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Effect of foliar application of zinc and copper on leaf nutrient content, growth and flowering in gladiolus (*Gladiolus* spp) cv. Pink Friendship

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ABSTRACT

An experiment was conducted in the year 2013-14 at Banaras Hindu University to find out the effect of foliar application of zinc and copper on nutrient accumulation and various growth and flowering parameters in gladiolus (*Gladiolus* spp). Maximum number of leaves (12.58), leaf area index (1.74), fresh weight (46.83 g) and dry weight (6.33 g) of the plant was recorded with the treatment combination Zn 0.4% + Cu 0.2% followed by Zn 0.4% + Cu 0.4% and was significant to the other treatment. While, maximum plant height (107.12 cm) was observed with the treatment combination Zn 0.4% + Cu 0.4% followed by Zn 0.4% + Cu 0.2%. Control plant treated with distilled water recorded minimum among various growth parameters studied. Among flowering parameters, early spike emergence (66.33 days) was noticed with the treatment combination Zn 0.4% + Cu 0.2%. Similarly, days to colour show of the spike (82.03 days), opening of the first (86.67 days), third (88.33 days), fifth (89.00 days) and seventh floret (90.08 days) was recorded earliest with the treatment combination Zn 0.4% + Cu 0.2% followed by Zn 0.2%. Thus, durability of the florets was recorded maximum with the treatment Zn 0.4% + Cu 0.2%. However, maximum duration of flowering was noticed with the treatment Zn 0.2% (17.45 days) followed by Zn 0.2% + Cu 0.4% (17.11 days) and was significant to the other treatments. Maximum zinc accumulation (58.94 ppm) was recorded with the treatment Zn 0.4% followed by Zn 0.4% + Cu 0.4% and Zn 0.2%. Whereas, treatment combination Zn 0.4% + Cu 0.4% (43.61 ppm) recorded maximum copper accumulation which was statistically at par with the treatment combination Zn 0.2% + Cu 0.4% (43.46 ppm). However, nitrogen, phosphorus and potassium accumulation showed a little variation among the various treatments.

Key words: Copper, Flowering, Growth, Gladiolus, Nutrient, Zinc

Popularity of gladiolus (*Gladiolus* spp) as a cut flower is increasing day by day because of its wide range of colours and magnificent inflorescence. This flower crop possesses a great potential for export market especially during winter. Production of quality flowers as well as plants depends on vigorous pre-flowering (vegetative) growth and it is mostly affected by the availability of micronutrients in the soil. The role of micronutrients is very crucial in gladiolus growth and development. Role of zinc (Zn) is well established in the formation of auxin and RNAase (Rashid 2005). It regulates the metabolic process and enhance the plant growth (Sarwar *et al*. 2012), flower production and quality as well. Application of zinc enhanced chlorophyll content and days to opening of flower in *Lilium* (Singh *et al*. 2015). $ZnSO_4$ at 0.2% improved dry weight of leaf and $ZnSO_4$ at 0.4% foliar dose increased length of longest leaf, width of longest leaf and also improved weight of corms/hill, weight of cormels/hill and diameters of corm in gladiolus (Hembrom *et al*. 2015). Copper is also an essential element because it is involved in a number of physiological processes such as the photosynthetic and respiratory electron transport chains (Van Assche and Clijsters 1990). Considering the importance of both Zn and Cu, it is necessary to apply judicious application of both either as soil application or either as foliar application. Zinc deficiency is global also in Uttar Pradesh. Higher zinc deficiency was recorded in Varanasi district. In a critical survey and analysis zinc deficiency was more pronounced in flower especially gladiolus growing blocks of Varanasi districts, i.e. Chiraigawn (69%), Kashi Vidyapeeth (67%), Araziline (49%) and Badagawn (46%). In Varanasi district 46% soil was found deficient to zinc and higher content zinc found only 17% soils (Singh *et al*. 2013). The available information regarding the impact of micronutrients on flower crops is scanty. In our country very little work has been

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done on the foliar spray of zinc and copper in gladiolus. The specific foreign trade standards cannot be obtained unless suitable cultural practices and techniques will be standardized. Therefore, keeping in view the above facts a field trial was conducted to investigate the effect of zinc and copper on growth, flowering and nutrient uptake in gladiolus cv. Pink Friendship.

