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Effect of pinching, gibberellic acid and kinetin on growth, flowering and seed yield in marigold

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Abstract
An investigation was carried out to study the response of African marigold to pinching and growth regulators at the Horticulture Research Farm, Banaras Hindu University, Varanasi, U.P. during summer season of 2017. Experiment consisted of three levels of pinching (no pinching, single pinching, double pinching) and seven level of plant growth regulators (Control, GA_3 50 ppm, GA_3 100 ppm, GA_3 150 ppm, kinetin 50 ppm, kinetin 100 ppm and kinetin 150 ppm). Experiment was laid out in a Randomized Block Design with three replications. The results revealed that, significantly higher number of primary branches per plant, leaf biomass, flower yield per plant, seed yield per plant were found under double pinching and spraying of GA_3 at 150 ppm. Whereas maximum fresh weight of leaf, dry weight of leaf, day to bud initiation, duration of flowering, bud length and number of petals per flower were recorded in no pinching treatment and application of GA_3 at 150 ppm.

Keywords: marigold, pinching, GA_3, kinetin, growth, seed yield

Introduction
Marigold belongs to the family Asteraceae and it is native to South and Central America especially Mexico. It is also known as 'Gainda' in Hindi. The aromatic oil extracted from the marigold plant is known as "tagetes oil". Marigold is extensively used for making garland, beautification and the repeutic uses. The carotenoid extracted from marigold petals are used in poultry feed to intensify yellow colour of egg yolk (Singh, 2014 and Singh and Sisodia, 2017) [9, 11]. Amongst different species of marigold, *Tagetes erecta* is more commonly grown for their ornamental values. In India, major flower growing states are West Bengal, Tamil Nadu, Karnataka, Uttar Pradesh, Kerala, Andhra Pradesh and Maharashtra, etc. In India about 307.87 thousand hectare area under floriculture with production estimated to 1805.92 thousand MT of loose flower and 704.23 thousand MT of cut flower (Anon., 2017) [1]. Application of growth regulators in flower played an important role in vegetative propagation, inhibition of abscission, prevention of bud dormancy, growth control and promotion of flowering, retarding senescence, etc. Gibberellic acid is a simple gibberellin, its application to plants results in a variety of responses like cell division, a change in leaf shape or size and a retardation of root growth. Kinetin, the most known cytokinin has been found to contain carbon, hydrogen, oxygen in the ratio $C_{10}H_9N_5O$. Kinetins are involved in all phases of plant growth and development. They are active in cell division and enlargement, leaf expansion, the breaking of dormancy, shoot inhibition, bud elongation, and root growth (Steward *et al*., 1961) [13]. Pinching is to promote branching and bushiness and production of more number of flowers, ultimately more flower yield. Since, flower yield is mainly dependent on number of flower bearing branches which can be manipulated by arresting the vertical growth of plants and encouraging side shoots by means of apical bud pinching. Hence, present investigation was carried out to see the response of pinching and growth regulators on growth and flowering in marigold during summer season.

Materials and Methods
The present investigation was carried out at the Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. from April 2017 to July 2017. The experimental site lies approximately in the centre of North-Gangetic alluvial plain, on the left bank of river Ganga at a distance of about 10 km away from Varanasi Railway Station in the South-East direction. Geographically, Varanasi city is situated at about 25°10' North latitude, 83°03' East longitudes. The altitude of location is 123.23 meters above the mean sea level. During growing period mean maximum (42.2ºC) and minimum (27.3ºC) temperature, relative humidity (93%) and rainfall (111.14 mm) was recorded. Treatment consisted of GA_3 (50, 100, and 150 ppm), kinetin (50, 100, and 150 ppm) along with control

and three pinching levels (no pinching, single pinching, and double pinching). Thus there were 21 treatment combinations. Experiment was laid out in Randomized Block Design with three replications. One month old, healthy seedlings were used for transplanting. Seedlings were planted at a spacing of 45 × 45 cm and light irrigation was given soon after transplanting. Gibberellic acid and kinetin treatment was applied third weeks after transplanting, while the control plants were sprayed with distilled water to run-off stage with the help of hand sprayer. Regarding pinching treatments, 4-5 cm terminal portion of growing tip was nipped out as per treatments. Observations were recorded on various growth, flowering and seed parameters. Results thus obtained were subjected to statistical analysis.

Results and Discussion

1. Growth characters

1.1 Pinching

Maximum number of primary branches/plant and leaf biomass/plant was exhibited with treatment double pinching which was statistically higher than single pinching and no pinching treatments (Table 1). However maximum fresh weight and dry weight of leaf was recorded with no pinching treatment followed by single and double pinching treatments. It is apparent from the data that pinching resulted in in-crease number of branches which alimentally resulted in to more leaf biomass. This result corroborates the findings of Sarkar *et al.* (2018) [6], Shinde *et al*. (2010) [7], Khandelwal *et al.* (2003) [2], Singh *et al*. (2017) [12] and Singh (2003) [8].

1.2 Growth regulators

All the growth parameters are significantly influenced due to application of various doses of growth regulators (Table 1). Treatment GA_3 at 150 ppm resulted in maximum number of primary branches/plant, fresh weight of leaf, dry weight of leaf and leaf biomass/plant followed by kinetin 150 ppm and GA_3 100 ppm. All the application of 150 ppm GA_3 was statistically higher than all other treatment on all the growth parameters. The enhancement in various growth characters in probably due to physiologically action of GA_3 which increased number and size of cell of meristematic tissue. GA_3 application stimulated growth and increased biomass in gladiolus (Padhi *et al*., 2018) [4]. This result corroborated with the findings of Sarkar *et al.* (2018) [6], Shinde *et al*. (2010) [7], Singh *et al*. (2017) [12], Yadav *et al*. (2014) [15], Singh and Sharma (2004) [10], Singh (2003) [8] and Neetu *et al*. (2013) [3].

