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Effect of growth regulators on growth and yield of marigold (*Tagetes erecta* L.) cv. BM-3

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Abstract
An experiment was conducted by using plant growth regulators, that is, GA3 and NAA, from December 2020 to April 2021 under the Odisha plains at the Agricultural Research Station, Institute of Agricultural Sciences, Siksha "O" Anusandhan (Deemed to be) University, Bhubaneswar, to find out the optimum concentration of GA3 and NAA for better growth and yield of marigold. The experiment was conducted in a randomized block design with nine treatments, comprising of four levels of Gibberellic acid (25, 50, 75, and 100 ppm) and Naphthalene acetic acid (100, 150, 200, and 250 ppm) with a control. Based on the findings of the present investigation, it is concluded that both GA3 and NAA had a pronounced effect on the growth and yield of marigold as compared to control. Of these two growth regulators, GA3 @100 ppm was found superior in enhancing the growth parameters like plant height (67.87 cm), plant girth (2.37 cm), plant spread (589.90 cm2), number of branches (35.10) and number of leaves (360.56), and flowering characters like the weight of the flower (7.57 gm) and the diameter of the flower (6.50 cm). whereas NAA @250 ppm was found superior in the rest of the flowering characters and yield parameters like number of flowers per plant (52.10), flower yield per plant (371.12), and flower yield per hectare (30.93 ton).

Keywords: Marigold, BM-3, growth regulators, GA_3, NAA

Introduction
Flowers have various meanings in myths and stories, ranging from new life to death, purity to passion. Swellings from tender bud to full bloom, flowers are associated with youth, beauty and pleasure. Marigold, a flowering annual cultivated commercially as a loose flower in India, belongs to the family Asteraceae. The bloom itself symbolizes beauty, warmth, creativity, a drive to succeed and celebration of the dead. It also represents the power, strength and light that lives inside a person. Marigold is a hardy plant with easy culture and wider adaptability, gaining popularity with growers' day by day.

The marigold (*T. erecta* L.) is native to Mexico. Because of its adaptability, popularity, and widespread cultivation in India, it is considered of Indian origin. Marigold flowers are traditionally used for offerings in temples and churches and beautifying the environment during festivals. Marigold cultivated as a loose flower. Loose flowers are in high demand, particularly in Asian nations, and are used to make Veni, rangoli, women's hair adornments, garlands, garden displays, religious gifts, and decorative purposes. The flowers are used in the soap making, perfumery and cosmetic industry, accounting for its carotenoid pigment and essential oil content and also use as poultry feed and textile industry. It is also highly preferred to plant beds in public parks and kitchen gardens to give mass effect. Marigold is habituated of free-flowering, short duration to produce marketable flowers, the broad spectrum of attractive colours like lemon Yellow to yellow, golden yellow to orange attract the attention of flower growers. The colour and shape of flower heads vary according to the variety of strains.

Growth regulators are now widely used and play a key role in plant growth, blooming, and yield by increasing, decreasing, or modifying physiological processes within the plant (Murugan *et al.* 2020) [9]. Gibberellic acid increased to be very useful in managing growth and flowering in marigolds (Kumar *et al.* 2014) [7]. The application of GA_3 in the early stage enhances the development of the plant. Thus, the GA3 allow obtaining the best ratio between vegetative growth and flower production, thereby improving the market quality of flowers. NAA is a growth factor that promotes cell division, cell expansion, and cell elongation in the apical region (Bairwa and Mishra 2017) [3] and also uses as a rooting promoter that increases plant growth by inhibiting shoot length and promoting root length (Ullah *et al*. 2013).

The experiment was conducted to assess the optimum concentration of various growth regulators to cause beneficial effect on the growth, flowering, yield of marigold (*T. erecta* L.) cv. BM-3.

Materials and Method

This experiment was conducted from December 2020 - April 2021 at Agricultural Research Station, Binjhagiri, Chatabara of the Institute of Agricultural Sciences, Siksha "O" Anusandhan (Deemed to be) University, Bhubaneswar, situated at 73 km away from the Bay of Bengal at an altitude of 25.5m above mean sea level (MSL). Geographically it is 20.23º North Latitude and 85.83º East longitude. The experiment was laid out in randomized block design with 3 replications and 9 treatments. The rooted cuttings of marigold cv. BM-3 of 7 days old were collected from BTCC, OUAT Bhubaneswar and transplanted into the field at a spacing of 40 cm × 30 cm during evening time. Immediately after transplanting a light irrigation was given for establishment of rooted cutting marigold. The recommended dose of fertilizer and manure i.e. 100 kg Nitrogen, 100 kg Phosphorous and 100 kg Potassium per hectare and 10 ton per hectare FYM were applied. N, P, K were applied in two split doses. Half dose of Nitrogen along with full dose of Phosphorus and Potash was applied as a basal. Remaining half dose of Nitrogen was applied 45 days after transplanting.

