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Effect of micronutrients (Fe and Zn) on flowering and yield attributes of chrysanthemum (*Chrysanthemum morifolium*) cv. Mayur 5

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ABSTRACT

A field experiment was carried out to study the effect of zinc and iron on growth, yield and quality of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. Mayur 5 during 2016 and 2017. The experiment was laid out in randomized block design with three replications comprising nine levels of micronutrients, i. e. control (T_1), $ZnSO_4$ @ 0. 1% (T_2), $ZnSO_4$ @ 0. 2% (T_3), $ZnSO_4$ @ 0. 5% (T_4), $FeSO_4$ @ 0. 2% (T_5), $FeSO_4$ @ 0. 5% (T_6), $FeSO_4$ @ 0. 8% (T_7), $FeSO_4$ + $ZnSO_4$ @ 0. 5% each (T_8) and $FeSO_4$ + $ZnSO_4$ @ 0. 7% each (T_9). Combined foliar spray of $FeSO_4$ + $ZnSO_4$@ 0. 5% recorded best results for number of branches per plant (37. 00), minimum days for flower opening (94. 67), petal length (2. 17 cm), petal width (0. 63cm), flower bud diameter (1. 339 cm), flower longevity (28. 00 days), single flower weight (1. 27g), plant dry weight (98. 33 g), number of flowers per plant (218. 33), flower yield per plant (218. 33g) and flower yield/m^2 (2988. 62g). Maximum flower diameter and chlorophyll content (SPAD reading) was also recorded with individual spray of $FeSO_4$ @ 0. 5% (T_6). Among the treatment, $ZnSO_4$ + $FeSO_4$ @ 0. 5% (T_8) gave best results for flower production and yield for chrysanthemum under open field conditions.

Key words: Chrysanthemum, $FeSO_4$, Flowering, Yield, $ZnSO_4$

Chrysanthemum (*Chrysanthemum morifolium* Ramat.) is the most imperative commercial loose flower crop as well as a popular cut flower worldwide. In India, it occupies more than 18 thousand ha area with production of 198. 95 MT of loose flowers (NHB 2016). It is commercially cultivated in Tamil Nadu, Karnataka, Maharashtra, West Bengal, Himachal Pradesh, Punjab, Rajasthan, Gujarat and Delhi. Micronutrients have stimulatory and catalytic effects on metabolic processes thus play vital roles in the growth and development of plants (Khosa *et al.* 2011). They are essential for crop growth and development although they are required in smaller quantities (Natesan 1995). Enrichment of the crop with micronutrients, especially iron and zinc may prove effective in regulating flowering in crops (Pratap *et al.* 2005) and aid in better flower production. Iron is a key element in different oxidation-reduction reactions of respiration, photosynthesis and of nitrates and sulphates (Reddy and Reddi 2002). Zinc is necessary for the synthesis of auxin IAA and for carbohydrate metabolism, protein synthesis, internodes elongation for stem growth (Shukla *et al.* 2009). For various ornamental flower crops, foliar sprays was found more economically than soil application and combination sprays of micronutrients have been successfully resorted. The quality of chrysanthemum flowers is influenced by application of micronutrients and optimising the dose and chosing right method of application will enhance the flower production and quality (Gurav *et al.* 2004). The demand for increasing flower production will require clear cut information on how the micronutrients have effect on crop growth. Keeping the above points in view, an experiment was conducted to study the effect of foliar application of micronutrients (Fe and Zn) on growth, flowering and yield of chrysanthemum cv. Mayur 5.

MATERIALS AND METHODS

The present investigation was done at Floriculture Research Farm, Indian Agricultural Research Institute, New Delhi during the year 2016 and 2017. The experiment was laid out in randomized block design with three replications and nine treatment combinations. The treatment comprised of eight levels of micronutrients, *i. e.* control (T_1), $ZnSO_4$ @ 0.1% (T_2), $ZnSO_4$ @ 0.2% (T_3), $ZnSO_4$ @ 0.5% (T_4), $FeSO_4$ @ 0.2% (T_5), $FeSO_4$ @ 0.5% (T_6), $FeSO_4$ @ 0.8% (T_7), $FeSO_4$ + $ZnSO_4$ @ 0.5% each (T_8) and $FeSO_4$ + $ZnSO_4$ @ 0.7% each (T_9). Five months old rooted cuttings of chrysanthemum were planted in September at a distance of 30 cm in rows spaced 30 cm apart in plots of size 1.2 × 1.2 m, accommodating 16 plants in each plot. Pinching was done to promote axillary branches a month after transplanting. Standard recommendations were followed

