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Effect of Plant Growth Regulators and Micronutrients on Growth, Flowering and Corm Production in Gladiolus (*Gladiolus grandiflorus* L.) cv. Nova Lux

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the Department of Horticulture, Janta College, Bakewar, Etawah, India, during 2022-23. The experiment was conducted in a randomized block design with 10 treatments in three replications. Different combinations of Plant Growth Regulators (GA_3) and Micronutrients - $ZnSO_4$ and $FeSO_4$ were used as treatments. The results revealed that, amongst all the treatments, the application of $ZnSO_4$ (0.5%)+$FeSO_4$ (0.5%)+GA_3 (200 ppm) in treatment

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produced significant results. No. of sprouts per corm 3.32, Height of Plant at 30 DAP (59.53cm), Height of Plant at 45 DAP (76.26cm), Number of leaves per plant at 30 DAP 9.13, Width of leaves per plant 30 DAP(3.50cm), Days to initiation of spike 72.95, Number of spike per plant 3.66, Days to opening of first floret 85.29**,** Length of spike (75.36cm)**,** Diameter of corm (10.36cm), Number of corms/plot 27.00 and average weight of single corm 209.61 gram. The findings suggest that the combination of $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5%) + GA_3 (200 ppm) might be used in production of gladiolus.

Keywords: Gladiolus; plant growth regulators; micronutrients; zinc sulfate.

1. INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.), commonly known as “Sword Lily”. It is a significant monocotyledonous flowering perennial bulbous plant belonging to the family Iridaceae. Often referred as "Queen of Bulbous" flower. Gladiolus is highly esteemed for its role in the cut flower industry. The genus "Gladiolus" includes 260 species, with 250 species native to sub- Saharan Africa and 10 species from Eurasia. The chromosome number is n=15, with most South African species being diploid (2n=30). The name "gladiolus" is derived from the Latin word "gladius" meaning "sword" referring to the sword-shaped leaves of the plant. The flowers open sequentially from the bottom to the top of the spike. The commercial cultivation of gladiolus is prominent in countries like India, Japan, the Netherlands, the United Kingdom, and the United States. Domestic Flower Markets: Delhi, Kolkata, Bangalore, Mumbai, and Hyderabad are major markets for gladiolus in India. Position in World Trade: Gladiolus holds the fourth position in the global trade of bulbous flowers [1] Leading states are Kerala (16.5%), Tamil Nadu (13.3%), Karnataka (11.4%), Madhya Pradesh (11.1%), Uttar Pradesh (7%), and production wise Loose Flowers 14.15 thousand tonnes, Cut Flowers: 246.62 thousand tonnes (NHB, 2020-21). Micronutrients such as zinc is an essential element for plants which acts as a cofactor of various enzymes or as a functional structural or regulatory biosynthesis component like protein of various synthesis, photosynthesis, the synthesis of auxin, cell division, the maintenance of membrane structure RNA and ribosome functions and sexual fertilization [2]. The micronutrients are responsible in activating several enzymes (catalase, peroxidase, alcohol dehydrogenase, carbonic dehydrogenase, etc.) and involve them self in chlorophyll synthesis and various physiological activities by which plant growth and development are encouraged [3], Zinc also controls the metabolism of plant by stimulating the hydrogenase and carbonic anhydrase activities, stabilization of ribosomal fractions and synthesis of cytochrome. Gladiolus remains a vital crop in floriculture, contributing significantly to both domestic and international flower markets due to its aesthetic appeal and economic value. Therefore, the current study was to determine optimal combination of plant growth regulators and micronutrients to enhance the vegetative growth, flowering, and yield of gladiolus, providing valuable insights for floriculture practices.

