EFFECT OF FOLIAR APPLICATION OF Ca Mg Zn AND DEPTH OF CORM ON GROWTH, FLOWERING AND CORM YIELD OF GLADIOLUS

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ABSTRACT

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from November 2016 to March 2017. The experiment comprised as two factors, factor A four levels of micronutrients i.e. M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg) and factors B three levels of depth of planting i.e. D_1 = 6 cm, D_2 = 9 cm and D_3 = 12 cm. The experiment was conducted following RCBD with three replications. The maximum number of spike (3,11,000 /ha) and corm yield (11.93 t/ha) was recorded in M_2 while the minimum number of spike (1,52,000 /ha) and corm yield (4.88 t/ha) was recorded in M_0. For depth, the maximum number of spike (3,09,000 /ha) and corm yield (11.73 t/ha) was recorded in D_2 while the minimum number of spike (1,96,000 /ha) and corm yield (6.83 t/ha) was recorded in D_1. For Combination the maximum number of spike (3,73,000 /ha) and corm yield (15.06 t/ha) was recorded in M_2D_2 while the minimum number of spike (1,20,000 /ha) and corm yield (6.80 t/ha) was recorded in M_0D_1. So, Zn 100 mg, Mg 300 mg, Ca 500 mg in 9cm depth was the best for growth, flowering and corm production of Gladiolus.

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LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAS	Days after sowing
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
mg	Milligram
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
Wt.	Weight

CHAPTER I
INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is one of the most cultivated, economically important and common flowering plant world-wide including Bangladesh and is among the elite cut flowers due to different shapes, hues and prolonged vase life (Bose *et al*., 2003). Gladiolus, a member of family Iridaceae and sub-family Ixidaceae, originated from South Africa, is a prominent cut flower plant. The genus Gladiolus contains 180 species with more than 10,000 cultivars (Sinha and Roy, 2002). It has great economic value as a cut flower and flower for decoration. It is commercially cultivated for ornamental and as well for medicinal purposes. It bears innumerable cultivars with assortment of attractive colors. Gladiolus is one of the most important flowering crops grown commercially for cut-flower trade in Bangladesh. It is a very popular flowering plant in the world and usually propagated by corm and cormels. Gladiolus is also known as the Sword Lily, due to its sword shaped leaves. Gladiolus is a very colorful decorative flower which is grown in herbaceous border, bed, rockery, pot and also for cut flower. Gladiolus is frequently used as cut flower in different social and religious ceremonies (Mitra, 1992). It is next to tulip in Holland in commercial importance (Negi and Raghavan, 1986). The flower varies in color with attractive shades of crimson, pink, salmon, red, scarlet, purple, apricot, cream, white or combination of two or more shades. Due to its variability in color, size, appearance and long vase life its demand is still increasing in global and local markets.

In Bangladesh, floriculture brought into limelight by some innovative farmers in late seventies with tuberose on a small-scale basis. Large-scale commercial production started from mid-eighties in Jhikargacha upazila of Jessore district (Sultana, 2003). Later it spreaded largely in Jessore, Savar, Chuandanga, Mymensingh and Gazipur which turned to be the major flower production belt in Bangladesh. Cultivation of

flower is reported to give 3- 5 times and 1.5-2 times more returns than obtained from rice and vegetable cultivation, respectively (Dadlani, 2003). At present, 10,000 hectares of land covers flower cultivation taking the lead by Jessore district. More than 5,000 resilient farmers are growing flower and foliage in the country and about 150,000 people are directly or indirectly involved in floriculture business as their sole livelihood (Chowdhury, 2010). Approximately 8,000 farmers are involved in flower cultivation and 2000 to 3000 farmers in ornamental plants on commercial basis. About 100,000 to 120,000 people are directly or indirectly involved in floriculture industry for their livelihoods. The area coverage under commercial flower cultivation is approximately 10,000 hectares of land while commercial nurseries have covered approximately 2,000 to 2,500 hectares of land (Momin, 2006).

Micronutrients plays an important role in enhancing the translocation of carbohydrates from the site of synthesis to the storage organ and also helps in increasing yield and quality of corm. (Jany *et al.* 2008). Micronutrients are works as coenzymes for large number of enzymes and also plays an essential role in improving yield and quality. They also useful in metabolic processes from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation etc. Zinc plays an important role in protein and starch synthesis and therefore a low zinc concentration induces accumulation of amino acids and reducing sugars in plant tissue (Graham and McDonald, 2001). Calcium is the chief constituent of plants as calcium pectate of middle lamella of cell wall and is therefore an important part of plant structure. Calcium is involved in formation of cell membrane. Magnesium serves specific physiological functions in plants. Magnesium helps the evaluation of yielding of plants, flowering and corm production.

Planting depth adversely affect corm and cormel production and delays flowering. Proper depth of corm is very important for moisture content of soil. Planting depth deep to ensure adequate moisture uptake and corm to soil contact. Deeper planting

may be recommended as the season progresses and soils become warmer and drier. Excessively shallow planting can cause slow, uneven emergence of corm (Sharma *et al.* 2002). However, number of spikes, corms and cormels produced per plot was affected by plant depth (Singh and Bijmol, 2003). The performance of bulbous crops is greatly influenced by depth of planting. Depth of planting has been found to influence growth, flowering and yield of daughter bulbs in gladiolus (Mukhopadhyay and Yadav, 1984). The optimum depth helps not only in obtaining good quality cut flowers but also in better utilization of land, providing good open position for sunlight, soil moisture conservation, weed control and availability of nutrients vital for successive crop production and quality (Sanjib *et al.* 2002).

The researches for the development of gladiolus are very limited in Bangladesh. So, it is important to carry out research to find out the effect of micronutrients and depth of planting on growth and yield of gladiolus. By keeping the above information the present research was undertaken with the following objectives:

- To find out the appropriate sowing depth on growth, flowering and corm production of Gladiolus.
- To optimize the different level of micronutrient on growth, flowering and corm production of Gladiolus.
- To determine the combination of sowing depth and micronutrient level on growth, flowering and corm production of Gladiolus.

CHAPTER II
REVIEW OF LITERATURE

2.1 Effect of micronutrient

Fahad *et al*. (2014) reported that, gladiolus (*Gladiolus grandiflorus* L.) is one of the most widely cultivated, economically important and common flowering plants worldwide including Pakistan. However, its yield of flower is quite low when grown under agro-climatic conditions of Multan. A field experiment was conducted at the Experimental Area, Department of Horticulture, Bahauddin Zakariya University, Multan (Pakistan), during 2010-2012 to investigate the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. *Traderhorn*. Eight treatments comprised of either each micronutrient alone or a combination of Fe, B and Zn were applied. Corms were planted within the first week of November 2010, and 2011 on 60 cm apart ridges with 20 cm distance allowed within rows. Twenty corms were planted in each treatment, of three replicates. Micronutrient sprays were applied at 30 and 60 Days after Planting (DAP). Application of the micronutrients significantly increased plant height, leaf chlorophyll content, flower stalk length, flower fresh weight, spike length, florets per spike, florets' fresh weight and diameter, flower vase-life, flower diameter as well as fresh weight of corms. Leaf number and days to spike emergence were only influenced by a combined application of all the three micronutrients. Among the micronutrient treatments, the treatment containing $FeSO_4.7H_2O$, H_3BO_3 and $ZnSO_4.7H_2O$ (all at 2% level) performed the best for all the parameters except for number of corms per plant, which was not affected significantly by the foliar application of the micronutrients.

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.

Singh *et al.* (2012) carried out an experiment in Kanpur to investigate the effect of zinc, iron and copper on yield parameters in gladiolus. The experiment consisted with two levels each of Zn (Zn_0 and Zn_1), Fe (Fe_0 and Fe_1) and Cu (Cu_0 and Cu_1) which were sprayed on gladiolus plant. The dose of foliar spray of zinc, iron and copper were 0.50%, 0.25% and 0.25%, respectively. Weight of corms significantly increased with the application of Zn and Cu (94.38 and 94.82 g, respectively). Diameter of corms influenced significantly with the application of Zn, Fe and Cu (5.71, 5.77 and 5.81 cm diameter, respectively). Foliar spray of Zn, Fe and Cu, significantly increased the number of corms per plant. Interaction between Zn x Fe and Zn x Cu, significantly enhanced number of corms per plant whereas, the number of corms per plant revealed by Zn (1.74), Fe (1.66) and Cu (1.68) over their respective controls. Maximum increase in cormels production per plant was influenced due to application of zinc (44.97) followed by spray of copper (43.18) and iron (42.11) over their respective controls.

Lahijie (2012) conducted a field experiment for two consecutive years to study foliar spray of $FeSO_4$ and $ZnSO_4$ on the growth and floral characteristics of gladiolus variety 'Oscar'. The experiment was laid out in a randomized complete block design with three replicates in the field, Varamin Research Center. The evaluated was response and to find out the optimum dose of the same for production of gladiolus variety 'Oscar' an efficient concentration of $FeSO_4$ and $ZnSO_4$ on quality and productivity of gladiolus. Plants were grown and treated with three levels of 0, 0.5%, and 1% of two micronutrients $FeSO_4$ and $ZnSO_4$ and their various combinations at two- leaf and six-leaf stages. The results disclosed that solutions of $FeSO_4$ and $ZnSO_4$ significantly affected plant growth and floral characteristics of gladiolus. Higher

contents of both $FeSO_4$ and $ZnSO_4$ speed the plant growth and increased flowering characteristics. Application of 1 % Feso4 accelerated flowering earlier than $ZnSO_4$, as well as elongated days to spike emergence (21.49 days) and first florets opening (38.28). The results showed that 2% of both $FeSO_4$ and $ZnSO_4$ solutions and their mixture delayed the days from basal floret opening and number of floret at a time. The flowering properties like plant height (83.47 cm), length of spike (66.03cm), number of leaves (9.52 /plant) floret number (11.55/spike), diameter of floret (8.53cm) were significantly different other treatments when a mixed solution of 2% $FeSO_4$ and $ZnSO_4$ was applied. It is concluded that no application of micronutrients on gladiolus ornamental at the commercial scale will produce poor quality of vegetative growth and low number of florets. However, It is suggested that micronutrients play a vital role on the growth and development of gladiolus plants, because of its stimulatory and catalytic effects on flower yield and metabolic processes.

Sairam *et al*. (2011) was study for the investigation the role of calcium on antioxidative enzymes activity during the post-harvest life of Gladiolus (*Gladiolus grandiflorus*). Among the various calcium (Ca) treatments, 50 mmol l^{-1} Ca treatments caused the highest increase in the vase life of the spike, from 5.5 days in control to about 9 days. Relative water content and membrane stability index (MSI) decreased from I to V stage. However, significant increase in relative water content and MSI were observed by 50 mmol l^{-1} Ca as compared to control. Indices of oxidative stress such as lipid peroxidation and lipoxygenase activity increased from I to V stage, but decreased significantly in 50 mmol l^{-1} Ca treatment. The activities of antioxidant enzymes superoxide dismutase (SOD) and catalase (CAT) decreased initially from stage I to II, followed by an increase in stage III and thereafter started to decline at stages IV and V. Ascorbate peroxidase (APX) activity increased initially from stage I to III and thereafter declined in stage IV and V in both control and treatment. However, Ca with concentration of 50 mmol l^{-1} increased the activities of

SOD, CAT and APX at all the stages. The results revealed that spikes treated with Ca (50 mmol l^{-1}) solution maintained higher level of antioxidant enzymes activity and also showed delayed senescence in comparison to control.

Bai *et al*. (2009) conduced an experiment in order to apply calcium to the vase solutions of cut gladiolus (*Gladiolus hybridus*), the vase life and some physiological characteristics were studied in this article. A gladiolus cultivar, Mascagni, was chosen for experiments, and its cut flowers were held into solutions, which contained calcium acetate, ethylene glycol bis-amino tetmacetate (EGTA), and water, respectively. The effects of calcium were probed by measuring the ornamental quality of cut gladiolus and the physiological characteristics such as calmodulin (CaM), abscisic acid (ABA), gibberellins (GA), zeatin (ZRs), endogenous calcium, malondialdehyde (MDA), and soluble sugar in florets. In a solution of 2 mmol L^{-1} calcium acetate, the opening rate of cut gladiolus was higher than that of control, and the vase life and ornamental value of flowers were better than that in control and other treatments of calcium acetate. Thus, the solution of 2 mmol L^{-1} calcium acetate has the best effect on the fresh keeping of cut gladiolus. In petals and bracts of cut gladiolus, the contents of CaM and GA and the ratios of GA/ABA and ZRs/ABA were higher in treatment of 2 mmol L^{-1} calcium acetate than that in control, while the contents of ABA and MDA were lower. Compared with the control, the solution of 2 mmol L^{-1} calcium acetate increased the endogenous calcium contents, and decreased the MDA contents, and alleviated the effects of EGTA on CaM, GA, GA/ABA, and ZRs/ABA. It made the soluble sugar content higher in petals than the control, but lower in bracts. Thus, the solution of 2 mmol L^{-1} calcium acetate not only stabilizes the membrane structure of cut gladiolus, but also activates CaM. It thereby controls the endogenous hormone levels, and transports soluble sugar into petals, and increases the vase life of the flower.

