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RESEARCH ARTICLE

EFFECTS OF GIBBERELLIN (GA3) ON GROWTH, FLOWERING AND YIELD OF AFRICAN MARIGOLD (Tagetes erecta)

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ABSTRACT

An experiment was carried out to assess the effectiveness of different concentration of gibberellin on plant growth, flowering and yield of African marigold (*Tageteserecta L.*) at the field of Rama University during August 2020 to November 2020. The experiment consisted of five treatments (T_1 control, T_2-100 ppm GA_3, T_3-200 ppm GA_3, T_4-300 ppm GA_3 and T_5 400 ppm) replicated four times and was laid out in randomized complete block design (RCBD). About one month old marigold seedlings were planted on August15thandfoliar applications were at 30 and 45 days after transplanting. Foliar application of 300 ppm GA_3 showed significant difference in 60 and 75 DAT in plant height (117.6 cm and 109.25 cm) and in plant spreading (93.04 cm and 94.31 cm followed byGA_3 400 ppm compared to control (91.10 cm and 96.4 cm, 79.14 cm and 79.14 cm respectively). Higher number of branches (17.20)per plant was recorded in GA_3 300 ppm compared to 400 ppm (17.20), 200 ppm (15.45), 100 ppm (12.20) and control (10.5). The GA_3 300 ppm treatment was also found effective in earliness of first flower initiation and 50% flowering (50.25 and 81.50 DAT) with higher flower diameter (4.720 cm)as compare to control treatment (41 DAT, 67.50 DAT and 3.835 cm respectively).The length of flower stalk, fresh weight, dry weight along with higher yield per plant and yield per hectare was recorded in $GA_3$300 ppm followed by GA_3 400 ppm (4.122 cm, 4.228 g, 0.7240 g, 358.2 g, 14.99 ton/ha and 4.115 cm, 3.937 g, 0.6990g, 344.5 g, 13.05 ton/ha respectively) as compared to control (3.570 cm, 3.235 g, 0.5142 g, 205.3 g and 7.35 t/ha respectively). However the application of 300 ppm $GA_3$was most effective as compared to other concentrations of GA_3.

KEYWORDS

Marigold, Gibberellin, Vegetative Parameter, Flowering and Yield

1. INTRODUCTION

Floriculture has been emerging as a popular and viable agro-business of agriculture. Floriculture is fast expanding in trade with estimated global floral production value USD 55 billion by 2016 (*Rabosearch, 2016).* It has a high value and can be cultivated on a small scale but it is a labor-intensive but mostly farmers are involved in cultivation as their main source of income.

Marigold is an important commercial flower belongs to family Composite and genus Tagets. The two popular species of marigold are '*Tageteserecta L.* also called African marigold and *Tagetespatula L.* also called French marigold which has their origin in Mexico and South Africa respectively. It is very popular due to easy to grow and wider adaptability. It is annual plant attain more than 100 cm height within its life span. It is propagated by seed and cutting.

The uses of marigold are many fold, often referred to as, "Versatile crop with golden harvest" (Raghava, 2000). Marigolds produce thiopenes, which are toxic to nematode and used as trap crop in tomato, Marigold, not only cultivated as ornamental cut flower and land escape plant but also a source of carotenoid pigment for poultry feed to intensify yellow color of egg yolks and broiler skin. Apart from poultry industry, marigold dye is also used in textile, pharmaceutical industries, food supplements, cosmetics etc. as they offer several advantages over synthetic dyes from natural point of view, safety and eco-friendly in nature (Hemla et al., 2012).

Hormone application has been an essential part of flower cultivation. Growth promoters as well as growth retardants have been used in floriculture to manipulate plant growth in a desired way (Sharma et al., 2001). To fulfill the demand of industrialists and local market, it is necessary to increase the production through use of plant growth regulators to accelerate growth, induce lateral buds and to increase flower yield. The plant growth regulator are that in small amounts modify the physiological process of plants and ultimately alter the yield and quality. Gibberellins fall in growth promoter group of plant hormones. Gibberellin is supposed to increase flower quality and maintains uniformity in flower size and number. It is also supposed to promote plant growth and increased number of primary and secondary branches which eventually ensures higher production of flower. The exogenous foliar spray of growth regulator stimulate flowering, pollination, fertilization and seed setting to get maximum yield (Doddagoudar et al., 2002).

2. METHOD AND METHODOLOGY

2.1 Study Area

The present experiment was conducted under the field of Rama University, Mandhana, Kanpur, Uttarpradesh, India during August 2020 to November, 2020.

