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Effect of bio-regulators on flowering behavior and yield attributes of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda

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Abstract
The present investigation entitled "Effect of bio-regulators on flowering behavior and yield attributes of African Marigold (*Tagetes erecta* L.)" was carried out at Horticultural Research Centre (HRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology Modipuram, Meerut, Uttar Pradesh during the year 2016-2017. The layout of experimental field was laid down in Randomized Block Design in which ten treatments along with 3 replications.
The Maximum days taken to first bud initiation were recorded application of Ethrel 400 ppm (T_{10}), days taken to opening of first flower was recorded with MH 400 ppm (T_7), duration of flowering (50.76 days) was recorded with GA_3 300 ppm (T_4), length of flower stalk was recorded with application of GA_3 300 ppm (T_4), Maximum number of flowers per plant was recorded with the application of GA_3 300 ppm (T_4), flowers diameter was recorded with the application of GA_3 300 ppm (T_4), number of flowers per plant was recorded with the application of GA_3 300 ppm (T_4), weight of flower was recorded with the application of GA_3 300 ppm (T_4), Maximum flower yield per plant was recorded with the application of GA_3 300 ppm (T_4), maximum flower yield per hectare was recorded with the application of GA_3 300 ppm (T_4).It is recommended to farmers for commercial cultivation of African marigold (*Tagets erecta* L.) cv. Pusa Narangi Gainda.

Keywords: African marigold (*Tagets erecta* L.), flowering behavior, flower yield, GA_3, MH and ethrel

Introduction
African Marigold (*Tagetes erecta* L.) is a native of Central and South America especially Mexico, and belongs to family Asteraceae is one of the most commonly grown loose flower and use extensively on religious and social functions in different forms. African Marigold flowers has attractive range of colours for a considerably prolonged period and the flowers can be kept remarkably well when cut. Sometimes, the whole plant can be used for decorations. They can be planted in beds for mass display, in mixed borders and can also be grown in pots. The generic name Tagetes is derived from, "Tages", the name of Estrucsch God, known for his beauty. French was the first to apply the name Tagetes, which was later adopted by others. Marigold were domesticated and used as an ornamental plant during pre-Columbian period before they were introduced in Europe and South Asia including India. Marigold is one of the oldest cultivated ornamental plants, being very popular in tropical and sub-tropical countries as a garden plant for beautification. Marigold is grown as landscape plants due to its variable height and various colours of flowers. It is highly suitable as a bedding plant, in herbaceous border and is also ideal for newly planted shrubbery to provide colour and fill spaces. French Marigold is ideal for rockeries, edging, hanging baskets and window boxes the use of plant growth substances has been found to be of great significance in the commercial cultivation of many ornamental crops. In our country, their use is very limited but in many Western countries they are creating many excitements in the field of agriculture. Gibberellic acid and cycocel are very important plant growth regulators and are widely used in agriculture and horticulture. GA_3 regulates the growth and involve in both cell division and cell enlargements (Haber and Leopold, 1960) [5]. The GA_3 has manifold effects, it affects the seed dormancy, seed germination, stem growth, root growth, flowering etc. (Rappaport and Singh, 1960) [12] Sachs *et al*. (1960) [13] reported that application of CCC retarded stem elongation by

preventing cell division in the sub-apical meristem, usually without similarly affecting the apical meristem. Cycocel treatments have been found effective in the direction of earliness in flowering and fruiting. The application of Ethrel retards plant height, number of nodes and internodal length in marigold. It increased branching, delayed flowering, more number of leaves formed below the terminal flower, increased number of flower per plant. Ethrel is growth retardant check cell division in apical meristem only resulting in vascular synthesis below the apical meristem but the cambial and vascular cell continue to divide over a larger period and this result increase in thickness of stem (Sachs, 1961) [13]. Marigold responds to application of Maleic hydrazide in, axillary bud controller, growth retardant, increase number of branches, increase in weight and number of flower, more number of leaves and increase number of seed per flower in marigold. Pawar *et al.* (2011) [11]. Number of studies on the effects of foliar application of plant growth regulators has been carried out in India on different flower crops. If we can determine the optimum concentration of various growths regulating chemicals to cause beneficial effect on growth and flowering behavior and maximum flower yield of marigold. The commercial flower production will be greatly benefited. The present study was aimed at investigating the effect of bio-regulators on vegetative growth of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda.

