INFLUENCE OF MICRONUTRIENTS AND MULCHES ON GROWTH, FLOWERING AND YIELD OF GLADIOLUS

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BY

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CERTIFICATE

This is to certify that the thesis entitled **"Influence of micronutrients and mulches on growth, flowering and yield of gladiolus"** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **Aysha Jannatul Ferdousi, Registration No. 11- 04254**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Dated: JUNE, 2017
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DEDICATED TO MY BELOVED PARENTS

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INFLUENCE OF MICRONUTRIENTS AND MULCHES ON GROWTH, FLOWERING AND YIELD OF GLADIOLUS

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ABSTRACT

A field experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2016 to May 2017. The experiment consisted of two factors such as Factor A: Micronutrients (B, Zn and Mn) (4 levels): MN_0 - control, MN_1-36 ppm of each micronutrient, MN_2 – 72 ppm of each micronutrient and MN_3 – 108 ppm of each micronutrient and Factor B: Mulches (4 levels) M_0 - Control, M_1 - Water hyacinth, M_2 - Rice straw, M_3 - Black polythene. This experiment was laid out in a randomized complete block design with three replications. The results of the experiment showed that the foliar application of micronutrients and mulches had significant effect on most of the parameters. Maximum number of spike (300500/ha) was recorded for MN_2 and minimum (234250/ha) for Control. Among all mulches, black polythene produced the highest number of spike (265250/ha) while control produced the lowest number of spike (242920/ha). However, the treatment combination of black polythene and 72 ppm of each micronutrient showed the best performance in respect of vegetative growth, flowering and corm production in Gladiolus.

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LIST OF ABBRIVIATIONS

AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
CV%	=	Co-efficient of Variance
DAP	=	Days after planting
et al.	=	and others *(at alia)*
kg/ha	=	Kilogram/hectare
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
pH	=	Hydrogen ion concentration.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
UNDP	=	The United Nations Development Program

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). It is considered to be the “queen of bulbous flowers”. The word gladiolus was coined by Pliny the Elder (AD 23-79) and has been derived from a Latin word “Gladius” meaning “Sword” (sword like leaves of plant). Gladiolus, a member of family Iridaceae and sub-family Ixidaceae, originated from South Africa, is a prominent bulbous cut flower plant. The genus Gladiolus contains 180 species with more than 10,000 cultivars (Sinha and Roy, 2002). It is of great economic value as a cut flower. It is commercially cultivated for ornamental and as well for medicinal purposes. It bears innumerable cultivars with the assortment of alluring colors.

Gladiolus is one of the most consequential bulbous flowering crops grown commercially for cut-flower trade in Bangladesh. In Bangladesh gladiolus was introduced from India around the year 1992 (Mollah *et al.*, 2002). The commercial growers are growing gladiolus in different zones of the country especially in Jessore, Savar, Comilla etc. province to fulfill the local consumption demand; however, the production and flower quality are still too low to meet the international standards.

Gladiolus occupies fourth place in international cut flower trade (Bhattacharjee and De, 2010). It has second rank after tulip among the bulbous flowers in India (Singh *et al*., 2012). It is now grown as a cut flower widely in Europe, particularly in Holland, Italy and Southern France (Butt, 2005).

Micronutrients play vital roles in the growth and development of plants, due to their stimulatory and catalytic effects on metabolic processes and ultimately on flower yield (Lahijie, 2012) and quality (Khosa *et al*., 2011). Although small amount of micronutrient is required compared to a macronutrient, nevertheless micronutrient deficiency can inhibit the crop growth and production. Moreover, micronutrients help to increase the efficiency of the use of macronutrients. Information regarding nutritional requirements and appropriate soil management practices are lacking for gladiolus cultivation in Bangladesh. So, the growers lack enough information on these elements and are not familiar with their prominent role in increasing yield and producing high quality cut flowers, causing soils deprived of micronutrients which in turn can hamper plants to produce their optimum size of spike, corms and cormels for flower cultivation.

Boron is a micronutrient requiring for plant growth relatively to a smaller amount. Plants require boron for a number of growth processes such as new development in meristematic tissue, translocation of sugars, starches, nitrogen and phosphorus and synthesis of amino acids and proteins (Tisdale *et al*., 1984). There are evidences that Boron plays a vital role as stabilizer of cell wall pectin network (Dordas & Brown, 2005). It promotes the stability and rigidity of cell wall structure and therefore, supports the shape and strength of the plant cell (Brown *et al*., 2002). Furthermore, boron is possibly involved in the integrity of the plasma membrane (Brown *et al*., 2002; Cara *et al*., 2002; Dordas & Brown, 2005).

Zinc has been identified as component of almost 60 enzymes, therefore, it has a role in many plant functions, also it has important role in producing the growth hormone IAA (Mallick and Muthukrishnan, 1979). The beneficial effect of Zn on photosynthetic pigments may be due to its role in increasing the rates of photochemical reduction (Kumar *et al*., 1988), chloroplast structure, photosynthetic electron transfer as well as photosynthesis (Romheld and Marschner, 1991).

Zinc is an essential micronutrient necessary for sugar regulation and assorted enzymatic activity associated with plant growth (Khosa *et al*., 2011). Zinc plays an important role in protein and starch syntheses, and therefore, a low zinc concentration induces accumulation of amino acids and reducing sugars in plant tissue (Graham and McDonald, 2001).

Manganese is used in plants as a major contributor to various biological systems including photosynthesis, respiration, and nitrogen assimilation. It is also involved in pollen germination, pollen tube growth, root cell elongation and resistance to root pathogens. Manganese is important in nitrogen metabolism and photosynthesis (Stout and Arnon, 1939). Manganese and iron play vital role in carbohydrate synthesis (Marshner, 1995).

Mulches is an important technology which decreases the loss of soil water through evaporation and conserves soil moisture thus reduces the irrigation requirements, increasing root development, promoting faster crop development, reducing weed attack and inducing earlier harvest of crop (Vavrina and Roka, 2000; Mahajan *et al*., 2007). Gladiolus is a long time and winter crop, so mulches is effective for cultivation. In soil management relationships, Mulches has been reported to influence organic matter content, activity of microorganisms, availability of soil nutrients, control of erosion and soil compaction and regulating soil temperature (Hassan, 1999; Stowell, 2000). Mulches improves the soil environment for increasing crop growth, development and yield. There is a scope of increasing flower and corm production of gladiolus using micronutrients and mulches.

Contemplating the above-mentioned facts, the present investigation was undertaken with the following objectives:

- To determine the optimum doses of micronutrients for growth, flowering and yield.
- To check the effect of mulches on growth, flowering and yield.
- To find out the best combination of micronutrients and mulches for ensuring the growth and flowering of gladiolus.

CHAPTER II

REVIEW OF LITERATURE

Gladiolus is one of the most important herbaceous annual and gorgeous cut flower. A very few studies on the related to growth, flower, and corm production due to standard level of micronutrients and mulch have been carried out in our country as well as many other countries of the world. So, the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative work and research findings related to the Influence of micronutrients and mulches on growth, flowering and yield of gladiolus reviewed under the following headings-

2.1 Influence of mulch on the growth and yield

Kumari et al. (2013) conducted an experiment to study the effect of plant density, planting methods and mulches on floral and cormel parameters in Gladiolus (*Gladiolus hybridus* L.) cv. American Beauty during both Kharif and Rabi seasons of 2007-08 and 2008-09. The experiments consisted of eight treatments with three replications, respectively were carried out by Randomized Complete Block Design. Days taken for spike emergence and first flower bud opening on the spike was, significantly less number of days (50.26 days) in T_7 (40x20 cm, paired row mulches) followed by T_1, T_3, T_5 (50.73, 51.27 and 51.63, respectively). The number of florets produced per spike, flower weight, flower yield per spike flower, yield per hectare recorded maximum in mulched plots with 30x20 spacing. There was increase in number of florets per spike, floret weight, floret yield per plot and per hectare was due to mulched plants i.e. T_1, T_3, T_5 and T_7 with single and paired row in both Kharif and Rabi season. The mulched plants like T_1, T_3, T_5 and T_7 with single row and paired row treatments showed significantly more number of corms, weight of corms, cormel number and cormel weight in mulched plots in both Kharif and Rabi seasons, respectively.

Mia (1996) conducted an experiment to observe the performance of different mulches in Bangladesh Agricultural University, Mymensingh. He noticed that mulches showed better performance in most of the yield contributing characters, such as plant height, number of leaves per plant, pseudo stem diameter and dry matters of root and shoot of onion. In Indonesia, straw has been proved to be the best mulch for garlic compared to transparent plastic, black plastic and cabbage residues as it yielded the largest bulbs and the highest number of cloves/bulb (Asandhi, 1989). Uddin (1997) observed similar result in garlic.

Majumder *et al*. (2016) described the effectiveness of organic and plastic mulches for potato mini tuber production in Bangladesh. The field experiment was carried out during the Rabi season of 2013-2014 to 2014-2015 with virus free *in vitro* cultured plantlets of var. Diamant. The mulches materials of water hyacinth mulch (WHM), rice straw mulch (RSM) and black polythene mulch (BPM) were compared with no-mulches (control) to find out suitable mulches material (s) for obtaining higher tuber yield. During the whole production period morphological characters, yield characters as well as of soil temperature and soil moisture were assessed. The results showed that WHM (5.28 t/ac) and RSM (4.59 t/ac) had a positive effect on increased the proportion of tuber size above 28 mm and on increasing of tuber yields by 54.0% to 77.2% compared with control (2.98 t/ac). Higher soil temperatures were recorded with plastic mulch caused lower potato tuber yield (3.04 t/ac) while WHM and RSM decreased soil temperatures and increased the moisture percentage. The mulches of mini tubers had negative effect on tubers quality in regards of scab, green tuber and weed biomass.

Gattorsen (1992) conducted an experiment to evaluate the effects of plastic mulch on the yield and yield contributing characters and reported that the double layer produced the higher yield than single layer mulches. Hossain (1996) carried out an experiment in Bangladesh Agricultural University, Mymensingh. Plant height, leaf number, pseudo stem and bulb diameter, dry matter content of foliage, bulb weight and bulb yield were found significantly higher for mulched plants.

Iroc *et al*. (1991) reported that different mulches materials influenced the average height and the average bulb diameter of garlic seedlings. Garlic mulched with rice husk and cogon produced the biggest bulb diameter while the other treatments resulted in reduced bulb diameters. The plants mulched with grab grass and cogon significantly developed the smallest bulb. Roy *et al.* (1990) by using water hyacinth, straw and sawdust as mulch on potato, opined that mulches increased leaf area index (LAI) and crop growth rate (CGR). Imam *et al.* (1990), Zehndar and Hough-Goldsteir (1989), Singh *et al*. (1987) and Prihar (1986) noted the same results. Supportive and explanatory results came from the studies of Maity *et al*. (1988) and Jha *et al*. (1986). They showed that highest yield was obtained from mulched treatment in comparison with unmulched on ginger.

Leaf area, leaf number of sweet potato cv. Jewel were significantly higher for mulched than for unmulched plants as concluded by Hockmuth and Howell (1983) adding that the highest marketable yield (18.6 t/ha) was obtained from mulched raised beds where flat unmulched beds gave the lowest yield (7.0 t/ha). Shyu (1979) agreed that *Dioscorea alata* mulched with rice straw, black plastic film or citronella yielded 350, 622 and 299 g fresh weight of tuber per plant respectively, compared with 131 g obtained from unmulched plants. Dry weight of stem, leaf number per plant, tuber length and dry weight of tuber were highest with black plastic mulch. Awal *et al*. (1978) obtained as significant increase in yield of mukhikachu with the use of rice straw as a mulch.

Solaiman *et al.* (2007) examined the effect of black plastic mulch and concluded that flower initiation with plants under black plastic mulch was earlier than the straw mulch or control and was identical with water hyacinth mulch. It was might be due to the increased soil temperature of black polythene mulch treatment, that was directly related to early initiation of flower and the increased cumulative number of flowers.

Kar and Kumar (2007) observed higher yield and better crop growth in the mulched plots, which might be due to conservation of soil moisture and reduction of soil temperature by 4-8 °C. Straw mulch at a rate of 6 t ha^{-1} was applied during the first earthing up in half of the plots to observe the variation of plant growth, water use efficiency and tuber production between mulched and non-mulched plots. Two years of pooled data with four irrigations resulted in air-dry tuber yields of 14.9 and 11.2 t ha^{-1}.

Chaudhry *et al.* (2004) evaluated the efficiency of different mulches materials on moisture conservation, soil properties and plant growth. The infiltration rate of the soil increased by 30 % at the end of the study and maximum saving of 45 % irrigation water was recorded under polythene sheet followed by 30 % under rice straw and 15 in mechanical loosing of soil. Maximum plant height was observed under mulches through mechanical loosing of indicating that mechanical loosing of soil had some positive impact on plant height where as non-application of mulches material had the minimum plant height. For the mulched and non-mulched plots, respectively. Significantly ($p<0.05$) higher leaf area index, water use efficiency and intercepted photo synthetically active radiation (IPAR) were recorded in the mulched plots compared to the non-mulched plots under the same irrigation treatment.

Khalak and Kumaraswamy (1992) conducted a field trial in 1985- 1987 on red sandy soil at Bangalore, karantakca. Potatoes cv. Kufrijyoti was irrigated with 20 or 40 mm water and the crop was given no mulch, straw mulch or polythene mulch. Tuber yield and N uptake were the highest in both years with 20mm irrigation water. Mulches with straw and polythene gave average tuber yields of 18.2 and 16.7 t/ha respectively compared with 14.3 t/ha without mulches.

Rashid *et al*. (1981) conducted a trial at Joydeppur, Dhaka on potato cv. Cardinal cultivated with or without ridges, without mulches or mulches with water hyacinth, rices straw, or spike lets (Chitta). Tuber yield was the highest (17.6 t/ha) when the plants ridged and mulched with water hyacinth. Emergence in the no mulched plots was significantly lower than that of mulched plots.

Burger and Nel (1984) reported that mulches by straw produced 30% more tubers than the no mulch potato crops. Similarly, Natheny *et al.* (1992) also found that white, pale blue and stripped straw mulch produced more than 15% marketable tubers of potato than the no much control plots.

Sutatcr (1987) found an increase in plant height and the number of potato leaf with different mulches treatments. Sarker and Hossain (1989) reported that one weeding just after emergence or mulches by paddy straw appeared optimal for the growth of a good potato crop. In another study, Taja *et al.* (1991) reported that mulches by rice straw with optimum inorganic fertilizer application of 50 kg N/ha were good for canopy coverage of potato.

Sarker and Hossain (1989) studied the effect of weeding and mulches on potato cv. Cardinal and reported that the percentage of foliage coverage, which ranged from40.0 to 65.00, was significantly different among the treatments, the lowest coverage being obtained from the control (no weeding) treatment. Mulches also increased growth of leaf and stem (kim *et al.* 1988). According to Devaux (1987), mulches reduced the soil temperature due to better ground cover.

Crusciol *et al.* (2005) reported that straw of covering plants kept on soil surface in no-tillage system is an important source of nutrients for subsequent tillage. This study investigated the decomposition and release of macronutrients from forage turnip residues. The experiment was set under field conditions during 1998 in Marechal Candido Rondon, Parana, Brazil. Forage turnip plants were desiccated and lodged 30 days after emergence. Straw persistence and nutrient release were evaluated at 0, 13, 35, and 53 days after management. Untill per-flowering stage, the crop turnip showed a high dry matter yield (2938 kg/ha) during winter, and accumulated 57.2, 15.3, 85.7 and 14.0 kg/ha of N, P, K, Ca, Mg and S, respectively. Forage turnip management at pre-flowering stage resulted a quick straw degradation and macronutrients release. Potassium and N were released in the highest amounts and in the shortest time to subsequent tillage. The fastest liberation of nutrients occurred between 10 and 20 days after plant management.

Chowdhury *et al.* (2000) conducted a field experiment in the rabi season of 1997-1998 on a clay terrace soil in Salna, Gazipur, Bangladesh, to study the effect of rice straw mulches and irrigation on the yield total water use and water use efficiency of an indigenous low yielding cultivar of potato, Lalpakri. Irrigation is indispensable in the rabi season of Bangladesh and the yield was significantly lowest in the treatment of no irrigation after seedlings establishment. Rice straw mulch conserved soil moisture and maintained a higher moisture regime in each irrigation level through the cropping period. The treatments of rice straw mulches and the single irrigation at 30 days after sowing were the best combination with a satisfactory high yield.