2. MATERIALS AND METHODS

The present study was conducted to investigate the “Effects of plant growth regulators and micronutrients on the effect of growth, flowering, and yield attributes of Gladiolus (*Gladiolus grandiflorus* L.) cv. Nova Lux”. The experiment was carried out during the 2022-2023 session at the experimental field of the Department of Horticulture, Janta College, Bakewar, Etawah (U.P.). The field are prepared by well-decomposed farmyard manure was applied before land preparation at the rate of 25t/ha and mixed well in to soil. Fertilizers were applied at the rate of 300:200:200kg NPK/ha. 50% of nitrogen and full dose of phosphorous and potash were applied as basal dose and remaining 50% of nitrogen was applied at 45 days after planting. Healthy, uniform-sized corms were treated with Bavistin (0.2%) and planted in October. The experiment followed a randomized block design with ten treatments and three replications. The spacing between rows and plants was maintained at 25 cm. During studies different treatments: T_1: Control (RDF), T_2: $ZnSO_4$ (0.2%), T_3: $ZnSO_4$ (0.5%), T_4: $FeSO_4$ (0.2%), T_5: $FeSO_4$ (0.5%), T_6: GA_3 (200 ppm), T_7: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%) + GA_3 (200 ppm), T_8: $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5%) + GA_3 (200 ppm), T_9: $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + GA_3 (200 ppm), T_{10}: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.5%) + GA_3 (200 ppm). The following parameters were recorded during course of studies are Number of sprouts per corm, Plant height at 30 days after planting (DAP), Number of leaves per plant, Width of leaves per plant, Days to spike initiation, Number of spikes per plant, Days to opening of the first floret, Length of spike (cm), Diameter of corm (cm), Number of corms per plot, Average weight of a single corm (g). The data collected were statistically analyzed following the method described by Panse and Sukhatme [4], with results evaluated at a 5% level of significance.

3. RESULTS AND DISCUSSION

Influence of plant growth regulators and micronutrients on vegetative characters of gladiolus: The data on various vegetative growth, flowering, and corm yield traits were recorded and analyzed, as depicted in Table 1. The results revealed that maximum number of sprouts per Corm, in treatment T_9 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.2% + GA_3 200 ppm) is 3.32 followed by T_7 ($ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + GA_3 200 ppm) 2.67. while minimum was observed in treatment T_1 (Control) 1.68. These results conform to the findings of Chopde et al. [5] and Deepika et al. [6], who reported that foliar application of GA_3, $FeSO_4$ and $ZnSO_4$ promotes the number of sprouts per corm. The maximum plant height is noted in treatment T_{10} ($ZnSO_4$ 0.2% + $FeSO_4$ 0.5% + GA_3 200 ppm) 59.53 cm followed by T_2 ($ZnSO_4$ 0.2%) 56.82 cm whereas the minimum was taken in T_1 (Control) 41.35 cm. These findings align with the results of Mishra et al. [7] and Patel et al. [8], who reported that the application of GA_3 @ 200 ppm and $FeSO_4$ 0.5% + $ZnSO_4$ 0.25% significantly increases plant height. The highest number of leaves per plant was observed in T_{10} ($ZnSO_4$ 0.2% + $FeSO_4$ 0.5% + GA_3 200 ppm) 9.13 followed by T_7 ($ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + GA_3 200 ppm) 8.88, while lowest was noted in T_1 (Control) 6.64. These results conform to the findings of Lahijie [9], Kumar and Haripriya [10], and Tamrakar et al. [11], who reported that foliar application of GA_3, $FeSO_4$ and $ZnSO_4$ promotes the number of leaves per plant.

The maximum width of Leaves per plant were observed in treatment T_{10} ($ZnSO_4$ 0.2% + $FeSO_4$ 0.5% + GA_3 200 ppm) 9.13 cm followed by T_7 ($ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + GA_3 200 ppm) 8.88 cm whereas minimum was recorded in T_1 (Control): 6.64 cm. These findings are in line with those of Dogra et al. [12], who reported that maximum leaf width was recorded at 300 ppm GA_3. Deepika et al. [6] and Tamrakar et al. [11] also reported significant increases in leaf width under the foliar application of $FeSO_4$ and $ZnSO_4$ (0.5%) and GA_3 @ 200 ppm, respectively.

