International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 651-658, 2023; Article no.IJECC.104877
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Micronutrients Foliar Application on Growth and Flowering of Gerbera (*Gerbera jamesonii*) in Naturally Ventilated Polyhouse under Prayagraj Agro Climatic Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102699

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104877

Original Research Article

Received: 10/06/2023
Accepted: 14/08/2023
Published: 19/08/2023

ABSTRACT

The present investigation entitled "Effect of Micronutrients Foliar Application on Growth and Flowering of Gerbera (*Gerbera jamesonii*) in Naturally Ventilated Polyhouse Under Prayagraj Agro Climatic Conditions" was carried out during November 2022 to March 2023 in, Naturally Ventilated Polyhouse, Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj. The experiment was conducted in Randomized Block Design with thirteen treatment combinations, with the application of three micronutrients; $FeSO_4$, $MgSO_4$ and $ZnSO_4$ at different levels, which was

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replicated thrice. It was concluded that the application of micronutrients treatments rendered their significant effect on almost all the growth, flowering and yield characters of gerbera. The treatment T_{11} i.e., application of $ZnSO_4$ at 0.6% found superior in terms of plant height (28.17cm), number of leaves (13.5), length of the leaves (33.9cm), plant spread (47.68cm), days taken for first flower bud initiation (88.6days), minimum days taken to first harvest (119days), flower diameter (11.35cm), stalk length (43.16cm), stalk diameter (7.16mm), number of flowers per plant (9.17) and vase life (9.66days). Among the different treatments the highest gross return (142590 Rs/200m^2), Net return (55938 Rs/200m^2), benefit cost ratio (1.64) was obtained under the use of $ZnSO_4$ at 0.6% (T_{11}).

Keywords: Gerbera; micronutrients; $FeSO_4$; $MgSO_4$; $ZnSO_4$.

1. INTRODUCTION

Gerbera is an important cut flower crop grown throughout the world in a wide range of climatic conditions. It belongs to the Asteraceae family which is also known as Transvaal daisy or Barberton daisy or African daisy. Gerberas are often associated with happiness, innocence, and purity. It has spread naturally in South Africa, Madagascar and tropical Asia. The first scientific description of gerbera was given by Traugott Gerber J D. The described species *Gerbera jamesonii*, is a South African species. Gerbera is native to tropical region of South America, Africa and Asia. It is a diploid species with somatic chromosome number of 2n = 50. Gerbera is a dwarf herbaceous perennial and grows in clump with solitary flower heads on a long slender stalk, which grows well in protected structures.

Micronutrients play vital roles in the growth and development of plants. Among them, ferrous sulphate, zinc sulphate, and magnesium sulphate are three important micronutrients that have a significant impact on the growth and flowering of gerbera plants. Due to their stimulatory and catalytic effects on metabolic processes and ultimately on flower yield and quality [1]. Enhancement in growth characters due to micronutrient application might basically be due to improved photosynthetic and other metabolic activities related to cell division and elongation [2]. Most necessary and essential micronutrients, such as Zn, Fe, Mn, Cu and B have an important role in the growth stage and quality of flower on gerbera.

Ferrous sulphate, also known as iron sulphate, is a micronutrient essential for various metabolic processes in plants. It is a key component of enzymes involved in chlorophyll synthesis, energy transfer, and nitrogen fixation. Iron is an important element in various reactions of respiration, photosynthesis and reduction of nitrate and sulphate [3].

Zinc sulphate is another micronutrient that plays a vital role in the growth and flowering of gerbera. Zinc is effective in plant nutrition for the synthesis of plant hormones and balancing intake of P and K inside the plant cells. Zinc deficiency in plants resulted in stunted growth, little leaf and fruit sizes which are recognized to altered IAA metabolism [4]. It involved in numerous enzymatic reactions and is necessary for the synthesis of growth hormones and proteins. Zinc is necessary for the synthesis of auxin IAA and for carbohydrate metabolism, protein synthesis, internodes elongation for stem growth and in pollen formation [5].

Magnesium sulphate, commonly known as Epsom salt, is a micronutrient that provides magnesium, an essential element for plant nutrition. Magnesium is a component of chlorophyll, the pigment responsible for photosynthesis. It is also involved in various enzymatic reactions, carbohydrate metabolism, and the synthesis of nucleic acids and proteins. Adequate magnesium levels promote vigorous growth, enhanced nutrient uptake, and increased flower production in gerbera plants.

