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Effect of zinc sulphate and iron sulphate on the growth and flower production of gladiolus (*gladiolus hortulanus*)

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In order to examined the effect of zinc sulphate ($ZnSO_4$) and iron sulphate ($FeSO_4$) on the growth and flower production of gladiolus. Treatments included T1= Control, T2=20 g $ZnSO_4$,T3=40 g $ZnSO_4$, T4=20 g $FeSO_4$, T5=20 g $ZnSO_4$ + 20 g $FeSO_4$ and T6=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 T1=Control, T2=20 g $ZnSO_4$,T3=40 g $ZnSO_4$, T4=20 g $FeSO_4$, T5=20 g $ZnSO_4$ + 20 g $FeSO_4$ and T6=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 $FeSO_4$.

Keywords: Gladiolus, *Gladiolus hortulanus,* $ZnSO_4$ + 20 g $FeSO_4$, flower production

Introduction

Gladiolus (*Gladiolus hortulanus*), also called sword lily, belongs to the family Iridaceae; and from commercial point of view, it is rated as the most popular flower in the world (Cohot, 1993). Magnificent inflorescence with variety of colors, made it attractive for use in herbaceous borders, beddings, rockeries, pots and for cut flowers (Abbasi*et al*., 2005). Gladiolus occupies 4th place in international cut flower trade after rose, carnation and chrysanthemum (Farhat, 2004). However, in Pakistan it is the second most important cut flower

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after rose. The area under floriculture in Pakistan is 17,000 acres; rose was cultivated on 9200 and tube rose on 2787 acres (Khan, 2005).

The requirement of fertilizers in gladiolus like other crops is of great importance for its growth, quality, corm and cormel production. There are some reports on the requirement of nitrogen (N), Phosphorus (P), Potassium (K) and other fertilization in some countries (Potti *et al*., 1986 and Afify, 1983). Major nutrients like nitrogen, phosphorus, potassium along with micronutrients noticeably increase the number of flowers, florets/spike, the longest spike and flowering stem of gladiolus (Afify, 1983). Increasing N fertilization substantially augmented plant growth, number of leaves/plant, spike length and number of florets/ spike (Shah *et al*., 1984). Production of quality flowers as well as plants depends on vigorous preflowering (vegetative) growth. Pre-flowering growth depends on the amount and availability of macro- and micronutrients in the soil. Nitrogen, Phosphorus and Potassium are the most important macronutrients that affect growth of gladiolus (Salisbury and Ross, 1992). It was also reported that hardness of the stick, flower colour and post-harvest life can be prolonged to some extent by applying micronutrients along with blanket dose of NPK and Mg. However, information regarding nutritional requirement and appropriate soil management practices are lacking for gladiolus cultivation. In this concern, Mahgoub *et al*. (2006) mentioned that further increments in nitrogen level 40g/m^2 N+ 35g K/m^2 recorded the highest values of plant highest, spike length and number of flowers/spike of iris. Paradhan *et al*. (2004) also found that on gladiolus, combined application of N at 40/m^2 and K at 30g/m^2 recorded the highest values of plant, leaf area, spike length and number of flowers spike^{-1}.