In this present investigation, 9 treatments were tried comprising of four level of Gibberellic acid (25,50,75 and 100 ppm) and Naphthalene acetic acid (100,150,200 and 250 ppm) with control. Spraying of growth regulators were done 2 times i.e. 25 and 40 days after transplanting. The observation on vegetative characters such as plant height, girth, spread, number of branches, number of leaves per plants, flowering characters like days to first bud emergence, days to colour development stage, days to full bloom stage, flower diameter, number of flower per plant and yield character like weight of flower, yield per plant, yield per plots and yield per hectare were recorded in five randomly selected plants per replication in each treatment. Data were analysed by method suggested by Panse and Sukatme (1978) [12].

Result and Discussions

Growth Characters

The growth characteristics were recorded on Table:1 for variables like plant height, plant girth, number of branches, plant spread, and number of leaves per plant.

The present investigation showed that foliar application of plant growth regulators significantly increased all vegetative or growth characteristics. As per Table 1, the maximum plant height of 67.87 cm, plant girth (diameter), i.e., 2.37 cm, number of branches per plant (35.10 no.), plant spread (589.90 cm^2) and number of leaves per plant (360.56 no.) over control (42.07 cm, 1.48 cm, 24.41 no., 444.92 cm2, 249.10 no., respectively) due to the application of GA3 @ 100 ppm. The application of GA3 @100 ppm recorded the maximum in all plant growth characteristics like plant height, plant girth, number of branches, plant spread, and the number of leaves per plant. So GA3 @100 ppm proved to be an optimum concentration for the vegetative growth of marigold.

This might be attributed to the higher concentration of GA3, which is more efficient in cell multiplication and elongation of immature tissues, whereas lesser quantities were less favorable. Palei *et al.* (2016) [11], Doddagoudar *et al.* (2004) [5], and all reported comparable results in marigold. Another reason is that foliar application of GA3 @100 ppm significantly increased the plant's girth compared to the other growth regulator treatments and controls. This may be due to enhanced cell division and cell enlargement, which promote protein synthesis by GA3, resulting in enhanced vegetative growth and increased production. Similar results were reported by Sunitha *et al.* (2007) [17] in the African marigold and incarnations.

Table 1: The growth characteristics were recorded

Treatments	Plant height (cm)	Plant girth (cm)	Number of Branches (No)	Plant spread (cm^2)	Number of leaves/plant (No)
T1 (Control)	42.07	1.48	24.41	444.92	249.10
T2 (GA3 @25ppm)	45.19	1.53	27.94	458.20	299.26
T3 (GA3 @50ppm)	48.07	1.59	28.20	493.55	324.00
T4 (GA3 @75ppm)	54.32	1.81	28.81	552.40	328.90
T5 (GA3 @100ppm)	67.87	2.37	35.10	589.90	360.56
T6 (NAA @100ppm)	52.89	1.61	28.70	549.92	326.50
T7 (NAA @150ppm)	60.89	1.84	29.10	558.20	340.50
T8 (NAA @200ppm)	62.46	1.94	29.20	570.40	340.33
T9 (NAA @250ppm)	64.89	2.01	30.12	575.20	351.43
SEM±	0.10	0.04	0.29	0.12	0.12
CD AT 5%	0.30	0.11	0.87	0.37	0.35

Flower character

The flowering character was recorded on various characteristics such as the number of days taken for first bud emergence, Number of days taken for colour development stage, Number of days taken for full bloom stage, Number of flowers per plant, Weight of the flower, and Diameter of the flower.