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while applying inorganic fertilizers. The micronutrients (zinc sulphate and ferrous sulphate) were applied as foliar spray at varying concentrations in two stages, viz. two months and three months after transplanting. Five plants from each replication of the cultivar were used for recording observation. Biometric observations were recorded on growth and physiological attributes, viz. plant height (cm), plant spread (cm), number of branches (nos.), chlorophyll content (mg/g FW); quality attributes, viz. days for flower opening (days), petal length (cm), petal width (cm), flower bud diameter (cm), flower diameter (cm) and flower longevity (days); flowering and yield attributes, viz. single flower weight (g), plant fresh weight (g), plant dry weight (g), number of flowers per plant, flower yield per plant (g) and flower yield per sq m (g) at full bloom. All the mean values of the recorded data on various biometrical parameters were subjected to statistical analysis as per the procedure given by Panse and Sukhatme (1985).

RESULTS AND DISCUSSIONS

Vegetative parameters: The perusal of the data revealed that single and combined foliar application of micronutrients ($ZnSO_4$ and $FeSO_4$) had significant effect on growth and physiological attributes, i.e. plant height, plant spread and number of branches of plant and leaf SPAD reading (Fig 1) in both the years. The highest plant height (46.67 cm) was recorded with foliar spray of $ZnSO_4$ @ 0.2% (T_3) whereas $FeSO_4$ @ 0.8% (T_7) recorded lowest plant height (38.17) (Table 1). Enhanced physiological activity and cell elongation with micronutrient treatment might result in increment of plant height. The combined effect of zinc and iron also enhanced synthesis of auxin, protein and biosynthesis of photo assimilates causing internode elongation and thereby height of the plants (Jawaharlal *et al.* 1986). The result is in agreement with earlier report of Sujatha *et al.* (2002) and Gurav *et al.* (2004) in gerbera. Kakade *et al.* (2009) also reported on increasing effect of zinc on plant height in china aster. The results for plant spread and number of branches per plant showed significant difference for the various treatments applied as foliar application of $ZnSO_4$ and $FeSO_4$. Maximum plant spread at full bloom (36.33 cm) was observed in foliar spray of $ZnSO_4$ @ 0.5% (T_4) whereas lowest plant spread (22.83 cm) at full bloom was observed in $FeSO_4$ @ 0.5% (T_6) which was statistically at par with control (T_1). Significantly, the highest number of branches per plant (37.00) at full bloom was observed in foliar spray of $ZnSO_4$ + $FeSO_4$ @ 0.5% each (T_8) whereas the lowest number of branches per plant (15.33) was observed $FeSO_4$ @ 0.2% (T_5). Increase in plant height, plant spread and number of branches per plant attributed to improved root system of plants resulting in nutrient absorption and utilization with $ZnSO_4$ and $FeSO_4$ application. Several enzymes, viz. catalase, peroxidase, alcohol, dehydrogenase, carbonic dehydrogenize, tryptophan synthates etc. responsible for chlorophyll synthesis and various physiological activities were activated which encourage plant growth and development (Kumar and Arora 2000). The increase in plant height, plant spread and number of branches per plant as a result of iron and zinc application was also reported by Kakade *et al.* (2009), Kumar and Haripriya (2010) in nerium and Barman and Pal (1999) in chrysanthemum.

