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# Effect of Plant Growth Regulators on Flowering Parameter of Marigold cv. Calcutta Marigold under Konkan Conditions

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**A B S T R A C T**

Among the all flowering parameters like, flower diameter, flower stalk length, fresh and dry weight of flower treatment of $GA_3$ was found significant. The maximum average flower diameter (65.48 mm), flower stalk length (9.85 cm), fresh weight (13.05 g/flower) and dry weight (2.69 g/flower) were recorded with $GA_3$ @ 100 ppm treatment. It was also observed that days required for flower appearance from transplanting (58.03) and days from bud initiation to harvest (15.85) were significantly recorded minimum with $GA_3$ @ 100 ppm. The above observations were then followed by $GA_3$ @ 200 ppm where the flower diameter recorded was (64.02 mm), stalk length (9.77 cm), fresh weight (13.00 g/flower) and dry weight (2.68 g/flower). The days required for flower appearance from transplanting and days from bud initiation to harvest recorded in $GA_3$ @ 200 ppm were (58.16) and (16.05) respectively as compared to other treatments and control.

## Introduction

The importance of flowers in the sociocultural and religious lives of the people is absolutely immense and can hardly exaggerate. Flowers have traditional use as well as significance in India. Besides being attractive to human being, flowers have power of attracting insect, which are recognized as predominant pollinators in many fields as well as orchard crops. Maharashtra, Karnataka, Andhra Pradesh, Haryana, Tamil Nadu, Rajasthan, West Bengal are emerging as major floriculture states in India. Suitable climate, availability for transport facilities and market demand provide an ideal situation for flower cultivation in Maharashtra. Maharashtra state has about 5,485 ha area under different flower crops with a production of 29,080 MT of loose flowers and 56,990 MT of cut flowers (Anonymous, 2019). Konkan is narrow strip of land situated along the bank of Arabian Sea

at West and Sahyadri mountains range in east that has got distinct Agro-climatic condition than rest of Maharashtra.

The largest city in Konkan coast, Mumbai, the State capital of Maharashtra is a potential market for all agricultural products and flowers too. There are five other districts in the region *viz.* Palghar, Thane, Raigad, Ratnagiri, Sindhudurg. Konkan is known as non-traditional area for production of commercial flowers. In the region, only 528 ha area is under different flower crops with a production of 3140.95 MT (Anonymous, 2019).

The African marigold plant is hardy, erect and branched, annual and grows about 90 cm tall. Leaves are pinnately divided and leaflets are lanceolate and serrated. The frequent changes in the climate alter the phenophases of the crops and many times it affects plant canopy architecture, initiation of flowering, number of flowers produced per plant as well as size and quality of the flowers. So far, no research work has been conducted under climatic conditions of the Konkan region to alter the phenophases of the marigold by using various agro-techniques like plant growth regulators, plant nutrients or by using other growth promoting substances. Among the plants growth regulators, gibberellins (GA) are the most widely used and proven growth regulators in horticulture crops.

Among the gibberellins, $GA_3$ influences a range of development processes like germination, breaking dormancy, stem elongation, flowering, enzyme induction, leaf and flower senescence, etc. (Brian, 1959) and (Gupta and Chakrabarty, 2013). The plant growth regulator triacontanol (TRIA) has a great role in enhancing growth, yield, photosynthesis, nitrogen fixation, enzymatic activities and level of free amino acids, reducing sugars and soluble proteins. TRIA application increases plant growth, the number of inflorescences and the quality of flower in Chrysanthemum (Skogen, *et al.,* 1982) and (Naeem, *et al.,* 2012). 1-Naphthalene acetic acid i.e. NAA is a plant growth regulator used for thinning in horticulture crops as well as used for root formation Widayani and Ansari, 1990 and Khandekar, *et al.,* 2017.

Cycocel (2-Chloroethyl trimethyl ammonium chloride) i.e. CCC an anti-gibberellin gives dwarfing effect and restricts the growth of the internodes and regulates the plant physiology Cockshull and Emden, 1969 and Bhat, *et al.,* 2011. Generally, it does not affect the yield of flowers.