The role of micronutrients is very crucial in gladiolus production as well as major nutrients in growth and development. The plant growth and development is greatly affected by zinc, boron, iron etc. Zn is a micronutrient and in case of its severe deficiency, the symptoms may remain throughout the season; and a Zn deficient plant appears to be stunted. Treatment of corms and cormlets with the micro- nutrient zinc, improved the plant growth, including leaf size and number of corms. Availability of zinc is markedly decreased under neutral or slightly alkaline soil condition. When gladiolus is grown in such soils it is suggested to apply zinc either in soil or as foliar spray to prevent the zinc deficiency (Halder *et al*., 2007a,b). Iron deficiency is manifested first by yellowing between the veins of new leaves and as the deficiency becomes more severe, the whole leaf becomes yellow. Iron deficiency may not be due to lack of iron only but due to a number of factors (Marchner, 1995). In gladiolus plant application of zinc at 2.5 Kg/ha^{-1} could be suitable for maximizing yield and flower quality (Halder *et al*., 2007b). Zinc plays an essential role in plant physiology where it activates some of enzymes and related to metabolism of carbohydrates, auxins and ribosome functions. The beneficial effects of zinc on several ornamental plants were studied (Farahat *et al*., 2007) on gladiolus. Many researchers have reported that zinc had a significant effect on corm and cormlet production. The growers do not have any recommended doses of chemical fertilizers especially micronutrients for quality corm and cormlet seed production. Even the flower producers multiply their corms without applying any chemical fertilizers. Resulting, they are deprived of getting maximum sized corms and cormlets for flower cultivation. So boron and zinc are treated to be the limiting elements for maximizing corm and cormlet production. However, there were scanty information regarding nutritional requirement on the production of corm and cormlet for gladiolus cultivation in Pakistan. Farahat *et al*. (2007), Halder *et al*. (2007a, b) gladiolus on thyme worked on the effect of micronutrients including Zn and Fe on the growth of ornamental plants including gladiolus and reported positive effects. From above context and justification, therefore, a field study was undertaken to find out the optimum dose of Zinc sulphate and Iron sulphate for maximizing yield of corm and cormlet for gladiolus cultivation.

Materials and methods

The experiment was conducted at department of Horticulture, Sindh Agriculture University Tandojam. The corms of gladiolus cultivar ‘White friendship’ of gladiolus were procured from New Pak Seed Company, Lahore. The experimental soil was loamy in texture. Manure and fertilizers were given according to recommendation. The experiment was laid out in Randomized Complete Block Design with three replications and six treatments.

The treatments were randomized for getting equal chance in respect of fertility. Row to row and plant to plant spacing was maintained 30x 20 cm, respectively. The planting material of uniform sized corms was dibbled on flat bed. Dia amino phosphate (DAP) was applied and well mixed with the soil during final land preparation. Irrigation, weeding, hoeing, earthing up and staking operations were completed according to needs. Four applications of $ZnSO_4$ and $FeSO_4$ were carried out, first after 30 days of sowing and subsequent at 15 days interval. After one month of spikes duration when leaves become yellow and dry and dryness comes in whole of the aerial portion, the corms were digout. Corms were practiced to clean and each corm was measured with the help of vernier callipers and indicated in cm. The number of corms and cormlets were recorded at the time of lifting the corm. Five plants were randomly selected from each sub plot for harvesting corms and cormlets at maturity after complete withering of the plants for data recording. All data were presented as mean values of three replicates. Data were analyzed statistically for analysis of variance (ANOVA) following the method described by Gomez & Gomez (1984). MSTAT-C computer software was used to carry out statistical analysis. The significance of differences among means was compared by using Least Significant Difference (LSD) test.

Results

Number of leaves plant^{-1}

There was significant ($P<0.05$) effect of $ZnSO_4$ and $FeSO_4$ concentrations on the number of leaves plant^{-1}. The gladiolus under treatment of 40 g $ZnSO_4$ + 20 g $FeSO_4$ resulted in maximum number of leaves (12.44) plant^{-1}, while gladiolus under treatment of 20 g $ZnSO_4$ + 20 g $FeSO_4$, 40 g $ZnSO_4$ and 20 g $ZnSO_4$ ranked 2nd, 3rd and 4th with 11.11, 10.00 and 10.00 average number of leaves plant^{-1}, respectively (Table-1). The gladiolus treated with 20 g $FeSO_4$ resulted in a decreased number of leaves plant^{-1}, while the minimum number of leaves (9.00) plant^{-1} was recorded under control, where $ZnSO_4$ and $FeSO_4$ were not applied. This indicates that increasing $ZnSO_4$upto 40 g in combination with 20 g $FeSO_4$ was more effective treatment to develop greater number of leaves in gladiolus as compared to any other $ZnSO_4$ and 40 g $FeSO_4$ treatment combination. The LSD test envisaged that the differences in the number of leaves plant^{-1} in gladiolus were non-significant ($P>0.05$) when 20 g $ZnSO_{4,}$ 40 g $ZnSO_4$ and 20 g $FeSO_4$ were compared, while significant ($P<0.05$) when these were compared with rest of the treatments.