Reddy *et al*. (2009) carried out a field experiment to study the effect of zinc ($ZnSO_4$) 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. Foliar application of $ZnSO_4$ at 0.5% found to be significant on different parameters like plant height (73.11 cm), leaf length (52.81 cm), days to flowering (66.11 days), length of spike (54.01 cm), length of rachis (46.26 cm), number of florets per spike (14.00) and floret length (9.08 cm). While borax and $CaSO_4$ have shown non-significant results for most of the characters except days to flowering (66.13 days) and number of florets (13.93) per spike with boron at 0.25%. However, the interaction between boron (0.25%), $ZnSO_4$ (0.5%) and $CaSO_4$ (0.5%), $ZnSO_4$ (0.5%) revealed significant results for plant height 73.27 and 73.33 cm, respectively. While the interaction between boron and $ZnSO_4$ was significantly affected by days to flowering (66.13 days) and rest of the interactions were non-significant.

Halder *et al*. (2007) conducted a field experiment to investigate the response of B and Zn on corm and cormel production and to find out the optimum dose of B and Zn for maximizing yield for gladiolus cultivation. It appeared in studied data reveals that B and Zn made promising response to the growth and floral characters of gladiolus. It is also reported that gladiolus is highly responsive to chemical fertilizers. The sixteen treatment combinations included in the study noted that B and Zn at the rate of B 2.0 Zn 4.5 kg/ha along with blanket dose of N 375 kg, P 150 kg, K 250 kg, S 20 kg and CD 5 t/ha exhibited the best performance in flower production and stretched the vase life of flower. The studied parameters like plant height (79.83 and 87.61 cm), length of spike (71.2 and 67.33 cm) length of rachis (48.86 and 45.08 cm) and leaves number (10.77 and 9.87/plant) significantly responded to the combined application of boron and zinc at the rate of B2.0 Zn 4.54 as compared to other treatment combinations. Floral characters like floret number (12.85 and 12.45/spike), floret size (9.76 x 8.93 and 10.28 x 9.77 cm) and weight of stick (36.73 and 45.12 g) also significantly influenced by said treatment (B 2.0, Zn 4.5 kg/ha) which was markedly

differed over rest of treatments combination. Single application of B and Zn also contribute to the yield parameters of gladiolus.

Singh and Chetan (2000) conducted an experiment in the in Uttar Pradesh, India to study the effects of different spacing and various levels of $ZnSO_4$ on the corms and cormels production of gladiolus cv. Sylvia. The corms were planted at 15 × 20, 20 × 20 and 25 × 20 cm distance and ZnSO4 at a different level viz. 0, 10 and 20 kg/ha were applied in the soil during the last ploughing. Planting of corms at 25 × 20 cm resulted to the highest weight of corms/plant, maximum diameter of corms/plant and number of cormlels /plant. Application of the highest level of $ZnSO_4$ caused the highest increase in weight of corms/plant, diameter of corms and average weight of corm. It is, therefore, suggested that gladiolus cv. Sylvia may be planted at spacing of 25 × 20 cm, and 20 kg ZnSO4/ha may be applied during the last ploughing.

Vinayak (2006) was carried out the investigation entitled a “Studies on effect of different micronutrients in Gladiolus cv. American BeautyÂ” in the year 2005-06 at Floricultural Research Farm of ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. The experiment was laid out in a Randomized Block Design having three replications and seventeen treatments. The treatments were comprised of three different concentrations of Zinc (Zn), Iron (Fe), Manganese (Mn) and Boron (B) at 100, 200 and 300 mg/L, combination of Fe, Mn and B with Zn each at 100 mg/L and combination of all the micronutrients Zn, Fe, Mn and B at 100 mg/L. Foliar spray was given at 3 and 6 leaf stages. Control plants were treated with distilled water. The study of foliar spray of different micronutrients revealed positive effect on some of the characters. The application of Zn (300 mg/L) gave significantly the higher plant height, number of cormels per plant, fresh and dry weight, number of florets per spike and the length of spike. The significantly highest Zn content of leaves was recorded with 300 mg/L Zn application which was at par with lower concentrations (200 mg/L Zn and 100 mg/L Zn). The foliar spray of Fe at 300 mg/L significantly improved the plant height, the weight of corms and cormels

per plant, fresh and dry weight of gladiolus plant. B at 300 mg/L also significantly produced the same results as Fe but number of cormels per plant was an added advantage. It is suggested that micronutrients play a vital role on the growth and development of gladiolus plants because of its stimulation and catalytic effect on flower yield and metabolic processes.

Boron is one of the important micronutrients among essential elements for plant growth, and plays a significant role in the physiological and biochemical processes within plants. Several reports in the literature indicated that the supply of B in the substrate may affect the behavior of other micronutrients in plants, but the specific function of B on the behavior of other micronutrients is not well defined. Presumably, due to its complex chemistry in soil and little known physiological and biochemical functions in plants. Moreover, it is well understood that the B chemistry in soil and its role in plant is differs from other micronutrients, such as Zn, Cu Fe, Mn and Mo, but its deficiency or excess may affect the solubility of these micronutrients in soil and uptake by plants (Mishra *et al.,* 2002).

Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates. Boron also plays an important role in flowering and fruit formation. Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins. In boron deficient plants the youngest leaves become pale green, losing more colour at the base then at the tip. Boron deficiency symptoms will often appear in the form of thickened wilted, or curled leaves, a thickened, cracked, or water-soaked condition of petioles and stems, and discoloration, cracking or rotting of fruit, tubers or roots (Singh *et al.,* 1996).

Boron's widespread role within the plant includes cell wall synthesis, sugar transport, cell division, differentiation, membrane functioning, root elongation, and regulation

of plant hormone levels (Marschner, 1995). Boron is one of the most commonly deficient micronutrients in agriculture, with reports of deficiencies in 132 crops and in 80 countries (Shorrocks, 1997). These deficiencies typically result from boron leaching occurring in humid areas with coarse textured soils (Mortvedt and Woodruff, 1993). A study was conducted by Nath and Biswas (2002) on the effect of boron on vegetative and reproductive growth in tuberose (*Polianthes tuberosa* L.) cv. Single. It revealed that the foliar application of boron 100 ppm twice at monthly interval produced the maximum height of plant and increased the number of leaves per clump resulting in improved yield of spikes per plot.

A field study of Boron and Zinc on flower production of Tuberose was conducted by Halder *et al*., (2007) at Floriculture Research Farm of Horticulture Research Centre, BARI, Joydebpur, Gazipur during the months of March to July in the year of 2005-2007. The objectives were to evaluate the response of tuberose to B and Zn micronutrients and to find out the optimum dose of Boron and Zinc for maximizing flower yield and quality of tuberose. Sixteen treatments comprising four levels of B (1, 1.2 and 3 kg ha^{-1}) and four levels of Zn (0, 1.5, 3.5 and 4.5 kg ha^{-1}) along with blanket does of N_{300} P_{90} K_{170} S_{20} kg/ha and cow dung 5 t/ha were used in the trial. Tuberose (CV. Double) was taken as a test crop. It was revealed that B and Zn and their combination had a profound effect on flower characters and flower yield of Tuberose. It was also evident that Boron-Zinc integration was appeared to be more responsive than their single applications. All the studied parameters like plant height, effective leaves, length of rachis and spike, number of florets and flower size and weight of stick were greatly influenced with the added higher doses of boron-zinc combination but subsequent augmentation of B and Zn suppressed the flower production. Mishra *et al.,* (2002) and Bhattacharjee (2010) reported that boron was needed for successful cultivation of flower. He again stated that application of B at a rate of 1kg/ha increased the number of leaves, leaf area, earlier time of flowering and harvest in lilium. It also improved the length and diameter of flower stalk, length of

floret, number of flower buds, yield of flower and number and weight of bulb and bulblet.

Prabhat and Arora (2000) stated that, in a field study in Indian Punjab, gladiolus cv. White Prosperity was given a foliar application of 0.2 or 0.4% $FeSO_4$, $ZnSO_4$ or $MnSO_4$ singly or in various combination at 3-leaf or 6-leaf stages. The application of 0.2% $FeSO_4$ induced flowering earlier than the other treatments, as well as increasing plant height and number of leaves. Spike length, number of florets, weight of spike and size of florets were significantly increased with the application of 0.2% $FeSO_4$ + 0.2% $ZnSO_4$. Flowering duration was longest with 0.4% $FeSO_4$+ 0.2% $ZnSO_4$. Corm production/plant was highest with 0.4% $FeSO_4$ + 0.4%, $MnSO_4$ + 0.2% $ZnSO_4$.

2.2 Effect of depth

Daneshvar and Zangeneh (2003) conducted an experiment and reported that gladiolus is one of the most famous and remarkable flowers among bulb flowers in the world and a favorite fan. Due to its easy cultivation, pretty flower, long spike, color diversity and longevity of cut flower, it is cultivated in large culture areas and sent to market. Various factors, such as climate, soil structure, depth culture, distance of the corm, soil nutrition and size of the corm, have vital function in the growth and development of the flower. The Khuzestan province, despite the limit-entailing factors of clays and heavy soil, is ranked third among the bulb flower production provinces in Iran. Moreover, due to the rapid increase of temperature after harvesting the cut flower in this province, the physiological growth of the corm is not completed. There for the corm, produced the province year, cannot be utilized next year. Thus, to minimized the expense and to appropriate use of water and land, it seems necessary to determine the best plant distance. Accordingly, to determine the effect of depth culture of corm and plant distance on culture line and between culture lines on quality and quantity of cut flowers of the Oscar cultivar, an experiment was

done in the research field of horticulture section of Ramin Agricultural Research and Education center, Shahid Chamran University in 2003. The long stem of cut flower, the results show that for two factors, long stem of cut flower and the number of stems were not be significant. But for the number of inflorescence and the number of cut flower in each plot were evaluated. The resulted show that for two factors, long stem of cut flower and the number of stems were not be significant. But for the number of inflorescences, the depth of culture and the effect of mutual of depth culture x plant distance were significant in the level of 1% and 5% respectively. It should be mentioned that the depth culture of 15 cm was superior to 10 cm.

Uddin *et al*. (2002) was studied the effect of corm size and depth of planting on the growth and flowering of gladiolus cv. Friendship using the combination of four corm sizes (15, 10, 5 and 3 g) and three planting depths planting (10.0, 7.5 and 5.0 cm). Corm size had significant influence on all the parameters studied. Large corm (15 g) took shortest time to complete 80% emergence (15.89 days) and flower initiation (60.44 days). The depth of planting had no marked effect on the parameters studied except percent lodging of plant. The highest lodging of plants (19.83%) was observed in shallowest depth of planting (5.0 cm), and the lowest (7.91%) was found in deepest planting depth (10.0 cm). The combined effect of corm size and depth of planting had significant effect on all the parameters studied except number of spikelets per plant. The highest plant height (97.56 cm), number of leaves (62.33), length of flower stalk (26.07 cm) and lodging of plants (33.14%) in the treatment combination of large sized corm planted at 5.0 cm depth and the lowest in the treatment combination of very small corm with 10 cm depth.

Sciortino and Incalcaterra (1993) investigated the effect of planting depth and plant density for corm production of gladiolus. Cormels were planted at a depth of 2, 4, 8, 16 or 20 cm. It was observed that higher yield and better quality was planting at a depth of 8 cm. Konoshima (1980) was studied the effects of planting depth and soil

covering at different stages on the dormancy of gladiolus corms. A significantly earlier sprouting was observed in corms from the plants planted 20 and 20 cm deep. The weight of corms from the plants deeply planted was found to be remarkably heavier than that of corms from plants shallowly planted. The sprouting of corms from the plants covered with soil after the four-leaf stage was considerably promoted. The number of inhibitors was decreased in the leaves and corms from the plants deeply planted. Vinceljak (1990) carried out an experiment to investigate the effects of planting depth and planting density on gladiolus corm production. Cormels were planted at a depth of 2, 4, 8, 16 or 20 cm. It was found that planting depth of 16 and 20 cm gave markedly lower yields than shallower planting depth. The best treatment combination for higher yield and better quality was planting at a depth of 8 cm.

Syamal *et al.* (1987) studied the effect corm size, planting distance and depth of planting on growth and flowering of gladiolus cv. Happy End in India. They found that large corms (4-5 and 5-6 cm in diameter) gave earlier sprouting and increased inflorescence and stem length. On the other hand, planting distance (20 x 25, 30 x 25, or 40 x 25 cm) and depth of planting had no effect on total number and size of individual flowers. They reported that corm size, planting distance and depth of planting had no interaction effect on different parameters studied. Mattos *et al.* (1984) reported that the propagation of gladiolus was influenced by the depth of planting. Planting depth of 7.3 cm was best for parent corms for the production of corms over the range "Jumbo" down to type 5. They also reported that a depth of 5.6 cm was better for producing large quantities of cormels.

Mattos *et al*. (1983) planted gladiolus corms of cultivars Hawaii, Snow Princess, Han Van Meegeren, Alfred Nobel, Aristocart, Happy End and Rosa De Lima at 5 or 15 cm depth in dark red latosol of high fertility. They observed that planting at 15 cm depth generally gave better results and planting at 5 cm led to excessive lodging. Iziro and Hori (1983) observed that at planting depth of 15 and 30 cm, the

contractiles of gladiolus elongated slightly but showed little thickening. On the other hand, at the standard depth of 5 cm, they elongated, thickened and contracted satisfactorily. Corm growth was found to be poor at 30 cm but good at 15 cm in spite of poor growth of contractile roots. Bhattacharjee (1981) investigated the effects of corm size, planting depth and spacing. Corms were planted at a depth of 5, 7 or 9 cm. The quality of flower spikes and corms were improved as planting depth increased. Konoshima (1980) studied the effect of planting depth and soil covering at different stages on the dormancy and weight of gladiolus corms in Japan. Corms at 5, 10, 15, 20 or 30 cm depth were planted. The deeper planted corms (20 or 30 cm) sprouted about 8 days earlier than those from the shallower planted corms and 12 days earlier than those grown on the surface. It was also found that individual weight of corms was heavier from deeper planted corms than from the others.