Keeping in view the scope and increased demand of African marigold (*Tagetes erecta* L.) flowers, the present investigation was undertaken to evaluate the effect of different plant growth regulators on flowering parameters of this crop under Konkan conditions.

## Materials and Methods

The present investigation was conducted during *rabi* season, of the year 2019-20 at Department of Floriculture and Landscape Architecture, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli to elucidate information on effect of different growth regulators on yield of marigold.

This experiment was carried out in randomized block design (RBD) replicated thrice with 9 treatments. The crop African marigold variety Calcutta Marigold was taken for the study with the treatments.

The stock solution was prepared before actual application of treatments. For preparing 1000 ml of stock solution, 1 g $GA_3$ was added and

dissolved in 10 ml of NaOH solution and then this solution was transferred into one litre of volumetric flask and then total volume one litre was prepared with distilled water. For preparation of concentration of 100 ppm $GA_3$ solution, 100 ml of stock solution was taken in volumetric flask and 1 lit volume was made up by using distilled water. By adopting similar procedure, the 200 ppm $GA_3$ solution was prepared.

The remaining three plant growth regulators (PGR) were available in liquid form, therefore these were dissolved in distilled water. Accordingly, different concentrations were prepared.

**Plant growth regulator solutions were prepared as follows**

| Chemicals | Conc. | Chemical used in ml | Water used in ml |
|---|---|---|---|
| **Triacontanol 0.1 % W/W** | 20 ppm | 20 | 980 |
| **Triacontanol 0.1 % W/W** | 30 ppm | 30 | 970 |
| **CCC 50 % SL** | 4000 ppm | 08 | 1000 |
| **CCC 50 % SL** | 5000 ppm | 10 | 1000 |
| **NAA 4.5 % SL** | 10 ppm | 0.24 | 1000 |
| **NAA 4.5 % SL** | 20 ppm | 0.48 | 1000 |

The following methods were used for observations.

## Flowering parameters

The effect of different treatments *viz.*, $GA_3$, TRIA, CCC and NAA at different concentrations on flowering attributes, were recorded carefully by recording following observations to see the effect of different treatments on flowering parameters.

## Days from bud appearance to harvest

The daily monitoring and observations were done to record the number of the days required for first bud appearance on each selected plant per treatment per replication and then average was worked out.

## Days required for initiation of flowering

The experimental plot was monitored daily to observe the days required for opening of first flower for each and every selected plant and further time taken for opening of respective flower. The average was then worked out.

## Number of flowers per plant

After attending the desirable and fully bloomed marketable size and in respective treatment, the harvesting was done manually. Total number of flowers harvested per plant were counted and recorded at each harvest from first to the last harvest. Then the summation of all harvested flowers and average was done to get total number of flowers harvested per plant.

## Flower diameter (mm)

Ten fully opened flowers were selected randomly from the tagged plants per treatment per replication and the diameter of flowers was measured with the help of digital Vernier Caliper and the average flower diameter of flower per treatment per replication was recorded in millimetres.

## Flower stalk length (cm)

The flower stalk length of ten selected flowers per treatment per replication was measured in millimetre with digital Vernier Caliper and average was worked out.

### Average flower fresh and dry weight (g/flower)

Ten flowers per treatment per replication were selected and their weight was recorded in grams with the help of digital balance and then the average was worked out.

## Results and Discussion

### Flowering Parameters

### Days required for flower appearance from transplanting

The variation for early or late flowering is an important PGR effect on marigold that might be directly governed by the apropos use of plant growth regulator. The data pertaining to average days required for flower appearance from transplanting was influenced significantly by the different concentrations of different plant growth regulators. The range extends from 58.03 to 65.37 days which is presented in Table 6.

The minimum average days required for flower appearance was noticed in $T_1$ - $GA_3$ @ 100 ppm (58.03 days) which was significantly at par with $T_2$ - $GA_3$ @ 200 ppm (58.16 days). Then it was followed by $T_7$ - NAA @ 10 ppm (59.99 days) which was at par with $T_8$ - NAA @ 20 ppm (60.19 days), $T_9$ - Control (60.33 days). Whereas, the maximum average days (65.20) for flower appearance was observed in $T_5$ - CCC @ 4000 ppm which was statistically at par with $T_6$ - CCC @ 5000 ppm (65.37 days).