Length of leaves (cm)

The length of leaves was significantly ($P<0.05$) influenced by $ZnSO_4$ and $FeSO_4$ levels. The gladiolus plantation treated with 40 g $ZnSO_4$ + 20 g $FeSO_4$ resulted in maximum length of leaves (115.7 cm), while gladiolus treated with 20 g $ZnSO_4$ + 20 g $FeSO_4$, 40 g $ZnSO_4$ and 20 g $ZnSO_4$ ranked 2nd, 3rd and 4th with average leaves length of 110.44, 108.11 and 106.22 cm, respectively (Table-1). The gladiolus kept untreated (control) ranked 5th with 105.33 g length of leaves on average, while the lowest length of leaves (99.55 cm) was recorded in gladiolus treated with 20 g $FeSO_4$. This suggested that combined application of $ZnSO_4$ and $FeSO_4$ proved to be markedly more effective to increase length of leaves as compared to those treated with $ZnSO_4$ or $FeSO_4$ alone. The LSD test suggested that the differences in the length of leaves of gladiolus between 40 g $ZnSO_4$ +20 g $FeSO_{4,}$ 20 g $ZnSO_4$ and 20 g $FeSO_4$ and 40 g $ZnSO_4$ were statistically non-significant. Moreover, the differences in length of leaves between 20 g $ZnSO_4$, 40 g $ZnSO_4$ and control were also non-significant ($P>0.05$), while significant ($P<0.05$) when these groups were compared with each other.

Life of spikes plant^{-1}

The life of spikes plant^{-1} was significantly ($P<0.05$) affected by various $ZnSO_4$ and $FeSO_4$ concentrations. The gladiolus plantation fertilized with 40 g $ZnSO_4$ + 20 g $FeSO_4$ resulted in maximum life of spikes (22.88) plant^{-1}, followed by 20 g $ZnSO_4$ + 20 g $FeSO_4$ and 20 g $FeSO_4$ with 21.88 and 19.10 average life of spikes plant^{-1}, respectively. The gladiolus receiving 40 g $ZnSO_4$ and 20 g $ZnSO_4$ separately without addition of $FeSO_4$ reduced life of spikes to 16.21 and 15.77 plant^{-1}, respectively (Table-1). However, the lowest life of spikes (15.66) plant^{-1} was recorded in gladiolus plants in control, where $ZnSO_4$ and $FeSO_4$ were not applied. It was observed that regardless the addition of $FeSO_4$, the increasing $ZnSO_4$ concentrations resulted in a considerable increase in the life of spikes plant^{-1}. However, combined effect of $ZnSO_4$ and $FeSO_4$ was more appreciable than when applied alone. The LSD test suggested that the differences in the life of spikes plant^{-1} of gladiolus between 40 g $ZnSO_4$ +20 g $FeSO_4$ and 20 g $ZnSO_4$ +20 g $FeSO_4$ or between 20 g $ZnSO_4$ and control were statistically non-significant, while significant ($P<0.05$) when these were compared with rest of the treatments.

Table 1. Effect of different concentrations of $ZnSO_4$ and $FeSO_4$ on the number of leaves plant^{-1}, length of leaves and life of spikes plant^{-1} of gladiolus

Treatments	**Number of leaves plant^{-1}**	**Length of leaves (cm)**	**life of spikes plant^{-1}**
Control	9.00 d	105.33 b	15.66 d
20 g $ZnSO_4$	10.00 c	106.22 b	15.77 d
40 g $ZnSO_4$	10.00 c	108.11 a	16.21 c
20 g $FeSO_4$	9.44 c	99.55 b	19.10 b
20 g $ZnSO_4$ +20 g $FeSO_4$	11.11 b	110.44 a	21.88 a
40 g $ZnSO_4$ +20 g $FeSO_4$	12.44 a	115.70 a	22.88 a
S.E.±	0.3512	3.7365	0.8657
LSD 0.05	0.7826	8.3255	1.9288
LSD 0.01	1.1131	11.842	2.7435

