

RESEARCH ARTICLE

Effect of Micronutrients and Plant Growth Regulators on Growth, Flowering and Yield Attributes of Marigold (*Tagetes erecta* L.)

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ABSTRACT

	An experiment was conducted at the Horticultural College and Research Institute for Women Tiruchirappalli, Tamil Nadu Agricultural University and Coimbatore during 2017-2018 to study the effect of micronutrients and plant growth regulators on growth, flower yield, pigment content and keeping quality of marigold (<i>Tagetes erecta</i> L). The experiment was laid out in a Randomized Block Design (RBD) with three replications and 16 treatments. The study revealed that application of micronutrients mixture
Received: 16 th August, 2018	+ $GA_{3}100$ ppm (T_{2}) showed the highest plant height (86.08 cm), the highest
Revised : 20 th November, 2018	internodal length (6.73 cm) and a maximum number of branches (15.97)
Accepted : 20 th November, 2018	at 90 days after transplanting over the absolute control. Among the floral parameters, the earliest days to first flower bud appearance (51.61 days), days to first flowering (66.95 days), the longest duration of flowering (50.50 days), crop duration (144.40 days), maximum number of flowers per plant (69.19), the highest flower diameter (7.00 cm), flower weight (15.19 g), flower stalk length (8.94 cm), flower stalk girth (5.30 mm) as well as highest flower yield per plant (439.33 g) and longest shelf life of flower (6.49 days) were recorded with treatment T_2 -micronutrients mixture + GA ₃ 100 ppm over the absolute control.

Keywords: Marigold, Flowering attributes, Yield, Micronutrients, Plant growth regulators

INTRODUCTION

Marigold (Tagetes erecta L.) one of the important commercial flower crops in India belong to the family compositae. It is very popular due to the easy grown and wider adoptability. It is mostly grown for the loose flower as well as a cut flower for making garland and garden display. Tagetes species vary in size from 1.0 -2.2 m tall and floral heads are 4-6 cm in diameter. Most species have pinnate green leaves. The globular shaped flower with long stalk length is used for cut flower purpose. Nowadays the use of growth regulators plays an important role in flower production, which in small amount promotes quantitatively, modifies growth and development. Flowers are expensively used for in religious and social functions in a different form. Because of their wide adoptability to varying soil and climatic conditions long duration of flowering and attractively coloured flowers of excellent keeping quality.

Growth regulators are used in plant small quantity enhanced plant physiological process greatly which may help greatly increase the yield and quality. Gibberellic acid increased to be very effect in manipulating growth and flowering in marigold (Kumar *et al.*, 2014). Ethrel retards plant height, a

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number of nodes and internodal length increasing branching and delayed flowering (Sachs, 1961). Commercially plant growth regulators are used for suppressing apical dominance retarding vegetative growth, lateral buds induction and production of a large number of flowers in various crops resulting in higher flower yield and easy cultivation (Naidu et al. 2014). Similarly micronutrients in small quantities influence the growth, floweringthe, as well as the quality of produce in flower crops among the micronutrients zinc, favours the storage of more carbohydrates through photosynthesis which may be the attributing factor for plants as well as early flowering. Marigold crop responds well to micronutrients and mainly to zinc. Zinc is involved in the biosynthesis of plant and reduces auxin content through its involvement in the synthesis of tryptophan a precursor of auxin and marigold absorb zinc in ionic form (Kumar et al., 2010 and Balakrishnan et al., 2007). Boron has primarily involved in a structural role, especially in cell walls. Boron deficiencies also influence cellulose synthesis. It causes a change in the growth of the cells and tissue including a shift in the orientation of a cell division, inhibition of cell growth and altered tissue growth.