The enhancement in flower formation may be due to increase in the endogenous levels of gibberellin which by virtue of its flower inducing characteristics might have also promoted the first bud formation. The similar observations with $GA_3$ were also made by Patel (1998), Dabas (2000), Pandya (2000), Nath (2005), Kumar *et al.*, (2012), Sherpa (2013), Rajhansa (2014), Wadgave (2016), Markam, (2017), Kumar (2017) in marigold, Shetty (1995) in China aster and Dudhe (2018) in chrysanthemum.

TRIA took more number of days for flower appearance than that of control. The delay in appearance of flower bud and flowers was attributed to various concentration of TRIA used. The late flower appearance was also recorded by Deshmukh (2000) while Patidar recorded minimum days to first flower in marigold plant.

The perusal of data indicates that the various concentrations of CCC treatments have significantly affected the number of days required for flowering. The flowering was delayed, and it was observed that number of days for first flowering required were more than any other treatments.

Close results were recorded by Jalagum (1191), Nath (2005), Pandya (2000), Kumar (2006), Singh *et al.*, (2018), while Joshi (2004) recorded less number of days for flowering with CCC concentration of 500 ppm in China aster. Contrariwise, Kumar *et. al*. (2011) put forth that CCC @ 2000 ppm in marigold did not affect the flower initiation.

The growth regulator effect was seen clearly with the plants treated with NAA. With two different concentrations experimental results were observed in the experiment. The results of the days required for flower appearance from transplanting was significantly reduced resembling to $GA_3$ compared to other treatments. Close to the present results, Dabas (2000), Wadgave (2016), Bairwa *et al.*, (2017) also recorded the results with different concentrations of NAA. Whereas, Jalagum (1991) recorded delayed flowering with NAA @ 100 ppm treated plants in marigold.

## Days from bud initiation to harvest

The average number of days from bud initiation to flower harvest in marigold cv. Calcutta Marigold was significantly influenced by various concentrations of different plant growth regulators, the data relating to number of days from bud initiation to harvest are presented in Table 1.

The range of days is between 15.85 to 20.44 days, which shows minimum days for bud initiation to flower harvest were required in plants treated with $T_1$ - $GA_3$ @ 100 ppm (15.85 days) which was significantly lesser than all other treatments and was statistically at par with $T_2$ - $GA_3$ @ 200 ppm (16.05 days). Then $T_7$ - NAA @ 10 ppm (16.71 days) was at par with $T_8$ - NAA @ 20 ppm (16.73 days). The $T_4$ - TRIA @ 30 ppm (20.12 days) was statistically at par with (20.41 days) and $T_6$ - CCC @ 5000 ppm was at par with $T_5$ - CCC @ 4000 ppm (20.44 days).

As reported in the preceding chapters that different concentrations of growth regulators used have significantly affected the number of days required for flower appearance from transplanting. Minimum days were taken for bud initiation to harvest by the plants treated with $GA_3$. The gibberellins induce different characteristics within the plants, as a result it might have also promoted formation of early buds as well as required minimum days for formation of bud to well-developed flower for harvest. The results are in agreement with observations recorded by Patel (1998), Dabas (2000), Pandya (2000), Patidar (2003), Kumar *et al.*, (2011), Rajhansa (2014), Wadgave (2016), Markam, (2017), Kumar (2017) while Palei *et al.*, (2016) recorded maximum average days for flowering with $GA_3$ @ 100 ppm.

TRIA effect was more or else same as that of control i.e. water sprayed plants. There was not much effect of TRIA on bud initiation to flower formation for harvest. Similar results were obtained by Deshmukh (2000), Patidar (2003) recorded that more duration was recorded with TRIA @ 2.5 ppm while minimum with TRIA @ 2 ppm in marigold, Khandekar *et al.*, (2013) in Bougainvillea.

CCC treatment required maximum average number of days for bud initiation to harvest of flower. Although flowers were observed early but days required for fully bloom stage and harvesting were more. Pandya (2000), Nath (2005), Kumar (2006), Singh *et al.*, (2018) recorded similar results in marigold.