Annu Verma and Sarnaik (2006) carried out an experiment at the farmer's field as On-farm trial (O.F.T.) during 2001-02 in the village Bhatagaon at Raipur district of Chhattisgarh state. was used for experiment with four replications and five treatments. Locally available materials like paddy straw (M_1), dry grass (M_2), palash leaves (M_3), along with plastic mulch (M_4, black polythene) were used as mulches material in this study. A treatment without mulch (M_5) was also included as control. Five treatments were replicated four times in randomized block design. The results indicated that the treatment in which paddy straw was used as mulch gives maximum average plant height (84.40 cm.) and number of leaves (10.32) as compared to other treatments. In case of yield of turmeric also, the black polythene mulch gave maximum yield (169.33 q/ha.) followed by mulches with dry grass (131.33q/ha.).

Liu and Hu (2000) carried out an experiment on growing turnip in an area of 2900 m above sea level in Gansu, China indicated that plastic mulches would promote the growth and yield of the turnip by improving soil temperature and moisture. Compared with the control (without mulches), the crop with mulches had earlier emergence by 6 days, a 2-fold faster average growth rates, a 1.65-fold larger maximum leaf area index, a 15 day longer closed canopy, a 20.8% higher yield and increased protein, fiber, Ca and P. Highest yield was attained than control.

Rahman *et al.* (2013) reported that the results of their research indicated that growth parameters such as plant height and number of leaves at different days after transplanting, dry weight of leaf, pseudostem and root were increased significantly with the application of mulches (M). Mulches of soil with straw (Ms) and water hyacinth (Mw) increased the length and diameter of bulb, fresh weight and dry weight of bulb and bulb yield. Interestingly, the bulb yield did not show significant differences between Ms and Mw. But mulches with water hyacinth numerically gave the highest yield (10.46 t /ha) than the mulches with rice straw (9.78 t /ha). Therefore, the use of water hyacinth as mulches material may be applied to grow onion.

Ruiz *et al*. (1999) conducted a field experiment about potato tubers (Solanum tuberosum var. Spunta) and analyzed that Use of white polyethylene (T_2) and white-black plastic (T_3) promoted optimal root temperatures for plant growth (23-27 °C). Under these experimental conditions, plants showed the greatest efficiency in N utilization and the greatest yield in tubers. Considering the sensitivity of this plant to thermal stress, high root temperatures caused by black polyethylene (>31 °C) (T_4) depressed N metabolism as well as yield, compared with the results of T_2 and T_3. Finally, clear polyethylene plastic (T_1) caused more damage than did the absence of mulch (control, T_0).

Salma *et al.* (2016) conducted an experiment at Precision Farming Development Centre, Department of Horticulture, CCS Haryana Agricultural University, Hisar, India during the years 2011-12 and 2012-13, to study the effect of mulches with different irrigation methods on weed growth and soil moisture percentage in gladiolus variety Advance Red. Black polythene mulch was used and weed growth was recorded at monthly intervals whereas soil moisture percentage was recorded using portable soil moisture meter at active root zone (5-10 cm depth). The experiment was laid out in RBD with seven treatments and replicated thrice. The results of the experiment revealed that the treatment having Raised beds with drip irrigation and black polythene mulch resulted in significantly minimum weed fresh weight (1.2 and 1.3 g/m^2) over all other treatments. Soil moisture content was higher and maintained an optimum range near active root zone during the entire growth period in drip irrigation and mulches treatment (19-26%) whereas unmulched treatments (13-16%) recorded least soil moisture percentage. It was concluded that mulches with black polythene in drip irrigation significantly helped to conserve soil moisture and to reduce the weed growth in gladiolus.

Mazed *et al.* (2015) reported that an experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Bangladesh during the period from November 2013 to March 2014 to study the effect of different types of organic manure (no organic manure, cowdung, compost and litter) and mulches on (non-mulch, water hyacinth, rice straw and black polythene) the growth and yield of carrot. The experiment was conducted in a Randomized Complete Block Design with three replications. Application of organic manure and mulches significantly influenced the growth and yield of carrot. Cowdung resulted in the highest gross yield (39.05 t/ha) whereas, the plants received no organic manure produced the lowest for the same (33.03 t/ha). The highest gross (39.12 t/ha) and marketable (35.79 t/ha) yield was obtained from the black polythene mulch while the lowest was obtained from non-mulched plot. Cowdung with black polythene mulch produced the highest yield (42.75 t/ha) followed by that of application of litter with black polythene mulch (41.46 t/ha). The lowest (32.00 t/ha) was recorded from the control.

Mishra and Pandey (2009) were conducted an experiment in participatory mode on farmers' field. Eight ginger growing farmers of four villages of Garhwa district were selected to grow the crop by application of four types of mulches viz., Palas (*Butea monosperma* L.) leaves, Paddy straw, Dried bushes (Lantana americana, Ocimum americana, Parthenium etc.), FYM @ 10 t/ha each along with unmulched control in plots of 20 m^2 area during kharif, 2006 and 2007. It is evident from above observations that mulches of ginger with FYM resulted in maximum rhizome yield per plot, width of rhizome, number of tillers per hill, plant height and earliest emergence whereas mulches with Palas leaves exhibited maximum rhizome length, numbers of leaves per plants and minimum number of weeds per unit area.

Mahmood *et al*. (2002) conducted a field experiment to study the effect of mulches on growth and yield of potato crop were conducted for three years (1998, 1999 and 2000) at NARC, Islamabad. Mulches has very positive effect on emergence. In all the trials, it was maximum in T_1. After 35 days of planting, highest emergence was 78.5% in T_1, 84.25% in T_2 and 83.25% in T_1 during spring 1998, 1999 and 2000 respectively. After 45 DAP (days after planting), during 1998, 1999 and 2000, highest emergence was 97.67% in T_1, 100% in T_2 and 98.75% in T_1, respectively. In the trials lowest emergence was recorded in T_5 (control). Growth rate was also better in all treatments where mulches was applied as compared to control at 45 and 60 DAP. In the year 1998, at 60 DAP, maximum growth rate (64%) was recorded in T1, followed by 53.67% in T_2 and lowest (36.67%) in T_5. In 1999 trial, maximum growth rate (46.5%) was noted in T_2, followed by 43% in T_4 and minimum (30.25%) in T_5. In 2000 trial also highest growth (49%) was recorded in T_1 followed by 45.25% in T_2 and lowest (31.75%) in T_5. Similarly, at 75 DAP, all treatments where mulches was applied were found significantly different than control at 75 DAP. Mulches has also a significant effect on yield of potato crop. In the treatments where mulches was done with plastic sheet (black or white), yield was more than 17 t/ha (T_1, T_2 and T_3). In T_4 where grass mulch was applied, yield was 16.44 t/ha. However, highest yield (18.42 t/ha) was recorded in T1, followed by 17.6, 17.11 and 16.44 t/ha in T_2, T_3 and T_4, respectively. Lowest yield (11.48 t/ha) was obtained in T_5. Overall increase in yield was 60.45% in T_1, 49.04% in T_2, 53.31% in T_3 and 43.2% in T_4 over T_5.

Jalil (1995) conducted an experiment at the Horticulture farm, Bangladesh Agricultural University, Mymensingh in order to study effect of mulch on potato. Black polythene mulched potato took minimum time to reach 80% emergence, resulted maximum coverage of area. However, yield was higher with water hyacinth mulch. Mulches helps checking evaporation and thus soil can retain sufficient amount of moisture. Polyethylene film mulches reduce evaporation in vegetable cultivation (Lamont, 1993). Natheny *et al.* (1992) also found that white, pale blue and stripped straw mulch produced more than 15% marketable tubers of potato than no much (control) plots.

Taja *et al.* (1991) reported that mulches by rice straw with optimum inorganic fertilizer application of 50 kg N/ha was good for canopy coverage of potato. Artificial mulches like polythene are reported to increase the growth and yield of onion (Greisenheim, 1952). Black polythene, sawdust and dried grass mulch in potato production improved soil moisture retention but black polythene mulch had the best result (Patil and Basad, 1972). In a separate experiment, Bieoral (1970) found that polythene sheets caused a 2% increase in the moisture content of the top 30cm of the soil.

2.2 Effect of Mulch on Soil environment

Mulches have a dramatic effect on soil temperature and moisture regimes. Many researchers noted that soil environments were greatly influenced by mulches.

The effect of mulch and five levels of irrigation on soil evaporation, transpiration, evapotranspiration and yield of onion were studied in a glasshouse pot experiment by Abu-Awad (1999) and described that increasing irrigation level significantly increased evapotranspiration and/or transpiration. With mulch treatments, evapotranspiration was significantly reduced, while transpiration was significantly increased compared with open soil surface treatments. In covered soil surface treatments, onion yields were significantly higher than in open surface treatments.

Another experiment conducted by Shock *et al.* (1999) with wheat straw mulch, increased onion yield by 64%. They also reported that yield improvements were attributed to decreased water runoff and increased lateral water movement and soil moisture. Temperature and moisture regimes of soil were greatly influenced by mulches as described by many researchers like Bragagnolo and Mielniczuk (1990), Ashworth and Harrison (1983) and Hill *et al.* (1982). Checking leaching loss of NO_3-N in irrigated field, mulches ensured the efficient use of applied N-fertilizer as viewed by Cook and Sanders (1990).

Ammonification and nitrification were increased by mulches as deliberated by Boyajieva and Rankov (1989) who also observed enhanced CO_2 levels and reduced redox potential in mulched soil. Plastic mulch influenced the soil temperature differently than did water-hyacinth, saw-dust and straw mulch or crop residues (Roy *et al*., 1990).

Form a seasonal study of mulches, Manrique and Mayer (1984) observed that plastic mulches raised soil temperature during the winter giving significantly higher yield. In summer, plastic mulches increased for plant growth and tuber formation in potato. But favorable soil temperature in both winter and summer was maintained by straw mulch.

2.3 Effect of Micronutrients

Prabhat and Arora (2000) reported about 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% $ZnSO_4$.

Fahad *et al.* (2014) investigated 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 corm per plant, which was not affected significantly by the foliar application of the micronutrients.

Saba *et al*. (2013) examined the effect of zinc sulphate ($ZnSO_4$) and iron sulphate ($FeSO_4$) on the growth and flower production of gladiolus. Treatments included T_1= Control, T_2=20 g $ZnSO_4$, T_3=40 g $ZnSO_4$, T_4=20 g $FeSO_4$, T_5=20 g $ZnSO_4$ + 20 g $FeSO_4$ and T_6=40 g $ZnSO_4$ + 20 g $FeSO_4$.The experiment was laid out in a three replicated Randomized Complete Block Design. The effect of zinc sulphate ($ZnSO_4$) and iron sulphate ($FeSO_4$) on the growth and flower production of gladiolus was examined during 2012 and treatments included T_1=Control, T_2=20 g $ZnSO_4$,T_3=40 g $ZnSO_4$, T_4=20 g $FeSO_4$, T_5=20 g $ZnSO_4$ + 20 g $FeSO_4$ and T_6=40 g $ZnSO_4$ + 20 g $FeSO_4$.The results showed that application of 40 g $ZnSO_4$ + 20 g $FeSO_4$ resulted in significantly better performance than rest of the treatments with 12.44 leaves plant^{-1}, 115.70 cm length of leaves, the control treatment resulted lowest values for almost all the studied traits. It was concluded that overall growth and flower production performance of gladiolus was remarkable when the plants were supplied with combined application of 40 g $ZnSO_4$ + 20 g $FeSO_4$ and lowest performance was noted in control. Hence, for achieving high performance in gladiolus, the plants may be fertilized with 40 g $ZnSO_4$ + 20 g $FeSO_4$.

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 (Zn0 and Zn1), Fe (Fe0 and Fe1) and Cu (Cu0 and Cu1) 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.

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.

Maurya and Kumar (2014) conducted a field experiment at Main Experimental Station, Horticulture, N.D.U.A. & T., Kumarganj, Faizabad (U.P.) during the year 2012-13, to investigate the "Effect of different micronutrients on growth, flowering behavior and corm yield of gladiolus (*Gladiolus grandiflorus* L.)". The experiment was laid out in Randomized Block Design with three replications and ten treatments i.e. three levels of boron (100, 200 and 300 mg/l), three levels of zinc (100, 200 and 300 mg/l) three levels of manganese (100, 200 and 300 mg/l) and control. Foliar spraying of micronutrients was done after sowing at 3rd and 6th leaf stage. Number of leaves/plant, number of corm/plant, number of cormels/plant, weight of corm/plant (g), weight of cormels/plant (g), yield of corm/ha (q) and yield of cormels/ha (q) was significantly influenced with spraying of Zn @ 300 mg/l after sowing at 3rd and 6th leaf stage. Spraying of Mn @ 300 mg/l after sowing at 3rd and 6th leaf stage was proved to be most effective to increase plant height (cm) of gladiolus.

Halder *et al.* (2007) conducted a field study of B and Zn on Gladiolus at Floriculture Farm of HRC, Gazipur and RARS, Jessore during 2005-2006. The objective was to evaluate the response of B and Zn and to find out the optimum dose of the same for production of gladiolus. It appeared in studied data reveals that B and Zn made promising response to the growth and floral characters of gladiolus. It was also noticed in the tables that B and Zn both either in single or in combination exerted tremendous effect on the yield and quality of gladiolus. However, with subsequent addition of higher rates of B and Zn progressively increased the selective growth and flower characters to some extent and beyond the further increment of the dosage declined the results noticeably. 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 B2.0 Zn4.5 kg $ha^{-1.}$ along with blanket dose of N375 P150 K250 S20 kg and CD 5 t ha^{-1} 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 Zn4.54 as compared to other treatment combinations. Floral characters like floret number (12.85 and 12.45/spike), floret size (9.76x8.93 and 10.28x9.77 cm) and weight of stick (36.73 and 45.12 g) also significantly influenced by said treatment (B2.0 Zn4.5 kg ha $^{(-1)}$ which was markedly differed over rest of treatments combination. Similar trend was noticed as well in single application of B and Zn with increase rates.

Yalek *et al.* (2016) carried out an investigation during October 2010- April 2011 to study the effect of polythene mulches (black, red and white each 25µ) and micronutrient ($FeSO_4$ 1.0% and $ZnSO_4$ 0.75%) foliar sprays on growth and flowering in gladiolus. White Prosperity. The quality and flowering attributes were significantly influenced by mulches and micronutrient foliar sprays. Significantly maximum plant height, minimum days for 50% flowering and days for basal flower opening was recorded with black polythene mulch 25µ and 1.0% $FeSO_4$. Spike quality attributes like spike length, florets per spike, weight of spike, diameter of flower were also more for the treatment with black polythene mulch 25µ and $FeSO_4$ 1.0%. However different mulches and spraying of $FeSO_4$ and $ZnSO_4$ failed to exert any significant effect on number of leaves, number of spikes per plant and number of florets open at a time. Effect of micronutrients on growth and corm yield of gladiolus.

Katiyar *et al.* (2005) carried out a study to observe the effect of Zn, Cu and mixture of both as foliar spray (0.2%) applied twice, i.e. at vegetative growth and after emergence of spike on growth, floral characteristics and corm yield of gladiolus (cultivars Aldebran, Friendship, Lady First and White Prosperity) grown in partially reclaimed sodic soils in Uttar Pradesh, India. Results showed that Zn, Cu or mixture of both sprays increased plant height of all cultivars except Lady First, which responded to the application of Cu compared to the control. The effect of the micronutrients was not significant on the number of tillers and spikes per plant. There was an increase of approximately 22-40% in spike length and 27-40% in the number of florets depending on the cultivar. Except Cu, the concentration of all micronutrients increased in the foliage accompanied by the increase in the content of only chlorophyll a in all the cultivars. The mixture of Zn and Cu increased the vegetative growth and enhanced the floral characteristics.

Manna and Maity (2016) conducted a field experiment to investigate the role of boron and zinc on growth, yield and quality of onion. There were eight treatment combinations consisted of four levels of boron (0, 0.1, 0.2 and 0.5%) and 4 levels of zinc (0, 0.1, 0.2 and 0.5%) were applied as foliar spraying. Application of 0.5% boron significantly increased the growth (plant height, 63.93cm and number of leaves per plant, 7.25), yield (30.74 t ha^{-1}) and quality (total soluble solids, 13.45 0B and pyruvic acid 5.94 µmol g^{-1}) of onion. Among various levels of zinc 0.5% exhibited the best growth (plant height, 67.25cm and number of leaves per plant, 7.75), yield (33.34 t ha^{-1}) and quality (total soluble solids, 14.57 0B and pyruvic acid, 5.86 µmol g^{-1}) attributes of onion. These results suggest that the foliar application of boron and zinc significantly influenced the growth, yield and quality of onion.