Materials and Methods

The present investigation entitled "Effect of bio-regulators on flowering behavior and yield attributes of African marigold (*Tagets erecta* L.) cv. Pusa Narangi Gainda." was undertaken during November - March in 2016-17 at Horticultural Research Centre (HRC), Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture & Technology Meerut, (UP). The layout of experimental field was laid down in Randomized Block Design in which ten treatments along with 3 replications. The treatments are T_1 (Control), T_2 (GA3 100 ppm), T_3 (GA3 200 ppm), T_4 (GA3 300 ppm), T_5 (MH 200 ppm.), T_6 (MH 300 ppm.), T_7 (MH 400 ppm), T_8 (Ethrel 200 ppm), T_9 (Ethrel 300 ppm), T_{10} (Ethrel 400 ppm). Seeds of Pusa Narangi Gainda were procured from GBPUAT, Pantnagar, (UK). The seeds of marigold were sown in well prepare raised nursery beds, mixture of 10 kg FYM and leaf mould per meter square was thoroughly mixed at the time of soil preparation. Seeds were sown in line and a thin layer of mixture of sand, soil and FYM was applied over the seed mulching was also employed to avoid the disturbance during watering and to conserve moisture. The sowing was done on 21 Oct 2017. The healthy seedlings were transplanted 25-30 days after seed sowing in the evening at a spacing 45×45 cm consisting of 20 plants per plot. After transplanting light irrigation was applied in the field. After establishment of seedlings uniform cultural operations were performed regularly in each plot to maintain the plants in proper health. The control measure for insect pest and disease were also taken from time to time. The observations on days taken to first bud initiation, days taken to opening of first flower, duration of flowering (days), length of flower stalk (cm), diameter of flower (cm), number of flowers per plant, weight of flower (g), yield of flower per plant (g) and flower yield per hectare (q). The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez (1984) [4]. The weed count data were analyzed after subjecting the original data to ($\sqrt{x} + 0.5$) transformation. The treatment means were compared by using the transformed values.

Results and Discussion

Days taken to first bud initiation: The earliest bud initiation was observed with the application of GA_3 200 ppm (T_3) followed by GA_3 300 ppm (T_4), while maximum days taken to bud initiation was noted with the application of Ethrel 400 ppm (T_{10}). By Gibberellins reduces juvenile period and termination of juvenile phase, the shoot apical meristem instead of producing leaves and branches start producing flower buds. Dahiya and Rana (2001) and Kumar *et al.* (2001) reported that GA_3 200 ppm induced early flowering in carnation. Similar finding were also reported by Tiwari (1992) in tuberose.

Days taken to opening of first flower: The minimum number of days taken to opening of first flower was observed with application of GA_3 300 ppm (T_4) followed by GA_3 100 ppm (T_2) and GA_3 200 ppm (T_3) while late flower opening was recorded noted T_7 (MH 400 ppm). The present finding confirms the reports made by Dutta *et al.* (1993) in chrysanthemum. Early flowering owing to GA_3 may be due to Gibbrellins reduces juvenile period and termination of juvenile phase the shoot apical meristem instead of producing vegetative growth start producing flower (Krishnamurthy 1981). The results are in line with findings of Dahiya and Rana (2001) reported earlier flowering in chrysanthemum with GA_3 150 ppm and Mohariya *et al.* (2003) [12] observed earlier flowering in chrysanthemum with GA_3 150 ppm.

Duration of flowering (days): GA_3 was found most effective in extending the flowering duration especially with GA_3 300 ppm (T_4) followed by GA_3 200 ppm (T_3) and GA_3 100 ppm (T_2) and it might be due to advanced stage of flowering in marigold. Dutta *et al.* (1993) and Gautam *et al.* (2006) [6] observed maximum flower duration in chrysanthemum with GA_3 200 ppm, Dahiya and Rana (2001) reported maximum flowering duration in chrysanthemum cv. Vasantika with GA_3 150 ppm. Kumar *et al.* (2010) [10] studied effect of growth regulators on flowering in African marigold with GA_3 (25, 50, 100 and 200 ppm) and longest duration of flowering with GA_3 200 ppm.