MATERIALS AND METHODS

The present experiment was conducted at Horticulture Research Farm and at Post-harvest Laboratory, Department of Horticulture, Banaras Hindu University, Varanasi, Uttar Pradesh, India during 2013-2014. The climate of Varanasi is sub-tropical with dry hot summers and cool winter with average rainfall in this region about 1000 mm/annum. The city is situated at 25^0 10' North latitude and 83^0 03' East longitudes. The altitude of the location is 123.23 meter above the mean sea level. Gladiolus cv. Pink Friendship corms of uniform size were selected and planted in the prepared beds with a spacing of row to row 30 cm and corm to corm 20 cm during November 2013. The treatments used were control, Zn 0.2%, Zn 0.4%, Cu 0.2%, Cu 0.4%, Zn 0.2% + Cu 0.2%, Zn 0.2% + Cu 0.4%, Zn 0.4% + Cu 0.2% and Zn 0.4% + Cu 0.4%. There were 9 treatments replicated thrice in Randomized Block Design (RBD). Foliar spray of zinc and copper was done two times, once at 30 days after planting of corms and again at 45 days after planting. Foliar application of these nutrients was done to run-off stage and control plants were treated in same manner with distilled water. Irrigation, weeding, hoeing, earthing up and staking operations were completed according to needs. The observations on each treatment were recorded on the leaf nutrient status, growth and flowering characters. Studied growth parameters were number of leaves, leaf area index (LAI), fresh weight and dry weight of leaves/plant and plant height and flowering parameters studied were days to spike emergence, days to colour show, opening and withering of 1st, 3rd, 5th and 7th florets and duration of flowering. Nutrient analyses were also done for the uptake nitrogen, phosphorus, potassium, zinc and copper. Zinc and copper content was measured by atomic absorption spectrophotometer (AAS). Results thus obtained were subjected to statistical analysis.

RESULTS AND DISCUSSION

Nutrient status

Data presented in Table 1 indicates that concentration of nitrogen, phosphorus, potassium, zinc and copper were influenced significantly due to foliar application of zinc and copper. Foliar spray of zinc, copper and its combination showed a significant accumulation of zinc and copper in leaves of gladiolus. Maximum zinc accumulation (58.94 ppm) in gladiolus leaves was recorded with the treatment Zn 0.4% followed by Zn 0.4% + Cu 0.4%, Zn 0.2%, Zn 0.4% + Cu 0.2%, Zn 0.2% + Cu 0.4% and Zn 0.2% + Cu 0.2% and it was statistically higher than other treatments. Control plants recorded less zinc content as it was not treated with the foliar spray of zinc or its combination. In the similar way treatment combination Zn 0.4% + Cu 0.4% gave pronounced effect and exhibited maximum copper accumulation (43.61 ppm) which was statistically at par with the treatment combination Zn 0.2% + Cu 0.4% (43.46 ppm) followed by Cu 0.4%, Zn 0.2% + Cu 0.2%, Zn 0.4% + Cu 0.2% and Cu 0.2%. Rest treatments were devoid of copper as foliar spray thus recorded less accumulation in its leaves as compared to the other treatments. Highest concentration of nitrogen was observed with the treatment Cu 0.2% (4.34%) which was statistically at par with the treatment combination Zn 0.4% + Cu 0.4%, Zn 0.4% + Cu 0.2%, Zn 0.2% + Cu 0.4%, Zn 0.2% + Cu 0.2% and Cu 0.4%. Control plant recorded minimum nitrogen concentration. Analysis of phosphorus content revealed that control plant treated with distilled water accumulated the maximum phosphorus (0.64%) which was significant to the other treatment. This is clear cut indication of antagonistic relation of phosphorus and zinc. With the increase in zinc concentration, phosphorus accumulation within leaves was less. However, it was noticed that no clear cut trend was estimated for potassium. Maximum potassium content (1.74%) was observed with the treatment Zn 0.2% + Cu 0.2% followed by Zn 0.2%, Cu 0.2%, Cu 0.4% and Zn 0.4%. These findings are in close conformity with the work of Pratap *et al*. (2005) and Naik *et al*. (2009) who reported significantly enhanced zinc content in the leaves sample of gladiolus. The present findings are also experimentally substantiated with the observation made by Katiyar *et al*. (2005) who observed increase in the concentration of micronutrients in the leaves when Zn, Cu and mixture of both was applied as a foliar application in gladiolus. Increased concentration of copper in the leaves was supported by the result of Khoshgoftarmanesh *et al*. (2008) in rose.

