EFFECT OF PHOSPHORUS AND ZINC ON GROWTH FLOWERING AND YIELD OF GLADIOLUS

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This is to certify that thesis entitled, "**EFFECT OF PHOSPHORUS AND ZINC ON GROWTH FLOWERING AND YIELD OF GLADIOLUS**" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **Amaily Akter, Registration No. 07-02554** under my supervision and guidance. No of part of the thesis has been submitted for any other degree of diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: JUNE, 2014

Dhaka, Bangladesh

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The Author

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ABSTRACT

The experiment was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during November 2012 to June 2013. The experiment consisted with two factors. Factor A: Four levels of phosphorus i.e. P_0: 0, P_1: 120, P_2: 140 and P_3: 160, P_2O_5 kg ha^{-1} respectively. Factor B: Four levels of zinc 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 with three replications. In case of phosphorus, 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. 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.

CONTENTS

CONTENTS (CONTD.)

CONTENTS (CONTD.)

CONTENTS (CONTD.)

CONTENTS (CONTD.)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATION AND SYMBOL

Abbreviations		Expansion
@	=	At the rate of
AEZ	=	Agro-Ecological Zone
Agric.	=	Agriculture
Agril.	=	Agricultural
ANOVA	=	Analysis of variance
BARC	=	Bangladesh Agricultural Researcher Council
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cm^2	=	Square Centimeter
CRD	=	Completely Randomized Design
CV (%)	=	Co-efficient of Variance
DAP	=	Days After Planting
DMRT	=	Duncan Multiple Range Test
et al.	=	and Others
FAO	=	Food and Agriculture Organization Of the United Nations
g	=	Gram
HRC	=	Horticulture Research Centre
IAAS	=	Institute of Agriculture and Animal Science
LSD	=	Least Significant Difference
m^2	=	Square Meter
Max.	=	Maximum
Min.	=	Minimum
MP	=	Murate of Potash
NS	=	Non Significant
ppm	=	Parts per million
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-E- Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
TSP	=	Triple Super Phosphate
UNDP	=	United Nations Development Programe
Viz.	=	Namely

CHAPTER I
INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.*)* is an herbaceous annual flower belongs to the family Iridaceae (Katiyar *et al*., 2012), is one of the most attractive and popular cut flower.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) .The development of modern gladioli started in eighteenth century. The modern gladioli are mostly hybrids.

Gladiolus was originally coined by Pliny the Elder (A.D 23-79) deriving from the Latin word gladiolus, meaning a sword, on account of the sword like shape of its foliage, however, previously it was the name of 'iris' which ancient Greeks used to call as 'xiphion'. It was introduced into cultivation towards the end of the 16^{th} century. In Indian subcontinent, its cultivation dates back to nineteenth century . 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). It is also used as bedding flower, herbaceous border or does quite well in pots. Gladiolus spikes are most popular in flower arrangements and for preparing attractive bouquet. Flower and corm of some gladiolus are used as food in many countries .There is an increasing demand for its attractive spikes having florets of huge forms, dazzling colours and varying sizes.

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. In Bangladesh gladiolus was introduced from India around the year 1992. However, its production is mainly concentrated in few districts such as Jessore, Jhenaidha, Satkhira, Dhaka, Mymensingh, Cox's Bazar, Chittagong and Rangpur where some farmers are producing gladiolus. Due to lack of technology and experiences, they can not produce good quality flowers and corm. Its 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 .

It is highly capable of exhausting huge nutrients from native soil. So, it requires higher amount of chemical fertilizers in balance proportion for ensuring maximizing flower production. 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.

Zinc is another important micronutrient for the growth and development of gladiolus. In Bangladesh, about 2.0 million hectares of Agricultural land are zinc deficient under different Agroecological zones in Bangladesh. 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) also 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. Petals are the floral organs that determine primarily the commercially acceptable esthetic value of flowers. Analysis of soil samples of important soil types and series of Bangladesh reveals that 80- 90% soils are poor in zinc and sulphur . While 100% soils are deficit in nitrogen (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 with the following objectives–

Objectives:

i) To select the optimum level of phosphorus for growth flowering and yield of gladiolus,

ii) To find out the optimum level of zinc for growth flowering and yield of gladiolus

iii) To determine the best combination of phosphorus and zinc for growth flowering and yield of gladiolus.

CHAPTER II
REVIEW OF LITERATURE

Gladiolus is one of the most important cut flower in the world market and is highly priced for its bright, beautiful and vivid colored flowers. Many research works have been done in different countries of the world on the aspect of its growth development, crom and cormel production due to the application of Phosphorus and Zinc. However, a few studies on the above aspect have been carried out in Bangladesh. Therefore, some review of literatures related to present study has is given in this chapter under the following headings:

2.1 Effect of phosphorus and zinc on growth, flowering and yield of Gladiolus

2.1.1 Effect of phosphorus

2.1.1.1 Plant height

Chandana and Dorajeerao (2014) studied on the effect of four levels of each nitrogen (100, 200, 300 and 400 kg ha^{-1}) and phosphorus (100, 150, 200 and 250 kg ha^{-1}) at Horticultural College and Research Institute, India. Among the P_2O_5, P_3 registered the highest (90.17 cm) followed by P_4 (86.14 cm).

Naznin *et al*. (2014) conducted an experiment at the Horticulture Farm of SAU, Dhaka during October 2010 to May 2011. The experiment consisted with four levels of phosphorus (P_0: control; P_1: 100 kg; P_2: 150 kg and P_3: 200 kg P_2O_5 ha^{-1}). They found that the plant height of gladiolus differed significantly due to the application of different levels of phosphorus where the longest plant (25.3 cm, 35.0 cm, 47.5 cm, 61.7 cm, 74.3 cm and 83.4 cm) was recorded from P_2 while the shortest (18.5 cm, 26.5 cm, 38.4 cm, 50.8 cm, 56.7 cm and 65.3 cm) was found from P_0.

Shaukat *et al*. (2012) investigate the effect of phosphorus on corm and flower productivity of Gladiolus. Result revealed that the P_5 (160 kg P_2O_5 ha^{-1}) produced maximum plant height i.e. (156.0 cm) followed by P_4 (151.8 cm) while minimum plant height was recorded in P_0 (128.4cm). The increase in plant height with increasing level of phosphorus levels was might be due to the fact that phosphorus is known to stimulate root growth and is connected with the early maturity of crops.

Hossain *et al*. (2011) found that the tallest plant (44.76 cm) was obtained from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar to P_4 (150 kg P_2O_5 ha^{-1}) and P_2 (130 kg P_2O_5 ha^{-1}) and the shortest (31.96 cm) was found from P_0 (0 kg P_2O_5 ha^{-1}) which was closely followed by P_1 (120 kg P_2O_5 ha^{-1}) at 30 DAP. The tallest plant (76.83 cm) was recorded from P_3 which was identical with P_4 and the lowest (61.97 cm) was recorded from P_0 at 90 DAP.

Hossain (2008) conducted an experiment at the Horticulture Farm of SAU, Sher–e–Bangla Nagar, Dhaka during November 2006 to June 2007. Factor A: Corm size (3 levels) and Factor B: Phosphorus (5 levels) as P_0: 0 kg (Control), P_1: 120 kg ha^{-1}, P_2: 130 kg ha^{-1}, P_3: 140 kg ha^{-1} and P_4: 150 kg ha^{-1}. At harvest, the tallest plant (76.83 cm) was recorded from 140 kg P_2O_5 ha^{-1} which was statistically identical (74.85 cm) with 150 kg P_2O_5 ha^{-1} and closely followed by (73.36 cm) by 130 kg P_2O_5 ha^{-1} and the shortest (61.97 cm) was recorded from control which was closely followed (70.56 cm) by 120 kg P_2O_5 ha^{-1}.

Zubair and Wazir (2007) found that the maximum plant height with higher level of phosphorus application i.e. 100 and 200 kg ha^{-1}. Haokip and Sing (2005) reported that the plant height increased with increasing levels of phosphorus.

Kumar *et al*. (2006) found significant different on vegetative characters of gladiolus due to Phosphorus. The different levels of phosphorus i.e. P_1–100 kg, P_2–150 kg and P_3–200 kg ha^{-1} were practiced for the experimental purpose. Results of the investigation revealed that, among the three doses of phosphorus, P_3 dose i.e. 200 kg ha^{-1} resulted maximum vegetative growth of plant as well longest plant (51.17 cm) at 90 days.

Qazi (2005) conducted an experiment at the research farm, division of floriculture, medicinal and aromatic plants, Sher–e–Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar during 2003 and 2004. Three levels of each nitrogen (100, 150 and 200 kg ha^{-1}), phosphorus (50, 75 and 100 kg ha^{-1}) and sheep manure (0, 15 and 30 t ha^{-1}) were tested. In case of Phosphorus, 75 kg P ha^{-1} recorded the highest plant height (148.87 and 149.26 cm) at 2003 and 2004 respectively compared other phosphorus treatments of the study while plant height was the lowest in control.

Pandey *et al*. (2000) found that the height of gladiolus plant did not vary significant due to various levels of P fertilizer. However, 40 g P_2O_5 m^{-2} was the best than other treatments.

2.1.1.2 Number of leaves plant^{-1}

Chandana and Dorajeerao (2014) showed that the number of leaves produced at different stages of crop growth due to phosphorus levels. The mean number of leaves increased from 4.0 at 30 DAP to 10.37 at 90 DAP. Among the P levels, P_3 recorded the highest number of leaves (11.82) per plant followed by P_4 (10.86) and the lowest (8.43) was recorded by P_1 (9.07).

Naznin *et al*. (2014) reported that the levels of phosphorus differed significantly for number of leaves per plant at different DAP. At 20, 30, 40, 50, 60 and 70 DAP the maximum number of leaves per plant (5.3, 8.1, 15.9, 22.3, 31.6 and 40.8 cm) was found from P_2 (150 kg P_2O_5 ha^{-1}) while the minimum number of leaves per plant (4.4, 6.5, 12.5, 24.0, 24.6 and 28.4) was obtained from P_0. It was revealed that with the increase of phosphorus fertilizer number of leaves increased up to a certain level than decreased. Phosphorus fertilizer ensured favorable condition for the growth with optimum vegetative growth with maximum number of leaves.

Shaukat *et al*. (2012) found that P_5 (160 kg P_2O_5 ha^{-1}) produced maximum number of leaves (8.68) followed by P4 (8.27). The minimum number of leaves per plant (6. 40) and (6.59) were produced by P0 and P1. This may be due to the effect of phosphorus because, when phosphorus is limiting, the most striking effects are a reduction in leaf expansion and leaf surface area, as well as then number of leaves.

Hossain *et al*. (2011) evaluate the effect of corm size and different doses of phosphorous where the highest number of leaves plant^{-1} (10.93) was recorded from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically identical with P_4 (150 kg P_2O_5 ha^{-1}) and the lowest (8.82) was recorded from P_0 (0 kg P_2O_5 ha^{-1}) at 75 DAP.

Hossain (2008) reported that the 140 kg P_2O_5 ha^{-1} produced significantly the maximum number of leaves (3.13, 5.67, 8.89 and 10.93) at 30, 45, 60 and 75 DAP, respectively which was statistically similar (3.04, 5.49, 8.71 and 10.69) to 150 kg P_2O_5 ha^{-1} while the minimum number of leaves plant^{-1} (2.24, 4.51, 7.13 and 8.82) was recorded from control (0 kg P_2O_5 ha^{-1}) which was closely followed (2.71, 5.09, 8.16 and 9.0) by 120 kg P_2O_5 ha^{-1}.

Zubair and Wazir (2006) reported that the P levels did not influence the number of leaves plant^{-1} of gladiolus while Kumar *et al*. (2006) found that the number of leaves plant^{-1} (6.84) was found with P_3 (200 kg ha^{-1}) at 90 days among the phosphorus level while minimum number of leaves plant^{-1} was found in P_2 (100 kg ha^{-1}).

2.1.1.3 Days required for spike emergence

Naznin *et al*. (2014) significantly found that the maximum days required to emergence of spike (87.4) was observed from P_0 which was statistically identical (86.4) with P_3 (200 kg P_2O_5 ha^{-1}). Again, the minimum number of days required to emergence of spike (81.7) was recorded from P_2 (150 kg P_2O_5 ha^{-1}).

Shaukat *et al*. (2012) found that the maximum days to spike emergence (78.82) were recorded for P_0 (control) and P_1 (78.20) while minimum days (68.10) were recorded for P_5 (160 kg P_2O_5 ha^{-1}) followed by P_4 (71.10 days). Increase in energy level enhanced biochemical processes due to phosphorus application might be the main reason for significant decrease in number of days to spike emergence with increasing levels of phosphorus.

Hossain (2008) reported that the days required for 50% emergence of spike of gladiolus showed significant differences for different level of P while the maximum (84.33 days) requiring time for 50% emergence of spike was recorded from 0 kg P_2O_5 ha^{-1} and the minimum (78.00 days) was obtained from 140 kg P_2O_5 ha^{-1}. Statistically similar effect was also found regarding days required for 80% emergence of spike.

Zubair and Faridullah (2007) conducted an experiment to investigate and standardize the optimum level of phosphorus. Eight cultivars of gladiolus were fertilized with phosphorus @ 0, 100 and 200 kg ha^{-1}. Phosphorus levels and cultivars had a significant effect only on size of full opened first florets. Phosphorus @ 200 kg ha^{-1} is recommended for gladiolus cultivars.

Qazi (2005) showed that the phosphorus @ 200 kg ha^{-1} produced the maximum growth and yield of gladiolus in the study of Kumar *et al*. (2006) but the early sprouting of corms was observed with P_2 (150 kg ha^{-1}) than P_1 (100 kg ha^{-1}) and P_3 (200 kg ha^{-1}). From the study of it was found that the Phosphorus at 50 kg ha^{-1} recorded highest number of days to spike emergence (65.61 and 69.40) and days taken to opening of second floret (74.84 and 81.84).

2.1.1.4 Number of florets spike^{-1}

Naznin *et al*. (2014) found significant variation for number of florets per spike due to the effect of P levels. The maximum number of florets per spike (14.5) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (14.4) with P_3 (200 kg P_2O_5 ha^{-1}) and closely followed (13.3) by P_1 (100 kg P_2O_5 ha^{-1}), whereas the minimum number of florets per spike (11.9) was found from P_0.

Kumar *et al*. (2008) studied a field trial due to the different doses of nitrogen, phosphorus and potassium on gladiolus cv. Jester Gold. Number of unopened florets spike^{-1} was not influenced by the different doses of nitrogen, phosphorus and potassium (Kumar *et al*., 2008).

Kumar *et al*. (2006) found that the number of florets was the highest (14.38) in 200 kg P ha^{-1} among the phosphorus doses reported by. Number of florets spike^{-1} also showed significant variation where 75 kg P ha^{-1} recorded the maximum number of florets spike^{-1} at both 2003 (20.34) and 2004 (19.53) season (Qazi, 2005).

Sharma *et al*. (2003) reported that the phosphorus up to 200 kg ha^{-1} increased floret size and number of florets per spike. Pant (2003) found that the 100 kg P_2O_5 ha^{-1} along with nitrogen dose of 50 kg ha^{-1} produced maximum number of florets while Kawarkhe *et al*. (2001) reported that the maximum number of florets per spike was influenced by the application of 20 g P/m2.

2.1.1.5 Percentage of flowering

Shaukat *et al*. (2012) found that minimum numbers (14.59) of flowers spike^{-1}were recorded for P_0 (control) while maximum numbers (19.15), (19.03) and (18.48) of flowers spike^{-1} were recorded for P_5: (160 kg P_2O_5 ha^{-1}), P_4: 130 kg P_2O_5 ha^{-1} and P_3: 100 kg P_2O_5 ha^{-1} respectively.

Hossain (2008) reported that the percentage of flowering plants of gladiolus showed significant differences for different level of P. The highest (93.67%) flowering plant was counted from 140 kg P_2O_5 ha^{-1} which was statistically similar (92.78 and 91.00%) to P_4 and P_2 (150 and 130 kg P_2O_5 ha^{-1}, respectively) and the lowest (81.78%) was noted from 0 kg P_2O_5 ha^{-1} (control) which was closely followed (88.33%) by P_1 (120 kg P_2O_5 ha^{-1}).

Kumar *et al*. (2006) studied to find out the number of flowers plant^{-1} was obtained in P_3 (200 kg ha^{-1} phosphorus) while 100 kg produced significantly the minimum flowers plant^{-1}.

2.1.1.6 Length of flower stalk

Naznin *et al*. (2014) found significant variation on length of flower stalk at harvest due to the various levels of phosphorus. The longest flowering stalk (70.1 cm) was recorded from P_3 (200 kg P_2O_5 ha^{-1}) which was statistically identical (69.6 cm and 67.4 cm) with P_2 (150 kg P_2O_5 ha^{-1}) and P_1 (100 kg P_2O_5 ha^{-1}), whereas the shortest flowering stalks (55.37 cm) was attained from P_0.

Hossain (2008) found that the maximum (73.64 cm) length of flower stalk at harvest was recorded from 140 kg P_2O_5 ha^{-1} which was statistically similar (72.43 and 70.90 cm) to P_4 and P_2 (150 and 130 kg P_2O_5 ha^{-1}, respectively) and the minimum (59.93 cm) was found from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (68.21 cm) by P_1 (120 kg P_2O_5 ha^{-1}).

2.1.1.7 Length of rachis

Naznin *et al*. (2014) also found that the levels of phosphorus differed significantly for length of rachis at harvest. The longest rachis (36.3 cm) was recorded from P_3 (200 kg P_2O_5 ha^{-1}) which was statistically identical (36.2 cm) with P_2 (150 kg P_2O_5 ha^{-1}) and closely followed (32.8 cm) by P_1 (100 kg P_2O_5 ha^{-1}), whereas the shortest rachis (31.3 cm) was found from P_0.

Hossain (2008) found that the maximum (38.99 cm) length of flower rachis at harvest was recorded from 140 kg P_2O_5 ha^{-1} which was statistically similar (38.31 and 37.54 cm) to P_4 and P_2 (150 and 130 kg P_2O_5 ha^{-1}, respectively) and the minimum (31.59 cm) was found from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (36.07 cm) by P_1 (120 kg P_2O_5 ha^{-1}).

Qazi (2005) reported that the levels of phosphorus showed significant variation for length of rachis while 75 kg ha^{-1} recorded the longest length (80.94 and 76.20 cm) during 2003 and 2004 season respectively while shortest rachis was found in without P. Pandey *et al*. (2000) reported that the length of rachis showed non significant variation due to the application of various levels of N and Phosphorus.

2.1.1.8 Length of spike

It is evident from the study of Shaukat *et al*. (2012) that the maximum spike length (78.73cm) was recorded for P_5 (160 kg P_2O_5 ha^{-1}) followed by P_4 which gave (75.33cm) spike length. P_0 (Control) showed the least response for spike length (61.33cm).

Kumar *et al*. (2008) reported that the maximum increase in spike length at senescence (2.73 cm) was produced by the application of higher doses of nitrogen and phosphorus i.e. $N_{80}P_{20}$ g m^{-2} followed by $N_{80}P_5$ g m^{-2} and $N_{80}P_{10}$ g m^{-2} (2.71cm).

Kumar *et al*. (2006) conducted an experiment where various levels of P (P_1–100 kg, P_2–150 kg and P_3–200 kg ha^{-1}) were used for the experiment. Among them, phosphorus @ 200 kg ha^{-1} showed the longest spike (64.17 cm) at 90 days than phosphorus @ 100 and 150 kg ha^{-1}. Kawarkhe *et al*. (2001) reported that the spike length increased with the increase in application of P fertilizers.

2.1.1.9 Number of spikelet, spike and corm

2.1.1.9.1 Spikelet

Hossain (2008) found that the number of spikelet $spike^{-1}$ of gladiolus performed significant variation for different level of phosphorus. The highest (13.67) number of spikelet $spike^{-1}$ was obtained from 140 kg P_2O_5 ha^{-1} which was statistically similar (13.43 and 13.08) to P_4 and P_2 (150 and 130 kg P_2O_5 ha^{-1}, respectively) and the lowest (10.44) was recorded from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (12.11) by P_1 (120 kg P_2O_5 ha^{-1}).

