J. Agr. Sci. Tech. (2014) Vol. 16: 1671-1682

The Effect of Micronutrients (B, Zn and Fe) Foliar Application on the Growth, Flowering and Corm Production of Gladiolus (*Gladiolus grandiflorus* L.) in Calcareous Soils

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ABSTRACT

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

Keywords: Boron, Iron, Number of florets per spike, Spike length, Vase life, Zinc.

[DOR: 20.1001.1.16807073.2014.16.7.10.6]

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is one of the most cultivated, economically important and common flowering plant world-wide including Pakistan and is among the elite cut flowers due to different shapes, hues and prolonged vase life (Bose *et al*., 2003). Gladiolus, a member of family Iridaceae and sub-family Ixidaceae, originated from South Africa, is a prominent 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 and flower for decoration. It is commercially cultivated for ornamental and as well for medicinal purposes. It bears innumerable cultivars with assortment of attractive colors. Gladiolus is one of the most important bulbous flowering crops grown commercially for cut-flower trade in Pakistan.

The commercial growers are growing gladiolus in different zones of the country especially in Punjab province to fulfill the local consumption demand; however the production and flower quality are still too low to meet the international standards. Its cultivation is gaining popularity among the farmers in different areas of Punjab and has recently been seen as a lucrative enterprise

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due to increased awareness and recognition of the high return on its investments. The suitable agro-climatic conditions of the country clearly indicate that a wide range of ornamental crops can be grown, which can improve the economic status of the growers. However, quality production is in dire need of standard agricultural practices, including nutrient management. Chemical fertilizers play a vital role in growth, quality of flowers, corm and cormel production. Gladiolus requires adequate amounts of chemical fertilizers in their balanced proportions for ensuring maximum flower production. Being involved in the physiology of plants, micronutrients well contribute to the growth and yield of the plants. Within different areas, productivity of crops is being adversely affected by micronutrient deficiencies, the deficiency having been markedly increased due to intensive cropping, loss of top soil by erosion, loss by leaching, liming of soil and as well, a decreased in the availability and use of farmyard manure (Fageria *et al*., 2002).

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). Information regarding nutritional requirements and appropriate soil management practices are lacking for gladiolus cultivation in Pakistan. 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.

There are evidences that iron deficiency impairs many plant physiological processes because it is involved in chlorophyll and protein synthesis and in root tip meristem growth. Tagliavini & Rombola (2001) illustrated that iron deficiency (chlorosis) is a common disorder which affects plants grown on soils of high pHs. This may lead to serious yield and quality losses, demanding the implementation of suitable plant iron-deficiency correction strategies. Iron application through foliar spray is a common practice to cure iron-deficiency (Mortvedt, 1991).

Boron plays a vital role as stabilizer of cell wall pectic 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 is an essential micronutrient necessary for sugar regulation and assorted enzymatic activity associated with plant growth (Evans and Solberg, 1998; 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). Amir *et al*. (2008) observed that rose cultivars' flower vase life had been extended when plants treated with Zn. Most soils in Pakistan are of high pH values (alkaline), which ultimately binds naturally present micronutrients with soil particles, making them unavailable to the plants with foliar application being one of the methods to overcome this. Rapid uptake of nutrients applied to crop foliage ensures a fast response within the plant as micronutrients directly enter the metabolic processes. Foliar applications of micronutrients are most completely available to the plant, because they are not either fixed or diluted in some large volumes of soil (Baloch *et al*., 2008). *Gladiolus* plants grown under Punjab conditions frequently suffer from iron and zinc deficiencies (Kumar and Arora, 2000). Considering the significance of micronutrients in plant structure and in physiological processes, they are treated with these nutrients as the limiting elements for maximizing corm and cormel production

(Halder *et al*., 2007b). Mukesh *et al*. (2001) investigated the effect of foliar application of Zn, Cu, and Fe at 0, 250, 500 and 1,000 ppm on the yield and quality of gladiolus. Plants treated with micronutrients exhibited better results as compared with the control. However, foliar application of Fe, Cu, and Zn at 1,000 ppm showed best results with respect to growth, flowering and other yield parameters. In gladiolus, spike length, number of florets, weight or spike and size of florets were significantly increased with 0.2% $FeSO_4$+0.2% $ZnSO_4$ application (Kumar and Arora, 2000).