Rahman *et al.* (2013) was conducted a field experiment at the Horticulture Farm, Hajee Mohammad to study the effects of Zinc and Manganese on growth and yield of potato cv. Granola. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were four levels of Zinc, viz. 0, 3,4 and 5 kg Zn ha^{-l} and also 4 levels of Manganese, i.e. 0, l, 2 and 3 kg Mn ha^{-1} in this study. The results of the experiment revealed that the tallest plant, maximum number of leaves plant, maximum number of main stems $hill^{-1}$, highest number of tubers $hill^{-l}$, maximum weight of tubers $hill^{-l}$ and the highest weight of tubers $plot^{-1}$ and $hectare^{-l}$ were found with 4kg Zn ha^{-1}, while Mn had no significant effect on the growth and yield of potato. Increasing doses of Zinc resulted in higher yield than the control. The results also showed that the plant height, number of leaves $plant^{-l}$, number of main stems $hill^{-1}$, number of tubers $hill^{-t}$, weight of tubers $hill^{-l}$, weight of tubers paleo as well as weight of tuber hectare were maximum at 4 kg Zn +l kg Mn ha^{-1}, while the minimum values were recorded from the control treatment. The maximum yield of tuber (23.82t ha^{-1}) was recorded in the combination of 4kg Zn + l kg Mn ha^{-1}.

Munawar *et al.* (2013) reported that three micronutrients i.e. zinc, manganese and boron were used to study the effect of seed priming on germination and seedling establishment in carrot. A triplicated randomized complete block experiment was designed with 11 treatments viz. Zn (1%, 1.5% and 2%), Mn (1%, 1.5% and 2%), B (1%, 1.5% and 2%), water soaked and untreated/dried (control). Significant differences were observed among treatments for emergence percentage and other seedling traits observed. Seed priming with boron solution inhibited the germination. Highest emergence percentage, rate of emergence, vigor index, hundred seedling weights were observed in case of seed priming with Zn (1.5%) solution. Mn (1.5%) and Mn (2%) solution showed highest mean shoot length and root length respectively.

Tohamy *et al.* (2009) an experiment was conducted under sandy soil conditions to study the effects of foliar application of Fe, Zn and Mn on essential oil, growth and yield of onion plants (*Allium cepa* L.). Plants were sprayed with two concentrations of each of Fe, Zn and Mn (chelated form). Essential oil, growth characters and yield were measured in response to the applications of these micronutrients. The results revealed that essential oil, growth and yield of onion plants significantly increased by the application of Fe, Zn and Mn compared to control plants. The results showed that the high concentration of Fe and the low concentrations of both Zn and Mn had the best effects compared to the other concentrations. The effects of Fe, Zn and Mn on essential oil, growth and yield of onion plants were discussed.

Acharya *et al.* (2015) reported that the application of zinc and boron shows positive effect towards the growth, yield and yield parameters of aggregatum onion. Growth parameters such as plant height, number of leaves and leaf girth and dry matter production were highly responsive to foliar spray and soil application of zinc sulphate and borax. Yield parameters highly responded to boron as well as zinc, so judicial application of zinc and boron may provide highest yield.

Sindhu and Tiwari (1993) studied the effect of micro-nutrients on yield and quality of onion. In a field trial conducted on the sandy loam soil during the rabi (winter) season of 1984-85, onion cv. Pusa Red plants received foliar sprays of Cu (1 or 3 ppm), Zn (3 or 5 ppm), B (0.5 or 1.0 ppm), Fe (100 ppm) and Mn (0.25 ppm) individually or combinedly. The micro-nutrients were applied once, at 50 days after planting or twice, at 50 and 65 days after planting. Bulb yield and TSS and total sugar contents were the highest (275q/ha, 15.36% and 16.74%, respectively) when 1 ppm Cu + 3 ppm Zn + 0.5 ppm B + 100 ppm Fe was applied twice. Ascorbic acid concentration was the highest with a single spray of 1 ppm.

Smriti *et al.* (2002) carried out a field trial in Bihar, India during 1998-99 and 1999-2000 to study the effect of S and B on the growth, yield and quality of onion cv. Nasik Red. The treatments comprised S at 0, 20, 40 and 60 kg/ha; and B at 0, 1 and 2 kg/ha. Plant height, the number of leaves, leaf length, leaf width, bulb size, bulb weight and bulb yield significantly increased up to 40 kg S/ha and 1 kg B/ha. The neck thickness and storability decreased with increasing levels of S but increased with increasing levels of B. The treatment combination of 40 kg S + 1 kg B/ha gave the highest net return and benefit cost ratio.

Jawaharlal *et al.* (1986) in their trials with onion applied as $ZnSO_4$ or $FeSO_4$ each at 25 or 50 kg/ha to the soil or at 0.5 or l% to the foliage. Bulb yield was the highest (17.1 t/ha) with the soil application of Zn or Fe at the highest rate. With foliar applications, the yields were just over 13t/ha.

Bhonde *et al.* (1995) conducted three years of studies on onion cv. Agnfound Dark Red grown during the kharif season under Nasik, India conditions. It was revealed that the trace elements zinc, copper and boron had a significant effect on bulb development and yield as well as bulb quality when applied in combination instead of singly. Foliar application of 3 ppm Zn + 1 ppm Cu + 0.5 ppm B at 30 and 45 days after transplanting gave the highest net return to the onion growers. Kabir *et al.* (1994) reported that application of B with different levels showed positive response on the yield of potato.

Mondal *et al.* (2016) reported that a field experiments were conducted under sub-tropical condition of Bangladesh for two consecutive years to study the response of garlic cv. Multiclove local to different combination of boron (B), zinc (Zn), cowdung (CD), chicken manure (CM) and mustard oil cake (OC) in the sandy loam soil. The treatments consisted of 12 combinations with B, Zn, CD, CM and OC. Application of boron had tremendous effect on growth and yield but Zn had no significant influence on growth and yield in garlic. OC added fertilizer combination showed the best performances regarding yield and yield attributes.

Sivaiah *et al.* (2013) was conducted field experiment during rabi-2010 to find out the response of foliar application of micronutrients on vegetative and reproductive growth attributes, in two varieties of tomato viz-Utkal Kumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all and control and the experiment was laid out in RBD with three replications. All the Micronutrients except manganese at 50 ppm were applied at 100 ppm in three sprays at an interval of ten days starting from 30 days after transplanting. All the treatments resulted in improvement of plant growth characteristics viz. plant height, number of primary branches, compound leaves, tender and mature fruits per plant in both the varieties out of which application of micronutrients mixture showed the maximum effect. In tomato cv. Utkal Kumari, maximum growth rate (85.7%) was observed with application of zinc, followed by application of micronutrients mixture (78.2%) and boron (77.5%). Tomato cv. Utkal Raja, maximum increase in branches per plant was observed with the application of manganese (148.7%) followed by micronutrient combination (144.1%). In UtkalKumari, the fruit yield per plant ranged from 1.336 kg to1.867 and in Utkal Raja, it ranged from 1.500 kg to 1.967 kg. In both the varieties, combined application of micronutrients produced the maximum fruit yield followed by application of boron and zinc.

Singh (2014) was conducted an experiment during Kharif 2010-11 to 2012-13 to assess the influence of micro-nutrients on growth, yield and economics of turmeric at the experimental field of Department of Horticulture, T.C.A., Dholi, Muzaffarpur. The experiment was allotted by ICAR under AICRP on spices. Among four types of micro-nutrients such as zinc sulphate, ferrous sulphate, borex and manganese sulphate were tested with three methods of application such as no application of micro-nutrients (control), soil application of micro-nutrients @ 25kg ha-1 and two foliar applications of micro-nutrients @ 0.5% at 60 and 90 days after sowing. Among the micro-nutrients, none of the micro-nutrients were found significant effect regarding yield and yield attributing characters. Among three methods of application, soil application of micro-nutrients @ 25kg ha-1 and two foliar applications of micro-nutrients @ 0.5% at 60 and 90 days after sowing gave significant effect regarding yield and yield attributing characters as compared to no application of micro-nutrients (control). Two foliar application of micro-nutrients @ 0.5% at 60 and 90 days after sowing was found at par with soil application of micro-nutrients @ 25kg ha^{-1} regarding yield and yield attributing characters. Among four type of micro-nutrients and three methods of application, ferrous sulphate @ 0.5% at 60 and 90 days after sowing gave the maximum plant height (127.23cm), number of tillers per plant (4.74), number of leaves tiller (12.57), length of leaves (56.75cm), width of leaves (13.89cm), area of leaves (811.34 cm^2), number of plant per plot (40), dry mater production per plot (1.79kg), yield per plot (19.80kg) and yield per hectare (60.39t) as compared to other micro-nutrients and other methods of application. Economics of the experiment, two foliar sprays of ferrous sulphate @ 0.5% at 60 and 90 days after sowing gave the maximum return Rs. 1,81,950 with cost of Rs.1,20,000 and it also gave the highest benefit: cost ratio Rs. 2.52:1.

CHAPTER III

MATERIALS AND METHODS

This field experiment entitled “Influence of micronutrients and mulches on growth, flowering and yield of gladiolus” was performed at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka. The following captions are presented the materials and methods that were used for carrying out the experiment.

3.1 Experimental site and duration

The experiment was performed at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, and Dhaka, Bangladesh. The experiment was performed during October 2016 to May 2017. Location of the experimental site was 23º74´ N latitude and 90º35´ E longitude with an elevation of 8.2 meter from sea level.

3.2 Climatic condition of the experimental site

The experimental site was located under the sub-tropical climate denoted by three distinct seasons, the monsoon and rainy season extending from May to October, winter or dry season from November to February and the pre-monsoon period or hot season from March to April (Edris *et al*., 1979). Maximum and minimum temperature, humidity and rainfall during the research period were collected from the Bangladesh Meteorological Department (climate division), Agargaon, Dhaka and have been presented in Appendix II.

3.3 Soil

The soil of the experiment belongs to the Modhupur Tract under AEZ No. 28 (UNDP, 1988). This selected site was well drained and above flood level. The land topography was medium high, fairly leveled and soil texture was silt clay with pH 5-6. The analyzed characteristics of soil under experimental field were collected from the SRDI, Soil testing Laboratory, Khamarbari, Dhaka and presented in Appendix I.

3.4 Land preparation

The selected land which was to conduct the experiment plot was first opened by a power tiller on lst September, 2016 and for sundry it kept seven days prior to further ploughing. Then using a power tiller to plough the land. The clods were broken. Weeds and stubbles were collected before final land preparation.

3.5 Planting materials

The Yellow Colored Corms of gladiolus were used as planting materials and they were collected from Horticultural Farm of Sher-e-Bangla Agricultural University. Br and Zn were applied respectively in the form of borax and Zinc oxide while Mn was applied as Mn_2O. A 36 ppm solution of micronutrients were prepared by dissolving 36 mg of it in 1 liter distilled water. In the similar way, 72 and 108 ppm concentrations of solutions were prepared. Plants were sprayed at 3 leaves condition with a hand sprayer.

3.6 Treatments of the experiment

This experiment was two factorials. The factors with their different levels are given below:

Factor A: Micronutrients (MN)

MN_0 (B_0, Zn_0, Mn_0) = 0 ppm of each micronutrient

MN_1 (B_1, Zn_1, Mn_1) = 36 ppm of each micronutrient

MN_2 (B_2, Zn_2, Mn_2) = 72 ppm of each micronutrient

MN_3 (B_3, Zn_3, Mn_3) =108 ppm of each micronutrient

Factor B: Mulches Materials (M)

M_0 = Control

M_1 = Water hyacinth

M_2 = Rice straw

M_3 = Black polythene

Treatment Combination: MN_0M_0, MN_0M_1, MN_0M_2, MN_0M_3, MN_1M_0, MN_1M_1, MN_1M_2, MN_1M_3, MN_2M_0, MN_2M_1, MN_2M_2, MN_2M_3, MN_3M_0, MN_3M_1, MN_2M_2, MN_3M_3.

3.7 Experimental design and layout

The experiment was designed in accordance to RCBD (randomized complete block design) with three replications. An area of 16.4 m × 3.8 m was divided into three equal blocks, each of which was divided into 16 plots where 16 treatment combinations were assigned at random. There were 48-unit plots altogether in the experiment. The size of each unit plot was 0.60 m × 0.60 m. The distance between the blocks was 50 cm and between the plots was 50 cm. The layout of the experiment is shown in Figure 1.

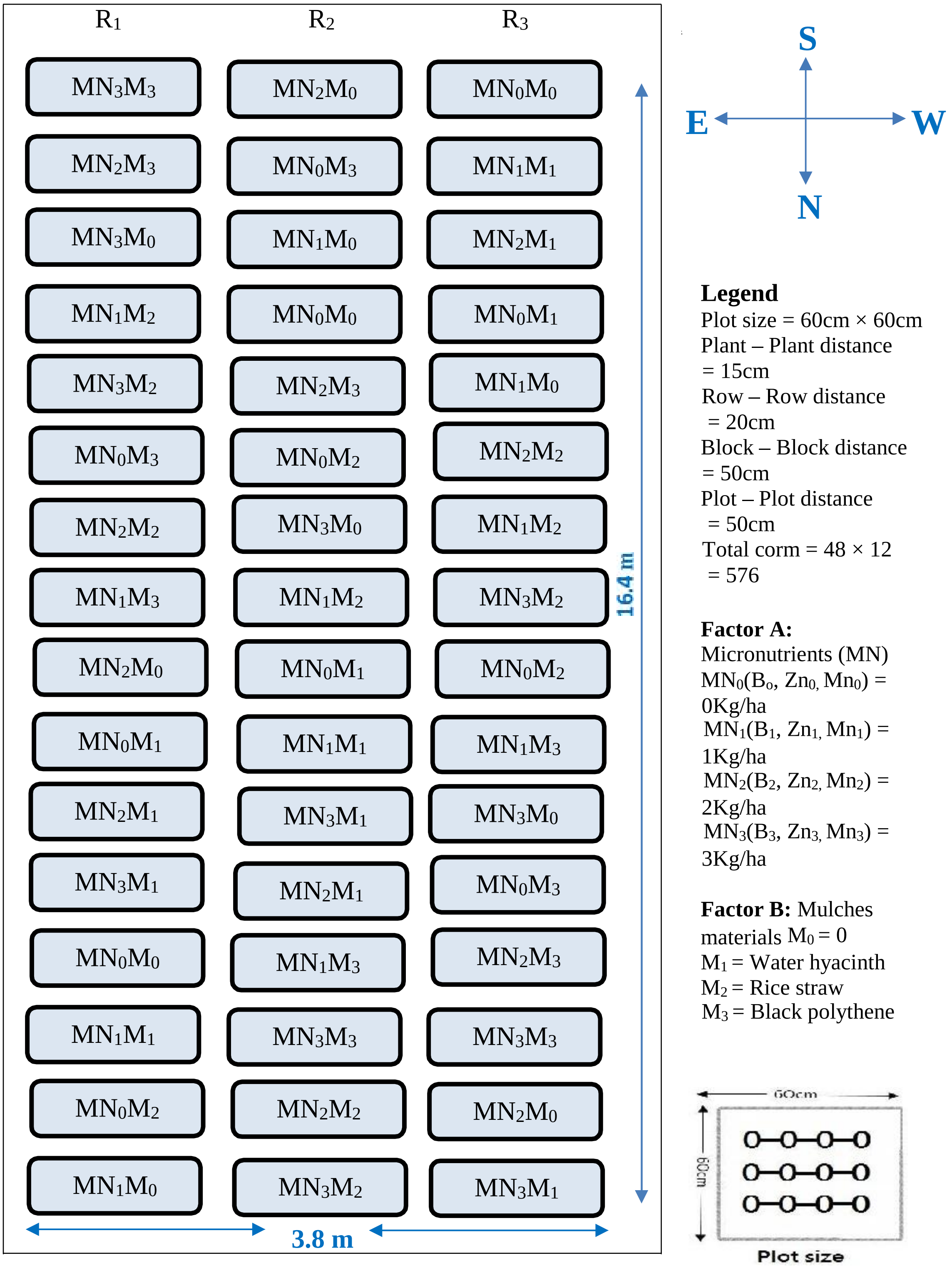

Figure 1. Layout of the experiment

3.8 Manure and fertilizer

The following doses of manure and fertilizers were applied as recommended in a report of BARI (BARI, 2005).

Table 1. Doses of manure and fertilizers

Manure/ fertilizers	**Doses**
Cow dung	10 t/ha
Urea	200 kg/ha
TSP	225 kg/ha
MoP	225 kg/ha

The plot at the entire amounts of TSP and MoP were applied during the final land preparation. Urea was applied in three equal installments at 15, 30 and 45 days after planting corms. Well-rotten cowdung also applied during final land preparation. (Appendix III).

