

Original Research Article

Effect of phosphorus and zinc on growth, flowering and yield of gladiolus

ABSTRACT

The investigations were conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2013 to March 2014. The studies were conducted on two factors Phosphorus and Zinc, where Phosphorus doses were adjusted at Four Doses i.e. P_0 : 0, P_1 : 120, P_2 : 140 and P_3 : 160, P_2O_5 kg ha⁻¹ respectively. Similarly Zinc was also adjusted at Four Doses as Zn_0 : 0, Zn_1 : 1, Zn_2 : 2 and Zn_3 : 3 Zn kg ha⁻¹ respectively. The experiment was laid out in a randomized complete block design (RCBD) with three replications. In case of phosphorus, highest corm yield (18.92 t ha⁻¹) and no. of spike (249300 ha⁻¹) was achieved from P_2 and lowest corm yield (16.57 t ha⁻¹) and no. of spike (208900 ha⁻¹) was from P_0 . In case of zinc, highest corm yield (19.64 t ha⁻¹) and no. of spike (251500 ha⁻¹) was from Zn_2 while lowest corm yield (15.79 t ha⁻¹) and no. of spike (201200 ha⁻¹) was from Zn_0 . For interaction effect, highest corm yield (20.64 t ha⁻¹) and no. of spike (268300 ha⁻¹) was from P_2Zn_2 while lowest corm yield (14.801 t ha⁻¹) and no. of spike (195000 ha⁻¹) was from P_0Zn_0 . So, 140 kg P_2O_5 and 2.0 kg Zn ha⁻¹ was found best for growth, flowering and yield of gladiolus.

Key words: Zn, P_2O_5 , corm yield, cormel number, gladiolus

1. INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is herbaceous annual flower belongs to the family Iridaceae (Sonmez *et al.*, 2013), is one of the most attractive and popular cut flowers. Based on geographical origin, gladiolus species are categorized into four groups viz., Eurasian group, East African group, Natalensis group and South African Cape species (Singh *et al.*, 2012). Gladiolus occupies fourth place in international cut flower trade and is ranked next to tulip among the bulbous flowers in India (Chopde *et al.*, 2015). It is now grown as a cut flower widely in Europe, particularly in Holland, Italy and Southern France. It is popular for its attractive spikes having floret of huge forms, dazzling colors, varying sizes and long durable quality as cut flower. It is frequently used in landscape, bedding, bouquets, flower arrangement etc. It is also used as cutflower in different social and religious ceremonies. It has been appropriately providing a symbol of glamour and perfection (Singh *et al.* 2012). Gladiolus are one on the most famous and well-liked cut flowers in the world as well as in Bangladesh for their majestic spikes, which contain attractive, elegant and delicate florets (Saeed *et al.*, 2013). It has recently become popular in Bangladesh and its demand in this country is increasing day by day. But its commercial production is still at the initial stages in

farming community because of lack of information regarding its cultivation technology. It's reported that income from gladiolus flower production in six times that returns from rice. The flower production area appears to have increased significantly and estimated area of around 10,000 ha and the annual trade at wholesale level to be worth between 500 & 1000 million taka in Bangladesh. Fertilizer requirements of gladiolus like other crops, has vital role in growth, quality, corm and cormel production (Halder *et al.*, 2007). Among them, phosphorus is also one of the most important essential macro elements for the normal growth and development of plant. Hossain *et al.* (2011) reported that the inadequate plant nutrition causes serious disorders and may eventually lead to decline of plant vigor and yield. Shaukat *et al.* (2012) also reported that phosphorus produced the tallest plants with longest spikes and most florets spike⁻¹. Higher rates of phosphorous tended to improve flower quality, cormel growth and corm production in cv. Friendship. Phosphorus also increases number of leaves clump⁻¹ (Pandey *et al.*, 2000). There is a scope of increasing flower yield, quality of flower and corm and cormel production of gladiolus with the optimum doses of phosphorous (P) fertilizer. The micronutrients play crucial and vital role in gladiolus production as well as major nutrients in growth and development of gladiolus (Singh *et al.*, 2012). Fahad *et al.* (2014) reported that the zinc influenced the vegetative growth and size of spike while found that the Zn enhances the plant growth, flower production and quality as well. Contribution of Zn in regulating the antioxidative activities, viz., SOD (Xu *et al.*, 2008), has been well documented. Analysis of soil samples of important soil types and series of Bangladesh reveals that 80- 90% soils are poor in zinc and sulphur (Haque *et al.*, 2015). However research works on phosphorus and zinc management for Gladiolus is lacking in Bangladesh. Considering the above mentioned facts the present study was undertaken and designed to select the optimum level of phosphorus and zinc for growth flowering and yield of gladiolus and finally to evaluate the best combination of phosphorus and zinc for growth flowering and yield of gladiolus for betterment of flowers growers.

2. MATERIALS AND METHODS

An experiment was conducted at the research field in Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, during the period from November 2013 to March 2014. Performance of test fertilizers was evaluated on growth variability, yield potentialities specially corm and cormel production, and vase life of Gladiolus as influenced by singly or interactions of various doses of Phosphorus and Zinc. The experimental field is located at 90.335° E longitude and 23.74° N latitude at a height of 8.5 meter above the seas level. The experimental soil belongs to the Modhupur Tract under AEZ No.28. The climate of the experimental site was under the subtropical climate characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period from May to October.