Influence of plant growth regulators and micronutrients on flowering characters of gladiolus: The results are shown that the minimum days to spike emergence In treatment treated with T_{10} ($ZnSO_4$ 0.2% + $FeSO_4$ 0.5% + GA_3 200 ppm) 71.62 DAP followed by T_5 ($FeSO_4$ 0.5%) 71.88 DAP, while maximum was observed in treatment T_1 (Control) 77.21 DAP. These results are consistent with the findings of Dhumal et al. [13], who reported that soaking tuberose bulbs in 160 ppm GA_3 solution for 24 hours before planting significantly reduced the days to spike emergence. The maximum number of spikes per plant were observed in T_9 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.2% + GA_3 200 ppm) 3.66, followed by T_{10} ($ZnSO_4$ 0.2% + $FeSO_4$0.5% + GA_3 200 ppm) 2.81 while minimum was taken in T_1 (Control) 1.88. These findings align with Padmalatha and Reddy [14], who reported that GA_3 150 ppm was effective in increasing the number of spikes per plant in gladiolus. Minimum days taken to first floret open noted in T_{10} ($ZnSO_4$ 0.2% + $FeSO_4$ 0.5% + GA_3 200 ppm) 80.10 DAP, followed by T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + GA_3 200 ppm) 80.25 DAP whereas maximum was observed in treatment T_1 (Control) 85.29 DAP. These results conform to the findings of Lahiji [9] and Rashmi and Bhagwan Deen [15], who reported that GA_3 @ 200 ppm significantly reduced the days to first floret opening. Highest length of spikes recorded in treatment T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + GA_3 200 ppm) 75.36 cm followed by T_1 (Control) 65.10 cm. These findings are consistent with Ei Shoura et al. [16], who revealed that GA_3 application increased the length of the spike compared to other treatments Reddy et al. [17] also reported similar results.

Influence of plant growth regulators and micronutrients on corm yield traits of gladiolus: The data on corm yield traits were recorded and analyzed, as depicted in Table 3. The results are indicated that maximum diameter of corm Were observed in treatment T_9 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.2% + GA_3 200 ppm) 10.36 cm followed by T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + GA_3 200 ppm) 9.43 cm while minimum was taken in treatment T_1 (Control) 6.83 cm. These results are consistent with the findings of Rashmi and Bhagwan Deen [15], who reported that the diameter of corms was significantly improved by the use of GA_3 @ 200 ppm compared to other treatments. The maximum number of corms per plant were recorded in treatment treated with T_7 ($ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + GA_3 200 ppm) and T8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + GA_3 200 ppm) 27.00 whereas minimum was noted in T_1

Table 1. Influenced of Plant Growth regulators and Micronutrients on Vegetative Characters of Gladiolus

Treatments Combinations	Vegetative Characteristics			
	Numberof sprout per corms	Height of Plant incm (30DAP)	Number of leaves per plant at 30DAP	Width of leaves perplant at 30DAP
T_1 – Control (RDF)	1.68	41.35	6.64	2.58
T_2- $ZnSO_4$ (0.2%)	2.01	56.82	7.78	3.08
T_3 - $ZnSO_4$ (0.5%)	2.26	56.53	8.73	3.01
T_4 - $FeSO_4$ (0.2%)	2.17	51.36	7.20	2.75
T_5 - $FeSO_4$ (0.5%)	2.51	55.80	8.81	2.99
T_6 - GA_3 (200ppm)	2.38	53.00	8.76	3.07
T_7 - $ZnSO_4$ (0.2%)+$FeSO_4$ (0.2%)+GA_3(200ppm)	2.67	55.50	8.88	3.10
T_8 - $ZnSO_4$ (0.5%)+$FeSO_4$(0.5%)+GA_3 (200ppm)	2.19	54.95	8.29	3.28
T_9 - $ZnSO_4$ (0.5%) +$FeSO_4$ (0.2%)+GA_3(200ppm)	3.32	54.06	8.21	3.50
T_{10} - ZnSO4 (0.2%) + $FeSO_4$ (0.5%)+GA_3 (200ppm)	2.48	59.53	9.13	3.23
S.E.M.	**0.27**	**1.97**	**0.42**	**0.16**
CD at 5%	**0.83**	**5.92**	**1.27**	**0.49**

Table 2. Influenced of plant growth regulators and micronutrients on flowering characters of gladiolus

