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Effect of Growth Regulators on Plant Growth and Flower Yield in Marigold (*Tagetes erecta*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out in the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. During rabi season (2022-2023). The aim of this study was to determine the effect of different growth regulators on plant growth, flowering and flower yield of African marigold and to estimate the economics of different treatments. This experiment was laid out in Randomized block design (RBD) with 10 treatments and each treatment replicated thrice. The treatments consist of different combinations of plant growth regulators (Gibberellic acid, Salicylic acid and Sea weed extract). Treatment T3 (Gibberellic acid @150ppm) was statistically significant compared to other treatment combination, which recorded highest plant height (44.11 cm), no. of branches (43.53), stem diameter (1.61 cm), no. of leaves (118.93), plant spread (37.17 cm^2), Bud length (0.93cm), days to 1^{st} flowering (66.07 days), Size of flower (8.77cm), Number of flower per plant (34.10), Self-life (8.67 days), single flower wt. (18.28 g) in African marigold (*Tagetes erecta*). The economics estimation revealed that maximum benefit cost ratio was at 2.44.

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1. INTRODUCTION

"Marigold is an important commercial flower crop in India. It belongs to family Asteraceae (Compositae). Marigold plant is popular among Indians because, it can be grown easily in different environmental conditions. In India, African marigold flowers are sold in the market as a loose flower for making garland. Marigold has not only religious importance but it is used during festivals and landscape beautification. It is highly suitable for making flower beds in herbaceous border and also found ideal for newly planted shrubberies to provide colour and fill the gap in landscape. Both leaves and flowers possess medicinal values" [1-5].

"Growth regulators find their extensive use in ornamental crops for modifying their developmental process. Plant growth regulators play an important role in flower production, which in small amount promotes or inhibits or quantitatively modifies growth and development. Gibberellic acid increased to be very effective in manipulating growth and flowering in chrysanthemum" [6-9]. "Salicylic acid (SA) is a phenolic compound of hormonal nature produced by plants and plays an important role in responses to several abiotic stresses and to pathogen attack" [10-14]. The application of seaweed extracts as soil conditioners and foliar sprays has been employed to enhance the growth, yield, and overall productivity of various crops. According to a report from FAO (2006). This study aimed to determine the effect of different growth regulators on plant growth, flowering and flower yield of African marigold and to estimate the economics of different treatments.

2. MATERIALS AND METHOD

This experiment was conducted at Floriculture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (UP) in the month of October to February during the winter season of the year 2022-2023.

The different treatment manipulated as follows T_0 - Control, T_1 - Gibberellic acid 50 ppm, T_2 - Gibberellic acid 100 ppm, T_3 - Gibberellic acid 150 ppm, T_4 – Salicylic acid 50 ppm, T_5 - Salicylic acid 100 ppm, T_6 - Salicylic acid 150 ppm, T_7 – Sew weed extract 50ppm, T_8 Sew weed extract 100 ppm, T_9 - Sew weed extract 150 ppm. The treatments were arranged in a Randomized Block Design (RBD) with 10 treatments in 3 replications.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

Vegetative parameters viz., plant height, number of branches per plant, diameter of stem, number of leaves per plant and plant spread were recorded at different stages of plant growth from 15, 30, 45, 60 and 90 days after transplanting and the results from the observations made are as follows.

3.2 Plant Height (cm)

Significant difference was observed due to different plant growth regulators for plant height, at 90 DAT. The Maximum Plant height at 90 days (44.11 cm) was recorded in the T3(Gibberellic acid @150 ppm), followed by T2 (Gibberellic acid @100 ppm) with (37.79 cm) and the minimum Plant Height at 90 days (40.57 cm) was recorded in T6 (Salicylic acid @150 ppm).

By promoting cell division and elongation, foliar treatment of GA3 may have affected the stem lengthening and canopy expansion. Additionally, under the impact of GA3, which retains swelling force against with the softening of cell wall and increases plant height, growth may be accelerated by osmotic uptake of water and nutrients. Similar findings were found by Pahare et al., (2020) in Asiatic lily and Singh et al., (2013).

3.3 Number of Branches per Plant

Significant difference was observed due to different plant growth regulators for number of branches, at 90 DAT. The Maximum number of branches at 90 days (45.53) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T1 (Gibberellic acid @50 ppm) with (42) and the minimum number of branches at 90 days (39.37) was recorded in T8 (Sea weed extract @100 ppm).