3.9 Planting of corms

The corms were planted on 16 October 2016 maintaining 15 cm plant to plant distance and 20 cm row to row distance.

3.10 Intercultural operation

For better growth and development of gladiolus seedlings it was always kept under careful observation. After emergence of seedlings, different intercultural operations, weeding, manual hoeing were accomplished.

3.10.1 Weeding

Weeding is important especially in the early stages of plant establishment, the newly emerged weeds were uprooted carefully after complete emergence of seedlings. Manual hoeing and weeding were done according to requirement.

3.10.2 Irrigation

The experimental plots were irrigated as and when necessary during the crop period and over flooding was avoided.

3.10.3 Staking

For staking bamboo stick was placed and spikes were tied with the stick.

3.10.4 Disease and pest management

No remarkable attack of disease was found.

3.11 Data collection

Data was collected on various growth stages of gladiolus crop and ten plants were selected randomly from each unit plot for the following parameters.

3.11.1 Days to germination percentage

It was attained by recording the time taken to complete 80% emergence of the plants.

3.11.2 Plant height

Plant height means to the length of the plant from ground level up to the top of the shoot of the plant. It was measured at an interval of 10 days starting from 30 days after planting (DAP) till 60 DAP.

3.11.3 Average number of leaves

Average number of leaves from plants were counted at an interval of 10 days starting from 30 days after planting (DAP) till 60 days.

3.11.4 Days to spike initiation

It was attained to complete 80% initiation of spikes of gladiolus in the experimental field.

3.11.5 Length of spikes at harvest

Ten plants were selected randomly from each unit plot and length of spike was measured from the base to the tip of the spike.

3.11.6 Number of floret/spike

All the florets of main spike were counted from 10 randomly selected plants and their mean was calculated.

3.11.7 Diameter of floret

Diameter of florets at 7 number floret from the bottom of the spike were measured from 10 randomly selected plants and their mean was calculated.

3.11.8 Leaf area

Leaf area of 10 leaves was measured by laser leaf area meter from 10 randomly selected plants and their mean was calculated.

3.11.9 Chlorophyll %

Chlorophyll % of 10 leaves from 10 randomly selected plants were measured by SPAD meter and their mean was calculated.

3.11.10 Weight of corms per plant

It was calculated from the weight of corms obtained from 10 randomly selected plants and mean was found out.

3.11.11 Number of corm per plant

Number of corms were counted from 10 randomly selected plants and their mean was calculated.

3.11.12 Diameter of individual corm

A slide calipers was used to measure the diameter of the corm.

3.11.13 Weight of cormels per plant

It was determined by weighing the cormels from 10 randomly selected plants and mean weight was calculated.

3.11.14 Number of cormels per plant

Number of cormels were counted from 10 randomly selected plants and their mean was calculated.

3.11.15 Diameter of individual cormel

Ten plants were selected randomly and a slide calipers was used to measure the diameter of the cormel.

3.11.16 Yield of spike per hectare

The total number of spike per unit plot was converted to yield of spike per hectare. It is very important how to calculate the yield. The land area is assumed to be divided into a number of plots of 60 cm x 60 cm and for both row to row and column to column 50 cm interval is assumed.

3.11.17 Yield of corm per hectare

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

3.11.18 Yield of cormel per hectare

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

3.12 Statistical analysis

Analysis of variance techniques were used to assess treatment means the calculated data were statistically analyzed for analysis of variance (ANOVA) by using SPSS computer software. Treatment means were compared using the LSD at the 0.05 probability level. Levels of significance are represented by * at $P < 0.05$, ** at $P < 0.01$, *** at $P < 0.001$, and NS (not significant).

3.13 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of different level of micronutrients and mulches materials**.** All input cost was considered in computing the cost of production. The market price of spike, corm and cormel was considered for estimating the return. The benefit cost ratio (BCR) was calculated as follows;

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return per hectare (TK.)}}{\text{Total cost of production per hectare (TK.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to find out the influences of micronutrients and mulch on growth and yield of gladiolus. Results and discussion have been presented by graphs, tables, figures and plates in this chapter. The analysis of variance (ANOVA) of the data on different characters and yield of flower, corm and cormel are presented in Appendix IV-IX. The results obtained from the present investigation as well as relevant discussion have been summarized under following headings:

4.1 Number of leaves per plant

Leaf number is considered as an important factor in growth, responsible for photosynthesis and ultimately affecting the flower yield and quality. Analysis of variance on the number of leaves indicated that the leaf number was only increased significantly (Appendix IV) when three micronutrients were applied (MN_2) and the maximum number of leaves per plant at 30, 40, 50 and 60 DAP were 4.15, 5.29,6.02 and 7.18 respectively (Figure 2.) while the minimum (2.65, 3.47,4.27 and 5.09) number of leaves at different days per plant was found from MN_0 (Control). These results are in partial support of Kumar and Arora (2000), Halder *et al*. (2007), (Lahijie, 2012) and Khosa *et al.* (2011) observed a significantly higher number of leaves per plant in Gerbera due to foliar application of micro power, a solution containing Zn, B, Fe and Mn.

Number of leaves per plant was significantly influenced by mulches (Appendix IV). Number of leaves per plant was increased with mulches (Water hyacinth, Rice straw and Black polythene) over no mulches (Figure 3.). The maximum results (3.53, 4.78, 5.63, 6.71) were recorded with black polythene mulch at different days per plant (Figure 3.). Annu Verma and Sarnaik (2006) found maximum number of leaves (10.32) with mulch as compared to other treatments.

The interaction effect between micronutrients and mulches with respect to number of leaves per plant was found significant (Appendix IV). At 30, 40, 50 and 60 DAP the maximum number of leaves (5.07, 6.47, 7.1 and 8.23) were reported from MN_2M_3 and the minimum was reported in control (Table 4).

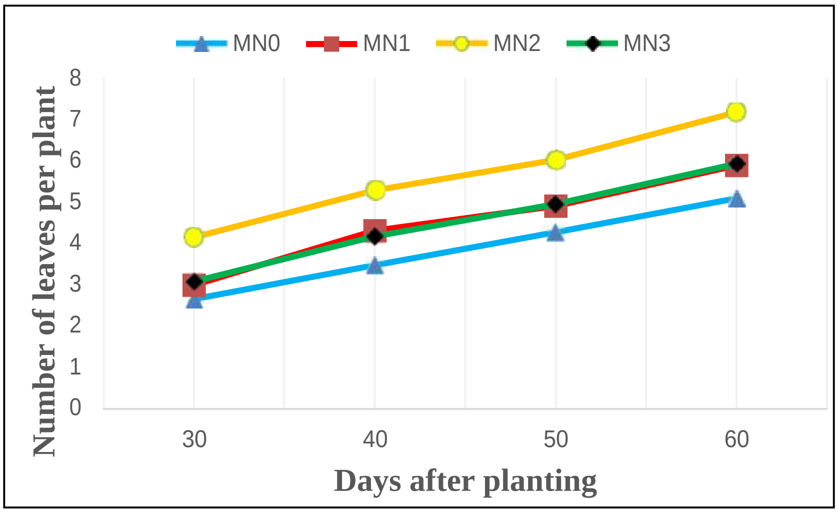

Figure 2. Effect of micronutrients on number of leaves per plant at different days after planting

MN_0: Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm

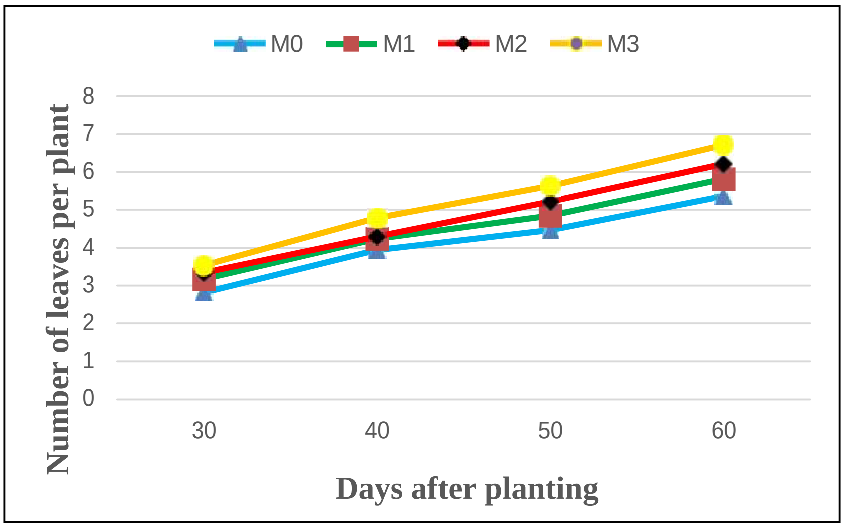

Figure 3. Effect of mulches on number of leaves per plant at different days after planting

M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

4.2 Leaf area (cm^2)

Different doses of micronutrients had significant effect on the leaf area of gladiolus (Appendix IV). The maximum leaf area (162 cm^2) was obtained from MN_2 while it was the minimum (131 cm^2) in control (Table 2).

Leaf area of gladiolus was statistically significant in case of mulches (Appendix IV). The maximum leaf area (149 cm^2) was obtained from M_3 while it was the minimum (134 cm^2) in control (Table 3).

Combined effect of mulches and micronutrients showed significant difference on leaf area of gladiolus (Appendix IV) The maximum leaf area (189 cm^2) was found from MN_2M_3, whereas the minimum leaf area (117 cm^2) was found from MN_0M_0 (Table 4).

4.3 Chlorophyll %

Statistical analysis of leaf chlorophyll content was significant (Appendix IV). The highest leaf chlorophyll content (78.3%) was recorded when plants were sprayed with micronutrients (MN_2) and the lowest chlorophyll content (77.6%) was also recorded in control (Table 2). These results indicated that MN_2 was indispensable for the increasing of leaf chlorophyll contents. Similarly, Khalifa *et al*. (2011) observed increased leaf chlorophyll content in the treated plants. Leaf chlorophyll contents were also significantly increased in rose cultivars in response to foliar application of B (0.5%), Zn (1.5%) and Fe (1.0%), applied either alone or in different combinations (Ahmad *et al*., 2010).

Mulches had non-significant effect on chlorophyll contents (Appendix IV). The maximum leaf chlorophyll contents (78.4%) was recorded when there had mulches (M_3) and closely result (77.9%) was found from M_2. The minimum leaf chlorophyll content (77.7%) was recorded in M_0 (Table 3).

Combined effect of mulches and micronutrients showed non-significant variation on leaf chlorophyll contents under the present trial (Appendix IV). The maximum leaf chlorophyll content (78.9%) was found from MN_2M_3 and closely result (78.5%) was recorded in MN_2M_2, whereas the minimum leaf chlorophyll contents (77.3%) was found from MN_0M_0 (Table 4).

Table 2. Effect of micronutrients on Leaf area (cm^2) and Chlorophyll % of gladiolus

Treatment	Leaf area (cm^2)	Chlorophyll %
MN_0	131d	77.6b
MN_1	141b	77.9ab
MN_2	162a	78.3a
MN_3	133c	77.8ab
LSD	1.277	0.654

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm

Table 3. Effect of mulches on Leaf area (cm^2) and Chlorophyll % of gladiolus

Treatment	Leaf area (cm^2)	Chlorophyll %
M_0	134d	77.7
M_1	138c	77.8
M_2	146b	77.9
M_3	149a	78.4
LSD $_{(0.05)}$	1.277	NS

M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

Table 4. Interaction effect of micronutrients and mulches of leaf number, leaf area (cm^2) and chlorophyll % of gladiolus

Treatment	Leaf Number in different days after planting				Leaf area (cm^2)	Chlorophyll %
	30 DAP	40 DAP	50 DAP	60 DAP		
MN_0M_0	2.37i	3.07m	3.77k	4.57k	117j	77.3
MN_0M_1	2.50hi	3.30l	4.03j	4.75j	120j	77.5
MN_0M_2	2.70gh	3.47kl	4.23ij	5.00i	153c	77.6
MN_0M_3	3.03cde	4.03hi	5.03ef	6.03f	140fg	78.0
MN_1M_0	2.73fgh	3.67jk	4.33hi	5.13i	137gh	77.6
MN_1M_1	2.87efg	4.23gh	4.78g	5.63f	135h	78.3
MN_1M_2	3.17cd	4.57de	5.17def	6.27e	141ef	77.7
MN_1M_3	3.20cd	4.77cd	5.37cd	6.53d	148d	78.1
MN_2M_0	3.23c	4.73cd	5.23de	6.13ef	145e	77.7
MN_2M_1	4.07c	4.87c	5.57c	7.03c	153c	78.3
MN_2M_2	4.23b	5.10b	6.17b	7.33b	162b	78.5
MN_2M_3	5.07a	6.47a	7.10a	8.23a	189a	78.9
MN_3M_0	2.97def	4.30fg	4.53h	5.62f	135h	77.5
MN_3M_1	3.27c	4.50ef	4.97fg	5.83g	143ef	77.6
MN_3M_2	3.27c	4.03hi	5.27d	6.23e	126i	77.7
MN_3M_3	2.83efg	3.84ij	5.03ef	6.03f	120j	78.4
LSD (0.05) CV%	0.262 2.68	0.224 1.71	0.203 1.33	0.161 0.88	3.50 0.81	NS 0.76

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm, M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

4.4 Plant height in different days after planting

Statistical analysis of the data on plant height revealed significant differences among the micronutrients treatments (Appendix V). The plants sprayed with micronutrients (MN_2) resulted in maximum plant height, followed by other level. At 30, 40, 50 and 60 DAP there were significant differences on plant height and the tallest plant height (41.85, 55.63, 67.53 and 73.44cm) were recorded from MN_2 (Figure 4). Whereas the shortest plant height (33.72. 43.93, 53.44 and 61.25cm) were found from MN_0 for the same DAP. Similarly, Kumar and Arora (2000), Lahijie (2012) and Katiyar *et al*. (2012) reported significant increase in plant height of gladiolus.

Mulches induced significant variation in plant height of gladiolus (Appendix V and Figure 5.) except the plant height as recorded on 40 DAP. At 40 DAP Maximum plant height was 51.36 from M_3 and closely height was 51 from M_2. Maximum plant height (39.33, 51.36 62.13 and 69.08 cm) were recorded in plants mulched with black polyethene while control had the lowest (33.15, 41.82, 53.77 and 61.15cm) at 30, 40, 50 and 60 DAP respectively. Suh *et al.* (1991) and Rahman *et al*. (1999) also found similar result.

The combined effect revealed that the plants sprayed with micronutrients (MN_2) with Mulches (M_3) produced maximum plant height (46.17, 62.50, 71.23 and 79.20cm) and it was minimum in control (29.33, 39.20, 49.23 and 57.27cm) (Appendix V and Table 5) at 30, 40, 50 and 60 DAP respectively.

