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Study on effect of different growth hormones on growth, yield and quality of African marigold (*Tagetes erecta* L)

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Abstract
This investigations were undertaken to study the effect different growth hormones on growth and yield of African marigold (*Tagetes erecta* L.) under Coimbatore condition, during March 2019 to October 2019 in two different seasons. The present experiment was laid out in randomized block design with three replications involving foliar application of Gibberellic acid, Cycocel, Brassinosteroids, and silicic acid. The study revealed that foliar application of Gibberellic acid (T_2) at the rate of 150ppm showed a significant improvement in morphology and yield and quality parameters in African marigold. The result recorded of maximum plant height (72.52 cm), plant spread (40.89 cm), number of primary branches (9.77), number of flowers per plant (36.52), single flower weight (6.56 g), flower diameter (6.40 cm), flower yield per plant (239.57 g) and highest total carotenoid content (1.32 mg/g) and total xanthophyll content (1.71 mg/g) and total chlorophyll content (2.60 mg/g) were recorded in the treatment T_2. whereas the Cycocel (CCC) at the rate of 2000ppm recorded dry matter production (62.93 g per plant), days taken for flower bud appearance (32.61 days), days to first harvest (51.53 days) as compared to control.

Keywords: African marigold, GA_3, cycocel, growth, yield

Introduction
Marigold is a genus of *Tagetes*, widely used as annual, perennial and herbaceous plant belongs to the family of asteraceae. The flower is known as 'flower of the dead' in Mexico and the name was described by Carl Linnaeus in 1753. It has gained popularity in India on account of its easy cultivation, wider adaptability and production throughout the year. Moreover, Commercial extraction of carotenoid pigments also plays a major role. It has been extracted from *T. erecta*, *T. patula* and *T. grandiflora* and *T. nana*. GA_3, CCC of preceding PGRs including new up-coming PGRs like BRs and elemental nutrients like Si application improves the growth and yield potentials of agronomics and horticultural crops, the treasury of research has been extended to marigold to obtain enhanced yield and improved flower quality. Gibberellic acid (GA_3) has been found to be effective in enhancing plant growth and marigold flower development (Girwani *et al*., 1990) [12]. Promoting the initiation of floral primordium by antagonizing the inhibitory effect on floral initiation of endogenous abscissic acid levels. Exogenous foliar application of growth regulators is also observed to promote flowering, pollination, fertilization and seed setting to achieve maximum seed yield (Doddagoudar *et al*., 2002) [11]

Materials and Methods
The experiment was conducted in in Kharif i.e., summer (March-June) and rainy (July-October) seasons at the Coimbatore District under the Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore in the year 2018-2019. The design of experiment is Randomized Block Design. The various plant growth hormones like Gibberellic acid (GA_3), Brassinosteroids (BRs), Cycocel (CCC) and supplemented mineral nutrient silicic acid (Si) were given as foliar spray. They were sprayed in two different intervals of 10 days and 15 days after transplanting from 30 days continued until 45 days. Observed all plant morphological, yield and quality parameters.

The treatments used were T1: Foliar spray of GA_3 @100ppm @10 days interval, T2: Foliar spray of GA_3 @150ppm @15 days interval, T3: Foliar spray of BRs @0.50ppm @10 days interval,T4: Foliar spray of BRs @0.75ppm @15 days interval,T5: Foliar spray of silicic acid @6 ml/l @10 days interval,T6: Foliar spray of silicic acid @8ml/l @15 days interval,T7: Foliar spray of CCC @1500ppm @10 days interval,T8: Foliar spray of CCC @2000ppm @15 days interval,T9: Control (water spray)