Table 1 Effect of zinc and copper on nutrient status in gladiolus cv. Pink Friendship

Treatment	Nitrogen (%)	Phos-phorus (%)	Potassium (%)	Zinc content (ppm)	Copper content (ppm)
Control	3.22	0.64	1.60	31.40	21.16
Zn 0.2%	3.88	0.38	1.68	48.37	26.27
Zn 0.4%	3.94	0.28	1.66	58.94	22.61
Cu 0.2%	4.34	0.38	1.67	31.68	27.15
Cu 0.4%	4.00	0.39	1.67	32.36	39.99
Zn 0.2% + Cu 0.2%	4.03	0.30	1.74	39.98	35.72
Zn 0.2% + Cu 0.4%	4.04	0.37	1.61	42.48	43.46
Zn 0.4% + Cu 0.2%	4.12	0.29	1.52	44.63	27.44
Zn 0.4% + Cu 0.4%	4.28	0.33	1.54	49.90	43.61
CD (P=0.05)	0.70	0.15	0.12	2.27	0.23

Growth parameters

All the studied growth characters were significantly influenced by the foliar application of zinc and copper in the gladiolus cv. Pink Friendship (Table 2). The maximum number of leaves/hill (12.58) was observed in the treatment combination Zn 0.4% + Cu 0.2% followed by Zn 0.4% + Cu 0.4%, Zn 0.2% + Cu 0.2% and Zn 0.2% + Cu 0.4% which was significant to the other treatment. Control plant (treated with distilled water) recorded minimum number of leaves/ hill (9.92) followed by Cu 0.4%, Cu 0.2%, Zn 0.4% and Zn 0.2%. Similarly, maximum leaf area index (1.74) was recorded in the treatment combination Zn 0.4% + Cu 0.2% followed by Zn 0.4% + Cu 0.4%, Zn 0.2% + Cu 0.2% and Zn 0.2% + Cu 0.4%. Minimum leaf area index (1.12) was observed in the plant treated with distilled water followed by Cu 0.2%, Zn 0.4%, Cu 0.4% and Zn 0.2%. Maximum fresh weight of leaves (46.83 g) was also observed with the treatment Zn 0.4% + Cu 0.2% followed by Zn 0.2% + Cu 0.4%, Zn 0.4% + Cu 0.4%, Zn 0.2% + Cu 0.2% and Zn 0.2%. Dry weight of leaves (6.33 g) was recorded maximum with the treatment Zn 0.4% + Cu 0.2% which was statistically at par with the treatment combination Zn 0.4% + Cu 0.4% followed by Zn 0.2% + Cu 0.4% and Zn 0.2% + Cu 0.2%. However, data pertaining to plant height was observed maximum (107.12 cm) with the treatment combination Zn 0.4% + Cu 0.4% followed by Zn 0.4% + Cu 0.2%, Cu 0.4% and Zn 0.2% + Cu 0.4%. Plant treated with distilled water recorded minimum plant height (96.69 cm) followed by Zn 0.2%, Zn 0.2% + Cu 0.2%, Cu 0.2% and Zn 0.4%. Improvement in the growth characteristics is due to fact that micronutrients activate several enzymes like catalase, peroxidase, tryptophan synthase, carbonic dehydrogenase, etc. and so regulates various metabolic and physiological activities. The importance of zinc is well known in plant growth and metabolism of carbohydrates, auxins and ribosome functions. Copper acts as a structural element in regulatory proteins and participates in mitochondrial respiration and hormone signalling. Thus, micronutrient helps in the biosynthesis of photo-assimilates and increase in various plant metabolites responsible for cell division and elongation resulting in an increased plant growth characteristic. These findings are in agreement with the result of Saeed *et al*. (2013) who obtained a significant positive response on increasing the leaf area index, fresh and dry biomass weight when worked on gladiolus. Katiyar *et al*. (2005) also observed improved growth characteristics particularly plant height in gladiolus. Increase in plant height was also in close conformity with the findings of Sharma *et al*. (2013) who worked on gladiolus. Similar observation has also been made by Singh *et al*. (2012) who carried out an experiment on gladiolus and reported that all the studied growth parameters were increased significantly on foliar application of zinc and copper. In an experiment of *Lilium*, application of $ZnSO_4$ at 0.4% enhanced chlorophyll content (Singh *et al*. 2015). Foliar application of $ZnSO_4$ at 0.2% increased dry weight of leaf and $ZnSO_4$ at 0.4% dose enhanced length of longest leaf and also width of longest leaf (Hembrom *et al*. 2015) in gladiolus.