85 **A. Morphological characteristics of the experimental field**

Morphological features	Characteristics
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

86

87 **B. Physical and chemical properties of the soil before starting the**
88 **experiment**

Characters	Value
Partical size analysis	
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty clay
p ^H	6.5
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/ 100g soil)	0.10
Available S (ppm)	45

89 **Source:** Soil Resources and Development Institute (SRDI)

90

For the experiment, healthy and uniform sizes of corms were collected from the Barishal Nursery, Savar Bazar, Dhaka. The zinc oxide was used as a source of zinc under study. The experiment is consisted with two factors. Factor A: Phosphorus (4 doses) viz., $P_0 = 0 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ (control), $P_1 = 120 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$, $P_2 = 140 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$, $P_3 = 160 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. Factor B: Zinc (4 doses) e.g. $Zn_0 = 0 \text{ kg Zn ha}^{-1}$ (Control), $Zn_1 = 1 \text{ kg Zn ha}^{-1}$ (1.28 kg ZnO), $Zn_2 = 2 \text{ kg Zn ha}^{-1}$ (2.56 kg ZnO), $Zn_3 = 3 \text{ kg Zn ha}^{-1}$ (3.84 kg ZnO). The experiment was laid out in the randomized completely block design (RCBD) with three replications responsive to two factors.

C. Manure and fertilizers used under present study except the treatment

Manure/ fertilizers	Dose
Cow dung	10 t ha ⁻¹
Urea	200 kg ha ⁻¹
MP	200 kg ha ⁻¹
TSP	As per treatment
Zinc	As per treatment

Over head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening and as per when need afterword's. Stagnant water was effectively drained out at the time of heavy rains. Data was recorded on the following parameters from the sample plants during the course of experiment. Ten plants were randomly selected from each unit plot for the collection of data while the whole plot crop was harvested to record per plot data. The height of plant was recorded in centimeter (cm) at 70 days after planting (DAP), all the leaves of ten plants were counted at 70 days after planting (DAP), days required for 80% emergence of spike, percentage of flowering per plant, length of flower stalk at harvest, length of rachis at harvest, number of spikelets per spike, number of spike ha⁻¹ (000), thickness of corm, diameter of corm, corm yield per hectare, number of cormel per plant and cormel yield per hectare. The collected data for various characters were statistically analyzed by using MSTAT-C computer package programme. The mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F test. The differences between the treatment means were evaluated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Growth attributes of gladiolus

3.1.1 Plant height

The highest plant (74.8 cm) was obtained in 140 kg $P_2O_5 \text{ ha}^{-1}$ while the least plant (71.1 cm) height was obtained in without Phosphorus at harvest (Table 1). Similar findings were also obtained by Naznin *et al.* (2014). These results was also supported by Chandana and Dorajeeroo (2014); Zubair and Wazir (2007); Pandey *et al.* (2000). The plant height had taller (83.9 cm) in 2.0 kg Zn ha⁻¹ while it was the shortest (64.57 cm) in without Zn at harvest

(Table 2). These findings are also agreed by the research work of Amin *et al.* (2014) which was also supported by Singh *et al.* (2012) and Reddy *et al.* (2009). Interaction effect revealed that 140 kg P₂O₅ ha⁻¹ along with 2.0 kg Zn ha⁻¹ produced significantly the tallest plant (85.92 cm) while untreated plant of P₂O₅ and Zn recorded the shortest plant (62.25 cm) at harvest (Table 3).

3.1.2 Number of leaves plant⁻¹

The maximum number of leaves plant⁻¹ (11.32) was produced from 140 kg P₂O₅ ha⁻¹ while 0 kg P₂O₅ ha⁻¹ (control) recorded the minimum number of leaves plant⁻¹ (9.58) at harvest (Table 1). Similar research findings was also found by Shaukat *et al.* (2012) and many other scientists of the home and abroad (Naznin *et al.*, 2014; Chandana and Dorajee Rao, 2014; Sharma *et al.*, 2003). Among the various doses of Zn, 2.0 kg Zn ha⁻¹ produced significantly the more leaves plant⁻¹ (11.75) and without Zinc showed the minimum number of leaves plant⁻¹ (9.46) at harvest (Table 2). This result appeared that the 2 kg Zn ha⁻¹ had highly effective for getting the proper vegetative growth of Gladiolus plant which ultimately produced the more leaves. Similarly, Amin *et al.* (2014) also found that the maximum number of leaves plant⁻¹ was found from Z₃: 3 kg Zn ha⁻¹ (11.1) while minimum from Z₀ (7.9). Similar results were reported by Singh *et al.* (2012) and Reddy *et al.* (2009). Among the interactions, 140 kg P₂O₅ ha⁻¹ and 2.0 kg Zn ha⁻¹ treated plant recorded the maximum number of leaves plant⁻¹ (12.20) and untreated plant of both (P₂O₅ and Zn) recorded the minimum number of leaves plant⁻¹ (8.62) at harvest (Table 3).

3.2 Flowering, yield attributes and yield (corm and cormel) of gladiolus

3.2.1 Days to 80% emergence of spike

Days to 80% emergence of spike did not vary significant due to the effect of phosphorus (P₂O₅) which indicated that all the doses of phosphorus were similar effective for emergence of spike (Table 1). Table 2 revealed that the time of 80% spike emergence had longer (88.94 days) in without Zn while it was earlier with 2.0kg Zn ha⁻¹ (84.47 days) while 3.0 kg Zn ha⁻¹ showed statistically same (84.47 days) time for spike emergence (Table 2). Such similar result was also obtained by Amin *et al.* (2014) who also found that without zinc requiring the more time for 80% spike emergence while Fahad *et al.* (2014) and Lahijie (2012) also agreed the present findings. All the interaction treatments required statistically same time for emergence of 80% spike due to non significant variation (Table 3).

