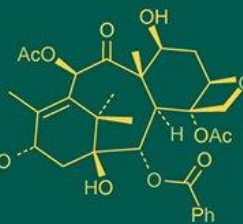
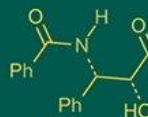


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Response of different plant growth regulators on growth, flowering and yield of african marigold (*Tagetes erecta* L.)

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Abstract

An experiment was conducted at the Research Farm, Department of Horticulture, Raja Balwant Singh College, Bichpuri, Agra (U.P.) during 2023–24 to study the response of different plant growth regulators on the growth, flowering, and yield of marigold (*Tagetes erecta* L.). The experiment was laid out in a Randomized Block Design with three replications and ten treatments. The treatments consisted of foliar applications of GA₃ at 50, 100, and 150 ppm; NAA at 50, 100, and 150 ppm and Ethrel at 50, 100, and 150 ppm, along with a control (water spray). Among all the treatments, GA₃ at 100 ppm proved to be the most effective in improving vegetative growth, flowering characters, and flower yield of marigold. The maximum plant height (62.1 cm), number of branches (25.4), flower diameter (7.9 cm), number of flowers per plant (41.7), flower yield per plant (331.8 g), and flower yield per hectare (148.8 q) were recorded under the GA₃ 100 ppm treatment. This treatment also reduced the number of days taken for flower bud appearance and opening of the first flower. Therefore, foliar application of GA₃ at 100 ppm may be recommended for improving the growth and flower yield of marigold.

Keywords: Marigold, GA₃, NAA, Ethrel, flowering, flower yield, plant growth regulators

Introduction

Marigold (*Tagetes erecta* L.) is one of the most important and commercially cultivated ornamental flower crop belonging to the family Asteraceae. It occupies a prominent position in floriculture owing to its attractive flower colour, wide adaptability, ease of cultivation and prolonged flowering period. Marigold is extensively grown throughout India for loose flower production, garland making, religious offerings, landscaping and decorative purposes. Due to its excellent keeping quality and higher productivity, it has become one of the most preferred flower crops among commercial growers. Apart from ornamental value, marigold also possesses considerable medicinal and industrial importance. The flowers are rich in carotenoid pigments, particularly xanthophylls, which are extensively used in poultry feed, food colouring and pharmaceutical industries. The essential oils extracted from marigold flowers exhibit antimicrobial, antifungal and nematocidal properties. Because of these diverse uses, the demand for quality marigold flowers has increased considerably in recent years. Growth, flowering and yield of ornamental crops are greatly influenced by environmental conditions, nutrient management and endogenous hormonal balance within the plant system. Among these factors, plant growth regulators (PGRs) play a significant role in regulating various physiological and biochemical processes associated with plant growth and development. Plant growth regulators are known to influence cell division, cell elongation, flowering behaviour, photosynthesis, assimilate translocation and sink-source relationship in plants.

Gibberellic acid (GA₃) is one of the most important growth-promoting hormones which stimulates cell division, stem elongation and flowering in many ornamental crops. It enhances vegetative growth and improves flower quality through increased metabolic activities and mobilization of nutrients. Naphthalene acetic acid (NAA), a synthetic auxin, plays an important role in promoting vegetative growth, root development, flower retention and fruit setting. Ethrel (ethephon), an ethylene-releasing compound, regulates flowering, senescence and various physiological activities in plants.

Several workers have reported that plant growth regulators improve vegetative growth, flowering behaviour and yield of African marigold. Application of GA₃ and NAA has been reported to increase plant height, branching, flower size, number of flowers and flower yield in African marigold cv. Pusa Narangi Gaiinda (Kumar *et al.*, 2012; Kumar *et al.*, 2014; Palei *et al.*, 2016; Mishra, 2017) [3, 4, 9, 6]. Similar beneficial responses of GA₃ and other bioregulators have also been recorded in studies on African marigold under different agro-climatic situations (Kanwar and Khandelwal, 2013; Ramdevputra *et al.*, 2009; Acharya *et al.*, 2021) [2, 14, 1].