Whereas Joshi (2004) and Dobaria (2012) recorded that, CCC @ 500 ppm and CCC @ 2000 ppm respectively took less number of days for first flower as compare to CCC @ 1000 ppm and CCC @ 1500 ppm in China aster. Kumar *et al.*, (2011) put forth that CCC @ 2000 ppm did not affect the days for bud initiation to formation of flower to harvest in marigold in plants.

The NAA effect was also seen more effective, where less days were recorded for bud to flower harvest compared to control treatment flowers. Wadgave (2016), Bairwa *et al.*, (2017) reported the same in marigold.

## Flower diameter (mm)

Flower diameter is the parameter that will eventually define the quality and suitability of variety as loose flower**.** There was significant difference among the different plant growth regulator treatments with respect to flower diameter, which is presented in Table 2.

Among the growth regulators spray, $T_1$ - $GA_3$ @ 100 ppm recorded significantly highest average flower diameter (65.48 mm) compared to other treatments and it was on par with $T_2$ - $GA_3$ @ 200 ppm (64.02 mm), $T_8$

- NAA @ 20 ppm (62.87 mm), $T_7$ - NAA @ 10 ppm (61.50 mm), $T_3$ - TRIA @ 20 ppm (61.44 mm), $T_4$ - TRIA @ 30 ppm (60.56 mm). The $T_9$ - Control plot resulted flowers with average diameter of 58.05 mm. The lowest diameter (56.37 mm) was obtained by $T_6$ - CCC @ 5000 ppm.

The quality of flowers was significantly changed due to use of PGRs. The diameter of flowers was seen increased in size when applied with PGRs. Girwani (1988), Patel (1998), Kumar *et al.,* (2012), Dobaria (2012), Yadav (2013), Rajhansa (2014), Palei *et al.*, (2016), Markam, (2017), Kumar (2017) observed that application of $GA_3$ with various concentrations effectively increased the size of flower compared control which was similar to the present investigation.

TRIA notably increased the flower diameter likewise other growth regulators. Patidar (2003) and Deshmukh (2000) observed good quality marigold flowers. Skogen *et. al*. (1982) recorded that the quality of *Chrysanthemum morifolium* was increased with the application of TRAI. Wuryaningsih *et al.,* (1997) put forth that TRIA increased flower quality of rose.

The retardant not only reduced the vegetative growth of the plant but also reduced the flower diameter where less quality was also obtained. Same observations were also observed by Jalagum (1991), Sunayana *et al.,* (2017) in marigold. Nath (2005) observed in his experiment on marigold that Cycocel @ 1000 ppm increased flower size than other treatments.

NAA as growth regulator significantly increased the diameter of flowers. Similar observations were recorded by Jalagum (1991), Dabas (2000), Bairwa *et al.,* (2017) in marigold.

**Table.1** Effect of plant growth regulators on days required for flower appearance from transplanting and days from bud initiation to harvest of marigold cv. Calcutta Marigold

| Treatments | Treatment details | Days required for flower appearance from transplanting | Days from bud initiation to harvest |
|---|---|---|---|
| **$T_1$** | $GA_3$ @ 100 ppm | 58.03 | 15.85 |
| **$T_2$** | $GA_3$ @ 200 ppm | 58.16 | 16.05 |
| **$T_3$** | TRIA @ 20 ppm | 62.75 | 19.34 |
| **$T_4$** | TRIA @ 30 ppm | 62.87 | 20.12 |
| **$T_5$** | CCC @ 4000 ppm | 65.20 | 20.44 |
| **$T_6$** | CCC @ 5000 ppm | 65.37 | 20.41 |
| **$T_7$** | NAA @ 10 ppm | 59.99 | 16.71 |
| **$T_8$** | NAA @ 20 ppm | 60.19 | 16.73 |
| **$T_9$** | Control | 60.33 | 19.57 |
| | **Mean** | 10.77 | 18.36 |
| | **S. Em. ±** | 0.25 | 0.15 |
| | **C.D. at 5%** | 0.75 | 0.44 |