2.2 Treatment Detail

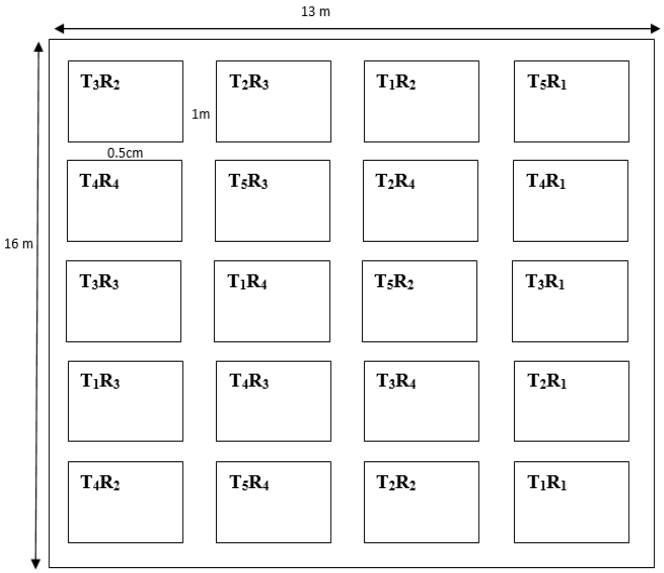
For this experiment different level of gibberellin were used as treatment.

Table 1: Different treatment used for marigold production

S.N.	Treatments	Concentration
1	T_1	Control (Distilled water)
2	T_2	GA_3@ 100 ppm
3	T_3	GA_3@ 200 ppm
4	T_4	GA_3@ 300 ppm
5	T_5	GA_3@ 400 ppm

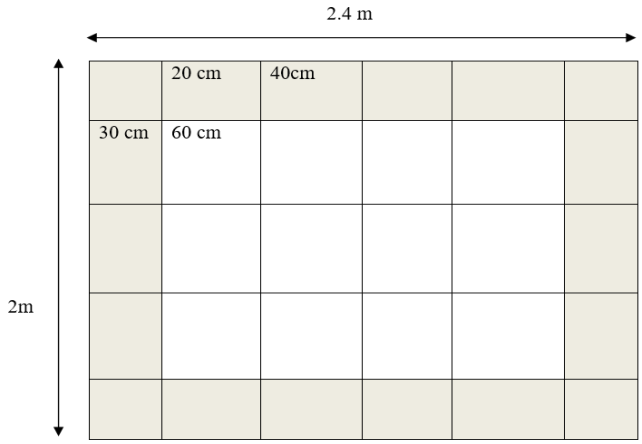
2.3 Field Layout

The layout was carried out to fit the experiment into Randomized Complete Block Design (RCBD). There were all together 5 treatments and replicated four time. Total experimental area was 224 m² (16m ×14m) and space between replication and plot was 1m and 0.5m respectively. The individual plot size was 2m × 2.4m i.e. 64.8 m². The row to row distance was 60 cm and plant to plant distance was 40 cm. There were 4 rows in each plot and 5 plants were planted in each row. There were all together 20 plants in each plot and inner 5 plants were selected for observation.



2.3.1 Single plot

Single plot size was 4.8 m² (2 m × 2.4 m). There were 20 plants in the plot. Row to row and plant to plant spacing was 60 cm and 40 cm respectively. The net plot (0.8 m²) contains 6 plants.



2.4 Experimental Details

2.4.1 Experimental Material Details

The experimental material which was used for the present experiment comprise of African marigold cv. Calcutta local. About one month old marigold seedlings were planted for the experiment in well labeled plot.

2.4.2 Manures and Fertilizers

Well decomposed farm yard manure (FYM) was applied in the plots @ 20 mt/ha two weeks before planting. Half dose of nitrogen and full dose of phosphorus and potash @ 160: 60: 60 kg NPK/ha were applied as basal dose. The remaining half dose of nitrogen was top dressed one month after the transplanting of seedlings. Nitrogen was applied through urea (46% N) and potash through murate of potash (60% K_2O) respectively.

2.4.3 Transplanting and Gap Filling of Seedlings

Seedlings were transplanted on 1st July, 2017. One month old healthy seedlings were transplanted at the spacing of 60 cm x 40 cm. Irrigation was done with watering can after transplanting. Seven days after transplanting the gap filling was done with fresh seedling, in order to maintain 100 percent plant population in each plot.