3.2.2 Percentage (%) of flowering

Flowering of gladiolus was the highest (95.69%) in 140 kg P₂O₅ ha⁻¹ while statistically same (94.28%) was in 160 kg P₂O₅ ha⁻¹ and the lowest (93.72%) was in without Phosphorus (Table 1). Similarly, Shaukat *et al.* (2012) also found similar results while this findings also agreed by the research work of Hossain (2008) and Kumar *et al.* (2006). Effect of zinc was significantly influenced the flowering where both 2.0 and 3.0 kg Zn treated plant gave the

highest flowering (96.68 and 95.90%, respectively) while lowest flowering (89.52%) was obtained from without Zn (Table 2). Similarly, Reddy and Rao (2012) also reported that the increase in the concentration of Zn delayed number of days taken for first flower appearance and number of days taken for 50% flowering which increase the flower production. Flowering data were statistically more or less similar among the interaction treatments due to non significant variation (Table 3).

3.2.3 Length of flower stalk

Effect of P was significantly affected the length of flower stalk where P_3 produced the longest flower stalk (75.06 cm) while shortest flower stalk (69.4 cm) was obtained in without Phosphorus treated plant (Table 1). Similarly, length of flower stalk was also statistically significant due to phosphorus reported by Hossain (2008).

The effect of zinc showed significant variation for length of flower stalk where Zn_2 recorded the longest flower stalk (78.27 cm) and without zinc obtained the shortest flower stalk (64.21 cm) (Table 2). Similarly, Sharma *et al.* (2013) also found significant variation in length of flower stalk due to zinc. All the interaction treatment of phosphorus and zinc produced statistically same length of flower stalk due to their non significant variation (Table 3).

3.2.4 Length of rachis

The effect of P on length of rachis at harvest was found to be significant where $140 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ showed the longest rachis (37.77 cm) while without phosphorus found to be the shortest rachis (32.25 cm) (Table 1). Naznin *et al.* (2014); Reddy *et al.* (2009) and many other scientists also found more or less similar result with the present study. The longest rachis (40.67 cm) was recorded in 2.0 kg Zn while shortest rachis (27.25 cm) was in control (Table 2). Length of rachis was also found to be the significant variation in the research findings of Amin *et al.* (2014); Reddy *et al.* (2009) and Halder *et al.* (2007a and 2007b) while Amin *et al.* (2014) and Halder *et al.* (2007a and 2007b) reported that the soil application of zinc @ 3.0 kg ha^{-1} enhanced the rachis length as compare to its higher and lower doses of zinc. The length of rachis was the highest (43.41 cm) in interactions of $140 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ and $2.0 \text{ kg Zn ha}^{-1}$ while without P and Zn showed the shortest rachis (25.38 cm) which was statistically differed from other interactions (Table 3).

3.2.5 Number of spikelets spike⁻¹

The maximum number of spikelets spike⁻¹ (17.43) was found in $140 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ and the minimum number of spikelets spike⁻¹ (13.55) was obtained in control (Table 4). Significant variation for number of spikelets spike⁻¹ due to P doses were also obtained by Hossain (2008). The spikelets spike⁻¹ had maximum (18.17) in $2.0 \text{ kg Zn ha}^{-1}$ and minimum (11.88) in without Zn (Table 5). Amin *et al.* (2014); Memon *et al.* (2013); Saeed *et al.* (2013); Halder *et al.* (2007a and 2007b) reported that the soil application of zinc also significantly influenced

the number of florets spike⁻¹. Interaction effect of P and Zn on the number of spikelets spike⁻¹ was significant (Table 6).

3.2.6 Number of spikes ha⁻¹

The maximum number of spikes (249300 ha⁻¹) was produced from 140 kg P₂O₅ ha⁻¹ while without P₂O₅ showed minimum number of spikes (208900 ha⁻¹) (Table 4). Similarly, number of spikes significantly influenced by the application of phosphorus was also obtained by Naznin *et al.* (2014); Shaukat *et al.* (2012); Hossain (2008); Zubair and Wazir (2006); Qazi (2005) and many other scientists of the home and abroad in *Gladiolus* while same findings were obtained by Hossain (2008). Incase of the Hossain (2008) reported that the maximum number of spike per plot was recorded from 140 kg P₂O₅ ha⁻¹ and minimum in P₀. The maximum number of spikes (251500 ha⁻¹) was recorded in 2.0 kg Zn ha⁻¹ while minimum number of spikes (201200 ha⁻¹) was found in without Zn (Table 5).

This result revealed that the higher doses of Zn (2 and 3 kg Zn ha⁻¹) produce significantly the more spikes of plot⁻¹ and ha⁻¹ than lower doses of Zn. Similarly, Amin *et al.* (2014) also reported that the Zinc application significantly influenced the number of spike hectare⁻¹. Number of spikes plot⁻¹ and '000' ha⁻¹ did not vary due to the interaction effect of P and Zinc which indicated that all the interaction treatments produced statistically similar number of spikes plot⁻¹ and '000' ha⁻¹ (Table 6).