Treatments Combinations	Flowering Characteristics			
	Days to initiation of spike	Number Of spikeper plant	Days to opening offirst floret	Length of spike (cm)
T_1 – Control (RDF)	77.21	1.88	85.29	65.10
T_2- $ZnSO_4$ (0.2%)	73.81	2.14	80.70	69.07
T_3 - $ZnSO_4$ (0.5%)	73.40	2.29	81.66	69.81
T_4 - $FeSO_4$ (0.2%)	72.70	2.29	81.99	71.62
T_5 - $FeSO_4$ (0.5%)	71.88	2.29	81.03	71.29
T_6 - GA_3 (200ppm)	73.99	2.70	82.18	71.51
T_7 - $ZnSO_4$ (0.2%)+$FeSO_4$ (0.2%)+GA_3(200ppm)	74.70	2.47	82.14	72.10
T_8 - $ZnSO_4$ (0.5%)+$FeSO_4$ (0.5%)+GA_3 (200ppm)	72.95	2.21	80.25	75.36
T_9 - $ZnSO_4$ (0.5%) +$FeSO_4$ (0.2%)+GA_3(200ppm)	72.84	3.66	81.92	71.40
T_{10} - ZnSO4 (0.2%) + $FeSO_4$ (0.5%)+GA_3 (200ppm)	71.62	2.81	80.10	70.92
S.E.M.	**1.00**	**0.24**	**0.81**	**1.59**
CD at 5%	**2.99**	**0.73**	**2.43**	**4.78**

Table 3. Influence of plant growth regulators and micronutrients on corm yield traitsof gladiolus

Treatments Combinations	Corms Characteristics		
	Diameterof corm(cm)	Number of corms per plant	Average weight of singlecorm (g)
T_1 – Control (RDF)	6.83	15.66	162.95
T_2- $ZnSO_4$ (0.2%)	7.20	18.33	157.97
T_3 - $ZnSO_4$ (0.5%)	6.90	20.33	164.19
T_4 - $FeSO_4$ (0.2%)	7.23	20.66	166.16
T_5 - $FeSO_4$ (0.5%)	7.90	23.00	178.86
T_6 - GA_3 (200ppm)	8.23	24.00	194.30
T_7 - $ZnSO_4$ (0.2%)(0.2%)+GA_3(200ppm) +$FeSo_4$	7.96	27.00	205.82
T_8 - $ZnSO_4$ (0.5%)(0.5%)+GA_3 (200ppm) +$FeSo_4$	9.43	27.00	211.20
T_9 - $ZnSO_4$ (0.5%)+$FeSO_4$(0.2%)+GA_3 (200ppm)	10.36	26.00	209.61
T_{10} - $ZnSO_4$ (0.2%)(0.5%)+GA_3 (200ppm) +$FeSO_4$	9.06	24.00	202.57
S.E.M.	**0.23**	**1.78**	**7.70**
CD at 5%	**0.69**	**5.34**	**23.07**