The increase in number of branches per plant application of GA3 may be ascribed to increase cell division and cell enlargement, promotion of

protein synthesis in the plant. Stimulation of branching may also be attributed to the breakage of apical dominance. Similar result were also reported by Singh et al., (2017) in Marigold.

3.4 Stem Diameter (cm)

Significant difference was observed due to different plant growth regulators stem diameter, at 90 DAT. The Maximum stem diameter at 90 days (1.61 cm) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T6 (Salicylic acid @150 ppm) with (1.56 cm) and the minimum stem diameter at 90 days (1.51 cm) was recorded in T9 (Sea weed extract @150 ppm).

Increase in stem diameter is directly proportional to increase in plant height. The maximum plant height was obtained in T3 which may have been lead to maximum diameter of stem T3. With the increase in the concentration of GA3 diameter increases due to a reflection of the stimulation of cambium and its immediate cell progeny. Similar results were also reported by Kumar et al*.,* [15] in Marigold.

3.5 Number of Leaves per Plant

Significant difference was observed due to different plant growth regulators for number of leaves, at 90 DAT. The Maximum number of leaves at 90 days (118.93) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T5 ((Salicylic acid @100 ppm) with (115.53) and the minimum number of leaves at 90 days (107.73) was recorded in T9 (Sea weed extract @150 ppm).

The initiation of more leaves was observed in plants treated with GA3, which may be due to anincrease in cell division, cell elongation, and tissue differentiation. Additionally, a greater number of shoots may have improved leaf commencement (Alhajhoj et al., 2017). Pahare et al*.,* (2020) found that "foliar application thrice a week recorded more no. of leaves". Similar results were obtained by Dahal et al., (2014).

3.6 Plant Spread (cm^2)

Significant difference was observed due to different plant growth regulators for plant spread (cm^2), at 90 DAT. The Maximum plant spread (cm^2) at 90 days (37.17 cm^2) was recorded in the T3 (Gibberellic acid @150ppm), followed by T1 (Gibberellic acid @50 ppm) with (35.94 cm^2) and the minimum plant spread (cm^2) at 90 days (31.93 cm^2) was recorded in T6 (Salicylic acid @150 ppm).

The plants treated with GA3 recorded maximum vegetative growth. This is may be due to an increase in cell division, and tissue differentiation. Similar observation was made by Sympli et al*.,* (2019). Plants treated with GA3 might have accelerated the rates of various physiological and metabolic processes in the plant system that ultimately resulted in better plant growth. Pahare et al*.,* (2020) found that "foliar application thrice a week recorded highest plant spread".

3.7 Flowering Attributes

3.7.1 Bud length (cm)

Significant difference was observed due to different plant growth regulators for bud length. The Maximum bud length (0.93 cm) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T1 (Gibberellic acid @50 ppm) with (0.91 cm) and the bud length (0.85 cm) was recorded in T6 (Salicylic acid @150 ppm).

The increase in the length of the flower bud in GA3 treated plants is due to rapid cell elongation, increased cell divisions and cell enlargement. Justo et al*.,* [16] recorded that foliar application of GA3 significantly increased bud length in carnation.

3.7.2 Days to 1st flowering

Significant difference was observed due to different plant growth regulators for days to 1st flowering, at DAT. The minimum days to 1st flowering (66.07 days) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T5 (Salicylic acid @100ppm) with (66.20 days) and the Maximum days to 1st flowering (69.13 days) was recorded in T8 (Sea weed extract @100 ppm).

The result revealed that foliar application of 200 ppm GA3 significantly advanced days to 1st flowering in Asiatic lily cultivar Litouwen. The reason behind this effect may be due to the stimulation and enhancement of vegetative place we growth. The present findings are in consonance with Singh et al*.,* (2018).

3.7.3 Number of flowers per plant

Significant difference was observed due to different plant growth regulators for number of flowers per plant, at 90 DAT. The Maximum number of flowers per plant at 00 days (34.10) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T2 (Gibberellic acid @100 ppm) with (31.73) and the minimum number of flowers per plant at 90 days (28.40) was recorded in T6 (Salicylic acid @150 ppm).