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

Number of florets spike^{-1}

The number of florets spike^{-1} were significantly ($P<0.05$) influenced by $ZnSO_4$ and $FeSO_4$ levels. The gladiolus receiving 40 g $ZnSO_4$ + 20 g $FeSO_4$ produced highestnumber of florets (14.55) spike^{-1}, while the plants fertilized with 20 g $ZnSO_4$ + 20 g $FeSO_4$ and 20 g $FeSO_4$ ranked 2nd and 3rd with 12.11 and 10.88 average number of florets spike^{-1}, respectively (Table 2). The plants given 40 g $ZnSO_4$ and control (no $ZnSO_4$ and no $FeSO_4$)showed adverse effects on this trait with 10.77 and 10.66 florets spike^{-1}, respectively. However, the lowest number of florets (10.11) spike^{-1} was achieved in gladiolus plants treated with 20 g $ZnSO_4$ alone without addition of $FeSO_4$. It was noted that combined application of $ZnSO_4$ and $FeSO_4$ showed noticeable improvement in the number of florets spike^{-1} when comparison was made with those supplied these nutrients separately. The LSD test showed that the differences in the number of florets spike^{-1} of gladiolus supplied with 40g $ZnSO_4$ +20 g $FeSO_4$,20 g $FeSO_4$, 20 g $ZnSO_4$ and control were statistically non-significant, while significant ($P<0.05$) when these were compared with other treatments.

Number of corms plant^{-1}

The effect of various $ZnSO_4$ and $FeSO_4$ concentrations on the number of corms plant^{-1} was statistically non- significant ($P>0.05$). The plants fertilized with 20 g $FeSO_4$ resulted in comparatively higher number of corms (1.44) plant^{-1}, equally followed by 40 g $ZnSO_4$ + 20 g $FeSO_4$, 40 g $ZnSO_4$,20 g $ZnSO_4$ and control (untreated) with 1.22 equal number of corms plant^{-1} (Table-2). The gladiolus receiving 20 g $ZnSO_4$ + 20 g $FeSO_4$ resulted in the lowest number of corms plant^{-1}. This indicates that number of corms plant^{-1} did not show any response to various $ZnSO_4$ and $FeSO_4$ concentrations and number of corms plant^{-1} in treated plants was almost equal when compared with control plants.

Number of cormlets plant^{-1}

The number of cormlets plant^{-1} was significantly ($P<0.05$) affected by $ZnSO_4$ and $FeSO_4$ levels. It is evident from the data that gladiolus fertilized with 40 g $ZnSO_4$ + 20 g $FeSO_4$ produced maximum number of cormlets (17.33) plant^{-1}, while the plants fertilized with 20 g $ZnSO_4$ + 20 g $FeSO_4$ and 20 g $FeSO_4$ ranked 2nd and 3rd with 16.22 and 14.88 average number of cormlets plant^{-1}, respectively (Table-2). The plants given 40 g $ZnSO_4$ and 20 g $ZnSO_4$ resulted in equally lower number of cormlets plant^{-1} (13.88). However, the lowest number of cormlets (11.99) plant^{-1} was recorded in gladiolus plants without treatment (control).

Table 2. Effect of different concentrations of $ZnSO_4$ and $FeSO_4$ on the number of florets spike^{-1}, Number of corms plant^{-1}, and Number of cormlets plant^{-1} of gladiolus

Treatments	Number of florets spike^{-1}	Number of corms plant^{-1}	Number of cormlets plant^{-1}
Control	10.66 b	1.22 a	11.99 d
20 g $ZnSO_4$	10.77 b	1.22 a	13.88 c
40 g $ZnSO_4$	10.77 b	1.22 a	13.88 c
20 g $FeSO_4$	10.88 b	1.44 a	14.88 c
20 g $ZnSO_4$ +20g $FeSO_4$	12.11 b	1.11 b	16.22 b
40 g $ZnSO_4$ +20 g $FeSO_4$	14.55 a	1.22 a	17.33 a
S.E.±	0.7360	0.1135	0.4964
LSD 0.05	1.6400	-	1.1060
LSD 0.01	2.3377	-	1.5731