2.5 Preparation of GA_3 Stock Solution

GA_3 was weighed with the help of digital balance. Four different concentrations viz.100, 200 300 ppm and 400 ppm of gibberlin (GA_3) were prepared manually with distilled water just before their use. In a few ml of 98 per cent ethyl alcohol 0.05 g of GA_3 was dissolved and diluted with distilled water to make 1 liter of GA_3 solution of 100 ppm. With same procedure concentrations of 200, 300 and 400 ppm solution were also prepared.

2.5.1 Time of GA_3 Application

Gibberellin was sprayed at 30 and 45 DAT days by using knapsack sprayer. In control treatment water was sprayed at the same time.

2.6 Observations Recorded

Five representative plants from the inner rows of each plot were labeled and tagged in each replication and were used for recording the following parameters.

2.6.1 Plant Height (cm)

The height of the five randomly selected and tagged plants were measured form base of the plant to the tip of the main stem at 45, 60 and 75 days after transplanting. The average height was calculated and expressed in centimeters.

2.6.2 Number of Branches Per Plant

The numbers of branches arising on the main stem and branches per primary branches in five randomly selected and tagged plants were recorded and average was calculated to obtain mean.

2.6.3 Days to Flower Initiation (days)

The number of days taken for commencement of flowering in each plot was recorded by counting the days from date of transplanting to first flower opening in tagged plants.

2.6.4 Days to 50 Percent Flowering (Days)

The number of days taken for 50 per cent of the plants to produce first flower in each plot was recorded by counting the days from date of transplanting and expressed as days to 50 per cent flowering.

2.6.5 Length of Flower Stalk (cm)

Ten flowers were selected randomly from sampled plant and their stalk length was measured and average length of flower stalk was calculated and expressed in centimeter.

2.6.6 Diameter of Flower (cm)

Ten fully opened flowers were selected randomly from the tagged plants and diameter of flower was measured and expressed in centimeter.

2.6.7 Fresh Weight of Flower (g)

After recording number of flowers harvested treatment wise, ten flowers were randomly selected and their total weight was recorded in gram and average fresh weight of single flower was obtained.

2.6.8 Dry Weight of Flower (g)

After recording ten fresh flower weights, the same flowers were oven dried at 60-70⁰ c till it reached constant weight and expressed in gram and average dry weight of single flower was obtained.

2.6.9 Yield Per Plant (g)

Flower yield of sampled plants was recorded and average was calculated as yield per plant and expressed in gram.

2.6.10 Yield of Flower Per Hectare (kg/ha)

The number of flowers per meter square was calculated by using the formula given below and expressed as number of flowers per meter square. Number of flowers/m2 = Number of flowers/plant × Number of plants/m2. The yield (kg/ha) of each treatment represented by = no. of flowers of each plant × weight of individual flowers × Plant population/ha.

2.7 Data Entry and Analysis

The collected data were entered, tabulated and processed in Microsoft Excel. The recorded data on different parameters were analyzed by using GENESTAT software and the means were separated using Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1 Effect of Gibberellin on Plant Height

At 60 DAT significantly higher plant height was recorded in GA_3 300 ppm (109.25cm) however the treatment was found at par with 400 ppm GA_3 and GA_3 200 ppm (102.55 cm). Similarly, at 75 DAT maximum plants height was recorded in $GA_3$300 ppm (117.60cm) in comparison with control treatment (96.40cm) but at par with GA_3 400 ppm (115.3 cm). Enhancement in growth and development at a specific concentration of exogenously applied $GA_3$was also reported by Kumar *et al.* (2014) and Swaroop *et al*. (2007) in African marigold.

Table 2: Effect of different levels of gibberellin on plant height at different stage of marigold in Kanpur, District (August-November2020)

Treatments	Plant height (cm)		
	45 DAT	60 DAT	75 DAT
Control	84.35^{b}	91.10^{d}	96.4^{d}
100 PPM GA_3	92.20^{a}	98.50^{c}	104.9^{c}
200 PPM GA_3	92.10^{a}	102.55^{bc}	110.9^{b}
300 PPM GA_3	98.00^{a}	109.25^{a}	117.6^{a}
400 PPM GA_3	95.90^{a}	107.35^{ab}	115.3^{ab}
Grand mean	92.51	101.75	109.01
CV (%)	4.0	3.9	3.5
SEM (±)	1.863	2.793	1.918
$LSD_{0.05}$	5.740**	6.085***	5.908***

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation.