2.1.1.9.2 Spike

Naznin *et al*. (2014) found that the levels of phosphorus differed significantly for number of spike per plot. The maximum number of spike per plot (25.8) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (25.2 and 23.8) with P_3 and P_1 (200 and 100 kg P_2O_5 ha^{-1}, respectively), whereas the minimum number of spike (17.0) was found from P_0.

Shaukat *et al*. (2012) also found that the maximum numbers of spikes per plant were produced by P_5: 160 kg P_2O_5 ha^{-1} (2.77) followed by P_4 (2.70) while minimum number of spikes was recorded in P_0 which was 1.11 spikes per plant.

Hossain (2008) also showed significant variations for different level of phosphorus on spike $plot^{-1}$. The highest (34.11) number of spike $plot^{-1}$ was recorded from 140 kg P_2O_5 ha^{-1} which was statistically similar (33.78) to P_4 (150 kg P_2O_5 ha^{-1}) and closely followed (31.22) by P_2 (130 kg P_2O_5 ha^{-1}), the lowest (26.00) was obtained from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (29.44) by P_1 (120 kg P_2O_5 ha^{-1}). Similarly, the highest (710.67 ha^{-1}) number of spike in thousand ha^{-1} was recorded from 140 kg P_2O_5 ha^{-1} while the lowest (541.89 ha^{-1}) was recorded from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (613.44 ha^{-1}) by P_1 (120 kg P_2O_5 ha^{-1}).

Zubair and Wazir (2006) showed that the significant effect on spikes $corm^{-1}$ at all the studied year. Among the three (P_1–100 kg, P_2–150 kg and P_3–200 kg ha^{-1}) level of phosphorus, number of spikes $corm^{-1}$ of gladiolus was recorded the maximum with P_3 dose while minimum was taken with P_1 (Kumar *et al*., 2006).

Qazi (2005) found that the maximum number of spikes $plant^{-1}$ (1.479 and 1.589) at 2003 and 200, respectively was obtained from 75 kg P ha^{-1} while it was the minimum in 0 kg P ha^{-1}. Kawarkhe *et al*. (2001) reported that number of spikes per plant increased with the increase in application of P fertilizers.

2.1.1.9.3 Corm

Shaukat *et al*. (2012) found highly significant differences among treatments for number of corms $plant^{-1}$. The maximum number of corms (4.18) and (4.11) $plant^{-1}$ were recorded for P_5 (160 kg P_2O_5 ha^{-1}) and P_4 respectively.

Qazi (2005) also recorded that the number of corms $plant^{-1}$ and m^{-2} were significant due to P levels in the study of. He found that the highest number of corms $plant^{-1}$ (1.48 and 1.58) and number of corms m^{-2} (22.07 and 24.93) were obtained in 75 kg P ha^{-1} compare to other levels of phosphorus.

2.1.1.10 Thickness of corm

Hossain *et al*. (2011) found significant variation among the whole characters of the study where thickness of corm was the highest (6.42 cm) in 140 kg ha^{-1} phosphorus while it was statistically similar (6.32 cm and 5.99 cm) with P_4 and P_2 (150 kg P_2O_5 ha^{-1} and 130 kg P_2O_5 ha^{-1}) and the minimum (4.65 cm) was recorded from control.

Hossain (2008) showed significant variations for individual corm thickness of gladiolus due to different level of phosphorus. The maximum (6.41 cm) corm thickness was recorded from 140 kg P_2O_5 ha^{-1} which was statistically similar (6.32 cm) to P_4 (150 kg P_2O_5 ha^{-1}) and the minimum (4.65 cm) was recorded from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (613.44) by P_1 (120 kg P_2O_5 ha^{-1}).

Pant (2005) studied on the effect of different doses of nitrogen and phosphorus where variable doses of phosphorous did not produce any significant effect on corm thickness. The application of 100 kg P_2O_5 ha^{-1} along with 50 kg N ha^{-1} showed significantly the highest thickness of corm (Pant, 2003).

2.1.1.11 Diameter of corm

Naznin *et al*. (2014) found that the highest diameter of corm (2.6 cm) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (2.5 cm) with P_3 (200 kg P_2O_5 ha^{-1}) and closely followed (2.2 cm) by P_1 (100 kg P_2O_5 ha^{-1}), whereas the lowest diameter (2.1 cm) was found from P_0. The P_4 (130 kg P_2O_5 ha^{-1}) gave the maximum size of corms i.e. (7.43) reported by Shaukat *et al*. (2012).

Hossain *et al*. (2011) found that the treatment P_3 (140 kg P_2O_5 ha^{-1}) showed the maximum diameter of corm (2.63 cm) and the minimum was recorded from control. Individual corm diameter of gladiolus showed significant variations due to different level of phosphorus (Hossain, 2008). The maximum (2.63 cm) individual corm diameter was obtained from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar (2.63 cm) to P_4 (150 kg P_2O_5 ha^{-1}) whereas the minimum

(2.10 cm) was recorded from P_0 (0 kg P_2O_5 ha^{-1}) which was closely followed (2.38) by P_1 (120 kg P_2O_5 ha^{-1}).

Kumar *et al*. (2006) reported that the phosphorus @ 200 kg ha^{-1} showed the maximum growth and yield of gladiolus but the maximum diameter of corms was recorded in P_1 (100 kg ha^{-1}) than P_2 (150 kg ha^{-1}) and P_3 (200 kg ha^{-1}).

2.1.1.12 Weight of individual corm

Naznin *et al*. (2014) further recorded that the highest weight of corm (27.5 g) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (25.7 g) with P_3 (200 kg P_2O_5 ha^{-1}) and closely followed (22.2 g) by P_1 (100 kg P_2O_5 ha^{-1}), whereas the lowest weight (19.7 g) was found from P_0.

Shaukat *et al*. (2012) also recorded that the P_5 (160 kg P_2O_5 ha^{-1}) and P_4 (130 kg P_2O_5 ha^{-1}) produced more weight of corms while P_0 was dominated by all the other treatments and gave the minimum results i.e. (46.67 gm) weight of corm. These results clearly predict that phosphorus at the rate of 160 kg ha^{-1} and 130 kg ha^{-1} is best as compared to control as for as average weight of corms concerned.

Hossain *et al*. (2011) conducted a field trial where the development of corm and cormel of gladiolus due to the effect of corm size and different doses of phosphorous were significant. The maximum corm weight (28.30 g) was recorded from P_3 (140 kg P_2O_5 ha^{-1}) and the minimum was recorded from control.

Hossain (2008) found significant differences for the weight of individual corm of gladiolus due to different level of phosphorus. The maximum (28.30 g) individual corm weight was noted from 140 kg P_2O_5 ha^{-1} which was statistically similar (27.93 g) to P_4 (150 kg P_2O_5 ha^{-1}) and closely followed (26.73 g) by P_2 (130 kg P_2O_5 ha^{-1}), and the minimum (21.21 g) was obtained from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (24.73 g) by P_1 (120 kg P_2O_5 ha^{-1}).

Kumar *et al*. (2006) reported that the highest weight of corm was found with P_3 (200 kg ha^{-1}) dose than P_1 (100 kg ha^{-1}) and P_2 (150 kg ha^{-1}) dose. Weight of corms m^{-2} showed significant variation due to the application of P (Qazi, 2005) at both years of 2003 and 2004. The highest weight of corms m^{-2} (1.080 and 1.099 kg) was taken from the application of 75 kg P ha^{-1}. Pant (2005) evaluate the effect of different doses of nitrogen and phosphorus where higher doses of phosphorous fertilizer (50 and 100 kg ha^{-1}) produced the highest corm weight as compared to the control (phosphorous 0 kg ha^{-1}), which produced the lowest weight.

Pant (2003) also found that the variable doses of P_2O_5 caused a significant increase in the weight of corm while 100 kg P_2O_5 ha^{-1} was the best dose for higher increment of corm weight with 50 kg N ha^{-1}.

2.1.1.13 Yield of corm

Chandana and Dorajeerao (2014) reported that the number of corms per plot was significantly influenced by different levels of phosphorus. Among phosphorus levels, highest number of corms per plot (44.73) was recorded in P_3, which was on par with P_4 (41.40). So, it increased up to 200 kg P ha^{-1} (P_3).

Naznin *et al*. (2014) found that the highest yield of corm per hectare (15.4 ton) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (14.3 ton) with P_3 (200 kg P_2O_5 ha^{-1}) and closely followed (12.4 ton) by P_1 (100 kg P_2O_5 ha^{-1}), whereas the lowest yield (10.3 ton) was found from P_0.

Hossain *et al*. (2011) further reported that the higher doses of phosphorous fertilizer produced the highest yield of corm (14.37 t ha^{-1}) as compared to the lowest doses of phosphorous (120 kg P_2O_5 ha^{-1}) and control (0 kg P_2O_5 ha^{-1}), which produced the lowest yields of corm. This suggests that corm responds better to the higher level of phosphorous.

Hossain (2008) conducted an experiment on flower production of gladiolus where corm yield $plot^{-1}$ of gladiolus showed significant variations due to different level of phosphorus. The highest corm yield (0.69 kg $plot^{-1}$) was obtained from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar (0.68 and 0.65 kg $plot^{-1}$) to P_4 (150 kg P_2O_5 ha^{-1}) and P_2 (130 kg P_2O_5 ha^{-1}) and the lowest (0.55 kg $plot^{-1}$) was recorded from P_0 (0 kg P_2O_5 ha^{-1}). They also found significant variations for corm yield ha^{-1} of gladiolus. The highest corm yield (14.30 t ha^{-1}) was recorded from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar (14.15 and13.64 t ha^{-1}) to P_4 (150 kg P_2O_5 ha^{-1}) P_2 (130 kg P_2O_5 ha^{-1}), while the lowest (11.46 t ha^{-1}) was recorded from P_0 (0 kg P_2O_5 ha^{-1}) which was closely followed (13.09 t ha^{-1}) by P_1 (120 kg P_2O_5 ha^{-1}).

2.1.1.14 Number of cormel $plant^{-1}$

Naznin *et al*. (2014) found that the levels of phosphorus showed significant variation for number of cormel per plant where it was the highest (20.7) in P_2 (150 kg P_2O_5 ha^{-1}) and the lowest (17.0) in P_0.

Shaukat *et al*. (2012) also found significant variation on number of cormels where it was the maximum in P_5: 160 kg P_2O_5 ha^{-1} (102.70) followed by P_4 (93.67) as compared to other treatments whereas the least number of cormels were produced by P_0 i.e. 1.22.

Hossain *et al*. (2011) reported that the highest number of cormel $plant^{-1}$ was recorded from large size corm and 140 kg P_2O_5 ha^{-1} and the lowest was recorded from small size corm and without phosphorous.

Hossain (2008) showed significant variations for number of cormel $plant^{-1}$ of gladiolus due to the application of different level of phosphorus. The highest (22.76) number of cormel $plant^{-1}$ was recorded from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar (22.19) to P_4 (150 kg P_2O_5 ha^{-1}) and closely followed (21.73) by P_2 (130 kg P_2O_5 ha^{-1}) and the lowest (18.25) was recorded from P_0 (0 kg P_2O_5 ha^{-1}) number of cormel $plant^{-1}$ which was closely followed (20.84) by P_1 (120 kg P_2O_5 ha^{-1}).

Kumar *et al*. (2006) found that the 200 kg ha^{-1} phosphorus recorded the maximum number of cormel $plant^{-1}$ while minimum number of cormel $plant^{-1}$ was obtained from P_1.

2.1.1.15 Diameter of cormel

Naznin *et al*. (2014) found significant variation due to the various levels of phosphorus for diameter of individual cormel. The highest diameter of individual cormel (1.4 cm) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (1.4 cm) with P_3 (100 kg P_2O_5 ha^{-1}) and closely followed (1.3 cm) by P_1 (100 kg P_2O_5 ha^{-1}), whereas the lowest diameter (1.2 cm) was found from P_0.

Shaukat *et al*. (2012) showed significant differences for size of cormels due to the effect of P. Among them, P_5: 160 kg P_2O_5 ha^{-1} (2.06) produced the maximum cormel size followed by P_4 (1.87) as compared to other treatments while least size of 1.35 was produced by P_0.

Hossain (2008) carried out an experiment where individual cormel diameter of gladiolus showed significant variations for different level of phosphorus. The maximum individual cormel diameter (1.40 cm) was obtained from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar (1.38 cm) to P_4 (150 kg P_2O_5 ha^{-1}) and closely followed (1.27 cm) by P_2 (130 kg P_2O_5 ha^{-1}) and the minimum (1.06 cm) was recorded from P_0 (0 kg P_2O_5 ha^{-1}) which was closely followed (1.21 cm) by P_1 (120 kg P_2O_5 ha^{-1}).

2.1.1.16 Weight of individual cormel

Naznin *et al*. (2014) studied the effect of various levels of phosphorus and found significant difference for weight of individual cormel where the highest weight of individual cormel (13.1 g) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (13.0 g) with P_3 (200 kg P_2O_5 ha^{-1}) and closely followed (12.6 g) by P_1 (100 kg P_2O_5 ha^{-1}). Similarly, the lowest weight (11.7 g) was found from P_0.

Shaukat *et al*. (2012) found that the weight of cormels^{-1} plant varied significantly due to the application of phosphorus. P_5: 160 kg P_2O_5 ha^{-1} (3.43) produced more weight of cormels as compare to other levels of phosphorus followed by P_4 (3.10) and least weight of cormels was produced by P_0 (0.98).
Hossain (2008) found that the individual cormel weight of gladiolus showed significant differences due to different level of phosphorus. The maximum (13.84 g) individual cormel weight was recorded from 140 kg P_2O_5 ha^{-1} which was statistically similar (13.78 g) to P_4 (150 kg P_2O_5 ha^{-1}) and P_2 (130 kg P_2O_5 ha^{-1}) and the minimum (10.36 g) was obtained from 0 kg P_2O_5 ha^{-1} (P_0) which was closely followed (12.29 g) by P_1 (120 kg P_2O_5 ha^{-1}).

Kumar *et al*. (2006) reported that the highest weight of cormel was recorded in P_3 (200 kg ha^{-1}) among the phosphorus levels while P_1 (100 kg ha^{-1}) showed comparatively better results than P_2 (150 kg ha^{-1}).

2.1.1.17 Yield of cormel

Naznin *et al*. (2014) showed that the levels of phosphorus differed significantly for yield of cormel per hectare. The highest yield of cormel per hectare (11.7 ton) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (11.2 ton and 11.0 ton) with P_3 (200 kg P_2O_5 ha^{-1}) and P_1 (100 kg P_2O_5 ha^{-1}), whereas the lowest yield (8.9 ton) was found from P_0 (150 kg P_2O_5 ha^{-1}).

Hossain *et al*. (2011) found that the higher doses of phosphorous fertilizer produced the highest yield of cormel (11.66 t ha^{-1}) as compared to the lowest doses of phosphorous (120 kg P_2O_5 ha^{-1}) and control (0 kg P_2O_5 ha^{-1}), which produced the lowest yields of cormel.

Hossain (2008) found that the cormel yield showed significant variations due to different level of phosphorus. The highest corm yield (0.56 kg plot^{-1}) was recorded from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar (0.55 kg plot^{-1}) to P_4 (150 kg P_2O_5 ha^{-1}) and the lowest (0.44 kg plot^{-1}) was recorded from P_0 (0 kg P_2O_5 ha^{-1}). They also reported that the cormel yield ha^{-1} of gladiolus showed significant differences for different level of phosphorus. The highest cormel yield (11.62 t ha^{-1}) was recorded from P_3 (140 kg P_2O_5 ha^{-1}) which was statistically similar (11.44 t ha^{-1}) to P_4 (150 kg P_2O_5 ha^{-1}) and closely followed (10.44 t ha^{-1}) by P_2 (130 kg P_2O_5 ha^{-1}),and the lowest (9.24 t ha^{-1}) was recorded from P_0 (0 kg P_2O_5 ha^{-1}) which was closely followed (10.44 t ha^{-1}) by P_1 (120 kg P_2O_5 ha^{-1}).

Pant (2005) found that the phosphorous @ 100 kg ha^{-1} application produced the highest cormel yield (25 g $plant^{-1}$) in contrast with nitrogen @ 150 kg ha^{-1} and without phosphorus produced the lowest cormel yield (1.95 g $plant^{-1}$).

2.1.2 Effect of zinc

2.1.2.1 Plant height

Reddy *et al*. (2014) found that the 2% zinc spray recorded maximum plant height over the lower concentrations. Maximum plant height due to higher concentration of zinc might be its role in synthesis of proteins.

Katiyar *et al.* (2012) carried out an experiment to investigate the effect of zinc, calcium and boron on spike production in gladiolus with foliar application in kanpur in Randomized Block Design with four replications.The experimental plots were 32 with 8 treatments and two levels of each of zinc , calcium and boron treated by zinc sulphate 0.5%,calcium sulphate 0.75% and borax 0.2% respectively.The results obtained revealed that the foliar spray of zinc at 0.5% to gladiolus plant was most effective to influence the vegetative growth and size of spike.

Amin *et al*. (2014) carried out an experiment on growth, flowering and production of corms and cormels of gladiolus to find out the better level of Zinc. Experiment consisted four different levels of zinc viz. Z_0= 0 kg Zn ha^{-1}, Z_1= 1 kg Zn ha^{-1} (1.28 Kg ZnO), Z_2= 2 kg Zn ha^{-1} (2.56 Kg ZnO), Z_3= 3 kg Zn ha^{-1} (3.84 Kg ZnO) and Z_4= 4 kg Zn ha^{-1} (5.12 Kg ZnO). They found that the statistically significant variation was recorded for plant height with different levels of zinc. Tallest plant was obtained from Z_3 (78.5 cm) while shortest from Z_0 (65.6 cm) at 80 days after planting (DAP).

Reddy *et al*. (2009) reported that the zinc helps to make available soil nutrient elements of which also ensures the advanced growth of gladiolus plants. Similar results were reported by Singh *et al*. (2012).

Saeed *et al*. (2013) was conducted a filed experiment by the applying graded levels of zinc, viz., 0, 2, 4, 6, 8 and 10 mg Zn kg^{-1} in soil media. Results in both the years revealed significant positive response to zinc application on growth attributes of gladiolus. Zinc at 6 mg kg^{-1} rendered the highest impact for increasing the plant height of gladiolus than other levels of Zinc.

Halder *et al*. (2007b) carried out a field experiment by the effect of Boron (B) and Zinc (Zn) on Gladiolus in Grey Terrace Soils at Floriculture Res. field of HRC, BARI, Gazipur during 2005–2006 and 2006–2007. Treatments comprising four levels of B (0, 1, 2 and 3 kg ha^{-1}) and four levels of Zn (0, 1.5, 3.0 and 4.5 kg ha^{-1}) along with combined blanket dose of $N_{375}P_{150}K_{250}S_{20}$ and cowdung 5 t ha^{-1} were used in the study. The results revealed that Zn had a positive effect on the studied parameters. However, the highest plant height (73.53 cm and 103.5 cm) was recorded with the single application of Zn at higher dose (3 kg Zn ha^{-1}) while lower (1.5 kg Zn ha^{-1}) and higher doses (4.5 kg Zn ha^{-1}) of Zn did not reflect on to the plant height.

Halder *et al*. (2007a) studied on the effect of Zn on growth and flower characters of gladiolus reveals that zinc made a promising response to the studied parameters. It appears from the obtained results in the study of Halder *et al*., (2007a) that the zinc either in single or combination exerted significant effect on growth and other floral characteristics. However, applied 4 levels of Zn at the rate of 0, 1.5, 3.0 and 4.5 kg ha^{-1}, significantly the highest plant height (74.13 and 87.70 cm) was obtained in 3.0 kg Zn ha^{-1} followed by rest of Zinc levels and Zn control (Zn_0) at both years.

2.1.2.2 Number of leaves plant^{-1}

Maurya and Kumar (2014) reported that significantly the maximum number of leaves per plant (7.89) was recorded with the spraying of Zn @ 300 mg l^{-1} followed by spraying of B @ 300 mg l^{-1} (7.83). The minimum number of leaves per plant (6.50) was recorded with water sprayed in control (T_1). They reported that the increased in number of leaves per plant may be due to cell division in plants.