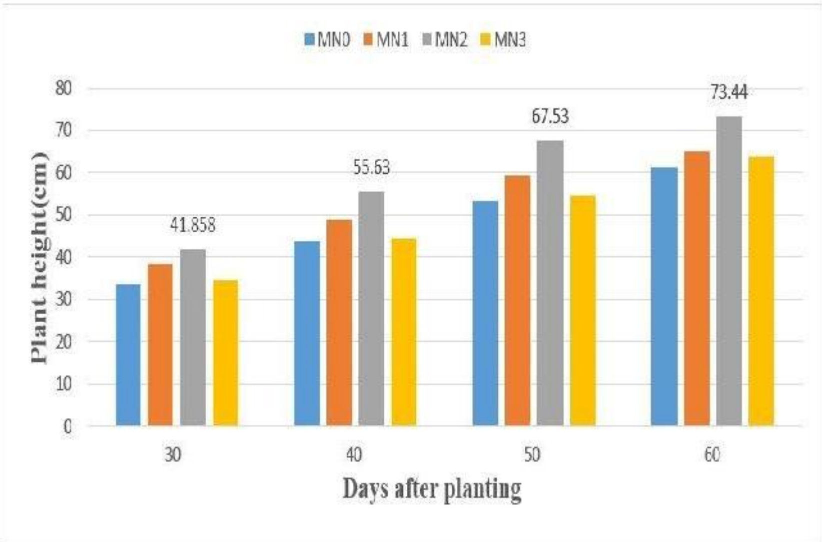

Figure 4. Effect of micronutrients on plant height of gladiolus at different days after planting

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm

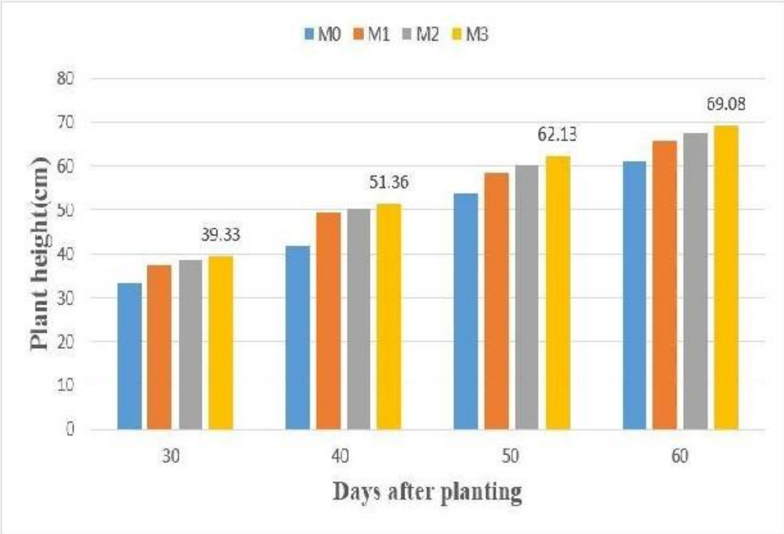

Figure 5. Effect of mulches on plant height of gladiolus at different days after planting

, M_0 : Control, M_1 : Water hyacinth, M_2 :Rice straw, M_3 : Black polythene

Table 5. Interaction effect of micronutrients and mulches on plant height at different DAP

Treatment	Plant height at different days after planting			
	30 DAP	40 DAP	50 DAP	60 DAP
MN_0M_0	29.33k	39.20m	49.23l	57.27l
MN_0M_1	32.20j	43.20j	52.20j	59.27jk
MN_0M_2	35.17h	45.13i	55.10hi	63.23gh
MN_0M_3	38.17e	48.17fg	57.22fg	65.23f
MN_1M_0	33.23i	41.67k	50.20k	58.50kl
MN_1M_1	39.27d	49.33ef	58.67f	64.27fg
MN_1M_2	39.97d	50.23e	61.17e	67.17e
MN_1M_3	41.33c	53.77d	66.77c	70.13cd
MN_2M_0	36.67fg	46.40hi	64.03d	68.67de
MN_2M_1	41.67c	55.67c	66.17c	71.60c
MN_2M_2	42.93b	57.93b	68.67b	74.30b
MN_2M_3	46.17a	62.50a	71.23a	79.20a
MN_3M_0	33.37i	40.00lm	51.63lm	60.20ij
MN_3M_1	37.13f	48.90ef	57.00ef	68.10e
MN_3M_2	36.10gh	47.20gh	56.13gh	65.23f
MN_3M_3	31.67j	41.00kl	53.30kl	61.77hi
LSD $_{(0.05)}$ CV%	0.937 0.83	1.373 0.94	1.879 1.05	1.650 0.82

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm, M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

4.5 Days required to 80% initiation of spike

Number of days to spike initiation is an important indicator of expected time of harvest and crop endurance. Days required to 80% emergence of inflorescence were significantly influenced by micronutrients (Appendix VI). The maximum (80) days were required for the control and the minimum (68) days were required for MN_2 (Table 6). The present finding agrees with the findings of Reddy *et al*. (2009); Kumar and Arora (2000) reported that foliar application of micronutrients induced earlier flowering in gladiolus. Similar effects of micronutrient foliar application have also been reported in Gerbera (Khosa et al., 2011).

Days required to 80% initiation of inflorescence were also significantly influenced by mulches from M_3, black polythene (Appendix VI). The maximum (76) days for emergence were required for control and the minimum (72) days were obtained from M_3, black polythene (Table 7). Similar effects of mulches have also been reported Solaiman *et al*. (2008).

The combined effect of micronutrients and mulches was statistically significant (Appendix VI). The maximum (86) days were required for the treatment combination of MN_0M_0 and the minimum (65) days were counted for the combination of MN_2M_3 (Table 8). Yalek *et al*. (2016) recorded minimum days for 50% flowering and days for basal flower opening with black polythene mulch and micronutrients.

4.6 Number of spikes per plot

Statistically significant variation was observed due to application of different level of micronutrients on number of spikes per plot in gladiolus (Appendix VI). The highest number of spikes per plot (14.92) was found from MN_2 and the lowest (9.58) was recorded from control (Table 6).

Different mulches were significant for number of spikes per plot in gladiolus (Appendix VI). The highest number of spikes per plot (13.12) was obtained from M_3 while the lowest (10.09) was recorded from M_0 (Table 7).

Interaction effect showed significant difference on number of spikes per plot of gladiolus (Appendix VI). The highest number of spikes per plot (18) was recorded from black polythene with MN_2 while the lowest (8.36) was obtained from control (Table 8).

4.7 Length of spike (cm)

Length of spike is an important determining factor counted for good economic return. Statistical analysis of the data on spike length demonstrated that the parameter was significantly influenced by the micronutrient treatments (Appendix VI). MN_2 significantly increased spike length and it differed from all the other treatments. The longest spike length (66.2 cm) was obtained from MN_2 and shortest spike length (45.5 cm) was recorded when plants were not sprayed with any micronutrients (MN_0) (Figure 6). Kumar and Arora (2000) stated that spike length, number of florets, weight of spike and size of florets significantly increased with foliar application of micronutrients. Similarly, Halder *et al*. (2007), Katiyar *et al*. (2012) and Lahijie (2012) reported significant increase in length of spikes of gladiolus.

Length of spike varied significantly for different mulches (Appendix VI). At harvest, the maximum length of spike (61.9 cm) was recorded from M_3 and the minimum (48.6cm) was found from M_0 (Figure 7).

Interaction effect of micronutrients and mulches showed significant differences on length of spike of gladiolus (Appendix VI). At harvest, the maximum length of spike (75.1 cm) was recorded from MN_2 x M_3 while the minimum (40.7 cm) was found from control (Plate 1 and Table 8).

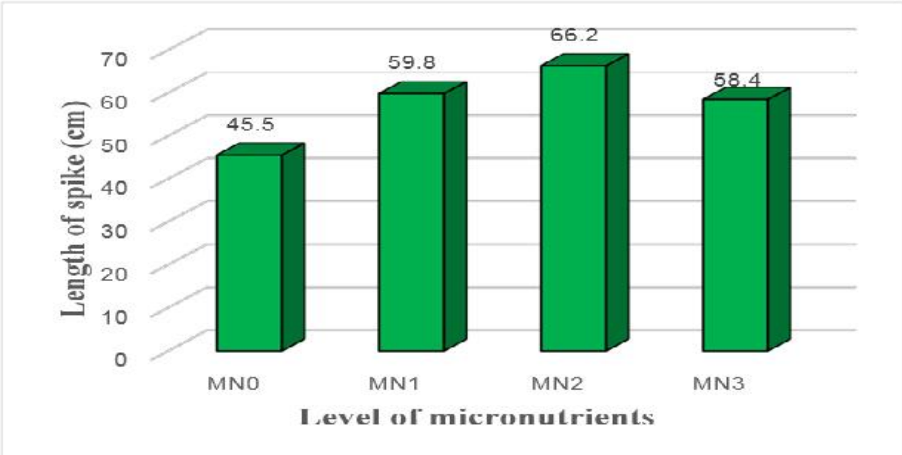

Figure 6. Effect of micronutrients on length of spike of gladiolus
MN_0 : Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm

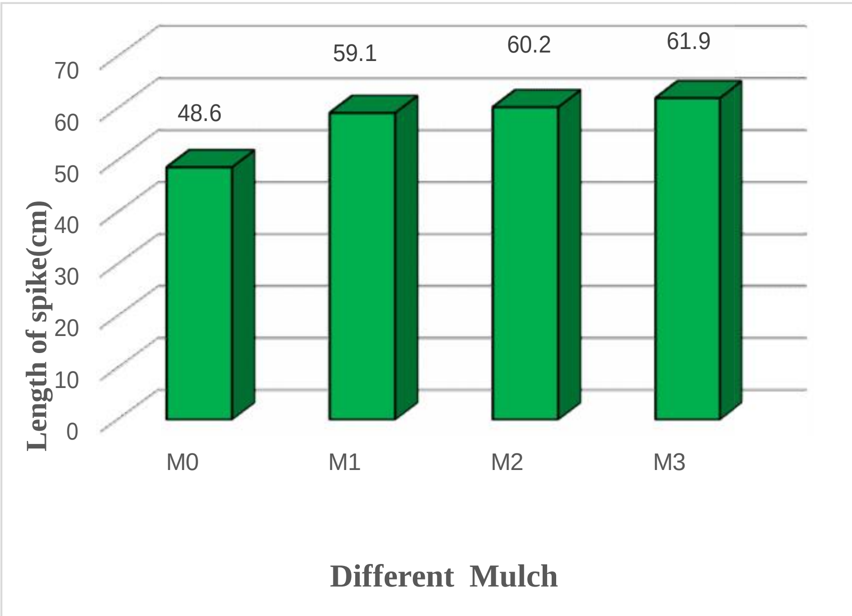

Figure 7. Effect of different mulches on length of spike of gladiolus
, M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

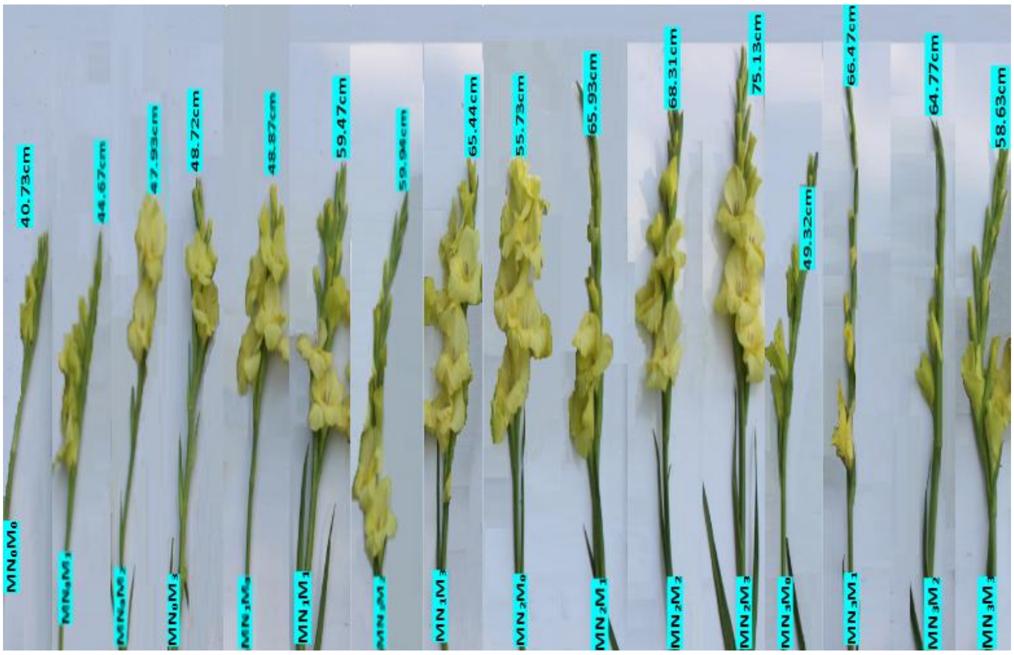

Plate 1. Effect of micronutrients and mulches on number of florets per spike
MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3: 108 ppm; M_0: Control, M_1: Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

4.8 Number of florets per spike

Analysis of variance of the data on number of florets per spike revealed statistically significant differences among treatments. The maximum number of florets per spike (13.39) was noted when micronutrients, MN_2 were applied and this number was significantly higher than other treatments and the minimum number of florets (9.12) per plant were counted for control, MN_0 (Plate 2 and Table 6).

It was shown in the present study that with an increase in the spike length, the number of florets per spike was also increased. These results also confirmed the findings of Kumar and Arora (2000), who observed that foliar application of different micronutrients significantly influenced the number of florets per spike.

Number of florets per spike was showed statistically significant differences due to different mulches (Appendix VI). The highest number of florets per spike (11.72) was found from M_3 while the lowest (9.58) was recorded from M_0 (Plate 3 and Table 7).

Number of florets per spike differed significantly for interaction effect of mulches and micronutrients (Appendix VI). The highest number of florets per spike (15.71) was obtained from $MN_2 M_3$ while the lowest (8.67) was recorded from control (Table 8).

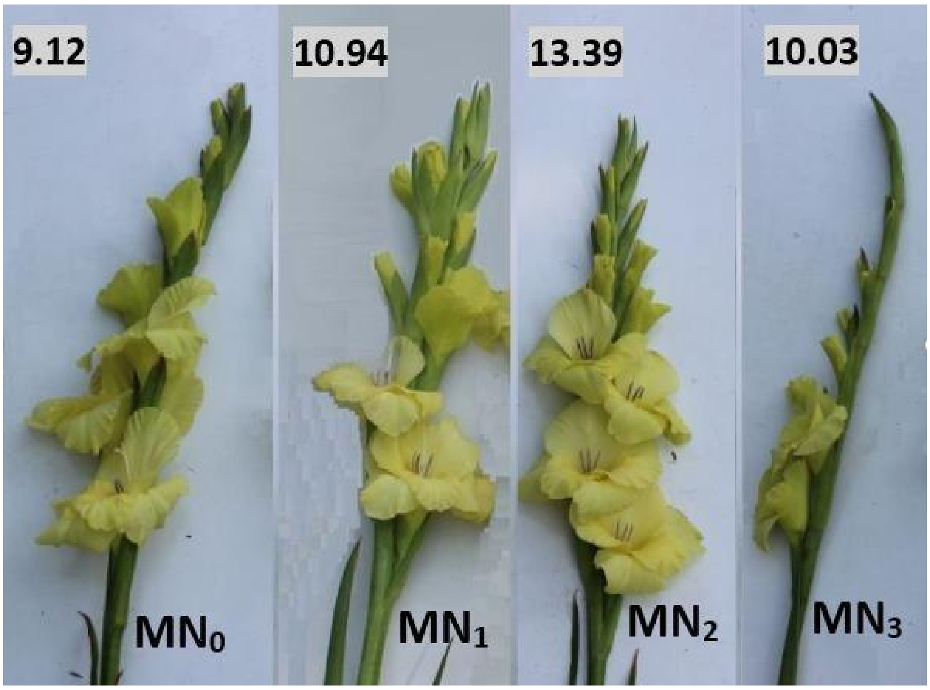

Plate 2. Effect of micronutrients on number of florets per spike
MN_0: Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm

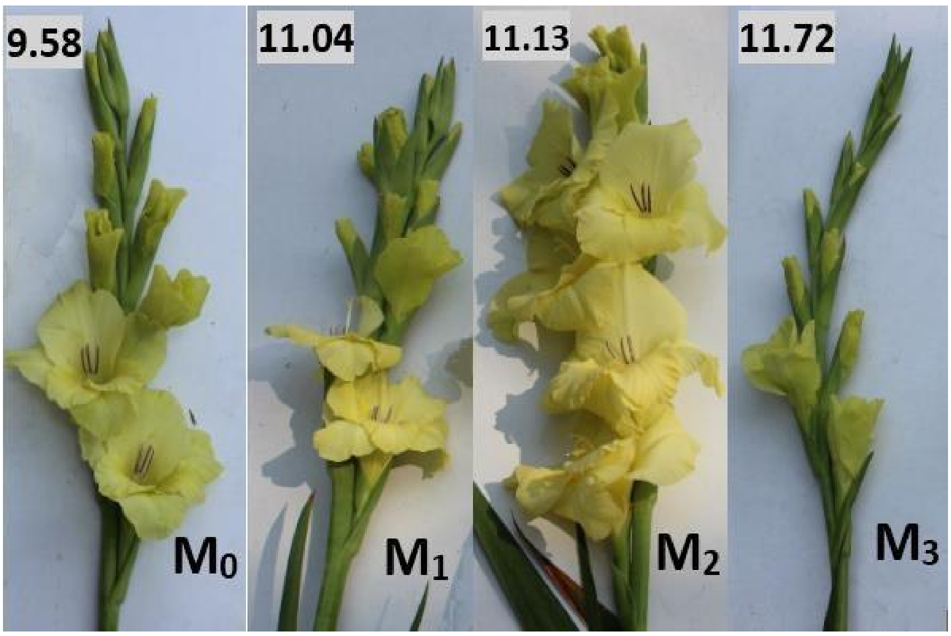

Plate 3. Effect of mulches on number of florets per spike
M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

4.9 Diameter of floret (cm)

Analysis of variance of floret diameter depicted significant differences among treatments. The different micronutrients had highly significant effect on the diameter of florets per spike. The maximum diameter of florets per plot (9.55cm) was observed when micronutrients, MN_2 were applied with water and minimum diameter of florets (6.78cm) was recorded from control (Table 6).