3.2.7 Thickness of corm

Among the various doses of P₂O₅, the maximum thickness of corm (7.46 cm) was obtained in 140 kg P₂O₅ ha⁻¹ and the minimum (6.13 cm) in untreated plant of P₂O₅ (Table 4). Hossain *et al.* (2011) also found that the thickness of corm was the highest in 140 kg ha⁻¹ phosphorus and lowest in control. The effect of zinc showed significant variation on corm thickness where the maximum thickness of corm (7.47 cm) was found in 2.0 kg Zn ha⁻¹ while untreated plant of Zn observed the minimum thickness of corm (6.22 cm) (Table 5). Similarly, Amin *et al.* (2014) also found significant variation in individual corm thickness due Zinc application. There was significant difference on thickness of corm due to the interaction effect of phosphorus and zinc where thickness of corm had maximum (8.17 cm) in 140 kg P₂O₅ ha⁻¹ along with 2.0 kg Zn ha⁻¹ and minimum (5.73 cm) in without phosphorus and zinc (Table 6).

3.2.8 Diameter of corm

The highest diameter of corm was found from P₂ whereas the lowest thickness was recorded in control treatment (Table 4). Such the same result was also obtained by Hossain *et al.* (2011) and Hossain (2008) while both scientists found that 140 kg P₂O₅ ha⁻¹ recorded the highest thickness. Naznin *et al.* (2014) in 150 kg P₂O₅ ha⁻¹; Shaukat *et al.* (2012) in 130 kg P₂O₅ ha⁻¹; Kumar *et al.* (2006) in 200 kg ha⁻¹ and Pant (2003) in 100 kg P₂O₅ ha⁻¹ along with 50 kg N ha⁻¹ also found better result. Where diameter of corm was the highest (2.45 cm) in 2.0 kg Zn ha⁻¹ and the lowest (163 cm) in control (Table 5). The increased corm size with zinc @ 2 kg ha⁻¹ might be due to the better growth vegetative and reproductive growth of

plant including higher cell division and greater recruitment of photosynthates to the places where the corms are formed. Singh *et al.* (2012) reported that the diameter of corm was significantly affected. The highest diameter of corm (2.84 cm) was obtained in 140 kg P₂O₅ ha⁻¹ along with 2.0 kg Zn ha⁻¹ while it was the lowest (1.42 cm) in without P₂O₅ and Zn (control) (Table 6).

3.2.9 Yield of corm (t ha⁻¹)

Among the phosphorus doses, 140 kg P₂O₅ ha⁻¹ produced the highest yield of corm (18.92 t ha⁻¹) while the lowest amount of yield of corm (16.57 t ha⁻¹) was found in P₀ (Table 4). Similar result was also obtained by Chandana and Dorajeerao (2014); Naznin *et al.* (2014). The production of corm had highest (19.64 t ha⁻¹) in 2.0 kg Zn ha⁻¹ while control treatment observed the lowest yield of corm (15.79 t ha⁻¹) (Table 5).

This result revealed that 2.0 kg Zn ha⁻¹ produced the best significant yield of corm compare to higher and lower doses of zinc while Amin *et al.* (2014) also found similar results. In case of corm yield kg plot⁻¹, interaction treatment of 140 kg P₂O₅ ha⁻¹ × 2.0 kg Zn ha⁻¹ produced the highest yield of corm while the lowest yield of corm was in both 0 kg of P₂O₅ and Zn ha⁻¹ (Table 6).

3.2.10 Number of cormels plant⁻¹

Number of cormels plant⁻¹ was significantly influenced by the effect of phosphorus where cormels plant⁻¹ was the maximum (24.07) in 140 kg P₂O₅ ha⁻¹ and the minimum (19.79) in without P₂O₅ (Table 4). Shaukat *et al.* (2012) also found similar result with the present study. Zn @ 2.0 kg ha⁻¹ produced significantly the maximum number of cormels plant⁻¹ (24.95) while without Zn showed the minimum cormels plant⁻¹ (18.87) (Table 5). Number of cormels plant⁻¹ also varied significantly due to the effect of zinc reported by Amin *et al.* (2014); Memon *et al.* (2013). Number of cormels plant⁻¹ varied significantly due to the interaction effect of phosphorus and zinc where the maximum number of cormels plant⁻¹ (26.93) was obtained from the interactions of 140 kg P₂O₅ ha⁻¹ and 2.0 kg Zn ha⁻¹ while without phosphorus and zinc showed the minimum number of cormels (17.63) (Table 6).

3.2.11 Yield of cormel (t ha⁻¹)

Yield of cormel was the highest (11.85 t ha⁻¹) in 140 kg P₂O₅ ha⁻¹ while without phosphorus obtained the lowest yield of cormel (9.62 t ha⁻¹) (Table 4). Similarly, Naznin *et al.* (2014); Iftikhar *et al.* (2013); Hossain *et al.* (2011); Hossain (2008); Pant (2005); and many other scientists were also obtained significant and similar findings regarding cormel production while Hossain *et al.* (2011) and Hossain (2008) also found higher significant result in 140 kg P₂O₅ ha⁻¹ regarding cormel yield. The yield of cormel was the highest (12.14 t ha⁻¹) in 2.0 kg Zn ha⁻¹ while without phosphorus and Zn showed the lowest yield of cormel (9.36 t ha⁻¹) (Table 5). Such the same results were also obtained by Amin *et al.* (2014); Maurya and Kumar (2014), Fahad *et al.* (2014), Reddy and Rao (2012), Halder *et al.* (2007, 2007a, b and c) and many researchers of the home and abroad. The highest yield of cormel (13.20 t ha⁻¹)

was produced from the interaction treatments of $140 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} \times 2.0 \text{ kg Zn ha}^{-1}$. Similarly, the lowest yield of cormel (8.37 t ha^{-1}) was produced from the control treatment (both P_2O_5 and $\text{Zn } 0 \text{ kg ha}^{-1}$) (Table 6).