2. MATERIALS AND METHODS

A field experiment entitled, “Effect of Micronutrients Foliar Application on Growth and Flowering of Gerbera (*Gerbera jamesonii*) in Naturally Ventilated Polyhouse Under Prayagraj Agro Climatic Conditions” was carried out in the Department of Horticulture, Naini, Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences during 2022-23. The experiment included application of different concentrations of micronutrients like ferrous sulphate, magnesium sulphate and zinc sulphate with 13 treatments in three replications. The gerbera suckers of rosaline variety were transplanted in the polyhouse with a planting distance of (30x30) cm and had four plants per plot. The experiment was laid out in Randomized

Block Design with thirteen treatments and three replications. The experiment includes foliar application of micronutrients nutrients, Ferrous sulphate ($FeSO_4$), Magnesium sulphate ($MgSO_4$) and Zinc sulphate ($ZnSO_4$), which were applied with differential concentrations of $FeSO_4$ at 0.2%, 0.4%, 0.6%, 0.8%; $MgSO_4$ at 0.2%, 0.4%, 0.6%, 0.8% and $ZnSO_4$ at 0.2%, 0.4%, 0.6%, 0.8% for 30, 60 and 90 days after planting. The four plants of each treatment of replications observations were recorded at 30 days interval. Data were statistically analyzed by Fisher's analysis of variance (ANOVA) technique, following the guidelines provided by Gomez and Gomez [6].

3. RESULTS AND DISCUSSION

Data in table in Table 1 indicates significant differences regarding the growth and flowering parameters like plant height(cm), number of leaves per plant, leaf length(cm), plant spread(cm), days taken for first flower bud initiation(days), days taken for first harvest(days) and number of flowers per plant treated with different $FeSO_4$, $MgSO_4$ and $ZnSO_4$ concentrations.

Plant height was recorded with significant variations among different treatments. Maximum plant height (28.17 cm) was recorded in T_{11}-$ZnSO_4$ at 0.6% followed by treatment T_3-$ZnSO_4$ at 0.6% (26.05 cm) and the shortest was found in the treatment T_0-Control (22.65 cm). It may be due to the synthesis of tryptophan, a precursor of indoleacetic acid (auxin) which is accelerated by zinc and IAA is known to promote apical dominance, maintain polarity and growth. And zinc promotes cell elongation, cell multiplication and cell division which resulting in increased photosynthesis and translocation of food materials enhanced plant height [4]. Similar results were reported by Kakade et al. [7] in china aster and Ahmad et al. [8] in Dutch rose.

Number of leaves per plant was recorded with significant variations among different treatments. Maximum number of leaves (13.5) was recorded in T_{11}- $ZnSO_4$ at 0.6%, followed by treatment T_3-$FeSO_4$ at 0.6% (12.25) and the lowest was found in the treatment T_0 -Control (8.5). The foliar application of zinc might be stimulating metabolic activity with stimulating effect on cell wall loosing, increased cell elongation along with cell enlargement and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the number of leaves (Joseph et al. 2019). Similar results were also obtained by Bashir et al. [1] in gerbera and Pal. et al. [9] in gerbera. Maximum leaf length was (33.91cm) was recorded in T_{11}- $ZnSO_4$ at 0.6%, followed by treatment T_3-$FeSO_4$ at 0.6% (32.25cm) and the lowest was found in the treatment T_0-Control (27.58cm). The application of $ZnSO_4$ might be stimulating metabolic activity and stimulating effect on cell wall loosing, increased cell elongation along with cell differentiation and cell enlargement resulting in increased photosynthesis and translocation of food materials enhances the leaves length [10]. Similar results were reported by Bashir et al. [1] in gerbera and Pal et al. [9] in gerbera.

The maximum plant spread (47.68cm) was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% followed by treatment T_3-$FeSO_4$ at 0.6% (46.06cm) and the minimum is found in the treatment T_0-Control (39.01cm). Micronutrients activate several enzymes and involved themselves in chlorophyll synthesis and various physiological activities all these factors help in cell differentiation, cell division and cell multiplication resulting in increase in photosynthesis and translocation of food materials that increased plant spread. Similar findings were reported in Pal et al. [9] in gerbera, Tara et al. [11] in chrysanthemum and Kakade et al. [7] in China aster.

Minimum days to first flower bud initiation was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (88.66 days) and followed by the treatment T_3 –$FeSO_4$ at 0.6% (91.75 days) whereas the maximum number of days taken to first flower bud initiation was recorded in T_0-Control (101.75 days). It may be due to the proper nutritional status i.e., nitrogen, potassium, zinc, copper, etc. and hormonal level within the plants. Sucrose and phyto-hormones moved in combination from leaves to apical meristem due to the application of micronutrients to induce early flowering. Similar findings were reported in Kashyap et al. [12] in gladiolus and Chaturvedi [3] in gladiolus.