In recent years, commercial cultivation of marigold has expanded rapidly due to increasing market demand for flowers in social, cultural and religious functions. Therefore, enhancement of flower yield and quality through scientific crop management practices has become essential. However, limited information is available regarding the optimum concentration of plant growth regulators under agro-climatic conditions of Agra region. Hence, the present investigation was undertaken to evaluate the effect of different plant growth regulators on growth, flowering and yield attributes of marigold (*Tagetes erecta* L.).

Materials and Methods

The present investigation was carried out at the Research Farm, Department of Horticulture Raja Balwant Singh College, Bichpuri, Agra (U.P.) during the winter season of 2023–24. The experimental site is situated at 27.20° N latitude and 78.50° E longitude with an elevation of 168 m above mean sea level. The climate of the region is subtropical in nature, characterized by hot summers and cold winters.

The experiment was laid out in Randomized Block Design (RBD) with three replications and ten treatments. The treatments comprised T₀ (Control-water spray), T₁ (GA₃ 50 ppm), T₂ (GA₃ 100 ppm), T₃ (GA₃ 150 ppm), T₄ (NAA 50 ppm), T₅ (NAA 100 ppm), T₆ (NAA 150 ppm), T₇ (Ethrel 50 ppm), T₈ (Ethrel 100 ppm) and T₉ (Ethrel 150 ppm).

Healthy and uniform seedlings of marigold about 4 weeks old were transplanted in well-prepared plots at recommended spacing 30 cm x 45 cm. All the recommended cultural and plant protection practices were followed uniformly for all treatments throughout the crop period. Foliar application of plant growth regulators was carried out at 30 days after appropriate growth stages using a hand sprayer during morning hours.

Observations were recorded on important vegetative, flowering and yield parameters such as plant height (cm), number of branches per plant, days taken to first flower bud appearance, days taken to opening of first flower, length of flower stalk (cm), weight of flower (g), flower diameter (cm), number of flowers per plant, flower yield per plant (g) and flower yield per hectare (q).

The recorded data were subjected to statistical analysis as per the method suggested by Panse and Sukhatme (1978). The significance of treatment effects was tested at 5 per cent level of significance.

Results and Discussion

Effect on growth and flowering parameters

The data presented in Table 1 clearly revealed that different plant growth regulators exerted significant influence on vegetative growth and flowering parameters of marigold.

Considerable variation among the treatments was observed for plant height, number of branches, days taken to flower bud initiation, days taken to opening of first flower and flower stalk length. Among all the treatments, foliar application of GA₃ @ 100 ppm proved superior over other treatments for most of the growth and flowering characters. Maximum plant height (62.1 cm) was recorded under GA₃ 100 ppm treatment, whereas minimum plant height was observed under Ethrel 150 ppm treatment. The promotive effect of GA₃ on plant height might be due to enhanced cell division, cell elongation and increased internodal growth induced by gibberellin activity. Gibberellic acid stimulates synthesis of hydrolytic enzymes and promotes mobilization of nutrients which ultimately enhances vegetative growth. Increased plant height under GA₃ treatment may also be associated with enhanced photosynthetic efficiency and rapid translocation of assimilates to actively growing regions of the plant. Similar increases in vegetative growth due to GA₃ application in African marigold have been reported by Ramdevputra *et al.* (2009), Kumar *et al.* (2012), Kanwar and Khandelwal (2013), and Acharya *et al.* (2021) [14, 3, 2, 1].

The number of branches per plant was significantly influenced by different plant growth regulators. Maximum number of branches (25.4) was recorded under GA₃ 100 ppm treatment followed by NAA 100 ppm, whereas the minimum number of branches (16.8) was recorded in control. Increased branching under GA₃ treatment may be attributed to enhanced vegetative vigour, activation of lateral buds and increased production of photosynthates. Gibberellic acid possibly improved nutrient absorption and metabolic activities within the plant system which resulted in greater vegetative growth and development of more branches. Increased branching directly contributes towards production of higher number of flowers due to availability of more flowering sites. Comparable findings were reported by Kumar *et al.* (2014), Palei *et al.* (2016), Mishra (2017), Kumar *et al.* (2016), Rajyalakshmi and Rajasekhar (2014) and Rajhansa *et al.* (2014) [4, 9, 6, 5, 13, 12].