CONCLUSION

The application of micronutrients is the main functioning of plant cell for their growth and development. Considering the above discussion it may be concluded that the highest corm yield (18.92 t ha^{-1}) and no. of spike (249300 ha^{-1}) was from P_2 and lowest corm yield (16.57 t ha^{-1}) and no. of spike (208900 ha^{-1}) was from P_0 . For zinc, highest corm yield (19.64 t ha^{-1}) and no. of spike (251500 ha^{-1}) was from Zn_2 while lowest corm yield (15.79 t ha^{-1}) and no. of spike (201200 ha^{-1}) was from Zn_0 and combinidly, $140 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ with $2.0 \text{ kg Zn ha}^{-1}$ is best for growth, flowering and yield of gladiolus.

CONFLICT OF INTEREST

The author declares on part of this article has been published elsewhere.

REFERENCES

- Amin, M. R., Tahmina, S., Mahasen, M., Mehraj, H., Jamal Uddin A. F. M. 2014. Influence of zinc doses on flowering and production of corm and cormel of yellow gladiolus (*Gladiolus grandiflorus* L.). *Bangladesh Res. Pub. J.*, 10(1): 54–57.
- Chandana, K., Dorajeerao, A. V. D. 2014. Effect of graded doses of nitrogen and phosphorus on growth and yield of gladiolus (*Gladiolus grandiflorus* L.) cv. white Prosperity in coastal A.P., India. *Pl. Arc.*, 14(1): 143–150.
- Chopde, N., Nehare, N., Maske, S. R., Lokhande, S., Bhute, P. N. 2015. Effect of foliar application of zinc and iron on growth, yield and quality of gladiolus. *Plant Archives*, 15(1), 417–419.
- Fahad, S., Ahmad, K. M., Anjum, M. A., Hussain S. 2014. The effect of micronutrients (B, Zn and Fe) foliar application on the growth, flowering and corm production of gladiolus (*Gladiolus grandiflorus* L.) in calcareous soils. *J. Agril. Sci. Tech.*, 16: 1671–1682.
- Halder, N. K., Ahmed, R., Sharifuzzaman, S. M., Anzu–Man–Ara Bagam, K., Siddiky, M.A. 2007c: Effect of boron and zinc fertilization on corm and cormel production of gladiolus in grey terrace soils of Bangladesh. *Intl. J. Sus. Crop Prodn.*, 2(5)85–89
- Halder, N. K., Ahmed, R., Sharifuzzanan, S. M., Begam, K. A., Siddiky M. A. 2007. Effect of boron and zinc fertilization on corm and cormel production of gladiolus in grey terrace soils of Bangladesh. *Int. J. Sust. Crop Prodn.*, 2(5): 85–89.

- 337 Halder, N. K., Rafiuddin, M., Siddiky, M. A., Gomes, R., Anju–Man–Ara Begam, K. 2007a.
338 Performance of gladiolus as influenced by boron and zinc. *Pak. J. Biol. Sci.*, 10: 581–
339 585.
- 340 Halder, N. K., Siddiky, M. A., Ahmed, R., Sharifuzzaman, S. M., Begum, R. A.. 2007b.
341 Effect of boron and zinc fertilization on flower yield and quality of gladiolus in grey
342 terrace soils of Bangladesh. *J. Soil .Natr.*, 1(3): 40–45.
- 343 Haque, M. M., Saleque, M. A., Shah, A. L., Biswas, J. C., Kim, P. J. 2015. Long-term effects
344 of sulfur and zinc fertilization on rice productivity and nutrient efficiency in double
345 rice cropping paddy in Bangladesh. *Commun. Soil Sci. Pl. Anal.*, 46(22): 2877-2887.
- 346 Hossain, M. J. 2008. Influence of corm size and phosphorus on growth flowering and yield of
347 gladiolus. *MS Thesis, Dept. of Horticulture and Postharvest Technology, Sher-E–*
348 *Bangla Agricultural University, Dhaka–1207.*
- 349 Hossian, M. J., Amin, M. R., Choudhury, S., Uddain, J. 2011. Effect of corm size and
350 different doses of phosphorous on the growth, corm and cormel development of
351 gladiolus. *Libyan Agric. Res. Center J. Intl.*, 2(1): 09–14.
- 352 Kumar, R., Misra, R. L., Singh, S. K. 2008. Post–harvest life of gladiolus cv. Jester Gold as
353 influenced by different doses of nitrogen, phosphorus and potassium. *Indian J. Hort.*,
354 65(1): 83–86.
- 355 Kumar, V., Rajwal, N., Sirohi, H. S. 2006. Performance of Phosphorus doses on gladiolus
356 *Gladiolus grandiflorus* L. cv. 'Happy End'. *Intl. J. Pl. Sci. Muzaffarnagar*, 1(2): 320–
357 321.
- 358 Lahijie, M. F. 2012. Application of micronutrients FeSO_4 and ZnO on the growth and
359 development of *Gladiolus* variety, Oscar. *Int. J. of Agril. & Crop Sci.*, p. 718–720.
- 360 Maurya, R., Kumar, A. 2014. Effect of micronutrients on growth and corm yield of gladiolus.
361 *Pl. Arc.*, 14(1): 529–531.
- 362 Memon, S. A., Baloch, A. R., Baloch, M. A., Buriro, M. 2013. Effect of zinc sulphate and
363 iron sulphate on the growth and flower production of gladiolus (*Gladiolus*
364 *hortulanus*). *J. Agrl. Tech.*, 9(6): 1621–1630.
- 365 Naznin, A., Amin, M. R., Obaidullah, A. T. A. B., Shamsuzzoha, M., Jamal Uddin, A. F. M.
366 2014. Response of gladiolous (*Gladiolus grandiflorus* l.) to different doses of
367 phosphorus. *Int. J. Bus., Soc. and Sci. Res.*, 1(2): 83–86.
- 368 Pandey, R. K., Rathore, P., Singh, M. K. 2000. Effect of different doses of phosphorus and
369 nitrogen on gladiolus under Agra conditions. *J. Orn. Hort.*, 3(1), 60-61.
- 370 Pant, S. S. 2003. Effect of different doses of nitrogen and phosphorus on growth and
371 development, cut–flower characteristics and vase life of gladiolus cv. American