MATERIAL AND METHODS

A field experiment was conducted at the farm of Horticultural College and Research Institute for (Women) Tiruchirappalli during 2017-18. The experiment was laid out in a Randomized Block Design with three replications. The experiment comprised of 16 treatments viz., T₀-Absolute control, T₁-Micronutrients mixture + GA₃ 50 ppm, T_2 -Micronutrients mixture + GA_3 100 ppm, T_3 -Micronutrients mixture + NAA 25 ppm, T_4 -Micronutrients mixture + NAA 50 ppm, T_5 -Micronutrient mixture + Kinetin 20 ppm, T₆-Micronutrients mixture + Kinetin 40 ppm,T₇-Micronutrients mixture + Ethrel 100 ppm, T₈-Micronutrients mixture + Ethrel 200 ppm,T_a-Micronutrients mixture + MH 100 ppm, +MH200ppm,T₁₁-T₁₀-Micronutrientsmixture Micronutrients mixture + CCC 250 ppm, T_{12} -Micronutrients mixture + CCC 500 ppm, T_{13} -Micronutrients mixture + Mepiquat chloride 100 ppm,T₁₄-Micronutrients mixture + Mepiquat chloride 200 ppm, T₁₅-Micronutrients mixture alone (ZnSO₄ 0.2 % + H_3BO_3 0.2% + $CuSO_0.2\%$). The transplanting was done at spacing of 60 x 45 cm distance and having a plot size 9.00 m².The recommended dose of manures and fertilizers were applied in the experimental field. The field was irrigated before transplanting. Thirty days old seedlings of African marigold were transplanted in the experimental plots in the evening hours. Immediately after transplanting the field was lightly irrigated for better establishment of the seedlings. The imposing of treatments were done at 30 days after transplanting. The vegetative attributes such as plant height, internodal length, number of branches and flowering attributes include days to first flower bud appearance, days to first flowering, duration of flowering, number of flowers per plant, flower diameter, flower weight, flower stalk length, flower stalk girth, flower yield per plant, flower yield per plot, crop duration and shelf life of flower was recorded in five selected plant per replication in each treatment. The data pertaining to various parameters were subjected to statistical analysis following the method of analysis of variance for randomized block design as per Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Performance of vegetative growth, flowering and yield attributes of African marigold cv. Coimbatore Orange Local are given in table 1.

Plants treated with treatment T₂-Micronutrients mixture + GA_3 100 ppm showed highest plant height (86.08 cm) followed by treatment T_{11} -Micronutrients mixture +CCC 250 ppm (78.96 cm).

The treatment T_o-absolute control recorded the lowest height of 58.83 cm at 90 DAT. This might be due to gibberellins enhanced cell division, cell enlargement, promotion protein synthesis with higher apical dominance by GA which might have resulted in enhanced vegetative growth. Similar was resulted by Bindu (2010), Shivaprakash, et al., (2011), Kanwar and Khandelwal (2013) in marigold. Zinc plays a vital role in the active synthesis of tryptophan which is a precursor of IAA. Nag et al., (2003) reported increased plant height due to the application of zinc.

The internodal length significantly differed among the treatments. The treatment T₂-Micronutrients mixture + GA₃ 100 ppm recorded highest internodal length (6.73 cm) followed by T₁₁- Micronutrients mixture + CCC 250 ppm (5.87 cm) which was on par with treatmentT₁-Micronutrients mixture + GA₃ 50 ppm (5.69 cm). The lowest internodal length was recorded in the treatment T_0 - absolute control (4.09 cm) at 90 DAT. The reason for the increase in internodal length might be due to cell elongation and rapid cell stimulation which has been reported Tyagi and Vijay Kumar (2006) in African marigold.

Among the 16 treatments, the higher number of branches (15.97) was recorded in the treatment T₂-Micronutrients mixture + GA₃100 ppm followed by T_{11} -Micronutrients mixture + CCC 250 ppm (13.08). The treatment T_{11} is statistically on par with T_{1} -Micronutrients mixture + GA_3 50 ppm(12.44) The lowest number of branches was recorded in the treatment T_o-absolute control (8.08). The number of branches per plant got increased with successive increasing concentration of GA₂. Significant increase in a number of branches per plant might be because of more vegetative growth especially the height of the plant due to the application of optimum GA, inducing more lateral branches. This has been already reported by Sunitha et al., 2007 and Putra et al., (2009) in African marigold.