At present, there is an urgent need to standardize agro techniques which are most suitable for local climatic and edaphic conditions. But the paramount problem, the farmers are facing is judicial use of chemical fertilizers. Keeping in view the significance of gladiolus in global cut flower trade, a field experiment was executed to find out the response of *Gladiolus grandiflours* cultivars to foliar application of various micronutrients for enhancing yield and improving quality and corm indices. The objective of the present study was to investigate the effect of micronutrients (B, Zn, and Fe) on growth, flowering, vase life and corm production of an exotic gladiolus cultivar 'Traderhorn' under agro-climatic conditions of Multan.

MATERIALS AND METHODS

The research was conducted at the Experimental Site, Department of Horticulture, Bahauddin Zakariya University, Multan (Pakistan) during 2010-2012. Soil was leveled, thoroughly prepared and the experiment laid out according to a Randomized Complete Block Design (RCBD) of one factor and three replications. Soil samples from various blocks of field were collected to determine the physico-chemical properties and fertility of the soil (Table 1).

The corms (3-4 cm diameter) of gladiolus (*Gladiolus grandiflorus* L.) cv. Traderhorn, imported from Netherlands, were placed at room temperature before being planted. The sowing was carried out in the first week of November during the two years of 2010 and 2011 on ridges spaced 60 cm apart with 20 cm interplant distance. Twenty corms were planted in each treatment of three replications. The treatments contained 2% solution of each of iron (Fe), boron (B), and zinc (Zn) salts, applied in various combinations. Fe was applied as ferrous sulphate ($FeSO_4.7H_2O$), B as boric acid (H_3BO_3) and Zn as zinc sulphate ($ZnSO_4.7H_2O$). Control plants were sprayed with plain water. The micronutrients were sprayed on the plants. A detail of the treatments is presented in Table 2.

The first spray was applied at 3-leaf while the second at 6-leaf stage. All other cultural practices like weeding, plant protection measures, macronutrient application, earthing up and staking were similar for all the treatments. Ten plants were randomly selected from each treatment for recording of the data. Within the course of time, data related to different growth parameters, flowering and corm production were collected using standard procedures. Plant

Table 1. Physico-chemical properties of the soil.

Characteristics	Soil depth	
	0-15 (cm)	15-30 (cm)
Texture	Loam	Loam
pH	8.56	8.50
EC (ds m^{-1})	1.74	1.65
Organic matter (%)	0.38	0.36
Available phosphorus (mg L^{-1})	5	3
Available potassium (mg L^{-1})	154	130

[DOR: 20.1001.1.16807073.2014.16.7.10.6]

Table 2. The details of treatments used in the study.

Treatments	$FeSO_4.7H_2O$ (%)	H_3BO_3 (%)	$ZnSO_4.7H_2O$ (%)
T_0	0	0	0
T_1	2	0	0
T_2	0	2	0
T_3	0	0	2
T_4	2	2	0
T_5	2	0	2
T_6	0	2	2
T_7	2	2	2

height was taken 30 days after planting. For an estimation of leaf chlorophyll content, non-destructive method was employed. Chlorophyll contents (spot values) were determined from ten randomly selected leaves from each treatment through chlorophyll meter (SPAD, Minolta, Japan). Stalk length was measured from the ground level to the top of the spikes. Spike length was determined, starting from the lowest floret up to the top of the spikes. For an estimation of the vase life, flower stalks were harvested when most of the lower florets had started showing color. Two lowest leaves were left intact with the plant for better development of corms. Spikes were immediately kept in buckets containing distilled water and brought to the laboratory. The leaves of the stem were removed and the stems kept individually in glass vases containing 200 ml of distilled water. Every two days, vase water was replaced with fresh distilled water and a lower 2.5 cm of stem was also cut for better water uptake. Five spikes per treatment in each of the replications were taken for vase life evaluation. Spikes were considered dead when more than 50% of the florets wilted, dried or faded away.

Data collected during both the years were pooled and statistically analyzed by use of Fisher's Analysis of Variance (ANOVA) technique. The treatment means were compared by employing Least Significant Difference (LSD) test at P= 0.05. Co-Stat Statistical package software was used for the purpose (Co-Stat Statistical Software, 2003).