Results and Discussion

Growth parameters

Among the treatments T_2 (Gibberellic acid at the rate of 150ppm at 15 days interval) influenced the plant height, plant spread and number of primary branches significantly. Increases in growth due to the increase in levels of exogenous gibberellins which are responsible for cell elongation. Table 1 results revealed that the treatment T_2 (GA_3 @150ppm) recorded maximum plant height (72.52 cm), plant spread (40.89 cm), number of primary branches (9.77) compared to all other treatments. Similar result were observed the treatment GA_3 150ppm recorded better results for marigold cv. Siracole. Swathi Imandi *et al*., (2017) [1]

Similar results were also obtained in African marigold cv. Pusa Narangi Gainda, where GA_3 at the rate of 150ppm with soil application of Azotobacter resulted in increased the maximum plant height, number of primary and secondary branches per plant, plant spread, compared to the control. Naresh Kumar *et al*., (2016) [2] and Sharma *et al*., (2016) [3] reported in African marigold (GA_3 @300ppm)

Table 1: Effect of growth hormones on morphological parameters of African marigold

Treatments	Plant height (cm) at DAT			Plant spread (cm) at DAT			Number of primary branches DAT		
	30	45	60	30	45	60	30	45	60
T1	40.52	57.53	68.13	18.92	24.85	39.06	5.81	8.16	8.99
T2	43.33	65.06	72.52	18.81	24.72	40.89	6.02	8.64	9.77
T3	30.55	51.11	61.11	20.77	26.21	35.17	4.92	7.42	8.56
T4	29.25	50.69	65.55	19.93	24.37	38.89	5.86	7.87	8.82
T5	28.24	48.11	65.20	17.70	23.78	36.27	5.01	7.90	8.92
T6	22.82	42.46	64.90	16.77	21.82	35.39	4.63	6.22	8.38
T7	25.87	44.39	48.64	17.35	22.40	30.90	4.22	6.13	7.36
T8	28.15	48.92	49.71	20.45	24.52	28.55	4.51	6.46	7.83
T9	23.82	43.01	54.43	15.66	21.61	30.06	3.92	5.89	6.76
Mean	30.28	50.14	61.13	18.48	23.81	35.02	4.99	7.19	8.38
SEd	0.623	0.713	1.284	0.429	0.426	0.646	0.1173	0.1573	0.1702
CD (p=0.05)	1.322	1.513	2.723	0.911	0.904	1.369	0.2486	0.3335	0.3609

T_1: Foliar spray of GA3 @100ppm @10 days interval,T_2: Foliar spray of GA3 @150ppm @15 days interval,T_3: Foliar spray of BRs @0.50ppm @10 days interval,T_4: Foliar spray of BRs @0.75ppm @15 days interval, T_5: Foliar spray of silicic acid @6 ml/l @10 days interval, T_6: Foliar spray of silicic acid @8ml/l @15 days interval, T_7: Foliar spray of CCC @1500ppm @10 days interval, T_8: Foliar spray of CCC @2000ppm @15 days interval,T_9: Control (water spray)

Yield and quality parameters

Flower yield parameters recorded number of flowers per plant (36.52), single flower weight (6.56g), flower diameter (6.40cm) and flower yield per plant (239.57g) in foliar application of GA_3 @150ppm (T_2) showed in table 2. Similar result were noted by C.T. Sathappan (2018) [5] GA_3 @150ppm in African marigold F1 hybrid viz., Gold Benz and Maxima yellow and Ramesh Kumar *et al*., (2010) [4] in African marigold cv. Pusa Narangi Gainda foliar application of (GA_3 @200ppm) and Mithilesh Kumar *et al*., (2014) [8]. As regard the treatment T_8 (CCC @2000ppm) recorded dry matter production (62.93 g per plant), days taken for flower bud appearance (32.61 days), days to first harvest (51.53 days). Similar findings were noticed by YR Khobragade *et al*., (2019) [9] and Queenie Syngkrem *et al*., (2018) [5] observed in white marigold (*Tagetes erecta* L.) Cv. Vanilla. (Table 3.)