Amin *et al*. (2014) studied to find the out better level of zinc on growth, flowering and production of corms and cormels of gladiolus. They reported 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).

Memon *et al*. (2013) also found significant effect of ZnO and $FeSO_4$ for number of leaves plant^{-1}. The gladiolus under treatment of 40 g ZnO + 20 g $FeSO_4$ resulted in maximum number of leaves (12.44) plant^{-1}, while gladiolus under treatment of 20 g ZnO + 20 g $FeSO_4$, 40 g ZnO and 20 g ZnO ranked 2nd, 3rd and 4th with 11.11, 10.00 and 10.00 average number of leaves plant^{-1}, respectively. The gladiolus treated with 20 g $FeSO_4$ resulted in a decreased number of leaves plant^{-1}, while the minimum number of leaves (9.00) plant^{-1} was recorded under control, where ZnO and $FeSO_4$ were not applied.

Halder *et al*. (2007b) conducted an experiment on flower production of gladiolus where the maximum effective leaves (10.42 and 13.07/plant) was obtained with the single application of Zn at higher dose (3 kg Zn ha^{-1}) while lower (1.5 kg Zn ha^{-1}) and higher doses (4.5 kg Zn ha^{-1}) of Zn did not reflect on to the effective leaves. From the study of Halder *et al*. (2007a) it was found that the maximum effective leaves (10.05 and 9.66/plant) was obtained in 3.0 kg Zn ha^{-1} among the Zn levels while it was followed by rest of Zinc levels and Zn control (Zn_0) showed the minimum effective leaves.

2.1.2.3 Days required for spike emergence

Amin *et al*. (2014) studied the effect of different levels of zinc where they found significant differences for days required for 80% spike emergence. Maximum days required for 80% spike emergence was recorded from Z_0 (95.7%) which was statistically similar with Z_1 (94.0%) whereas minimum days from Z_3 (91.8%).

Fahad *et al*. (2014) reported that the analysis of variance for days to spike emergence revealed significant differences while T_7 significantly delayed flowering by increasing the number of days to emergence of spikes. Spike emergence was earlier in control (T_0) plants.

Lahijie (2012) reported that the application of 1 % $FeSO_4$ accelerated flowering earlier than ZnO, as well as elongated days to spike emergence (21.49 days) and first florets opening (38.28).

2.1.2.4 Number of florets spike^{-1}

Amin *et al*. (2014) found that the number of floret spike^{-1} showed significant variation due to Zinc levels where the maximum number of floret spike^{-1} was obtained from Z_3 (16.1) while minimum from Z_0 (11.1).

Memon *et al*. (2013) found that the number of florets spike^{-1} were significantly influenced by ZnO and $FeSO_4$ levels while 40 g ZnO + 20 g $FeSO_4$ produced highest florets spike^{-1} (14.55). The plants fertilized with 20 g ZnO + 20 g $FeSO_4$ and 20 g $FeSO_4$ ranked 2nd and 3rd with 12.11 and 10.88 average florets spike^{-1}, respectively. However, the lowest number of florets (10.11) spike^{-1} was achieved in gladiolus plants treated with 20 g ZnO alone without addition of $FeSO_4$.

Saeed *et al*. (2013) conducted an experiment on the effect of zinc for growth, flowering and vase life of gladiolus. Among the various levels of zinc, less number of days to flowering and higher count of florets per spike was recorded with 8 mg Zn kg^{-1}. Similarly, without Zinc recorded the minimum number of florets $spike^{-1}$.

Halder *et al*. (2007b) reported that the number of florets was also influenced by single doses of Zn at increasing levels. The highest floret numbers (12.42 and 13.20/spike) was also obtained in said Zn level (3.0 kg Zn ha^{-1}) was closely followed by higher Zn rate (4.5 kg ha^{-1}) and statistically different over Zn_0. Halder *et al*. (2007a) also reported that the highest number of florets at both years (12.18 and 11.01/spike) was found in 3.0 kg Zn ha^{-1} while Zn control (Zn_0) showed the minimum number of florets.

2.1.2.5 Percentage of flowering

Reddy and Rao (2012) reported that the increase in the concentration of zinc delayed number of days taken for first flower appearance and number of days taken for 50% flowering. More number of days taken for first flower appearance and 50% flowering with highest concentration of zinc (2%). Control and zinc at low concentration induced early flowering.

2.1.2.6 Length of flower stalk

Sharma *et al*. (2013) reported that the length of floret is a qualitative parameter in gladiolus. More the length and width of floret, compact will be the spike, giving better look of the spike. The longer florets (8.29 cm) were found in the plants sprayed with boron followed by Zn (8.23 cm).

2.1.2.7 Length of rachis

Amin *et al*. (2014) found that the length of rachis at harvest also showed significant variation due to the application of zinc. Longest rachis was recorded from Z_3 (36.3 cm) while shortest from was recorded from Z_0 (31.5 cm) at harvest.

Reddy *et al.* (2009) studied on the effect of zinc (ZnO) at 0.5%, calcium ($CaSO_4$) at 0.5% and boron (borax) at 0.25% on growth and flowering in gladiolus cv. Red Majesty with four replications. Application of ZnO at 0.5% found to be significant on length of rachis (46.26 cm) than that of other all treatments of the study.

Halder *et al.* (2007b) found that the length of rachis was highly influenced by Zn up to 3 kg ha^{-1} which was significantly different over higher and lower doses of Zn and Zn_0. However, farther augmenting Zn level (4.5 kg Zn ha^{-1}) and that dose (3.0 kg Zn ha^{-1}) did not respond positively. However, significantly the highest rachis length (46.62 cm and 57.07 cm) was recorded with highest level of Zn (3.0 kg ha^{-1}) which was markedly differed over other Zn levels and Zn_0.

Halder *et al.* (2007a) conducted an experiment with 4 levels of Zn (0, 1.5, 3.0 and 4.5 kg ha^{-1}). Among the Zn levels, significantly the longest length of rachis (47.14 and 39.58 cm) at both seasons, respectively was found in 3.0 kg Zn ha^{-1} followed by rest of Zinc levels and Zn control (Zn_0).

2.1.2.8 Length of spike

Amin *et al.* (2014) found that the length of spike was significantly influenced due to the application of Zinc at different levels. Among the Zn levels, longest spike was found from Z_3 (69.5 cm) followed by Z_4, Z_2 and Z_1 (65.1, 66.3 and 64.0 cm respectively) where minimum from Z_0 (60.8 cm) at harvest.

Saeed *et al.* (2013) reported that the Zinc being an activator of certain enzymes, regulates antioxidant activity; therefore, it could enhance the shelf life of cut flowers. This study on zinc (Zn) nutrition of gladiolus was conducted for two years (2010–2011) in the greenhouse. Graded levels of zinc, viz., 0, 2, 4, 6, 8 and 10 mg Zn kg^{-1} were applied in soil media. Results in both the years revealed significant positive response to zinc application on growth and vase life attributes of gladiolus. Zinc at 6 mg kg^{-1} rendered the highest impact for increasing the spike length and size of flower.

Halder *et al*. (2007b) found that the length of spike was highly influenced with the subsequent addition of Zn up to 3 kg ha^{-1} which was significantly different over higher and lower doses of Zn and Zn_0. Significantly the highest length of spike (62.80 cm and 91.40 cm) was recorded with highest level of Zn (3.0 kg ha^{-1}) which was markedly differed over other Zn levels and Zn_0.

Halder *et al*. (2007a) studied with 4 levels of Zn (0, 1.5, 3.0 and 4.5 kg ha^{-1}) where significantly the longest length of spike (63.84 and 76.89 cm) was recorded in 3.0 kg Zn ha^{-1} followed by rest of Zinc levels and Zn control (Zn_0).

Halder *et al*. (2007) also found significant variation for length of spike while B2.0 Zn4.5 kg ha^{-1} produced significantly the longest spike (71.2 and 67.33 cm) at 2005 and 2006 season, respectively as compare to control.

2.1.2.9 Number of spikelet, spike and corm

2.1.2.9.1 Spikelet

Amin *et al*. (2014) reported that the Zinc application significantly influenced the number of florets $spike^{-1}$. They found that the maximum number of florets $spike^{-1}$ was obtained from Z_3 (16.16) while minimum number of florets $spike^{-1}$ (11.1) was obtained from without Zinc.

2.1.2.9.2 Spike

Amin *et al*. (2014) found that the Zinc application significantly influenced the number of spike $plot^{-1}$ and $hectare^{-1}$. Among the various levels of Zinc, the maximum number of spike $plot^{-1}$ was obtained from Z_3 (22.3) while minimum from Z_0 (17.9). Number of spike in thousand per hectare of gladiolus differed significantly for the application of different levels of zinc. Maximum number of spike (297.8 ha^{-1}) was obtained from Z3 while minimum from Z0 (238.5 ha^{-1}).

Sharma *et al*. (2013) reported that the yield of spike significantly influenced due to the application of Zn, B and Ca where the maximum yield of spike (16904.50) was recorded with foliar application of zinc followed by calcium (16781.25).

2.1.2.9.3 Corm

Reddy *et al*. (2014) reported that the no. of replacement corms produced per mother corm were not significant with zinc applications. However, the highest number of replacement corms observed with 2% zinc sprayed at 6 weeks after planting while Reddy and Rao (2012) found that the maximum number of corms was observed with the highest concentration of zinc (2%) sprayed at 6 weeks after planting.

Singh *et al*. (2012) reported that the foilar spray of Zn, Fe and Cu significantly increased the number of corms per plant showing 1.74, 1.66 and 1.68 corms per plant, respectively when compared with their respective controls Zn (1.46), Fe (1.55) and Cu (1.53).

Halder *et al*. (2007c) carried out a field trial on corm and cormel production where the addition of zinc from 0 to 3.0 kg ha^{-1} in treated plants multiplied the bulb yield and their numbers significantly over the zinc control (Zn_0). It was noticed that the number of corms per plants found to be narrowly increased wh ile it is progressively increased with increase of zinc levels up to 3.0 kg ha^{-1}.

2.1.2.10 Thickness of corm

Amin *et al*. (2014) also found that there was a significant variation in individual corm thickness due to the application of Zinc where themaximumindividual corm thickness was recorded from Z_3 (7.2 cm) while the minimum from Z_0 (6.0 cm).

Halder *et al*. (2007c) found significant response on length of corm due to the application of Zn fertilizer but narrowly differed to each other. The length of corm was the highest in 3.0 kg Zn ha^{-1} than that of other Zn levels (Zn1.5 kg and Zn4.5 kg ha^{-1}) while control or without Zn showed the lowest length of corm.

2.1.2.11 Diameter of corm

Amin *et al*. (2014) reported that the individual corm diameter was significantly influenced due to the effect of Zinc. The maximum individual corm diameter was recorded from Z_3 (2.4 cm) while minimum from Z_0 (1.7 cm).

Reddy and Rao (2012) found that the highest corm size was observed with the highest concentration of zinc (2%) sprayed at 6 weeks after planting. The increased corm size with zinc sprays might be due to increased cell division and greater mobilization of photosynthates to the places where the corms are formed.

Singh *et al.* (2012) reported that the diameter of corm was significantly affected by Zn, Fe and Cu denoting 5.71 cm, 5.81 cm, and 5.77 cm, respectively and their respective controls (Zn0, Fe0 and Cu0) produced (5.50 cm, 5.44 cm and 5.40 cm, respectively. Singh *et al.* (2000) reported that various levels of ZnO was significantly influenced the diameter of corms while highest level of ZnO (20 kg ha^{-1}) showed significantly the highest diameter of corm compare other doses of Zn.

2.1.2.12 Weight of individual corm

Amin *et al*. (2014) also found to be the significant variation for individual corm weight due to Zinc application. Among the Zinc levels, the maximum individual corm weight was found from Z_3 (26.3 g) and minimum from Z_0 (19.5 g).

Maurya and Kumar (2014) carried out an experiment on flower production of gladiolus where the maximum weight of corm (92.64 g) per plant was recorded with the spraying of Zn @ 300 mg l^{-1} followed by spraying of B @ 300 mg l^{-1} (86.67 g). However, minimum weight of corm (73.09 g) per plant was recorded with water sprayed under control (T_1).

Halder *et al*. (2007C) reported that the increment of zinc dosage depressed the yield of corm. However, the highest individual weight of corm (22.22 g and 24.21 g) was obtained in 3 kg Zn ha^{-1}which was marginally differed among zinc levels but significantly higher over zinc control (8.87 g and 11.65g).

Singh *et al.*, (2000) reported that the weight of corm was significantly influenced the average weight of corm due to the effect of Zinc sulphate. Among the various levels of ZnO, 20 kg ZnO ha^{-1} recorded the highest average weight of corm while without Zn showed t he lowest weight of corm.

2.1.2.13 Yield of corm

Amin *et al*. (2014) also found that the yield of corm (kg $plot^{-1}$) was varied significantly among different levels of zinc. Maximum yield $plot^{-1}$ was found from Z_3 (1.26 kg) followed by Z_4 (1.07 kg) whereas minimum from Z_0 (0.86 kg). Maximum yield ha^{-1} was calculated from Z_3 (16.7 t) followed by Z_4 and Z_2 (14.3 t) whereas minimum from Z_0 (11.5 t).

Maurya and Kumar (2014) conducted an experiment on the flower production of gladiolus where significantly, the Maximum yield of corm (115.80 q) per hectare was recorded with the spraying of Zn @ 300 mg l^{-1} followed by spraying of B @ 300 mg l^{-1} (108.34 q). However, minimum yield of corm (91.36 q) per hectare.

Halder *et al*. (2007b) reported that the flower yield noticeably responded to Zn fertilizer up to 3 kg Zn ha^{-1} where higher dose of Zn failed to give desired flower yield of gladiolus. However, the higher level of Zn (3 kg Zn ha^{-1}) progressively increased the highest flower yield (15.86 t ha^{-1}) which was sharply different over lower (1.5 kg Zn ha^{-1}) and higher levels (4.5 kg Zn ha^{-1}) and higher than Zn_0.

2.1.2.14 Number of cormel

Amin *et al*. (2014) reported that the number of cormel plant^{-1} varied significantly due to the effect of Zinc. Maximum number of cormel plant^{-1} was found from Z_3: 3.0 kg ha^{-1} (26.3) while minimum from Z_0 (19.6).

Maurya and Kumar (2014) also found significant variation number cormels per plant where the maximum number cormels per plant (38.17) was recorded with the spraying of Zn @ 300 mg l^{-1} followed by spraying of B @ 300 mg l^{-1} (36.80). The minimum number of cormels (25.83) per plant was recorded with water sprayed in control (T_1). The increased in cormels might be due to role of zinc in translocation of constituents from one part to other part.

Singh *et al*. (2012) reported that the foliar application of Zn, Fe and Cu significantly increased the number of cormels per plant. The number of cormels per plant increased by Zn (44.97), Fe (42.11) and Cu (43.18) over their respective controls Zn0 (33.69), Fe0 (36.65) and Cu0 (35.48).

Halder *et al*. (2007c) studied on flower yield of Gladiolus due to Zinc application. The highest number of cormels (9.78 and 12.09) was recorded with 3.0 kg Zn ha^{-1} where zinc control in untreated plants performed poor than that of other Zn levels (Zn1.5 kg and Zn 4.5 kg ha^{-1}).

2.1.2.15 Diameter of cormel

Amin *et al*. (2014) found significant difference for individual cormel diameter due to different levels of zinc. Among the various levels of Zinc, the maximum individual cormel diameter was found from Z_3 (1.6 cm) while minimum from Z_0 (1.2 cm).

Halder *et al*. (2007c) found that the length of cormel also significantly responded to the Zn fertilizer but narrowly differed to each other. Among the Zn levels, 3.0 kg Zn ha^{-1} obtained the longest cormel compare to other Zn levels.

2.1.2.16 Weight of individual cormel

Maurya and Kumar (2014) found that the maximum weight of corm (92.64 g) and cormels (8.48 g) per plant was recorded with the spraying of Zn @ 300 mg l^{-1} followed by spraying of B @ 300 mg l^{-1} (7.94 g). However, minimum weight of cormels (4.81 g) per plant was recorded with water sprayed under control (T_1). The result might be due to micronutrients helps in nitrogen assimilation and synthesis of protein and also because of catalytic role in the activation of enzymes.

Reddy *et al*. (2014) found that the highest weight of cormel was observed in higher concentration of zinc (2%) and lowest weight of cormel observed in control. This may be due to accumulation of proteins in cormels.

Amin *et al*. (2014) found that the maximum individual weight of cormel was found from Z_3 (14.5 g) which was statistically similar with Z_2 (13.6 g) and Z_4 (13.5 g) while minimum from Z_0 (12.0 g). Maximum weight of cormels was observed in higher concentration of zinc (2%) and lowest weight of cormels observed in control (Reddy and Rao, 2012).

Halder *et al*. (2007C) reported that the increment of zinc dosage depressed the yield of cormel. However, the highest individual weight of cormel was obtained in 3 kg Zn ha^{-1}which was marginally differed among zinc levels but significantly higher over zinc control. As a result, the highest weight of cormels per plant (20.92 g and 36.24 g) was recorded with 3.0 kg Zn ha^{-1} where zinc control in untreated plants performed poor yield than that of other Zn levels (Zn1.5 kg and Zn 4.5 kg ha^{-1}).

2.1.2.17 Yield of cormel

Amin *et al*. (2014) found that the yield of cormel was significantly influenced due to the effect of Zinc. Maximum cormel yield was found from Zn_3 (1.06 kg $plot^{-1}$) while minimum from Z_0 (0.80 kg $plot^{-1}$). Maximum cormel yield was found from Z_3 (14.2 t ha^{-1}) while minimum from Z_0 (10.6 t ha^{-1}).

Maurya and Kumar (2014) reported that the maximum yield of cormels (10.60 q) per hectare was recorded with the spraying of Zn @ 300 mg l^{-1} followed by spraying of B @ 300 mg l^{-1} (9.92 q). However, minimum yield of cormels (6.01 q) per hectare was recorded with water sprayed under control (T_1). The result might be due to micronutrients helps in nitrogen assimilation and synthesis of protein and also because of catalytic role in the activation of enzymes.

CHAPTER III
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 to study on the performance of 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. This section for convenience of presentation has been divided into various sub–sections such experimental site, soil and climatic condition, experimental materials, land preparation, experimental design, fertilizer application, seed sowing, intercultural operations, harvesting and threshing, data collection, statistical analysis etc.

3.1 Experimental site

The experiment was conducted at the Horticulture Farm, SAU, Dhaka. 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.

3.2 Agro–ecological Zone

The experimental field belongs to the Agro–ecological zone of AEZ–28 under Modhupur Tract.

3.3 Soil

The experimental soil belongs to the Modhupur Tract under AEZ No.28. The selected experimental plot was medium high land and the soil series was Tejgaon. The characteristics of soil under experimental plot were analyzed in the SRDI, Soil testing Laboratory, Khamarbari, Dhaka and presented in Appendix 1.

3.4 Climate

The climate of the experimental site was under the subtropical climate characterized by three district seasons, the monsoon or the rainy season from The climate of the experimental site was under the subtropical climate characterized by three district seasons, the monsoon or the rainy season from November to February and the pre-monsoon period from May to October. Meteorological data related to the temperature, relative humidity, rainfalls and sunshine during the period of experiment was collected from the Bangladesh meteorological department, Sher-e-Bangla Nagar, Dhaka and presented in Appendix II.

3.5 Experimental Materials

For the experiment, healthy and uniform sizes of corms were collected from the Barishal Nursery, Savar Bazar, Dhaka. In this research work the experimental material consisted of 960 corms as planting materials where 20 corms are planted in each plot while total plots were 48 (16 plots in each block). The source of zinc is used as zinc oxide.

3.6 Treatment of the experiment

The experiment was carried out to find out the effect of phosphorus and zinc on growth, flowering (corm and cormel yield) and vase life of gladiolus. The experiment is consisted with two factors.

