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***Original Research Paper***

# Effect of plant growth regulators and pinching on growth and flower yield of African marigold (*Tagetes erecta* L.)

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## ABSTRACT

**Marigold is one of the commercially exploited flower crop that belong to the family Asteraceae. Presently, in our country the commercial extraction of marigold carotenoids is becoming popular in many states. The production of economical yield and better quality of marigold flowers, requires proper crop management techniques. Crop regulation and flower forcing are important techniques to make the marigold production profitable. This can be done by adopting pinching and application of PGRs. Hence, an experiment was carried out in the Department of Horticulture, in factorial randamized block design replicated thrice with 14 treatments with two $F_1$ hybrids *viz.*, Gold Benz tall and Maxima yellow. The experiment comprised of $GA_3$ @ 50, 100 and 150ppm, NAA @ 50, 100 and 150ppm, MH @ 250, 500 and 750ppm, Alar @ 200, 400 and 600ppm and pinching with untreated control. The study revealed that the growth parameter like plant height, number of laterals per plant, number of leaves per plant were significantly influenced by the application of $GA_3$ and NAA. Among the varieties, Gold Benz tall performed better for all the growth attributes but var. Maxima yellow performed better for the number of laterals per plant. The plant sprayed with of $GA_3$ @ 150ppm registered the maximum plant height (70.44cm), number of laterals per plant (16.13), number of leaves per plant (383.76) and leaf area (113.51cm$^2$) and control evinced the least values in the growth parameters. Application of $GA_3$ and NAA significantly enhanced flowering when compared to control, while pinching delayed flowering. The treatment of $GA_3$ @ 150ppm in both Gold Benz tall (30.13 and 406.21 g plant$^{-1}$) and Maxima yellow (33.16 and 402.83 g plant$^{-1}$ recorded maximum number of flowers per plant and flower yield respectively as compared to control. Based on the above results, it is revealed that foliar spray of $GA_3$ @ 150 ppm was found to be superior in increasing the yield of flowers in both the varieties.**

**Keywords:** Marigold, growth regulators, $GA_3$, NAA, flowering.

## INTRODUCTION

Marigold is one of the commercially exploited flower crops that belong to the family Asteraceae and genus *Tagetes*. The two main popularly grown species in marigold are *Tagetes erecta* L. and *Tagetes patula* L. which have their origin in Mexico and South Africa, respectively. Presently, in our country, the commercial extraction of marigold carotenoids is done in Cochin (Kerala), Hyderabad (Andra Pradesh), Satyamangalam (Tamil Nadu) and Telagi near Harihar, Davenagere, Haveri and Kolar, Chikmagalur district and around Bangalore (Karnataka). Consequently large area in Karnataka, Andra Pradesh, Tamil Nadu and Maharashtra are under contract farming of marigold for xanthophyll extraction. The production of economical yield and better quality of marigold flowers, requires proper crop management techniques. Crop regulation and flower forcing are important techniques to make the marigold production profitable. Growth regulation can be done by adopting pinching and application of PGRs. The response for these practices may vary depending up on the variety cultivated. Plant growth regulators have gained wide acceptance for optimizing the yield of plants by modifying growth, development and stress behavior (Shukla and Farooqi, 1990). Synthetic plant growth regulators, such as auxins, cytokinins and various growth retardants when applied exogenously to the plant, influence various aspects of plant development and biosynthesis of its important components (Kewalanand and Pandy, 1998). Control of flowering is one of the most important practical aspects in application of plant growth regulators. There are many examples of utilization of plant growth hormones to regulate the flowering in many plants. Hence, the present investigation was undertaken to study the effect of plant growth regulators and special horticultural practice like pinching for increasing yield and quality of flowers.

## MATERIAL AND METHODS

The experiment was carried out in Department of Horticulture, Faculty of Agriculture, Annamalai University during the period 2012-2013 to elucidate information on effect of different growth regulators and pinching on growth and yield of marigold. This experiment was carried out in factorial randamized block design replicated thrice with 14 treatments. Two $F_1$ hybrids namely Gold Benz tall and Maxima yellow were taken for the study with the treatments comprising of $GA_3$ @ 50, 100 and 150ppm, NAA @ 50, 100 and 150ppm, MH @ 250, 500 and 750ppm, Alar @ 200, 400 and 600ppm, pinching and untreated control. These growth regulators were applied as foliar spray to the respective plots as per treatment schedule in two doses at ten days after planting and twenty days after first spray. Pinching was done at twenty days after transplanting. The growth and yield parameters were recorded at different stages of crop growth (30, 45 and 60 days after transplanting). The statistical analysis of data was done by adopting the standard statistical procedure given by Panse and Sukhatme (1967).