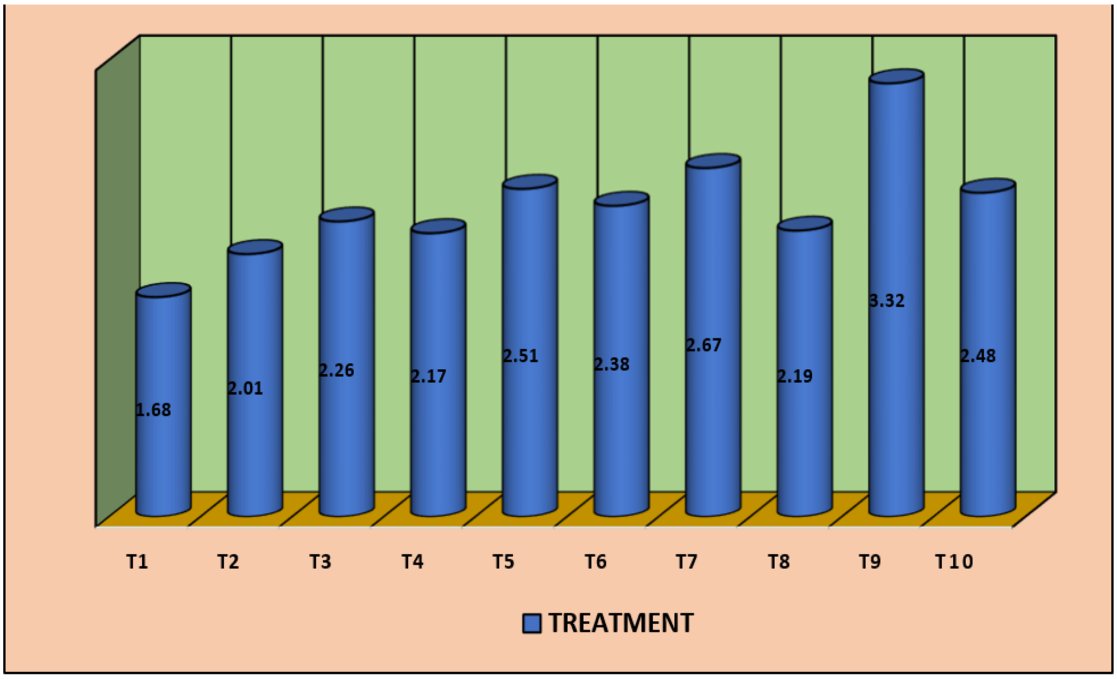

Fig. 1. Average number of sprouts per corm

Fig. 2. Average height of plant (cm) at 30 DAP of corm

(Control) 15.66. These findings corroborate with Devi et al. [18], who reported that the application of GA_3, specifically 100 ppm, improved the number of corms per plant. The maximum weight of corms was recorded in treatment treated with T8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + GA_3 200 ppm) 211.20 g followed by T9 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.2% + GA_3 200 ppm): 209.61 g while minimum was found in T2 ($ZnSO_4$ 0.2%) 157.97 g. These results align with Rashid [19], who reported that maximum corm weight was achieved by soaking corms in GA_3 @ 500 ppm for 12 hours and then shade drying [20,21].