372 Beauty. *MS Thesis, Department of Horticulture, IAAS, Rampur, Chitwan, Nepal*, pp.
373 1–82.

374 Pant, S. S. 2005. Effect of different doses of nitrogen and phosphorus on the corm and cormel
375 development of gladiolus (*Gladiolus* sp.). Cv. *American Beauty*. *J. Inst. Agric. &*
376 *Animal Sci.*, 26: 153–157.

377 Qazi, A. H. D. 2005. Studies on nutrient management of Gladiolus (Tourn.) L. cv. White
378 Prosperity under temperate conditions of Kashmir. *MS Thesis, Department of Library*
379 *and Information Science, University of Kashmir*. Online available at:
380 <http://dspace.uok.edu.in/handle/1/265>.

381 Reddy, A. G. K., Chaturvedi, O. P. 2009. Effect of zinc (ZnO), calcium (CaSO₄) and boron
382 (borax) on growth and flowering in gladiolus cv. Red Majesty. *Crop Res. (Hisar) J.*,
383 38: 135–137.

384 Reddy, G. V. S., Nageswara Rao, M. B., Chandhra Sekhar, R. 2014. Studies on the effect of
385 foliar application of zinc on vegetative growth, flowering, corm and cormel
386 production in gladiolus cv. White Prosperity. *The bioscan*, VI: 35–39: 2014

387 Reddy, G. V. S., Rao, M. B. N. 2012. Precision foliar application of zinc to improve the
388 growth and yield of gladiolus. *Proceedings of AIPA 2012, Agro-Informatics and*
389 *Precision Agriculture*, pp. 44–45.

390 Saeed, T., Hassan, I., Jilani, G., Abbasi, N. A. 2013. Zinc augments the growth and floral
391 attributes of gladiolus, and alleviates oxidative stress in cut flowers. *Scientia Hort.*,
392 164(17): 124–129.

393 Sharma, J. R., Gupta, R. B., Panwar, R. D., Kaushik, R. A. 2003. Growth and flowering of
394 gladiolus as affected by nitrogen and phosphorus doses. *J. Orn. Hort. New Series*,
395 6(1): 76–77.

396 Sharma, J., Gupta, A. K., Kumar, S., Gautam, R. K. S. 2013. Influence of zinc, calcium and
397 boron on vegetative and flowering parameters of gladiolus cv. Aldebran. *The*
398 *Bioscan.*, 8(4): 1153–1158.

399 Shaukat, S. A., Shahb, S. Z. A., Ishaq, Y., Ahmed, M., Shaukate, S. K., Shoukat, S. W.
400 2012. Influence of phosphorus fertilization on gladiolus corm and flower production.
401 *Scientific J. Agril.*, 1(5): 105–111.

402 Singh, A. K., Chetan, S. 2000. Effect of spacing and zinc on production of corms and
403 cormlets in gladiolus (*G. grandiflorus*) cv. Sylvia. *Hort. J.*, 13(2): 61–64.

404 Singh, J. P., Kumar, K., Katiyar, P. N., Kumar, V. 2012. Influence of zinc, iron and copper on
405 growth and flowering attributes in gladiolus cv. sapna: *MS Thesis, Dept. of Hort., C.S.*
406 *Azad Univ. of Agri. & Tech., Kanpur*, pp. 138–143

407 Singh, J. P., Kumer, K., Katiyar, P. N. 2012. Effect of zinc, iron and copper on yield
408 parameters of gladiolus. *Hort. Flora Res. Spect.*, 1(1): 64–68.

409 Sonmez, F., Çig, A., Gulser, F., Basdogan, G. 2013. The effects of some organic fertilizers on
410 nutrient contents in hybrid Gladiolus. *Eurasian J. soil sci.*, 2(2), 140-144.

411 Zubair M., Wazir F.K. 2006. Phosphorus doses affect growth and yield of gladiolus cultivars
412 in Peshawar. *Online publication* and its available at
413 <http://prh.hec.gov.pk/Chapters/3018H-4.pdf>.

