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Response of Fe and Zn on growth, flowering and yield on chrysanthemum (*Chrysanthemum morifolium*)

Mahesh Kumar Singh, Vishwanath and Sachin Devlal

Abstract
An experiment was carried out at Experimental Research Farm, R.B. S College Bichpuri, Agra (U.P.) during rabi season of 2019-20 to the Response of Fe and Zn on growth, flowering and yield of chrysanthemum (*Chrysanthemum morifolium*). The experiment was laid out in randomized block design with three replications comprising nine treatments were formulated with three levels (0.2, 0.4 and 0.6%) each of zinc sulphate and ferrous sulphate and its combination. The results revealed that the treatment combined foliar spray of $FeSO_4$ + $ZnSO_4$ @ 0.4% recorded best results for growth, flowering and qulaity yield followed by combined foliar spray of $FeSO_4$ + $ZnSO_4$ @ 0.6%.

Keywords: GA_3, *Chrysanthemum morifolium*, zinc sulphate, ferrous sulphate and flowering

Introduction
Chrysanthemum (*Chrysanthemum morifolium*) is that the most vital commercially cultivated flower crop belongs to the Compositae and also referred to as "Queen of the East". Chrysanthemum admired by enthusiasts everywhere the planet. It's an herbaceous perennial crop with attractive flower colour, lobed leaves and branched stems. Some varieties have the characteristic of both cut and loose flower. Economy of space, time, material, a superb range of colour, form, long lasting quality of blooms and straightforward handling has made this sort of growing very promising. Commercially, it's grown as a loose flower for garland making besides as cut flower in green house for interior decoration and as pot mums. Broadly, the whole chrysanthemum group has been classified into two group's viz., small and enormous flowered. It's going to attain a height of seven to 24 inches when it's in flowering. Chrysanthemum includes both annual also as perennial plants. Today the Chrysanthemum has earned tremendous popularity in floriculture industry thanks to wide selection of flower colour, form and excellent keeping quality. Modern Chrysanthemum cultivars are available an astonishing sort of colours, colour combinations and petal styles (spoon, quill & flat). Chrysanthemum is having an inherent sensitivity to naturally available photoperiod and temperature limits. Delayed planting of Chrysanthemum leads to poor flower quality with short stem length and vase life.

Zinc is an important micro nutrient for plant and plays a vital role in various processes in plants. Zinc is helpful for the production of proteins in plants and a major constituent of ribosomes and important for its development. Zinc is an active nutrient in various biological and chemical processes and has interaction with other elements due to which the uptake of other elements increased. The production of auxin also related with zinc which plays a vital role in plant growth.

Zinc is also involved in the production of carbohydrates, absorption of phosphorus and production of RNA. It has noted that zinc is an essential factor of various enzymes and is an important element for the growth and development of plant.

Plant needs iron to produce chlorophyll and to activate several enzymes including those involved in the oxidation/ reduction processes of photosynthesis and respiration. Studies showed that iron is an important nutrient for the growth of plant tissues. The shortage of iron can cause several physiological abnormalities such as chlorosis, scorching and resetting etc. Iron is also related with the establishment of chlorophyll. Iron has also a key character in the activation of several enzymes. The studies showed that the application of iron and zinc play a role in the physiological growth the flowers and reduced the amount of ethylene and abscisic acid and visual attraction of the flowers increased. Thus, present experiment was conducted to study the response of zinc and iron on growth, flowering and yield of chrysanthemum by foliar application.

Materials and Methods

The experiment was conducted at Experimental Research Farm, R.B.S College Bichpuri, Agra (U.P.) during rabi season of 2019-20. The experimental area is situated at 27.20 N latitude 78.50 East longitudes at height of 168 m above the mean sea level. The climate of experimental site is sub-tropical with large variation between summer and winter temperature. During the summer, temperature ranges from 30 °C to 46 °C or even more during May and June whereas in winter, it ranges from 1 °C to 22 °C. Monsoon generally starts from June and recedes by the end of September with an annual rainfall of 700 mm. The soil of the experimental field was fertile well drained sandy loam with good water holding capacity. The pH of the experimental soil was 7.5. The soil had 168.0 kg ha^{-1} available potassium, 14.0 $kgha^{-1}$ available phosphorus and 147 kg ha^{-1} available nitrogen and 3.0 g kg^{-1} organic carbon. The experiment was laid out in Randomized Block Design having three replications and nine treatments. The treatments were; control (T_1), $ZnSO_4$ @ 0.2% (T_2), $ZnSO_4$ @ 0.4% (T_3), $ZnSO_4$ @ 0.6% (T_4), $FeSO_4$ @ 0.2% (T_5), $FeSO_4$ @ 0.2% (T_6), $FeSO_4$ @ 0.4%(T_7), $FeSO_4$0.2% + $ZnSO_4$ @ 0.2% (T_8), $FeSO_4$ @ 0.4% + $ZnSO_4$ @ 0.4% (T_9) and $FeSO_4$ @ 0.6% + $ZnSO_4$ @ 0.6% (T_{10}). Twenty-five days old uniform and healthy seedlings were transplanted at the spacing of 45×45 cm. Recommended dose of 100 kg N, 100 kg P_2O_5 and 100 kg K_2O fertilizers were applied as basal through urea, diammonium phosphate and muriate of potash, respectively. Hand sprayer was used to spray micronutrients. $ZnSO_4$ and $FeSO_4$ were applied as foliar spray as per treatment schedule on 30 and 45 days after transplanting.

