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Influence of micronutrients on growth, flowering and yield of African marigold (*Tagetes erecta* L.)

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Abstract
The study investigated the influence of four selected micronutrients *viz.*, Zinc, Boron, Ferrous sulphate and Mangenese each at 0.5% and their combinations on the yield of African Marigold var. Pusa Narangi Gainda. The micronutrients and their combinations were applied as foliar spray in two different intervals (One at 20 days after transplanting and other at 40 days after transplanting) to African marigold in the experimental farm of the Adhiparasakthi Horticultural College, Kalavai, during 2017-19. The experiment was laid out in randomized block design with three replications. Regular cultural practices were adopted and observations such as plant height, number of branches, number of leaves, leaf area, days to first flowering, duration of flowering, number of flowers, flower head diameter, flower yield and xanthophyll content were recorded at regular intervals and statistically analyzed. Among the treatments, plants sprayed with Zinc @ 0.5% and Boron @ 0.5% twice recorded maximum plant height, more number of branches, maximum number of leaves, Maximum leaf area, earliness in flowering, more number of flowers, highest flower diameter, flower yield and maximum xanthophyll content.

Keywords: African marigold, micronutrients, zinc, boron, Feso4, Manganese

Introduction
Micronutrients though required in small quantities proven to be important as macronutrients for maximum growth, yield and quality in plants. In recent years, its importance has been significantly researched because in the past, these trace elements were naturally supplied by soil. However, in recent years due to intensive cultivation, increase in salinity and soil pH in most of soils, these nutrients are not available to plants. Hence it need to be supplemented through foliar application for good growth, increasing yield of crops and maximizing the efficient use of applied N, P and K. Moreover, absence of these micronutrients also causes physiological disorders physiological disorders which eventually lead to imbalanced growth and low yield.
Marigold (*Tagetes erecta*. L) is the most important traditional flower crop of India one of the commonly grown loose flowers. Recently due to presence of pigments, the commercial potential of the flower has been explored and in view of it, the crop has been gaining importance in cultivation. At present, there are large areas in Karnataka, Andhra Pradesh and Maharashtra where cultivation of marigold is done extensively for pigment extraction on contract basis.
With respect to cultivation aspects various fertilizer and micronutrient application methodologies were investigated. To state few, recently Sumita Pradhan and Mitra (2020) [10] found that application of $FeS0_4$, $MnS0_4$ and their combination produced maximum plant spread, number of branches, leaf area, fresh and dry matter accumulation, crop growth rate, number of flowers per plant, yield of flowers and carotene content in *Tagetes erecta* cv. Siracole. Similarly Patokar *et al.* (2017) [8] stated that foliar application of 0.5% Zinc recorded significantly maximum vegetative growth in respect of plant height, spread, yield in respect of number of flowers plant and flower yield, quality in respect of flower diameter, weight of flower and longevity of intact flower and the earliest first flower bud initiation in African marigold 'F1 Hybrid Yellow'. The above investigations has shown the importance of micronutrients in yield of marigold and considering this, an investigation has been planned find out the influence of micronutrients on growth, flowering and yield of African marigold.

Materials and Methods
In the present investigation four different micro nutrients *viz.*, Zinc (@ 0.5%, Boron (@ 0.5%, Ferrous sulphate (@ 5%) and Mangenese (@ 0.5%, and their combinations were chosen based on the previous reports and eleven different treatements were planned. The treatment details were provided in Table 1. African Marigold var. Pusa Narangi Gainda were chosen for the

study and the plants were raised in the Experimental farm of the Adhiparasakthi Horticultural college, Kalavai, during 2017-19.

The micronutrients were applied singly and in combinations as foliar spray in two different intervals (One at 20 days after transplanting and other at 40 days after transplanting). The experiment was laid out in randomized block design with three replications. Regular cultural practices were adopted to raise the crop successfully. Observations on plant height, number of branches, number of leaves, leaf area, days to first flowering, duration of flowering, number of flowers, flower head diameter, flower yield and xanthophyll content were recorded and statistically analyzed and critical difference were worked out.

Results and Discussion

The present investigation was planned systematically to determine the significance of micronutrients in the growth of African Marigold. The results of the treatments were presented in Table 1. Significant variations were noticed among the eleven treatments investigated. Maximum plant height (109.30 cm) was recorded under the treatment T_6 (Zinc @ 0.5% + Boron @ 0.5%). This is followed by the treatment T_5 (Zinc @ 0.5% + FeSo4 @ 5%) which recorded a plant height of 108.32 cm. However, the minimum plant height (101.12 cm) was noticed under the treatment T_{11} (Control). Maximum number of branches (18.31) was recorded under the treatment T_6 (Zinc @ 0.5% + Boron @ 0.5%) and the minimum number of branches (15.31) were noticed under T_{11} (Control). Maximum number of leaves (134.21) and highest leaf area (130.33 cm^2) were recorded under treatment T_6 (Zinc @ 0.5% + Boron @ 0.5%) respectively. The lowest number of leaves (120.94) and minimal leaf area (110.49 cm^2) was recorded under control (T_{11}). The increased values obtained under the treatment T_6 may be due to the application of micronutrient, Zn as it encourages, cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the plant height and is also improved root system of plants resulting in absorption of more water and nutrients and its utilization. Moreover, micronutrients activate several enzymes (catalase, carbonic dehydrogenize, tryptophan synthates etc.) and involved various physiological activities. Similar results were also obtained by Kakade *et al*. (2009) [5] in China aster, Balakrishnan (2005) [2] in marigold and Ahmad *et al*. (2010) [1] in Rose.