Flowering parameters: Earliest flower opening (94.67 days) was observed with foliar application of $ZnSO_4$ + $FeSO_4$ @ 0.5% each (T_8), whereas control (T_1) took maximum days (121.00) for flowering. Micronutrients zinc and iron favour the storage of more carbohydrates through photosynthesis, which may be the attributing factor for early flower bud initiation and early flowering as well. The similar results were reported by the Jadhav (2004) in gerbera. Combined foliar spray of $ZnSO_4$ + $FeSO_4$ @ 0.5% each (T_8) resulted maximum petal length (2.17cm) and petal width (0. 63cm) at full bloom, whereas control (T_1) (1.53cm) and $FeSO_4$ @ 0.8% (T_7) (1.53cm) recorded minimum for petal length and

Table 1 Growth and quality attributes (mean ± SEm) of chrysanthemum as influenced by foliar application of micronutrients ($ZnSO_4$ and $FeS0_4$)

Treatment	Plant height (cm)	Plant spread (cm)	Number of branches per plant (nos.)	Days for flower opening (days)	Flower diameter (cm)	Flower longevity (days)
Control (T_1)	46. 33 ± 0. 88	22. 83 ± 0. 50	30. 33 ± 0. 88	121. 00 ± 0. 88	3. 60 ± 0. 41	22. 67 ± 0. 33
$ZnSO_4$ @ 0.1% (T_2)	42.00 ± 2.31	33.50 ± 0.87	23.67 ± 0.88	115.67 ± 1.86	4.20 ± 0.12	24.33 ± 1.20
$ZnSO_4$ @ 0.2% (T_3)	46.67 ± 1.45	35.17 ± 0.69	20.00 ± 2.89	119.00 ± 2.65	4.17 ± 0.09	19.33 ± 0.33
$ZnSO_4$ @ 0.5% (T_4)	40.00 ± 0.58	36.33 ± 0.81	24.00 ± 0.58	96.33 ± 1.20	4.43 ± 0.26	25.67 ± 0.67
$FeSO_4$ @ 0.2% (T_5)	43.67 ± 0.44	34.17 ± 0.17	15.33 ± 0.44	119.33 ± 1.33	4.23 ± 0.01	27.33 ± 0.88
$FeSO_4$ @ 0.5% (T_6)	39.33 ± 0.88	22.83 ± 0.44	17.50 ± 0.88	96.00 ± 1.15	4.47 ± 0.25	27.00 ± 0.17
$FeSO_4$ @ 0.8% (T_7)	38.17 ± 2.74	23.92 ± 0.16	22.67 ± 2.60	102.00 ± 1.15	3.68 ± 0.07	24.33 ± 0.33
$FeSO_4$ 0.5% + $ZnSO_4$ 0.5% @ (T_8)	39.00 ± 1.73	34.50 ± 0.29	37.00 ± 1.15	94.67 ± 1.86	4.33 ± 0.01	28.00 ± 1.15
$FeSO_4$ 0.7% + $ZnSO_4$ 0.7% @ (T_9)	40.33 ± 2.60	24.58 ± 0.35	25.67 ± 0.88	114.67 ± 1.45	3.77 ± 0.01	26.94 ± 0.33
CD (P=0.05)	5.21	1.42	5.00	2.81	0.51	1.83

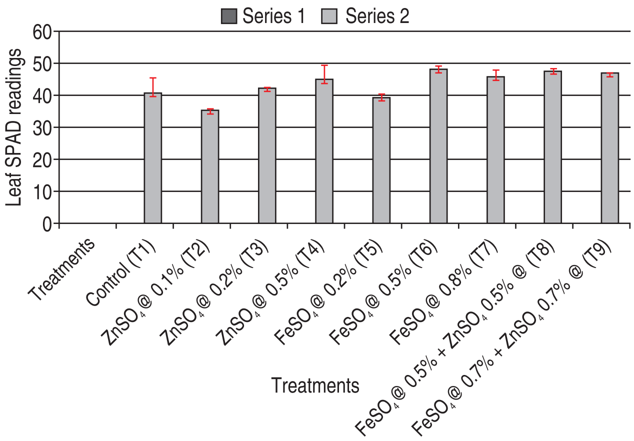

Fig 1 Effect of micronutrients ($ZnSO_4$ and $FeSO_4$) on leaf SPAD readings of chrysanthemum. Bar represents the mean of three replicates ± SEm and treatment were significant at P<0.05.