2. Flowering parameters

2.1 Pinching

Early bud initiation was recorded with no pinching treatment where as it was deled in single and double pinching. Similarly maximum duration of flowering, bud length and number of petals/flower were exhibited with no pinching treatments followed by single and double pinching (Table 2). Maximum number of flower/plant was recorded with double pinching treatment which was significantly higher than single pinching and no pinching treatment. Bud length and number of petals/flower were higher in no pinching and single pinching treatment probably due to less production of flower/plant. These results are in close agreement with the findings of Shinde *et al*. (2010) [7], Sarkar *et al.* (2013), Parhi *et al.* (2016) [5], Singh *et al*. (2017) [12] and Singh (2003) [8].

2.2 Growth regulators

Early bud initiation was recorded with application of GA_3 at 150 ppm which was significantly higher than other treatments. Maximum duration of flowering was also recorded with GA_3 at 150 ppm. Maximum duration of flower and bud length was recorded with 150 ppm GA_3 which was statically at par with Kinetin 150 ppm treatment and significant to other treatments. Maximum number of flower/plant was registered with GA_3 150 ppm which was significant to other treatments. Maximum number of petals/flower was also significantly higher than other treatments except kinetin 150 ppm treatments. Lower value in all the parameters was recorded with control. Flowering parameters enhanced with the parameters of GA_3 might be due to increased level of RNA and protein in the GA_3 treatment plant which probably played some role in production of flower. These results are in close agreement with the findings of Shinde *et al*. (2010) [7], Sarkar *et al.* (2013), Parhi *et al.* (2016) [5], Singh *et al*. (2017) [12], Yadav *et al*. (2014) [15], Singh and Sharma (2004) [10], Singh (2003) [8] and Neetu *et al*. (2013) [3].

3. Seed yield

Significantly higher seed yield per plant are found in the double pinching treatment and minimum seed yield per plant was found in no pinching treatment (Table 3). Maximum seed yield were recorded significantly with the application of GA_3 at 150 ppm and followed by followed by application of GA_3 100 ppm, kinetin 100 ppm, GA_3 50 ppm, kinetin 50 ppm and control treatment and at par with kinetin 150 ppm. Increased in seed yield with application of GA_3 might be due to cell division and increased level of carbohydrates which resulted in yield of seed. Similar results were reported by Sunitha *et al*. (2007) [14] in marigold, Singh *et al*. (2017) [12], Yadav *et al*. (2014) [15], Singh and Sharma (2004) [10], Singh (2003) [8].

Table 1: Effect of pinching and growth regulators on growth characters.

Treatment	No. of primary branches/plant	Fresh weight of leaf (g)	Dry weight of leaf (g)	Leaf biomass/plant (g)
Pinching				
No pinching	27.03	0.26	0.07	64.16
Single pinching	30.23	0.24	0.06	73.51
Double pinching	36.15	0.21	0.06	87.91
CD at 5%	0.70	0.008	0.002	1.14
Growth regulators				
Control (Distilled water)	27.92	0.19	0.05	62.04
GA_3 50 ppm	29.93	0.24	0.06	72.78
GA_3 100 ppm	32.42	0.25	0.06	78.83
GA_3 150 ppm	34.84	0.26	0.07	84.73
Kinetin 50 ppm	28.88	0.23	0.06	70.23
Kinetin 100 ppm	31.44	0.24	0.06	76.44

Kinetin 150 ppm	33.62	0.25	0.07	81.70
CD at 5%	0.71	0.001	0.003	1.74

Table 2: Effect of pinching and growth regulators on flowering parameters.

Treatment	Days to bud initiation	Duration of flowering	Bud length (cm)	Number of flowers/plant	Number of petals/flower
Pinching					
No pinching	42.06	32.60	0.68	12.82	186.73
Single pinching	55.45	29.35	0.61	14.66	168.11
Double pinching	66.32	26.35	0.55	17.40	150.93
CD at 5%	0.86	0.95	0.02	0.11	8.35
Growth regulators					
Control (Distilled water)	63.91	23.96	0.50	12.38	137.26
GA_3 50 ppm	59.47	30.44	0.63	14.52	174.40
GA_3 100 ppm	54.90	30.51	0.63	15.60	174.77
GA_3 150 ppm	31.71	32.13	0.67	16.92	184.02
Kinetin 50 ppm	61.63	28.42	0.59	14.06	162.81
Kinetin 100 ppm	57.66	29.35	0.61	15.26	168.11
Kinetin 150 ppm	52.98	31.21	0.65	16.30	178.76
CD at 5%	1.31	1.45	0.03	0.17	8.03

Table 3: Effect of pinching and growth regulators on seed yield.

Treatment	Seed yield per plant (g)
Pinching	
No pinching	5.64
Single pinching	6.89
Double pinching	8.24
CD at 5%	0.21
Growth regulators	
Control (Distilled water)	5.44
GA_3 50 ppm	6.82
GA_3 100 ppm	7.39
GA_3 150 ppm	7.94
Kinetin 50 ppm	6.85
Kinetin 100 ppm	7.16
Kinetin 150 ppm	7.66
CD at 5%	0.32

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