RESULTS AND DISCUSSION

Plant Height

Statistical analysis of the data on plant height revealed significant differences among the micronutrients treatments. The plants sprayed with all the three micronutrients (T_7) resulted in maximum plant height, followed by those which received any two of the micronutrients (T_5, T_6 and T_4). All these four treatments were statistically at par. The minimum plant height was recorded for control (T_0, sprayed with plain water), which remained at par with T_1, T_2, and T_3 (Table 3).

These findings indicated that all the three micronutrients (Fe, B and Zn) applied as foliar spray were needed for the plant's growth and contributed towards better growth of gladiolus in terms of plant height. Kumar and Arora (2000) have already reported increased plant height with foliar application of 0.2% $FeSO_4$, when gladiolus cv. White prosperity plants were sprayed at 3- and 6-leaf stages with $FeSO_4$, $MnSO_4$ and $ZnSO_4$ at 0.2 and 0.4% levels of each. Similarly, increased vegetative growth has also been reported in gladiolus grown on partially reclaimed sodic soils by foliar application of Zn+Cu, each at 0.2% applied twice (Katiyar *et al*., 2005). Lahijie (2012) too, found that an application of $FeSO_4$ (0.5 or 1%) and $ZnSO_4$ (0.5 or 1%) either singly or in combination, applied at 2- and 6-leaf stages, significantly increased height of

Table 3. Effect of foliar application of nutrients on growth characteristics of gladiolus.[a]

Treatments	Plant height 30 DAP (cm)	Number of leaves plant^{-1}	Leaf chlorophyll content (Spot value)	Days to spike emergence
T_0	49.60 c	6.02 b	68.73 d	106.40 b
T_1	52.80 bc	6.06 b	71.46 cd	107.06 b
T_2	52.86 bc	6.08 b	72.33 c	107.06 b
T_3	53.20 bc	6.11 b	72.60 c	107.53 b
T_4	54.13 ab	6.24 b	73.66 bc	109.33ab
T_5	54.93 ab	6.33 b	80.20 a	109.33 ab
T_6	54.33 ab	6.26 b	75.60 b	109.33 ab
T_7	57.46 a	6.86 a	80.20 a	111.00 a
LSD at 5%	3.76	0.50	2.77	2.28

[a] Means sharing similar letters for each parameter separately are statistically non-significant at *P*= 0.05 (LSD test).

gladiolus cv. Oscar plants. Similarly, application of either $ZnSO_4$ (0, 0.15, 0.30 or 0.45%) or H_3BO_3 (0, 5, 10 or 20 ppm) either singly or in combinations twice as foliar spray 45 and 60 days after planting significantly increased height of Iris plants (Khalifa *et al*., 2011). Foliar spray of micro power, containing Zn, B, Fe and Mn, also significantly increased plant height of Gerbera (Khosa *et al*., 2011).

Number of Leaves per Plant

Analysis of variance on the number of leaves indicated that the leaf number was only increased significantly when all the three micronutrients were applied together (T_7). When micronutrients were sprayed either singly or in combinations of two, these did not affect the leaf number and stood statistically at par with control (Table 3). Leaf number is considered as an important factor in growth, responsible for photosynthesis and ultimately affecting the flower yield and quality.

These results are in partial support of Kumar and Arora (2000) and Halder, *et al*. (2007a) findings, who observed increase in number of leaves as a result of foliar application of different micro-nutrients on gladiolus. Kumar and Arora (2000) sprayed gladiolus cv. White prosperity with $FeSO_4$, $MnSO_4$ and $ZnSO_4$ at 0.2 and 0.4% levels of each. The results revealed the number of leaves increased when 0.2% $FeSO_4$ was applied at 3- and 6-leaf stages. Foliar application of $FeSO_4$ (0.5 or 1%) and $ZnSO_4$ (0.5 or 1%) alone or in combination and at 2- and 6-leaf stages, significantly increased number of leaves per plants in gladiolus (Lahijie, 2012). Foliar application of either $ZnSO_4$ (0, 0.15, 0.30 or 0.45%) or H_3BO_3 (0, 5, 10 or 20 ppm) alone or in various combinations applied twice after 45 and 60 days past of planting significantly increased the number of leaves per plant in Iris (Khalifa *et al*., 2011). Similarly, 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.