414 Zubair, M., Faridullah, K. W. 2007. Phosphorus affects production and quality of cut flowers
415 of gladiolus cultivars in Peshawar. *Pak. J. Agric Res.*, 20(3–4): 148–155

416 Zubair, M., Wazir, F. K. 2007. Phosphorus affects production and quality of cut flowers of
417 gladiolus cultivars in Peshawar. *Pak. J. Agri. Res.*, 20(3/4), 148-155.

418 Xu, P. L., Guo, Y. K., Bai, J. G., Shang, L., Wang, X. J. 2008. Effects of long-term chilling
419 on ultrastructure and antioxidant activity in leaves of two cucumber cultivars under
420 low light. *Physiologia Plantarum*, 132(4): 467-478.

421

422

423

424

425

426

427

428

429

430

431

432

433

434

435

436

437

438

439

440

441

442

443

444

445

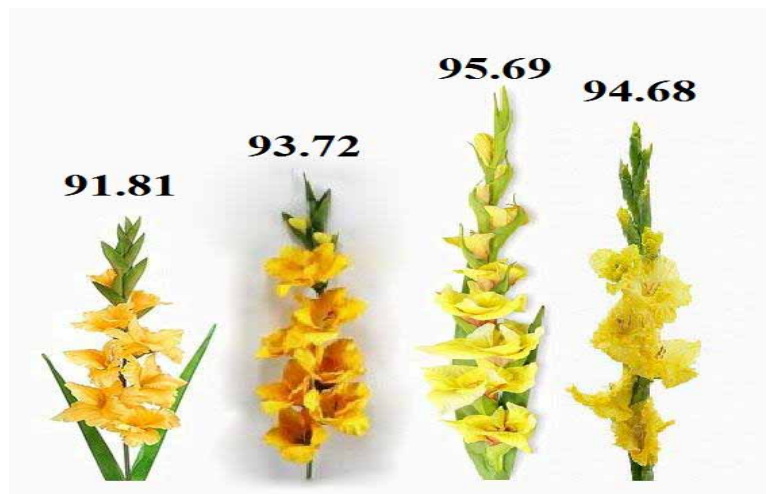


Plate 1: Effect of phosphorus on length of flower stalk



Plate 2: Effect of zinc on length of flower stalk

470 **Table 1. Effect of phosphorus on growth and flowering traits of gladiolus**

471

P (kg ha⁻¹)	Plant height (cm)	No. of leaves plant⁻¹	80% Emergence	% of flowering	Length of flower stalk	Length of rachis
0	71.17 c	9.579 d	87.52 a	91.81 b	69.54 c	32.25 d
120	72.61 b	10.42 c	86.45 ab	93.72 ab	71.77 b	34.48 c
140	74.88 a	11.32 a	85.55 b	95.69 a	75.06 a	37.77 a
160	73.72 b	10.99 b	86.04 ab	94.28 a	73.84 a	36.55 b
LSD_(0.05)	1.14	0.1035	1.668	2.12	1.253	0.5339
CV (%)	1.87	1.16	2.32	2.71	2.07	1.82
SE	0.3948	0.03536	0.5776	0.7339	0.4339	0.1848

472

473

474

475

476 **Table 2. Effect of zinc on growth and flowering traits of gladiolus**

477

Zn (kg ha⁻¹)	Plant height (cm)	No. of leaves plant⁻¹	80% Emergence	% of flowering	Length of flower stalk	Length of rachis
	85	85				
0	64.57 d	9.462 d	88.94 a	89.52 c	64.21 d	27.25 d
1	69.88 c	10.17 c	87.22 b	93.40 b	70.82 c	33.62 c
2	83.97 a	11.75 a	84.47 c	96.68 a	78.27 a	40.67 a
3	73.95 b	10.93 b	84.92 c	95.90 a	76.90 b	39.51 b
LSD_(0.05)	1.14	0.1035	1.668	2.12	1.253	0.5339
CV (%)	1.87	1.16	2.32	2.71	2.07	1.82
SE	0.3948	0.03536	0.5776	0.7339	0.4339	0.1848

478

479

480
481
482

Table 3. Combined effect of phosphorus and zinc on growth and flowering traits of gladiolus

P	Zn	Plant height (cm)	No. of leaves plant ⁻¹	80% Emergence	% of flowering	Length of flower stalk	Length of rachis
(Kg ha⁻¹)							
0	0	62.25 g	8.617 j	90.53 a	88.32 g	62.34 j	25.38 k
	1	66.84 f	9.083 i	88.37 abcd	90.63 cdefg	67.93 gh	30.73 h
	2	82.26 b	10.87 e	85.10 bcdef	94.90 abcd	74.54 d	36.94 e
	3	73.31 cd	9.750 gh	86.07 bcdef	93.40 bcdef	73.36 de	35.96 e
120	0	63.50 g	9.033 i	88.83 ab	89.30 fg	63.52 ij	26.56 j
	1	70.37 e	9.617 h	87.20 abcde	93.37 bcdef	70.13 fg	32.93 g
	2	83.10 b	11.83 b	84.77 cdef	96.30 ab	77.38 bc	39.78 c
	3	73.49 cd	11.20 d	85.00 bcdef	95.90 ab	76.04 cd	38.64 d
140	0	66.67 f	10.25 f	87.90 abcde	90.40 defg	65.99 hi	29.03 i
	1	71.89 de	11.25 d	86.37 bcdef	95.37 abc	73.95 d	36.75 e
	2	85.92 a	12.20 a	83.83 f	98.80 a	81.01 a	43.41 a
	3	75.03 c	11.57 c	84.10 ef	98.20 ab	79.29 ab	41.89 b
160	0	65.87 f	9.950 g	88.50 abc	90.07 efg	64.98 i	28.02 i
	1	70.40 e	10.73 e	86.97 abcde	94.23 abcde	71.27 ef	34.07 f
	2	84.62 ab	12.08 a	84.20 ef	96.70 ab	80.16 a	42.56 ab
	3	73.98 cd	11.18 d	84.50 def	96.10 ab	78.93 ab	41.53 b
CV (%)		1.87	1.16	2.32	2.71	2.07	1.82
SE		0.7895	0.07071	1.155	1.468	0.8678	0.3697