With foliar application of different micronutrients, increased bud diameter in gladiolus (Kumar and Arora, 2000), increased floret diameter in Gerbera (Khosa *et al*., 2011) as well as in Iris (Khalifa *et al*., 2011) have been reported. Similarly, Lahijie (2012) also observed that.

Different mulches varied significantly for diameter of florets per plot of gladiolus (Appendix VI). The maximum diameter of florets (8.31cm) was obtained from M_3 while the lowest (6.99cm) was recorded from M_0 (Table 7).

Interaction effect showed significant differences on diameter of florets per plot of gladiolus (Appendix VI). The maximum diameter of florets per plot (10.43cm) was recorded from black polythene with MN_2 and M_3 while the minimum (5.42) was obtained from control (Table 8).

Table 6. Effect of micronutrients on days required to 80% initiation of spike, number of spikes, floret and diameter of floret

Treatment	Days required to 80% initiation of spike	Number of spike per plot	Number of floret per spike	Diameter of floret (cm)
MN_0	80.75a	9.58d	9.12d	6.78d
MN_1	74.33c	12.32b	10.94b	7.92b
MN_2	68.67d	14.92a	13.39a	9.55a
MN_3	77.75b	9.89c	10.03c	7.25c
$LSD_{(0.05)}$	.997	0.408	0.116	0.164

MN_0: Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm

Table 7. Effect of mulches on days required to 80% initiation of spike, number of spike, floret and diameter of floret

Treatment	Days required to 80% initiation of spike	Number of spike per plot	Number of floret per spike	Diameter of Floret (cm)
M_0	76a	10.09d	9.58c	6.99c
M_1	77a	11.49c	11.04b	8.13b
M_2	74b	12.00b	11.13b	8.07b
M_3	72c	13.12a	11.72a	8.31a
LSD $_{(0.05)}$	0.839	0.408	0.116	0.164

M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

Table 8. Interaction effect of mulches and micronutrients on days required to 80% initiation of spike, number of spike, length of spike, number and diameter of floret of gladiolus

Treatment	Days required to 80% initiation of spike	Number of spike per plot	Length of spike (cm)	Number of floret per spike	Diameter of floret (cm)
MN_0M_0	86a	8.36j	40.73k	8.67j	5.42k
MN_0M_1	84a	9.17ij	44.67j	9.17i	6.76ij
MN_0M_2	79bc	9.63hi	47.93i	9.18i	7.17hi
MN_0M_3	74ef	11.17fg	48.72hi	9.46i	7.77fg
MN_1M_0	75de	10.83fg	48.87hi	9.25i	7.34gh
MN_1M_1	78cd	11.77ef	59.47ef	10.67g	7.87ef
MN_1M_2	73e-g	13cd	59.94e	11.54e	8.19d-f
MN_1M_3	71gh	13.67cd	65.44cd	12.28d	8.27de
MN_2M_0	71f-h	12.67de	55.73g	11.18f	8.76c
MN_2M_1	70hi	14bc	65.93c	13.15c	9.43b
MN_2M_2	68i	15b	68.31b	13.54b	9.57b
MN_2M_3	65j	18a	75.13a	15.71a	10.43a
MN_3M_0	74ef	8.5j	49.32h	9.23i	6.43j
MN_3M_1	77cd	11.03fg	66.47c	11.18f	8.47cd
MN_3M_2	79bc	10.38gh	64.77d	10.27h	7.34gh
MN_3M_3	81b	9.66hi	58.63f	9.44i	6.75ij
LSD $_{(0.05)}$ CV%	2.732 1.19	1.118 3.15	1.124 0.64	0.318 0.96	0.449 1.88

MN_0: Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm; M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

4.10 Number of spike/ ha (‘000)

Statistically significant variations were recorded in respect of thousand number of spike due to the effect of different micronutrients under the study (Appendix VI). The highest number of spike (300500/ha) was recorded in MN_2 and the lowest number of spike (234250/ha) was recorded for MN_0 (Figure 8).

Mulches showed statistically significant variation for thousand number of spike (Appendix VI). The highest number of spike (265250/ha) was recorded in the plot with M_3 that was black polythene and the lowest number of spike (242920/ha) was recorded in the plot with no mulches (Figure 9).

Interaction effects were found between micronutrients and mulches for number of spike/ha which was Significant (Appendix VI). The highest number of spike (324670/ha) was recorded in mulches (M_3) with MN_2 which was closely followed by MN_2M_2 (308000/ha). This result suggested that micronutrients significantly associated with mulches in flower production. However, the lowest number of spike (223000 /ha) was recorded in control (Figure 10).

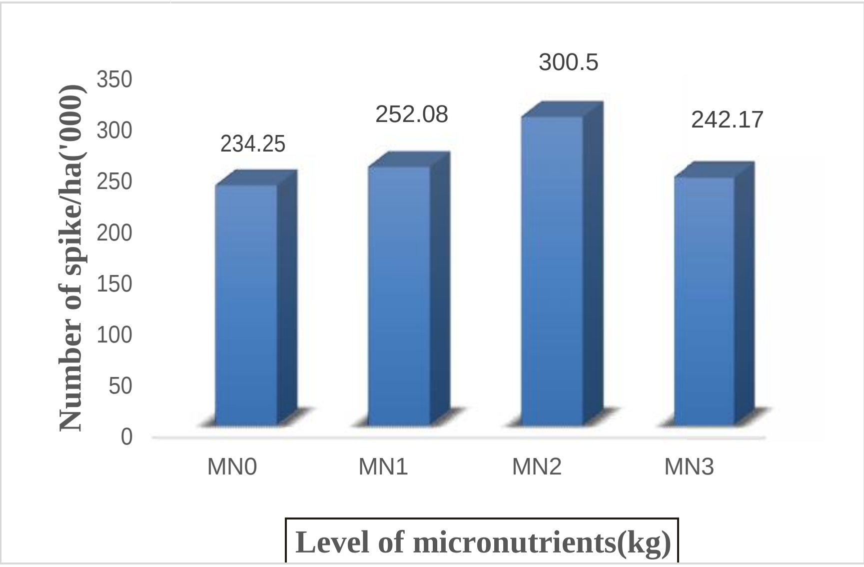

Figure 8. Effect of micronutrients on number of spike/ ha (‘000) of gladiolus

MN_0: Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm

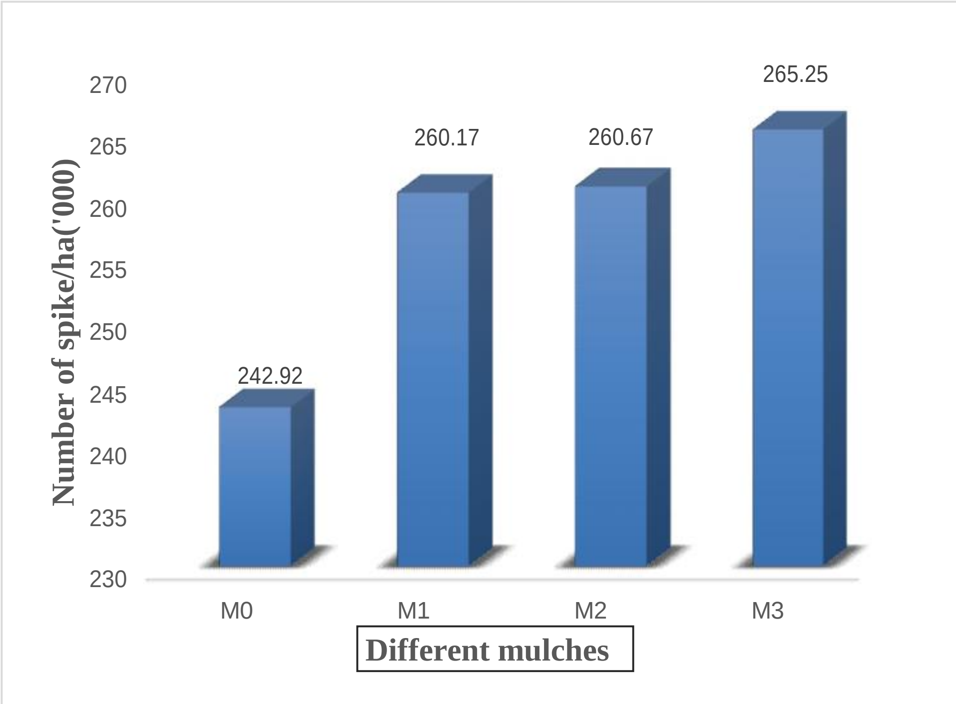

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Figure 9. Effect of mulches on number of spike/ ha (‘000) of gladiolus

M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

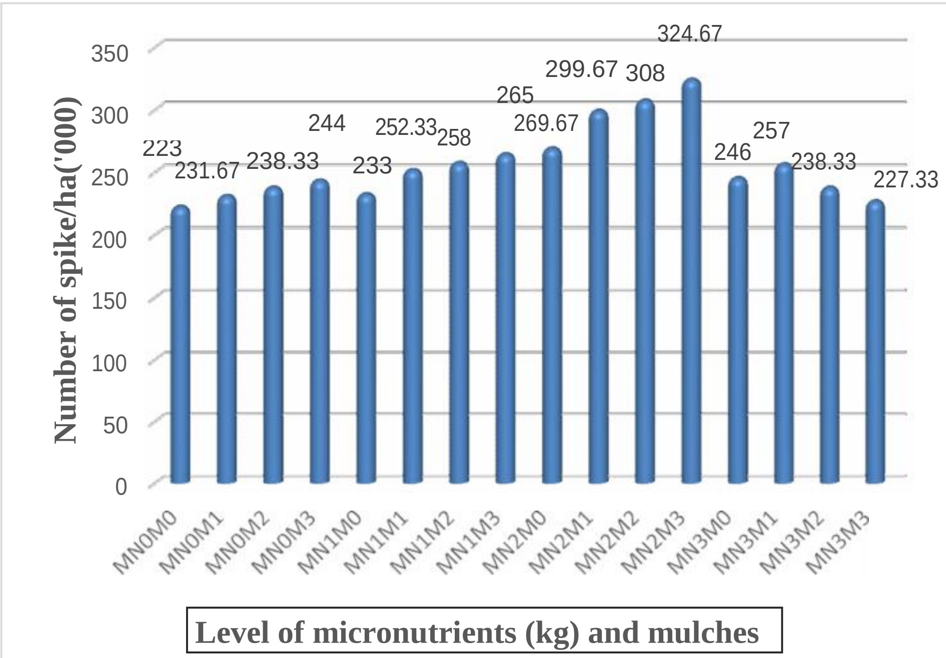

Figure 10. Effect of micronutrients and mulches on number of spike/ ha (‘000)

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm; M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

4.11 Number of corm per plot

Analysis of variance of the data on number of corms produced per plant depicted significant differences for treatments (Appendix VII), indicating that the parameter was affected by the micronutrients. The maximum number of corms (16.5) produced per plot in MN_2 (Figure 11); hence no foliar application of micronutrients was showed the minimum number of corms (10.8).

Mulches (M_3) was showed significant differences on number of corm production (Appendix VII), the maximum number of corms (13.7) produced per plant in M_3 (black polythene) (Figure 12); hence no mulches (M_0) was showed the minimum number of corms (11.12).

The result showed that micronutrients significantly associated with mulches in corm production (Appendix VII). The maximum number of corms (18.7) were obtained from the combination of MN_2 and M_3 (Table 9). The combination effect of MN_2 and M_3 showed the lowest number of corms (9.2).

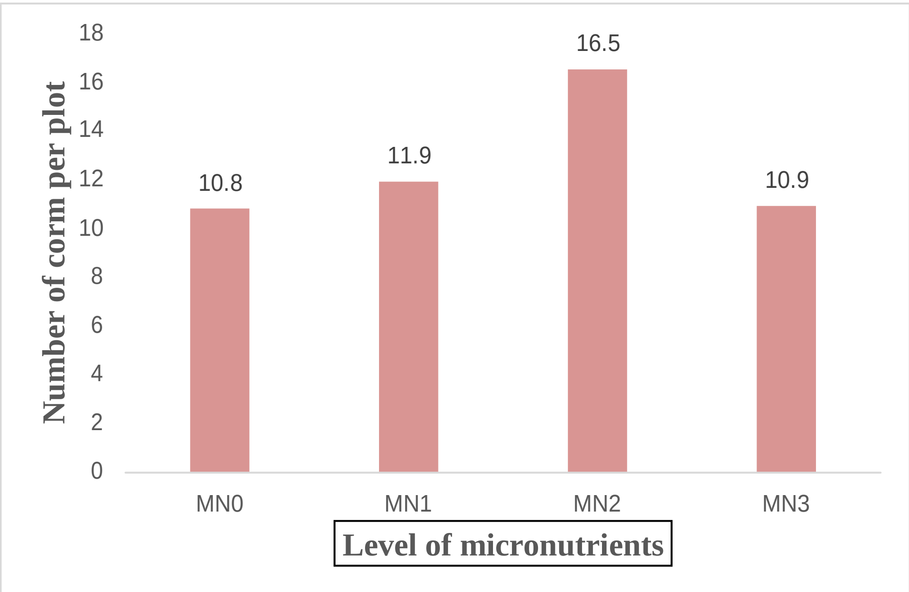

Figure 11. Effect of micronutrients on number of corm per plot

MN_0: Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm

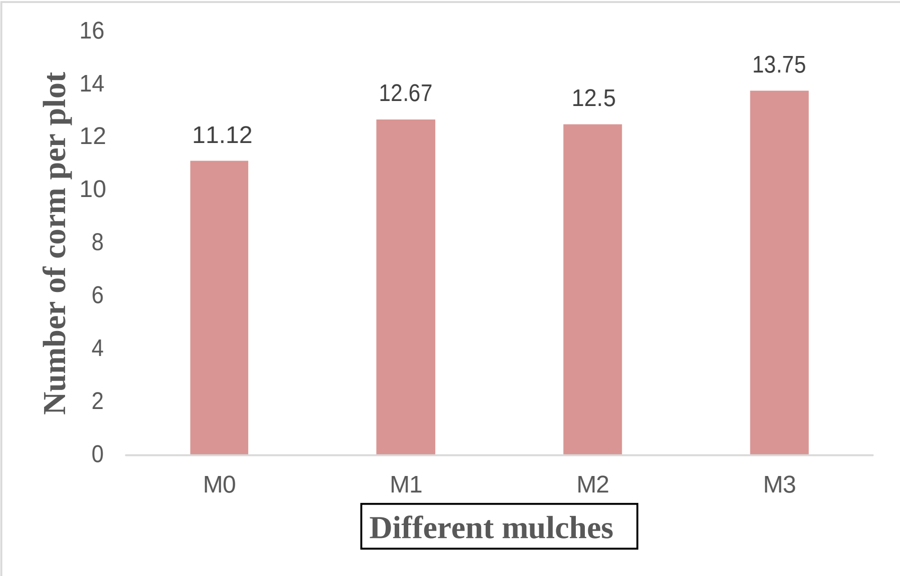

Figure 12. Effect of mulches on number of corm per plot

M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

4.12 Diameter of individual corm (cm)

Statistical analysis of the data for corm diameter revealed significant differences among treatments (Appendix VII). The corms attained maximum diameter (6.89cm) when plants sprayed with micronutrients (MN_2), which differed significantly. A minimum corm diameter (4.32 cm) was recorded when the plants did not receive any micronutrient (MN_0), which also differed statistically from all the other micronutrient treatments (plate 4). These results also confirmed the findings of Kumar & Arora (2000), Singh (2012), Ahmed *et al*. (2002) and Halder *et al*. (2007), who observed increase in corm diameter as a result of foliar application of different micronutrients on gladiolus.

Mulches showed statistically significant variation on corm diameter (Appendix VII). The highest number of corm diameter (5.81 cm) was recorded in the plot with black polythene and the lowest corm diameter (4.69 cm) was recorded in the plot with no mulches (Plate 5 and Table 9). Iroc *et al*. (1991) reported that different mulches materials influenced the average height and the average bulb diameter of garlic seedlings.

Statistically significance was found in interaction between mulches and micronutrients (Appendix VII). Maximum diameter of corm (7.82 cm) was recorded in MN_2M_3 and the minimum diameter of corm (3.52 cm) was recorded in control (Table 9).

