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Short Communication

Effect of Micronutrients and Plant Growth Regulators on Physiological and Biochemical Attributes of Marigold (*Tagetes erecta* L.)

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Marigold (*Tagetes erecta* L.) important commercial flower crops in India belong to family compositae. It is very popular due to easy grown and wider adoptability. It is mostly grown for loose flower as well as 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 used for cut flower purpose [1]. Now days 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 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 increasing the yield and quality [2]. Gibberellic acid increased to be very effect in manipulating growth and flowering in marigold [3]. Ethrel retards plant height, number of nodes and internodal length, increasing branching and delayed flowering [4]. Commercially plant growth regulators are used for suppressing apical dominance retarding vegetative growth, lateral buds induction and production of large number of flowers in various crops resulting in higher flower yield and easy cultivation [5].

Similarly, micronutrients in small quantities influence the growth, flowering as well as 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 respond well to micronutrients and mainly to zinc. Zinc is involved in biosynthesis of plant and reduces auxin content through its involvement in synthesis of tryptophan a precursor of auxin and marigold absorb zinc in ionic form [6]. Boron has primarily involved in structural role especially in cell walls [7]. Boron deficiencies also influence cellulose synthesis. It causes change in growth of the cells and tissue including a shift in orientation of a cell division, inhibition of cell growth and altered tissue growth.

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 with 16 treatments viz. T_0- Absolute control, T_1- Micronutrients mixture + GA_3 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, T_6- Micronutrients mixture + Kinetin 40 ppm, T_7- Micronutrients mixture + Ethrel 100 ppm, T_8- Micronutrients mixture + Ethrel 200 ppm, T_9- Micronutrients mixture + MH 100 ppm, T_{10}- Micronutrients mixture + MH 200 ppm, T_{11}- Micronutrients mixture + CCC 250 ppm, T_{12}- Micronutrients mixture + CCC 500 ppm, T_{13}- Micronutrients mixture + Mepiquat chloride 100 ppm, T_{14}- Micronutrients mixture + Mepiquat chloride 200 ppm, T_{15}- Micronutrients mixture alone ($ZnSO_4$ 0.2% + H_3BO_3 0.2% + $CuSO_4$0.2%). The transplanting was done at spacing of 60 × 45 cm distance and having a plot size 9.00 m^2. The recommended dose of manures and fertilizers was applied in 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 was done at 30 days after transplanting. The vegetative attributes such as plant height, internodal length, number of branches and flowering attributes includes days to first flower bud appearance, days to firs12t 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 [8].

Total chlorophyll content

Total chlorophyll content varied significantly among the treatments (Table 1). The mean value for total chlorophyll content ranged from 2.98 mg/g to 1.29 mg/g. Among all the

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treatments, the treatments T_2- Micronutrients mixture + $GA_3$100 ppm recorded higher total chlorophyll content of 2.98 mg/g followed by T_1- Micronutrients mixture + GA_3 50ppm (2.69 mg/g) which was on par with treatment, T_8- Micronutrients mixture + ethrel 200 ppm (2.66 mg/g). The lowest chlorophyll content of 1.29 mg/g was recorded in the treatment, T_0- absolute control [9].

Potassium and sodium content in leaves

Data on potassium and sodium content of leaves are presented in (Table 1). The observations recorded on potassium content in leaves are non-significant [10]. The mean value for sodium content ranged between 1.95 per cent to 0.55%. Among all the 16 treatments, T_2- Micronutrients mixture + $GA_3$100 ppm recorded the highest sodium content of 1.95 per cent followed by T_1- Micronutrients mixture + GA_3 50 ppm (1.920%). The lowest sodium content (0.55%) was recorded in the treatment T_0- absolute control.

Proline content

The data for proline content are presented in (Table 1). The mean value for proline content ranged from 294.20 µg/g to182.66 µg/g [11]. Among the 16 treatments, T_2- Micronutrients mixture + $GA_3$100 ppm recorded the highest proline content of 294.20 µg/g followed byT_{11}- Micronutrient mixture + CCC 250 ppm 265.80 µg/g. The lowest proline content (182.66 µg/g) was recorded in the treatment T_0- absolute control.

Table 1 Effect of micronutrients and plant growth regulators on physiological and biochemical attributes of African marigold cv. Coimbatore Orange Local