Length of flower stalk (cm): The maximum length with foliar application of GA_3 300 ppm (T_4). The increment in stalk length with application of GA_3 might be due to enhanced cell-division and cell enlargement, promotion of protein synthesis coupled with higher dry matter of apical dominance (Dalal *et al.* 2009) [4]. Similar results were also reported by Dahiya and Rana (2001) observed maximum flower stalk length in chrysanthemum with GA_3 150 ppm. Tiwari (1992) concluded that treatments of GA_3 200 ppm increased the length of spike in tuberose and Gautam *et al.* (2006) [6] reported maximum length of flower stalk with GA_3 200 ppm in chrysanthemum.

Diameter of flower (cm): The diameter of flower was found significantly maximum with GA_3 300 ppm (T_4) followed by Ethrel 300 ppm (T_9) whereas minimum flower diameter was recorded under control (T_1). GA_3 and Ethrel both increases flower diameter at 300 ppm concentrations. Patel *et al.* (2010) [15] told that maximum diameter of flower was found with GA_3 150 ppm in chrysanthemum. Similar result was also reported by Dalal *et al.* (2009) [4] with Gibberellic acid and Maleic hydrazide spray at 30th and 60th days after transplanting on growth flowering and yield of chrysanthemum under net house conditions. The results

revealed that foliar application of gibberellic acid at 200 ppm concentration resulted maximum flowering, increased diameter of flower, length of flower stalk and flower yield in chrysanthemum. Tyagi and Kumar (2006) [21] found that the beneficial effect of GA_3 on African marigold (*Tagetes erecta* L.). Maximum flower diameter was recorded with GA_3 spray at 200 ppm. Nagarjuna *et al.* (1988) [13] apply foliar spray of GA_3 100 and 200 ppm. 70 days after planting, flowering was hastened by 17 days and diameter (5.92 – 5.99 cm) was greatest with GA_3 at 200 ppm.

Number of flowers per plant: The maximum numbers of flower per plant were recorded with foliar application of GA_3 300 ppm (T_4) followed by GA_3 200 ppm (T_3). The enhancement in number of flower per plant might be due to the production of large number of laterals at early stage of growth which had sufficient time to accumulate carbohydrate for proper flower bud differentiation due to enhanced reproductive efficiency and photosynthesis restricted plant type. The result was in close conformity with Sunitha *et al.* (2007) [20] studied foliar application of GA_3 (100 and 200 ppm) in African marigold cv. Orange Double increase the number of flowers per plant, Gautam *at al.* (2006) [6] observed that GA_3 200 ppm increased flowering and yield of chrysanthemum flower. Mohariya *et al.* (2003) [12] observed that 150 ppm GA_3 hastened flowering and highest number of flower per plant in chrysanthemum. Patel *et al.* (2010) [15] observed maximum number of flower per plant with GA_3 150 ppm in chrysanthemum and Tannirwar *et al.* (2011) [22] in chrysanthemum.

Weight of flower (g): The weight of flower was reported significantly maximum with foliar application of GA_3 300 ppm (T_4). Tyagi and Kumar (2006) [21] evaluated the effect of GA_3 on African marigold (*Tagetes erecta* L.) and observed maximum fresh weight of flower with GA_3 spray at 200 ppm Gautam *et al.* (2006) [6] studied the effect of foliar application of GA_3, NAA, Etherel on chrysanthemum and observed that GA_3 200 ppm and NAA 100 ppm increased growth, flowering and yield of chrysanthemum flower. Sunitha *et al.* (2007) [20] in African marigold (*Tagetes erecta* L.) and reported maximum flower weight. Patel *et al.* (2010) [15] studied the effect of GA_3 (50, 100 and 150 ppm). Significantly maximum flower diameter (8.76 cm), flower weight (5.93 g) and shelf-life of flowers (8.00 days) were obtained with GA_3 150 ppm treatment. Number of flowers per plant (48.30), flower yield per plant (170.77 g) and flower yield per hectare (12.65 t) were found maximum in the same treatment in case of chrysanthemum. Varma and Arha (2004) [23] also observed maximum flower yield with GA_3 200 ppm as compared to control in marigold.