Among all the treatments, the treatment T_{a} -Micronutrients mixture + GA_3 100 ppm (51.16 days) recorded the earliest flower bud appearance with minimum days for first flower bud appearance followed byT₄-Micronutrients mixture + GA₂ 50 ppm (53.47 days). The longer days for first flower bud appearances were recorded in the treatment T_oabsolute control with 65.09 days. Early flower bud appearance with the application of GA₃ might be due to the early production of florigen in GA₃ treated plants, as GA₃ is a component of florigen which is mainly involved in flower initiation in the plant system. Similar findings were also reported by many scientists in African marigold (Sunitha et al., 2007, Palei et al., 2016, Pragnyashree Mishra, 2017).

Among the treatments, the treatment T_{2} -

Micronutrients mixture + GA_3 100 ppm was the earliest (66.95 days) for first flowering followed byT₁-Micronutrients mixture + GA_3 50 ppm (70.87 days) while the longest days for first flowering was recorded by the treatment T₀-absolute control (82.32 days). The reason for earlier anthesis with the application

of GA_3 may be the ability of gibberellins to modify the photoperiodic requirements of plants which is essential for flower anthesis. Similar results noted by Himabindu (2010), Kumar *et al.*, (2015) and Mithilesh Kumar *et al.*, (2014) in African marigold.

Table 1. Effect of micronutrients and plant growth regulators on vegetative growth, f	lowering a	nd yield
attributes of African marigold cv. Coimbatore Orange Local		

Treatments	Plant height (cm)	Internodal length (cm)	Number of branches	Days to first flower bud Appearance (Days)	Days to first Flowering (Days)	Duration of flowering (Days)	Number of flowers per plant	Flower Diameter (cm)	Flower weight (g)	Flower yield per plant (g)	Flower yield per plot (kg)	Flower stalk length (cm)	Flower stalk girth (mm)	Crop Duration (Days)	Shelf life of flower (Days)
T _o	58.83	4.09	8.08	65.09	82.32	28.51	45.35	4.99	7.30	265.80	1.05	6.75	3.41	124.52	3.31
T ₁	75.32	5.69	12.44	53.47	70.87	42.18	58.00	6.20	10.48	362.67	1.43	7.53	4.56	132.00	4.17
T ₂	86.08	6.73	15.97	51.16	66.95	50.50	69.19	7.00	15.19	439.33	1.74	8.94	5.30	144.40	6.49
T ₃	73.33	5.06	11.54	55.15	75.27	34.33	56.67	5.73	11.21	321.20	1.23	7.44	4.17	127.62	5.01
T ₄	71.67	5.08	12.08	54.88	74.85	35.67	52.67	6.24	10.97	315.20	1.30	7.54	4.26	131.85	4.20
Т ₅	70.71	5.03	10.99	58.51	76.47	36.00	54.88	6.17	11.71	329.30	1.31	7.43	4.80	128.91	4.19
T ₆	70.02	5.01	10.92	56.82	74.41	35.30	52.32	5.60	10.01	320.60	1.27	7.47	4.21	126.19	4.26
Τ,	72.70	5.07	11.32	60.26	77.43	37.33	56.00	5.62	11.35	315.73	1.24	7.82	4.29	125.91	4.21
T ₈	69.85	5.08	10.74	61.78	78.02	39.67	58.33	5.97	10.70	356.85	1.41	7.45	4.06	130.02	4.24
T ₉	74.00	5.09	10.83	60.96	76.65	34.97	60.00	5.67	10.20	351.67	1.39	7.51	4.09	129.61	4.25
T ₁₀	72.23	5.10	11.00	58.04	78.16	35.98	51.99	5.83	10.75	345.19	1.36	7.39	4.00	127.09	5.25
T ₁₁	78.96	5.87	13.08	56.53	75.78	43.65	63.60	6.60	13.32	398.00	1.57	8.20	5.04	138.12	5.09
T ₁₂	73.17	5.04	11.18	59.23	77.10	33.99	59.00	5.69	11.26	325.92	1.29	7.46	3.64	128.00	4.27
T ₁₃	69.78	5.05	10.96	55.90	74.60	34.00	57.00	6.08	10.41	345.04	1.36	7.42	3.68	126.71	4.34
T ₁₄	68.87	5.12	10.97	57.94	76.27	36.98	56.67	5.48	11.45	358.46	1.42	7.50	3.89	128.14	4.18
T ₁₅	67.67	4.67	9.04	62.91	80.74	31.00	50.98	5.40	8.32	311.91	1.25	7.38	3.57	125.78	4.15
SEd	3.48	0.33	1.11	0.88	1.51	2.61	2.30	0.13	0.83	19.18	0.13	0.30	0.23	3.12	0.42
CD (p=0.05)	7.12	0.68	2.27	1.79	3.09	5.33	4.74	0.27	1.69	39.17	0.36	0.63	0.47	6.14	0.85