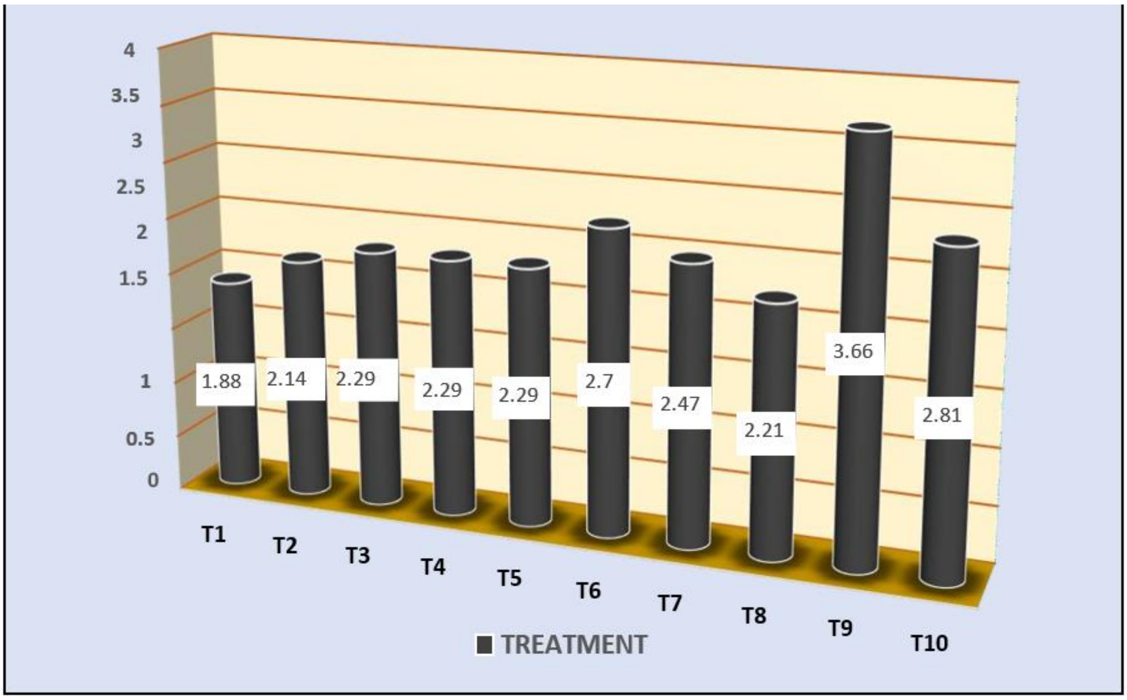

Fig. 3. Number of spikes per plant

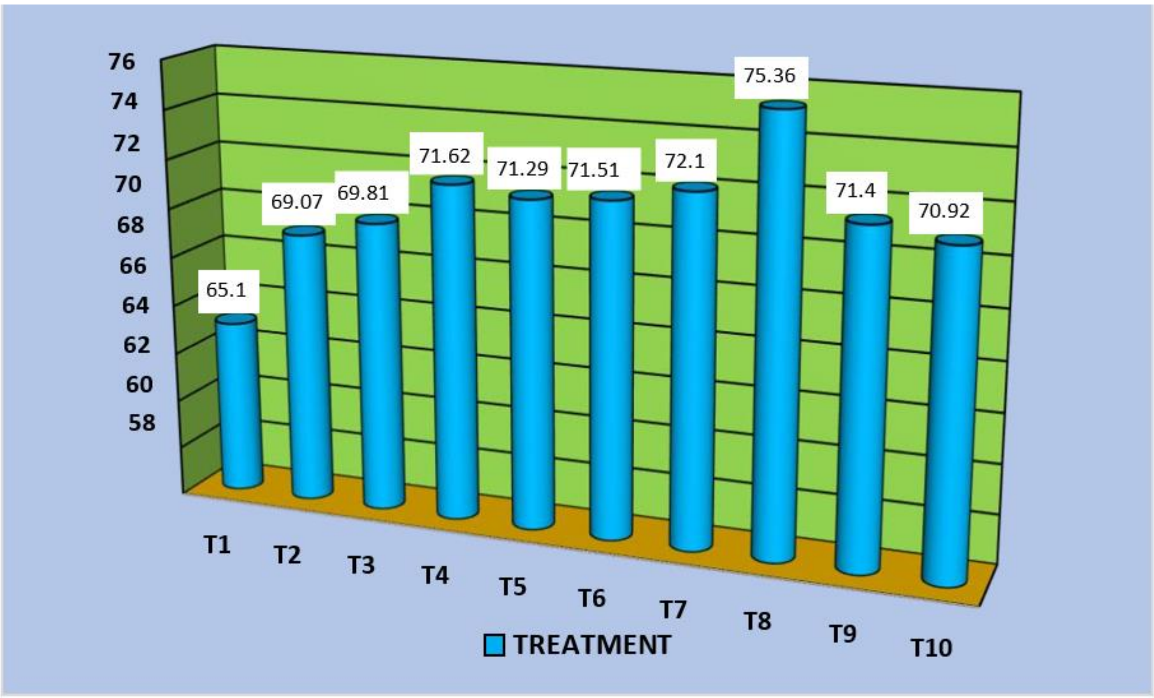

Fig. 4. Average length of spike (cm)

4. CONCLUSION

Based on the findings of the present investigation, it can be concluded that the application of $ZnSO_4$ (0.2%) + $FeSO_4$ (0.5%) + GA_3 (200 ppm) is highly beneficial for enhancing the commercial traits of Gladiolus cv. Nova Lux. This combination of plant growth regulators and micronutrients resulted in: Increased number of sprouts per corm: Higher number of sprouts was observed with this treatment. Improved plant height: The tallest plants were achieved under this treatment. Enhanced number of leaves and leaf width: More leaves and wider leaves were recorded. Earlier spike emergence and First floret opening: This treatment led to earlier flowering. Longer spike length: The longest spikes were observed with this combination. Larger corm diameter: The diameter of corms was significantly improved. Higher Number of corms per plot and greater corm weight: Both metrics were maximize with this treatment. Overall, this combination of $ZnSO_4$, $FeSO_4$, and GA_3 supports better growth, flowering, and yield parameters, making it highly effective for improving the commercial viability of Gladiolus cv. Nova Lux.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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