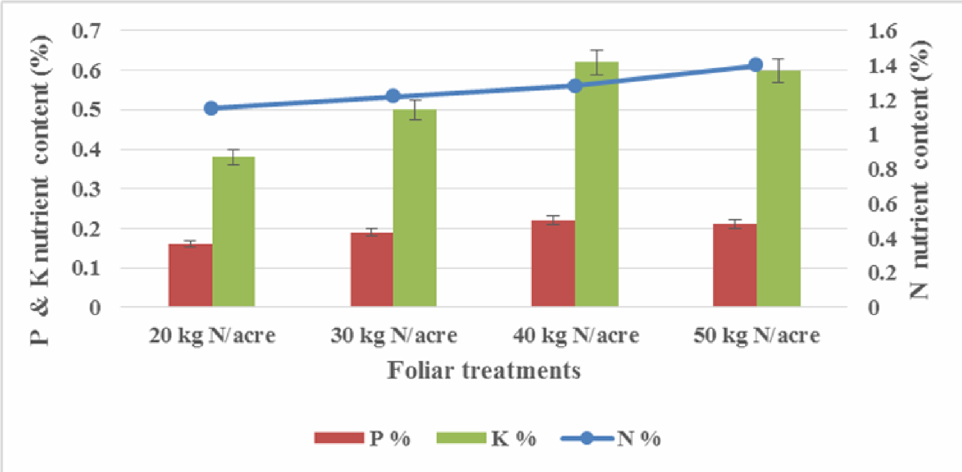

Fig. 3 : Effect of different doses of nitrogen fertilization on leaf nutrient analysis

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