Increased number of flower is attributed to the production of large number of flower buds along with the fact that termination of vertical growth by pinching lead to more laterals /secondary branches at early stage of growth, which then had sufficient time to accumulate carbohydrates for proper flower bud differentiation producing a greater number of flowers per plant [17-20]. GA3 helps in breaking bud dormancy and acts as florigen initiating flowering. Similar results were also reported by Mithilesh Kumar et al*.,* (2014) in Marigold.

3.7.4 Single flower wt. (g)

Significant difference was observed due to different plant growth regulators single flower weight. The Maximum single flower weight (18.28 g) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T8 (Sea weed extract @100 ppm) with (17.59 g) and the single flower weight (13.75 g) was recorded in T9 (Sea weed extract @150 ppm).

Thus, it was found that single flower weight increased with an increase in GA3 concentrations. Stimulation of the corella growth, pollen germination, and pollen tube growth occurred with the GA3 application which in turn increases weight of flower. Similar results were recorded by Kumar et al., [15]; Ardalani et al*.,* 2014; Kumar and Beniwal, [21]; Tiwari 2018; Sarkar 2018 in marigold and Holkar 2018 in Gladiolus.

3.8 Quality attributes

3.8.1 Flower diameter (cm)

Significant difference was observed due to different plant growth regulators for flower diameter. The Maximum flower diameter (8.77 cm) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T4 (Salicylic acid @50 ppm) with (8.12 cm) and the flower diameter (7.68 cm) was recorded in T0 (Control).

Increased cell elongation, rapid cell division and active cell enlargement due to the application of GA3 might be the reason for increased diameter of the flower.

3.8.2 Self-life (Days)

Significant difference was observed due to different plant growth regulators for self-life. The Maximum self-life (8.67 days) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T2 (Gibberellic acid @100 ppm) with (8.27 days) and the self-life (7.73 days) was recorded in T7 (Sea weed extract @50 ppm).

The data presented in significant effect of growth regulators on self-life of flowers, with GA3 150 ppm concentration. The improvement in flower shelf life might have been due to the increase activity of amylase enzyme by GA3, which hydrolyzed the extensive starch reserves and released the reducing sugar. Reducing sugars being osmotic ally active cause an influence of water, resulting in increased self-life of flowers.

3.8.3 Economics

Significant difference was observed due to different plant growth regulators for gross return. The Maximum gross return (294000 Rs/t) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T2 (Gibberellic acid @100 ppm) with (285000 Rs/t) and the gross return (240000 Rs/t) was recorded in T0 (Control).

Significant difference was observed due to different plant growth regulators for net return. The Maximum net return (173702 Rs/t) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T2 (Gibberellic acid @100 ppm) with (164852 Rs/t) and the net return (120152 Rs/t) was recorded in T0 (Control).

Significant difference was observed due to different plant growth regulators for benefit cost ratio. The Maximum benefit cost ratio (2.44) was recorded in the T3 (Gibberellic acid @150 ppm), followed by T2 (Gibberellic acid @100 ppm) with (2.37) and the benefit cost ratio (2) was recorded in T0 (Control).

Table 1. Effect of different levels of growth regulators on plant growth of Marigold (90 days after planting)

Treatment Symbol	Treatment	Plant height (cm)	Number of branches per plant	Diameter of stem (cm)	Number of leaves per plant	Plant spread (cm^2)
T_0	Control	41.24	40.2	1.53	109.2	34.99
T_1	Gibberellic acid 50 ppm	41.18	42	1.55	114.87	35.94
T_2	Gibberellic acid 100 ppm	42.75	41.13	1.54	108.87	34.53
T_3	Gibberellic acid 150 ppm	44.11	43.53	1.61	118.93	37.17
T_4	Salicylic acid 50 ppm	41.63	39.47	1.55	109.87	34.37
T_5	Salicylic acid 100 ppm	41.35	40.5	1.51	115.53	33.64
T_6	Salicylic acid 150 ppm	40.57	40	1.56	111.33	31.93
T_7	Sea weed extract 50 ppm	41.77	39.73	1.53	110.73	33.33
T_8	Sea weed extract 100 ppm	42.44	39.37	1.55	110.73	34.83
T_9	Sea weed extract 150 ppm	40.88	41.13	1.51	107.73	32
F-Test		**S**	**S**	**S**	**S**	**S**
SE(d)		**0.68**	**0.69**	**0.02**	**3.09**	**1.22**
C.D at 5%		**1.43**	**1.45**	**0.04**	**6.42**	**2.53**
C.V		**2**	**2.1**	**1.76**	**3.39**	**4.37**