Table 2 Effect of zinc and copper on growth characteristics in gladiolus cv. Pink Friendship

Treatment	Number of leaves/ hill	Leaf area index	Fresh weight of leaves/ plant (g)	Dry weight of leaves/ plant (g)	Plant height (cm)
Control	9.92	1.12	30.07	4.60	97.69
Zn 0.2%	10.83	1.36	36.37	5.20	99.49
Zn 0.4%	10.50	1.32	34.57	5.07	100.93
Cu 0.2%	10.17	1.25	32.90	4.68	100.26
Cu 0.4%	10.00	1.34	34.05	5.13	102.79
Zn 0.2% + Cu 0.2%	11.33	1.51	38.23	5.22	100.12
Zn 0.2% + Cu 0.4%	11.00	1.44	39.30	5.38	101.24
Zn 0.4% + Cu 0.2%	12.58	1.74	46.83	6.33	105.14
Zn 0.4% + Cu 0.4%	12.25	1.54	38.56	5.91	107.12
CD (P=0.05)	1.37	0.26	6.41	1.08	8.58

Flowering attributes

Response of micronutrients at different concentrations was observed to assess the flowering behaviour under uniform management situation. The application of micronutrient (zinc and copper) strikingly influenced the various flowering attributes as compared to control (Table 3). Early spike emergence (66.33 days) was noticed with the treatment combination Zn 0.4% + Cu 0.2% followed by Cu 0.2%, Cu 0.4%, Zn 0.2% and Zn 0.2% + Cu 0.2%. Plants treated with distilled water showed delay in spike emergence (73.50 days) as compared to the other treatment.

Table 3 Effect of zinc and copper on flowering parameters in gladiolus cv. Pink Friendship

Treatment	Days to spike emergence	Days to colour show	Opening 1st floret of (days)	Opening 3rd floret of (days)	Opening of 5th floret (days)	Opening of 7th floret (days)
Control	73.50	86.58	90.92	91.75	93.08	94.25
Zn 0.2%	68.08	83.58	87.00	88.33	89.42	91.25
Zn 0.4%	69.33	84.75	89.00	89.92	91.17	92.58
Cu 0.2%	67.75	84.42	88.50	89.42	90.50	91.83
Cu 0.4%	67.83	83.67	88.42	89.50	91.00	92.58
Zn 0.2% + Cu 0.2%	68.58	83.83	88.25	89.25	90.75	92.08
Zn 0.2% + Cu 0.4%	69.25	85.41	89.67	90.75	92.41	93.50
Zn 0.4% + Cu 0.2%	66.33	82.08	86.67	88.33	89.00	90.08
Zn 0.4% + Cu 0.4%	70.67	84.08	88.58	89.75	91.17	92.25
CD (P=0.05)	5.43	4.05	4.20	4.20	4.05	4.05

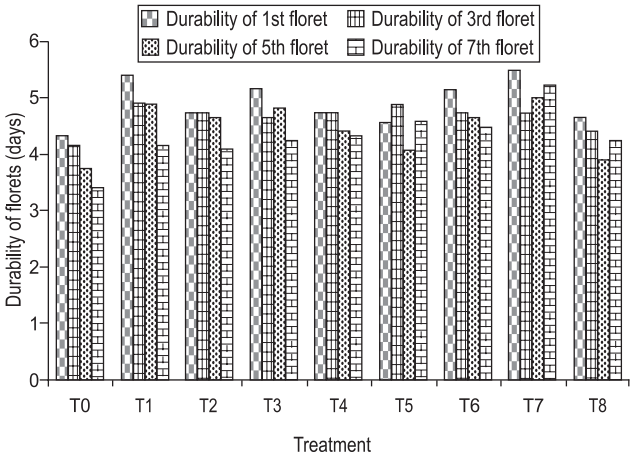

Fig 1 Durability of florets as influenced by various concentrations of zinc and copper.
T0 = Control, T1 = Zn 0.2%, T2 = Zn 0.4%, T3 = Cu 0.2%, T4 = Cu 0.4%, T5 = Zn 0.2% + Cu 0.2%, T6 = Zn 0.2% + Cu 0.4%, T7 = Zn 0.4% + Cu 0.2%, T8 = Zn 0.4% + Cu 0.4%

