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Research Article

Foliar Application of Boron and Zinc can Alter Growth and Yield of Gladiolus

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ABSTRACT

An experiment was carried out at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during the period from October 2018 to March 2019 with the objective to investigate the effects of foliar application of boron and zinc on the growth and yield of gladiolus. The experiment consisted of two factors, Factor A: four levels of boron (0ppm, 100 ppm, 200 ppm, 300 ppm) and Factor B: four levels of zinc (0ppm, 100 ppm, 200 ppm, 300 ppm) which was laid out in Randomized Complete Block Design with three replications. The spraying was done at 25 days after sowing (DAS) and 45 DAS. At 60 DAS the 200-ppm concentration of boron showed best performance for plant height (98.33 cm) and number of leaves per plant (6.06), minimum days (62.12 and 72.12 days) required to 80% spike initiation and harvest, maximum spike length (89.17cm), number of spikelets per spike (12.85), yield of corm (14.87 t/ha) and cormel (18.06 t/ha) were recorded from 200 ppm concentration of boron. On the other hand, 200 ppm zinc was found to be the best for plant height (94 cm) and number of leaves per plant (5.45) at 60 DAS. Minimum days required for 80% initiation of spike (66.14 days) and 80% harvest of spike (77.43), maximum length of spike (85.66 cm), maximum number of spikelets per spike (12.16) was also observed when 200 ppm zinc was used. Considering the combined effect 200 ppm of boron and zinc was found to be best for plant height (108.60 cm) and number of leaves (8.01) at 60 DAS, and the other parameters. The maximum number of spike (183300/ha), yield of corm (15.51 t/ha) and cormel (23.08 t/ha) was recorded for 200 ppm of boron and 200 ppm of zinc. Considering the above findings, it was clear that the combination of 200 ppm of boron and zinc as foliar application was suitable for better growth, and yield contributing characters of gladiolus.

Introduction

Gladiolus (*Gladiolus grandiflorus*), generally called "Glad", a member of family Iridaceae. It is believed to be originated in South Africa where it is being cultivated from the Greek period (Randhawa, 1986). But in Indian subcontinent, cultivation of gladiolus started only in 19th century. Gladiolus is frequently used as cut flower in different religion and social ceremonies (Mitra, 1992). Flower and corm of some gladiolus are used as food in many countries (Khan, 2009). Gladiolus is grown as flower bed in gardens and used in floral arrangements for interior decoration as well as making high quality bouquets (Lepcha *et al.*, 2007). Apart from ornamental value, gladiolus have extensively utilized in medicines for headache, lumbago, diarrhea, rheumatism, and allied pains (Bhattacharjee, 2010). The income from gladiolus is six times higher than returns from rice (Momin, 2006). Commercial cultivation of gladiolus is gaining popularity in Bangladesh mainly concentrated only in few districts such as Jashore, Jenaidah, Rajshahi, and Dhaka. It has recently become very popular in Bangladesh and its demand is increasing day by day. Though the agro-ecological condition of Bangladesh is suitable for cultivating gladiolus as a flower crop, its commercial cultivation has not been popular due to lack of knowledge regarding modern technology and unavailability of quality planting materials (corms).

Micronutrients play crucial and vital role in gladiolus production which contribute most important role on various metabolism and synthesis processes in plants. The deficiency of micronutrients creates different abnormalities like chlorosis, resetting and scorching etc. (Singh *et al.*, 2012). In gladiolus foliar application of boron and zinc is very effective and there was less information about concentration and stage of application which affect more on plant growth and yield (Halder *et al.*, 2007).

Boron is a micronutrient requiring for plant growth relatively to a smaller amount. Plants require boron for

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several 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 is evidence that boron plays a vital role as stabilizer of cell wall pectin network (Dordas and Brown, 2005).

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). Considering the above things, our aim was to identify the suitable combination of boron and zinc by foliar application which maximize the growth and yield.

Materials and methods

Location, climate and soil

The field experiment was conducted at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh during the period from October 2018 to April 2019 to investigate the effect of foliar application of boron and zinc on the growth, flowering, corm and cormel production of gladiolus. The selected plot was a medium high land having proper drainage and irrigation facilities. The soil of the experimental area was sandy loam in texture belonging to the Brahmaputra Flood Plain (FAO, 1971).