## RESULTS AND DISCUSSION

The study revealed that the growth parameter *viz.,* plant height, number of laterals per plant, number of leaves per plant were significantly influenced by the application of growth regulators **(Table 1).** Among the varieties $V_1$ (Gold Benz tall) performed better for all the growth attributes, however, the number of laterals per plant was recorded highest in $V_2$ (Maxima yellow). The plant sprayed with of $GA_3$ @ 150 ppm ($T_3$) registered maximum plant height (70.44 cm) which was followed by $GA_3$ @ 100 ppm ($T_2$) (67.46 cm). Similarly, the data on number of laterals per plant (16.13), showed were maximum under $GA_3$ @ 150 ppm ($T_3$) which was followed by $GA_3$ @ 100 ppm ($T_2$) with 15.16. Among the growth attributes, plant height and number of laterals per plant were significantly increased as the concentration of $GA_3$ and NAA increased. The increase in plant height and number of branches per plant with application of $GA_3$ seems to be due to enhanced cell division and cell enlargement, promotion of protein synthesis coupled with higher dry matter accumulation in the plant. Similar results were also reported by Daddagoudar (2002) in China aster and Dalal *et al.* (2009) in Chrysanthemum.

However, the reduction of plant height in pinched plants is mainly due to elimination of apical dominance and diversion of the plant metabolites from vertical growth to horizontal growth leading to production of more number of branches per plant. As the apical dominance is removed usually the plant itself adjusts to encourage the growth of auxiliary buds, which may be converted into branches. Similar effects were reported by Sen and Naik (1977) in chrysanthemum and Khanna *et al.* (1981) in carnation and Sunitha *et al.* (2007) in African marigold.

The number of leaves per plant also showed similar results with maximum leaves (383.76 / plant) under treatment $GA_3$ @ 150 ppm ($T_3$) and largest leaf area (113.51cm$^2$). The control treatment evinced the least values for all the growth parameters. Variation in number of leaves/ plant was pronounced by the application of different growth regulators. The effects of the $GA_3$ treatments were observed significantly superior to the rest of the treatments. This trend was in concurrence with findings of Narayana Gowda (1985) in China aster and Talukdar and Paswan (1988) in Chrysanthemum.

In general, the yield parameters were significantly varied due to *per se* and interaction effects of growth regulating treatments and varieties **(Table 2).** In the present study, number of days taken for first flowering was significantly altered due to the application of different growth regulators. Pinching hastened the flowering when compared to application of $GA_3$, NAA, MH and Alar. The yield parameters are also significantly influenced due to growth regulator and pinching treatments. Application of $GA_3$ and NAA significantly enhanced flowering when compared to control, while, pinching delayed flowering. Significantly earlier flower initiation were registered