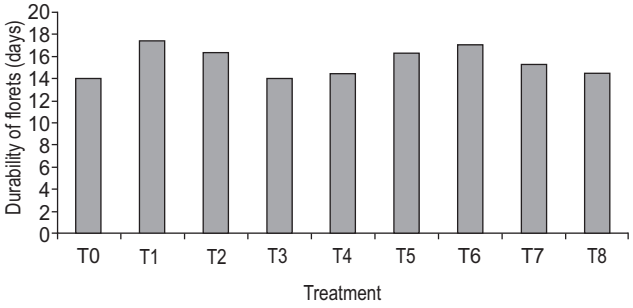

Fig 2 Duration of flowering as influenced by various concentrations of zinc and copper.
T0 = Control, T1 = Zn 0.2%, T2 = Zn 0.4%, T3 = Cu 0.2%, T4 = Cu 0.4%, T5 = Zn 0.2% + Cu 0.2%, T6 = Zn 0.2% + Cu 0.4%, T7 = Zn 0.4% + Cu 0.2%, T8 = Zn 0.4% + Cu 0.4%.

Similar observation was noticed to the days to colour show of the spike. Early colour show of the spike (82.03 days) was recorded with the treatment combination Zn 0.4% + Cu 0.2% followed by Zn 0.2%, Cu 0.4% and Zn 0.2% + Cu 0.2% which was significant to the other treatments, whereas control (86.58 days) took more days for colour show. Similarly, opening of the first floret was earliest (86.67 days) with the treatment combination Zn 0.4% + Cu 0.2% followed by Zn 0.2% and Zn 0.2% + Cu 0.2% and late in control. Opening of the third (88.33 days), fifth (89.00 days) and seventh floret (90.08 days) was also recorded earliest with the treatment combination Zn 0.4% + Cu 0.2% followed by Zn 0.2% and were significant to the other treatments. Control plants were late in the floret opening as compared to the other treatments. Maximum durability of the first floret (5.50 days) was recorded with the treatment Zn 0.4% + Cu 0.2% followed by Zn 0.2% and minimum under control condition (Fig 1). While, durability of third floret (4.92 days) was recorded maximum with the treatment Zn 0.2% this was statistically at par with Zn 0.2% + Cu 0.2% (4.92 days). Whereas, durability of the fifth floret (5.00 days) and seventh floret (5.25 days) was found maximum with the treatment combination Zn 0.4% + Cu 0.2% under field condition. Duration of flowering varied from 14.00 days to 17.45 days with maximum in Zn 0.2% (17.45 days) followed by Zn 0.2% + Cu 0.4% (17.11 days) and minimum was recorded under control (14.00 days). Treatment Zn 0.4% showed flowering duration of 16.35 days while, treatment combination Zn 0.2% + Cu 0.2% flowered for a duration of 16.29 days (Fig 2). In this experiment accumulation various nutrients, i.e. N, K, Zn and Cu increased in the leaves of gladiolus due to application of zinc and copper in the gladiolus plants which augmented some role thereby early spike emergence and flowering was noticed. It also enhanced durability and duration of flowering. The reason behind enhanced flowering attributes is due optimum supply of micronutrients advocated by Cakmak (2002) who corroborated that proper nutritional status, i.e. nitrogen, potassium, zinc, copper, etc. and hormonal level within the plants might be the reason for the early induction of spike emergence and colour show. Sucrose and phyto-hormones moved in combination from leaves to shoot apical meristem due to application of these micronutrients to induce early flowering and consequently prolonged duration of flowering. These results are incongruence with the observation made by Sharma *et al.* (2004) who conducted a study on gladiolus cv. Friendship and observed enhanced flowering duration. Early flowering was reported by Balakrishnan *et al*. (2007) when carried out an experiment in African marigold to see the response of micro-nutrients on flowering. Earliness in floret opening was also in line with the observation made by Reddy and Chaturvedi (2009) who worked on gladiolus. Singh *et al*. (2012) also reported significant effect on all flower characters studied such as early flowering and enhanced duration of flowering when conducted an experiment on gladiolus. In another experiment it was also observed that $ZnSO_4$ 0.4% improved flowering (Singh *et al*. 2015) in *Lilium*.

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