Minimum days taken for first harvest was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (119 days) and followed by the treatment T_3 –$FeSO_4$ at 0.6% (122 days) whereas the maximum days taken for first harvest was recorded in T_0- Control (132.5 days). Micronutrients like zinc, manganese, boron and iron favours in the storage of more carbohydrates through photosynthesis which plays an important role in chlorophyll synthesis, photosynthesis and respiration. This may be responsible for the beneficial effects of optimum dose of zinc on reducing juvenile phase of plant. Similar findings were reported by Jadhav et al*.* [13] and Kashyap et al*.* [12] in gladiolus.

Maximum Number of flowers per plant was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (9.17) and followed by the treatment T_3 – $ZnSO_4$ at 0.6% (7.83) whereas the minimum number of flowers per plant was recorded in the treatment T_0 – Control (5.33). The increase in flower per plant is due to the application of $ZnSO_4$, which plays an important role by involving in photosynthesis; break down of IAA (auxin) and protein synthesis and this will lead to produce more food materials which in turn utilized for the development of number of flowers [4]. Similar results were also reported by Nag and Biswas [14] and Hardeep et al*.* [15] in tuberose.

The data regarding floral parameters like flower diameter, stalk length, stalk diameter, number of flowers per 200 square meter and vase life of gerbera flower is shown in the Table 2. Maximum flower diameter was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (11.35cm) and followed by the treatment T_7 – $MgSO_4$ at 0.6% (10.71 cm) whereas the shortest flower diameter was recorded in the treatment T_0 –Control (8.79cm). Micronutrients such as zinc, it helps in regulating semi permeability of cell walls, thus mobilizing more water into flowers and also increase the synthesis of iron which promotes the flower size and weight of the flowers [15]. The plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which increase the flower size [9]. Similar results were reported by Nath and Biswas [14] in tuberose, Thirumalmurugan et al*.* [4] in African marigold.

Maximum flower stalk length was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (43.16 cm) and followed by the treatment T_7 – $MgSO_4$ at 0.6% (41.41 cm) whereas the shortest flower diameter was recorded in the treatment T_0 – Control (37.1 cm). Foliar application of micronutrients promotes cell elongation, cell division and cell enlargement which helps in the increase of flower stalk length. These findings are in strong conformity with Aparna et al*.* [16] in gerbera. Maximum flower stalk diameter was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (7.166 mm) and followed by the treatment T_7 – $MgSO_4$ at 0.6% (6.25 mm) whereas the shortest stalk was recorded in the treatment T_0 – Control (5.25mm). The moderate dose of micronutrients enhanced the growth rate of vegetative part, increased physiological activity and also more cell elongation, which increased the diameter of flower stalk [9]. These findings are in close conformity with the results of Sujatha et al*.* [5].

Maximum number of flowers per 200 square meter was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (20370) and followed by the treatment T_3 – $ZnSO_4$ at 0.6% (17407) whereas the minimum number of flowers per plant was recorded in the treatment T_0 – Control (11852). It is due to the application of zinc relieved the plants from chlorosis and produced healthy green leaves which resulted increase photosynthesis; break down of IAA (auxin) and protein synthesis and this will lead to produce more food materials which assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production. Similar results were also obtained by Joseph et al*.* [17] in China aster, Nath and Biswas [14] in tuberose and Pal et al*.* [9] in gerbera.

Maximum vase life was recorded in treatment T_{11}- $ZnSO_4$ at 0.6% (9.66 days) and followed by the treatment T_7 – $MgSO_4$ at 0.6% (7.91 days) whereas the minimum vase life was recorded in the treatment T_0 – Control (5.5 days). The increase in vase life of gerbera is due to the increase in number of leaves which increases increase in the dose of $ZnSO_4$ application which resulted in the formation of more carbohydrate reserve due to the increase photosynthesis which might have delayed the senescence of flowers by reducing the effect of ethylene and this can be the reason for increase in vase life of flower. Similar results were obtained by Pal et al*.* [9] in gerbera. Economics of different treatments in 200 square meter is illustrated in Table 3, where the treatment T_{11} – $ZnSO_4$ at 0.6% (142590) followed by treatment T_3 – $FeSO_4$ at 0.6% (121849) with net return of 55938 and 35286 respectively. These treatments exhibited maximum Benefit: Cost ratio of 1.64 and 1.407 respectively [18-23].