Factor A: Phosphorus (4 levels)

P_0= 0 kg P_2O_5 ha^{-1} (control)

P_1= 120 kg P_2O_5 ha^{-1}

P_2= 140 kg P_2O_5 ha^{-1}

P_3= 160 kg P_2O_5 ha^{-1}

Factor B: Zinc (4 levels)

Zn_0= 0 kg Zn ha^{-1} (Control)

Zn_1= 1 kg Zn ha^{-1} (1.28 kg ZnO)

Zn_2= 2 kg Zn ha^{-1} (2.56 kg ZnO)

Zn_3= 3 kg Zn ha^{-1} (3.84 kg ZnO)

There were on the whole 16 (4×4) treatments combination as P_0Zn_0, P_0Zn_1, P_0Zn_2, P_0Zn_3, P_1Zn_0, P_1Zn_1, P_1Zn_2, P_0Zn_3, P_2Zn_0, P_2Zn_1, P_2Zn_2, P_0Zn_3, P_3Zn_0, P_3Zn_1, P_3Zn_2, and P_0Zn_3.

3.7 Experimental design

The two factors experiment was laid out in the randomized completely block design (RCBD) with three replications. The experimental plot was first divided into three blocks where each block was used as replication. Each block was consisted of 16 unit plots. Thus the total number of plots was 48. Different combinations of Phosphorus (4 levels) and Zinc (4 levels) were assigned randomly to each block as per design of the experiment. The size of the unit plot was 1.0 m x 1.0 m. The corm was plant into the soil with maintaining row to row distance at 25 cm and plant to plant distance at 20 cm. There were 20 plants containing in each plot. The layout of the experiment is presented in the below.

3.8 Land preparation

The land was first open by ploughing with the help of power tiller and then it kept open to sun for seven days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth.

3.9 Application of manure and fertilizers

The sources of N as Urea, TSP, MP and Zinc Oxide (Zn) were applied, respectively. The entire amounts of TSP, MP, P and Zn were applied during the final land preparation. Nitrogen (as urea) was applied in three equal installments at 15, 30 and 45 days after sowing seeds. Well–rotten cowdung also applied during final land preparation (Appendix III). The following amount of manures and fertilizers were used which shown as tabular form recommended by BARI, 2002.

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

Plate 1: Experimental plot of gladiolus

3.10 Intercultural operation

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations, like weeding, top dressing, irrigation was accomplished for better growth and development of gladiolus seedlings.

3.10.1 Irrigation and drainage

Over head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening .Further irrigation was done when needed .Stagnant water was effectively drained out at the time of heavy rains.

3.10.2 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete the emergence of gladiolus seedlings whenever it was necessary. Breaking the crust of soil was done when needed.

3.10.3 Top dressing

After basal dose, the remaining doses of urea were top–dressed in 3 equal installments. The fertilizers were applied on both sides of plant rows and mixed with the soil by hand. Earthing up was done with the help of nirani immediately after top dressing of nitrogen fertilizer.

3.11 Plant protection

For controlling leaf caterpillars Nogos @ 1 ml L water were applied 2 times at an interval of 10 days starting soon after the appearance of infestation. There was No remarkable attack of disease was found.

3.12 Data collection

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.

3.12.1 Plant height

The height of plant was recorded in centimeter (cm) at 25, 40, 55, 70 and 85 days after planting (DAP). The height was measured from the attachment of the ground level up to the tip of the growing point.

3.12.2 Number of leaves per plant

All the leaves of ten plants were counted at an interval of 15 days at 25, 40, 55, 70 and 85 days after planting (DAP) in the experimental plots.

3.12.3 Days required for 80% emergence of spike

It was achieved by recording the days taken for 80% emergence of spike from each unit plot.

3.12.4 Percentage of flowering plant

It was calculated by counting the numbers of plants bearing flowers in each unit plot divided by the number of plants emerged and converted to percentage.

3.12.5 Length of flower stalk at harvest

Length of flower stalk was measured from the base to the tip of the spike and expressed in centimeter.

3.12.6 Length of rachis at harvest

Length of rachis refers to the length from the axil of first floret up to the tip of the inflorescence and expressed in centimeter.

3.12.7 Number of spikelets per spike

Number of spikelets per spike was counted from 10 randomly selected plants and their mean was calculated.

3.12.8 Number of spike per plot

It was calculated from the number spike per plot obtained from counting all spike in a plot in each replication and mean was recorded.

3.12.9 Number of spike ha^{-1} ("000)

Number of spikes per hectare was computed from numbers of spikes per plot and converted to hectare.

3.12.10 Thickness of corm

Corms were separated from the plant and the thickness of corm was taken by a slide calipers and expressed in centimeter.

3.12.11 Diameter of corm

A slide calipers was used to measure the diameter the corm and expressed in centimeter.

3.12.12 Weight of individual corm

It was determined by electrical balance and weighting the corms from the ten randomly selected plants and mean weight was calculated.

3.12.13 Corm yield per plot

Total corm yield per plot was recorded by adding the total harvested corm in a plot and expressed in kilogram.

3.12.14 Corm yield per hectare

It was calculated by converting the yield of corm per plot to per hectare.

3.12.15 Number of cormels per plant

It was calculated from the number of cormels obtained from ten randomly selected plants and mean was recorded.

3.12.16 Diameter of cormel

A slide calipers was used to measure the diameter of the cormel and expressed in centimeter.

3.12.17 Weight of individual cormel

Individual weight of cormel was recorded from mean weight of ten randomly selected sample cormels and expressed in gram.

3.12.18 Cormel yield per plot

Total cormel yield per plot was recorded by adding the total harvested corm in a plot and expressed in kilogram.

3.12.19 Cormel yield per hectare

It was calculated by converting the yield of cormel per plot to per hectare.

3.13 Statistical analysis

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.

CHAPTER IV
RESULTS AND DISCUSSION

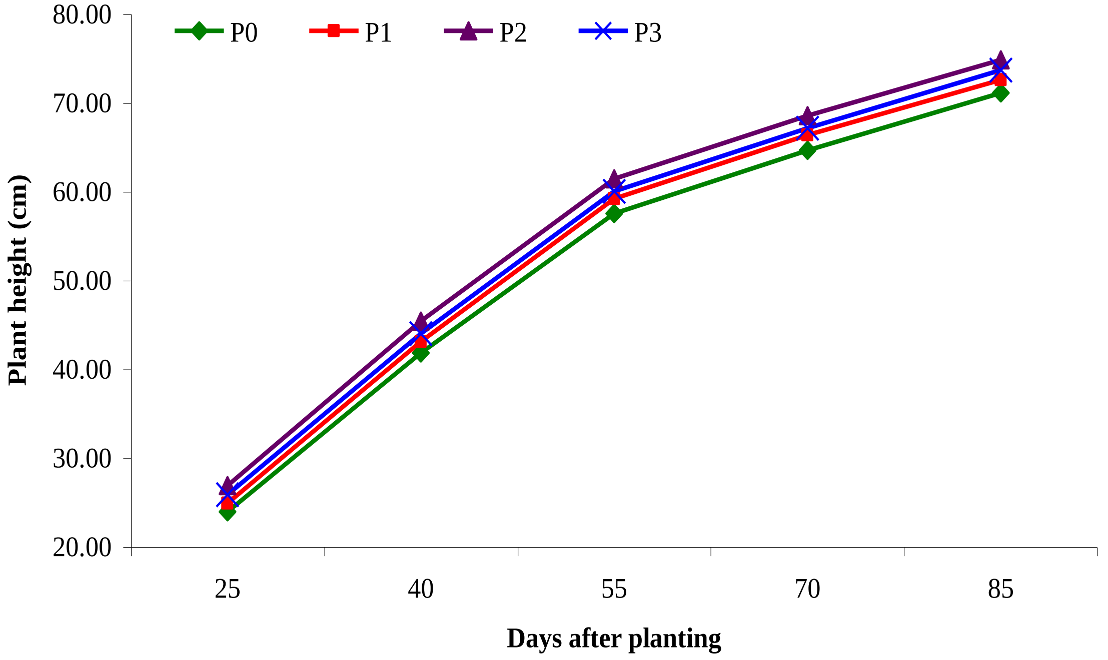
This chapter comprises the presentation and discussion of the results obtained from the experiment. The growth and flowering components were influenced by organic manure treatments. Data on different parameters were analyzed and the results have been presented in tables and figures. The results of each parameter have been presented, discussed and possible interpretations have been made in this chapter. The analysis of variance (ANOVA) for different characters studied with their sources of variation and corresponding degrees of freedom have been shown in Appendix.

4.1 Performance study of phosphorus (P_2O_5) and zinc on growth attributes of gladiolus

4.1.1 Plant height

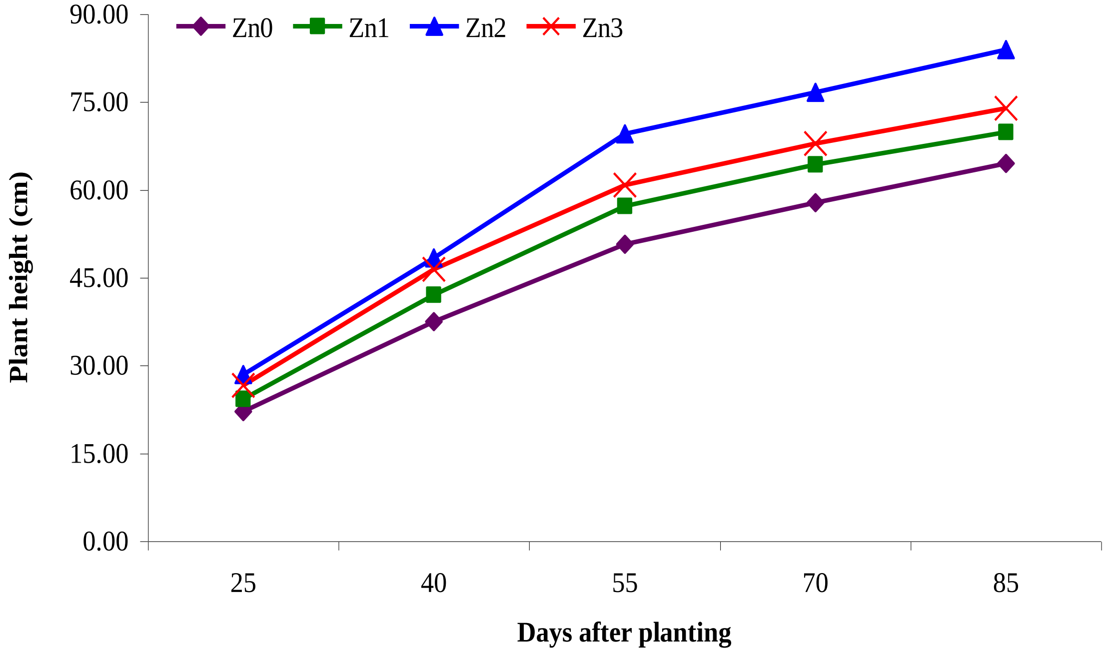
Analysis of variance data regarding plant height at different days after planting (DAP) was significantly influenced by the effect of phosphorus (P_2O_5) (Appendix IV). The tallest plant (74.8 cm) was obtained in 140 kg P_2O_5 ha^{-1} while the shortest plant (71.1 cm) was obtained in without Phosphorus at harvest (Fig. 4.1). These result revealed that the phosphorus fertilizer ensures favorable condition for growth of gladiolus while the 140 kg P_2O_5 ha^{-1} showed proper vegetative growth than that of other higher and lower doses of Phosphorus which ultimately produced the tallest plant. Similar findings was also obtained by Naznin *et al*. (2014). These results was also supported by Chandana and Dorajeerao (2014); Zubair and Wazir (2007); Pandey *et al*. (2000).

Plant height at different DAP was significantly influenced due to the effect of Zinc (ZnO) in this study (Appendix IV). 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 (Fig. 4.2).



P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 $ha^{-1;}$ P_2= 140 kg P_2O_5 $ha^{-1;}$ P_3= 160 kg P_2O_5 ha^{-1}

Fig. 4.1. Effect of phosphorus on plant height at different days after planting



Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

Fig. 4.2. Effect of zinc on plant height at different days after planting

Above observing showed that all the levels of zinc significantly influence the plant growth while 2.0 kg Zn ha^{-1} showed proper growth which might be due to higher significant response for serving the adequate soil nutrients and other necessary elements form the soil to the root zone which ultimately ensured the higher vegetative growth as well as tallest plant. 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 of phosphorus and zinc showed significant variation on plant height at different DAP except 40 DAP (Appendix IV). Interaction effect revealed that 140 kg P_2O_5 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.

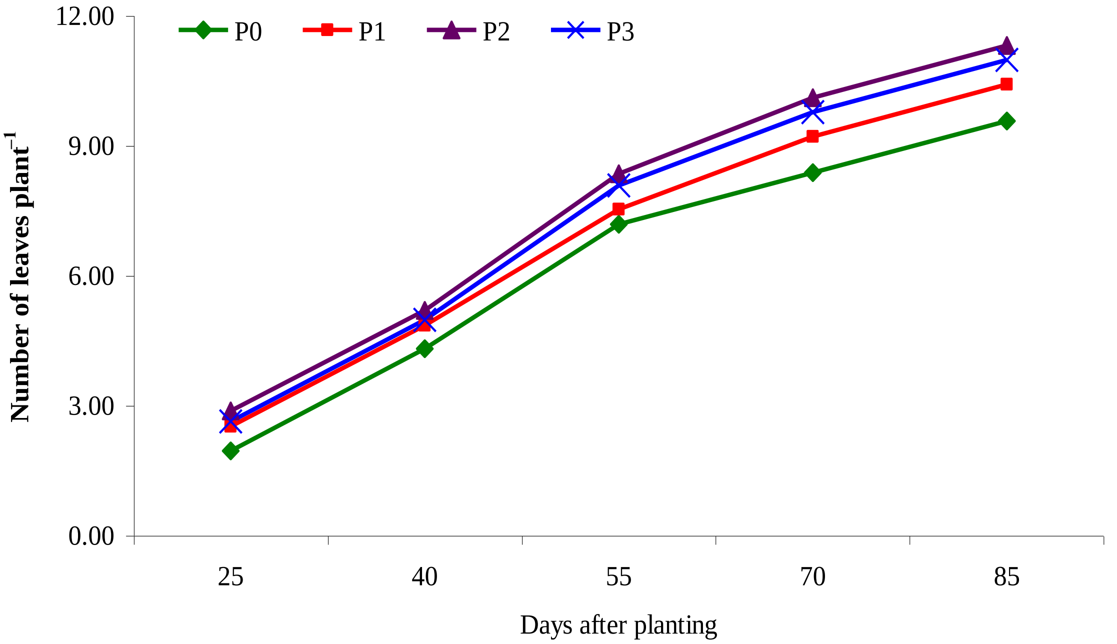
4.1.2 Number of leaves plant^{-1}

Effect of Phosphorus (P_2O_5) was significantly affected the production of leaves plant^{-1} at different DAP (Appendix IV). The maximum number of leaves plant^{-1} (11.32) was produced from 140 kg P_2O_5 ha^{-1} while 0 kg P_2O_5 ha^{-1} (control) recorded the minimum number of leaves plant^{-1} (9.58) at harvest (Fig. 4.3). The maximum number of leaves plant^{-1} was found with the 140 kg P_20_5 ha^{-1} might be due to the enhancing the soil nutrients and favourable condition which enhancing the leaves primordial by activating the apical meristems and consequently produced more leaves of Gladiolus. 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 Dorajeerao, 2014; Sharma *et al*., 2003).

There was a significant variation on number of leaves plant^{-1} at different DAP due to the effect of zinc (Appendix IV). 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 (Fig. 4.4). 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.

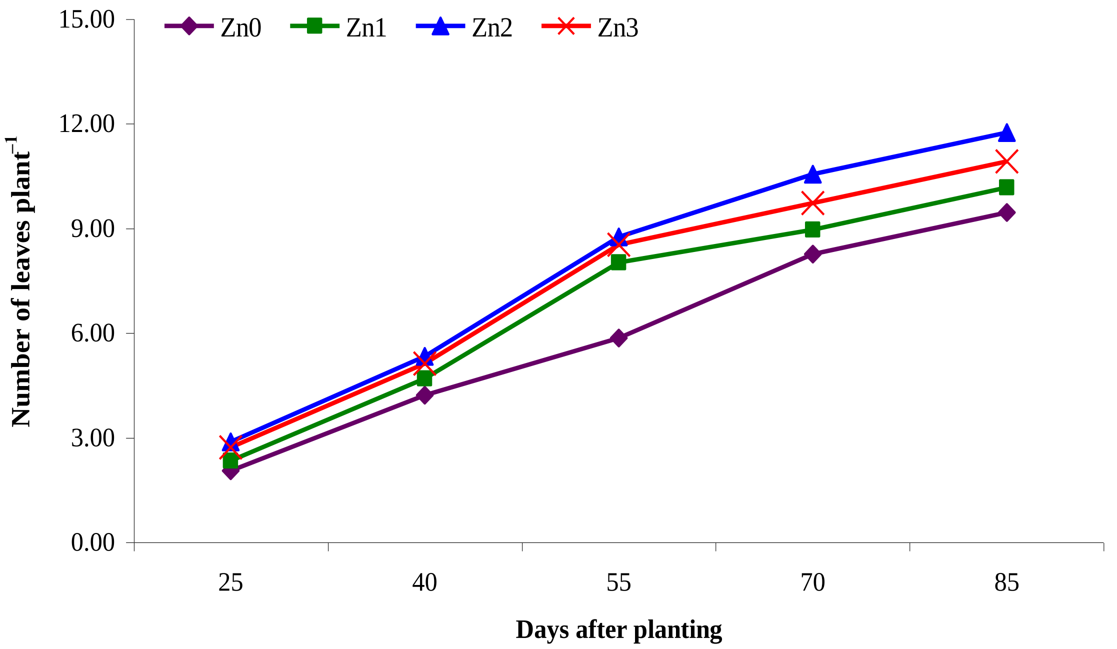
Table 4.1 Interaction effect of phosphorus and zinc on plant height and number of leaves at different days after planting (DAP), days to 80% emergence of spike, flowering (%), length of flower stalk and length of rachis at harvest

P	Zn	Plant height (cm) at different DAS					No. of leaves plant^{-1} at different DAS					80% Emergence	% flowering	Length of flower stalk	Length of rachis
(Kg ha^{-1})		25	40	55	70	85	25	40	55	70	85				
0	0	20.63 h	35.73 k	47.95 i	55.08 i	62.25 g	1.750 m	4.017 l	5.117 l	7.417 m	8.617 j	90.53 a	88.32 g	62.34 j	25.38 k
	1	22.80 f	40.57 i	54.20 g	61.33 f	66.84 f	1.833 l	4.183 k	7.433 h	7.883 l	9.083 i	88.37 abcd	90.63 cdefg	67.93 gh	30.73 h
	2	27.08 c	46.71 de	67.86 c	74.99 b	82.26 b	2.217 ij	4.667 h	8.250 f	9.667 f	10.87 e	85.10 bcdef	94.90 abcd	74.54 d	36.94 e
	3	25.27 d	44.54 fg	60.17 de	67.30 cd	73.31 cd	2.033 k	4.433 i	7.983 g	8.550 j	9.750 gh	86.07 bcdef	93.40 bcdef	73.36 de	35.96 e
120	0	21.82 g	37.25 j	50.20 h	57.33 hi	63.50 g	2.067 k	4.167 k	5.533 k	7.833 l	9.033 i	88.83 ab	89.30 fg	63.52 ij	26.56 j
	1	24.33 e	42.10 h	57.73 f	64.86 e	70.37 e	2.367 h	4.717 h	7.967 g	8.417 k	9.617 h	87.20 abcde	93.37 bcdef	70.13 fg	32.93 g
	2	28.02 b	47.55 cd	68.70 bc	75.83 b	83.10 b	2.883 d	5.333 d	8.467 e	10.63 c	11.83 b	84.77 cdef	96.30 ab	77.38 bc	39.78 c
	3	25.45 d	45.72 ef	60.35 de	67.48 cd	73.49 cd	2.783 e	5.200 e	8.167 f	10.00 e	11.20 d	85.00 bcdef	95.90 ab	76.04 cd	38.64 d
140	0	23.99 e	39.42 i	53.24 g	60.37 fg	66.67 f	2.233 i	4.333 j	6.467 i	9.050 h	10.25 f	87.90 abcde	90.40 defg	65.99 hi	29.03 i
	1	25.85 d	43.62 g	59.25 ef	66.38 de	71.89 de	2.683 f	5.033 f	8.500 e	10.05 e	11.25 d	86.37 bcdef	95.37 abc	73.95 d	36.75 e
	2	29.84 a	50.37 a	71.52 a	78.65 a	85.92 a	3.433 a	5.883 a	9.333 a	11.00 a	12.20 a	83.83 f	98.80 a	81.01 a	43.41 a
	3	27.99 b	48.26 bc	61.89 d	69.02 c	75.03 c	3.167 b	5.567 b	9.150 b	10.37 d	11.57 c	84.10 ef	98.20 ab	79.29 ab	41.89 b
160	0	22.19 fg	37.62 j	51.37 h	58.50 gh	65.87 f	2.150 j	4.350 j	6.317 j	8.750 i	9.950 g	88.50 abc	90.07 efg	64.98 i	28.02 i
	1	24.36 e	42.13 h	57.76 f	64.89 e	70.40 e	2.483 g	4.833 g	8.233 f	9.533 g	10.73 e	86.97 abcde	94.23 abcde	71.27 ef	34.07 f
	2	29.16 a	49.07 ab	70.22 ab	77.35 ab	84.62 ab	3.017 c	5.467 c	9.000 c	10.88 b	12.08 a	84.20 ef	96.70 ab	80.16 a	42.56 ab
	3	27.97 b	47.21 cde	60.84 de	67.97 cd	73.98 cd	2.933 d	5.300 d	8.817 d	9.983 e	11.18 d	84.50 def	96.10 ab	78.93 ab	41.53 b
$LSD_{(0.05)}$		**0.7768**	**1.427**	**1.801**	**2.277**	**2.28**	**0.07457**	**0.07457**	**0.1395**	**0.07457**	**0.2042**	**3.337**	**4.239**	**2.506**	**1.068**
CV (%)		**1.83**	**1.96**	**1.81**	**2.05**	**1.87**	**1.88**	**0.93**	**1.09**	**0.48**	**1.16**	**2.32**	**2.71**	**2.07**	**1.82**
SX		**0.2689**	**0.4944**	**0.6237**	**0.7885**	**0.7895**	**0.02582**	**0.02582**	**0.0483**	**0.02582**	**0.07071**	**1.155**	**1.468**	**0.8678**	**0.3697**



P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 ha$^{-1;}$ P_2= 140 kg P_2O_5 ha$^{-1;}$ P_3= 160 kg P_2O_5 ha^{-1}

Fig. 4.3. Effect of phosphorus on number of leaves plant^{-1} at different days after planting



Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

Fig. 4.4. Effect of zinc on number of leaves plant^{-1} at different days after planting

This was also found due to the appropriate soil nutrients and favourable growth condition were obtained by the application of 2 kg Zn ha^{-1} compare to more or less levels of Zn. 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).