Leaf Chlorophyll Content

Statistical analysis of leaf chlorophyll content depicted significant differences. Significantly higher leaf chlorophyll contents were recorded when plants were sprayed with all the three micronutrients each at 2% (T_7), followed by when the plants were sprayed by 2% $FeSO_4$+2% Zn SO_4 (T_5). These two treatments were statistically alike but differed from the rest of the treatments. The minimum leaf chlorophyll contents were recorded in control (T_0), followed by the treatment in which only $FeSO_4$ was applied at 2% (T_1) and while these two treatments being also statistically similar (Table 3). These results indicated that any of the three micronutrients proved indispensable for better development of leaf chlorophyll content by fulfilling the micro-nutritional requirements of the plants. Increased in leaf chlorophyll content is also directly related to an availability of nutrients in proper proportion and at appropriate time.

Khalifa *et al*. (2011) applied either $ZnSO_4$ (0, 0.15, 0.30 or 0.45%) or H_3BO_3 (0, 5, 10 or 20 ppm) alone or in various combinations as foliar spray 45 and 60 days past after planting to Iris plants and 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). Fernandez *et al*. (2008) conducted a trial to assess the effects of applying several Fe-containing formulations on Fe-deficient (chlorotic) peach leaves under field conditions. They found that treatment with Fe-containing solutions always resulted in increased leaf chlorophyll content.

Days to Spike Emergence

Analysis of variance for days to spike emergence revealed significant differences. When all the three micronutrients were used in combination (T_7), it significantly delayed flowering by increasing the number of days to emergence of spikes, followed by the treatments when two micronutrients were used (T_4, T_5 and T_6). However, all these four treatments stood statistically at par with each other. Spike emergence was earlier in control (T_0) plants, followed by the treatments in which only one micronutrient was sprayed (T_1, T_2 and T_3). All these four treatments were statistically alike and were also similar to those in which two micronutrients were applied (T_4, T_5 and T_6) (Table 3). Number of days to spike emergence is an important indicator of expected time of harvest and crop endurance. However, not only the early flowering but quality of spikes is also important for better return. The results demonstrated that foliar application of all the micronutrients in combination improved plant growth and also delayed flowering in gladiolus. In contrast, 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).

Stalk Length

Statistical analysis of the data on stalk length depicted significant differences. Stalk length was significantly improved in response to foliar application of a combination of all the three micronutrients (T_7), followed by the treatments when $FeSO_4$ was applied in combination with H_3BO_3 (T_4) or $ZnSO_4$ (T_5). All these three treatments behaved statistically alike. Significantly shorter stalk lengths were observed when plants were not sprayed with any micronutrient (T_0) as compared with all the other treatments (Table 4).

Stalk length is an important factor for good price of cut flower in domestic and international markets. The longer the stalk, the higher will be the price and finally the income. The results indicated that all the micronutrients were essential for longer stalks and better economic return. Khosa *et al*. (2011) have reported significant increase in stalk length of Gerbera flowers when plants sprayed with micronutrient solution containing Zn, B, Fe and Mn.

Fresh Weight of Flower Stalk

Analysis of variance on fresh weight of complete flower stalk revealed significant differences. Maximum fresh weight of flower stalk (as a result of foliar application) was recorded for a combination of all the three micronutrients (T_7), significantly

[DOR: 20.1001.1.16807073.2014.16.7.10.6]

Table 4. Effect of foliar application of nutrients on flower quality parameters and vase life of gladiolus.[a]

Treatments	Stalk length (cm)	Fresh weight of stalk (g)	Length of spikes (cm)	Number of floret spile^{-1}	Fresh weight floret^{-1} (g)	Diameter of florets (cm)	Vase life of spikes (days)
T_0	70.33 d	78.66 d	45.46 e	12.53 e	2.20 d	1.33 c	9.06 d
T_1	77.08 c	86.22 c	47.99 d	15.60 d	3.66 c	1.36 bc	9.80 c
T_2	76.93 c	86.13 c	48.40 cd	15.86 cd	3.26 c	1.44 bc	9.80 c
T_3	77.06 c	87.06 c	48.73 cd	15.13 d	3.83 bc	1.48 bc	12.53 b
T_4	83.66 ab	94.40 ab	50.73 b	16.46 bc	4.86 a	1.51 bc	12.53 b
T_5	83.66 ab	93.60 b	50.73 b	16.93 b	4.53 ab	1.54 b	14.73 a
T_6	82.66 b	93.00 b	50.20 bc	16.73 b	4.87 a	1.52 bc	12.53 b
T7	85.73 a	98.33 a	54.26 a	18.73 a	5.13 a	1.79 a	14.73 a
LSD at 5%	2.32	4.00	1.89	0.84	0.86	0.19	0.55

[a] Means sharing similar letters for each parameter separately are statistically non-significant at P= 0.05 (LSD test).

higher than all the other micronutrient treatments except when $FeSO_4$ was applied in combination with H_3BO_3 (T_4), which was statistically at par with the former one. A minimum fresh weight of flower stalk was recorded for control plants (T_0), with this being significantly lower than those for all the other treatments (Table 4).