Minimum days taken to first flower bud appearance (36.6 days) and opening of first flower (37.6 days) were recorded under GA₃ 100 ppm treatment, which was found significantly superior to all other treatments. However, maximum days were recorded in control in this respect. Early flowering under gibberellic acid treatment might be due to enhanced physiological activities, accelerated metabolic processes and early differentiation of floral primordia. GA₃ is known to influence endogenous hormonal balance and stimulate synthesis of flowering-related enzymes and proteins which promote early floral initiation. Enhanced translocation of carbohydrates from source to sink tissues might also have contributed towards early flowering. These findings are in agreement with Kumar *et al.* (2012), Kanwar and Khandelwal (2013), Acharya *et al.* (2021), Sadique *et al.* (2021) and Selvarasu and Abinaya (2022) [3, 2, 1, 16, 17].

Table 1 also indicated that significantly longest flower stalk length (10.1 cm) was observed under GA₃ 100 ppm treatment followed by NAA 100 ppm, while minimum stalk length (6.1 cm) was measured in control. Increased flower stalk length under gibberellin treatment may be due to rapid cell elongation and enhanced growth of peduncle tissues. Improved nutrient mobilization and increased cell

enlargement under GA₃ might have enhanced stalk growth resulting in better flower presentation and market value. Long flower stalks are considered desirable traits in ornamental crops as they improve visual appeal and

handling quality. Similar responses of flowering parameters to plant growth regulators have been reported by Kumar *et al.* (2014), Palei *et al.* (2016), Mishra (2017) and Murugan *et al.* (2020) [4, 9, 6, 7].

Table 1: Effect of plant growth regulators on growth and flowering parameters of marigold

Treatments		Plant height (cm)	Number of branches	Days taken to first flower bud appearance	Days taken to opening of first flower	Length of flower stalk (cm)
T ₀	Control (water spray)	51.6	16.8	46.6	49.54	6.1
T ₁	GA ₃ 50 ppm	58.5	21.8	42.6	43.6	9.1
T ₂	GA ₃ 100 ppm	62.1	25.4	36.6	37.6	10.1
T ₃	GA ₃ 150 ppm	56.5	20.4	39.3	41.3	8.4
T ₄	NAA 50 ppm	53.5	22.6	39.0	42.6	8.2
T ₅	NAA 100 ppm	59.3	23.4	38.3	41.0	9.3
T ₆	NAA 150 ppm	53.3	21.3	41.3	44.0	7.2
T ₇	Ethrel 50 ppm	49.7	21.6	43.0	46.0	8.6
T ₈	Ethrel 100 ppm	47.4	20.0	43.0	46.0	8.8
T ₉	Ethrel 150 ppm	46.7	19.2	39.6	44.0	7.6
SEm±		0.492	0.095	0.258	0.833	0.050
CD (P=0.05)		0.942	0.286	0.542	1.750	0.149

Effect on flower yield and quality parameters

The data presented in Table 2 indicated that different plant growth regulators significantly influenced flower quality and yield attributes of marigold. Significant variation among treatments was observed with respect to flower weight, flower diameter, number of flowers per plant, flower yield per plant and flower yield per hectare.

Among all the treatments, GA₃ 100 ppm recorded significantly maximum flower weight (9.3 g), flower diameter (7.9 cm), number of flowers per plant (41.7), flower yield per plant (331.8 g) and flower yield per hectare (148.8 q) followed by application of 150ppm NAA. However, statistically minimum values were recorded in control with this respect. The improvement in flower quality and yield parameters under GA₃ treatment may be attributed to enhanced vegetative growth, increased photosynthetic activity and better translocation of assimilates towards reproductive organs.

The increase in flower weight and flower diameter under GA₃ application might be due to enhanced cell enlargement and accumulation of carbohydrates in floral tissues. Gibberellic acid possibly stimulated synthesis of proteins, nucleic acids and growth-promoting enzymes which enhanced flower development and quality. Increased flower diameter under GA₃ treatment might also be associated with improved uptake and utilization of nutrients by the plant system. Similar findings were reported by Ramdevputra *et al.* (2009), Kanwar and Khandelwal (2013), Kumar *et al.* (2014), Palei *et al.* (2016) and Sadique *et al.* (2021) [14, 2, 4, 9, 16].