Table 2: Effect of growth hormones on flower yield and quality of African marigold

Treatments	Number of flowers per plant (No.)	Flower yield per plant (g)	Total Chlorophyll content (mg/g)	Total Carotenoid content (mg/g)	Total Xanthophyll content (mg/g)
T1	35.70	226.16	2.38	1.23	1.55
T2	36.52	239.57	2.60	1.32	1.71
T3	29.15	148.67	1.91	1.04	1.28
T4	30.20	151.00	2.06	1.13	1.38
T5	34.94	180.64	1.92	1.06	1.23
T6	33.49	190.73	2.13	1.15	1.42
T7	35.03	211.76	1.65	0.89	1.04
T8	35.57	209.33	1.78	0.96	1.18
T9	27.32	118.30	1.60	0.81	1.00
Mean	33.10	186.24	2.00	1.07	1.31
SEd	0.554	4.1718	0.0504	0.0196	0.0262
CD (p=0.05)	1.175	8.8440	0.1068	0.0415	0.0556

T_1: Foliar spray of GA3 @100ppm @10 days interval,T_2: Foliar spray of GA3 @150ppm @15 days interval,T_3: Foliar spray of BRs @0.50ppm @10 days interval,T_4: Foliar spray of BRs @0.75ppm @15 days interval,T_5: Foliar spray of silicic acid @6 ml/l @10 days interval,T_6: Foliar spray of silicic acid @8ml/l @15 days interval, T_7: Foliar spray of CCC @1500ppm @10 days interval,T_8: Foliar spray of CCC @2000ppm @15 days interval,T_9: Control (water spray)

Table 3: Effect of growth hormones on flower yield and quality of African marigold

Treatments	Days taken for flower bud appearance (days)	Days to first harvest (days)	Dry matter production (g/plant)	Flower diameter (cm)	Single flower weight (g)
T_1	37.66	58.32	48.10	6.22	6.34
T_2	37.39	54.98	50.56	6.40	6.56
T_3	37.06	57.74	53.83	5.60	5.10
T_4	38.61	57.97	55.32	5.61	5.00
T_5	35.50	59.56	56.61	5.28	5.17
T_6	36.16	55.30	56.75	5.49	5.70
T_7	33.93	53.83	57.89	5.74	6.05
T_8	32.61	51.53	62.93	5.35	5.89
T_9	41.61	63.89	46.32	5.06	4.33
Grand Mean	36.72	57.01	54.25	5.64	5.57
SEd	0.741	1.601	0.9202	0.1013	0.1133
CD (p=0.05)	1.572	3.395	1.9507	0.2147	0.2401

T_1: Foliar spray of GA3 @100ppm @10 days interval,T_2: Foliar spray of GA3 @150ppm @15 days interval,T_3: Foliar spray of BRs @0.50ppm @10 days interval,T_4: Foliar spray of BRs @0.75ppm @15 days interval,T_5: Foliar spray of silicic acid @6 ml/l @10 days interval,T_6: Foliar spray of silicic acid @8ml/l @15 days interval,T_7: Foliar spray of CCC @1500ppm @10 days interval, T_8: Foliar spray of CCC @2000ppm @15 days interval,T_9: Control (water spray)

Quality Parameters

The highest total carotenoid content (1.32 mg/g) and total xanthophyll content (1.71 mg/g) and total chlorophyll content (2.60 mg/g) were recorded in the treatment T2 (foliar application of GA3 at the rate of 150ppm at 15 days interval) Gibberellic acid is responsible for the favourable changes which influenced the quality (Table 2). These results are in accordance with the findings of Gibberellic acid at 150ppm was recorded growth, flower yield and quality of African marigold by Dweepjyoti Sarkar *et al*., (2018) [6] and chrysanthemum cv. Yellow Gold Raveendra Choudhari *et al*., (2018) [7]

Conclusion

It is concluded that GA_3 @150ppm (T_2) for foliar application at 15 days interval is found to be the growth hormone could be used to improve the productivity and xanthophyll content of African marigold.

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