The plants sprayed with Zinc @ 0.5% + Boron @ 0.5% showed earliness in flowering (56.34 days) which is closely followed by those plants sprayed with T_5 (Zinc @ 0.5% + FeSo4 @ 5%) with 57.80 days. Micronutrients like Zinc, favour to storage of more carbohydrates through photosynthesis, which will help in early flowering . The result indicated that 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 might be enhanced the flowering mechanism. Similar results were also obtained by Bashir *et al*. (2013) [3] and Pal. *et al*. (2016) [7] in Gerbera.

The data pertaining to the flowering character showed significant variations among the micronutrient treatments. Maximum number of flowers (60.12) was noticed under the treatment T_6 (Zinc @ 0.5% + Boron @ 0.5%) which is closely followed by T_5 (Zinc @ 0.5% + FeSo4 @ 5%) with 58.97 flowers. However, minimum number of flowers (50.33) were recorded under T_{11} (Control). The data on flower diameter recorded maximum values (6.83 cm) in the treatment T_6 (Zinc @ 0.5% + Boron @ 0.5%) which is followed by the treatment T_5 (Zinc @ 0.5% + FeSo4 @ 5%) with 6.70 cm and the lowest flower diameter (5.63 cm) was observed under T_{11} (Control). Application of Zinc relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production, flower size and ultimately flower yield. Similar results were also obtained by Nath and Biswas (2002) in tuberose and Pal *et al*. (2016) [7] in Gerbera. Maximum flower yield (428.05 g/plant) was recorded under the treatment T_6 (Zinc @ 0.5% + Boron @ 0.5%) which is followed by T_5 (Zinc @ 0.5% + FeSo4 @ 5%) with 404.53 g/plant. However, minimum number of flowers (250.64) were recorded under T_{11} (Control). The increased yield of flowers might be due to the application of Zinc and Boron which 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. Similar results were also reported by Nag and Biswas (2003) [6] and Hardeep Kumar *et al*. (2003) in tuberose.

Maximum xanthophyll content (18.93 g kg-1 petal meal) was obtained from those plants sprayed with Zinc @ 0.5% + Boron @ 0.5%. This is followed by T_5 (Zinc @ 0.5% + FeSo4 @ 5%) with 18.61 g kg-1 petal meal. However, minimum xanthophyll content (16.01 g kg-1 petal meal) were recorded under T_{11} (Control). Better quality flowers of marigold were produced due to application of 0.5% Zinc which might be due to enhanced vegetative growth resulted into production of more food material which in turn might have been utilized for better development of flowers. The results are in close conformity with the findings of Shah *et al*. (2016) [9] in marigold.

Table 1: Influence of micronutrients on growth, flowering and yield of African marigold (*Tagetes erecta* L.)

T.no	Treatment details	Plant height (cm)	Number of branches	Number of leaves	Leaf area cm ^{2}	Days to first flower initiation	Number of flowers per plant	Flower diameter (cm)	Single flower weight (g)	Flower yield per plant (g/plant)	Xanthophyll content (g kg^{-1}) petal meal
T1	Zinc @ 0.5%	104.21	16.80	126.29	120.11	61.95	54.02	6.09	5.74	310.07	17.16
T2	FeSo4 @ 5%	102.49	16.21	123.60	116.35	65.18	51.77	5.87	5.26	272.31	16.55
T3	Boran @ 0.5%	103.25	16.21	124.82	118.23	63.63	52.86	5.95	5.50	290.73	16.83
T4	Manganese @ 0.5%	101.84	15.95	122.28	114.36	67.06	50.77	5.75	5.02	254.86	16.31
T5	Zinc @ 0.5% + FeSo4 @ 5%	108.32	18.03	132.86	128.34	57.80	58.97	6.70	6.86	404.53	18.61
T6	Zinc @ 0.5% + Boran @ 0.5%	109.30	18.31	134.21	130.33`	56.34	60.12	6.83	7.12	428.05	18.93
T7	Zinc @ 0.5% + Manganese @ 0.5%	105.16	17.11	127.97	121.98	60.50	55.17	6.23	5.99	330.46	17.49
T8	FeSo4 @ 5% + Boran @ 0.5%	107.35	17.77	131.48	126.35	59.23	57.82	6.57	6.62	382.76	18.28

T9	FeSo4 @ 5% + Manganese @ 0.5%	107.12	17.69	130.83	125.70	59.56	57.47	6.49	6.51	374.13	18.13
T10	Boran@ 0.5% + Manganese @ 0.5%	106.14	17.40	129.36	123.83	59.07	56.32	6.36	6.26	352.56	17.81
T11	Control	101.12	15.31	120.94	110.49	68.71	50.33	5.63	4.98	250.64	16.01
	S.Ed.	0.48	0.15	0.64	0.86	0.68	0.52	0.05	0.12	5.69	0.15
	CD(p=0.05)	0.96	0.31	1.30	1.73	1.37	1.04	0.12	0.24	11.45	0.31

Conclusion

The results of the experiment had clearly bought out the importance of micronutrients in African Marigold cultivation. Among the treatmetns foliar application of Zinc @ 0.5% + Boron @ 0.5% at two different intervals 20 and 40 days after transplanting showed better growth, flowering and xanthophyll content in African Marigold var. Pusa Narangi Gainda. Thus the micronutrient has positive influence on African marigold growth attributes and xanthophyll content compared to control which could be adopted by farmers.

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