Maximum number of flowers per plant recorded under GA₃ 100 ppm treatment may be due to vigorous vegetative growth, production of more branches and increased flower initiation. Better source-sink relationship and enhanced synthesis of photosynthates under GA₃ treatment might have contributed towards increased flower production. Production of higher number of branches under GA₃ treatment provided more flowering sites which ultimately resulted in higher number of flowers per plant. Similar observations were also reported by Kumar *et al.* (2012), Kumar *et al.* (2016),

Mishra (2017), Acharya *et al.* (2021), Pal *et al.* (2021) and Selvarasu and Abinaya (2022) [3, 5, 6, 1, 17].

Higher flower yield per plant and per hectare observed under GA₃ 100 ppm treatment may be attributed to cumulative effects of increased flower size, higher flower weight and greater number of flowers per plant. Gibberellic acid possibly enhanced photosynthetic efficiency and mobilization of assimilates towards reproductive tissues, thereby improving overall flower production. Enhanced nutrient uptake and improved metabolic activities under GA₃ treatment may also have contributed towards higher flower yield. Similar beneficial effects of GA₃ and other growth regulators on flower yield of African marigold were reported by Ramdevputra *et al.* (2009), Kumar *et al.* (2012), Kanwar and Khandelwal (2013), Palei *et al.* (2016), Reddy (2018), Narute *et al.* (2020) and Acharya *et al.* (2021) [14, 3, 2, 9, 15, 8, 1].

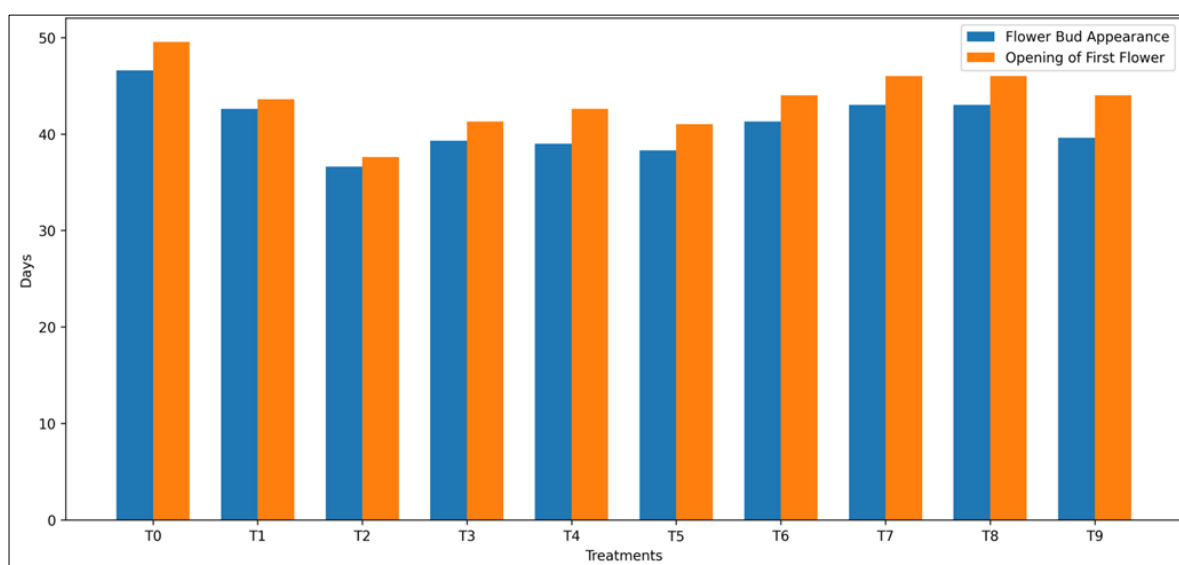
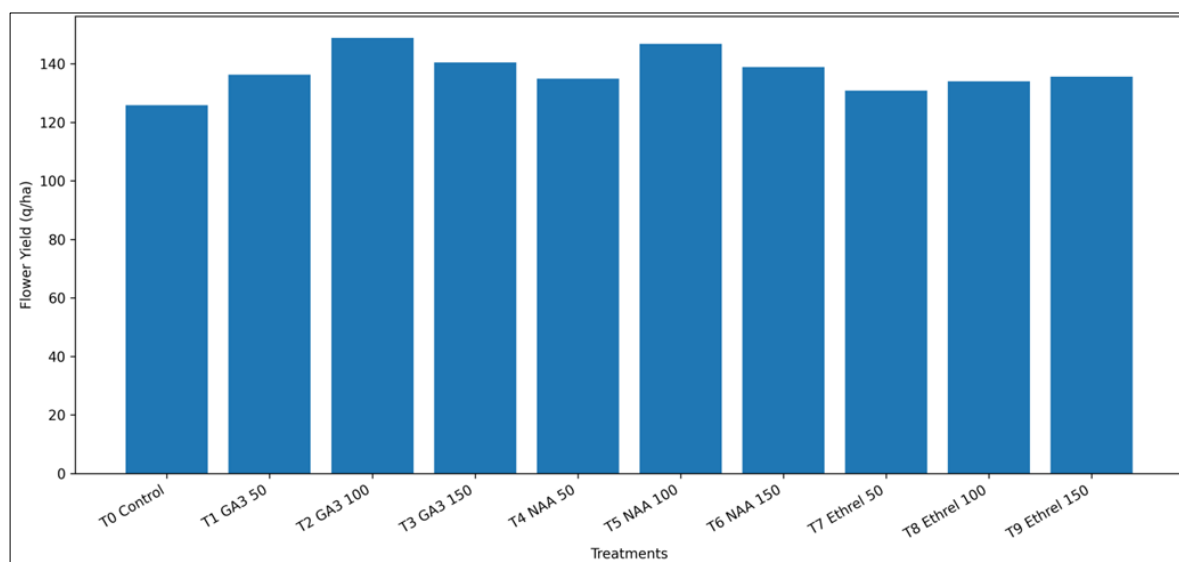
Among the auxin treatments, NAA 100 ppm also performed effectively and remained statistically close to GA₃ 100 ppm for several characters. The favourable effect of NAA on growth and flower yield may be due to improved cell division, enhanced flower retention and better translocation of nutrients and assimilates towards floral organs. Auxin application might have promoted balanced vegetative growth and reproductive development resulting in improved flower yield.