Plant materials and treatments

The corms were collected from Gadkhali, Jhikorgachcha, Jashore, Bangladesh and used in the present study. Boron and zinc were applied in the form of borax and zinc oxide, respectively. A 100-ppm solution of micronutrients was prepared by dissolving 36 mg of it in 1-liter distilled water. In the similar way, 200 and 300 ppm concentrations of solutions were prepared. Plants were sprayed at 25 days after sowing (DAS) and 45 DAS with a hand sprayer. The study consisted of two factors, Factor A: Different concentrations of boron (4) B_0: 0 ppm, B_1: 100 ppm, B_2: 200 ppm, B_3: 300 ppm. Factor B: Different concentrations of zinc (4) Zn_0: 0 ppm, Zn_1: 100 ppm, Zn_2: 200 ppm, Zn_3: 300 ppm.

Land preparation and planting of corms

The selected land for the experiment was opened during 28 October 2018 and thoroughly prepared by several ploughings and cross ploughings with power tiller followed by laddering to obtain a good tilth. The weeds and stubbles were removed from the plot and the clods were broken before final land preparation. The basal doses of manures and fertilizers were applied during final land preparation. On November 08, 2018, the corms were planted at a depth of 6 cm in furrows maintaining 25 cm plant to plant distance and 20 cm row to row distance.

Experimental design

The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Each block was divided into 16 plots where 16 treatments were allotted at random. Thus, there were 48 (16×3) unit plots in the experiment. The size of a unit plot was 1 m × 1 m. The distance between the blocks was 0.5 m and between the adjacent plots was 0.5 m.

Manure and fertilizers

The crop was fertilized with Cowdung 15-ton, urea 225 kg, Triple superphosphate (TSP) 147 kg and muriate of potash (MoP) 113 kg were applied for per hectare of land as recommended by FRG, 2012. Entire amount of well decomposed cowdung was applied during general land preparation and entire quantity of TSP was applied during final land preparation. Urea and MoP were applied as side dressing in three equal installments after 20, 40 and 60 days after planting.

Data collection

Ten plants were selected at random form the middle rows of each unit plot for avoiding border effect except yield. Data were collected in respect of Plant height and Number of leaves per plant at an interval of 15 days starting from 30 days after sowing (DAS) till 60 days after sowing. The plant height also measured at harvest time in centimeter from the ground level up to the tip of the spike. Days required to 80% spike initiation and harvest was achieved by recording the time taken to complete 80% spike initiation and complete 80% harvest of spike. Length of the spike was measured from the base to the tip of the spike. Corms were separated from the plant and the weight of corms was taken by a beam balance and the mean was calculated. Weight of cormels found from 10 harvested sample plants. The weight of corms per plot was taken by a beam balance and the mean was calculated. The yields of the corms and cormels per plot were recorded and the yield per hectare was calculated from the yield per plot.

Results

Plant height

There was significant difference in plant height due to the concentrations of boron and zinc. The tallest gladiolus plant (37.39 cm, 66.74 cm and 98.33 cm) at 30 DAS, 45 DAS and 60 DAS were recorded in plants sprayed with 200 ppm of boron and the shortest gladiolus plant (35.36 cm, 62.46 cm and 84.24 cm) were recorded for control (Fig. 1). These results agree with Mohanta *et al*., (2013) who concluded that plant height was significantly improved by application of boron in carrot. In case of zinc the tallest plant height (38.27 cm, 65.56 cm, 92.95 cm) at 60 DAS was obtained from plant spraying with 200 ppm of zinc at different stages of growth and the shortest plant height (36.23 cm, 65.77 cm, 89.11 cm) were obtained from control (Fig. 1). In case of combined effect, the maximum plant height (42.48 cm, 74.12 cm, and 108.60 cm) at 30 DAS, 45 DAS and 60 DAS were recorded from the treatment combination of 200 ppm boron and 200 ppm Zinc whereas the shortest gladiolus plant (34.77 cm, 62.61 cm, and 80.40 cm) at 30 DAS, 45 DAS and 60 DAS were recorded for control (Table 1).