**Table.1 Effect of growth regulators and pinching on vegetative characters in African marigold**

| Treatments | Plant height (cm) | | | Number of laterals/plant | | | Number of leaves/ plant | | | Leaf area/ plant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V1 | V2 | Treatment mean | V1 | V2 | Treatment mean | V1 | V2 | Treatment mean | V1 | V2 | Treatment mean |
| $T_1$ – $GA_3$ 50 ppm | 83.86 | 38.40 | 61.13 | 13.53 | 14.20 | 13.86 | 345.40 | 312.20 | 328.00 | 96.23 | 92.13 | 94.18 |
| $T_2$ – $GA_3$ 100 ppm | 91.48 | 43.44 | 67.46 | 14.73 | 15.60 | 15.16 | 377.80 | 343.33 | 360.56 | 110.00 | 104.36 | 107.18 |
| $T_3$ – $GA_3$ 150 ppm | 93.56 | 45.52 | 70.44 | 15.53 | 16.73 | 16.13 | 399.40 | 368.13 | 383.76 | 116.53 | 110.50 | 113.51 |
| $T_4$ – NAA 50 ppm | 81.14 | 37.48 | 59.31 | 13.33 | 14.00 | 13.66 | 340.00 | 308.00 | 324.00 | 94.83 | 88.86 | 91.85 |
| $T_5$ – NAA 100 ppm | 86.44 | 40.46 | 63.45 | 14.06 | 14.60 | 14.33 | 359.80 | 321.20 | 340.50 | 102.60 | 96.53 | 99.56 |
| $T_6$ – NAA 150 ppm | 88.40 | 41.66 | 65.03 | 14.33 | 15.26 | 14.80 | 367.00 | 335.86 | 351.43 | 108.76 | 102.83 | 105.80 |
| $T_7$ – MH 250 ppm | 74.48 | 33.58 | 54.03 | 12.20 | 13.06 | 12.63 | 310.73 | 287.46 | 299.10 | 80.50 | 74.46 | 77.48 |
| $T_8$ – MH 500 ppm | 70.66 | 30.62 | 50.64 | 10.93 | 11.46 | 11.20 | 300.26 | 240.53 | 270.40 | 84.76 | 78.96 | 81.86 |
| $T_9$ – MH 750 ppm | 67.04 | 28.47 | 47.76 | 10.53 | 10.80 | 10.66 | 288.93 | 231.73 | 260.33 | 92.80 | 86.73 | 89.76 |
| $T_{10}$ – Alar 200 ppm | 76.44 | 36.48 | 55.46 | 12.66 | 13.60 | 13.13 | 322.00 | 299.20 | 310.60 | 76.83 | 70.83 | 73.83 |
| $T_{11}$ – Alar 400 ppm | 73.56 | 32.47 | 53.02 | 11.46 | 11.80 | 11.63 | 302.60 | 255.20 | 278.90 | 82.70 | 76.06 | 79.38 |
| $T_{12}$ – Alar 600 ppm | 67.83 | 29.49 | 48.66 | 10.60 | 11.40 | 11.00 | 299.80 | 233.20 | 266.50 | 88.76 | 82.76 | 85.76 |
| $T_{13}$ – Pinching | 65.39 | 26.58 | 45.98 | 9.73 | 10.53 | 10.13 | 284.40 | 214.13 | 249.26 | 68.80 | 62.66 | 65.73 |
| $T_{14}$ – Control | 78.25 | 35.54 | 56.89 | 9.13 | 9.60 | 9.36 | 246.60 | 211.20 | 228.90 | 68.63 | 62.30 | 65.46 |
| **Variety Mean** | 78.59 | 35.58 | 57.09 | 12.53 | 12.85 | 12.69 | 324.62 | 282.97 | 303.79 | 90.91 | 85.00 | 87.95 |
| | **SEd** | **CD($p=0.05$)** | | **SEd** | **CD($p=0.05$)** | | **SEd** | **CD($p=0.05$)** | | **SEd** | **CD($p=0.05$)** | |
| **V** | 0.02 | 0.04 | | 0.33 | 0.66 | | 0.78 | 1.57 | | 0.34 | 0.68 | |
| **T** | 0.06 | 0.12 | | 0.08 | 0.17 | | 2.07 | 4.16 | | 0.90 | 1.80 | |
| **V x T** | 0.09 | 0.18 | | 0.12 | 0.24 | | 2.93 | 5.88 | | 1.27 | 2.55 | |