are statistically at par. Minimum petal width was recorded in $FeSO_4$ @ 0.8% (T_7) (0.47cm) (Table 1). For the rest of the micronutrient treatment, the value for petal length and width ranges from 1.63 to 2.00 cm and 0.53 to 0.60 cm, respectively. Micronutrient spray significantly influenced flower bud diameter and it was maximum (1.339 cm) with foliar spray of $ZnSO_4$ + $FeSO_4$ @ 0.5% each (T_8) and minimum (1.331 cm) was recorded in $ZnSO_4$ @ 0.1% (T_2). Pal *et al.* (2015) reported that increase in size of ray florets leads to increasing cell size which also increase diameter of flower bud. The results were in conformity with the findings of Muthumanikam *et al.* (1999) in gerbera. It can be inferred from the data that maximum flower diameter (4. 47 cm) was recorded with the foliar application of $FeSO_4$ @ 0.5% (T_6) and the minimum flower diameter (3.60 cm) was recorded in control (T_1) (Table 1). The increase in flowering attributes might be due to the beneficial role of zinc and iron in enhancing the translocation of carbohydrates, minerals, water and amino acids from the site of synthesis to the storage tissue especially on flowers which in turn increase the number, size and weight of flowers. Similar results were also recorded by Naveen kumar *et al.* (2009) in chrysanthemum. Iron might also help in producing more food material which in turn resulted in higher assimilate synthesis and partitioning of flower growth. A similar trend was in consonance with Muthumanickam *et al.* (1999) in gerbera and Nag and Biswas (2003) in tuberose. Maximum flower longevity (28.37 days) was observed with foliar application of $ZnSO_4$+$FeSO_4$ @ 0.5% (T_8), whereas the minimum longevity (19.33 days) was observed in $ZnSO_4$ @ 0.2% (T_3) (Table 1). Role of iron in the synthesis of plant hormones and higher carbohydrate, plant growth regulators and enzymes deposition in flower cells by the zinc might enhance the longevity of flowers. The obtained results were in conformity with the findings of Rao (2005) in gladilous and Singh and Bhattacharjee (1997) in rose. Enhanced flower longevity with foliar application of ferrous sulphate is also in agreement with reports by Naveen kumar *et al.* (2009) in chrysanthemum and Muthumanikam *et al.* (1999) in gerbera.

Quality and yield parameters: The perusal of the data revealed that single and combined foliar application of $ZnSO_4$ and $FeSO_4$ exerted a significant effect on flowering and yield parameters, viz. single flower weight, plant fresh weight, plant dry weight, number of flowers per plant, flower yield per plant and flower yield per sq m (Table 2 and Fig 2). Maximum single flower weight (1.27g) at full bloom was recorded with $ZnSO_4$+$FeSO_4$ @ 0.5% (T_8) and lowest single flower weight (0.89 g) was recorded in control (T_1). 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 for increased flower size and weight. Similar results were also reported by Nag and Biswas (2003) and Hardeep Kumar *et al.* (2003) in tuberose. The highest plant fresh weight (448. 33g) was recorded with single spray of $FeSO_4$ @ 0.8% (T_7) and maximum dry weight (98.33g) of plant was recorded in $FeSO_4$ @ 0.5% (T_6). The lowest fresh weight (215.00 g) and dry weight (53.33 g) of plant was obtained with $FeSO_4$ @ 0.5% (T_6) and control (T_1) respectively. The combined effect might encouraged vegetative growth and ultimately increased the fresh and dry weights of plant. The significant effect of fresh weight and dry weight with

Table 2 Yield attributes (mean ± SEm) of chrysanthemum as influenced by foliar application of micronutrients ($ZnSO_4$ and $FeSO_4$)