In contrast, Ethrel treatments exhibited comparatively lower values for most of the growth, yield and quality parameters. Excessive ethylene activity induced by Ethrel might have suppressed vegetative growth and adversely affected flower development at higher concentrations. Reduced flower size and lower flower yield under Ethrel treatments may also be associated with inhibition of cell elongation and reduced photosynthetic efficiency.

Control plants recorded minimum values for most of the flowering and yield parameters due to absence of exogenous growth regulator application. Lower vegetative growth and reduced flower production under control treatment indicated the importance of plant growth regulators in enhancing productivity and flower quality of marigold.

Table 2: Effect of plant growth regulators on flower yield and quality parameters of marigold

Treatments	Weight of flower (g)	Diameter of flower (cm)	Number of flowers per plant	Flower yield per plant (g)	Flower yield (q/ha)
T ₀ Control (water spray)	5.5	4.8	27.3	161.9	125.8
T ₁ GA ₃ 50 ppm	8.4	6.6	38.6	261.5	136.3
T ₂ GA ₃ 100 ppm	9.3	7.9	41.7	331.8	148.8
T ₃ GA ₃ 150 ppm	7.2	6.2	36.0	238.0	140.5
T ₄ NAA 50 ppm	6.7	5.9	37.8	219.3	134.9
T ₅ NAA 100 ppm	8.8	6.7	39.4	323.4	146.8
T ₆ NAA 150 ppm	6.8	6.2	34.7	220.9	138.86
T ₇ Ethrel 50 ppm	6.3	5.3	29.4	193.3	130.86
T ₈ Ethrel 100 ppm	6.9	6.0	30.5	226.1	134.06
T ₉ Ethrel 150 ppm	7.1	6.3	32.5	234.0	135.6
SEm±	0.042	0.027	0.311	1.595	0.265
CD (P=0.05)	0.126	0.082	0.932	4.776	0.793