All the submitted data were analysed together in one sheet (Table: 2) and as a result, it was found that some treatments, like Number of days taken for first bud emergence, colour development and full bloom stage, T1 (control) took the maximum number of days and T9 (NAA @ 250 ppm) took the minimum number of days. So, the number of flowers per plant in treatment T9 (NAA @ 250 ppm) is higher than the other treatment. As per Table number-2 represent that the minimum days taken for 1st bud emergence i.e., 56.20 days, for colour development stage i.e., 5.12 days, and for full bloom stage i.e. 12.33 days, as a result number of flowers will be more i.e. (52.10 per/plant). It was found that fresh flower weight increased with an increase in GA3 concentrations. Stimulation of the corolla growth, pollen germination and pollen tube growth occurred with the GA3 application, which increases the flower's weight. Similar results were recorded by Kumar *et al.* (2010) [8], Ardalani *et al.* (2014) [2], and

Sarkar D. (2018) [15] in marigold, and Holkar P.S. (2018) [6] in Gladiolus. A significant increase in the number of flowers obtained in different concentrations of NAA might be due to the mobilisation or movement of nutrients into flowers; a similar effect of NAA has been reported by Ramdevputra (2009). A similar result was observed in the experimentation done by Bairwa *et al*. (2017) [3], who recorded the maximum number of flowers in NAA-treated plants @ 250 ppm.

Table 2: All the submitted data were analysed together in one sheet

Treatments	No. of days taken for 1st bud emergence	No. of days taken for color development stage	No. of days taken for full bloom stage	No. of flowers/plant	Wt. of flower (gm)	Diameter of flower head (cm)
T1 (Control)	74.60	6.24	14.18	40.19	5.69	4.00
T2 (GA3 @25ppm)	67.30	5.87	14.01	41.51	6.09	4.10
T3 (GA3 @50ppm)	66.00	5.59	13.83	42.53	6.57	4.50
T4 (GA3 @75ppm)	64.70	5.46	13.22	43.79	7.06	6.20
T5 (GA3 @100ppm)	62.40	5.24	13.08	48.09	7.57	6.50
T6 (NAA @100ppm)	59.30	5.36	13.81	43.09	6.05	4.40
T7 (NAA @150ppm)	61.50	5.26	13.69	46.59	7.02	4.90
T8 (NAA @200ppm)	57.30	5.23	12.81	50.02	7.04	5.40
T9 (NAA @250ppm)	56.20	5.12	12.33	52.10	7.12	5.60
SEM±	0.07	0.08	0.10	0.15	0.13	0.09
CD AT 5%	0.22	0.25	0.31	0.46	0.39	0.27

Yield characters

Yield characters are recorded on (Table: 3) various characteristics like flower yield per plant, flower yield per plot, and flower yield per hectare. The yield characteristics recorded on a single sheet were compiled and analysed. After analysis, it was discovered that the treatment of T9 (NAA @ 250 PPM) showed maximum yield in all three yield characters because the number of flowers per plant would be the maximum.

The favorable effect of NAA might be attributed to a greater amount of carbohydrate accumulation and increased metabolic activities, which lead to the initiation of cell division and cell enlargement through the promotion of protein synthesis coupled with higher dry matter in the apical dominance. That's why the number of flowers and yield will be maximum in NAA treatment (@ 200 ppm). Similar results were also reported by Patel *et al*. (2010) [14] and Dahia *et al*. (2001) [4] in chrysanthemum, in marigolds, Neetu *et al*. (2013) [10] in gladiolus, Parmar *et al*. (2009) [13] in spider lily, and Abadi (2010) [1] in rose.

Table 3: Yield characters are recorded

Treatments	Flower yield/Plant (gm)	Flower yield/ Plot (kg)	Flower yield/ha (ton.)
T1 (Control)	228.69	6.86	19.06
T2 (GA3 @ 25ppm)	252.65	7.58	21.05
T3 (GA3 @ 50ppm)	279.42	8.38	23.29
T4 (GA3 @ 75ppm)	309.13	9.27	25.76
T5 (GA3 @ 100ppm)	364.24	10.93	30.35
T6 (NAA @ 100ppm)	260.81	7.82	21.73
T7 (NAA @ 150ppm)	327.11	9.81	27.26
T8 (NAA @ 200ppm)	352.31	10.57	29.36
T9 (NAA @ 250ppm)	371.12	11.13	30.93
SEM±	5.88	176.40	0.49
CD AT 5%	17.63	528.79	1.47

Conclusion

Based on the findings of the present investigation, it is concluded that both GA3 and NAA had a pronounced effect on the growth and yield of marigold as compared to control. Of these two growth regulators, GA3 @100 ppm was found superior in enhancing growth parameters like plant height, plant girth, plant spread, number of branches, number of leaves, and flowering characters like the weight of the flower and the diameter of the flower. In comparison, NAA @250 ppm was found superior in the rest of the flowering characteristics and yield parameters. So, the application of GA3 @100 ppm and NAA @250 ppm in marigold cultivation may be recommended to the farmers for cultivation in BBSR agroclimatic conditions.

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