Banker and Mukhopadhyay (1980) carried out an experiment to investigate the effects of corm size, depth of planting and spacing on the production of flowers and corms in gladiolus. The experiment was consisted of three depth of planting viz. 3, 5 or 7 cm. It was observed that shallow planting increased the number of cormels per plant (28.59).

Fodder (1976) studied the effect of soil covering and depth of planting on gladiolus corm production. The corms of gladiolus were planted at 5, 10 or 15 cm depth and soil was mulched with a 2 cm deep layer of wood shavings or was left unmulched. Planting at 9 cm depth produced the highest percentage of large corms. Kolesnikov (1965) found that when gladiolus is grown for cormel production, it will be beneficial to plant mother corms at shallow depth. However, in light soil too much shallow planting could result in the toppling of plants. This can be prevented by staking and reducing spacing between corms within a row.

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap-filling, stalking, aftercare, harvesting and collection of data.

3.1 Experimental site

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka. The experiment was carried out during the period from October 2016 to March 2017. The location of the site in 23°74" N latitude and 90°35" E longitude with an elevation of 8.2 meter from sea level.

3.2 Climate

The experimental site is located in subtropical region where climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during rest of the month (Rabi season).The maximum and minimum temperature, humidity rainfall and soil temperature during the study period are collected from the Sher-e-Bangla Agricultural University Mini weather station (Appendix I).

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract. Soil analysis +report of the experimental area was collected from Khamarbari, Dhaka which was determined by Soil Resource Development Institute (SRDI), Soil testing Laboratory. The analytical data have been presented in appendix-II. The experimental site was a medium high land and pH of the soil was 5.4 to 5.6. AEZ No. 28 Soil series- Tejgaon General soil - Non-calcareous dark gray. Soil test report was shown in Appendix II.

3.4 Plant Materials

The gladiolus cultivar i.e. BARI gladiolus-4 seed was used as a test crop.

3.5 Treatments of the Experiment

The experiment consisted of two factors as follows:

Factor A: **Micronutrient**

a. M_0= Control
b. M_1= (Zn 50 mg, Mg 200 mg, Ca 400 mg) / L solution
c. M_2= (Zn 100 mg, Mg 300 mg, Ca 500 mg) / L solution
d. M_3= (Zn 150 mg, Mg 400 mg, Ca 600 mg) / L solution

Factor B: **Depth of planting**

a. D_1= 6 cm
b. D_2= 9 cm
c. D_3= 12 cm

Treatments combinations M_0D_1, M_0D_2, M_0D_3, M_1D_1, M_2D_1, M_3D_1, M_1D_2, M_2D_2, M_3D_2, M_1D_3, M_2D_3, M_3D_3

3.6 Experimental design and layout

It was a factorial experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into three equal blocks. Each block was divided into 12 plots. Every replication had twelve plots where 12 treatments were allotted at random. The total number of plots was 36. The size of each plot was 1 m × 1 m. The distance between two blocks were l.0 m.

3.7 Land preparation

The selected land for the experiment was opened 5 October, 2016 with the help of a power tiller and then it was kept open to sun for 4 days prior to further ploughing. Then the land was prepared well by ploughing and cross ploughing followed by well

by laddering at 9 October, 2016. Weeds and stubble were removed and the basal dosed of fertilizers were applied and mixed thoroughly with the soil before final land preparation. The unit plots were prepared by keeping lm spacing in between two plots and 50cm drain was dug around the land. The space between two blocks and two plots were made as drain having a depth of about 50 cm.

3.8 Application of manures and fertilizers

Following doses of manures and fertilizers were recommended for Gladiolus production fertilizer recommendation guide.

Fertilizers	Doses ha^{-1}
Cowdung	10 t
Urea	200 kg
TSP	225 kg
MoP	190 kg

A common dose of cowdung, urea, TSP and MoP was applied during plot preparation in the respective plots a week before seed sowing. Micronutrients was applied as per the treatment. The Furadan 5g was also applied during pit preparation to avoid the pest attack.

3.9 Sowing of Corms

Healthy and uniform corms were sown in the experimental plots in the afternoon of 20^{th} October, 2016 maintaining a spacing of 1m × 0.9 m between the rows and plants, respectively. The plots were watered after sowing corms. Corms were also planted around the border area of the experimental plots for gap filling.

3.10 Intercultural Operations

After sowing the corms, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows.

3.10.1 Weeding

Weeding was done whenever necessary to keep the crop free from weeds.

3.10.2 Staking

When the seedlings were established, staking was given to each plant. Stick of dhaincha plant was given to support the growing stem.

3.10.3 Irrigation

The experiment was done in robi season. So, irrigation was given when it is necessary.

3.10.4 Plant protection

To protect gladiolus plant various protection measures were taken i.e. insecticide and pesticide were applied as per needed.

3.11 Harvesting

When the flowers were in marketable condition then they were harvested.

3.12 Data collection

Data was collected for the following parameters

I. Plant height (cm)
II. Number of leaves plant^{-1}
III. Leaf area (cm^2)
IV. Chlorophyll content
V. Days to spike emergence
VI. Length of spike (cm)
VII. Number of florets
VIII. Diameter of florets
IX. Number of spike plot^{-1}

X. Spike yield ha^{-1} (ton)

XI. Number of corm $plant^{-1}$

XII. Individual corm weight (g)

XIII. Diameter of corm (cm)

XIV. Length of corm (cm)

XV. Corm yield ha^{-1} (ton)

3.13 Data collection procedure

3.13.1 Plant height

Plant height was taken at three times at 30 DAS, 45 DAS and at harvest and was measured in centimeter from ground level to tip of the plant from each plant of each treatment and mean value was calculated.

3.13.2 Number of leaves per plant

Total number of leaves was counted at 30 DAS, 45 DAS and at harvest from each plant of the treatment and mean value was calculated.

3.13.3 Leaf area

Leaf area of the plant was measured using the leaf area meter and mean value was recorded as cm^2.

3.13.4. Chlorophyll content

Chlorophyll content of gladiolus was measured using the SPAD value.

3.13.5 Days to spike emergence

The days to spike emergence was check everyday

3.13.6 Length of spike

The length of spike was measured using the measuring tape and mean values was calculated as cm.

3.13.7 Number of florets

The florets number was counted and mean value was recorded.

3.13.8 Diameter of florets

The florets diameter was taken by measuring tape in centimeter. Diameter of florets was measured at the middle portion of it from each plot and their average was taken.

3.13.9 Number of spike plot^{-1}

The total number of spikes was counted and mean value was recorded as number spike plot^{-1}.

3.13.10 Spike yield ha^{-1}

The marketable total spike yield was calculated as t ha^{-1}.

3.13.11 Number of corm plant^{-1}

The total number of corms was counted from each treatment and measured as number of corm plant^{-1}.

3.13.12 Individual corm weight

The corm weight of individual corm was measured from each of the treatments and mean value of calculated as gram.

3.13.13 Corm diameter

The corm diameter was measured using the measuring tape from middle of the corm and mean value was calculated as gram.

3.13.14 Length of corm

The corm length was measured using the measuring tape from tip of corm to bottom and mean value of calculated as cm.

3.13.15 Corm yield

The corm yield from each treatment was measured using ton and then it converted to t ha^{-1}.

3.13 Statistical analysis

All mean data were analyzed by two way ANOVA using SPSS Software Version 22.0 (SPSS inc. Chicago IL, USA). Comparisons of the mean and standard errors were calculated by Dancan's multiple range test at $P \leq 0.05$ level of significance.

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was conducted to study the effect of depth of corm and use of micronutrient (Mg, Ca and Zn) foliar application on the growth, flowering and corm production of gladiolus. Data on different growth, other parameter, yield attributes were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix section. The results have been presented with the help of graphs and table and possible interpretations given under the following headings.

4.1 Plant height

4.1.1 Effect of micronutrient

Due to application of micronutrient plant height of gladiolus showed significant variations (Figure 1 and Appendix III, IV, V). From Figure-1, the plant height ranges from 34.20 cm to 47.55 cm at 30 DAS. It was revealed that at 30 DAS the maximum plant height was 47.55cm (M_2) and the minimum plant height was 34.20 cm (M_0) (Appendix-III). The plant height ranges from 48.42 cm to 61.80 cm at 45 DAS. At 45 DAS the maximum plant height was 61.80 cm (M_2) and the minimum plant height was 48.42cm (M_0) (Appendix-IV). The plant height ranges from 54.13 cm to 67.91 cm at harvest. The maximum plant height was 67.91 cm (M_2) and the minimum plant height was 54.13 cm (M_0) at harvest (Appendix-V). For the application of micronutrient, the tallest plant was recorded in M_2 treatment while the shortest plant was recorded in M_0 treatment at all sampling dates. Fahad *et al*. (2014), Katiyar *et al.* (2012), Singh *et al.* (2012), Sairam *et al*. (2011) also reported the similar finding.

4.1.2 Effect of depth of sowing

The height of gladiolus plant showed statistically significant impact due to different depth of sowing of gladiolus cultivation (Figure 2 and Appendix III, IV, V). The tallest plant was recorded in D_2 while the shortest plant was in D_1. The plant height ranges from 38.68 cm to 46.90 cm at 30 DAS. From Figure-2, It was revealed that at 30 DAS the maximum plant height 46.90 cm on D_2 and the minimum plant height 38.68 cm on D_1 (Appendix-III). The plant height ranges from 51.99 cm to 61.80 cm 45 DAS. The maximum plant height was 51.99 cm D_1 and the minimum plant height was 61.80 cm D_2 at 45 DAS cm (Appendix-) and 58.76 cm to 67.30 cm at harvest time. The maximum plant height was 67.30 cm D_2 and the minimum plant height was 58.76 cm D_1 at harvest (Appendix-). The similar result also reported by Uddin *et al.* (2002) and Konoshima (1980).

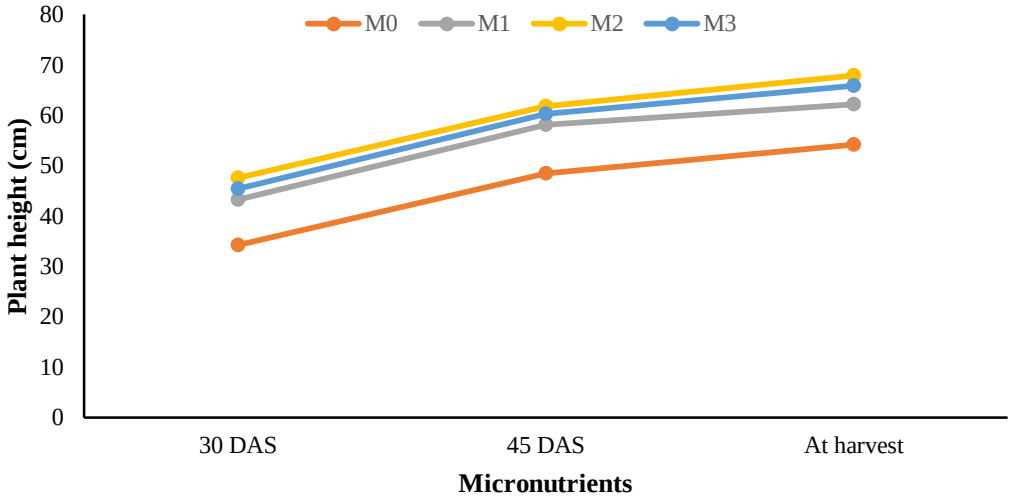


Figure 1. Effect of micronutrient on plant height

DAS= Days after sowing; M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

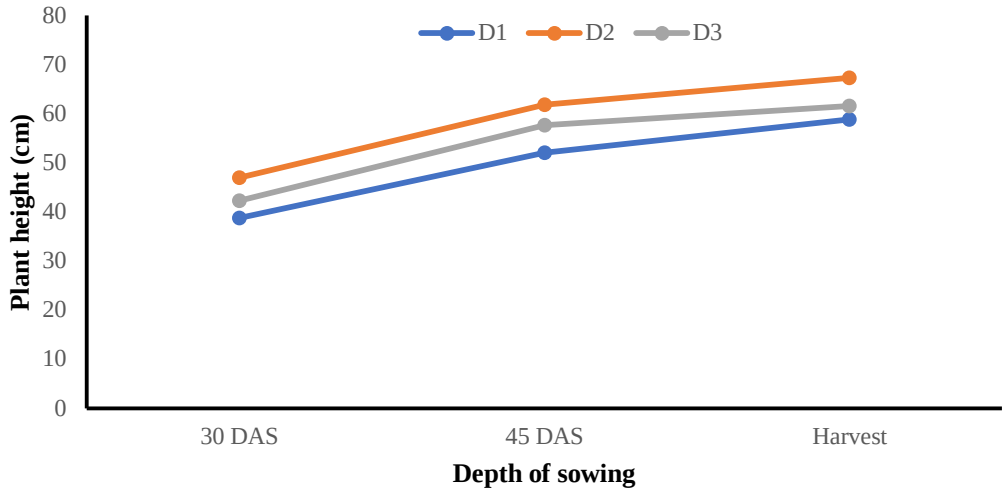


Figure 2. Effect of depth of sowing on plant height

DAS= Days after sowing; D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. The data represents the mean values ± standard error.