Number of leaves $plant^{-1}$ at different DAP varied significantly due to the interaction effect of Phosphorus and Zinc (Appendix IV). Among the interactions, 140 kg P_2O_5 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 (P_2O_5 and Zn) recorded the minimum number of leaves $plant^{-1}$ (8.62) at harvest (Table 4.1).

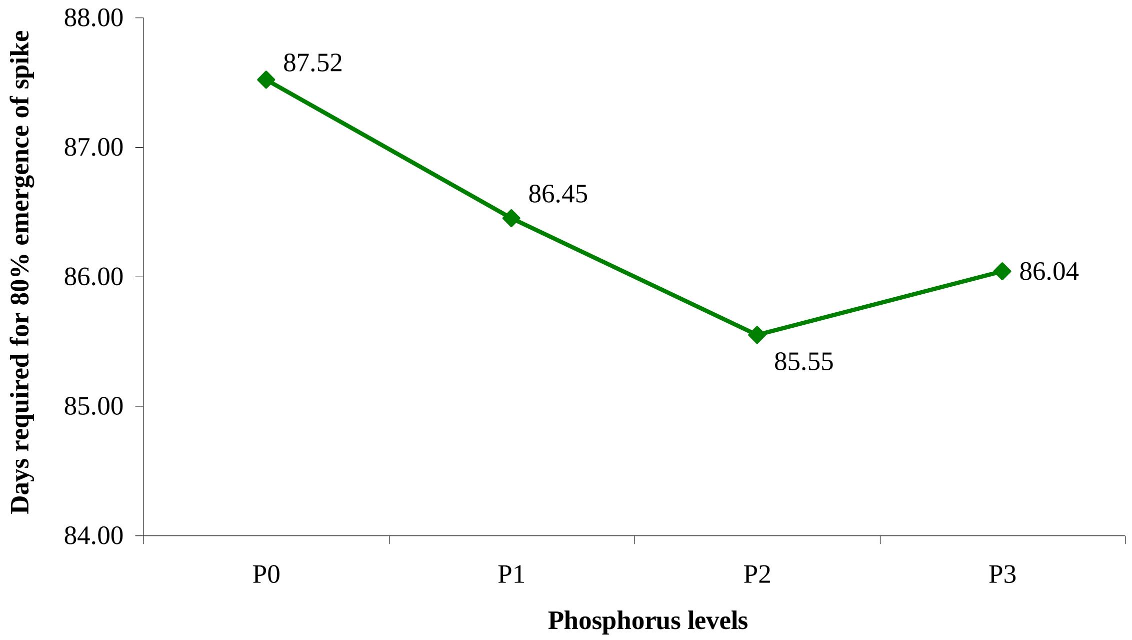
4.2 Performance study of phosphorus (P_2O_5) and zinc on yield attributes and yield (corm and cormel) of gladiolus

4.2.1 Days to 80% emergence of spike

Effect of Phosphorus (P_2O_5)

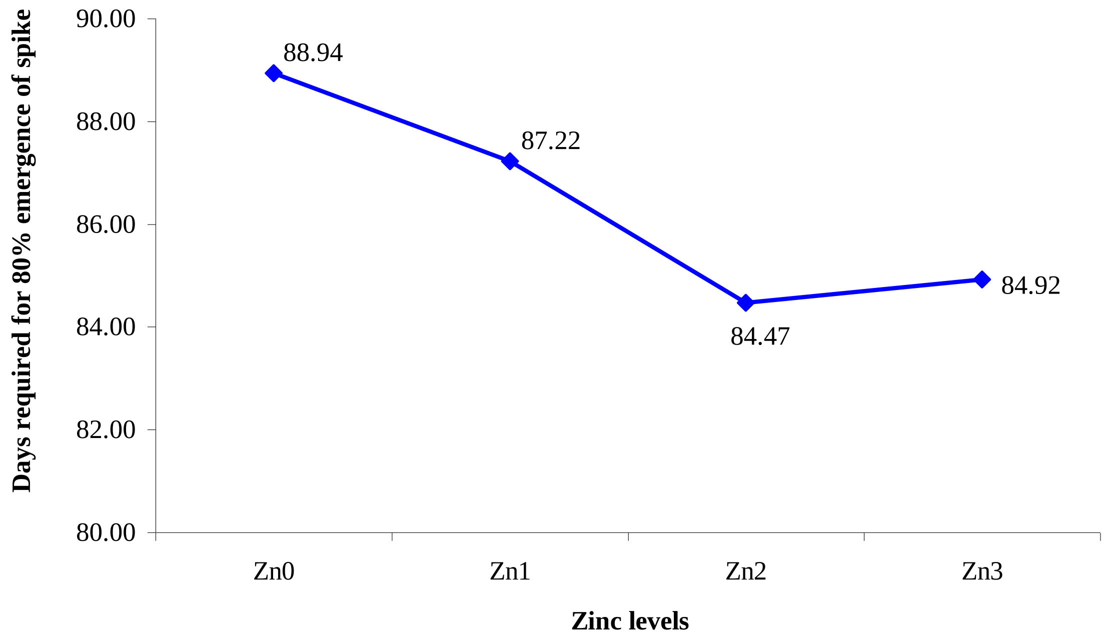
Days to 80% emergence of spike did not vary significant due to the effect of phosphorus (P_2O_5) which indicated that all the levels of phosphorus were similar effective for emergence of spike (Appendix IV and Fig. 4.5).

A significant variation due to the effect of zinc was found for days to 80% emergence of spike (Appendix IV). Fig. 4.6 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 (Fig. 4.6). These results revealed that without zinc delay the spike emergence compared to zinc application. 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.



P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 ha$^{-1;}$ P_2= 140 kg P_2O_5 ha$^{-1;}$ P_3= 160 kg P_2O_5 ha^{-1}

Fig. 4.5. Effect of phosphorus on days to 80% spike emergence



Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

Fig. 4.6. Effect of zinc on days to 80% spike emergence

All the interaction treatments required statistically same time for emergence of 80% spike due to non significant variation (Appendix IV and Table 4.1).

4.2.2 Percentage (%) of flowering

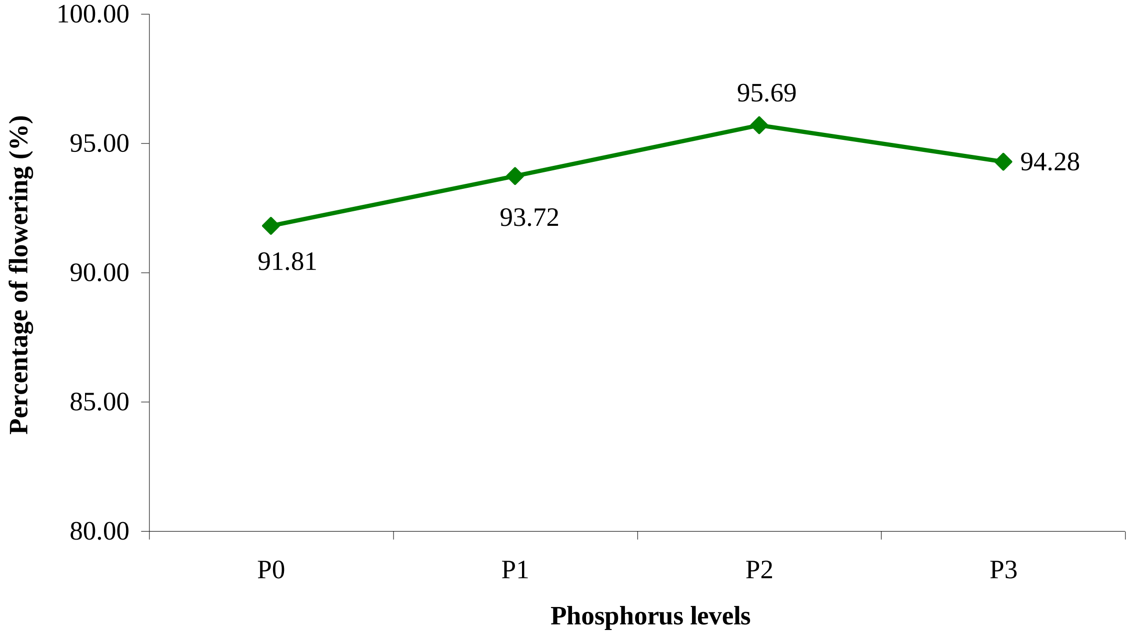
Analysis of variance data on flowering percentage in Appendix IV indicated significant difference due to the effect of phosphorus (Appendix IV). Flowering of gladiolus was the highest (95.69%) in 140 kg P_2O_5 ha^{-1} while statistically same (94.28%) was in 160 kg P_2O_5 ha^{-1} and the lowest (93.72%) was in without Phosphorus (Fig. 4.7). Besides, results of this study revealed that 140 kg P_2O_5 ha^{-1} provide the favorable conditions in which a gladiolus plant can utilize maximum nutrients. 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 (Fig. 4.8). From the above results it was found that the higher levels of Zn enhance the flowering might be due to better vegetative growth. 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 4.1).

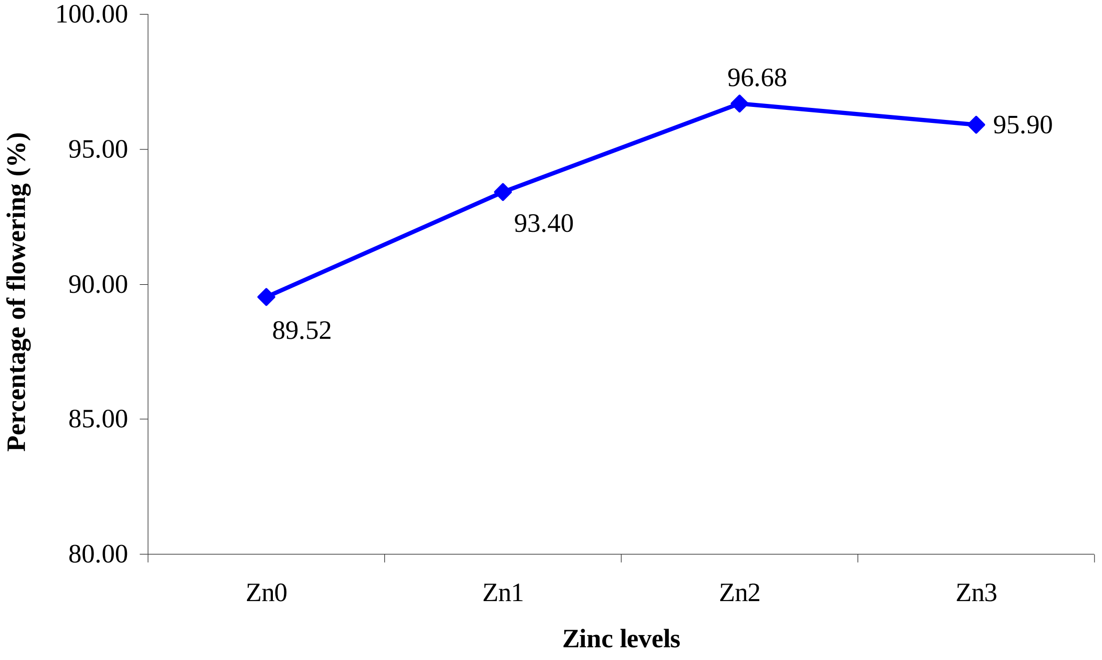
4.2.3 Length of flower stalk

Effect of P was significantly affected the length of flower stalk where both 140 and 160 kg P_2O_5 ha^{-1} produced statistically identical longest flower stalk (75.06 and 73.84 cm) while shortest flower stalk (69.4 cm) was obtained in without Phosphorus treated plant (Fig. 4.9). Similarly, length of flower stalk was also statistically significant due to phosphorus reported by Hossain (2008) who also found maximum in 140 kg P_2O_5 ha^{-1} and minimum in 0 kg P_2O_5 ha^{-1} (P_0).



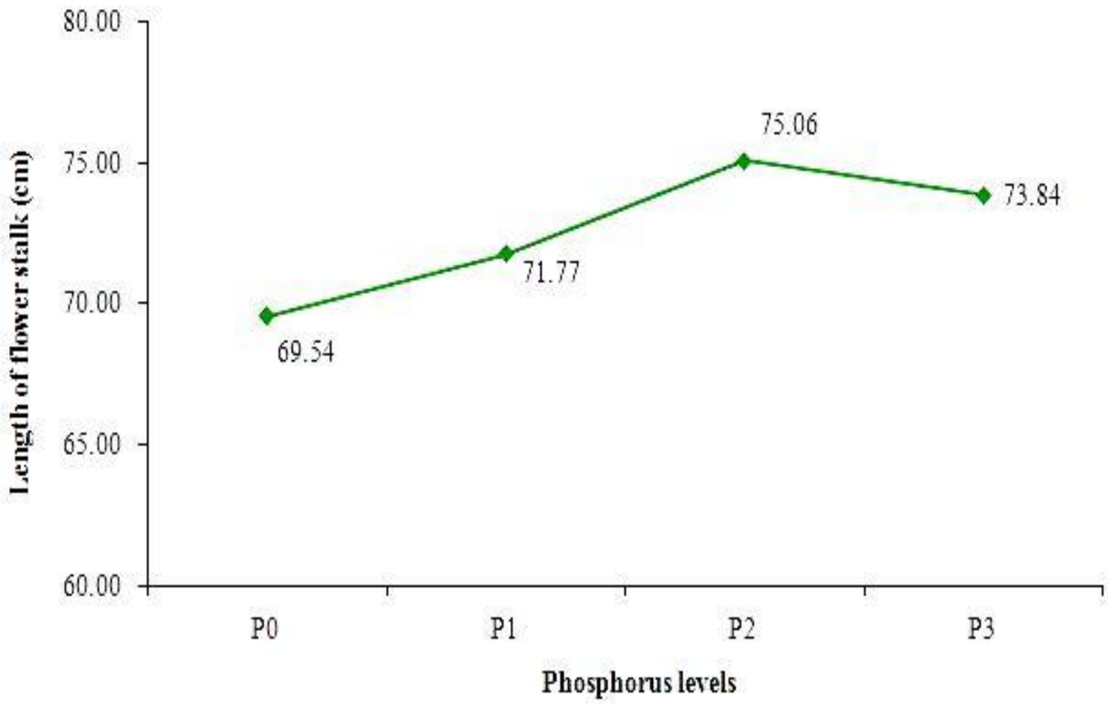
P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 $ha^{-1;}$ P_2= 140 kg P_2O_5 $ha^{-1;}$ P_3= 160 kg P_2O_5 ha^{-1}

Fig. 4.7. Effect of phosphorus on percentage of flowering



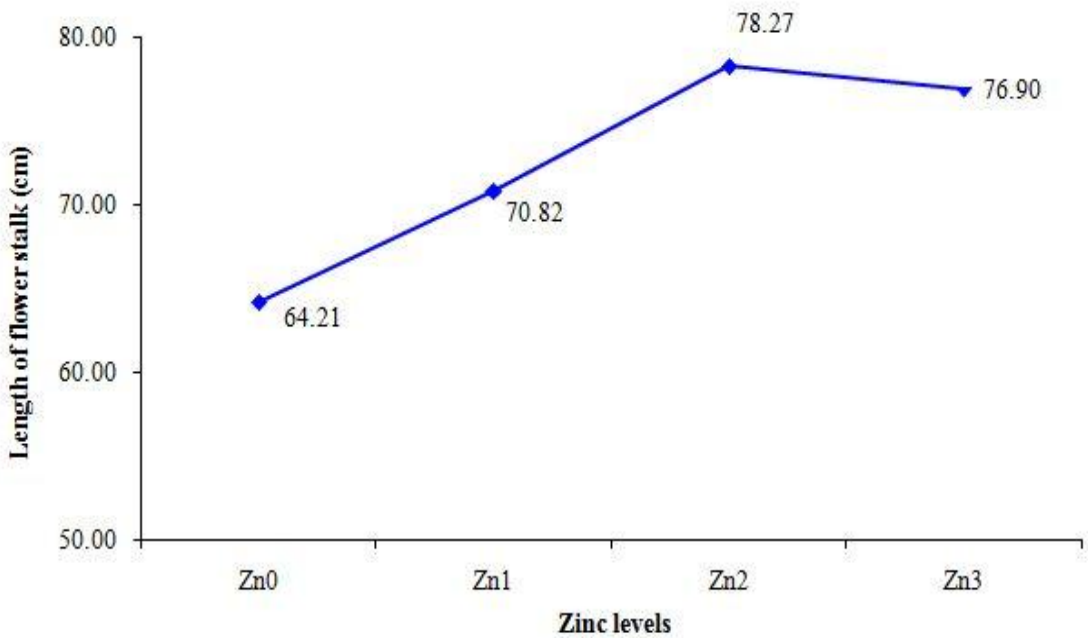
Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