3.2 Effect of Gibberellin on Plant Spread

At 45, 60 and 75 days after transplanting plant spread were significantly higher in $GA_3$300 ppm (52.40cm, 94.31cm and 94.04cm) which was at par with GA_3 400 ppm (49.60 cm, 92.04 cm and 92.31cm), GA_3 200 ppm (47.25 cm, 88.31 cm and 88.81 cm) whereas significantly lower plant spread was noticed in control treatment (44.70 cm, 79.14 cm and79.14 cm respectively). Similar result was obtained by Ramdevputra *et al.* (2009).

Table 3: Effect of different levels of gibberellin on plant spread at different stages of marigold in Kanpur, District (August-November2020)

Treatments	Plant Spread		
	45 DAT	60 DAT	75 DAT
Control	44.70^{c}	79.14^{d}	79.14^{d}
100 PPM GA_3	45.65^{bc}	85.31^{c}	84.81^{c}
200 PPM GA_3	47.25^{bc}	88.31^{bc}	88.81^{bc}
300 PPM GA_3	52.40^{a}	94.31^{a}	94.04^{a}
400 PPM GA_3	49.60^{ab}	92.04^{ab}	92.31^{ab}
Grand mean	47.92	87.80	87.70
CV (%)	5.5	3.1	2.9
SEM (±)	1.329	1.367	1.270
$LSD_{0.05}$	4.094**	4.213***	3.914***

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation.

3.3 Effect of Gibberellin on Number of Branches Per Plant

The results revealed that plants treated with GA_3at 300 ppm produced the maximum number of branches per plant (18.02) and control had least number of branches per plant (10.05) whereas GA_3 100 ppm, GA_3 200 ppm and $GA_3$400 ppm had 12.30, 15.45 and 17.20 number of branches per plant respectively.

Table 4: Effect of different levels of gibberellin on number of branches per plant of marigold in Kanpur, District (August-November 2020)

Treatments	Number of Branches
Control	10.05^{e}
100 PPM GA_3	12.30^{d}
200 PPM GA_3	15.45^{c}
300 PPM GA_3	18.02^{a}
400 PPM GA_3	17.20^{b}
Grand Mean	14.84
CV (%)	5.9
SEM (±)	0.514
$LSD_{0.05}$	1.585**

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation.

3.4 Effect of Gibberellin on Days to Flower Initiation

Application of GA3 300 ppm induced early flowering (50.25 days) in comparison with control treatment (41 days). Similarly,GA3 200ppm and GA3100 ppm and GA3400 ppm induced flower in 43.50 days, 43 days and 45.75 days, respectively.

3.4.1 Effect of Gibberellin on Days to 50 Percent Flowering

Exogenous application of different concentrations of GA_3 on African marigold cv. Calcutta local was observed statistically significant in days to 50 percent flowering of marigold. Similarly, days to 50 percent flowering was recorded earlier in GA_3 300 ppm sprayed treatment (81.50 days) in comparison with control treatment (67.50 days).The result obtained in the investigation is close with the findings of Shinde et al. (2010) in chrysanthemum.

Table 5: Effect of different levels of gibberellin on days to 50% flowering of marigold in Mandhana, Kanpur (August- November 2020)

Treatments	Days to Flowering	
	Days to 1st Flower Initiation	Days to 50% Flowering
Control	41^{d}	67.50^{e}
100 PPM GA_3	43^{c}	70^{d}
200 PPM GA_3	43.50^{c}	73.75^{c}
300 PPM GA_3	50.25^{a}	81.50^{a}
400 PPM GA_3	45.75^{b}	77.75^{b}
Grand mean	44.70	74.10
CV (%)	2.4	1.8
SEM (±)	0.546	0.666
$LSD_{0.05}$	1.682***	2.053***

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

3.5 Effect of Gibberellin on Length of Flower Stalk

A level of gibberellin was differed significantly higher length of flower stalk was recorded in $GA_3$300 ppm sprayed treatment (4.122 cm) in comparison with GA3 200 ppm (3.972 cm), GA_3 100 ppm (3.90 cm) and control treatment (3.57cm) but at par with GA_3 400 ppm (4.115cm).The increment in stalk length and flower diameter might be due to enhanced

cell division and cell enlargement, promotion of protein synthesis coupled with higher dry matter of apical dominance (Dalai *et al.,* 2009). Similar result was also reported by Tyagi and Kumar (2006).