4.1.3 Combined effect of micronutrient and depth of sowing

The interaction effect of micronutrient and depth of sowing produced statistically significant plant height at all sampling dates (Table 1 and Appendix III, IV, V). For the interaction effect, the height of gladiolus ranges from 32.50 cm to 52.26 cm at 30 DAS. From Table -1. The maximum plant height was 52.26 cm (M_2D_2) and the minimum plant height was 32.50 cm (M_0D_1) (Appendix –III). The height of gladiolus ranges from 46.06 cm to 67.16 cm at 45 DAS. The maximum plant height was 67.16 cm (M_2D_2) and the minimum plant height was 46.06 cm (M_0D_1) (Appendix-IV). At harvest time the maximum plant height was 73.76 cm (M_2D_2) and the minimum plant height was 52.43 cm (M_0D_1) (Appendix-V). The tallest plant was found in M_2D_2 and the shortest plant was found in M_0D_1 combination compared to the others combination.

Table 1. Combined effect of micronutrient and depth of sowing on plant height

Treatments	Plant height (cm) at		
	30 DAS	45 DAS	Harvest
M_0D_1	32.50 g	46.067 k	52.433 g
M_0D_2	35.86 f	50.167 j	55.900 fg
M_0D_3	34.23 fg	49.033 j	54.067 fg
M_1D_1	38.57 e	51.900 i	57.667 ef
M_1D_2	48.00 b	64.100 c	68.200 bc
M_1D_3	43.17 d	58.267 f	60.667 de
M_2D_1	43.83 d	55.900 g	64.167 cd
M_2D_2	52.27 a	67.167 a	73.767 a
M_2D_3	46.57 bc	62.333 d	65.800 c
M_3D_1	39.83 e	54.100 h	60.800 de
M_3D_2	51.50 a	65.767 b	71.333 abc
M_3D_3	44.87 cd	61.033 E	65.567 c
SE (±)	0.76	0.39	1.46

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg) D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. Different letter(s) Corresponds to significance differences at $p \leq 0.05$ by Duncan's Multiple Range Tests.

4.2 Number of leaves plant^{-1}

4.2.1 Effect of micronutrient

The number of leaves plant^{-1} showed significant difference for the application of different types of micronutrients (Figure 3 and Appendix VI, VII, VIII). From Figure-3, it was revealed that at 30 DAS the maximum number of leaves per plant was 4.07 (M_2) and the minimum number of leaves per plant was 2.58 (M_0) (Appendix-IV). At 45 DAS the maximum number of leaves per plant was 4.53 and the minimum number of leaves per plant was 3.09 (M_0) (Appendix-VII). At harvest the maximum number of leaves per plant was 6.34 and the minimum number of leaves per plant was 4.71 (M_0) (Appendix-VIII). The maximum number of leaves plant^{-1} was recorded in M_2 while the minimum number of leaves plant^{-1} was recorded in treatment M_0. Sairam *et al*. (2011) also reported the similar finding.

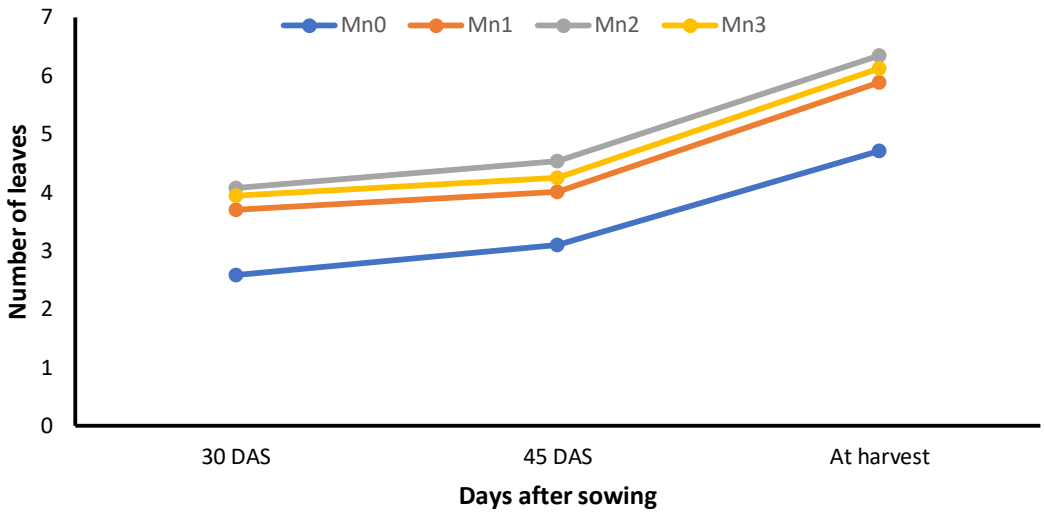


Figure 3. Effect of micronutrient on number of leaves plant^{-1} of gladiolus

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

4.2.2 Effect of sowing depth

The different sowing depth on gladiolus showed significant effect for number of leaves plant^{-1} at all sampling dates (Figure 4 and Appendix VI, VII, VIII). The maximum number of leaves plant^{-1} was found in D_2 treatment while the minimum number of leaves plant^{-1} was recorded in D_1 treatment. It was revealed that at 30 DAS the maximum number of leaves per plant was 4.03 (M_2) and the minimum number of leaves per plant was 3.08 (M_0) (Appendix-VI). At 45 DAS the maximum number of leaves per plant was 4.45 (M_2) and the minimum number of leaves per plant was 3.50 (M_0) (Appendix-VII). At harvest the maximum number of leaves per plant was 6.33 (M_2) and the minimum number of leaves per plant was 5.18 (M_0) (Appendix-VIII). Daneshvar and Zangeneh (2003) also reported the similar finding.

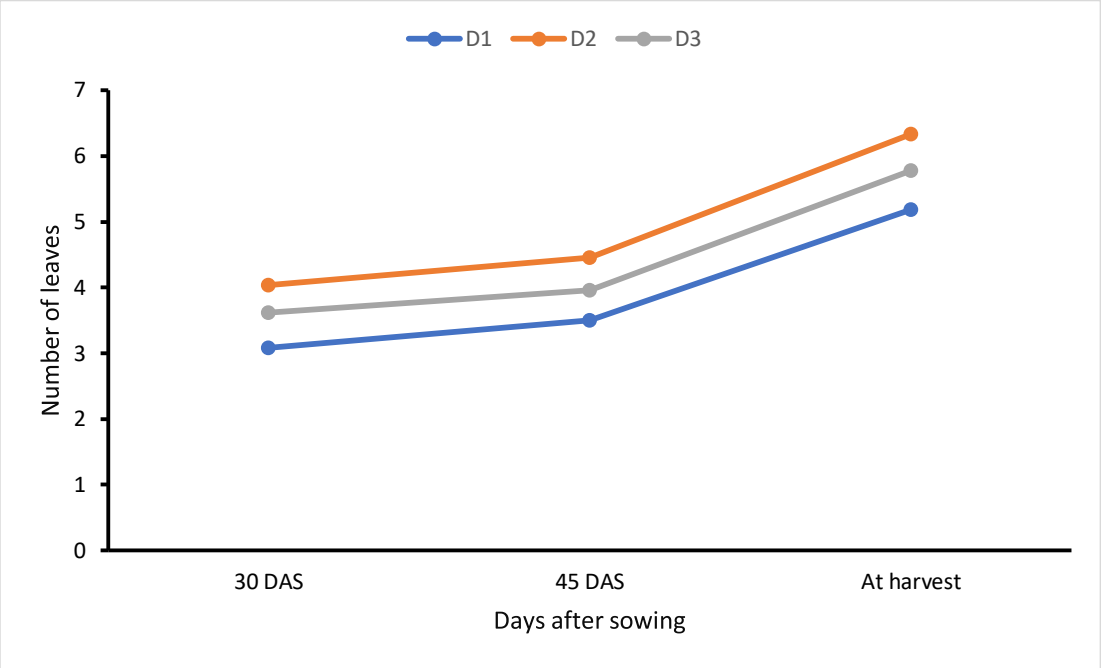


Figure 4. Effect of depth of sowing on number of leaves plant^{-1}

DAS= Days after sowing; D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. The data represents the mean values ± standard error**.**

4.2.3 Combined effect of micronutrient and depth of sowing

The interaction effect of micronutrient and depth of sowing showed wide range of variations on number of leaves per plant only at all sampling dates (Table 2 and Appendix VI, VII, VIII). It was revealed that at 30 DAS the maximum number of leaves per plant was 4.56 (M_2D_2) and the minimum number of leaves per plant was 2.23 (M_0D_1) (Appendix-VI). At 45 DAS the maximum number of leaves per plant was 5.16 (M_2D_2) and the minimum number of leaves per plant was 2.83 (M_0D_1) (Appendix-VII). At harvest the maximum number of leaves per plant was 7.20 (M_2D_2) and the minimum number of leaves per plant was 4.53 (M_0D_1) (Appendix-VIII) while M_2D_2 produced the maximum number of leaves plant^{-1} and M_0D_1 produced minimum number of leaves plant^{-1}.

Table 2. Combined effect of micronutrient and depth of sowing on number of leaves plant^{-1}

Treatment	Number of Leaf		
	30 DAS	45 DAS	At harvest
M_0D_1	2.23 j	2.83 j	4.53 i
M_0D_2	2.90 h	3.35 h	4.90 h
M_0D_3	2.63 i	3.10 i	4.70 hi
M_1D_1	3.10 g	3.54 gh	5.20 g
M_1D_2	4.30 bc	4.50 c	6.50 bc
M_1D_3	3.70 e	4.00 de	5.97 e
M_2D_1	3.53 ef	3.90 ef	5.50 f
M_2D_2	4.57 a	5.17 a	7.20 a
M_2D_3	4.13 cd	4.53 c	6.33 cd
M_3D_1	3.47 f	3.75 fg	5.50 f
M_3D_2	4.37 b	4.80 b	6.73 b
M_3D_3	4.00 d	4.20 d	6.13 de
SE (±)	0.06	0.08	0.09

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg), D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. Different letter(s) Corresponds to significance differences at $p \leq 0.05$ by Duncan's Multiple Range Tests.

4.3 Leaf area

4.3.1 Effect of Micronutrient

The leaf area of gladiolus showed significant difference for different doses of micronutrient application (Table 3 and Appendix IX). Due to micronutrient application, the ranges of leaf area were found 82.55 cm^2 to 144.33 cm^2. The maximum leaf area was recorded in M_2 while the minimum leaf area was recorded in M_0. The present finding consisted with the finding Sairam *et al*. (2011) also reported the similar finding.

4.3.2 Effect of depth of sowing

The different depth of sowing of gladiolus showed significant effect for leaf area (Table 4 and Appendix IX). The maximum leaf area was found in D_2 treatment while the minimum leaf area was recorded in D_1 treatment. The leaf area ranges from 97.16

cm^2 to 145.75 cm^2. The similar result also reported by Uddin *et al*. (2002) and Konoshima (1980).

Table 3. Effect of micronutrient on leaf area, chlorophyll content and days to spike emergence

Treatment	Leaf Area (cm^2)	Chlorophyll (%)	Days to Spike Emergence
M_0	82.56 d	58.32 d	81.83 a
M_1	124.11 c	67.68 c	69.64 b
M_2	144.33 a	71.11 a	65.56 c
M_3	134.11 b	69.62 b	68.13 d
SE (±)	1.12	0.32	0.38

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

Table 4. Effect of depth of sowing on leaf area, chlorophyll content and days to spike emergence

Treatment	Leaf Area (cm^2)	Chlorophyll (%)	Days to spike Emergence
D_1	97.17 c	61.92 c	76.86 a
D_2	145.75 a	71.69 a	66.01 c
D_3	120.92 b	66.43 b	71.01 b
SE (±)	0.97	0.27	0.33

D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. The data represents the mean values ± standard error.

4.3.3 Combined effect of micronutrient and depth of sowing

The interaction effect of micronutrient and depth of sowing showed significant impact ($p \leq 0.05$) on leaf area (Table 5 and Appendix IX). The leaf area ranges from 77.66 cm^2 to 177.67 cm^2 while M_2D_2 produced the maximum leaf area and M_1D_1 produced the minimum leaf area.

4.4 Chlorophyll content of leaf

4.4.1 Effect of Micronutrient

The chlorophyll content showed significant variations for different doses of micronutrient application (Table 3 and Appendix X). Due to micronutrient application, the ranges of chlorophyll content were found 58.32% to 71.11%. The maximum chlorophyll content was recorded in M_2 while the minimum chlorophyll

content was recorded in M_1. The present finding consisted with the finding of Sairam *et al*. (2011) also reported the similar finding.

4.4.2 Effect of sowing depth

The different sowing depth on gladiolus showed significant effect for chlorophyll content (Table 4 and Appendix X). The maximum chlorophyll content was found in D_2 treatment while the minimum chlorophyll content was recorded in D_1 treatment. The chlorophyll content ranges from 61.92% to 71.69%. The present finding consisted with the finding of Daneshvar and Zangeneh (2003), Uddin *et al*. (2002) and Konoshima (1980).

Table 5. Combined effect of micronutrient and depth of sowing on leaf area, chlorophyll content and days of spike emergence

Treatment	Leaf Area (Cm^2)		Chlorophyll (%)		Days to spike emergence	
M_0D_1	77.67	k	55.17	h	83.93	a
M_0D_2	86.33	j	60.90	f	79.56	c
M_0D_3	83.67	j	58.90	g	82.00	b
M_1D_1	95.33	i	62.23	f	77.06	d
M_1D_2	152.33	c	74.23	b	62.80	i
M_1D_3	124.67	f	66.57	d	69.06	g
M_2D_1	112.67	g	65.57	de	71.76	f
M_2D_2	177.67	a	77.07	a	59.50	j
M_2D_3	142.67	d	70.70	c	65.40	h
M_3D_1	103.00	h	64.73	e	74.66	e
M_3D_2	166.67	b	74.57	b	62.16	i
M_3D_3	132.67	c	69.57	c	67.56	g
SE (±)	1.94		0.55		0.66	

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg), D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. Different letter(s) Corresponds to significance differences at $p \leq 0.05$ by Duncan's Multiple Range Tests.