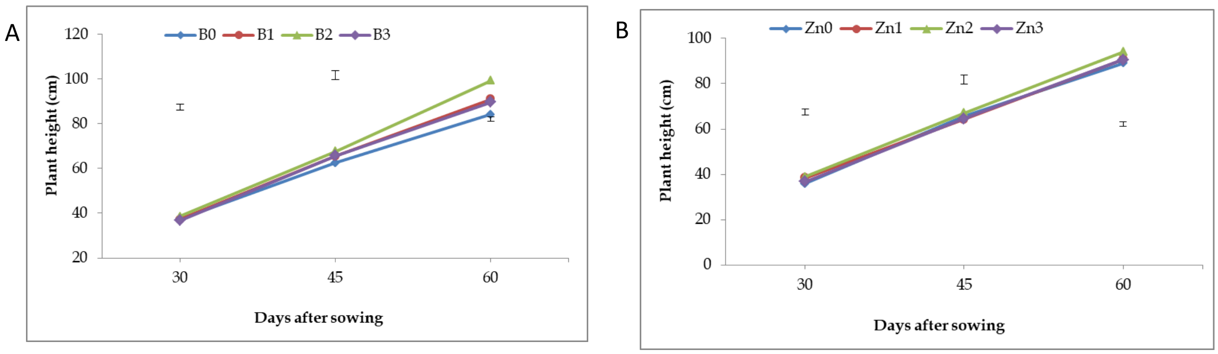

Figure 1. Main effect of A. boron and B. zinc on plant height of gladiolus at different days after sowing. Vertical bars indicate LSD at 1% level of significance: B_0 = 0 ppm (control), B_1 = 100 ppm, B_2 = 200 ppm, B_3 = 300 ppm, Zn_0 = 0 ppm (control), Zn_1 = 100 ppm, Zn_2 = 200 ppm, Zn_3 = 300 ppm.

Number of leaves per plant

The highest number of leaves (6.38 and 5.88) at 60 DAP was found with the concentration of 200 ppm boron and zinc while it was the lowest (4.62) in control (Fig. 2) which support the findings of Halder *et al*. (2007) who reported that a greater number of leaves in case of application of boron. The interaction between boron and zinc was found to be highly significant. The combined effect showed that plant sprayed with 2(B ppm boron and 200 ppm Zinc had the maximum number of leaves (8.01) at 60 DAP (Table1)

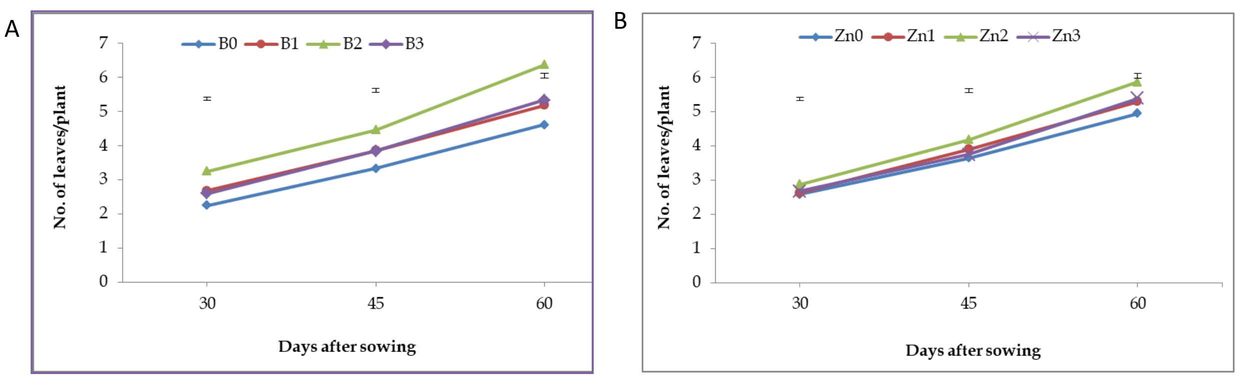

Figure 2. Main Effect of A. boron and B. zinc on number of leaves per plant of gladiolus at different days after planting. Vertical bars indicate LSD at 1% level of significance: B_0 = 0 ppm (control), B_1 = 100 ppm, B_2 = 200 ppm, B_3 = 300 ppm, Zn_0 = 0 ppm (control), Zn_1 = 100 ppm, Zn_2 = 200 ppm, Zn_3 = 300 ppm.