Table 6: Effect of Different Levels of Gibberellin on Length of Flower Stalk of Marigold in Mandhana, Kanpur (August-November 2020)

Treatments	Length of Flower Stalk (cm)
Control	3.570^{c}
100 PPM GA_3	3.900^{b}
200 PPM GA_3	3.972^{b}
300 PPM GA_3	4.122^{a}
400 PPM GA_3	4.115^{a}
Grand mean	3.935
CV (%)	4.8
SEM (±)	0.0273
$LSD_{0.05}$	0.0842

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

Table 7: Effect of Different Levels of Gibberellin on Diameter of Marigold Flower in Mandhana, Kanpur (August- November 2020)

Treatments	Diameter (cm)
Control	3.835^{c}
100 PPM GA_3	4.020^{c}
200 PPM GA_3	4.272^{b}
300 PPM GA_3	4.720^{a}
400 PPM GA_3	4.420^{b}
Grand mean	4.253
CV (%)	3.7
SEM (±)	0.0788
$LSD_{0.05}$	0.2429***

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. LSD = Least significant difference, SEm = Standard error of mean and CV = Coefficient of variation

3.7 Effect of Gibberellin on Fresh Weight and Dry Weight of Flower

In the present experiment though exogenous application of GA_3 300 ppm, fresh weight and dry weight of flower were found higher (4.228 g and 0.7240 g respectively) which were at par with GA_3 400 ppm (3.937 g and 0.6990 g) compared to control (3.235g and 0.5142g).

Table 8: Effect of Different Levels of Gibberellin on Fresh Weight and Dry Weight of Marigold in Mandhana, Kanpur (August- November 2020)

Treatments	Fresh Weight and Dry Weight of Flower (g)	
	Fresh Weight of Flower	Dry Weight of Flower
Control	3.235^{c}	0.5142^{c}
100 PPM GA_3	3.395^{bc}	0.6150^{b}
200 PPM GA_3	3.788^{ab}	0.6385^{ab}
300 PPM GA_3	4.228^{a}	0.7240^{a}
400 PPM GA_3	3.937^{a}	0.6990^{ab}
Grand mean	3.716	0.638
CV (%)	8.6	9.9
SEM (±)	0.1590	0.0315
$LSD_{0.05}$	0.4899**	0.0971**

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

3.8 Effect of Gibberellin on Flower Yield

Higher yield per plant was recorded in $GA_3$300 ppm sprayed treatment (358.2 g) in comparison with GA_3 200ppm (271.8 g), $GA_3$100 ppm (260.8 g) and control treatment (205.3 g) but at par withGA_3 400ppm (344.5 g). Similarly, significantly higher yield per hectare was recorded in $GA_3$300 ppm sprayed treatment (14.99 t/ha) in comparison with $GA_3$400 ppm (13.5 t/ha), $GA_3$200 ppm (11.10 t/ha), GA_3 100 ppm (9.65 t/ha) and control treatment (7.35 t/ha) respectively. The result was in close conformity with Sunith *et al.* (2007), Kumar *et al.* (2015), Verma and Arha (2004) observed maximum flower yield per hectare with GA_3 treatment in African marigold.

Table 9: Effect of Different Levels of Gibberellin on Flower Yield of Marigold in Mandhana, Kanpur (August- November 2020)

Treatments	Flower Yield	
	Yield Per Plant (g)	Yield Per Hectare (t/ha)
Control	205.3^{c}	7.35^{d}
100 PPM GA_3	260.8^{b}	9.65^{c}
200 PPM GA_3	271.8^{b}	11.10^{bc}
300 PPM GA_3	358.2^{a}	14.99^{a}
400 PPM GA_3	344.5^{a}	13.05^{ab}
Grand Mean	288.1	11.23
CV (%)	9.1	12.9
SEM (±)	13.69	0.722
$LSD_{0.05}$	42.20***	2.223

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. LSD = Least significant difference, SEm = Standard error of mean and CV = Coefficient of variation

4. Conclusion

In this study, GA_3at different concentrations (control, 100 ppm, 200 ppm, 300 ppm and 400 ppm) were applied exogenously to the African marigold cultivar Calcutta local to evaluate the effect of GA_3in growth, development and flowering in African marigold and obviously the prime important "the yield". Based on the information obtained on growth parameters, phenological parameters, yield and yield parameters, it is concluded that, 300 ppm GA_3showed marked influenced on plant growth, flowering and yield parameters of marigold under Kanpur district condition. In some cases, some of the treatments were showing statistically at par effects but still the improvement is realized from the analysis of the calculated data obtained from the field.

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