Fig. 4.8. Effect of zinc on percentage of flowering



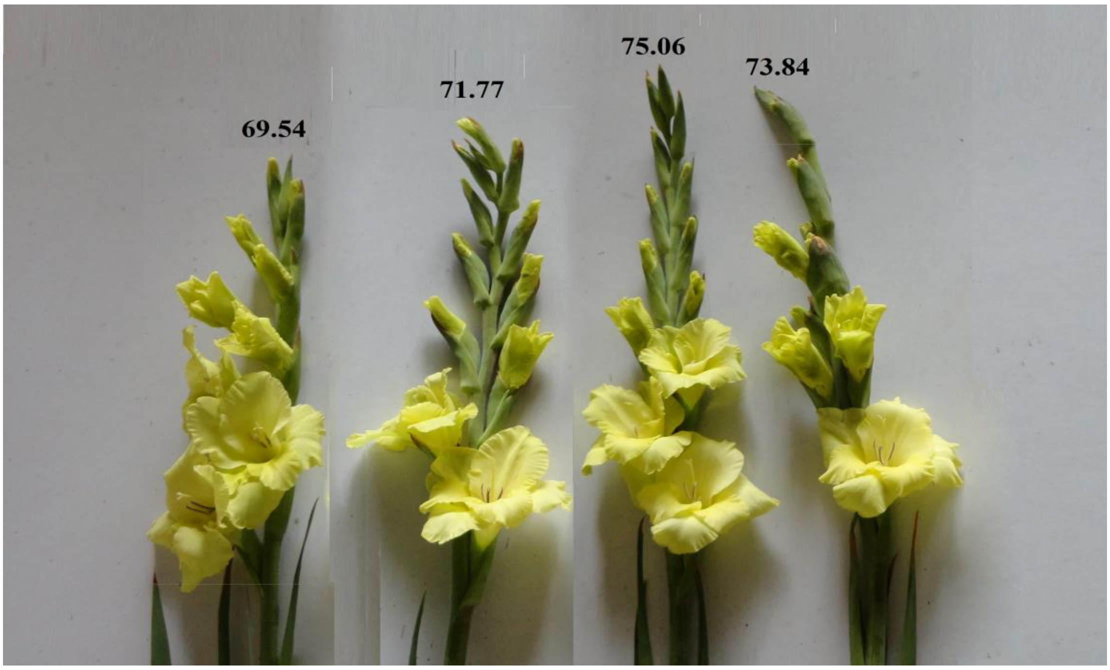
P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 ha$^{-1;}$ P_2= 140 kg P_2O_5 ha$^{-1;}$ P_3= 160 kg P_2O_5 ha^{-1}

Fig. 4.9. Effect of phosphorus on length of flower stalk



Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

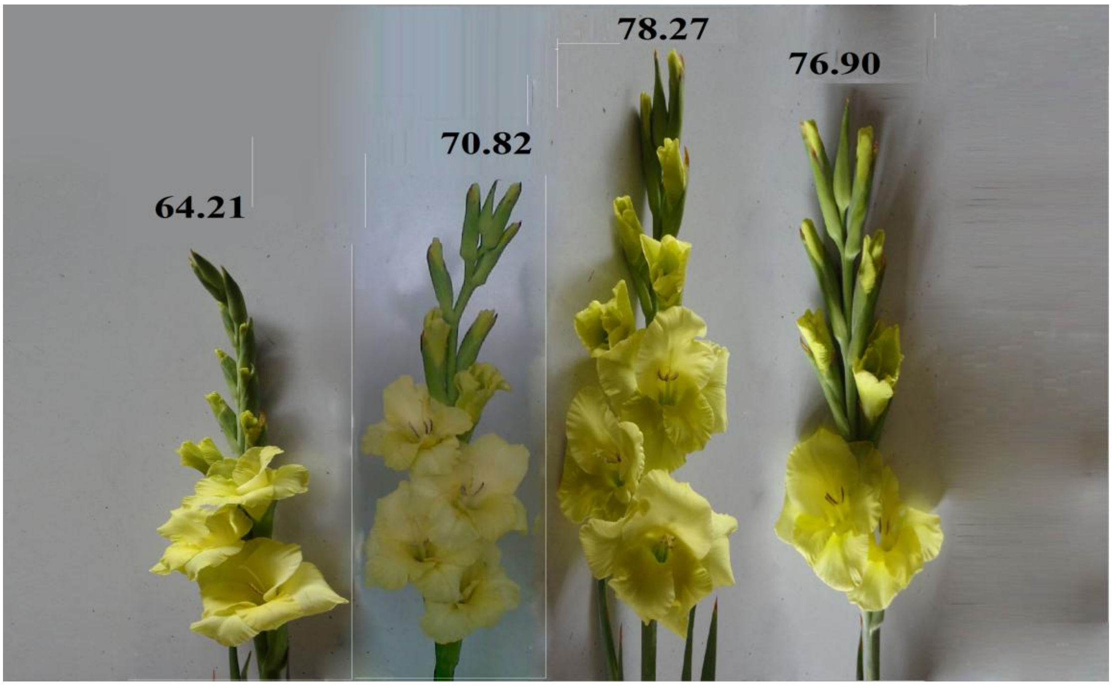
Fig. 4.10. Effect of zinc on length of flower stalk



P_0 P_1 P_2 P_3

P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 ha^{-1}; P_2= 140 kg P_2O_5 ha^{-1}; P_3= 160 kg P_2O_5 ha^{-1}

Plate 2: Effect of phosphorus on length of flower stalk



Zn_0 Zn_1 Zn_2 Zn_3

Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

Plate 3: Effect of zinc on length of flower stalk

The effect of zinc showed significant variation for length of flower stalk where2.0 kg Zn recorded the longest flower stalk (78.27 cm) and without zinc obtained the shortest flower stalk (64.21 cm) (Appendix IV and Fig. 4.10). Similarly, Sharma *et al*. (2013) also found significant variation in length of flower stalk due to zinc.

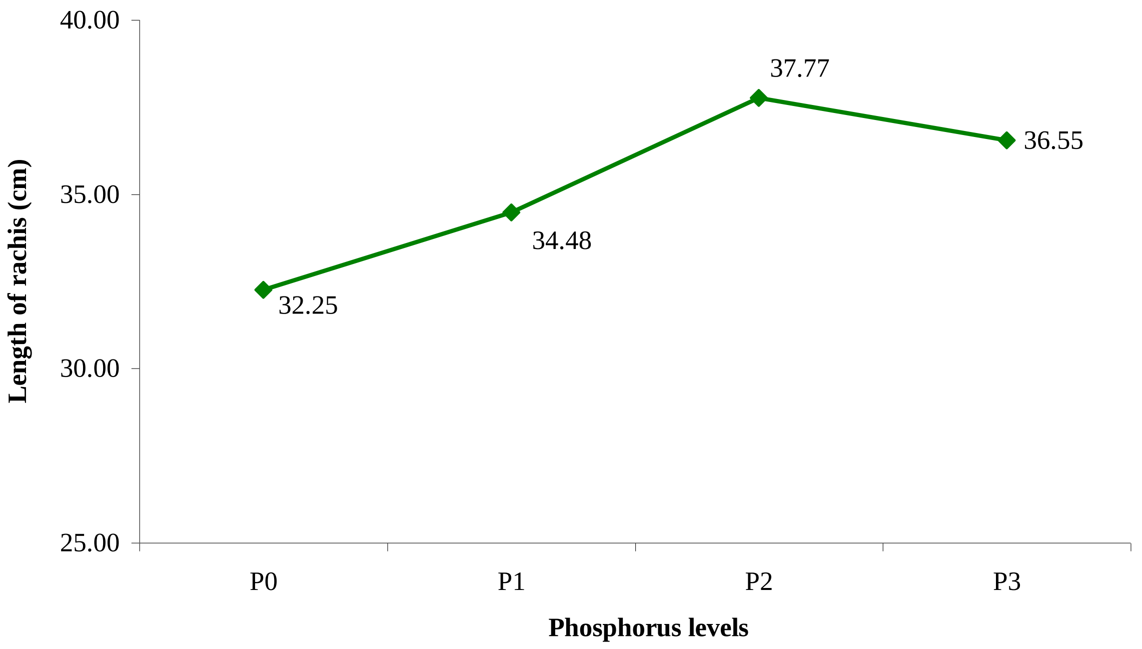
All the interaction treatment of phosphorus and zinc produced statistically same length of flower stalk due to their non significant variation (Appendix IV and Table 4.1).

4.2.4 Length of rachis

The effect of P on length of rachis at harvest was found to be significant where 140 kg P_2O_5 ha^{-1} showed the longest rachis (37.77 cm) while without phosphorus found to be the shortest rachis (32.25 cm) (Appendix IV and Fig. 4.11). Probably, phosphorus helps to make available other nutrients elements of soil which also ensures the advance growth of gladiolus plant as well as the longest rachis. The finding of the present study was agreed by the research work of Hossain (2008). He also found that the maximum length of rachis was in 140 kg P_2O_5 ha^{-1} and minimum in 0 kg. Naznin *et al*. (2014); Reddy *et al*. (2009) and many other scientists also found more or less similar result with the present study.

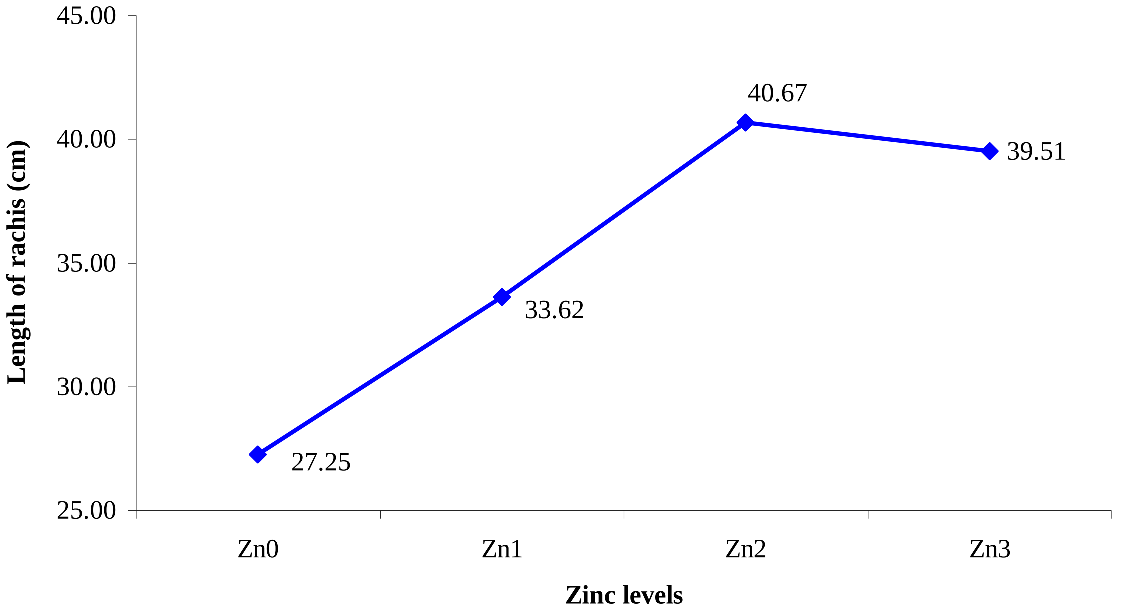
The length of rachis was significantly influenced by the effect of zinc (Appendix IV). The longest rachis (40.67 cm) was recorded in 2.0 kg Zn while shortest rachis (27.25 cm) was in control (Fig. 4.12). Length of rachis was also found to be the significant variation in the research findings of Amin *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.

Interaction effect of phosphorus and zinc was significantly influenced the length of flower stalk (Appendix IV). The length of rachis was the highest (43.41 cm) in interactions of 140 kg P_2O_5 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 4.1).



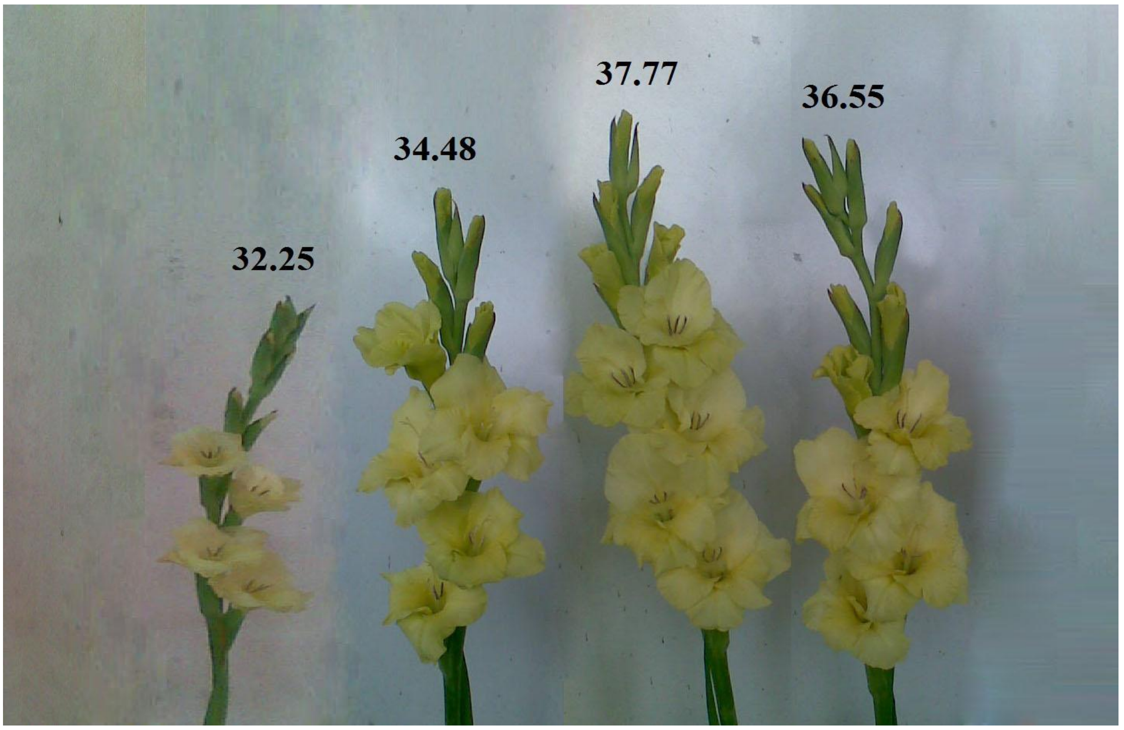
P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 $ha^{-1;}$ P_2= 140 kg P_2O_5 $ha^{-1;}$ P_3= 160 kg P_2O_5 ha^{-1}

Fig. 4.11. Effect of phosphorus on length of rachis



Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

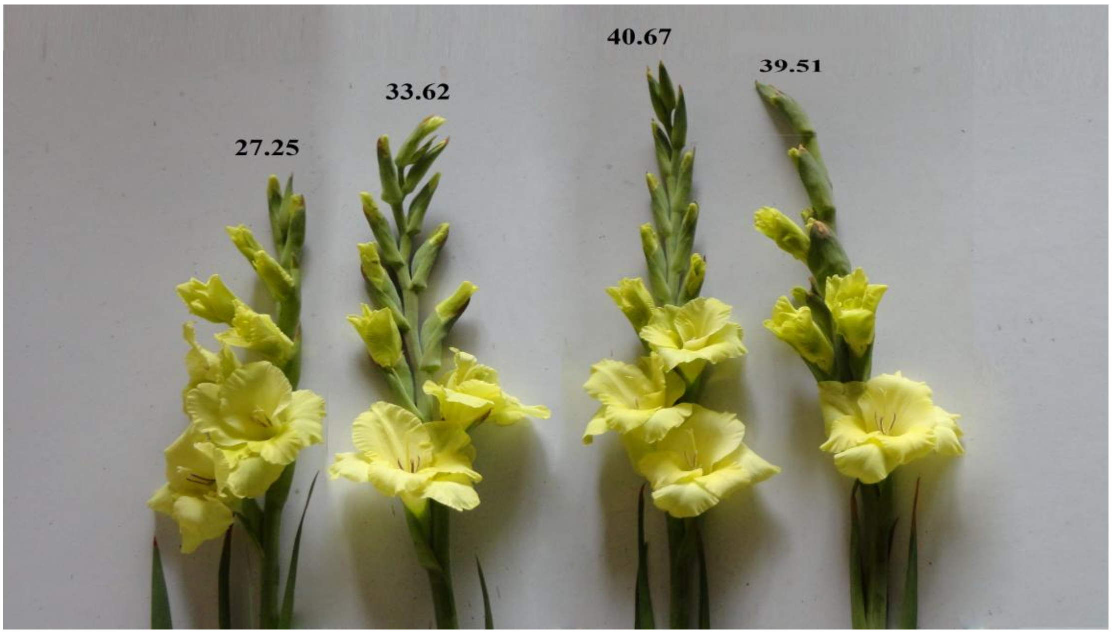
Fig. 4.12. Effect of zinc on length of rachis



P_0 P_1 P_2 P_3

P_0= 0 kg P_2O_5 ha^{-1} (control); P_1= 120 kg P_2O_5 $ha^{-1;}$ P_2= 140 kg P_2O_5 $ha^{-1;}$ P_3= 160 kg P_2O_5 ha^{-1}

Plate 4: Effect of phosphorus on length of rachis



Zn_0 Zn_1 Zn_2 Zn_3

Zn_0= 0 kg Zn ha^{-1} (Control); Zn_1= 1 kg Zn ha^{-1}; Zn_2= 2 kg Zn ha^{-1}; Zn_3= 3 kg Zn ha^{-1}

Plate 5: Effect of zinc on length of rachis

4.2.5 Number of spikelets spike^{-1}

There was a significant variation on number of spikelets spike^{-1} due to the effect of phosphorus at harvest (Appendix V). The maximum number of spikelets spike^{-1} (17.43) was found in 140 kg P_2O_5 ha^{-1} and the minimum number of spikelets spike^{-1} (13.55) was obtained in control (Table 4.2). Significant variation for number of spikelets spike^{-1} due to P levels were also obtained by Hossain (2008) who also found more spikelet in 140 kg P_2O_5 ha^{-1} and the lowest in 0 kg P_2O_5 ha^{-1} .

The effect of zinc had significant influence on the number of spikelets spike^{-1} (Appendix V). The spikelets spike^{-1} had maximum (18.17) in 2.0 kg Zn ha^{-1} and minimum (11.88) in without Zn (Table 4.3). 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} while many of them were found more significant result in 3 kg ha^{-1}.

Interaction effect of P and Zn on the number of spikelets spike^{-1} was significant (Appendix V). The number of spikelets spike^{-1} had maximum (20.29) in 140 kg P_2O_5 ha^{-1} with 2.0 kg Zn ha^{-1} and minimum (10.81) in while without P_2O_5 and Zn (Table 4.4).

4.2.6 Number of spikes plot^{-1} and ha^{-1}

There was significant variation due to the effect of Phosphorus on number of spikes plot^{-1} and '000' ha^{-1} (Appendix V). The maximum number of spikes (24.92 plot^{-1} and 249300ha^{-1}) was produced from 140 kg P_2O_5 ha^{-1} while without P_2O_5 showed minimum number of spikes (20.89 plot^{-1} and 208.90 '000' ha^{-1}) (Table 4.2). 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 P_2O_5 ha^{-1} and minimum in P_0.