4.4.3 Combined effect of micronutrient and depth of sowing

The interaction effect of micronutrient and depth of sowing showed wide range of variations at P (≤ 0.05) on chlorophyll content (Table 5 and Appendix X). The chlorophyll content ranges from 55.16% to 65.56% while M_2D_2 produced the height chlorophyll content and M_1D_1 produced the lowest chlorophyll content.

4.5 Days to spike emergence

4.5.1 Effect of micronutrient

The days to pike emergence showed significant difference for different levels of micronutrient application (Table 3 and Appendix XI). The ranges of number of leaves hill^{-1} was found 65.55 days to 81.83 days. The shorter days was required for spike emergence in M_2 treatment while the longest times was required for M_0 treatment. Fahad *et al*. (2014), Katiyar *et al.* (2012) and Singh *et al.* (2012) also reported the similar finding.

4.5.2 Effect of sowing depth

The different types of sowing depth on gladiolus showed significant influence on days to pike emergence (Table 4 and Appendix XI). The longest time of days to pike emergence was needed in D_1 treatment while the shorter times of days to pike emergence was required in D_2 treatment. The days to pike emergence ranges from 66.01 days to 76.85 days. Daneshvar and Zangeneh (2003) also reported the similar finding.

4.5.3 Combined effect of micronutrient and depth of sowing

The interaction effect of micronutrient and depth of sowing showed significant impact on days to pike emergence (Table 5 and Appendix XI). The highest value of days to spike emergence were in M_0D_1 (83.93 days) and lowest value of days spike emergence were in M_2D_2 (59.50 days). The result revealed that M_2D_2 facilitated earlier seedling emergence compared to others combination while M_0D_1 took maximum time to seedling emergence.

4.6 Spike length

4.6.1 Effect of micronutrient

Due to the micronutrient application spike length showed significant variations (Table 6 and Appendix XII). The spike length ranges from 46.12 cm to 60.04 cm. The height spike length (60.04 cm) was recorded in M_2 treatment and the lowest spike length (46.12 cm) was recorded in M_1 treatment. This might be due to that micronutrient application made a positive effect in plant to promote the growth of spike and ultimately increase the reproductive growth of plant also reported the similar finding.

4.6.2 Effect of sowing depth

The spike length showed statistically significant impact due to different sowing depth on gladiolus (Table 7 and Appendix XII). The highest spike length (145.75 cm) was recorded in D_2 while the lowest spike length (97.16 cm) was found in treatment D_1. The similar result also reported by Uddin *et al*. (2002) and Konoshima (1980).

Table 6. Effect of micronutrient on spike length, number of florets and floret diameter

Treatment	Length of Spike (cm)	Number of Floret	Diameter of Floret (cm)
M_0	46.12 c	4.28 d	3.31 d
M_1	54.44 b	9.16 c	8.18 c
M_2	60.04 a	11.26 a	10.23 a
M_3	57.62 a	10.03 b	9.18 b
SE (±)	1.02	0.12	0.09

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

4.6.3 Combined effect of micronutrient and depth of sowing

The interaction effect of micronutrient and depth of sowing produced statistically significant variation in terms of spike length of gladiolus (Table 8 and Appendix XII). The highest spike length was found in M_2D_2 and lowest spike length was found

in M_0D_1 combination compared to the others interaction. For combined effect the spike length ranges from 46.06 cm to 66.40 cm.

Table 7. Effect of depth of sowing on spike length, florets number and floret diameter

Treatment	Length of Spike (cm)	Number of Floret	Diameter of Floret (cm)
D_1	97.17 c	6.28 c	5.21 c
D_2	145.75 a	11.21 a	10.19 a
D_3	120.92 b	8.56 b	7.78 b
SE (±)	0.88	0.10	0.07

D_1= 6 cm, D_2= 9 cm, D_3= 12 cm**.** The data represents the mean values ± standard error.

Table 8. Combined effect of micronutrient and depth of sowing on spike length, floret number and floret diameter

Treatment	Length of Spike(cm)	Number of Floret	Diameter of Floret(cm)
M_0D_1	46.07 f	3.33 k	2.30 l
M_0D_2	46.23 f	5.27 i	4.20 j
M_0D_3	46.07 f	4.23 j	3.43 k
M_1D_1	48.00 f	6.20 h	5.20 i
M_1D_2	57.73 cd	12.07 c	11.10 c
M_1D_3	57.60 cd	9.20 e	8.23 f
M_2D_1	53.67 de	8.27 f	7.10 g
M_2D_2	66.40 a	14.27 a	13.27 a
M_2D_3	60.07 bc	11.23 d	10.33 d
M_3D_1	51.50 ef	7.30 g	6.23 h
M_3D_2	63.40 ab	13.23 b	12.20 b
M_3D_3	57.97 cd	9.57 c	9.10 c
SE (±)	1.77	0.21	0.15

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg), D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. Different letter(s) Corresponds to significance differences at $p \leq 0.05$ by Duncan's Multiple Range Tests.

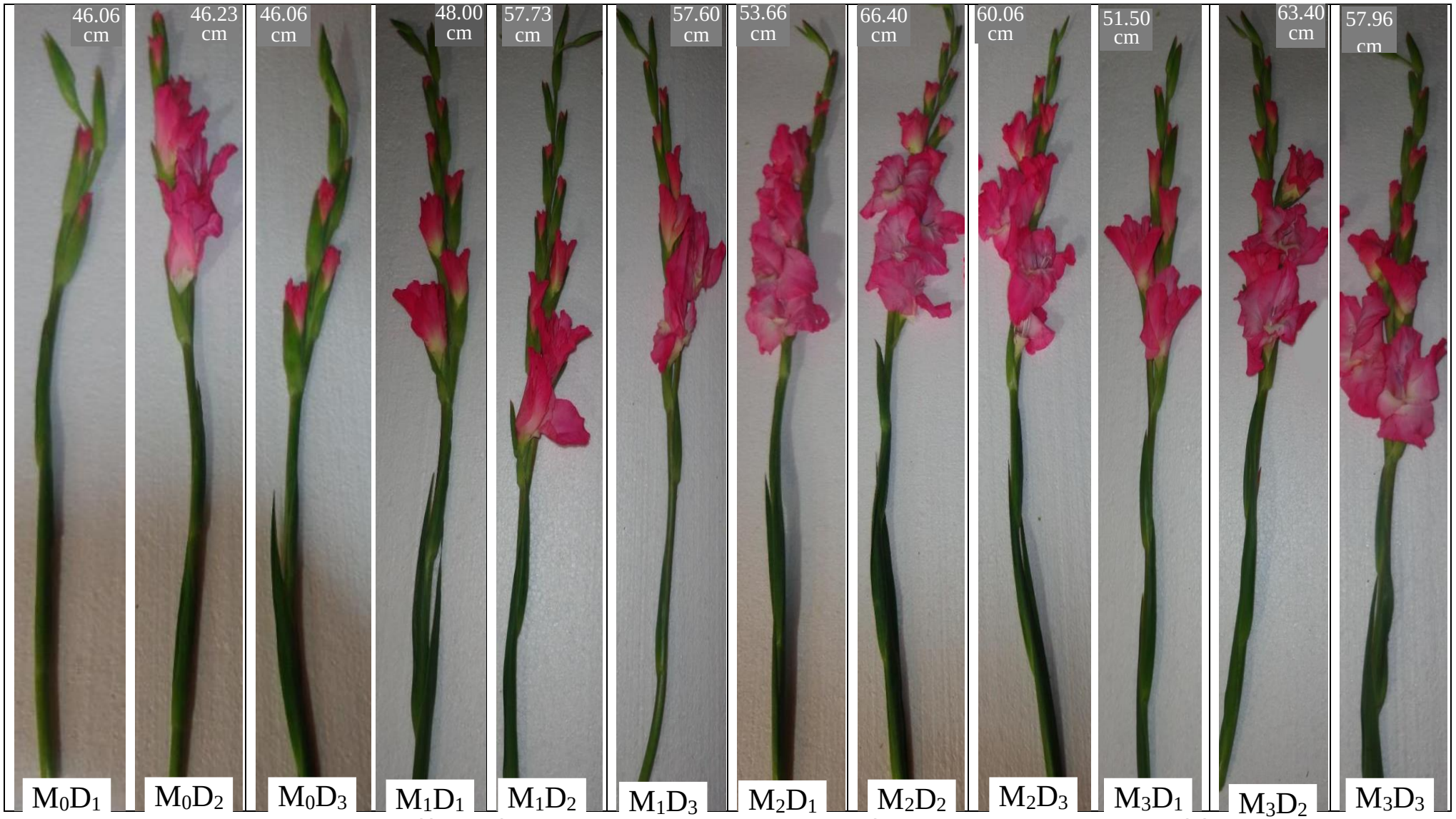


Plate 1: Combined effect of micronutrients and depth of corm on spike length of florets

4.7 Number of florets

4.7.1 Effect of Micronutrient

Number of florets of gladiolus showed significant difference for the application of different doses of micronutrient (Table 6 and Appendix XIII). The highest value of number of floret (11.25) was recorded in M_2 while the lowest value of the same traits (4.27) was recorded in the treatment M_0. This might be due to that micronutrient application made a positive effect to improve the reproductive development of gladiolus. The present finding consisted with the finding of Singh *et al.* (2012).

4.7.2 Effect of sowing depth

Impact of sowing depth on gladiolus showed significant effect on the number of florets (Table 7 and Appendix XIII). The highest value of the number of floret (11.20) was found in D_2 treatment while the lowest value of the number of floret (6.27) was recorded in D_1 treatment. The fact that optimum depth sowing held to absorb proper nutrient for increasing reproductive development. Daneshvar and Zangeneh (2003) also reported the similar finding.

4.7.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing showed significant variations on number of florets of gladiolus (Table 8 and Appendix XIII). The M_2D_2 produced the height value of number of floret and the combination M_0D_1 produced the lowest value of number of florets. The number of floret ranges from 3.33 to 14.26.

4.8 Diameter of floret

4.8.1 Effect of Micronutrient

Due to application of micronutrient the diameter of floret showed significant variations (Table 6 and Appendix XIV). The diameter of floret ranges from 3.31 cm to 10.23 cm. The maximum diameter of floret was recorded in M_2 treatment and the minimum diameter of floret was recorded in M_0 treatment. Katiyar *et al.* (2012) and Lahijie (2012) also reported the similar finding.

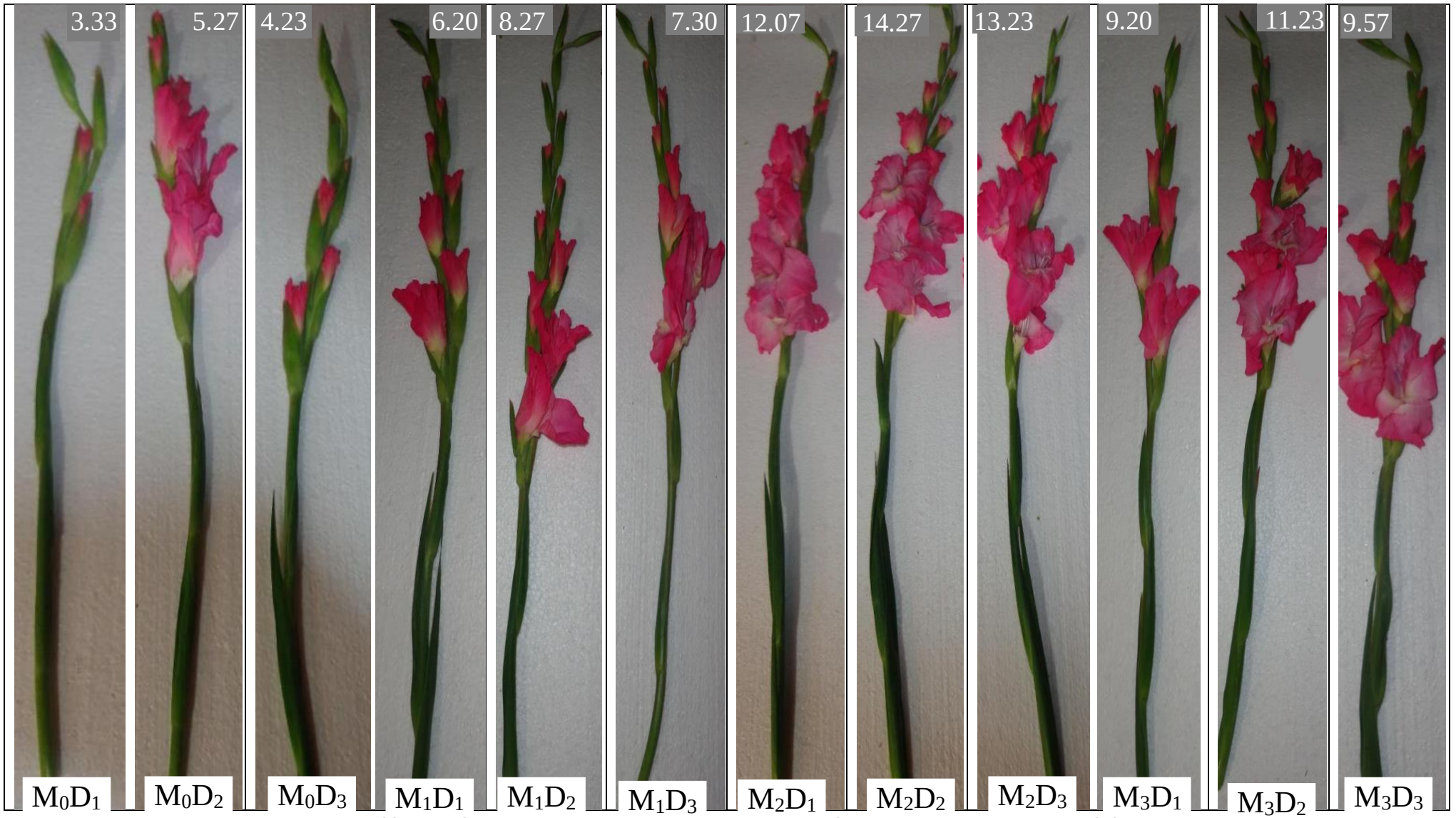


Plate 2: Combined effect of micronutrients and depth of corm on number of florets per spike

4.8.2 Effect of sowing depth

The diameter of floret showed statistically significant impact due to different sowing depth on gladiolus (Table 7 and Appendix XIV). The maximum diameter of floret was recorded in D_2 while the lowest values of diameter of floret was found in D_1.