Treatments	Chl 'a'	Chl 'b'	Total chlorophyll (mg/g)	Na (%)	K (%)	Proline content (□g/g)	Nitrate Reductase Activity (□g/NO_2 g^{-1} hr^{-1})	Catalase activity (Δ OD/min/µg protein)	Peroxidase activity (Δ OD/min/g protein)	Total xanthophyll content (mg/g)	Total carotenoid content (mg/g)
T_0	1.00	0.29	1.29	0.55	2.15	182.66	249.27	5.54	69.62	1.30	1.27
T_1	1.61	1.07	2.69	1.92	2.05	239.02	361.04	7.05	82.02	1.73	1.52
T_2	1.99	0.99	2.98	1.95	2.40	294.20	428.50	9.64	85.45	1.91	1.56
T_3	1.26	0.55	1.81	0.75	2.25	227.14	318.02	7.08	78.46	1.69	1.47
T_4	1.21	0.75	1.97	0.75	2.31	221.59	322.60	7.50	77.23	1.66	1.38
T_5	1.72	0.80	2.52	0.75	2.26	219.28	325.16	7.56	76.42	1.63	1.34
T_6	1.50	0.88	2.38	0.82	2.19	224.17	320.59	7.48	80.06	1.64	1.44
T_7	1.49	0.77	2.26	1.08	2.23	225.31	328.67	7.22	81.10	1.61	1.35
T_8	1.84	0.82	2.66	1.02	2.28	220.97	335.31	7.42	79.80	1.56	1.37
T_9	1.66	0.69	2.34	0.83	2.19	229.27	330.42	7.36	79.01	1.58	1.39
T_{10}	1.59	0.49	2.07	0.80	2.22	230.49	345.29	7.49	75.02	1.53	1.46
T_{11}	1.66	0.54	2.20	1.05	2.27	265.80	394.26	8.60	83.25	1.76	1.49
T_{12}	1.24	0.80	1.92	0.95	2.34	228.30	340.18	6.96	74.05	1.60	1.41
T_{13}	1.19	0.73	1.92	0.78	2.37	237.05	334.90	6.78	78.42	1.50	1.45
T_{14}	1.72	0.78	2.49	0.76	2.33	220.54	320.10	7.19	77.02	1.59	1.42
T_{15}	1.10	0.47	1.57	0.75	2.35	210.23	283.41	6.5	72.04	1.45	1.32
SEd	0.10	0.11	0.15	0.09	NS	13.49	16.27	0.48	1.06	0.07	0.01
CD (p=0.05)	0.21**	0.23**	0.31**	0.19**		27.57**	33.22**	0.99**	2.1**	0.14**	0.03**

Nitrate reductase activity

The data for Nitrate Reductase activity are presented in (Table 1). The mean value ranged from 428.50 µg/NO_2 $g^{-1}hr^{-1}$ to 249.27µg/NO_2 $g^{-1}hr^{-1}$ [12]. All the treatments statistically differed with respect to Nitrate Reductase activity. The treatment T_2-Micronutrients mixture + $GA_3$100 ppm recorded higher Nitrate Reductase activity (428.50 µg/NO_2 $g^{-1}hr^{-1}$) followed by T_{11}-Micronutrients mixture + CCC 250 ppm (394.26 µg/NO_2 $g^{-1}hr^{-1}$). The lowest Nitrate Reductase activity (249.27µg/NO_2 $g^{-1}hr^{-1}$) was recorded in the treatment T_0- absolute control [13].

Catalase activity

The mean value for this trait ranged from 9.64ΔOD/min/µg protein to 5.54Δ OD/min/µg protein. The data on catalase activity are presented in (Table 1). Among all the treatments the treatment T_2- Micronutrients mixture + $GA_3$100 ppm recorded higher catalase activity (9.64 Δ OD/min/µg protein) followed by T_{11}- Micronutrients mixture + CCC 250 ppm (8.60 Δ OD/min/µgprotein). The lower catalase activity was recorded in the treatment, T_0- absolute control (5.54Δ OD/min/µgprotein) [14].

Peroxidase activity

The data on peroxidase activity are presented in (Table 1). The mean value for this trait ranged from 85.45ΔOD/min/µgprotein to 69.62 ΔOD/min/µg protein [15].

Among the 16 treatments, the treatment T_2- Micronutrients mixture + $GA_3$100 ppm recorded higher peroxidase activity (85.45ΔOD/min/µgprotein) followed by, T_{11}- Micronutrients mixture + CCC 250 ppm (83.25 ΔOD/min/µg protein) which was on par with treatment, T_1-

Micronutrients mixture + GA_3 50 ppm (82.02 ΔOD/min/µg protein). The lowest peroxidase activity was recorded in the treatment, T_0- absolute control (69.62 ΔOD/min/µg protein).

Biochemical parameters

Total xanthophyll content

Significant differences in total xanthophyll content was observed among the treatments. The xanthophyll content ranged from 1.91 mg/g to 1.30 mg/g (Table 1). The treatment T_2- Micronutrients mixture + $GA_3$100 ppm recorded higher xanthophyll content of 1.91 mg/g followed by T_{11}- Micronutrients mixture + CCC 250 ppm (1.76 mg/g) while the lowest xanthophyll content was registered by the treatment T_0- absolute control (1.30 mg/g) [16].

Total carotenoid content

Significant differences in total carotenoid content of flowers were observed among the treatments. The carotenoid content ranged from 1.56 mg/g to 1.27 mg/g (Table 1). The treatment, T_2- Micronutrients mixture + $GA_3$100 ppm recorded the highest carotenoid content of 1.56 mg/g followed by, T_1- Micronutrients mixture + GA_3 50 ppm 1.52 mg/g which was on par with treatment, T_{11}- Micronutrients mixture + CCC 250 ppm 1.49 mg/g. The lowest carotenoid content of 1.27 mg/g was recorded in the treatment, T_0- absolute control [17].

SUMMARY

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 (*Tagetes erecta* L). The study revealed that application of micronutrients mixture + $GA_3$100 ppm (T_2) showed highest total chlorophyll content of 2.98 mg/g, highest sodium content of 1.95 per cent, highest catalase activity (9.64 Δ OD/min/µg protein, highest peroxides activity (85.45ΔOD/min/µg protein) as well as biochemical parameter recorded highest in treatment T_2- Micronutrients mixture + $GA_3$100 ppm higher xanthophyll content of 1.91 mg/g, highest carotenoid content of 1.56 mg/g at 90 days after transplanting over the absolute control.

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