

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

Make a brief introduction and make clear the objectives. To answer if there was interaction between abating with phosphorus and zinc

ABSTRACT

An experiment was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during November 2013 to March 2014. The experiment consisted with two factors. Factor A: Four levels of phosphorus *i.e.* P₀: 0, P₁: 120, P₂: 140 and P₃: 160, P₂O₅ kg ha⁻¹ respectively. Factor B: Four levels of zinc as Zn₀: 0, Zn₁: 1, Zn₂: 2 and Zn₃: 3 Zn kg ha⁻¹ respectively. The experiment was laid out in a randomized complete block design with three replications. In case of phosphorus, highest corm yield (18.92 t ha⁻¹) and no. of spike (249300 ha⁻¹) was from P₂ and lowest corm yield (16.57 t ha⁻¹) and no. of spike (208900 ha⁻¹) was from P₀. For zinc, highest corm yield (10.7 t ha⁻¹) and spike (251500 ha⁻¹) was from Zn₂ while lowest corm yield (15.7 t ha⁻¹) and spike (201200 ha⁻¹) was from Zn₀. For interaction effect, highest corm yield (18.92 t ha⁻¹) and spike (268300 ha⁻¹) was from P₂Zn₂ while lowest corm yield (15.7 t ha⁻¹) and spike (201200 ha⁻¹) was from P₀Zn₀. So, 140 kg P₂O₅ and 2.0 kg Zn kg ha⁻¹ were the best levels for corm yield, flowering and yield of gladiolus.

Update the introduction references. The citations are outdated. The most recent citation of 2013

Key words: Zn, P₂O₅, yield.

1. INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is a herbaceous annual flower belongs to the family Iridaceae (Katiyar *et al.*, 2012), 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 second rank after tulip among the bulbous flowers in India (Singh *et al.*, 2012). 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 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 stage in this country due to lack of information regarding its cultivation technology. Due to lack of technology and experiences, they can't produce good quality flowers and corm. 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. Shaukat *et al.* (2012) reported that the Phosphorus is an important constituent of DNA that is known as genetic memory unit of all living things. 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). So, 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). Katiyar *et al.* (2012) 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 (Pandey *et al.*, 2002), 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 (Porch and Islam, 1984). 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. The study on the performance of growth variability, yield potentialities species, flower production, and vase life of Gladiolus as influenced by singly and combined application of Phosphorus and Zinc. The experimental field is located at the latitude of 23°N and longitude of 90°E at a height of 8.5 meter above the seas level. The soil is Modhupur Tract under AEZ No.28. The climate is subtropical climate characterized by three distinct seasons. The experiment was conducted from November to February and the pre-monsoon period. The soil is the experiment, healthy and uniform sizes of corms were used. The source of Phosphorus is Savar Bazar, Dhaka. The source of zinc is used as zinc oxide. The experiment is consisted with two factors. Factor A: Phosphorus (4 levels) viz., P₀= 0 kg P₂O₅ ha⁻¹ (control), P₁= 120 kg P₂O₅ ha⁻¹, P₂= 140 kg P₂O₅ ha⁻¹, P₃= 160 kg P₂O₅ ha⁻¹. Factor B: Zinc (4 levels) e.g. Zn₀= 0 kg Zn ha⁻¹ (Control), Zn₁= 1 kg Zn ha⁻¹ (1.28 kg ZnO), Zn₂= 2 kg Zn ha⁻¹ (2.56 kg ZnO), Zn₃= 3 kg Zn ha⁻¹ (3.84 kg ZnO).

Change levels by doses.
Change levels by doses

The two factors experiment was laid out in the randomized completely block design (RCBD) with three replications. The following amount of manures and fertilizers were used which shown as tabular form recommended by BARI, 2002. 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 program. Mean for all the treatments was calculated and the analysis of variance was done by F test. The differences between the treatments were tested by Multiple Range Test (DMRT) at 5% level of probability.

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3. RESULTS AND DISCUSSION

3.1 Growth attributes of gladiolus

3.1.1 Plant height

The tallest plant (74.8 cm) was obtained in 140 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ while the shortest plant (71.1 cm) was obtained in without Phosphorus at harvest (Table 1). Similar findings was 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 $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ along with 2.0 kg Zn ha^{-1} produced significantly the tallest plant (85.92 cm) while untreated plant of P_2O_5 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 $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ while 0 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ (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 Dorajeeroo, 2014; Sharma *et al.*, 2003). Among the various levels 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 Z_3 : 3 kg Zn ha^{-1} (11.1) while minimum from Z_0 (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 levels 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 P₃ 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 Zn₂ 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 kg P₂O₅ 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 kg P₂O₅ ha⁻¹ and 2.0 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 kg P₂O₅ 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 levels were also obtained by Hossain (2008). The spikelets spike⁻¹ had maximum (18.17) in 2.0 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 levels of P_2O_5 , the maximum thickness of corm (7.46 cm) was obtained in 140 kg P_2O_5 ha^{-1} and the minimum (6.13 cm) in untreated plant of P_2O_5 (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 P_2O_5 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 P_2 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 P_2O_5 ha^{-1} recorded the highest thickness. Naznin *et al.* (2014) in 150 kg P_2O_5 ha^{-1} ; Shaukat *et al.* (2012) in 130 kg P_2O_5 ha^{-1} ; Kumar *et al.* (2006) in 200 kg ha^{-1} and Pant (2003) in 100 kg P_2O_5 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 (1.63 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 P_2O_5 ha^{-1} along with 2.0 kg Zn ha^{-1} while it was the lowest (1.42 cm) in without P_2O_5 and Zn (control) (Table 6).

3.2.9 Yield of corm ($t\ ha^{-1}$)

Among the phosphorus levels, 140 kg P_2O_5 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 P_0 (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 P_2O_5 $ha^{-1} \times 2.0$ kg Zn ha^{-1} produced the highest yield of corm while the lowest yield of corm was in both 0 kg of P_2O_5 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. Zinc @ 2.0 kg ha⁻¹ was the highest (12.14 t ha⁻¹) in 2.0 kg Zn ha⁻¹ while without phosphorus showed the lowest yield of cormel (9.36 t ha⁻¹) (Table 5). Such the similar findings were also reported by Amin *et al.* (2014); Maurya and Kumar (2014), Fahad *et al.* (2014), and many researches. The highest yield of cormel (13.20 t ha⁻¹) was produced from the interaction of 140 kg P₂O₅ ha⁻¹ × 2.0 kg Zn ha⁻¹. Similarly, the lowest yield of cormel (9.62 t ha⁻¹) was obtained from the control treatment (both P₂O₅ and Zn 0 kg ha⁻¹) (Table 4).

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 treatment under the study, 140 kg P₂O₅ ha⁻¹ with 2.0 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.

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

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

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

Zn (kg ha ⁻¹)	Plant height (cm)	No. of leaves plant ⁻¹	80% Emergence	% of flowering	Length of flower stalk	Length of rachis
0	85	85				
	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

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

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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

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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

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

P	Zn	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)
	(kg 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

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