Observations were recorded on growth parameters, viz. plant height (52.80 cm), number of primary branches/plants (16.54), length of longest primary branch (47.13 cm), plant spread (N-S and E-W) (33.88 and 36.27 cm) and number of suckers /plants (7.26), flowering parameters, viz. days taken to first flower bud initiation (54.73 days), days taken to colour break of 1st flower bud, days taken to1st plucking of flower, days of 50% flowering, number of flowers/plants (30.88) and days to last plucking flower, yield and quality attributes viz.fresh weight of flower (9.38 g), dry weight of flower (g), flower diameter (10.04 cm), vase life of flower (days), fresh weight of plant bio-mass (g)dry matter of plant bio-mass(g), weight of flowers/plant (287.80), yield of flower/ plotand yield of flower (201.4q/ ha^{-1}) at full bloom. The data on various parameters were analysed statistically as suggested by Panse and Sukhatme (1985) [10].

Results and Discussion

Growth Parameters

The data (Table 1and Table 2) revealed that thecombined foliar spray of $FeSO_4$ and $ZnSO_4$ had significant effect on growth parameters. Maximum plant height and number of primary branches was recorded on combined application of 0.4% of zinc and 0.4% iron followed by combined application of 0.6% Zinc and Fe 0.6%, while the smallest height of plant (46.18 cm) and number of primary branches was observed in control. The increased plant height and primary branches with application of micronutrients might be due to its role in synthesis of tryptophan which is a precursor of auxin (IAA). Similarly iron acts as an important catalyst in the enzymatic reactions of the metabolism and would have helped in larger biosynthesis of photo assimilates thereby enhancing growth of the plants. Similar results were reported by Karuppaiah (2014) [3] in chrysanthemum.

The maximum number of leaves per plant, length of longest of primary branch and plant spread were noticed in combined foliar spray of 0.4% of zinc and 0.4% iron followed by combined application of 0.6% Zinc and Fe 0.6%, while the minimum found in untreated plants. Iron and zinc were reported to act as important catalyst in several metabolic reactions occurring in plants and also contribute in accumulation of bio-synthates through various processes and hence vegetative growth is enhanced. Zinc and iron also favour the storage of more carbohydrates through photosynthesis, which may inturn be the attributing factor for the positive effect on growth attributes (Senthamizhselvi, 2000) [9]. These findings were in agreement with the results of Hussain *et al.,* (2020) [4] in marigold

Flowering indices

Response of iron and zinc at different concentrations was recorded to assess the flowering behaviour under uniform management condition. The application of iron and zinc significantly influenced the various flowering indices as compared to control. The minimum days to flowering was recorded on 0.4% foliar application of zinc which was statistically at par combined application of Zn 0.4% and Fe 0.4% each. The maximum days to flowering was recorded on control. The foliar application of zinc enhanced the metabolic activities of the plant which increased cell enlargement and cell elongation due to which the rate of photosynthesis increased and plant produced early flowering.These findings were also supported by Tayade *et al.* (2018) [6] in tuberose and Thirumalmurugan *et al.,* 2021 [1] in African marigold.

Yield and Quality attributes

The flower weight and flower size was significantly affected by the foliar application of zinc and iron. The maximum flower weight and diameterwas noticed with $ZnSO_4$+$FeSO_4$ @ 0.4% followed by combined spray of Zn and Fe@0.6%. Association of zinc and iron regulates semi-permeability of cell walls, thus mobilizing more water into flowers and also increase the synthesis of iron which might be responsible forincreased flower size and weight. These results are in consonance with the results obtained by Karuppaiah (2014) [3] and Vanlalruati *et al.,* (2019) [8] who worked on chrysanthemum.

The foliar application of zinc and iron significantly affected the numbers of flowers/ plant, flower yield/ plant and flower yield/ ha. The maximum numbers of, flowers/ plant, flower\plant yield/ plant and flower yield/ ha were observed in those plots which were treated with combined spray of 0.4% Zinc and Fe each followed by combined application of 0.6% Zinc and Fe, whereas these parameters minimum found in control plot. The reason for behind for this plant maybe due to the useful and essential character of zinc and iron in improving the translocation of carbohydrates, water, amino acid, synthesis of chlorophyll as a result of which the photosynthesis rate increased and produced more food, due to which the flower numbers flowers/ plant was increased and ultimately flower yield.. The results are in confirmatory with the results of Thirumalmurugan *et al.,* 2021 [1] and Hussain *et al.,* 2020 [4] in marigold, Khosa, *et al.* 2011 [7] in gerbera and Tayade *et al.,* 2018 [6] in tuberose.