The diameter of floret ranges from 5.20 cm to 7.77 cm. The present finding consisted with the finding of Daneshvar and Zangeneh (2003), Uddin *et al*. (2002) and Konoshima (1980).

4.8.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing produced statistically significant variations on diameter of floret (Table 8 and Appendix XIV). For the combined effect, the diameter of floret ranges from 2.30 cm to 13.26 cm. The maximum diameter of floret was found in M_2D_2 and minimum diameter of floret was recorded in M_0D_1 combination compared to the others combination.

4.9 Number of spikes plot^{-1}

4.9.1 Effect of micronutrient

Number of spike plot^{-1} showed significant difference for different doses of micronutrient application (Table 9 and Appendix XV). Due to micronutrient application, the spike plot^{-1} ranges were found from 11.44 to 20.11. The maximum number of spike plot^{-1} was recorded in M_2 while the minimum number of spike plot^{-1} was recorded in M_0. The similar finding also reported by Katiyar *et al.* (2012) and Sairam *et al*. (2011).

4.9.2 Effect of depth sowing

Impact of sowing depth on gladiolus showed a significant variation on number of spike plot^{-1} (Table 10 and Appendix XV). The maximum number of spike plot^{-1} was found in D_2 while minimum number of spike plot^{-1} was recorded in D_1 treatment. The

number of spike plot^{-1} ranges from 14.75 to 23.25. The similar result also reported by Uddin *et al*. (2002) and Konoshima (1980).

Table 9. Effect of micronutrient on number of spike/plot, number of corm/plant and individual corm weight

Treatment	Number of spike/plot	Number of Corm/Plant	Individual Weight of Corm (gm)
M_0	11.44 d	1.22 d	49.46 d
M_1	20.11 c	2.10 c	63.13 c
M_2	23.33 a	2.53 a	69.12 a
M_3	21.44 b	2.33 b	66.41 b
SE (±)	0.41	0.03	0.47

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

Table 10. Effect of depth of sowing on number spike/plot, number of corm/plant and individual corm weight

Treatment	Number of Spike/Plot	Number of Corm/Plant	Individual Weight of Corm (gm)
D_1	14.75 c	1.57 c	54.58 c
D_2	23.25 a	2.55 a	69.92 a
D_3	19.25 b	2.03 b	61.59 b
SE (±)	0.36	0.03	0.41

D_1= 6 cm, D_2= 9 cm, D_3= 12 cm**.** The data represents the mean values ± standard error.

4.9.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing showed significant impact on number of spike plot^{-1} (Table 11 and Appendix XV). The number of spike plot^{-1} ranges from 9.00 to 28.00 while M_2D_2 produced the maximum number of spike plot^{-1} and M_0D_2 produced minimum number of spike plot^{-1}.

4.10 Spike yield

4.10.1 Effect of micronutrient

Due to micronutrient application the spike yield showed significant result on gladiolus (Figure 5 and Appendix XVI). The spike yield ranges from 1,52,000 ha^{-1} to 3,11,000 ha^{-1}. The highest spike yield was recorded in M_2 treatment and the lowest

spike yield was recorded in M_1 treatment. The present finding consisted with the finding of Fahad *et al*. (2014) and Katiyar *et al.* (2012).

4.10.2 Effect of depth sowing

The spike yield showed statistically significant impact due to different depth sowing on gladiolus (Figure 6 and Appendix XVI). The highest spike yield (1,96,000 ha^{-1}) was recorded in D_2 while lowest spike yield (3,09,000.ha^{-1}) was in D_0. The present finding consisted with the finding of Daneshvar and Zangeneh (2003), Uddin *et al*. (2002) and Konoshima (1980).

4.10.3 Combined effect of micronutrient and depth of sowing

The combined effect of micronutrient and depth of sowing produced statistically significant spike yield (Table 11 and Appendix XVI). For combined effect, the spike yield ranges from 1,20,000 ha^{-1} to 3,73,000 ha^{-1}. The highest spike yield found in M_2D_2 and lowest spike yield was found in M_0D_1.

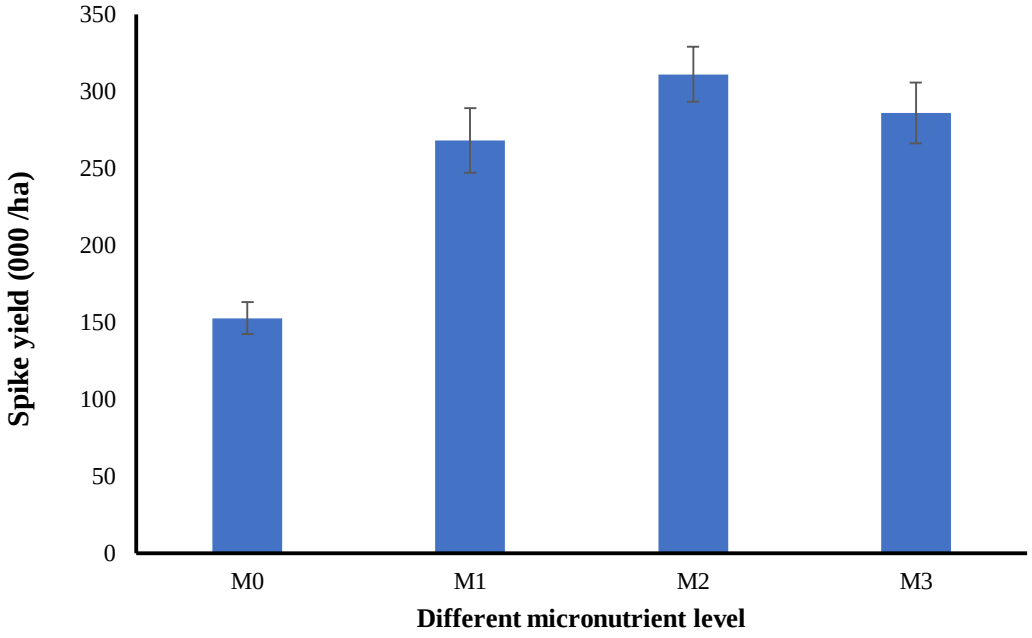


Figure 5. Effect of micronutrient on spike yield

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

4.11 Number of corms plant^{-1}

4.11.1 Effect of Micronutrient

The number of corm plant^{-1} of gladiolus showed significant difference for different doses of micronutrient application (Table 9 and Appendix XVII). Due to micronutrient application, the ranges of number of corm plant^{-1} of gladiolus was found 1.22 to 2.53. The highest number of corm plant^{-1} was recorded in M_2 while lowest number of corm plant^{-1} was recorded in M_0. The present finding is consisted with the finding of Sairam *et al*. (2011) combination compared to the others combination.

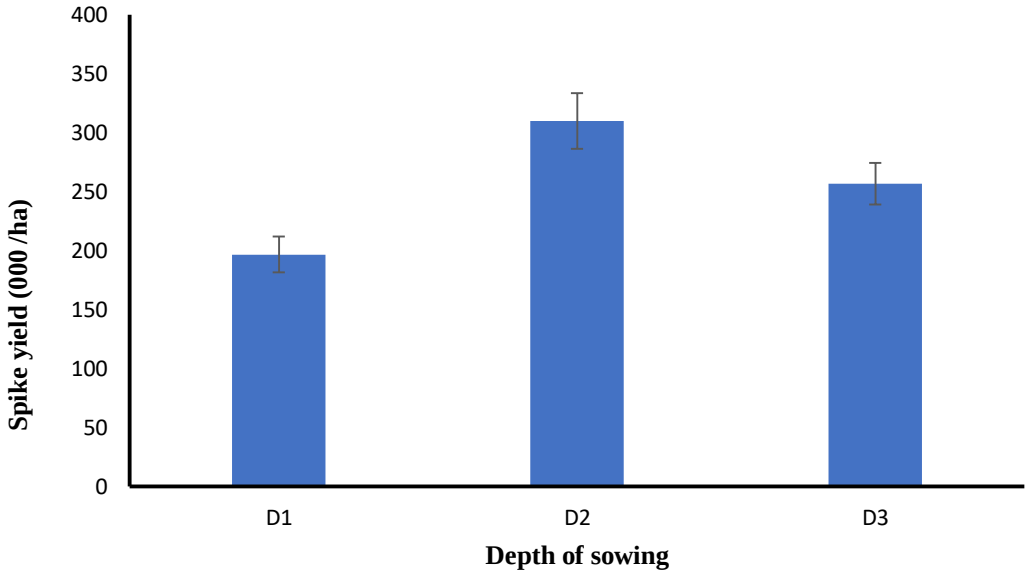


Figure 6. Effect of depth of sowing on spike yield

D_1= 6 cm, D_2= 9 cm, D_3= 12 cm**.** The data represents the mean values ± standard error.

4.11.2 Effect of sowing depth

Impact of depth sowing on gladiolus showed significant variations for number of corm plant^{-1} of gladiolus (Table 10 and Appendix XVII). Due to the effect of depth of sowing on number of corm plant^{-1} of gladiolus, the highest number of corm plant^{-1} was found in D_2 while the lowest number of corm plant^{-1} was recorded in D_1 treatment. The number of corm plant^{-1} ranges from 1.56 to 2.55. Daneshvar and Zangeneh (2003) also reported the similar finding.

4.11.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing showed significant variations on number of corm plant^{-1} of gladiolus (Table 11 and Appendix XVII). The number of corm plant^{-1} of gladiolus ranges from 1.10 to 3.16 while the treatment M_2D_2 produced the highest number of corm plant^{-1} and M_0D_1 produced the lowest number of corm plant^{-1}.

4.12 Individual corm weight

4.12.1 Effect of micronutrient

Due to application of micronutrient individual corm weight showed significant variations (Table 9 and Appendix XVIII). The individual corm weight ranges from 49.45 g to 69.12 g. The highest values of individual corm weight (69.12 g) were recorded in M_2 treatment and the lowest value of individual corm weight (49.45 g) was recorded in M_0 treatment. The present finding is consisted with the finding of Katiyar *et al.* (2012).

Table 11. Combined effect of micronutrient and depth of sowing on spike number/plot, spike yield, corm number/plant and individual corm weight

Treatment	Number of Spike/Plot		Yield/ha of Spike ('000')		Number of Corm/Plant		Individual Weight of Corm (gm)	
M_0D_1	9.00	j	120000	i	1.10	i	45.97	j
M_0D_2	13.33	gh	177000	gh	1.33	hi	51.47	i
M_0D_3	12.00	i	160000	h	1.23	h	50.93	i
M_1D_1	14.67	fg	195000	fg	1.50	g	55.07	h
M_1D_2	25.33	b	337000	b	2.67	b	72.50	c
M_1D_3	20.33	de	271000	de	2.13	d	61.83	f
M_2D_1	19.00	e	253000	e	1.97	e	59.83	f
M_2D_2	28.00	a	373000	a	3.17	a	79.23	a
M_2D_3	23.00	c	306000	c	2.47	c	68.30	d
M_3D_1	16.33	f	217000	f	1.70	f	57.47	g
M_3D_2	26.33	abc	351000	abc	3.00	a	76.48	b
M_3D_3	21.67		288000	cd	2.27	d	65.30	e
SE (±)	0.71		9.52		0.06		0.81	

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg), D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. Different letter(s) Corresponds to significance differences at $p \leq 0.05$ by Duncan's Multiple Range Tests.

4.12.2 Effect of sowing depth

The individual corm weight showed statistically significant impact due to different depth of sowing on gladiolus (Table 10 and Appendix XVIII). The significant influence of depth of sowing facilitated highest individual corm weight in D_2 while the lowest individual corm weight was recorded in D_1. The individual corm weight ranges from 54.58 g to 69.91 g.

4.12.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing produced statistically significant value of individual corm weight on gladiolus (Table 11 and Appendix XVIII). For the interaction effect, individual corm weight ranges from 45.96 g to 79.23 g. The highest individual corm weight (79.23 g) was found in M_2D_2 and the lowest individual corm weight (45.96 g) was found in M_0D_1 combination compared to the others combination.