Table 4.2 Effect of phosphorus on number of spikelets and spike, thickness and diameter of both corm and cormel, weight of individual corm and cormel, yield of corm and cormel at harvest

P (kg ha^{-1})	No. of spikelet $spike^{-1}$	No. of spike $plot^{-1}$	No. of spike ha^{-1} (000)	Thickness of corm (cm)	Diameter of corm (cm)	Weight of individual corm (g)	Yield of corm (kg $plot^{-1}$)	Yield of corm (t ha^{-1})	No. of cormel $plant^{-1}$	Diameter of cormel (cm)	Wight of individual cormel (g)	Yield of cormel (kg $plot^{-1}$)	Yield of cormel (t ha^{-1})
0	13.55 d	20.89 d	208.9 d	6.133 d	1.628 d	25.99 d	1.657 d	16.57 c	19.79 d	1.408 d	12.33 d	0.962 d	9.617 d
120	15.37 c	22.92 c	229.3 c	6.582 c	1.929 c	28.46 c	1.778 c	17.77 b	21.39 c	1.709 c	13.19 c	1.073 c	10.73 c
140	17.43 a	24.92 a	249.3 a	7.455 a	2.186 a	30.37 a	1.892 a	18.92 a	24.07 a	1.966 a	14.92 a	1.185 a	11.85 a
160	15.97 b	24.08 b	240.8 b	7.043 b	2.067 b	29.41 b	1.840 b	18.40 a	23.48 b	1.847 b	14.05 b	1.138 b	11.38 b
$LSD_{(0.05)}$	**0.3229**	**0.6825**	**6.824**	**0.05273**	**0.02637**	**0.7259**	0.02637	**0.5679**	**0.5213**	0.02637	**0.3596**	0.02637	**0.1344**
CV (%)	**2.48**	**3.53**	**3.53**	**0.92**	**0.93**	**3.05**	**0.61**	**3.8**	**2.82**	**1.04**	**3.16**	**1.71**	**1.49**
SX	**0.1118**	**0.2363**	**2.363**	**0.01826**	**0.00913**	**0.2513**	**0.009129**	**0.1966**	**0.1805**	**0.00913**	**0.1245**	**0.00913**	**0.04655**

Table 4.3 Effect of zinc on number of spikelets and spike, thickness and diameter of both corm and cormel, weight of individual corm and cormel, yield of corm and cormel at harvest

Zn (kg ha^{-1})	No. of spikelet $spike^{-1}$	No. of spike $plot^{-1}$	No. of spike ha^{-1} (000)	Thickness of corm (cm)	Diameter of corm (cm)	Weight of individual corm (g)	Yield of corm (kg $plot^{-1}$)	Yield of corm (t ha^{-1})	No. of cormel $plant^{-1}$	Diameter of cormel (cm)	Wight of individual cormel (g)	Yield of cormel (kg $plot^{-1}$)	Yield of cormel (t ha^{-1})
0	11.88 d	20.12 c	201.2 c	6.222 d	1.563 d	25.33 d	1.579 d	15.79 d	18.87 d	1.342 d	11.66 d	0.936 d	9.358 d
1	14.89 c	23.01 b	230.1 b	6.574 c	1.741 c	27.67 c	1.727 c	17.27 c	20.79 c	1.521 c	13.26 c	1.049 c	10.48 c
2	18.17 a	25.15 a	251.5 a	7.474 a	2.445 a	31.04 a	1.964 a	19.64 a	24.95 a	2.225 a	15.07 a	1.214 a	12.14 a
3	17.39 b	24.54 a	245.4 a	6.943 b	2.062 b	30.19 b	1.895 b	18.95 b	24.12 b	1.842 b	14.50 b	1.158 b	11.58 b
$LSD_{(0.05)}$	**0.3229**	**0.6825**	**6.824**	**0.05273**	**0.02637**	**0.7259**	0.02637	**0.5679**	**0.5213**	0.02637	**0.3596**	0.02637	**0.1344**
CV (%)	**2.48**	**3.53**	**3.53**	**0.92**	**0.93**	**3.05**	**0.61**	**3.8**	**2.82**	**1.04**	**3.16**	**1.71**	**1.49**
SX	**0.1118**	**0.2363**	**2.363**	**0.01826**	**0.00913**	**0.2513**	**0.009129**	**0.1966**	**0.1805**	**0.00913**	**0.1245**	**0.00913**	**0.04655**

Zinc application also significantly influenced the number of spike plot^{-1} and '000' ha^{-1} (Appendix IV). The maximum number of spikes (25.15 plot^{-1} and 251500 ha^{-1}) was recorded in 2.0 kg Zn ha^{-1} while minimum number of spikes (20.12 plot^{-1} and 201200 ha^{-1}) was found in without Zn (Table 4.3). 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 plot^{-1} and hectare^{-1} while the maximum was obtained from 3 kg Zn ha^{-1} and minimum from Z_0. The findings of the present study were also similar to Sharma *et al*. (2013).

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} (Appendix V and Table 4.4).

4.2.7 Thickness of corm

Corm thickness was significantly influenced by the effect of phosphorus at harvest (Appendix V). 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 4.2). Hossain (2008) reported that the 140 kg P_2O_5 ha^{-1} showed the highest thickness of corm and 0 kg P_2O_5 ha^{-1} observed the lowest thickness while 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) (Appendix V and Table 4.3). Zinc @ 2 kg ha^{-1} had highly effective for better vegetative and reproductive growth of Gladiolus plant which ultimately produced the maximum thickness of corm. Similarly, Amin *et al*. (2014) also found significant variation in individual corm thickness due Zinc application where it was the maximum in 3.0 kg Zn ha^{-1} and minimum in Z_0 while Halder *et al*. (2007c) agreed the present result.

Table 4.4 Interaction effect of phosphorus and zinc on number of spikelets and spike, thickness and diameter of both corm and cormel, weight of individual corm and cormel, yield of corm and cormel at harvest

P (kg ha^{-1})	Zn (kg ha^{-1})	No. of spikelet spke^{-1}	No. of spike plot^{-1}	No. of spike ha^{-1} (000)	Thickness of corm (cm)	Diameter of corm (cm)	Weight of individual corm (g)	Yield of corm (kg plot^{-1})	Yield of corm (t ha^{-1})	No. of cormel plant^{-1}	Diameter of cormel (cm)	Wight of individual cormel (g)	Yield of cormel (kg plot^{-1})	Yield of cormel (t ha^{-1})
0	0	10.81 k	18.50 i	195.0 i	5.733 j	1.420 l	23.92 j	1.480 j	14.80 j	17.63 i	1.200 l	11.11 i	0.837 h	8.367 j
	1	12.12 i	20.13 h	201.3 h	5.977 i	1.503 k	25.27 ij	1.603 hi	16.03 hi	18.83 gh	1.283 k	12.06 gh	0.937 g	9.367 i
	2	16.39 e	22.83 e	228.3 e	6.637 f	1.887 g	27.62 fg	1.823 d	18.23 def	22.10 de	1.667 g	13.20 ef	1.067 de	10.67 f
	3	14.89 g	22.10 efg	221.0 efg	6.187 h	1.703 ij	27.15 fgh	1.720 ef	17.20 fgh	20.60 f	1.483 ij	12.97 f	1.007 f	10.07 g
120	0	11.46 j	19.93 h	199.3 h	6.000 i	1.490 k	24.99 ij	1.560 i	15.60 ij	18.40 hi	1.270 k	11.46 hi	0.920 g	9.200 i
	1	14.86 g	22.43 ef	224.3 ef	6.240 h	1.737 i	27.94 efg	1.680 fg	16.80 ghi	19.70 fg	1.517 i	12.77 fg	1.020 ef	10.17 g
	2	17.79 bc	24.93 cd	249.3 cd	7.210 c	2.453 c	30.78 c	1.980 b	19.80 abc	24.13 b	2.233 c	14.59 cd	1.203 b	12.03 c
	3	17.39 cd	24.40 d	244.0 d	6.877 e	2.037 f	30.14 cd	1.890 c	18.90 bcd	23.33 bc	1.817 f	13.92 de	1.150 bc	11.50 d
140	0	12.89 h	21.23 fgh	212.3 fgh	6.783 e	1.650 j	26.49 ghi	1.657 gh	16.57 ghi	20.27 f	1.430 j	12.11 gh	1.017 ef	10.17 g
	1	16.86 de	25.17 bcd	251.7 bcd	7.040 d	1.903 g	29.20 de	1.860 cd	18.60 cde	22.90 cd	1.683 g	14.76 c	1.130 c	11.30 de
	2	20.29 a	26.83 a	268.3 a	8.170 a	2.837 a	33.33 a	2.040 a	20.40 a	26.93 a	2.617 a	16.71 a	1.320 a	13.20 a
	3	19.69 a	26.47 ab	264.7 ab	7.827 b	2.353 d	32.46 ab	2.010 ab	20.10 ab	26.17 a	2.133 d	16.11 ab	1.273 a	12.73 b
160	0	12.36 hi	20.80 gh	208.0 gh	6.373 g	1.690 ij	25.92 hi	1.620 h	16.20 hi	19.17 gh	1.470 ij	11.97 h	0.970 fg	9.700 h
	1	15.72 f	24.30 d	243.0 d	7.040 d	1.820 h	28.28 ef	1.767 e	17.67 efg	21.73 e	1.600 h	13.45 ef	1.110 cd	11.10 e
	2	18.19 b	26.00 abc	260.0 abc	7.880 b	2.603 b	32.44 ab	2.013 ab	20.13 ab	26.63 a	2.383 b	15.79 b	1.267 a	12.67 b
	3	17.59 bc	25.20 bcd	252.0 bcd	6.880 e	2.153 e	31.01 bc	1.960 b	19.60 abc	26.37 a	1.933 e	14.99 c	1.203 b	12.03 c
$LSD_{(0.05)}$		**0.6458**	**1.365**	**13.65**	**0.1055**	**0.05273**	**1.452**	**0.05273**	**1.136**	**1.043**	**0.05273**	**0.7192**	**0.05273**	**0.2689**
CV (%)		**2.48**	**3.53**	**3.53**	**0.92**	**0.93**	**3.05**	**0.61**	**3.8**	**2.82**	**1.04**	**3.16**	**1.71**	**1.49**
SX		**0.2236**	**0.4726**	**4.725**	**0.03651**	**0.01826**	**0.5027**	**0.01826**	**0.3933**	**0.361**	**0.01826**	**0.249**	**0.01826**	**0.09309**

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 (Appendix V and Table 4.4).

4.2.8 Diameter of corm

Diameter of corm was also highest in 140 kg P_2O_5 ha^{-1} which might be due to the proper vegetative growth of plant and earlier emergence of spike enhances the diameter of corm. Besides, 140 kg P_2O_5 ha^{-1} make sure the appropriate nutrient of soil and favourable condition which help the proper growth of corm. 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 and control treatment recorded the lowest 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.

Phosphorus application showed significant variation for diameter of corm where diameter of corm was the highest (2.19 cm) in 140 kg P_2O_5 ha^{-1} and lowest (1.63 cm) in 0 kg P2O5 ha^{-1}. Diameter of corm was highest in 140 kg P_2O_5 ha^{-1} incase of the 140 kg P_2O_5 ha^{-1} ensure the proper vegetative growth of plant and earlier emergence of spike which enhances the diameter of corm. Besides, 140 kg P_2O_5 ha^{-1} make sure the appropriate nutrient of soil and favourable condition which help the proper growth of corm. 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 and control treatment recorded the lowest thickness compare other higher and lower levels of P.

The data on diameter of corm was statistically significant among the various levels of zinc where diameter of corm was the highest (2.45 cm) in 2.0 kg Zn ha^{-1} and the lowest (163 cm) in control (Appendix V and Table 4.3). 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 by Zn while Singh *et al.* (2000) also found significant variation regarding corm diameter.

Appendix V revealed significant variation on diameter of corm due to interaction effect (Appendix V). 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 the it was the lowest (1.42 cm) in without P_2O_5 and Zn (control) (Table 4.4).

4.2.9 Weight of individual corm

A significant variation on weight of individual corm was found due to the effect of Phosphorus (Appendix V). Weight of individual corm was the highest (30.37 g) in 140 kg P_2O_5 ha^{-1} while the lowest (25.99 g) was in control treatment (Table 4.2). This result revealed that the 140 kg P_2O_5 ha^{-1} ensure the higher growth of corm as well as the bigger corm compared to control and other levels due to more energy is stored in the corms and they look healthier and stronger. Such the same report was also obtained by Shaukat *et al.*, 2012. Similarly, Hossain *et al.* (2011); Hossain (2008) found that @ 140 kg P_2O_5 ha^{-1} was the best for producing the heavier sizes corm which was fully agreed the present result.

There was a significant variation due to zinc for weight of individual corm (Appendix V). Zinc @ 2.0 kg ha^{-1} recorded the highest weight of individual corm (31.04 g) while the lowest weight of individual corm (23.33 g) was found in control treatment (Table 4.3). Result revealed that the 2.0 kg Zn ha^{-1} produced the larger corm compare to other levels of zinc which might be due to the better vegetative and reproductive growth of plant as well as the longest and widest corm. Besides, soil nutrient are highly accumulated by this level which ultimately ensured the longest and widest corm. Similarly, Amin *et al.* (2014) also found significant effect on individual corm weight where 3 kg Zn ha^{-1} was the best while same results were also found by Halder *et al.* (2007c).

A non significant variation due to interaction effect of phosphorus and zinc was found for weight of individual corm at harvest which indicated that there was no variation among the whole interaction treatments (Appendix V and Table 4.4).

4.2.10 Yield of corm (kg plot^{-1} and t ha^{-1})

Phosphorus application also significantly influenced the yield of corm (kg plot^{-1} and t ha^{-1}) (Appendix V). Among the phosphorus levels, 140 kg P_2O_5 ha^{-1} produced the highest yield of corm (1.89 kg plot^{-1} and 18.92 t ha^{-1}) while without P obtained the lowest yield of corm (1.66 kg plot^{-1} and 16.57 t ha^{-1}) (Table 4.2). Higher yield of corm was produced by the application of 140 kg P_2O_5 ha^{-1} which might be due to the higher vegetative growth, longest floret, longest rachis, more number of spikelets and spikes, and healthier corm were produced. Similarly, Hossain *et al*. (2011) and Hossain (2008) also found highest yield of corm in 140 kg P_20_5 ha^{-1} Similar result was also obtained by Chandana and Dorajeerao (2014); Naznin *et al*. (2014) and many other scientists of the home and abroad.

A significant variation due to the effect of zinc was also found on corm yield (kg plot^{-1} and t ha^{-1}) at harvest (Appendix V). The production of corm had highest (1.96 plot^{-1} and 19.64 t ha^{-1}) in 2.0 kg Zn ha^{-1} while control treatment observed the lowest yield of corm (1.58 plot^{-1} and 15.79 t ha^{-1}) (Table 4.3). 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) and Halder *et al*. (2007a, 2007b and 2007c) also found similar results.

Yield of corm kg plot^{-1} was significantly influenced by the interaction effect of phosphorus and zinc at harvest but corm yield t ha^{-1} did not vary significant (Appendix V). In case of corm yield kg plot^{-1}, interaction treatment of 140 kg P_2O_5 ha^{-1} × 2.0 kg Zn ha^{-1} produced the highest yield of corm (2.04 kg plot^{-1}) while the lowest yield of corm (1.48 kg plot^{-1}) was in both 0 kg of P_20_5 and Zn ha^{-1} (Table 4.4).

4.2.11 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 P_2O_5 ha^{-1} and the minimum (19.79) in without P_2O_5 (Table 4.2). With the increasing levels of phosphorus up to 140 kg ha^{-1} will be produced more cormels because phosphorus plays very important role in vegetative and reproductive growth of plant which ultimately producing the more cormels. Shaukat *et al*. (2012) also found similar result with the present study. The above findings of the present study was also similar to the study of Hossain *et al*. (2011) and Hossain (2008) while this findings were also agreed to the findings of Iftikhar *et al*. (2013);; Kumar *et al*. (2006).

Effect of zinc was also statistically significant on number of cormels plant^{-1} (Appendix V). 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). Number of cormels plant^{-1} also varied significantly due to the effect of zinc reported by Amin *et al*. (2014); Memon *et al*. (2013); Halder *et al*. (2007a, 2007b and 2007c) and many other researchers where 2 kg Zn ha^{-1} was the best.

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 P_2O_5 ha^{-1} and 2.0 kg Zn ha^{-1} while without phosphorus and zinc showed the minimum number of cormels (17.63) (Appendix V and Table 4.4).

4.2.12 Diameter of cormel

Diameter of cormel was significantly influenced by the effect of phosphorus where the highest diameter of cormel (1.97 cm) was found in 140 kg P_20_5 ha^{-1} and lowest (1.41 cm) in control (Table 4.2). These results revealed that increasing levels of phosphorus up to 140 kg P_20_5 ha^{-1} increased the diameter of cormel and thereafter decreased at 160 kg ha^{-1} Hossain (2008) found similar findings.

A significant variation due to the effect of zinc was found on diameter of cormel at harvest (Appendix V). Table 4.3 revealed that the diameter of cormel was the highest (2.23 cm) in 2.0 kg Zn ha^{-1} and the lowest (1.34) in control (without zinc) treatment (Table 4.3). From the above result it was found that the 2.0 kg Zn ha^{-1} showed higher vegetative and reproductive growth which ultimately produced the more cormels while Amin *et al*. (2014); Halder *et al*. (2007a, b and c) also showed similar results.

Significant variation also found for diameter of cormel due to interaction effect where the highest diameter of cormel (2.62 cm) was produced from the interaction effect of 140 kg P_2O_5 ha^{-1} and 2.0 kg Zn ha^{-1} while it was the lowest (1.20 cm) in interaction of both control (Table 4.4).

4.2.13 Weight of individual cormel

Weight of individual cormel varied significantly due to the effect of phosphorus (Appendix V). The highest weight of individual cormel (14.92 g) was obtained from 140 kg P_2O_5 ha^{-1} while the lowest weight of individual cormel (12.33 g) was found in control treatment (Table 4.2). Increasing levels of phosphorus up to 140 kg ha^{-1} ensure the better vegetative and reproduction growth of gladiolus including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant compare to control and other doses of phosphorus. Similarly, Shaukat *et al*. (2012) also found similar result in 160 kg P_20_5 ha^{-1} while Hossain *et al*. (2011) and Hossain (2008) found better result in 140 kg P_20_5 ha^{-1} compare to its higher and lower doses of phosphorus which ultimately supported the present findings.

Weight of individual cormel at harvest found to be the significant variation due to the effect of zinc (Appendix V). Among the zinc levels, 2.0 kg Zn ha^{-1} showed significantly the highest weight of individual cormel (15.07 g) while the lowest weight of individual cormel (11.66 g) was recorded in control treatment (Table 4.3). Weight of individual cormel varied significantly were also reported by the many researchers (Reddy *et al*., 2014; Amin *et al*., 2014; Reddy and Rao; 2012; Halder *et al*., 2007 a, b and c).

Weight of individual cormel at harvest showed significant variation due to the interaction effect of phosphorus and zinc (Appendix V). P_2O_5 @ 140 kg ha^{-1} along with 2.0 kg Zn ha^{-1} produced significantly the highest weight of individual cormel (16.71 g) while weight of individual cormel was the lowest (11.11 g) in without phosphorus and zinc which was significantly differed from other all interactions (Table 4.4).

4.2.14 Yield of cormel (kg $plot^{-1}$ and t ha^{-1})

Cormel yield of both kg $plot^{-1}$ and t ha^{-1} of the present study was statistically influenced by the effect of Phosphorus (Appendix V). Yield of cormel was the highest (1.19 kg $plot^{-1}$ and 11.85 t ha^{-1}) in 140 kg P_2O_5 ha^{-1} while without phosphorus obtained the lowest yield of cormel (0.96 kg $plot^{-1}$ and 9.62 t ha^{-1}) (Table 4.2). These results revealed that the 140 kg P_2O_5 ha^{-1} was the best for getting the higher production of cormel than that of other levels of phosphorus which might be due to the better performance were found regarding vegetative and reproductive growth. 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 P_20_5 ha^{-1} regarding cormel yield.

Effect of zinc was also found to be the significant variation on the production of cormel of both kg $plot^{-1}$ and t ha^{-1} at harvest (Appendix V). The yield of cormel was the highest (1.51 $plot^{-1}$ and 12.14 t ha^{-1}) in 2.0 kg Zn ha^{-1} while without phosphorus and Zn showed the lowest yield of cormel (0.94 $plot^{-1}$ and 9.36 t ha^{-1}) (Table 4.3). Yield of cormel was the highest in 2.0 kg Zn ha^{-1} in this study might be due to the treatment also produced tallest plant, longest flower stalk, longest rachis, longest spike, highest number and diameter of cormel and larger cormel which confirmed the higher yield of cormel. Such the same results were also obtained by Amin *et al*. (2014); Maurya and Kumar

(2014), Fahad *et al*. (2014), Reddy and Rao (20120, Halder *et al*. (2007, 2007a, b and c) and many researchers of the home and abroad.

Both types (kg $plot^{-1}$ and t ha^{-1}) of cormel yield were statistically significant among interaction effect of phosphorus and zinc at harvest (Appendix V). The highest yield of cormel (1.32 kg $plot^{-1}$ and 13.20 t ha^{-1}) was produced from the interaction treatments of 140 kg P_2O_5 ha^{-1} × 2.0 kg Zn ha^{-1}. Similarly, the lowest yield of cormel (0.84 kg $plot^{-1}$ and 8.37 t ha^{-1}) was produced from the control treatment (both P_2O_5 and Zn 0 kg ha^{-1}) (Table 4.4).