Table 2. Effect of different levels of growth regulators on flowering parameters of marigold

Treatment Symbol	Treatment	Bud length (cm)	Days taken to 1st flowering	Number of flowers per plant	Weight (g) of single flower	Flower diameter (cm)	Self-life (Days)
T_0	Control	0.9	68.43	30.07	13.77	7.68	7.87
T_1	Gibberellic acid 50 ppm	0.91	67.20	31.53	16.30	7.97	8.20
T_2	Gibberellic acid 100 ppm	0.87	68.27	31.73	16.50	7.97	8.27
T_3	Gibberellic acid 150 ppm	0.93	66.07	34.10	18.28	8.77	8.67
T_4	Salicylic acid 50 ppm	0.87	67.73	28.80	17.18	8.12	7.87
T_5	Salicylic acid 100 ppm	0.9	66.20	30.00	15.04	7.82	8.07
T_6	Salicylic acid 150 ppm	0.85	67.33	28.40	14.18	7.87	8.07
T_7	Sea weed extract 50 ppm	0.87	68.13	28.80	15.41	8.03	7.73
T_8	Sea weed extract 100 ppm	0.87	69.13	29.27	17.59	7.94	7.93
T_9	Sea weed extract 150 ppm	0.86	67.40	30.60	13.75	7.75	8.00
F-Test		**S**	**S**	**S**	**S**	**S**	**S**
SE(d)		**0.01**	**0.76**	**1.26**	**1.07**	**0.20**	**0.13**
C.D at 5%		**0.03**	**1.59**	**2.66**	**2.24**	**0.43**	**0.28**
C.V		**2.47**	**1.37**	**5.12**	**8.30**	**3.19**	**2.06**

Table 3. Economics of various treatments in marigold cultivation

Treatments	Cost of cultivation (Rs/ha)	Flower yield(t/ha)	Selling price/ha	Gross return (Rs/t)	Net return (Rs/t)	Benefit costratio
T0 – Control	119848	8	30000	240000	120152	2.00
T1 - Gibberellin acid 50 ppm	119998	9.2	30000	276000	156002	2.30
T2 - Gibberellin acid 100 ppm	120148	9.5	30000	285000	164852	2.37
T3 - Gibberellin acid 150 ppm	120298	9.8	30000	294000	173702	2.44
T4 - Salicylic acid 50 ppm	120238	8.4	30000	252000	131762	2.09
T5 - Salicylic acid 100 ppm	120628	8.6	30000	258000	137372	2.13
T6 - Salicylic acid 150 ppm	121018	9	30000	270000	148982	2.23
T7 - Sea weed extract 50 ppm	120148	8.5	30000	255000	134852	2.12
T8 - Sea weed extract 100 ppm	120448	8.9	30000	267000	146552	2.21
T9 - Sea weed extract 150 ppm	120748	9.1	30000	273000	152252	2.26