Treatment	Single flower weight (g)	Plant fresh weight (g)	Plant dry weight (g)	Number of flowers per plant (nos.)	Flower yield per plant (g)
Control (T1)	0.89 ± 0.01	330.00 ± 5.77	53.33 ± 4.41	146.67 ±8.82	132.71 ± 1.17
$ZnSO_4$ @ 0.1% (T2)	1.04 ± 0.01	315.67 ± 2.33	55.17 ± 1.30	125.00 ± 4.41	143.17 ± 2.24
$ZnSO_4$ @ 0.2% (T3)	0.96 ± 0.03	341.67 ± 6.01	75.33 ± 2.60	166.00 ± 3.46	175.10 ± 1.07
$ZnSO_4$ @ 0.5% (T4)	1.15 ± 0.09	276.67 ± 4.41	80.00 ± 5.77	118.00 ± 1.15	143.79 ± 2.13
$FeSO_4$ @ 0.2% (T5)	1.09 ± 0.03	415.67 ± 3.48	72.33 ± 4.33	200.33 ± 8.37	202.45 ± 1.44
$FeSO_4$ @ 0.5% (T6)	1.05 ± 0.01	215.00 ± 5.77	60.00 ± 2.89	95.00 ± 2.89	101.81 ± 1.60
$FeSO_4$ @ 0.8% (T7)	1.16 ± 0.05	448.33 ± 14.81	86.67 ± 8.82	173.83 ± 7.67	186.61 ± 3.30
$FeSO_4$ 0.5% + $ZnSO_4$ 0.5% @ (T8)	1.27 ± 0.07	320.00 ± 5.77	98.33 ± 4.33	201.67 ± 4.04	218.33 ± 4.41
$FeSO_4$ 0.7% + $ZnSO_4$ 0.7% @ (T9)	1.06 ± 0.01	439.33 ± 2.96	97.33 ± 10.14	153.50 ± 6.73	164.87 ± 2.78
CD (P=0.05)	0.12	19.52	17.62	18.15	7.01

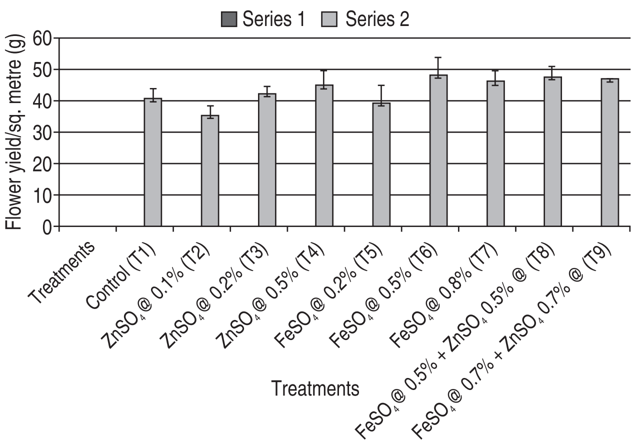

Fig 2 Effect of micronutrients ($ZnSO_4$ and $FeSO_4$) on flower yield per sq m of chrysanthemum. Bar represents the mean of three replicates ± SEm and treatment were significant at $P<0.05$.

Fe and Zn application was also reported by Sunder Pal *et al.* (2016) in gerbera, Balakrishnan (2005) in marigold, Nag and Biswas (2003) in tuberose. Maximum number of flowers per plant (201.67) was recorded in foliar application of $ZnSO_4$+$FeSO_4$ @ 0.5% (T_8) and minimum number of flowers per plant was recorded in $FeSO_4$ @ 0.5% (T_6) (95.00). Observations on flower yield per plant as influenced by micronutrients were significant. Foliar application of $ZnSO_4$+$FeSO_4$ @ 0.5% each (T_8) gave maximum flower yield per plant (218.33 g) whereas FeSO4 @ 0.5% (T_6) gave minimum flower yield per plant (101.81 g). Greater assimilate synthesis and storage of more food material helps in better development of buds and flowers. Zinc and iron were also part of large number of organic compounds which plays an important role in synthesis of chlorophyll, growth promoting substances and mobility of minerals, water and photosynthates which may in turn increase the flower production and ultimately flower yield. Significant effect of micronutrient on flower yield is in agreement with the reports of Balakrishnan *et al.* (2007) in African marigold, Naveen Kumar *et al.* (2009) in chrysanthemum, Kumar and Haripriya (2010) in nerium, Muthumanikam (1999) in gerbera and Hadel *et al.* (2007) in gladiolus.

From the result of the experiment, it was concluded that combined foliar application of micronutrients was effective than single application. Among the treatments, combined foliar spray of $ZnSO_4$+$FeSO_4$ @ 0.5% recorded best results for growth, flowering, yield and quality of chrysanthemum under open field conditions.

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