**Fig 1:** Effect of Plant Growth Regulators on Flowering Parameters of Marigold**Fig 2:** Effect of Plant Growth Regulators on Flower yield of Marigold

Conclusion

On the basis of the present investigation, it may be concluded that foliar application of GA₃ @ 100 ppm proved most effective in improving vegetative growth, flowering behaviour and flower yield of marigold under agro-climatic

conditions of Agra region. The treatment significantly increased plant height, number of branches, flower diameter, number of flowers per plant and flower yield, while reducing the number of days taken to flower initiation and opening of first flower.

References

- Acharya S, Ghimire B, Gaihre S, Aryal K, Chhetri LB. Effect of gibberellic acid on growth and flowering attributes of African marigold (*Tagetes erecta*) in inner terai of Nepal. *J Agric Nat Resour*. 2021;4(2):134-147.
- Kanwar J, Khandelwal SK. Effect of plant growth regulators on growth and yield of African marigold (*Tagetes erecta* Linn.). *Madras Agric J*. 2013;100(1-3):45-47.
- Kumar A, Kumar J, Mohan B, Singh JP, Rajbeer, Ram N. Studies on the effect of plant growth regulators on growth, flowering and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. *Ann Hortic*. 2012;5(1):47-52.
- Kumar M, Singh AK, Kumar A. Effect of plant growth regulators on flowering and yield attributes of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. *Plant Arch*. 2014;14(1):363-365.
- Kumar N, Kumar J, Singh JP, Kaushik H, Singh RK. Effect of GA3 and *Azotobacter* on growth and flowering in African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. *Asian J Hortic*. 2016;11(2):382-386.
- Mishra P. Effect of plant growth regulators on growth and flowering characters of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. *Int J Agric Sci Res*. 2017;7(1):173-178.
- Murugan VT, Manivannan K, Nanthakumar S. Studies on the effect of plant growth regulators on growth, flowering and xanthophyll content of African marigold (*Tagetes erecta* L.). *Int J Curr Microbiol Appl Sci*. 2020;9(11):3767-3771.
- Narute TT, Parulekar YR, Narute TK. Effect of plant growth regulators on vegetative parameter of marigold cv. Calcutta marigold under Konkan conditions. *Int J Curr Microbiol Appl Sci*. 2020;9(10):3985-3997.
- Palei S, Das AK, Dash DK. Effect of plant growth regulators on growth, flowering and yield attributes of African marigold (*Tagetes erecta* L.). *Int Educ Res J*. 2016;2(6):44-45.
- Pal H, Malik S, Pal A, Shivran B. Effect of bio-regulators on flowering behavior and yield attributes of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. *Int J Chem Stud*. 2021;9(1):1173-1176.
- Panse VG, Sukhatme PV. Statistical methods for agricultural workers. New Delhi: Indian Council of Agricultural Research; 1978.
- Rajhansa KC, Dikshit SN, Sharma G. Effect of pinching and growth regulators on growth, flowering and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. *J Ornam Hortic*. 2014;16(3&4):126-132.
- Rajyalakshmi R, Rajasekhar M. Effect of different growth regulators (NAA, GA, Cycocel and Ethrel) and pinching on growth and flowering of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda in different dates of planting. *J Res ANGRAU*. 2014;42(1):52-54.
- 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. *Asian J Hortic*. 2009;4(1):82-85.
- Reddy P. Effect of plant growth hormones on growth and flower yield of African marigold (*Tagetes erecta* L.). *Int J Curr Microbiol Appl Sci*. 2018;7(10):3799-3803.
- Sadique S, Anjum MA, Akhtar S, Ahmad R, Ali A, Nazir F, et al. Effect of foliar supplied plant growth regulators on flower growth and antioxidant activity of African marigold (*Tagetes erecta* L.). *Horticulturae*. 2021;7(10):378.
- Selvarasu M, Abinaya D. Effect of plant growth regulators on flowering and yield attributes of African marigold (*Tagetes erecta* L.). *J Pharm Negat Results*. 2022;13(Special Issue):2760-2764.