Days required to 80% spike initiation and harvest

The plants sprayed with 200 ppm Boron took the shortest time (62.12 days) to complete 80% inflorescence initiation and to reach harvesting stage (72.12 days). The plants treated with 200 ppm Zinc also took the shortest period (66.14 days) to complete 80% inflorescence initiation and (77.43 days) for harvest. The combined effect of boron and zinc was significant on days required to 80% spike initiation. Similar findings were also found by Halder (2007) and Kumar (2014). The maximum number of days (75.74 days) required for 80% spike initiation from B_0Zn_0 treatment combination and the minimum days (56.73 days) required for 80% spike initiation from B_2Zn_2 treatment combination (Table 2).

Table 1. Combined effects of levels of boron and zinc on plant height and amount of leaves/plant at different days after sowing of gladiolus.

Treatment combination	Plant height (cm) at different days after sowing (DAS)			No. of leaves/plant at different days after sowing (DAS)		
	30	45	60	30	45	60
B_0Zn_0	34.77	62.61	80.40	1.93	2.83	3.67
B_0Zn_1	39.85	61.14	84.32	2.27	3.35	4.82
B_0Zn_2	39.35	63.49	86.00	2.30	3.61	4.95
B_0Zn_3	35.83	63.38	86.25	2.47	3.54	5.03
B_1Zn_0	36.87	65.33	89.33	2.54	3.72	5.07
B_1Zn_1	37.69	64.43	90.28	2.55	3.78	5.10
B_1Zn_2	36.58	66.48	92.00	2.87	4.01	5.21
B_1Zn_3	37.70	65.78	92.55	2.76	3.91	5.38
B_2Zn_0	36.87	66.97	94.41	2.87	4.02	5.40
B_2Zn_1	39.00	66.29	97.02	3.14	4.42	6.03
B_2Zn_2	42.48	74.12	108.60	3.86	5.15	8.01
B_2Zn_3	36.30	63.60	97.49	3.12	4.27	6.07
B_3Zn_0	35.06	68.17	92.29	3.02	4.03	5.66
B_3Zn_1	37.32	64.92	91.24	2.55	4.07	5.27
B_3Zn_2	37.55	64.27	89.40	2.47	3.97	5.33
B_3Zn_3	37.30	65.33	85.95	2.36	3.30	5.09
$LSDs_{0.05}$	2.29	3.58	1.82	0.129	0.167	0.230
$LSD_{0.01}$	3.09	4.82	2.45	0.174	0.225	0.310
Level of significance	**	**	**	**	**	**

** = Significant at 1% level of probability. B_0 = 0 ppm (control), B_1 = 100 ppm, B_2 = 200 ppm, B_3 = 300 ppm; Zn_0 = 0 ppm (control), Zn_1 = 100 ppm, Zn_2 = 200 ppm, Zn_3 = 300 ppm

Spike length

The results on spike length showed that there was significant variation in the treatments of boron. The highest spike length (89.17cm) was obtained from 200 ppm Boron which was in partial agreement with the findings of (Ara *et al.*, 2015) and in gladiolus who concluded that application of boron significantly increased spike length. Plants sprayed with 200 ppm zinc produced the longest spike (85.66 cm). The combined effect showed that the highest length (72.08 cm) was found from the treatment combination of B_2Zn_2 (Table 2).

Table 2. Main Effect of levels of boron on different parameters of gladiolus

Levels of boron	Days required to 80% spike initiation	Days required to 80% harvest of spike	Length of spike(cm) at harvest	No. of spike per plot	No. of Spikelets per spike	Weight of corm (g)	Weight of corm (kg) per plot	Yield of corm (t/ha)
B_0	72.25	85.06	73.39	10.58	9.47	44.44	0.89	8.89
B_1	66.55	78.35	85.83	12.17	11.90	67.68	1.35	13.54
B_2	62.12	72.12	89.17	15.42	12.85	74.36	1.49	14.87
B_3	70.37	81.25	82.10	13.00	10.53	64.55	1.29	12.91
$LSD_{0.05}$	0.52	0.87	0.61	0.82	0.17	0.38	0.023	0.087
$LSD_{0.01}$	0.70	1.17	0.83	1.10	0.23	0.51	0.047	0.118
Level of significance	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

B_0 = 0 ppm (control), B_1 = 100 ppm, B_2 = 200 ppm, B_3 = 300 ppm.