**Table.2** Effect of plant growth regulators on flower diameter and flower stalk length of marigold cv. Calcutta Marigold

| Treatments | Treatment details | Average flower diameter (mm) | Average flower stalk length (cm) |
|---|---|---|---|
| **$T_1$** | $GA_3$ @ 100 ppm | 65.48 | 9.85 |
| **$T_2$** | $GA_3$ @ 200 ppm | 64.02 | 9.77 |
| **$T_3$** | TRIA @ 20 ppm | 61.44 | 9.14 |
| **$T_4$** | TRIA @ 30 ppm | 60.56 | 9.10 |
| **$T_5$** | CCC @ 4000 ppm | 58.01 | 6.79 |
| **$T_6$** | CCC @ 5000 ppm | 56.37 | 6.60 |
| **$T_7$** | NAA @ 10 ppm | 61.50 | 9.58 |
| **$T_8$** | NAA @ 20 ppm | 62.87 | 9.53 |
| **$T_9$** | Control | 58.05 | 9.28 |
| | **Mean** | 60.92 | 8.85 |
| | **S. Em. ±** | 1.85 | 0.10 |
| | **C.D. at 5%** | 5.53 | 0.30 |

**Table.3** Effect of plant growth regulators on fresh weight and dry weight of flower of marigold cv. Calcutta Marigold

| Treatments | Treatment details | Average fresh flower weight (g) | Average dry flower weight (g) |
|---|---|---|---|
| **$T_1$** | $GA_3$ @ 100 ppm | 13.05 | 2.69 |
| **$T_2$** | $GA_3$ @ 200 ppm | 13.00 | 2.68 |
| **$T_3$** | TRIA @ 20 ppm | 10.60 | 2.18 |
| **$T_4$** | TRIA @ 30 ppm | 10.54 | 2.17 |
| **$T_5$** | CCC @ 4000 ppm | 8.15 | 1.68 |
| **$T_6$** | CCC @ 5000 ppm | 8.12 | 1.67 |
| **$T_7$** | NAA @ 10 ppm | 11.52 | 2.37 |
| **$T_8$** | NAA @ 20 ppm | 11.49 | 2.32 |
| **$T_9$** | Control | 10.50 | 2.16 |
| | **Mean** | 10.77 | 2.21 |
| | **S. Em. ±** | 0.29 | 0.02 |
| | **C.D. at 5%** | 0.86 | 0.05 |

**Flower stalk length (cm)**

There was significant difference among the flower stalk length treated with diverse concentrations of different plant growth regulators. The data collected regarding flower stalk length is presented in Table 2.

The trial data collected represents that the maximum average flower stalk length was noted in $T_1$ - $GA_3$ @ 100 ppm (9.85 cm) and was on par with $T_2$ - $GA_3$ @ 200 ppm (9.77 cm) and $T_7$ - NAA @ 10 ppm (9.58 cm). Whereas minimum flower stalk length was noted in $T_5$ - CCC @ 4000 ppm (6.79 cm) which was at par with $T_6$ - CCC @ 5000 ppm (6.60 cm).

The increase in stalk length is a direct effect of plant growth regulators used. The

significant increase in the stalk length may be to the characteristics effect of PGRs used which promotes cell division and elongation. In present studied it was observed that maximum average stalk length was recorded in $GA_3$ treated plants. Similar types of observations were made by Girwani (1988), Patel (1998), Dabas (2000), Pandya (2000), Naidu (2011), Kumar *et al*., (2012), Palei *et al.,* (2016), Markam (2017).

TRIA recorded length was found non-significant as compared to regular plant growth. The Control (water spray) effect was close to TRIA effect. Wuryaningsih *et al.,* (1997) found significant difference in stalk length in roses. On the other hand, significantly reduced stalk length was recorded in CCC treated plants. Whereas, Singh *et al.,* (2018) recorded increased length of stalk with treatment of CCC @ 5000 ppm.

NAA being a growth enhancer significantly induced the stalk length. Along with $GA_3$, NAA showed results of cell division and elongation. Close to the results reported by Jalagum (1991), Palei *et al.,* (2016), Bairwa *et al.,* (2017).