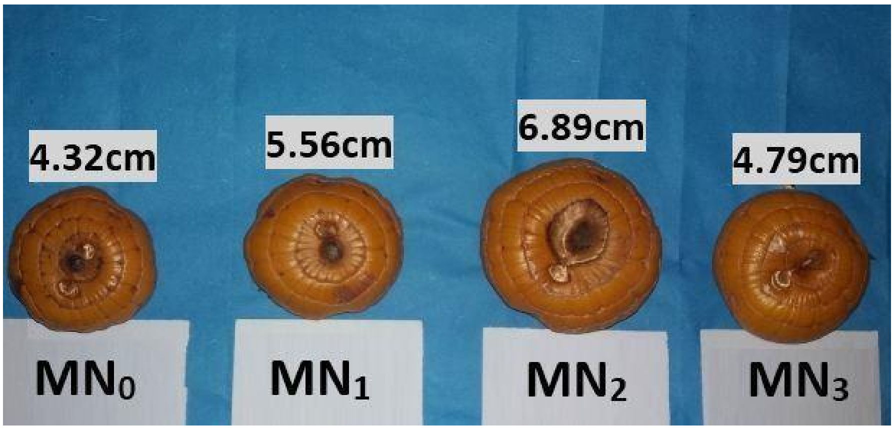

Plate 4. Effect of micronutrients on diameter of individual corm

MN_0: Control, MN_1: 36 ppm, MN_2: 72 ppm, MN_3: 108 ppm

Plate 5. Effect of mulches on diameter of individual corm

M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

4.13 Number of cormel per plot

Analysis of variance of cormel number showed statistically significant differences among treatments (Appendix VII). The different micronutrients had significant effect on the number of cormel per plot. The maximum number of cormel per plot (30.88) was recorded when micronutrients MN_2 were applied and minimum number of cormel (18.29) from control (Figure 13).

Different mulches varied significantly for number of cormel per plot in gladiolus (Appendix VII). The maximum number of cormel per plot (27.75) was obtained from M_3 while the minimum (19.58) was recorded from M_0 (Figure 14).

Interaction effect showed significant differences on number of cormel per plot of gladiolus (Appendix VII). The highest number of cormel per plot (38.33) was recorded from black polythene with MN_2 while the lowest (15.10) was obtained from control (Table 9). The results of the present study are therefore in match with the findings of the previous mentioned workers.

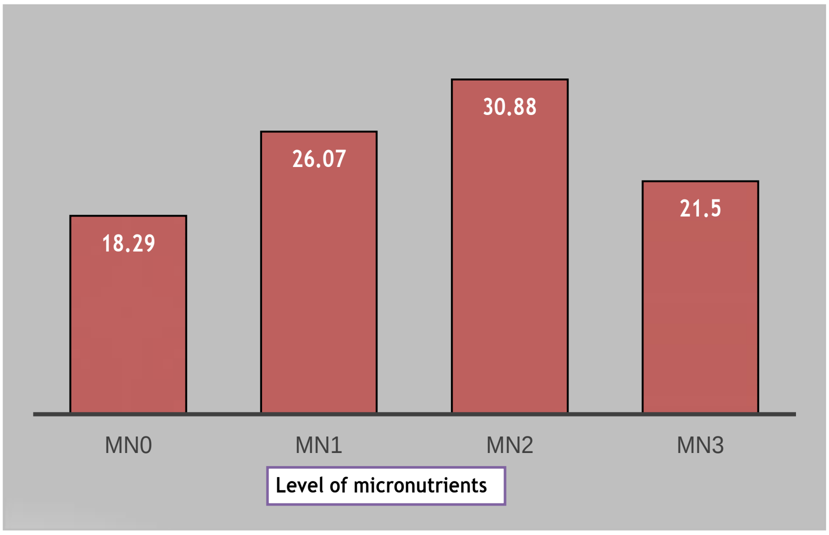

Figure 13. Effect of micronutrients on number of cormel

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm

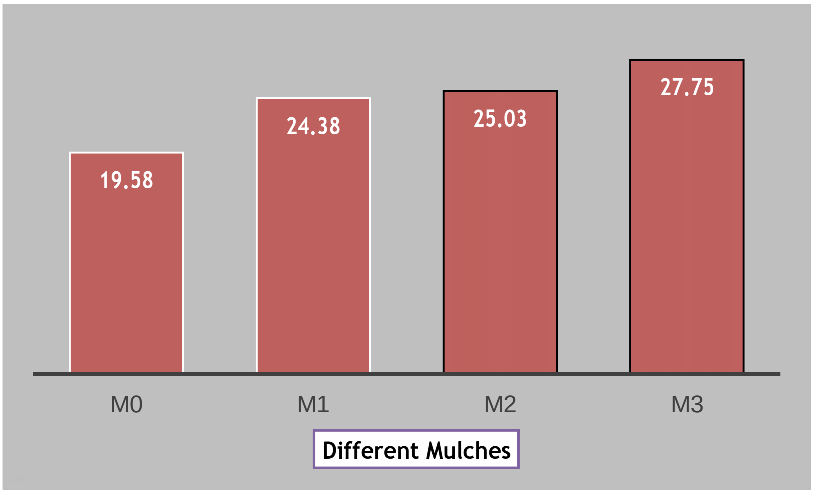

Figure 14. Effect of mulches on number of cormel

M_0: Control, M_1: Water hyacinth, M_2: Rice straw, M_3: Black polythene

4.14 Diameter of individual cormel (cm)

Depending on the species, a cormel takes several months or years before it develops, flowers, and become a mature corm. It is important as a survival strategy. Cormel diameter showed significant differences among treatments. The different micronutrients had statistically significant effect on the diameter of cormel (Appendix VII). The maximum diameter of cormel (1.49 cm) was observed when micronutrients, MN_2 were applied and minimum diameter of cormel (1.12 cm) from control (Figure 15).

Mulches was significant in variation on cormel diameter (Appendix VII). The maximum corm diameter (1.39 cm) was recorded in the plot with black polythene (Figure 16) and 1.35 cm corm diameter was recorded from M_2. The minimum corm diameter (1.16 cm) was recorded in the plot with no mulches.

Cormel diameter differed significantly for interaction effect of mulches and micronutrients (Appendix VII). The highest diameter of cormel (1.64 cm) was obtained from MN_2 and M_3 while the lowest (0.87) was recorded from control (Table 9).

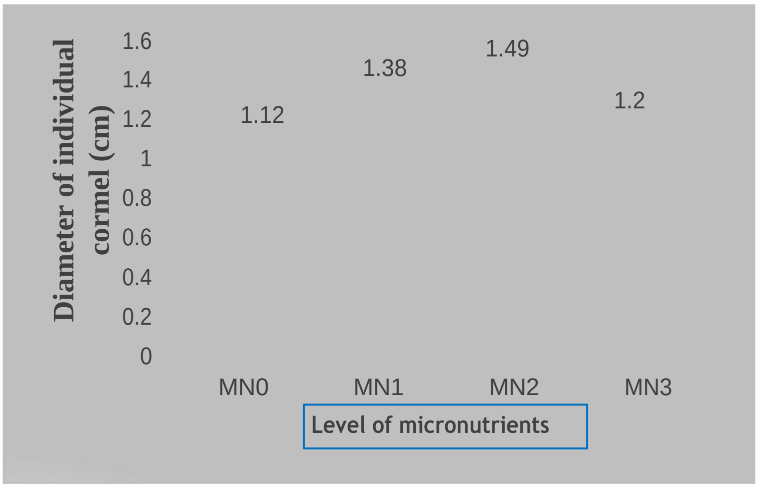

Figure 15. Effect of micronutrients on diameter of cormel

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm

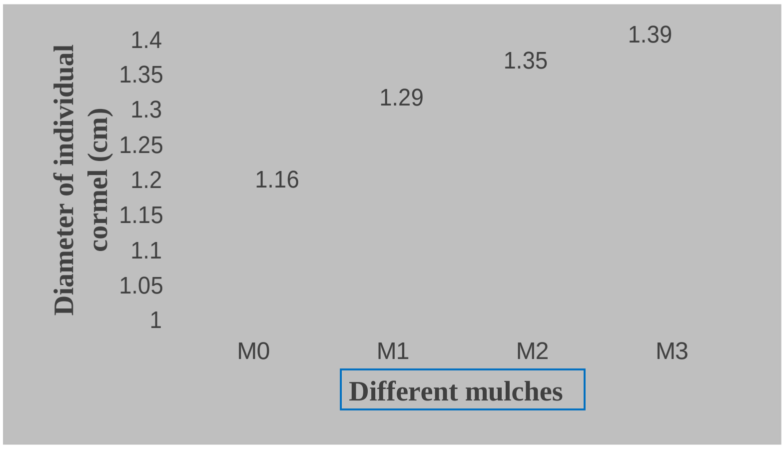

Figure 16. Effect of mulches on diameter of cormel (cm)

M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

Table 9. Interaction effect of mulches and micronutrients on Number, Diameter of corm and cormel of gladiolus

Treatment	Number of corm per plot	Diameter of individual corm (cm)	Number of cormel per plot	Diameter of individual cormel (cm)
MN_0M_0	9.2h	3.52h	15.10k	0.87i
MN_0M_1	10.3f-h	4.23gh	18.20j	1.13h
MN_0M_2	11.3ef	4.43fg	19.20ij	1.21g
MN_0M_3	12.7de	5.10ef	20.67hi	1.31e
MN_1M_0	11.3ef	4.62fg	21.70gh	1.31e
MN_1M_1	11.7ef	5.52de	24.67de	1.36d
MN_1M_2	11.3ef	6.25b-d	26.27d	1.42c
MN_1M_3	13.3cd	5.87cd	31.67b	1.44c
MN_2M_0	14.3c	6.36bc	23.53ef	1.35de
MN_2M_1	16.3b	6.50bc	29.33c	1.42c
MN_2M_2	16.7b	6.92b	32.33b	1.53b
MN_2M_3	18.7a	7.82a	38.33a	1.64a
MN_3M_0	9.7gh	4.27gh	18.00j	1.12h
MN_3M_1	12.3de	5.81c-e	25.33d	1.26f
MN_3M_2	10.7fg	4.65fg	22.33fg	1.23fg
MN_3M_3	10.3f-h	4.45fg	20.33hi	1.20g
LSD $_{(0.05)}$	1.486	0.758	1.627	0.048
CV%	3.90	4.62	2.21	1.21

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm; M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

4.15 Yield of corm (g/plot)

Yield of corm was statistically significant due to the effect of micronutrients (Appendix VIII). It was found that the maximum corm (973g/plot) was found from MN_2 and the minimum (673g/plot) was obtained from MN_0 (Table 10)

Yield of corm was varied statistically significantly with mulches (Appendix VIII). The maximum (816g/plot) corm was found from M_3 whereas 815g corms were also found from M_1 and the minimum (761g/plot) was recorded from the M_0 (Table 11).

The combined effect of mulches and micronutrients had statistically significant effect on Yield of corm (Table 12). The maximum yield (994g/plot) was found from the treatment combination of MN_2M_3 and the minimum (615g/plot) was measured from the treatment combination of MN_0M_0.

4.16 Yield of corm (t/ha)

Yield of corm was significantly influenced by different micronutrients (Appendix VIII). The maximum (26.5 t/ha) yield of corm was recorded from MN_2 and the minimum (18.7 t/ha) was recorded from MN_0 (Table 10). Similar trend of results was obtained by Maurya and Kumar (2014) and Halder, *et al.* (2007).

The maximum (22.6 t/ha) yield of corm was found from M_3 and the minimum (21.1 t/ha) was obtained from M_0 and this had significantly significant effect (Appendix VIII and Table 11). Hochmuth and Howell (1983) observed that the highest marketable yield (18.6 t/ha) was obtained from mulched raised beds where flat unmulched beds gave the lowest yield (7.0 t/ha) in sweet potato.

Combined effect of mulches and micronutrients showed statistically significant effect on yield of corm (Appendix VIII). The maximum (27.6 t/ha) yield of corm was found the treatment combination of MN_2M_3 and the minimum (17.1 t/ha) was measured from the treatment combination of MN_0M_0 (Table 12).

4.17 Yield of cormel (g/plot)

Effect of micronutrients on yield of cormel was found statistically significant (Appendix VIII). The maximum (34.4 g/plot) yield of cormel was found from MN_2 and the minimum (20.3 g/plot) was recorded from MN_0 (Table 10). This result is in agreement with the findings of Maurya and Kumar (2014).

Effect of mulches on yield of cormel was statistically significant (Appendix VIII). The maximum (30 g/plot) yield of cormel was found from M_3 while the minimum (21.9 g/plot) was obtained from M_0 (Table 11).

Combination of mulches and micronutrients had statistically significant effect on yield of cormel production (Appendix VIII). The maximum (40.8 g/plot) yield was found from the treatment combination of MN_2M_3 and the minimum (14.7 g/plot) was measured from the treatment combination of MN_0M_0 (Table 12).

4.18 Yield of cormel (t/ha)

Yield of cormel for micronutrients showed statistically significant variation (Appendix VIII). The highest yield of cormel (0.95 t/ha) was recorded in the plot micronutrients MN_2 (Table 6) and the lowest yield of cormel (0.57 t/ha) was recorded in the plot with no micronutrients (Table 10). This huge variation might be caused due to no supply of micronutrients which is an essential element for development.

A statistically significant variation was recorded with respect to yield of cormel of gladiolus due to the effect of different mulches (Appendix VIII). The highest yield of cormel (0.84 t/ha) was recorded in M_3 (Table 11). The lowest yield of cormel (0.61 t/ha) was recorded for no mulches.

There were statistically significant interaction effects between mulches and micronutrients for yield of cormel (Appendix VIII). The highest yield of cormel (1.13 t/ha) was recorded in MN_2M_3 and the lowest yield of cormel (0.407 t/ha) was recorded in MN_0M_0 (Table 12).

Table 10. Effect of micronutrients on yield of corm and cormel of gladiolus

Treatment	Yield of corm (g/plot)	Yield of corm (t/ha)	Yield of cormel (g/plot)	Yield of cormel (t/ha)
MN_0	673d	18.7c	20.3d	0.57d
MN_1	858b	23.8b	28.4b	0.79b
MN_2	973a	26.5a	34.4a	0.95a
MN_3	698c	19.3c	23.7c	0.66c
LSD $_{(0.05)}$	3.402	0.938	0.429	0.012

MN_0 : Control, MN_1 : 36 ppm, MN_2 : 72 ppm, MN_3 : 108 ppm

Table 11. Effect of mulches on yield of corm and cormel of gladiolus

Treatment	Yield of corm (g/plot)	Yield of corm (t/ha)	Yield of cormel (g/plot)	Yield of cormel (t/ha)
M_0	761c	21.15b	21.9d	0.61d
M_1	815a	22.15a	26.8c	0.74c
M_2	810b	22.51a	28.2b	0.78b
M_3	816a	22.68a	30.a	0.83a
LSD $_{(0.05)}$	3.402	0.938	0.429	0.012

M_0 : Control, M_1 : Water hyacinth, M_2 : Rice straw, M_3 : Black polythene

Table 12. Interaction effect of mulches and micronutrients on number, diameter of corm and cormel of gladiolus

Treatment	Yield of corm (g/plot)	Yield of corm (t/ha)	Yield of cormel (g/plot)	Yield of cormel (t/ha)
MN_0M_0	615l	17.10h	14.67l	0.41l
MN_0M_1	678k	18.84f-h	18.73k	0.52k
MN_0M_2	689j	19.14f-h	22.65i	0.63i
MN_0M_3	710i	19.73fg	25.37f-h	0.71f-h
MN_1M_0	766g	21.29ef	24.50gh	0.68gh
MN_1M_1	841f	23.37de	26.50ef	0.73ef
MN_1M_2	890e	24.72cd	29.11d	0.81d
MN_1M_3	938d	26.06a-c	33.67c	0.93c
MN_2M_0	941d	26.14a-c	25.58fg	0.71fg
MN_2M_1	973c	25.05b-d	34.50c	0.95c
MN_2M_2	983b	27.31ab	36.73b	1.02b
MN_2M_3	994a	27.62a	40.78a	1.13a
MN_3M_0	722h	20.07f	22.83i	0.63i
MN_3M_1	767g	21.32ef	27.40e	0.76e
MN_3M_2	679k	18.86f-h	24.25h	0.67h
MN_3M_3	623l	17.32gh	20.28j	0.56j
LSD $_{(0.05)}$ CV%	9.319 0.38	2.571 3.82	1.176 1.45	0.032 1.46

4.19 Economic analysis

The economic analysis was calculated to find out the gross and net return and the benefit cost ratio in the experiment and presented under the following headings

4.19.1 Influence of mulch on the growth and yield

In the combination of different level of micronutrients and mulches the highest gross return (Tk 791960) was obtained from the treatment combination of black polythene and micronutrients and the second highest gross return (Tk 756630) was obtained from MN_2M_2. The lowest gross return (Tk 533128) was found from control (Table 13).