Table 1. Effect of foliar application of micronutrients on growth and floral parameters of gerbera

Treatments	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Plant spread (cm)	Days taken for first flower bud initiation (days)	Days taken for first harvest (days)	Number of flowers per plant
T_0- Control	22.65	8.5	27.58	39.01	101.75	132.5	5.33
T_1-$FeSO_4$@0.2%	24.47	11.08	30	42.5	97.08	126.91	5.83
T_2-$FeSO_4$@0.4%	25.5	10.83	30.5	43.29	96.25	126.33	5.91
T_3-$FeSO_4$@0.6%	26.05	12.25	32.25	46.06	91.75	122.33	7.83
T_4-$FeSO_4$-@0.8%	24.85	11	30.95	44.86	97.41	127.25	6.41
T_5-$MgSO_4$@0.2%	23.98	11.41	29.8	41.95	96.66	128.16	5.75
T_6- $MgSO_4$@0.4%	25.16	10.58	29.84	43.41	94.08	124.41	6.75
T_7- $MgSO_4$@0.6%	25.52	12	31.12	44.73	94.08	126.08	6.66
T_8 -$MgSO_4$@0.8%	24.14	11.08	31.2	41.9	95.58	126.33	6.91
T_9-$ZnSO_4$@0.2%	24.62	10.91	29.41	41.63	97.08	125.83	6.5
T_{10}- $ZnSO_4$@0.4%	24.94	12.08	32.08	43.025	94.25	124.16	7.08
T_{11}- $ZnSO_4$@0.6%	28.17	13.5	33.91	47.68	88.66	119.66	9.17
T_{12}- $ZnSO_4$@0.8%	25.35	10.83	30.18	43.2	96.33	125.5	6.83
F-Test	S	S	S	S	S	S	S
SE(d)	0.229	0.297	0.518	0.445	0.841	1.08	0.584
C. D (0.05)	0.473	0.613	1.07	0.918	1.736	2.22	1.206

Table 2. Effect of foliar application of micronutrients on floral parameters of gerbera

Treatments	Flower diameter (cm)	Stalk length (cm)	Stalk diameter (mm)	Number of flowers per 200 sq. m	Vase life (days)
T_0- Control	8.79	37.1	5.25	11851.84	5.5
T_1-$FeSO_4$@0.2%	9.81	39.62	5.5	12962.96	6.33
T_2-$FeSO_4$@0.4%	10.38	39.92	5.75	13148.146	6.66
T_3-$FeSO_4$@0.6%	10.52	40.95	5.75	17407.403	7.8
T_4-$FeSO_4$-@0.8%	10.17	39.75	5.66	14259.25	7.083
T_5-$MgSO_4$@0.2%	9.83	37.41	5.66	12777.77	6.416
T_6- $MgSO_4$@0.4%	9.72	39.33	5.5	14999.99	7.66
T_7- $MgSO_4$@0.6%	10.71	41.41	6.25	14814.81	7.91
T_8 -$MgSO_4$@0.8%	10.33	40.08	6	15370.36	7.25
T_9-$ZnSO_4$@0.2%	9.68	39.79	5.5	14444.44	7.33
T_{10}- $ZnSO_4$@0.4%	10.15	40.12	5.5	15740.736	7.41
T_{11}- $ZnSO_4$@0.6%	11.35	43.16	7.16	20370.366	9.66
T_{12}- $ZnSO_4$@0.8%	10.2	41.08	5.08	15185.143	7.41
F-Test	S	S	S	S	S
SE(d)	0.0801	0.3463	0.1424	1299	0.1875
C. D (0.05)	0.165	0.71483	0.294	2681.01	0.387

Table 3. Effect of foliar application of micronutrients on economics of different treatments of gerbera

Treatments	Gross return ($Rs/200m^2$)	Net return ($Rs/200m^2$)	Benefit cost ratio
T_0- Control	82985	-3245	0.96
T_1-$FeSO_4$@0.2%	90741	4399.89	1.05
T_2-$FeSO_4$@0.4%	92036	5472.67	1.06
T_3-$FeSO_4$@0.6%	121849	35285.67	1.407
T_4-$FeSO_4$-@0.8%	99813	13138.56	1.15
T_5-$MgSO_4$@0.2%	89446	3141.93	1.03
T_6- $MgSO_4$@0.4%	105000	17621.93	1.21
T_7- $MgSO_4$@0.6%	103705	17252.79	1.19
T_8 -$MgSO_4$@0.8%	107590	21063.72	1.24
T_9-$ZnSO_4$@0.2%	101108	14737.26	1.17
T_{10}- $ZnSO_4$@0.4%	110187	23675.52	1.27
T_{11}- $ZnSO_4$@0.6%	142590	55937.78	1.64
T_{12}- $ZnSO_4$@0.8%	106295	19502.04	1.22

4. CONCLUSION

From the present study, it is concluded that the foliar application of micronutrients, i.e., the treatment T_{11}- $ZnSO_4$ at 0.6% found to be superior among all the treatments in terms of growth and flowering like plant height, number of leaves per plant, leaves length, plant spread, days taken for first flower bud initiation, days taken for first harvest, flower diameter, stalk length, stalk diameter, number of flowers per plant, number of flowers per 200 m^2, vase life, gross return, net return and benefit cost ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/104877