4.13 Corm diameter

4.13.1 Effect of micronutrient

The corm diameter showed significant difference for different doses of micronutrient application (Table 12 and Appendix XIX). The ranges of corm diameter were found 4.35 cm to 5.97 cm. The highest value of corm diameter (5.97 cm) was recorded in M_2 treatment while the lowest value of corm diameter (4.35 cm) was recorded in M_0 treatment. Fahad *et al*. (2014), Katiyar *et al.* (2012), Singh *et al.* (2012), Sairam *et al*. (2011) also reported the similar finding.

4.13.2 Effect of depth of sowing

Impact of depth of sowing on gladiolus showed significant variation for corm diameter (Table 13 and Appendix XIX). The highest value of corm diameter (5.65 g) was found in D_2 while the lowest value of corm diameter (4.95 g) was recorded in D_1 treatment. The present finding consisted with the finding of Daneshvar and Zangeneh (2003), Uddin *et al*. (2002) and Konoshima (1980).

Table 12. Effect of micronutrient on corm diameter, corm length and corm number/plot and yield/ha of corm

Treatment	Diameter of corm (cm)	Length of corm (cm)	Number of Corm/Plot	Yield/ha of corm (t/ha)
M_0	4.35 c	2.63 c	12.22 d	4.88 d
M_1	5.33 b	3.66 d	24.22 c	9.68 c
M_2	5.98 a	3.91 a	29.89 a	11.93 a
M_3	5.46 b	3.68 b	26.56 b	10.62 b
SE (±)	0.06	0.05	0.40	5.39

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

4.13.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing showed significant impact on corm diameter (Table 14 and Appendix XIX). The corm diameter was ranges from 4.06 g to 6.32 g. The treatment M_2D_2 produced the highest value of corm diameter and M_0D_1 produced lowest value of corm diameter.

Table 13. Effect of depth of sowing on corm diameter, corm length and corm number/plot and yield/ha of corm

Treatment	Diameter of corm (cm)	Length of corm (cm)	Number of Corm/Plot	Yield/ha of corm (t/ha)
D_1	4.95 c	3.11 c	17.08 c	6.83 c
D_2	5.66 a	3.83 a	29.33 a	11.73 a
D_3	5.24 b	3.47 b	23.25 b	9.30 b
SE (±)	0.05	0.05	0.35	4.67

D_1= 6 cm, D_2= 9 cm, D_3= 12 cm**.** The data represents the mean values ± standard error.

4.14 Corm length

4.14.1 Effect of micronutrient

The corm length showed significant difference for different doses of micronutrient application in gladiolus (Table 12 and Appendix XX). Due to the micronutrient application, the ranges of corm length were found 2.63 cm to 3.90 g. The highest

value of corm length was recorded in M_2 while the lowest value of corm length was recorded in M_0. The present finding is suggested by and Sairam *et al*. (2011).

4.14.2 Effect of sowing depth

Impact of sowing depth on gladiolus showed significant effect on corm length (Table 13 and Appendix XX). The highest corm length was found in D_2 while the lowest corm length was recorded in D_1. The value of corm length ranges from 3.10 cm to 3.82 cm. The similar result also reported by Uddin *et al*. (2002) and Konoshima (1980).

4.14.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing showed significant impact on corm length (Table 14 and Appendix XX). The values of corm length were ranges from 2.10 cm to 4.37 cm while M_2D_2 produced the highest value of corm length. The lowest corm length (2.10 cm) was found in the treatment M_0D_1.

4.15 Number of corm plot^{-1}

4.15.1 Effect of micronutrient

Due to micronutrient application the number of corm plot^{-1} showed significant result of gladiolus plant (Table 12 and Appendix XXI). The number of corm plot^{-1} ranges from 12.22 to 29.88. The highest number of corm plot^{-1} (29.88) was recorded in M_2 treatment and the lowest number of corm plot^{-1} (12.22) was recorded in M_0 treatment. The present finding is suggested by Fahad *et al*. (2014), Katiyar *et al.* (2012) and Singh *et al.* (2012).

Table 14. Combined effect of corm diameter, corm length, corm number and corm yield

Treatment	Diameter of corm (cm)		Length of corm (cm)		Number of corm/plot		Yield of corm (t/ha)	
M_0D_1	4.06	I	2.10	h	10.33	h	6.80	i
M_0D_2	4.60	Fg	3.00	g	14.00	g	8.57	g
M_0D_3	4.40	H	2.79	g	12.33	gh	7.60	gh
M_1D_1	4.77	F	3.46	ef	17.00	f	9.57	f
M_1D_2	5.77	bc	3.93	bc	32.00	bc	12.80	bc
M_1D_3	5.45	cd	3.60	def	23.67	e	10.00	e
M_2D_1	5.89	B	3.51	ef	22.00	e	8.80	e
M_2D_2	6.33	A	4.37	a	37.67	a	15.06	a
M_2D_3	5.72	bc	3.83	bcd	30.00	c	12.00	c
M_3D_1	5.09	E	3.36	f	19.00	f	9.13	f
M_3D_2	5.94	B	4.00	b	33.67	b	13.47	b
M_3D_3	5.37	de	3.67	cde	27.00	d	10.80	d
SE (±)	0.11		0.09		0.70		9.34	

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg), D_1= 6 cm, D_2= 9 cm, D_3= 12 cm. Different letter(s) Corresponds to significance differences at $p \leq 0.05$ by Duncan's Multiple Range Tests.

4.15.2 Effect of sowing depth

The number of corm plot^{-1} showed statistically significant variations due to different depth of sowing on gladiolus cultivation (Table 13 and Appendix XXI). The highest number of corm plot^{-1} (29.33) was recorded in D_2 while lowest number of corm plot^{-1} (17.08) was in D_1. The present finding consisted with the finding of Uddin *et al.* (2002).

4.15.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing produced statistically significant number of corm plot^{-1} (Table 14 and Appendix XXI). For combined effect, the number of corm plot^{-1} ranges from 10.33 to 37.66. The highest number of corm per plot found in M_2D_2 and lowest number of corm plot^{-1} was found in M_0D_1 combination compared to the others combination.

4.16 Corm yield

4.16.1 Effect of micronutrient

Corm yield showed significant difference for different doses of micronutrient application (Figure 7 and Appendix XXII). Due to the micronutrient application, the ranges of corm yield was found 4.88 t/ha to 11.93 t/ha. The highest value of corm yield was recorded in M_2 while the lowest value of corm yield was recorded in M_0. Fahad *et al*. (2014), Katiyar *et al.* (2012), Singh *et al.* (2012), Sairam *et al*. (2011) also reported the similar finding.

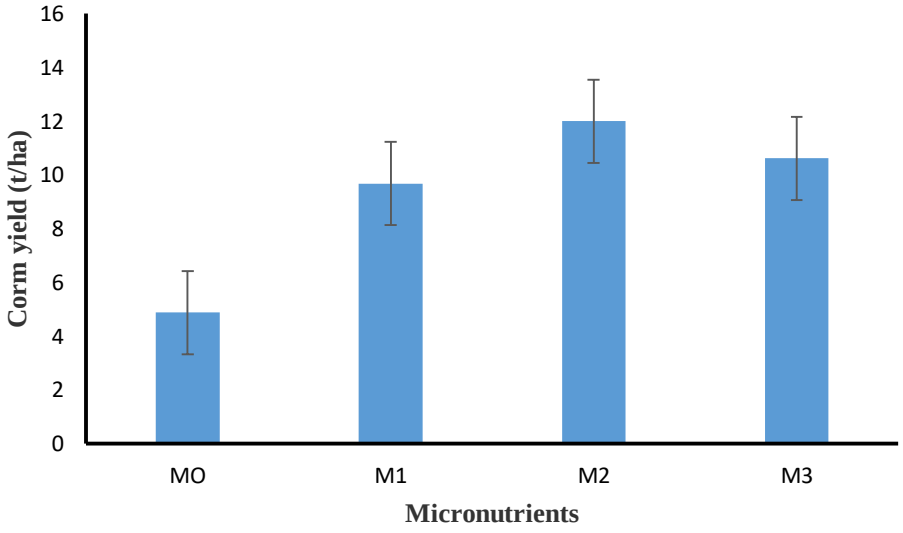
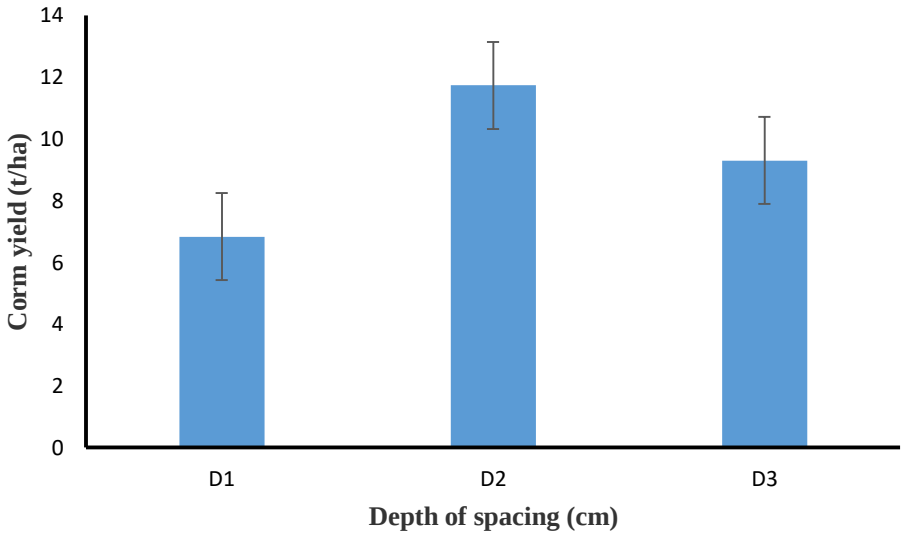


Figure 7. Effect of micronutrient on corm yield of Gladiolus

M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg). The data represents the mean values ± standard error.

4.16.2 Effect of sowing depth

Impact of depth of sowing of gladiolus showed significant effect on corm yield (Figure 8 and Appendix XXII). The highest corm yield (11.73 t ha^{-1}) was found in D_2 while the lowest value of corm yield (6.83 t ha^{-1}) was recorded in D_1 treatment. The present finding consisted with the finding of Daneshvar and Zangeneh (2003), Uddin *et al*. (2002) and Konoshima (1980).



Figue 8. Effect of sowing depth on corm yield of Gladiolus

D_1= 6 cm, D_2= 9 cm, D_3= 12 cm**.** The data represents the mean values ± standard error

4.16.3 Combined effect of micronutrient and depth of sowing

Combined effect of micronutrient and depth of sowing showed significant impact on corm yield (Table 14 and Appendix XXII). The values of corm yield were ranges from 6.80 t/ha to 15.06 t/ha while M_2D_2 produced the highest value of corm yield (15.06 t/ha). The lowest corm yield (6.80 t/ha) was found in M_0D_1.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to study the effect of depth of corm and use of micronutrient (Mg, Ca and Zn) foliar application on the growth, flowering and corm production of gladiolus. The experiment comprised as two factors, Factor A micronutrients i.e M_0 = Control, M_1 = (Zn 50 mg, Mg 200 mg, Ca 400 mg), M_2 = (Zn 100 mg, Mg 300 mg, Ca 500 mg), M_3 = (Zn 150 mg, Mg 400 mg, Ca 600 mg) and factors B three levels of depth of planting i.e. D_1 = 6 cm, D_2 = 9 cm and D_3 = 12 cm. The experiment was laid out in Randomized Complete Block Design with three replications. Data on different growth parameters, yield attributes and yield were recorded and analyzed.

The plant height ranges from 34.20 cm to 47.55 cm, 48.42 cm to 61.80 cm and 54.13 cm to 67.91 cm at 30 DAS, 45 DAS and at harvest, respectively. For the application of micronutrient, the tallest plant was recorded in M_2 treatment while the shortest plant was recorded in M_0 treatment at all sampling dates. The tallest plant was recorded in D_2 while the shortest plant was in D_1. The plant height ranges from 38.68 cm to 46.90 cm, 51.99 cm to 61.80 cm and 58.76 cm to 67.30 cm at 30 DAS, 45 DAS and at harvest time, respectively. For the interaction effect, the height of gladiolus ranges from 32.50 cm to 52.26 cm, 46.06 cm to 67.16 cm and 52.43 cm to 73.76 cm at 30 DAS, 45 DAS and at harvest time, respectively. The tallest plant was found in M_2D_2 and the shortest plant was found in M_0D_1 combination compared to the others combination.

Due to micronutrient, the ranges of number of leaves plant^{-1} was found 2.58 to 4.07, 3.09 to 4.53 and 4.71 to 6.34 at 30 DAS, 45 DAS and at harvest times, respectively. The maximum number of leaves plant^{-1} was recorded in M_2 while the minimum

number of leaves plant^{-1} was recorded in treatment M_0. The maximum number of leaves plant^{-1} was found in D_2 treatment while the minimum number of leaves plant^{-1} was recorded in D_1 treatment. The leaves number ranges from 3.08 to 4.03 cm, 3.50 to 4.45 and 5.18 to 6.33 at 30 DAS, 45 DAS and harvest time, respectively. The number of leaves plant^{-1} ranges from 2.23 to 4.56, 2.83 to 5.16 and 4.53 to 7.20at 30 DAS, 45 DAD and harvest time, respectively while M_2D_2 produced the maximum number of leaves plant^{-1} and M_1D_1 produced minimum number of leaves plant^{-1}.