This increase in fresh weight of complete flower stalk in the present study might be attributed to longer stalk length in T_7 and possibly as a result of more proper plant growth.

Spike Length

Statistical analysis of the data on spike length demonstrated that the parameter was significantly influenced by the micronutrients' treatments. Combined application of all the three micronutrients (T_7) significantly improved spike length, and it differed from all the other treatments. Shorter spike length was recorded when plants were not sprayed with any micronutrient (T_0, water spray) and this too, differed from all the other micronutrients treatments (Table 4).

Length of spike is an important determining factor counted on for good economic return. Spike length is directly correlated with stalk length, and it did follow the same pattern in the present study. Kumar and Arora (2000) stated that spike length, number of florets, weight of spike and size of florets significantly increased with 0.2% $FeSO_4$+0.2% $ZnSO_4$ foliar application. Similarly, Lahijie (2012) also reported significant increase in length of spikes of gladiolus cv. Oscar, when $FeSO_4$ (0.5 or 1%) and $ZnSO_4$ (0.5 or 1%) were applied either singly or in combination. Katiyar *et al*. (2005) found that foliar spray of Zn (0.2%) and Cu (0.2%) applied twice increased the length of spikes in gladiolus grown in partially reclaimed sodic soils. Increase in spike length and length of inflorescence has also been reported in Iris for foliar application of $ZnSO_4$ (0, 0.15, 0.30 or 0.45%) and H_3BO_3 (0, 5, 10 or 20 ppm) either singly or in various combinations, when applied twice within 45 and 60 days past after planting (Khalifa *et al*., 2011).

Number of Florets per Spike

Analysis of variance of the data on number of florets per spike revealed significant differences among treatments. A maximum number of florets per spike was noted when all the three micronutrients were applied in combination (T_7) and this number

[DOR: 20.1001.1.16807073.2014.16.7.10.6]

was significantly higher than that for all the other micronutrients treatments. Minimum number of spikes per plant were counted for control (T_0, water spray), the number being significantly lower than those for other treatments (Table 4). Furthermore, a combined application of two micronutrients (T_4, T_5 and T_6) worked better than the application of a single micronutrient (T_1, T_2 and T_3).

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. The number of florets per spike was also significantly increased in gladiolus (as a result of the application of $FeSO_4$ and $ZnSO_4$) either singly or in combination (Lahijie, 2012). Katiyar *et al.* (2005) also found that foliar application of Zn (0.2%) and Cu (0.2%) to gladiolus plants, grown in partially reclaimed sodic soils, enhanced such floral characteristics as the number of florets per spike.

Fresh Weight of Florets

Statistical analysis of the data on fresh weight of floret revealed significant differences among micronutrients treatments. Maximum fresh weight of florets was obtained when all the three micronutrients (T_7) were applied together, followed by the treatments in which two micronutrients were applied in combination (T_6, T_5 and T_4) and these four treatments were statistically at par with each other. The minimum fresh weight per floret was recorded in control where plants were not sprayed with any micronutrient (T_0), significantly lower than that in other treatments (Table 4).

Increase in fresh weight of florets might be attributed to increased fresh weight of complete stalks due to good growth of plants. These findings are in accordance with the results of Singh and Bhattacharjee (1997), who observed increase in fresh weight of rose flower as a result of foliar application of different micronutrients. Khalifa *et al.* (2011) also noted Iris flowers' fresh and dry weight increase as due to either foliar application of $ZnSO_4$ (0, 0.15, 0.30 or 0.45%) or H_3BO_3 (0, 5, 10 or 20 ppm), applied singly or in various combinations.

Diameter of Floret

Analysis of variance of floret diameter depicted significant differences among treatments. Combined application of all the three micronutrients (T_7) significantly increased the diameter of florets. A minimum diameter of florets was recorded when no micronutrient was applied (T_0, plain water spray) to the plants, this being statistically par with all the other treatments except with T_7 (Fe + B + Zn), and T_5 (Fe + Zn) (Table 4).