4. CONCLUSION

From the present investigation it is concluded that the treatment (T_3) (Gibberellic acid @150ppm) was found to be the best in terms of plant height (44.11 cm), number of branches (43.53), diameter of stem (1.61 cm), number of leaves (118.93), plant spread (37.17 cm^2), bud length (0.93 cm), days taken 1^{st} flowering (66.07 days), size of the flower (8.77 cm), number of flower per plant (34.10), Weight of single flower (18.28 g), self-life for this treatment shows (8.67 days) which is best among other treatments. The highest benefit cost ratio was found in the same treatment with 2.24.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Abadi D. II. Yield and quality management of Rosa hybrida Polson' will plant growth regulators. American-Eurasian J. Agril. Envi. Sci. 2010;8(6):736-7-40.
2. Basit Abdul, Shah Kamran, Salicylic acid an emerging growth and flower inducing hormone in marigold (*Tagetes sp. L*.). Pure and Applied Biology. 2018;7(4):1301-1308.
3. Bhuneshwar. An investigation on effect of plant growth regulator on yield and quality parameters of calendula *(Calendula officinalis L.).* TPI. 2022;11(1):839-840.
4. Ramdevputra MV, Deshmukh HN, Butani AM, Savaliya JJ, Pansuriya AG, Kanzaria DR. Effect of different gibberellic acid (GA3) concentrations on growth, flowering and yield of African marigold. The Asin journal horticulture. 2009;4(1):82-85.
5. Suchitha N. Effect of Biostimulants on growth and yield of cut flower of Chrysanthemum (*Dendranthema grandiflora*) cv. Denjigar White. TPI. 2021;10(12):752-756.
6. Chaudhary A, Mishra A. Effect of foliar application of zinc and salicylic acid on flowering and yield of African marigold cv. Pusa narangi gainda. Hort Flora Research Spectrum. 2015;4(4):351-355.
7. Dalal SR, Somavanshi AV, Karale GD. Effect of gibberellic acid on growth, flowering, yield and quality of gerbera under polyhouse conditions. International Journal of Agricultural Sciences. 2009; 5(2):355-356.
8. Parinitha D, Seetharamu GK. Effect of bio-stimulants and biofertilizers on quality and yield of Floribunda roses. The Pharma Innovation Journal. 2022;11(9):2372-2376.
9. Dobariya K. Effect of integrated nutrient management and pinching on growth and yield of annual chrysanthemum. TPI. 2023;12(7) 483-488.
10. Gayatri K, Singh LJ, Maitra S, Mandal S. Influence of foliar application of Gibberellic acid on growth, development, yield and biochemical constituents of African marigold cv. Pusa Narangi Gainda Journal of Pharmacognosy and Phytochemistry. 2019;8(4):1581-1585.
11. Kanwar J, Khandelwal SK. Effect of plant growth regulators on growth and yield of African marigold (*Tagetes erecta* Linn.). Madras Agricultural Journal. 2013;100(1-3):45-47.
12. Kumar PS, Bhagawati R, Kumar R, Ronya T. Effect of plant growth regulators on vegetative growth, flowering and corm production of gladiolus in Arunachal Pradesh. J. Orna. Hort. 2008;11(4):265-270.
13. Saha M, Shukla N, Sangeeta. conducted on Effect of GA, and Ethrel along with pinching on yield of Marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. The Pharma Innovation Journal. 2019;8(9):18-19.
14. Moond SK, Gehlot R. Flowering and yield responses of chrysanthemum to foliar application of GA3. CCC and MH. Haryana J. Hort. Sci. 2007;36(3/4):280- 281.
15. Kumar R, Mohan R, Gaur GS. Effect of GA3 and Ethrel on growth and flowering of African marigold cv. Pusa Narangi Gainda. Indian Journal of Horticulture. 2010;67: 362-366.
16. Justo CB, Singh D, Fatmi U, Jose DA. Effect of plant growth regulators, gibberellic acid (GA3) and naphthalene acetic acid (NAA) on growth and yield of ~ 3458 ~ International Journal of Chemical Studies carnation (*Dianthus caryophyllus* L.) under naturally ventilated polyhouse. Plant Archives. 2017;17(2): 803-812.
17. Nowak J, Mynett K. The effect of growth regulators on post-harvest characteristics of cut *Lilium* 'Prima' inflorescences. Acta Horticulturae. 1985;167:109- 116.
18. Meshram P, Badge S, Gaidhani A. Influence of Foliar Application of Gibberellic Acid and NAA on Growth,

Quality and Flower Yield in African Marigold. Journal of Agroecology and Natural Resource Management. 2015;2(2):162–164.
19. Sujatha A Nair, Singh V, Sharma TVRS. Effect of plant growth regulator on gerbera (*Gerbera jamesoni*) Indian J. Hort. 2002;60(2):192-194.
20. Tripathi AN, Tripathi SN, Shukla RK, Pandey G. Effect of GA3, NAA and CCC on growth and flowering of French marigold. Journal of Applied Horticulture, Lucknow. 2003;5(2):112-113.
21. Kumar VS. Conducted on Effect of plant growth regulators on flower quality, yield and post-harvest shelf life of China aster. International Journal of Agricultural Science and Research (IJASR). 2017;7(2): 297-304.
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