Due to micronutrient application, the ranges of leaf area were found 82.55 cm^2 to 144.33 cm^2. The maximum leaf area was recorded in M_2 while the minimum leaf area was recorded in M_0. The maximum leaf area was found in D_2 treatment while the minimum leaf area was recorded in D_1 treatment. The leaf area ranges from 97.16 cm^2 to 145.75 cm^2.The leaf area ranges from 77.66 cm^2 to 177.67 cm^2 while M_2D_2 produced the maximum leaf area and M_1D_1 produced the minimum leaf area.

Due to micronutrient application, the ranges of chlorophyll content were found 58.32% to 71.11%. The maximum chlorophyll content was recorded in M_2 while the minimum chlorophyll content was recorded in M_1. The maximum chlorophyll content was found in D_2 treatment while the minimum chlorophyll content was recorded in D_1 treatment. The chlorophyll content ranges from 61.92% to 71.69%. The chlorophyll content ranges from 55.16% to 65.56% while M_2D_2 produced the height chlorophyll content and M_1D_1 produced the lowest chlorophyll content.

The ranges of number of leaves hill^{-1} was found 65.55 days to 81.83 days. The shorter days was required for spike emergence in M_2 treatment while the longest times was required for M_0 treatment. The longest time of days to pike emergence was needed in D_1 treatment while the shorter times of days to pike emergence was required in D_2 treatment. The days to pike emergence ranges from 66.01 days to 76.85 days. The highest value of days to spike emergence were in M_0D_1 (83.93 days)

and lowest value of days spike emergence were in M_2D_2 (59.50 days). The result revealed that M_2D_2 facilitated earlier seedling emergence compared to others combination while M_0D_1 took maximum time to seedling emergence.

The spike length ranges from 46.12 cm to 60.04 cm. The height spike length (60.04 cm) was recorded in M_2 treatment and the lowest spike length (46.12 cm) was recorded in M_1 treatment. The highest spike length (145.75 cm) was recorded in D_2 while the lowest spike length (97.16 cm) was found in treatment D_1. The highest spike length was found in M_2D_2 and lowest spike length was found in M_0D_1 combination compared to the others interaction. For combined effect the spike length ranges from 46.06 cm to 66.40 cm.

The highest value of number of floret (11.25) was recorded in M_2 while the lowest value of the same traits (4.27) was recorded in the treatment M_0. The highest value of the number of floret (11.20) was found in D_2 treatment while the lowest value of the number of floret (6.27) was recorded in D_1 treatment. The M_2D_2 produced the height value of number of floret and the combination M_0D_1 produced the lowest value of number of florets. The number of floret ranges from 3.33 to 14.26.

The diameter of floret ranges from 3.31 cm to 10.23 cm. The maximum diameter of floret was recorded in M_2 treatment and the minimum diameter of floret was recorded in M_0 treatment. The maximum diameter of floret was recorded in D_2 while the lowest values of diameter of floret was found in D_1. The diameter of floret ranges from 5.20 cm to 7.77. For the combined effect, the diameter of floret ranges from 2.30 cm to 13.26 cm. The maximum diameter of floret was found in M_2D_2 and minimum diameter of floret was recorded in M_0D_1 combination compared to the others combination.

Due to micronutrient application, the spike plot^{-1} ranges were found from 11.44 to 20.11. The maximum number of spike plot^{-1} was recorded in M_2 while the minimum number of spike plot^{-1} was recorded in M_0. The maximum number of spike plot^{-1} was found in D_2 while minimum number of spike plot^{-1} was recorded in D_1 treatment. The number of spike plot^{-1} ranges from 14.75 to 23.25.The number of spike plot^{-1} ranges from 9.00 to 28.00 while M_2D_2 produced the maximum number of spike plot^{-1} and M_0D_2 produced minimum number of spike plot^{-1}.

The spike yield ranges from 1,52,000 ha^{-1} to 3,11,000 ha^{-1}. The highest spike yield was recorded in M_2 treatment and the lowest spike yield was recorded in M_1 treatment. The highest spike yield (3,09,000 ha^{-1}) was recorded in D_2 while lowest spike yield (1,96,000 ha^{-1}) was in D_0. For combined effect, the spike yield ranges from 1,20,000 ha^{-1} to 3,73,000 ha^{-1}. The highest spike yield found in M_2D_2 and lowest spike yield was found in M_0D_1 combination compared to the others combination.

Due to micronutrient application, the ranges of number of corm plant^{-1} of gladiolus was found 1.22 to 2.53. The highest number of corm plant^{-1} was recorded in M_2 while lowest number of corm plant^{-1} was recorded in M_0. Due to the effect of depth of sowing on number of corm plant^{-1} of gladiolus, the highest number of corm plant^{-1}was found in D_2 while the lowest number of corm plant^{-1} was recorded in D_1 treatment. The number of corm plant^{-1} ranges from 1.56 to 2.55.The number of corm plant^{-1} of gladiolus ranges from 1.10 to 3.16 while the treatment M_2D_2 produced the highest number of corm plant^{-1} and M_0D_1 produced lowest number of corm plant^{-1}.
The individual corm weight ranges from 49.45 g to 69.12 g. The highest values of individual corm weight (69.12 g) were recorded in M_2 treatment and the lowest value of individual corm weight (49.45 g) was recorded in M_0 treatment. The significant influence of depth of sowing facilitated highest individual corm weight in D_2 while the lowest individual corm weight was recorded in D_1. The individual corm weight

ranges from 54.58 g to 69.91 g. For the interaction effect, individual corm weight ranges from 45.96 g to 79.23 g. The highest individual corm weight (79.23 g) was found in M_2D_2 and the lowest individual corm weight (45.96 g) was found in M_0D_1 combination compared to the others combination.

The ranges of corm diameter were found 4.35 cm to 5.97 cm. The highest value of corm diameter (5.97 cm) was recorded in M_2 treatment while the lowest value of corm diameter (4.35 cm) was recorded in M_0 treatment. The highest value of corm diameter (5.65 g) was found in D_2 while the lowest value of corm diameter (4.95 g) was recorded in D_1 treatment. The corm diameter was ranges from 4.06 g to 6.32 g. The treatment M_2D_2 produced the highest value of corm diameter and M_0D_1 produced lowest value of corm diameter.

Due to the micronutrient application, the ranges of corm length were found 2.63 cm to 3.90 g. The highest value of corm length was recorded in M_2 while the lowest value of corm length was recorded in M_0. The highest corm length was found in D_2 while the lowest corm length was recorded in D_1. The value of corm length ranges from 3.10 cm to 3.82 cm. The values of corm length were ranges from 2.10 cm to 4.37 cm while M_2D_2 produced the highest value of corm length. The lowest corm length (2.10 cm) was found in the treatment M_0D_1.

The number of corm plot^{-1} ranges from 12.22 to 29.88. The highest number of corm plot^{-1} (29.88) was recorded in M_2 treatment and the lowest number of corm plot^{-1} (12.22) was recorded in M_0 treatment. The highest number of corm plot^{-1} (29.33) was recorded in D_2 while lowest number of corm plot^{-1}(17.08) was in D_1. For combined effect, the number of corm plot^{-1} ranges from 10.33 to 37.66. The highest number of corm plot^{-1} found in M_2D_2 and lowest number of corm plot^{-1} was found in M_0D_1 combination compared to the others combination.

Due to the micronutrient application, the ranges of corm yield were found 4.88 t/ha to 11.93 t/ha. The highest value of corm yield was recorded in M_2 while the lowest value of corm yield was recorded in M_0. For depth, the highest corm yield (11.73 t/ha) was found in D_2 while the lowest value of corm yield (6.83 t/ha) was recorded in D_1 treatment. The values of corm yield were ranges from 6.80 t/ha to 15.06 t/ha while M_2D_2 produced the highest value of corm yield (15.06 t/ha). The lowest corm yield (6.80 t/ha) was found in M_0D_1.

Recommendations

The present experiment was conducted only one season even in a single location. So, it is difficult to recommend this finding without conducting and validating by further study. By considering the results of the present experiment, further studies should have carried out in different location with an increasing and decreasing the treatments.

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APPENDICES

Appendix I. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from October 2016 to March 2017.

Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2016	36.4	28.1	69	12.8	5.5
November, 2016	35.4	25.7	68	7.7	5.6
December, 2016	24.1	12.5	68	28.9	5.5
January, 2017	22.5	16.4	64	65.8	5.2
February, 2017	32.9	23.6	70	76.4	5.7
March, 2017	40.5	29.5	75	80.6	5.8

Source: Sher-e-Bangla Agricultural University Weather Station

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
pH	6.00-6.65
Organic mater	0.86
Total N (%)	0.49
Available phosphorous	18.2ppm
Exchangeable K	0.41meq/100gsoil
S	15.23 µg/g soil
Boron	0.29
Ca	6.30 meq/100g soil

Source: Soil Resource Development Institute (SRDI), Dhaka

Appendix III: Analysis of variance on plant height at 30 DAS

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	930.356	310.119	19.517	0.000
Depth	2	408.665	204.333	6.546	0.004
Micronutrient × Depth	11	1397.400	127.036	73.609	0.000

Appendix IV: Analysis of variance on plant height at 45 DAS

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	977.405	325.802	15.807	0.000
Depth	2	581.974	290.987	9.102	0.001
Micronutrient × Depth	11	1625.976	147.816	322.703	0.000

Appendix V: Analysis of variance on plant height at harvest

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	998.472	332.824	15.829	0.000
Depth	2	455.107	227.554	6.174	0.001
Micronutrient × Depth	11	1518.443	138.040	21.674	0.000

Appendix VI: Analysis of variance on leaf number at 30 DAS

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	12.396	4.132	22.086	0.000
Depth	2	5.442	2.721	6.939	0.003
Micronutrient × Depth	11	18.076	1.643	128.601	0.000

Appendix VII: Analysis of variance on leaf number at 45 DAS

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	10.478	3.493	17.765	0.000
Depth	2	5.400	2.700	7.837	0.002
Micronutrient × Depth	11	16.333	1.485	81.809	0.000

Appendix VIII: Analysis of variance on leaf number at harvest

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	14.304	4.768	15.357	0.000
Depth	2	7.940	3.970	8.037	0.001
Micronutrient × Depth	11	23.687	2.153	93.398	0.000

Appendix IX: Analysis of variance on leaf area

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	19833.222	6611.074	11.950	0.000
Depth	2	14164.389	7082.194	9.999	0.000
Micronutrient × Depth	11	37265.889	3387.808	299.659	0.000

Appendix X: Analysis of variance on chlorophyll content

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	892.432	297.477	14.912	0.000
Depth	2	573.652	286.826	9.889	0.000
Micronutrient X Depth	11	1509.225	137.202	152.747	0.000

Appendix XI: Analysis of variance on days to spike emergence

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	1410.463	470.154	18.162	0.000
Depth	2	707.780	353.890	7.628	0.002
Micronutrient × Depth	11	2207.634	200.694	154.314	00.000

Appendix XII: Analysis of variance on length of spike

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	995.992	331.997	12.162	0.000
Depth	2	460.727	230.363	5.420	0.009
Micronutrient × Depth	11	1639.121	149.011	15.945	0.000

Appendix XIII: Analysis of variance on number of florets

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	252.636	84.212	16.033	0.000
Depth	2	146.296	73.148	8.796	0.001
Micronutrient × Depth	11	417.676	31.971	299.768	0.000

Appendix XIV: Analysis of variance on diameter of floret

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	252.808	84.269	15.879	0.000
Depth	2	149.047	74.523	8.989	0.001
Micronutrient X Depth	11	421.034	38.276	576.540	0.000

Appendix XV: Analysis of variance on number of spikes per plot

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	747.417	249.139	15.653	0.000
Depth	2	434.000	217.000	8.704	0.001
Micronutrient X Depth	11	1220.083	110.917	72.600	0.000

Appendix XVI: Analysis of variance on yield of spike/ha

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	132874076296.528	44291358765.509	15.653	0.000
Depth	2	77155444444.500	38577722222.250	8.704	0.001
Micronutrient X Depth	11	216903596296.750	19718508754.250	72.600	0.000

Appendix XVII: Analysis of variance on number of corm/plot

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	9.014	3.005	13.326	0.000
Depth	2	5.811	2.905	9.202	0.001
Micronutrient X Depth	11	16.010	1.455	158774	0.000

Appendix XVIII: Analysis of variance on individual weight of corm

Source of variation	df	SS	MS	F- value	Significance level
Micronutrient	3	2059.450	686.483	13.071	0.000
Depth	2	1414.134	707.067	10.032	0.000
Micronutrient X Depth	11	3692.776	335.707	170.482	0.000

Appendix XIX: Analysis of variance on diameter of corm

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	12.440	4.147	29.076	0.000
Depth	2	3.055	1.528	3.614	0.038
Micronutrient X Depth	11	16.187	1.472	43.253	0.000

Appendix XX: Analysis of variance on length of corm

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	8.791	2.930	23.379	0.000
Depth	2	3.075	1.537	5.215	0.011
Micronutrient X Depth	11	12.208	1.110	44.785	0.000

Appendix XXI: Analysis of variance on number of corm/plot

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	1598.000	532.667	15.692	0.000
Depth	2	900.389	1450.194	8.328	0.001
Micronutrient X Depth	11	2648.889	240.808	163.568	0.000

Appendix XXII: Analysis of variance on yield of corm/ha

Source of variation	Df	SS	MS	F- value	Significance level
Micronutrient	3	284089004444.556	94696334814.852	15.692	0.000
Depth	2	160069462716.222	80034731358.111	8.328	0.001
Micronutrient X Depth	11	470914049383.222	42810368125.747	163.567	0.000