## Fresh flower weight (g/flower)

The fresh weight of single flower was influenced significantly by the different plant regulator treatments of marigold as shown in Table 8. The fresh weight of single flower ranged from 8.12 to 13.05 g per flower.

The maximum average fresh flower weight was recorded in $T_1$ - $GA_3$ @ 100 ppm (13.05 g/flower) which was at par with $T_2$ - $GA_3$ @ 200 ppm (13.00 g/flower). Then it was followed by $T_7$ - NAA @ 10 ppm (11.52 g/flower) and was at par with $T_8$ - NAA @ 20 ppm (11.49 g/flower). The treatment $T_3$ - TRIA @ 20 ppm recorded (10.60 g/flower) which was at par with $T_4$ - TRIA @ 30 ppm (10.54 g/flower), $T_9$ - Control (10.50 g/flower). The minimum fresh flower weight recorded was of $T_5$ - CCC @ 4000 ppm (8.15 g/flower) and was at par with $T_6$ - CCC @ 5000 ppm (8.12 g/flower).

The results of present investigation exhibited significant variation in fresh weight of flowers. Such variation among flowers weight could be due to effect of PGR on flower size and number of petals. This variation in flower weight among various plant growth regulator treatments might be attributed to the higher water and carbohydrate level in the flower. Water plays an important role in maintaining the flower turgidity, petal orientation and freshness. This finally results into increased fresh weight of the flower. Similar results were also noted by Girwani (1988), Patel (1998), Dabas (2000), Naidu (2011), Kumar *et al*. (2011), Kumar *et al*. (2012), Dobaria (2012), Rajhansa (2014), Palei *et al.,* (2016), Kumar (2017) in marigold. Markam, (2017) put forth that application of $GA_3$ @ 300 ppm + CCC @ 1500 ppm increased the flower weight compared to any other treatments and combinations in marigold. The increased weight of flowers treated with TRIA was also observed by Skogen *et al.,* (1982) who reported that use of TRIA in chrysanthemum in all increased the quality and value of flower.

The fresh weight per flower was significantly noted less in CCC treated plants. As the size of flower and number of petals might be reduced due to cycocel, the fresh weight was also reduced. The water content in the flowers might be less as compared to other flowers. Close results were observed by Nath (2005), Kumar *et al.,* (2011) in marigold flower. Moreover Dabas (2000), Bairwa *et al.,* (2017) recorded increased weight of flowers when treated with NAA. Sherpa (2013), recorded the fresh weight of flowers with application of NAA @ 50 ppm resulted into production of higher flower weight of marigold.

**Dry flower weight (g/flower)**

The data regarding dry weight of flower is given in Table 8, showed significant difference between different treatments which had different dry flower weight. The dry weight of single flower ranged from 1.67 to 2.69 g per flower.

The maximum average dry flower weight was recorded in $T_1$ - $GA_3$ @ 100 ppm (2.69 g/flower) which was on par with $T_2$ - $GA_3$ @ 200 ppm (2.68 g/flower). These observations were followed by $T_7$ - NAA @ 10 ppm (2.37 g/flower) which was at par with $T_8$ - NAA @ 20 ppm (2.32 g/flower). The treatment $T_3$ - TRIA @ 20 ppm noted (2.18 g/flower), and was at par with the treatments $T_4$ - TRIA @ 30 ppm (2.17 g/flower) and $T_9$ - Control (2.16 g/flower). The minimum dry flower weight was observed in $T_5$ - CCC @ 4000 ppm (1.68 g/flower) and was at par with $T_6$ - CCC @ 5000 ppm (1.67 g/flower).

The results of present experiment revealed significant variation in dry weight of single marigold flower. The results of this experiment are close to the results of Girwani (1988), Patel (1998), Dabas (2000), Naidu (2011), Kumar *et al*. (2011), Kumar *et.al*. (2012), Dobaria (2012), Rajhansa (2014), Palei *et al.*, (2016), Kumar (2017) in case of $GA_3$.

The dried flowers weight of TRIA, CCC and NAA treated plants was parallel to that of fresh flower weight.

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