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 already been reported. Similarly, Lahijie (2012) also observed that foliar application of $FeSO_4$ (0.5 or 1%) and $ZnSO_4$ (0.5 or 1%) either singly, or in combination, and when applied at 2- and 6-leaf stages, significantly increased the diameter of florets in gladiolus. The results of the present study are therefore in match with the findings of the previous mentioned workers.

Vase-life of Spikes

Statistical analysis of the data for vase-life of spikes demonstrated significant differences among treatments. Foliar application of all the three micronutrients (T_7) resulted in longest vase life of spikes, followed by the combined application of $FeSO_4$+$ZnSO_4$ (T_5). The shortest vase life

[DOR: 20.1001.1.16807073.2014.16.7.10.6]

was observed for the spikes harvested from plants not treated with any micronutrients (T_0) and significantly differing from all the other treatments. All the other treatments stood in the middle (Table 4).

Pratap *et al*. (2008) studied the effect of pre-harvest micro-nutrient foliar sprays on post-harvest vase life of gladiolus cv. Traderhorn using post-harvest vase chemicals. Pre-harvest foliar application of $FeSO_4$ 0.75 or 1% along with $ZnSO_4$ 0.5% significantly extended the vase life of the flowers. The results of the present study also confirmed the findings of Amir *et al*. (2008) who observed that application of Zn to rose cultivars resulted in extended vase life of the flowers.

Number of Corms per Plant

Analysis of variance of the data on number of corms produced per plant depicted non-significant differences for treatments, indicating that the parameter was not affected by the micronutrients treatments applied (Table 5). In the present study, the number of corms produced per plant varied from 1.0 to 1.2; hence neither a single foliar application of micronutrients nor in combination have any influence on corm number per plant.

Corm Diameter

Statistical analysis of the data for corm diameter revealed significant differences among treatments. The corms attained maximum diameter when plants sprayed with all the three micronutrients i.e. Fe, B and Zn (T_7), which differed significantly from the corm diameter recorded in other micronutrients treatments. This was followed by the treatments in which two micronutrients were applied in combination (T_4, T_5 and T_6) and all these three micronutrients treatments stood statistically at par with each other but differed from the rest of the treatments. A minimum corm diameter was recorded when the plants did not receive any micronutrient (T_0), which also differed statistically from all the other micronutrient treatments. This was followed by the treatments in which only a single one micronutrient was applied (T_1, T_2 and T_3) with these treatments behaving statistically alike (Table 5).

These results indicated that all the three micronutrients are indispensable for the development of the underground corms. These results also confirmed the findings of Kumar & Arora (2000), Singh and Singh (2000), Ahmed *et al*. (2002) and Halder *et al*. (2007b), who observed increase in corm diameter as a result of foliar application of different micronutrients on gladiolus. These findings also partially support the results of Kumar and Arora (2000), who found that corm production per plant was highest with 0.4% $FeSO_4$+0.4% $MnSO_4$+0.2% $ZnSO_4$. Singh *et al*. (2012) also found that diameter of corms was significantly influenced by the foliar application of Zn (0.50%), Fe (0.25%) and Cu (0.25%) to gladiolus plants.

Table 5. Effect of foliar application of nutrients on corm production in gladiolus.[a]

Treatments	No. of corms plant^{-1}	Corm diameter (cm)	Corm weight (g)
T_0	1.00 a*	3.89 d	29.40 d
T_1	1.10 a	4.49 c	34.20 c
T_2	1.00 a	4.51 c	34.20 c
T_3	1.00 a	4.51 c	34.23 c
T_4	1.10 a	5.03 b	38.00 b
T_5	1.20 a	5.03 b	38.36 b
T_6	1.10 a	5.03 b	38.00 b
T_7	1.20 a	5.88 a	44.46 a
LSD at 5%	0.22	0.06	0.61

[a] Means sharing similar letters for each parameter separately are statistically non-significant at P= 0.05 (LSD test).