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

It was observed that combined application of $ZnSO_4$ and $FeSO_4$ showed considerable increase in the number of cormlets plant^{-1} when comparison was made with those given these nutrients alone and control. The LSD test showed that the differences in the number of cormlets plant^{-1} of gladiolus supplied with 20 g $FeSO_4$,40 g $ZnSO_4$ and 20 g $ZnSO_4$ were statistically non-significant, while significant ($P<0.05$) when these were compared with rest of the treatments.

Discussions

The present findings indicated that all the growth and flower production traits of gladiolus were significantly ($P<0.05$) affected by zinc sulphate ($ZnSO_4$) and iron sulphate ($FeSO_4$) concentrations while corms plant^{-1} was non-significantly ($P>0.05$) by Zn and Fe levels. The application of 40 g $ZnSO_4$ + 20 g $FeSO_4$ resulted in significantly better performance than rest of the treatments with 14.44 leaves plant^{-1}, 115.70 cm length of leaves, , 22.88 life of spike plant^{-1}, 14.55 florets spike^{-1}, 1.22 corms plant^{-1} and 17.33 cormlets plant^{-1}. Similarly, application of 20 g $ZnSO_4$ + 20 g FeSO4, 20 g $FeSO_4$, 40 g $ZnSO_4$ and 20 g $ZnSO_4$ resulted lower values for almost all the parameters studied. The control treatment resulted lowest values for almost all the studied traits. The findings of the present research coincide with those of Kumar and Arora (2000) carried out studies on the effect of $FeSO_4$ on the flowering of gladiolus. The results indicated that foliar application of 0.2% $FeSO_4$ singly or in various combinations at three or six leaf stages of gladiolus induced flowering earlier.

Similarly, Roychowdhury and Sarkar (2000) reported that gladiolus treatments with $FeSO_4$ hastened flower opening. The longevity of the spikes was increased compared to control. Warren and Alloway (2001) found that Ferrous sulfate caused mobilization of micronutrients and heavy metals contents. Katiyar*et al.* (2005) studied foliar spray of Zn on growth, floral characteristic and yield of gladiolus grown in sodic soil. The effect of Zn at vegetative growth and after emergence of spike on growth, floral characteristics and corm yield of gladiolus grown in partially reclaimed sodic soils was significant ($P<0.05$). Halder *et al.* (2007a) concluded that single application of Zn contributed to the yield parameters but their response was not pronounced as their integration performed. Halder *et al.* (2007b) reported positive effect of Zn and Fe alongwith B concentrations on gladiolus; while Halder *et al.* (2007c) reported that flower characters like length and weights of rachis and spike and number and weight of florets per spike and stick weights and size of the florets greater influenced with the increase of B and Zn but subsequent addition of B and Zn beyond that level (B2.0Zn3.0 kg ha^{-1}) depressed the flower yield. In another study, Kumar *et al.* (2009) tested $ZnSO_4$, $FeSO_4.7\ H_2O$ and $MnSO_4$, each at 4 levels (0.2, 0.4, 0.6 and 0.8% including a control), and found that $FeSO_4.7\ H_2O$ at 0.2% recorded the maximum flowers, followed by $ZnSO_4$ at 0.6 or 0.2% and $FeSO_4$ at 0.6% which were at par with each other. Reddy and Chaturvedi (2009) concluded that interaction between boron and $ZnSO_4$ significantly affected days to flowering (66.13 days); while Ahmad *et al.* (2010) concluded that application of micronutrients could help better to improve flower yield and quality of roses. Eid *et al.* (2010) found that combination of 3.0g Zn/l with 100 ppm BA, and 1.5g Zn/l with 50 ppm BA, respectively improved the gladiolus growth; while Singh *et al.* (2012) reported that Zn x Fe and Zn x Cu interactions 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.

Conclusion

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 $FeSO_4$.

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