Yield of flower per plant (g): The yield of flower per plant differs significantly. Maximum flower yield per plant was recorded with foliar application of GA_3 300 ppm (T_4) followed by GA_3 200 ppm (T_3) and Ethrel 400 ppm (T_{10}). Tyagi and Kumar (2006) [21] evaluated the effect of GA_3 on flower weight per plant of African marigold (*Tagetes erecta* L.) were maximum with GA_3 spray at 200 ppm, Mohariya *et al.* (2003) [12] also reported that the effect of GA_3 at 100, 150 ppm and TIBA at 100, 200 ppm on different varieties of chrysanthemum and observed that 150 ppm GA_3 hastened flowering and highest number of flower per plant.

Flower yield per hectare (q): The yield of flower per hectare differs significantly. The maximum flower yield per hectare was recorded with application of GA_3 300 ppm (T_4) followed by GA_3 200 ppm (T_3). Patel *et al.* (2010) [15] studied the effect of GA_3 (50, 100 and 150 ppm). Significantly maximum flower diameter (8.76 cm), flower weight (5.93 g) and shelf life of flowers (8.00 days) were obtained in the treatment GA_3 150 ppm. Number of flowers per plant (48.30), flower yield per plant (170.77 g) and flower yield per hectare (12.65 t) were found significantly maximum in the same treatment in chrysanthemum, Varma and Arha (2004) [23] reported maximum flower yield with GA_3 200 ppm as compared to control in marigold. Devadanam *et al.* (2007) GA_3 at 150 ppm resulted maximum flower yield per hectare in tuberose.

Table 1: Effect of Bio-regulators on flowering behavior and yield attributes of marigold

Treatments	Days taken to first flower bud initiation	Days taken to opening of first flower	Duration of flowering (Days)	Length of flower stalk (cm)	Number of flowers per plant	Diameter of flower (cm)	Weight of flower (g)	Yield of flower per plant (g)	Yield of flower per hectare (q)
T_1 Control	57.65	99.45	36.39	7.73	21.00	6.73	10.02	210.42	103.90
T_2 $GA_3$100 ppm	52.21	91.13	46.34	8.11	27.31	7.91	11.98	327.17	161.56
T_3 GA_3 200 ppm	48.77	91.25	48.7	7.88	28.25	7.81	12.25	346.07	170.89
T_4 GA_3 300 ppm	50.76	89.76	50.76	9.1	29.01	9.49	13.05	378.50	186.95
T_5 MH 200 ppm	62.01	101.35	38.84	9.01	23.23	7.02	11.12	256.28	127.56
T_6 MH 300 ppm	62.01	104.07	41.19	7.34	24.02	7.31	11.50	276.23	136.41
T_7 MH 400 ppm	65.64	114.52	41.15	7.1	23.15	6.98	11.23	259.97	128.37
T_8 Ethrel 200 ppm	58.67	101.15	43.21	7.93	24.95	7.41	11.75	233.16	144.76
T_9 Ethrel 300 ppm	63.18	104.57	44.91	7.62	26.12	8.37	11.89	310.36	153.36
T_{10} Ethrel 400 ppm	72.69	112.14	43.61	7.36	27.39	6.95	12.17	333.34	164.60
SE(m)±	2.14	3.6	1.59	0.28	0.94	0.28	0.43	11.11	5.59
CD at 5%	6.19	10.41	4.61	0.81	2.71	0.81	1.23	32.13	16.16

Conclusion

On the basis of result obtained from the present investigation it can be concluded that foliar application of GA3 300 ppm one month after transplanting was found most effective with respect to flowering behavior, and maximum flower yield and of African marigold (*Tagetes erecta* L.) and can be recommended to farmers for commercial cultivation of African marigold (*Tagets erecta* L.) cv. Pusa Narangi Gainda.

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