The maximum shelf life of flower was found in combined application of Zn and Fe @ 0.4% each followed by 0.6%

combined application of zinc and Fe. The minimum shelf life of chrysanthemum flower noticed in control. Application of zinc plays an important role to produce good quality flowers and increased the shelf life of flower (Patel *et al*., 2016) [5]. The shelf life of tuberose improved with the application of zinc and Iron increased the storage of carbohydrates, formation of plant hormones and chlorophyll through the increased in the rate of photosynthesis. The studies showed that the application of iron and zinc play a role in the physiological growth of the flowers and reduced the amount of ethylene and abscisic acid and as a result of which the shelf life and visual attraction of the flowers increased. These results are in confirmation with the findings of Karuppaiah (2014) [3] in chrysanthemum flower and Thirumalmurugan *et al.*, (2021) [1] in African marigold

Based on present investigation, it may be concluded that combined foliar application of $FeSO_4$ + $ZnSO_4$ @ 0. 4% was found superior among all other treatments for increasing growth, flowering and quality yield of chrysanthemum.

Table 1: Effect of Fe and Zn on Growth parameters

Sr. N.	Treatments	Plant Height (cm)	Number of Primary Branches/Plant	Length of Longest Primary Branches/Plant	Plant Spread (N-S)	Plant Spread (E-W)	Number of Suckers/Plants	First Flower Bud Initiation (Days)
1	T_1- Control	44.83	9.70	33.70	24.79	26.46	2.99	63.83
2	T_2- $ZnSO_4$ @ 0.2%	45.93	11.61	35.99	27.38	29.35	4.11	62.30
3	T_3- $ZnSO_4$ @ 0.4%	46.62	12.79	37.59	29.63	31.29	4.58	61.80
4	T_4- $ZnSO_4$ @ 0.6%	49.22	14.66	43.34	30.85	34.19	5.71	58.78
5	T_5- $FeSO_4$ @ 0.2%	46.99	12.74	38.33	28.55	30.48	4.80	61.45
6	T_6- $FeSO_4$ @ 0.4%	47.59	13.04	40.22	30.46	32.39	5.20	60.66
7	T_7- $FeSO_4$ @ 0.6%	47.36	13.47	41.35	30.79	33.48	5.34	59.92
8	T_8- $ZnSO_4$ @ 0.2% + $FeSO_4$ @ 0.2%	48.32	14.32	43.33	31.94	33.90	5.67	57.50
9	T_9- $ZnSO_4$ @ 0.4% + $FeSO_4$ @ 0.4%	52.80	16.54	47.13	33.88	36.27	7.26	54.73
10	T_{10}- $ZnSO_4$ @ 0.6% + $FeSO_4$ @ 0.6%	50.60	15.25	45.50	32.99	35.23	6.28	55.58
	CD	1.058	0.776	.849	1.206	0.66	0.706	1.00
	SEm±	0.353	.259	.283	0.403	0.221	0.236	0.334

Table 2: Effect of Fe and Zn on yield and quality parameters

Sr. N.	Treatments	Flower Diameter (cm)	Flower Weight (g)	Max. Number of Flower/Plants	Flower yields/Plant	Flower Yield q/ha^{-1}
1	T_1- Control	7.17	6.43	23.79	161.61	159.1
2	T_2- $ZnSO_4$ @ 0.2%	7.52	6.85	24.27	173.58	161.4
3	T_3- $ZnSO_4$ @ 0.4%	8.11	7.78	26.29	206.04	173.3
4	T_4- $ZnSO_4$ @ 0.6%	8.93	8.27	28.85	240.25	186.1
5	T_5- $FeSO_4$ @ 0.2%	7.59	6.92	24.88	176.25	171.0
6	T_6- $FeSO_4$ @ 0.4%	8.18	7.52	26.24	180.32	172.5
7	T_7- $FeSO_4$ @ 0.6%	8.47	7.88	28.79	225.92	184.0
8	T_8- $ZnSO_4$ @ 0.2% + $FeSO_4$ @ 0.2%	8.62	8.28	29.27	246.92	190.7
9	T_9- $ZnSO_4$ @ 0.4% + $FeSO_4$ @ 0.4%	10.04	9.38	30.88	287.80	201.4
10	T_{10}- $ZnSO_4$ @ 0.6% + $FeSO_4$ @ 0.6%	9.57	8.87	29.99	270.90	192.5
	CD	0.272	0.926	0.894	1.451	0.144
	SEm±	0.091	0.309	0.298	0.484	0.048

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