4.19.2 Net return

In case of net return different treatment combination showed different types of net return. In combination of different levels of micronutrients and mulches the highest net return (Tk 413232) was obtained from MN_2M_3 and the second highest net return (Tk 379597) was found from MN_2M_2. The lowest net return (Tk 162649) was obtained from control (Table 13).

4.19.3 Benefit cost ratio

In the combination of different levels micronutrients and mulches the highest benefit cost ratio (2.09) was attained from MN_2M_3 and the second highest benefit cost ratio (2.01) was obtained from MN_2M_2. The lowest benefit cost ratio (1.43) was obtained from control (Table 13).

Table 13. Effect of micronutrients and mulches on economic point of view showing gross return, net return and benefit cost ratio (BCR)

Treatment Combination	Cost of production (Tk./ha)	Yield of corm (t/ha)	Price of corm (Tk./ha)	Yield of Cormel (t/ha)	Price of Cormel (Tk./ha)	Yield of spike no/ha	Price of Cut Flower (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
MN_0M_0	370479	17.10	85500	0.407	1628	223.00	446000	533128	162649	1.43
MN_0M_1	374434	18.84	94200	0.522	2088	231.67	463340	559628	185194	1.49
MN_0M_2	376129	19.14	95700	0.630	2520	238.33	476660	574880	198751	1.53
MN_0M_3	377824	19.73	98650	0.705	2820	244.00	488000	589470	211646	1.56
MN_1M_0	370931	21.29	106450	0.680	2720	233.00	466000	575170	204239	1.55
MN_1M_1	374887	23.37	116850	0.737	2948	252.33	504660	624458	249571	1.67
MN_1M_2	376581	24.72	123600	0.810	3240	258.00	516000	642840	266259	1.71
MN_1M_3	378276	26.06	130300	0.933	3732	265.00	530000	664032	285756	1.78
MN_2M_0	371383	26.14	130700	0.710	2840	269.67	539340	672880	301497	1.79
MN_2M_1	375338	25.05	125250	0.957	3828	299.67	599340	728418	353080	1.94
MN_2M_2	377033	27.31	136550	1.020	4080	308.00	616000	756630	379597	2.01
MN_2M_3	378728	27.62	138100	1.133	4520	324.67	649340	791960	413232	2.09
MN_3M_0	371835	20.07	100350	0.633	2520	246.00	492000	594870	223035	1.59
MN_3M_1	375790	21.32	106600	0.760	3040	257.00	514000	623640	247850	1.66
MN_3M_2	377485	18.86	94300	0.673	2692	238.33	476660	573652	196167	1.52
MN_3M_3	377180	17.32	86600	0.567	2268	227.33	454660	543528	164348	1.44

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2016 to May 2017 with the objective to study the effects of micronutrients (B, Zn and Mn) and mulches on growth, flowering and yield of gladiolus. Four levels of micronutrients: control - MN_0, 36 ppm of each micronutrient - MN_1 ,72 ppm of each micronutrient- MN_2 and 108 ppm of each micronutrient - MN_3 and Four different mulches M_0- Control, M_1- Water hyacinth, M_2 - Rice straw, M_3- Black polythene were used for this purpose. The two-factor experiment was laid out in randomized complete block design with three replications. There were all together 48 treatment combinations in this experiment.

Corms of gladiolus (*Gladiolus grandiflorus* L.) were planted on 16 October 2016 with spacing of 15 x 20 cm. At first the spikes of gladiolus were harvested in 29 December 2016 and Continued till February, 2017 at the tight bud stage and when three basal flower buds showed colour so that these may easily open indoors one by one. Corm and cormel were harvested on 28 May, 2017 when leaves turned brown. Data were collected on days required to 80% plant emergence, plant height, number of leaves, leaf area, chlorophyll percentage days required to 80% spike initiation, spike length, number of florets per spike, spike number, flower yield, corm number, corm weight, corm diameter, cormel number, cormel diameter and weight per plot.

The results of the experiment revealed that micronutrients and mulches had significant effect on most of the parameters studied. The maximum leaves (4.15, 5.29, 6.02 and 7.18) were recorded respectively by micronutrients (MN_2) at 30, 40, 50 and 60 DAP whereas it was minimum (2.65, 3.47, 4.27 and 5.09) in control. The maximum results (3.53, 4.78, 5.63 and 6.71) were recorded with black polythene mulch at the same time, but number of leaves per plant was not significant at 40 DAP. Black polythene treated with micronutrients (MN_2)

produced the highest number of leaves (5.07, 6.47, 7.10 and 8.23) at different days (30, 40 ,50 and 60) respectively.

The results under the present study revealed that there was no significant effect on chlorophyll percentage with the interaction effect of micronutrients and mulches. Individually, micronutrients had significant effect on chlorophyll percentage of leaves but mulches showed non-significant effect on it. Leaf area of gladiolus was also significant in case of mulches and micronutrients. Combined effect of mulches and micronutrients showed significant difference on leaf area of gladiolus.

Plant height at different days per plot was significantly increased with mulches. The plant height as recorded on 40 DAP was not significant. Micronutrients showed better performance with respect to plant growth over control. Black polythene treated with micronutrients (MN_2) produced the highest number of plant height.

Days required to 80% spike initiation were significantly earlier in plant influenced by mulches (M_3) (72 days) than in no mulches. Micronutrients (MN_2) completed 80% spike initiation by 68 days earlier than the control (80 days).

The highest number of spike per plot (14.92) was with the treatment of MN_2 and the lowest (9.58) was recorded from control. Mulches (M_3) had significant effect on number of spike. The number of spike was maximum (13.12) found from M_3 while the lowest (10.09) was recorded from M_0. MN_2 in combination with M_3 showed highest number of spike (18) over control (8.36).

The mulches (M_3) on plant produced the highest spike length (61.98 cm) and the shortest spike length was produced in plant grown from control (48.66 cm). The length of spike was highest (66.28 cm) with the treatment of MN_2 (B, Zn and Mn) followed by MN_1 (59.80 cm) over control (45.51 cm). The best performance was showed in the combination of MN_2 M_3 (75.13cm).

Number of florets per spike was maximum in mulches (M_3) (11.72) followed by M_2 (11.13) and was minimum in no mulches (9.58). MN_2 produced the maximum number of florets per spike (13.39) and the control treatment produced the minimum number of florets (9.12). However, the combined effect of micronutrients and mulches revealed that the maximum number of florets (15.71) was obtained from the treatment combination of MN_2 M_3.

The maximum diameter of florets per spike (9.55 cm) was observed when micronutrients, MN_2 were applied with water and minimum diameter of florets (6.78 cm) recorded from control. The maximum diameter of florets per plot (8.31cm) was obtained from M_3 while the lowest (6.99cm) was recorded from M_0. However, the combined effect of micronutrients and mulches showed that the maximum number of florets (10.43cm) was obtained from MN_2 M_3.

The highest flower number (324670 spikes/ha) was recorded from mulches (M_3) with MN_2 while control showed the lowest performance (223000 spikes/ha).

Corm and cormel production also influenced by different mulches and micronutrients level. The maximum number of corm and cormel (18.67 and 38.33) were produced by MN_2 M_3. The same level of micronutrients with black polythene also showed better performance in corm diameter (7.82 cm), corm weight (994.33 g/plot), cormel diameter (1.64 cm) and cormel weight (40.78 g/plot). Mulches was significant in case of corm yield both g/plot and t/ha.

There were significant interaction effects between mulches and micronutrients for yield of corm and cormel in g/ha and t/ha was significant. The maximum (27.62 t/ha) yield of corm was found the treatment combination of MN_2M_3 and the minimum (17.10 t/ha) was measured from the treatment combination of MN_0M_0. The highest yield of cormel (1.13 t/ha) was recorded in MN_2M_3 and the lowest yield of cormel (0.407 t/ha) was recorded in MN_0M_0.

The highest benefit cost ratio (2.09) was attained from MN_2M_3 and the second highest benefit cost ratio (2.01) was obtained from MN_2M_2. The lowest benefit cost ratio (1.43) was obtained from control.

CONCLUSION

Micronutrients applied to gladiolus as foliar spray at an early stage of growth, not only influenced vegetative growth and flowering in the plant, but also affected number of corms, corm diameter and weight. Although, the mulches were significantly affected on the performance of vegetative growth, flowering and corm production. From the findings of the present study, it can be concluded that in terms of yield and yield contributing parameters, MN_2 (B, Zn and Mn) at 72 ppm application and black polythene (MN_2M_3) was the best treatment compared to all other treatment combinations.

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APPENDICES

Appendix I. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

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

Source: SRDI

Appendix II: Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from October 2016 to May 2017

Month (2016-2017)	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)
	Maximum	Minimum		
October, 2016	24.3	16.2	72	32
November,2016	26.7	17.4	66	30
December,2016	23.5	12.3	63	26
January, 2017	27.3	13.5	54	24
February, 2017	29.8	19.1	49	12
March, 2017	33.1	22.6	45	100
April, 2017	35.1	26.9	55	230
May, 2017	33.7	24.9	72	202

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

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

Fertilizer	Nutrient	%
Urea	N	46
TSP	P_2O_5	48
	P	21.12
MOP	K_2O	60
	K	49.8
Cow dung	N	0.5-1.5
	P	0.4-0.8
	K	0.5-1.9
H_3BO_3	B	17
ZnO	Zn	78
MnO_2	Mn	55.8

Source: Fertilizer Recommendation Guide, BARC

Appendix IV. Analysis of variance of the data on leaf no in different DAP, leaf area and chlorophyll% influenced by mulches and micronutrients

Source of variation	Degrees of freedom	Mean square Leaf Number in different days at				Leaf area(cm^2)	Chlorophyll %
		30 DAP	40 DAP	50 DAP	60 DAP		
Replication	2	0.0018	0.0076	0.0006	0.005	1.15	1.29
Micronutrients (MN)	3	5.04**	6.78**	6.30**	8.99**	2475.02*	1.19*
Mulches (M)	3	1.08*	1.44	3.0**	3.92**	609.26*	0.94
Interaction (MN×M)	9	0.38*	0.64*	0.27**	0.34**	605.03*	0.32
Error	30	0.007	0.005	0.004	0.002	1.32	0.35

* = Significant at 5% level of probability   ** = Significant at 1% level of probability

Appendix V. Analysis of variance of the data on plant height per plant at different days after planting of gladiolus as influenced by mulches and micronutrients

Source of variation	Degrees of freedom	Mean square Plant Height per plot at different days after planting			
		30 DAP	40 DAP	50 DAP	60 DAP
Replication	2	0.013	0.045	0.290	0.009
Micronutrients(MN)	3	169.28**	356.5**	493.22**	334.3**
Mulches(M)	3	91.51**	222.3*	154.03*	140.5*
Interaction (MN×M)	9	18.63**	31.5*	24.104*	23.5*
Error	30	0.095	0.204	0.382	0.294

* = Significant at 5% level of probability ** = Significant at 1% level of probability

Appendix VI. Analysis of variance of the data on Days required to 80% initiation of spike, spike thousand/ha, number, length of spike and floret of gladiolus as influenced by mulches and micronutrients

Source of variation	Degrees of freedom	Days required to 80% initiation of spike	Number of spike per plot	Length of spike	Number of floret per spike	Diameter of Floret	Spike thousand /ha
Replication	2	3.562	0.0045	0.018	0.0042	0.0130	6.8
Micronutrients(MN)	3	322.47*	13.71**	907.5**	40.63***	17.59**	10615.1**
Mulches(M)	3	50.75**	1.52*	433.2**	9.99**	4.32*	1158.5*
Interaction (MN×M)	9	38.25*	0.74*	41.5**	2.74**	1.01*	571.2*
Error	30	0.81	0.008	0.14	0.02	0.02	6.3

* = Significant at 5% level of probability ** = Significant at 1% level of probability

Appendix VII. Analysis of variance of the data on number, diameter of corm and cormel as influenced by mulches and micronutrients.

Source of variation	Degrees of freedom	Number of corm per plot	Diameter of individual corm	Number of cormel per plot	Diameter of individual cormel
Replication	2	0.505	0.0128	0.038	0.0004
Micronutrients(MN)	3	88.17**	15.20**	361.55*	0.33*
Mulches(M)	3	13.92*	2.84*	138.51*	0.13*
Interaction(MN×M)	9	2.92*	0.87*	24.52*	0.02*
Error	30	0.2385	0.0622	0.286	0.00025

* = Significant at 5% level of probability ** = Significant at 1% level of probability

Appendix VIII. Analysis of variance of the data on yield of corm and cormel as influenced by mulches and micronutrients

Source of variation	Degrees of freedom	Yield of corm (g/plot)	Yield of corm (t/ha)	Yield of cormel (g/plot)	Yield of cormel (t/ha)
Replication	2	8	0.843	0.18	0.00091
Micronutrients(MN)	3	2397*	166.24**	3208.97**	0.342**
Mulches(M)	3	812*	5.64*	367.47*	0.11*
Interaction(MN×M)	9	851*	7.83*	195.72*	0.03*
Error	30	9	0.714	0.50	0.00012

* = Significant at 5% level of probability ** = Significant at 1% level of probability

Appendix IX. Per hectare Production Cost of Gladiolus

A. Input cost

Treatment Combination	Labor cost	Ploughing cost	Corm Cost	Irrigation Cost	Pesticides	Micronutrients	Mulches	Manure and fertilizers				Miscellaneous	Sub Total (A)
								Cow dung	Urea	TSP	MP		
MN_0M_0	70000	15500	115875	8000	2500	0	0	10000	5000	6750	6750	1200	241575
MN_0M_1	70000	15500	115875	8000	2500	400	3500	10000	5000	6750	6750	1200	245075
MN_0M_2	70000	15500	115875	8000	2500	800	5000	10000	5000	6750	6750	1200	246575
MN_0M_3	70000	15500	115875	8000	2500	1200	6500	10000	5000	6750	6750	1200	248075
MN_1M_0	70000	15500	115875	8000	2500	0	0	10000	5000	6750	6750	1200	241975
MN_1M_1	70000	15500	115875	8000	2500	400	3500	10000	5000	6750	6750	1200	245475
MN_1M_2	70000	15500	115875	8000	2500	800	5000	10000	5000	6750	6750	1200	246975
MN_1M_3	70000	15500	115875	8000	2500	1200	6500	10000	5000	6750	6750	1200	248475
MN_2M_0	70000	15500	115875	8000	2500	0	0	10000	5000	6750	6750	1200	242375
MN_2M_1	70000	15500	115875	8000	2500	400	3500	10000	5000	6750	6750	1200	245875
MN_2M_2	70000	15500	115875	8000	2500	800	5000	10000	5000	6750	6750	1200	247375
MN_2M_3	70000	15500	115875	8000	2500	1200	6500	10000	5000	6750	6750	1200	248875
MN_3M_0	70000	15500	115875	8000	2500	0	0	10000	5000	6750	6750	1200	242775
MN_3M_1	70000	15500	115875	8000	2500	400	3500	10000	5000	6750	6750	1200	246275
MN_3M_2	70000	15500	115875	8000	2500	800	5000	10000	5000	6750	6750	1200	247775
MN_3M_3	70000	15500	115875	8000	2500	1200	6500	10000	5000	6750	6750	1200	249275

Appendix IX. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 7,50000/year)	Interest on running capital for 12 months (Tk. 13% of cost/year)	Subtotal (Tk) (B)	Total cost of production (Tk. ha) [Input cost (A)+ overhead cost (B)]
MN_0M_0	97500	31404	128904	370479
MN_0M_1	97500	31859	129359	374434
MN_0M_2	97500	32054	129554	376129
MN_0M_3	97500	32249	129749	377824
MN_1M_0	97500	31456	128956	370931
MN_1M_1	97500	31911	129411	374887
MN_1M_2	97500	32106	129606	376581
MN_1M_3	97500	32301	129801	378276
MN_2M_0	97500	31508	129008	371383
MN_2M_1	97500	31963	129463	375338
MN_2M_2	97500	32158	129658	377033
MN_2M_3	97500	32353	129853	378728
MN_3M_0	97500	31560	129060	371835
MN_3M_1	97500	32015	129515	375790
MN_3M_2	97500	32210	129710	377485
MN_3M_3	97500	32405	129905	379180

Appendix X. The experimental sites under study