The flowering duration ranged from 50.50 days to 28.51 days (Table 1). Among the different treatments, the treatment T_2 -Micronutrients mixture + GA_3 100 ppm recorded the longest flowering duration of 50.50 days followed by T_{11} -Micronutrients mixture + CCC 250 ppm (43.65 days). The shortest flowering duration was recorded in the treatment T_0 -absolute control (28.51 days).

Increase in duration of flowering might be due to advanced bud formation and stimulating flowering in GA_3 treated plants. Increased bloom duration may be due to the availability of GA_3 under treatments as a result flowering period might have significantly increased. Similar results were noted by Mithilesh Kumar *et al.*, (2014), Kumar *et al.*, (2015), and Pragnyashree Mishra (2017) in African marigold.

Among the treatments, the longest flower stalk length of 8.94 cm was observed in the treatmentT₂-Micronutrients mixture + GA₃100 ppm followed by T₁₁-Micronutrients mixture + CCC 250 ppm (8.20 cm) while, the shortest flower stalk length was

recorded in the treatment T_0 -absolute control (6.75 cm). Significant increase in the length of flower stalk may be due to the effect of gibberellins to promote cell division and elongation in the flower bud region coupled with ample quantities of carbohydrates translocated in the developing flowers. A similar result was noted by Pragnyashree Mishra (2017), Dalal *et al.*, (2009), Tyagi and Kumar (2006) noted the longest flower stalk length due to GA₃ treatment in African marigold.

Among the 16 treatments, the treatmentT₂-Micronutrients mixture + GA₃100 ppm exhibited the highest flower stalk girth of 5.30 mm followed by T₁₁- Micronutrients mixture + CCC 250 ppm with 5.04 mm. The flower stalk girth was lowest in the treatment T₀ - absolute control with 3.41mm. This might due to the enhancement of cell division and cell elongation by GA₃ resulted in increased flower stalk girth.

The treatment T_{2} - Micronutrients mixture + GA₂100 ppm recorded the highest flower diameter

of 7.00 cm followed by T_{11} -Micronutrients mixture + CCC 250 ppm (6.60 cm). The lowest flower diameter (4.99 cm) was recorded in the treatment T_0 -absolute control. Increased bloom duration may be due to the availability of GA_3 under treatments as a result flowering period might have significantly increased. Similar findings were also reported by many researchers in African marigold cv. Pusa Narangi Gainda, (Tyagi and Kumar 2006 and Ramesh kumar et al., 2010).

The number of flowers per plant varied significantly among the treatments. Among the 16 treatments, the treatment T_2 -Micronutrients mixture + GA_3 100 ppm recorded the highest number of flowers per plant (69.19) followed by T_{11} -Micronutrients mixture + CCC 250 ppm (63.60) The lowest number of flowers was recorded in the treatment T_0 -absolute control (45.35). The reason for more number of flowers might be due to more number of branches. As the apical dominance of the plant was suppressed it allowed the lateral branches to grow resulting in an increased number of flowers per plant. This finding is in accordance with Tyagi and Kumar (2006) and Ramesh kumar *et al.*, (2010).

The increments in flower diameter might be due to the association of zinc in regulating semipermeability of cell walls, thus mobilizing more water into flowers and increasing the size of the flowers. Among the treatments, the higher flower weight of 15.19 g was recorded in the treatmentT₂-Micronutrients mixture + GA₃100 ppm followed by T₁₁-Micronutrients mixture + CCC 250 ppm (13.32 g). The lowest flower weight (7.30 g) was recorded in TO- absolute control.