Number of spikes per plot and spikelets

The variation in the number of spikes per plot and spikelets per spike because of different application of micronutrient treatment had significant influence. The highest number of spikes per plot (15.42) and spikelets per spike (12.85) was obtained from treatment at B_2 (200 ppm) while the lowest at B_0 (control). The number of spikes and spikelets was varied significantly due to different concentration of zinc spray. The maximum number of spikes per plot (13.33) and spikelets per spike (12.16) was found at Zn_2 (200 ppm) while lowest at Zn_0 (control) (Table 2).

Table 3. Main effect of levels of zinc on length of spike, length of rachis, number of spikes per plot and number of spikelets per spike of gladiolus of gladiolus.

Levels of zinc	Days required to 80% spike initiation	Days required to 80% harvest of spike	Length of spike (cm) at harvest	No. of spike per plot	No. of spikelet per spike	Weight of corm (g)	Weight of corm (kg) per plot	Yield of corm (t/ha)
Zn_0	69.57	80.80	80.03	12.33	10.42	60.24	1.20	12.05
Zn_1	67.30	78.93	81.95	12.50	11.24	61.84	1.24	12.37
Zn_2	66.14	77.43	85.66	13.33	12.16	64.86	1.30	12.97
Zn_3	68.27	79.63	82.84	13.00	10.94	64.08	1.28	12.82
$LSD_{0.05}$	0.52	0.87	0.61	0.82	0.17	0.38	0.026	0.087
$LSD_{0.01}$	0.70	1.17	0.83	1.10	0.23	0.51	0.051	0.118
Level of significance	**	**	**	*	**	**	**	**

** = Significant at 1% level of probability, * = Significant at 5% level of probability. Zn_0 = 0 ppm (control), Zn_1 = 100 ppm, Zn_2 = 200 ppm, Zn_3 = 300 ppm

Table 4. Combined effects of levels of boron and zinc on different parameters of gladiolus

Treatment combination	Days required to 80% spike initiation	Days required to 80% harvest of spike	Length of spike(cm) at harvest	No. of spike per plot	No. of spikelet per spike	Weight of corm (g)	Weight of corm (kg) per plot	Yield of corm (t/ha)
B_0Zn_0	75.74	88.01	65.67	9.33	8.47	36.25	0.73	7.25
B_0Zn_1	72.53	86.47	70.24	10.33	9.46	41.86	0.84	8.37
B_0Zn_2	70.66	83.68	78.30	11.33	9.73	45.23	0.90	9.05
B_0Zn_3	70.07	82.09	79.35	11.33	10.21	54.41	1.09	10.88
B_1Zn_0	68.98	80.48	82.65	11.67	10.41	62.61	1.25	12.52
B_1Zn_1	65.12	76.04	86.69	11.67	12.44	65.55	1.31	13.11
B_1Zn_2	66.42	79.30	89.62	11.67	13.48	74.34	1.49	14.87
B_1Zn_3	65.68	77.59	84.36	13.67	11.25	68.23	1.36	13.65
B_2Zn_0	64.90	75.42	87.42	13.33	11.44	70.02	1.40	14.00
B_2Zn_1	62.23	72.70	88.58	14.33	12.46	74.51	1.49	14.90
B_2Zn_2	56.73	64.91	93.40	18.33	15.13	77.54	1.55	15.51
B_2Zn_3	64.61	75.45	87.27	15.67	12.39	75.37	1.51	15.07
B_3Zn_0	68.67	79.29	84.38	15.00	11.35	72.10	1.44	14.42
B_3Zn_1	69.34	80.52	82.29	13.67	10.58	65.45	1.31	13.09
B_3Zn_2	70.75	81.84	81.33	12.00	10.30	62.34	1.25	12.47
B_3Zn_3	72.72	83.37	80.40	11.33	9.91	58.31	1.17	11.66
$LSDs_{0.05}$	1.04	1.74	1.23	1.63	0.34	0.76	0.012	0.175
$LSD_{0.01}$	1.40	2.34	1.65	2.20	0.46	1.03	0.024	0.235
Level of significance	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