Corm Weight

Analysis of variance of the data for corm weight indicated significant differences among treatments. The corms gained maximum weight under combined application of all the three micronutrients (T_7) significantly higher than the corm weight produced in other treatments. This was followed by the treatments in which two micronutrients were sprayed (T_4, T_5 and T_6), itself followed by the treatments in which only one micronutrient was applied to the plants (T_1, T_2 and T_3). However, members of both recent groups were statistically at par with each other while significantly different from the members of the first group. The control plants (T_0), which did not receive any micronutrients through foliar sprays resulted in minimum corm weight and significantly differed from all the other micronutrients treatments (Table 5).

These results indicate the role of all the three micronutrients (i.e. Fe, B, Zn) in growth and development of underground corms. These results also confirm the findings of Kumar and Arora (2000); Ahmed *et al*. (2002) and Halder *et al.* (2007b) who observed increase in corm weight as a result of foliar application of different micronutrients on gladiolus. Singh *et al*. (2012) found that foliar application of Zn (0.50%) significantly increased weight of corms in gladiolus. Application of either $ZnSO_4$ (0, 0.15, 0.30 or 0.45%) or H_3BO_3 (0, 5, 10 or 20 ppm) either singly or in various combinations as foliar spray also significantly increased both fresh and dry weight of bulbs in Iris (Khalifa *et al*., 2011).

CONCLUSIONS

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 vase life of spikes. Although, the number of corms produced per plant remained unaffected by the micronutrients applied, corm diameter and weight were significantly affected. From the findings of the present study, it can be concluded that gladiolus can more successfully be grown in alkaline soils by applying micronutrients to the plants through foliar sprays.

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[DOR: 20.1001.1.16807073.2014.16.7.10.6]

تأثیر محلول‌پاشی ریزمغذی‌های بُر، روی و آهن بر رشد، گلدهی و تولید پیاز گلایول (*Gladiolus grandiflorus* L.) در خاکهای آهکی

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چکیده

گلایول (*Gladiouls grandiflorus* L.) یکی از گلهائی است که دارای بیشترین سطح زیر کشت، از نظر اقتصادی دارای اهمیت و از گیاهانی است که در سطح وسیعی در سرتا سر دنیا ازجمله در پاکستان کشت می‌شود. اما، در هر صورت، تحت شرایط آب و هوائی مولتان برداشت گل از این گیاه خیلی اندک است. آزمایشی در مزارع پژوهشی گروه باغبانی دانشگاه بهاءالدین زکریا در مولتان پاکستان در سالهای ۱۳۸۹ تا ۱۳۹۱ برای بررسی تأثیر ریزمغذی‌های برن (بور)، روی و آهن بر رشد، تولید گل و کیفیت گلایول کلیتوار ترا درهورن برگزار شد. هشت رفتار شامل هریک از ریزمغذی‌ها به تنهایی و یا در ترکیب با یکدیگر به کارگرفته شدند. پیازها در اولین هفته ماه نوامبر هریک از سالها۲۰۱۰ و ۲۰۱۱ روی پشته‌هایی که فاصله آنها از یکدیگر ۶۰ سانتیمتر بود با فاصلهٔ بین بوتهٔ ۲۰ سانتیمتر کاشت شدند. هرکدام از تیمارها دارای سه تکرار و در هر یک از تکرارها تعداد بیست پیاز کشت گردید. محلول پاشی در روزهای ۳۰ و ۶۰ بعد از کاشت پیازها انجام شد. کاربرد ریزمغذی‌ها (به نحوی معنی‌داری) ارتفاع بوته، محتوای کلروفیل برگ، طول ساقهٔ گل، وزن گل تازه، طول سنبله گل، تعداد فلورت در هر سنبله، وزن و قطر فلورت‌های تازه، طول عمر گلدانی گل، قطر گل و همچنین وزن پیازهای تازه را افزایش داد. تعداد برگ و تعداد روزهای لازم برای پیدایش سنبله فقط تحت تأثیر کارگیری هر سه ریزمغذی B و Zn و Fe قرار داشت. در بین رفتارهای ریزمغذی‌ها، رفتاری که شامل $FeSo_4.\ 7H_2O$، H_3BO3 و $ZnSO_4.7H_2O$ (تمامی در سطح ۲ درصد) بود بهترین نتیجه را در مورد تمامی پارامترها، به جز تعداد پیازچه در بوته که (به طرز معنی‌داری) تحت تأثیر محلول‌پاشی قرار نگرفت، در پی داشت.

[DOR: 20.1001.1.16807073.2014.16.7.10.6]