The increase in fresh weight of flowers per plant with GA3 might be due to the production of more number of flowers and bigger sized flowers. This might be attributed to rapid synthesis in the cell, increase in cell size, cell elongation and rapid translocation of assimilates to sink under the influence of phytohormones. Similar results were reported by Mithilesh Kumar *et al.*, (2014), Palei *et al.*, (2016) and Pragnyashree Mishra (2017) in African marigold cv. Pusa Narangi Gainda.

Among the 16 treatments, the higher flower yield per plant was observed in the treatment T_2 -Micronutrients mixture + GA₃ 100 ppm (439.33g) followed by T_{11} -Micronutrients mixture + CCC 250 ppm with 398.00 g and T_1 -Micronutrients mixture + GA₃ 50 ppm 362.67 g. The lowest flower yield per plant (265.80 g) was recorded in the treatment T_0 -absolute control. The increase in yield with GA₃ spray may be due to better crop growth and more number of flowers per plant and maximum fresh weight per flowers thus increased the flower yield plant. The

result was findings Tripathi *et. al.*, (2003) reported that spraying GA_3 100,200,300 ppm on French marigold increased flower yield per plant with a successive increase in concentrations. Balakrishnan *et al.*, (2007) reported that application of nutrients at different level leads to a rapid increase in cell size which is reflected in flower size and simultaneously on the flower weight in African marigold.

Among the 16 treatments, the treatment T₂-Micronutrients mixture + GA₃100 ppm recorded the highest flower yield per plot of 1.74 kg followed by T₁₁-Micronutrients mixture + CCC 250 ppm (1.57 kg) and T_1 -Micronutrients mixture + GA_3 50 ppm (1.43 kg). The lowest flower yield per plot (1.05 kg) was registered in the treatment T_o- absolute control. This might be due to the longer duration of crop enhances the flower yield by increasing the number of harvests per plant and also more number of flowers per plant. The increase in flower yield might be due to the fact that increased amount of micronutrients level in leaves helped the plants to produce a higher number of flowers by involving in the photosynthesis, breakdown of IAA, Auxin and protein synthesis (Muthumanikam et al., 1999).

The mean value for crop duration ranged from 144.40 days to 124.52 days. Among the 16 treatments, the treatmentT₂- Micronutrients mixture + GA₃100 ppm recorded the longest crop durationof144.40 days followed by T₁₁- Micronutrients mixture + CCC 250 ppm (138.12 days). The lowest crop duration was recorded in the treatment T₀- absolute control (124.52 days). This might due to vegetative growth and cell division, cell enlargement, promotion of protein synthesis with higher apical dominance and optimum concentration of GA₃helps to increase crop duration.

Among the 16 treatments, the treatment T_{2} -Micronutrients mixture + GA₃100 ppm recorded the maximum shelf life of flower (6.49 days) followed by T₁₀-Micronutrients mixture + MH 200 ppm with 5.25 days which was on par with the treatment T₁₁-Micronutrients mixture + CCC 250 ppm (5.09 days) and T₃-Micronutrients mixture + NAA 25 ppm (5.01 days). The minimum shelf life of flower (3.31days) was recorded in the treatment T_o- absolute control. Increased quality of flowers might be caused by drawing of photosynthetes to flower as a consequence of the intensification of the sink which also increased cell division and cell elongation of GA₃ which might have been utilized for the production of quality flowers in African marigold. This result is in close agreement with the findings of Tyagi et al. (2006) and Ramdevputra et al. (2009).

CONCLUSION

On the basis of the result obtained from the present investigation, it can be concluded that foliar

application of micronutrients mixture + GA_3 100 ppm (T_2) one month after transplanting was found most effective with respect to vegetative growth, flowering and yield attributes of African marigold (*Tagetes erecta* L.) cv. Coimbatore Orange Local. This can be used to maximize the return from African marigold cultivation.

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