B_0 = 0 ppm (control), B_1 = 100 ppm, B_2 = 200 ppm, B_3 = 300 ppm

Zn_0 = 0 ppm (control), Zn_1 = 100 ppm, Zn_2 = 200 ppm, Zn_3 = 300 ppm

Weight of corm

There was significant variation among the concentrations of boron and zinc on the weight of corm. The maximum weight of corm/plot (1.49 kg) was recorded from 200 ppm of boron while it was the lowest at control (Table 2). The highest weight of corm per plant (64.86 g) corm/plot (1.30 kg) was obtained from 200 ppm of zinc (Table 3). The interaction between concentration of boron and zinc was found to be significant. The maximum weight of corm/plant (77.54 g) and weight of corm/plot (7.25 kg) was found from the treatment combination of 200 ppm of Boron and 200 ppm of Zinc while it was minimum weight in the treatment combination of 0 ppm boron and 0 ppm of zinc (Table 4).

Yield of corm and cormel

Different concentrations of boron and zinc had significant effect on the yield of corm and cormel. The highest yield (14.87 t/ha) of corm and (18.06 t/ha) of cormel was found in 200 ppm of Boron while it was lowest 8.89 and 10.21 t/ha at control (Table 2 and figure 3). The yield of corm was significantly affected by the foliar application of micronutrients. The highest yield of corm and cormel per hectare (12.97 and 17.26 t/ha was recorded from the 200 ppm of Zinc while the lowest yield of corm per hectare was obtained from the control (Table 3 and figure 3). The yield of corm was significantly affected by the concentration of boron and zinc. At the concentration of boron 200 ppm and zinc 200 ppm gave the maximum yield of corm (15.51 t/ha, Table 4).

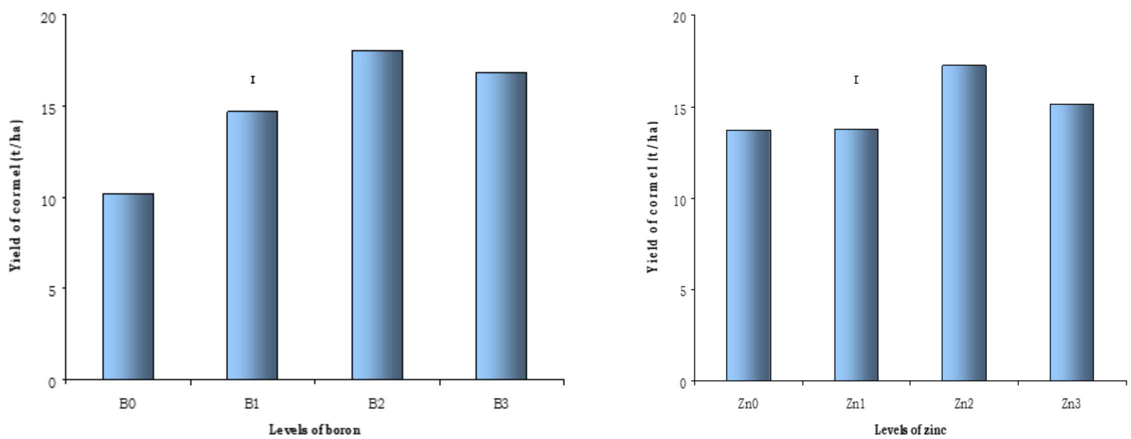

Figure 3 Main effect of concentration of boron and zinc on yield of cormel of gladiolus. The vertical bar indicates LSD at 1% level of significance: B_0 = 0 ppm (control), B_1 = 100 ppm, B_2 = 200 ppm, B_3 = 300 ppm, Zn_0 = 0 ppm (control), Zn_1 = 100 ppm, Zn_2 = 200 ppm, Zn_3 = 300 ppm.

Conclusion

Based on present study, it can be concluded that various application of different concentrations of boron and zinc plays significant role in increasing the performance of growth, yield and yield attributing characters of gladiolus. 200 ppm of boron was observed to be best in no. of spikelet per spike, as well as yield of corm and cormel. Application of 200 ppm zinc showed the best result for 80% initiation of spike, 80% harvest of spike, plant height, length of spike, number of leaves, number of spikelets per spike. In this experiment combination of 200 ppm of boron and 200 ppm Zinc was found to be the best treatment for most of the parameters studied and the combination of 200 ppm Boron and 200 ppm zinc significantly influenced number of spike (183300/ha), yields of corm (15.51 t/ha) and cormel (23.08 t/ha) of gladiolus.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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