CHAPTER 5
SUMMARY AND CONCLUSION

The present research work was conducted at the Horticulture Farm, Sher–E–Bangla Agricultural University (SAU), Dhaka–1207 during the period from November 2013 to March 2014 to find out the influence of different levels of phosphorus and zinc on growth, flowering, corm and cormel production of gladiolus. The experiment is consisted with two factors. Factor A: Four levels of phosphorus i.e. P_0: 0 kg P_20_5 ha^{-1}, P_1: 120 kg P_20_5 ha^{-1}, P_2: 140 kg P_20_5 ha^{-1} and P_3: 160 kg P_20_5 ha^{-1} and Factor B: Four levels of zinc as Zn_0: 0 kg Zn ha^{-1}, Zn_1: 1 kg Zn ha^{-1}, Zn_2: 2 kg Zn ha^{-1} and Zn_3: 3 kg Zn ha^{-1}. There were on the whole 16 treatments combination. The experiment was laid out in a factorial (two factors) Randomized Complete Block Design (RCBD) with three replications. Data were collected on growth characters, yield contributing characters and yield of gladiolus.

Analysis of variance data revealed that all the studied growth, yield (flowering as corm and cormel production) and yield contributing characters, and vase life of Gladiolus varied significantly at 1% level of probability due to the singly effect of Phosphorus and zinc. Similarly, interaction effect of phosphorus and zinc was also significantly influenced the most of the studied characters while plant height at 40 DAP, days to 80 emergence of spike, flowering percentage, length of flower stalk, number of spike $plot^{-1}$ and ha^{-1}, weight of individual corm and yield of corm (t ha^{-1}) did not vary significant due to interaction effect.

In case of the application of phosphorus, application of 140 kg P_2O_5 recorded the tallest plant (74.88 cm), more leaves $plant^{-1}$, highest flowering (95.69%), spikelets $spike^{-1}$, spikes $plot^{-1}$ and ha^{-1} and cormels $plant^{-1}$ (11.32, 17.43, 24.92, 249.30 and 24.07, respectively), longest flower stalk and rachis (75.06 and 37.77 cm, respectively), maximum thickness of corm, highest diameter of corm and cormel (7.46, 2.19 and 1.97 cm, respectively), highest weight of individual corm and cormel (30.37 and 14.92 g, respectively), yield of corm and cormel of kg $plot^{-1}$ (1.89 and 1.19, respectively) and t ha^{-1} (18.92 and 11.85, respectively) and longest vase life of spike (8.12 days) than that of other highest and lowest levels of phosphorus while control or without phosphorus obtained the poorer effect among the above whole characters of the study (71.17 cm, 9.58 plant^{-1}, 91.81%, 13.55 spike^{-1}, 20.89 plot^{-1}, 208.90 ha^{-1}, 19.79 cm, 69.54 cm, 32.25 cm, 6.13 cm, 1.63 cm, 1.41 cm, 25.99 g, 12.33 g, 1.66 kg plot^{-1}, 0.96 kg plot^{-1}, 16.57 t ha^{-1}, 9.62 t ha^{-1} and 6.50 days, respectively). Among other observation of the study, it was found that the control (0 kg P_2O_5 ha^{-1}) treatment requiring more days for 80% emergence of spike (87.52 days) while 140 kg P_2O_5 ha^{-1} showed minimum time for 80% emergence of spike (85.55 days).

In case of zinc application, tallest plant (83.97 cm), maximum leaves (11.75 plant^{-1}), highest flowering (96.68%), more number of spikelets spike^{-1}, spikes plot^{-1} and ha^{-1} and cormels plant^{-1} (18.17, 25.15, 251.50 and 24.95, respectively) were obtained in 2.0 kg Zn ha^{-1} while control or without Zinc (0 kg Zn ha^{-1}) recorded the shortest plant (64.57 cm), minimum leaves (9.46 plant^{-1}), lowest flowering (89.52%), minimum number of spikelets spike^{-1}, spikes plot^{-1} and ha^{-1}, cormels plant^{-1} (11.88, 20.12, 201.20 and 18.87, respectively). Similarly, longest flower stalk and rachis (78.27 and 40.67 cm, respectively), maximum thickness of corm, highest diameter of corm and cormel (7.47, 2.45 and 2.23 cm, respectively) were also recorded in 2.0 kg Zn ha^{-1} and shortest flower stalk and rachis (64.21 and 27.25 cm, respectively), minimum thickness of corm, lowest diameter of corm and cormel (6.22, 1.56 and 1.34 cm, respectively) were found in without zinc treatment. Among other characters of the study, the highest weight of individual corm and cormel (31.04 and 15.07 g, respectively), highest yield of corm and cormel of kg plot^{-1} (1.96 and 1.21, respectively) and t ha^{-1} (19.64 and 12.14, respectively) and the longest vase life of spike (8.85 days) were produced from 2.0 kg Zn ha^{-1} while without zinc shoewd the poorer effect on weight of individual corm and cormel (25.33 and 11.66 g, respectively), yield of corm and cormel of kg plot^{-1} (1.58 and 0.94, respectively) and t ha^{-1} (15.79 and 9.36, respectively) and vase life of spike (6.63 days). Requiring days required for 80% emergence of spike was highest (88.94 days) in 0 kg Zn ha^{-1} and lowest (84.47 days) in 2.0 kg Zn ha^{-1}.

In case of interaction effect, tallest plant (85.92 cm) and mores leaves (12.20 plant^{-1}) at harvest were taken from the interactions of 140 kg P_2O_5 ha^{-1} and 2.0

kg Zn ha^{-1} while it was also produced significantly the longest rachis (43.41 cm), more spikelet (20.29 spike^{-1}) and cormels (26.93 plant^{-1}), maximum thickness of corm (8.17 cm), highest diameter of corm and cormel (2.84 and 2.62 cm, respectively) weight of single cormel (16.71 g) as well was highest yield of corm (2.04 kg plot^{-1}) and cormel (1.32 kg plot^{-1} or 13.20 t ha^{-1}). Rest of the characters such as days to 80% emergence of spike, flowering (%), length of flower stalk, number of spike of both plot^{-1} and ha^{-1}, weight of individual corm and yield of corm (t ha^{-1}) were statistically identical among the all interaction treatments due to non significant variation. Similarly, both control (without phosphorus and zinc) recorded significantly the shortest plant (62.25 cm), minimum leaves (8.62 plant^{-1}), shortest rachis (25.38 cm), minimum spikelets (10.81 spike^{-1}), minimum thickness of corm (5.73 cm), lowest diameter of corm and cormel (1.42 and 1.20 cm, respectively), lowest weight of individual cormel (11.11 g), lowest yield of corm (1.48 kg plot^{-1}) and cormel (1.20 kg plot^{-1} or 8.37 t ha^{-1}). Vase life of spikes were also observed after harvest while 140 kg P_2O_5 ha^{-1} and 2.0 kg Zn ha^{-1} treated spike showed longest vase life (9.97) than that of other all treatments of the study.

CONCLUSION

Considering the above discussion it may be concluded that

1. The treatment under the study, 140 kg P_2O_5 ha^{-1} with 2.0 kg Zn ha^{-1} is best for growth, flowering and yield of gladiolus.
2. Considering the situation of the present experiment, further studies might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances.

REFERENCES

Amin, M. R., Tahmina, S., Mahasen, M., Mehraj, H., Jamal Uddin A. F. M. 2014. Influence of zinc levels 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 levels 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.

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., 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.

Halder, N. K., Rafiuddin, M., Siddiky, M. A., Gomes, R., Anju–Man–Ara Begam, K. 2007a. Performance of Gladiolus as Influenced by Boron and Zinc. *Pak. J. Biol. Sci.*, 10: 581–585.

Halder, N. K., Siddiky, M. A., Ahmed, R., Sharifuzzaman, S. M., Begum, R. A.. 2007b. Effect of Boron and Zinc Fertilization on Flower Yield and Quality of Gladiolus in Grey Terrace Soils of Bangladesh. *J. Soil .Natr.*, 1(3): 40–45

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

Hossain, M. J. 2008. Influence of corm size and phosphorus on growth flowering and yield of gladiolus. *MS Thesis, Dept. of Horticulture and Postharvest Technology, Sher–E–Bangla Agricultural University, Dhaka–1207.*

Hossian, M. J., Amin, M. R., Choudhury, S., Uddain, J. 2011. Effect of Corm Size and Different Doses of Phosphorous on the Growth, Corm and Cormel Development of Gladiolus. *Libyan Agric. Res. Center J. Intl.,* 2(1): 09–14.

Katiyar, P., Chaturvedi, O. P., Katiyar, D. 2012. Effect of foliar spray of zinc, calcium and boron on spike production of gladiolus cv. Eurovisio. *Hort. Flora Res. Spect.,* 4: 334–338.

Kumar, R., Misra, R. L., Singh, S. K. 2008. Post–harvest life of gladiolus cv. Jester Gold as influenced by different doses of nitrogen, phosphorus and potassium. *Indian J. Hort.,* 65(1): 83–86.

Kumar, V., Rajwal, N., Sirohi, H. S. 2006. Performance of Phosphorus levels on gladiolus *Gladiolus grandiflorus* L. cv. 'Happy End'. *Intl. J. Pl. Sci. Muzaffarnagar,* 1(2): 320–321.

Lahijie, M. F. 2012. Application of micronutrients $FeSO_4$ and ZnO on the growth and development of Gladiolus variety, Oscar. Int. J. of Agril. & Crop Sci., p. 718–720.

Maurya, R., Kumar, A. 2014. Effect of micronutrients on growth and corm yield of gladiolus. *Pl. Arc.,* 14(1): 529–531.

Memon, S. A., Baloch, A. R., Baloch, M. A., Buriro, M. 2013. Effect of zinc sulphate and iron sulphate on the growth and flower production of gladiolus (*Gladiolus hortulanus*). *J. Agrl. Tech.,* 9(6): 1621–1630.

Naznin, A., Amin, M. R., Obaidullah, A. T. A. B., Shamsuzzoha, M., Jamal Uddin, A. F. M. 2014. Response of gladiolous (*Gladiolus grandiflorus* l.) to different levels of phosphorus. *Int. J. Bus., Soc. and Sci. Res.,* 1(2): 83–86.

Pandey, N., Pathak, G. C., Singh, A. K., Sharma, C. P. 2002. Enzymatic changes in response to zinc nutrition. *J. Plant Physiol.,* 156: 1151–1153.

Pandey, R. K., Rathore, P., Singh, M. K. 2000. Effect of different levels of phosphorus and nitrogen on gladiolus under Agra conditions. *J. Orn. Hort.,* 3(1), 60-61.

Pant, S. S. 2003 (ID Bo. R–19999–HRT–28–M, Advisor: Upreti G, Member: Gautam DM and Shakya SM). Effect of different doses of nitrogen and phosphorus on growth and development, cut–flower characteristics and vase life of gladiolus cv. American Beauty. *MS Thesis, Department of Horticulture, IAAS, Rampur, Chitwan, Nepal*, pp. 1–82.

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

Qazi, A. H. D. 2005. Studies on nutrient management of Gladiolus (Tourn.) L. cv. White Prosperity under temperate conditions of Kashmir. *MS Thesis, Department of Library and Information Science, University of Kashmir.* Online available at: http://dspaces.uok.edu.in ha^{-1}ndle/1/265.

Reddy, A. G. K., Chaturvedi, O. P. 2009. Effect of zinc (ZnO), calcium ($CaSO_4$) and boron (borax) on growth and flowering in gladiolus cv. Red Majesty. *Crop Res. (Hisar) J.,* 38: 135–137.

Reddy, G. V. S., Rao, M. B. N. 2012. Precision foliar application of zinc to improve the growth and yield of gladiolus. *Proceedings of AIPA 2012, Agro–Informatics and Precision Agriculture,* pp. 44–45. Online available at http://insait.in/AIPA2012/articles/072.pdf.

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

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

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

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

Shaukat, S. A., Shahb, S. Z. A., Ishaqc, Y., Ahmedd, M., Shaukate, S. K., Shoukatf, S. W. 2012. Influence of phosphorus fertilization on gladiolus corm and flower production. *Scientific J. Agril.,* 1(5): 105–111.

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

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

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

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

Zubair M. and Wazir F.K. 2006. Phosphorus levels affect growth and yield of gladiolus cultivars in Peshawar. *Online publication* and its available at http://prr.hec.gov.pk/Chapters/3018H–4.pdf.

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

APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Horticulture Garden , 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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2012

Appendix II. Monthly record of air temperature, rainfall, relative humidity, rainfall and Sunshine of the experimental site during the period from November 2013 to June 2014

Month (2012)	*Air temperature (ºc)		*Relative humidity (%)	*Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
November, 2013	25.82	16.04	78	00	6.8
December, 2013	22.40	13.50	74	00	6.3
January, 2014	24.50	12.40	68	00	5.7
February, 2014	27.10	16.70	67	30	6.7
March. 2014	31.40	19.60	54	11	8.2

* Monthly average,

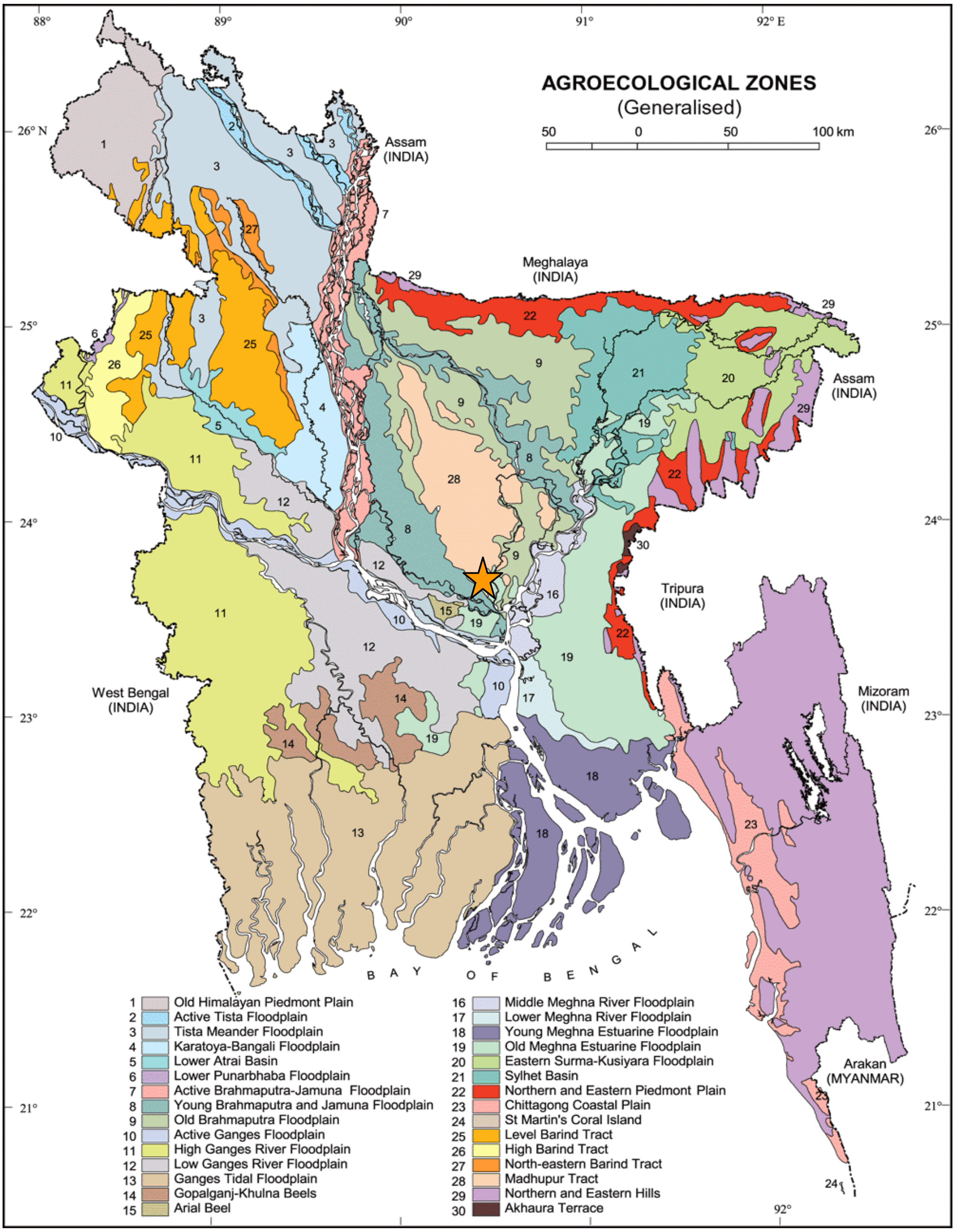
Source: Bangladesh Meteorological Dept (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Name of Fertilizers and manure used in gladiolus production and their Nutrient composition (%)

Fertilizer	Nutrient	%
Urea	N	46
TSP	P_2O_5	48
	P	21.12
MP	K_2O	60
	K	49.8
ZnO	Zn	78
Cowdung	N	0.5-1.5
	P	0.4-0.8
	K	0.5-1.9

Source :Fertilizer Recommendation Guide-2012, BARC

Appendix IV. Map showing the experimental sites under study



☆ **The experimental site under study**

Appendix IV. Analysis of variance for plant height and number of leaves plant^{-1} at different DAP and days to 80% emergence of spike, flowering (%), length of flower stalk and length of rachis at harvest

Source of variance	Degrees of freedom	Plant height (cm) at different DAS					No. of leaves plant^{-1} at different DAS					Days to 80% Emergence of spike	Percentage of flowering	Length of flower stalk	Length of rachis
		25	40	55	70	85	25	40	55	70	85				
Replication	2	7.94	15.489	21.859	35.109	28.09	0.181	0.175	0.324	0.181	0.406	88.14	119.508	77.056	33.391
Factor A (P)	3	19.737**	26.408**	32.258**	32.258**	30.079**	1.836**	1.679**	3.35**	6.943**	6.943**	8.4ns	30.957**	70.466**	70.466**
Factor B (Zn)	3	92.108**	282.796**	743.853**	743.853**	808.429**	1.721**	2.957**	21.13**	11.577**	11.577**	52.185**	124.5**	497.161**	456.77**
AB	9	0.697**	0.363ns	1.982*	1.982*	2.015*	0.059**	0.088**	0.046**	0.274**	0.274**	0.222ns	1.073ns	1.677ns	1.677**
Error	30	0.217	0.732	1.167	1.865	1.87	0.002	0.002	0.007	0.002	0.015	4.004	6.463	2.259	0.41

Appendix V. Analysis of variance for number of spikelets and spike, thickness and diameter of both corm and cormel, weight of individual corm and cormel, yield of corm and cormel of spike at harvest

Source of variance	Degrees of freedom	No. of spikelet spke^{-1}	No. of spike plot^{-1}	No. of spike ha^{-1} (000)	Thickness of corm (cm)	Diameter of corm (cm)	Weight of individual corm (g)	Yield of corm (kg plot^{-1})	Yield of corm (t ha^{-1})	No. of cormel plant^{-1}	Diameter of cormel (cm)	Wight of individual cormel (g)	Yield of cormel (kg plot^{-1})	Yield of cormel (t ha^{-1})
Replication	2	28.692	12.871	1287.146	0.168	0.104	8.918	0.034	10.644	13.783	0.101	2.345	0.035	3.109
Factor A (P)	3	30.921**	36.581**	3658.083**	3.921**	0.692**	42.463**	0.123**	12.305**	46.249**	0.692**	14.907**	0.112**	11.222**
Factor B (Zn)	3	96.572**	60.585**	6058.472**	3.437**	1.806**	80.081**	0.359**	35.883**	97.317**	1.806**	27.337**	0.182**	18.235**
AB	9	1.087**	0.598ns	59.806ns	0.13**	0.053**	1.301ns	0.003**	0.265ns	1.9.00**	0.053**	0.723**	0.001**	0.122**
Error	30	0.15	0.67	66.99	0.004	0.001	0.758	0.001	0.464	0.391	0.001	0.186	0	0.026

** and *= significant at 1% and 5% level, respectively of probability and ns= non significant