483
484

Table 4. Effect of phosphorus on yield and yield traits of gladiolus

P (kg ha ⁻¹)	No. of spikelet spke ⁻¹	No. of spike ha ⁻¹ (000)	Thickness of corm (cm)	Diameter of corm (cm)	Yield of corm (t ha ⁻¹)	No. of cormel plant ⁻¹	Yield of cormel (t ha ⁻¹)
0	13.55 d	208.9 d	6.133 d	1.628 d	16.57 c	19.79 d	9.617 d
120	15.37 c	229.3 c	6.582 c	1.929 c	17.77 b	21.39 c	10.73 c
140	17.43 a	249.3 a	7.455 a	2.186 a	18.92 a	24.07 a	11.85 a
160	15.97 b	240.8 b	7.043 b	2.067 b	18.40 a	23.48 b	11.38 b
CV (%)	2.48	3.53	0.92	0.93	3.8	2.82	1.49
SE	0.1118	2.363	0.01826	0.00913	0.1966	0.1805	0.04655

Table 5. Effect of zinc on yield and yield traits of gladiolus

Zn (kg ha ⁻¹)	No. of spikelet spke ⁻¹	No. of spike ha ⁻¹ (000)	Thickness of corm (cm)	Diameter of corm (cm)	Yield of corm (t ha ⁻¹)	No. of cormel plant ⁻¹	Yield of cormel (t ha ⁻¹)
0	11.88 d	201.2 c	6.222 d	1.563 d	15.79 d	18.87 d	9.358 d
1	14.89 c	230.1 b	6.574 c	1.741 c	17.27 c	20.79 c	10.48 c
2	18.17 a	251.5 a	7.474 a	2.445 a	19.64 a	24.95 a	12.14 a
3	17.39 b	245.4 a	6.943 b	2.062 b	18.95 b	24.12 b	11.58 b
CV (%)	2.48	3.53	0.92	0.93	3.8	2.82	1.49
SE	0.1118	2.363	0.01826	0.00913	0.1966	0.1805	0.04655

495
496
497

Table 6. Combined effect of phosphorus and zinc on yield and yield traits of gladiolus

P	Zn	No. of spikelet	No. of spike ha⁻¹	Thickness of corm	Diameter of corm	Yield of corm	No. of cormel plant⁻¹	Yield of cormel
(kg ha⁻¹)		spke⁻¹	(000)	(cm)	(cm)	(t ha⁻¹)		(t ha⁻¹)
0	0	10.81 k	195.0 i	5.733 j	1.420 l	14.80 j	17.63 i	8.367 j
	1	12.12 i	201.3 h	5.977 i	1.503 k	16.03 hi	18.83 gh	9.367 i
	2	16.39 e	228.3 e	6.637 f	1.887 g	18.23 def	22.10 de	10.67 f
	3	14.89 g	221.0 efg	6.187 h	1.703 ij	17.20 fgh	20.60 f	10.07 g
120	0	11.46 j	199.3 h	6.000 i	1.490 k	15.60 ij	18.40 hi	9.200 i
	1	14.86 g	224.3 ef	6.240 h	1.737 i	16.80 ghi	19.70 fg	10.17 g
	2	17.79 bc	249.3 cd	7.210 c	2.453 c	19.80 abc	24.13 b	12.03 c
	3	17.39 cd	244.0 d	6.877 e	2.037 f	18.90 bcd	23.33 bc	11.50 d
140	0	12.89 h	212.3 fgh	6.783 e	1.650 j	16.57 ghi	20.27 f	10.17 g
	1	16.86 de	251.7 bcd	7.040 d	1.903 g	18.60 cde	22.90 cd	11.30 de
	2	20.29 a	268.3 a	8.170 a	2.837 a	20.40 a	26.93 a	13.20 a
	3	19.69 a	264.7 ab	7.827 b	2.353 d	20.10 ab	26.17 a	12.73 b
160	0	12.36 hi	208.0 gh	6.373 g	1.690 ij	16.20 hi	19.17 gh	9.700 h
	1	15.72 f	243.0 d	7.040 d	1.820 h	17.67 efg	21.73 e	11.10 e
	2	18.19 b	260.0 abc	7.880 b	2.603 b	20.13 ab	26.63 a	12.67 b
	3	17.59 bc	252.0 bcd	6.880 e	2.153 e	19.60 abc	26.37 a	12.03 c
CV (%)		2.48	3.53	0.92	0.93	3.8	2.82	1.49
SE		0.2236	4.725	0.03651	0.01826	0.3933	0.361	0.09309

498