**(V1-Goldbenz Tall/v2-Maxima Yellow)**

**Table.2 Effect of growth regulators and pinching on flowering and yield characters in African marigold**

| Treatments | Days taken for flower appearance | | | Number of flowers per plant | | | Single flower weight (g) | | | Flower yield per plant (g) | | | Xanthophyll content (mg g$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V1 | V2 | Treatment mean | V1 | V2 | Treatment mean | V1 | V2 | Treatment mean | V1 | V2 | Treatment mean | V1 | V2 | Treatment mean |
| $T_1$ – $GA_3$ 50 ppm | 38.20 | 39.66 | 38.93 | 26.60 | 28.40 | 27.50 | 12.07 | 10.96 | 11.51 | 321.06 | 311.26 | 316.16 | 5.77 | 5.73 | 5.75 |
| $T_2$ – $GA_3$ 100 ppm | 33.20 | 34.40 | 33.80 | 28.26 | 31.20 | 29.73 | 13.07 | 11.96 | 12.51 | 373.15 | 369.35 | 371.25 | 6.56 | 6.52 | 6.54 |
| $T_3$ – $GA_3$ 150 ppm | 31.40 | 32.40 | 31.90 | 30.13 | 33.16 | 31.80 | 13.37 | 12.25 | 12.81 | 406.21 | 402.83 | 404.52 | 6.77 | 6.73 | 6.75 |
| $T_4$ – NAA 50 ppm | 40.00 | 41.46 | 40.73 | 26.53 | 28.00 | 27.26 | 11.76 | 10.68 | 11.22 | 311.99 | 299.04 | 305.51 | 5.58 | 5.54 | 5.56 |
| $T_5$ – NAA 100 ppm | 36.00 | 37.53 | 36.76 | 27.80 | 29.20 | 28.50 | 12.37 | 11.27 | 11.82 | 343.88 | 329.08 | 336.48 | 5.95 | 5.90 | 5.93 |
| $T_6$ – NAA 150 ppm | 35.20 | 36.93 | 36.06 | 28.00 | 30.53 | 29.26 | 12.77 | 11.66 | 12.21 | 357.56 | 355.97 | 356.76 | 6.17 | 6.13 | 6.15 |
| $T_7$ – MH 250 ppm | 42.00 | 43.46 | 42.73 | 24.20 | 26.13 | 25.16 | 9.98 | 8.84 | 9.41 | 241.51 | 230.98 | 236.24 | 4.58 | 4.54 | 4.56 |
| $T_8$ – MH 500 ppm | 45.40 | 47.86 | 46.63 | 21.86 | 23.53 | 22.70 | 10.76 | 9.66 | 10.21 | 235.21 | 227.29 | 231.25 | 4.98 | 4.93 | 4.96 |
| $T_9$ – MH 750 ppm | 48.40 | 50.26 | 49.33 | 21.06 | 22.20 | 21.63 | 11.46 | 10.36 | 10.91 | 241.34 | 229.99 | 235.66 | 5.38 | 5.34 | 5.36 |
| $T_{10}$ – Alar 200 ppm | 41.00 | 42.60 | 41.80 | 24.40 | 27.20 | 25.80 | 9.66 | 8.53 | 9.09 | 235.70 | 232.01 | 233.85 | 4.38 | 4.34 | 4.36 |
| $T_{11}$ – Alar 400 ppm | 43.20 | 45.73 | 44.46 | 22.93 | 23.80 | 23.36 | 10.47 | 9.37 | 9.92 | 240.07 | 223.00 | 231.53 | 4.78 | 4.74 | 4.76 |
| $T_{12}$ – Alar 600 ppm | 47.40 | 49.66 | 48.53 | 21.33 | 23.46 | 22.40 | 11.06 | 9.93 | 10.49 | 235.90 | 232.95 | 234.42 | 5.19 | 5.15 | 5.17 |
| $T_{13}$ – Pinching | 52.60 | 54.46 | 53.53 | 19.46 | 22.13 | 20.80 | 9.16 | 8.07 | 8.61 | 178.58 | 178.25 | 178.41 | 4.08 | 4.04 | 4.06 |
| $T_{14}$ – Control | 50.20 | 52.40 | 51.30 | 18.46 | 19.20 | 18.83 | 9.13 | 8.04 | 8.58 | 168.53 | 154.36 | 161.44 | 4.07 | 4.03 | 4.05 |
| **Variety Mean** | 41.72 | 43.49 | 42.60 | 24.96 | 25.71 | 25.34 | 11.22 | 10.11 | 10.67 | 277.37 | 270.27 | 273.82 | 5.30 | 5.26 | 5.28 |
| | **SEd** | **CD ($p$=0.05)** | | **SEd** | **CD ($p$=0.05)** | | **SEd** | **CD ($p$=0.05)** | | **SEd** | **CD ($p$=0.05)** | | **SEd** | **CD ($p$=0.05)** | |
| **V** | 0.08 | 0.17 | | 0.07 | 0.14 | | 0.03 | 0.05 | | 0.18 | 0.36 | | 0.003 | 0.007 | |
| **T** | 0.23 | 0.47 | | 0.18 | 0.37 | | 0.05 | 0.09 | | 0.34 | 0.69 | | 0.010 | 0.020 | |
| **V x T** | 0.33 | 0.67 | | 0.26 | 0.53 | | 0.07 | 0.14 | | 0.54 | 1.05 | | 0.014 | 0.029 | |

**(V1-Goldbenz Tall/v2-Maxima Yellow)**

in the plants sprayed with $GA_3$ @ 150 ppm in Gold Benz tall (31.40 days) and 32.40 days in Maxima Yellow. However, it was delayed in the plants sprayed with MH @ 750 ppm and Alar @ 600 ppm. Thus, it is evident that the days taken for flower initiation were delayed significantly by spraying growth retardants. In general, it is concluded that $GA_3$ @ 150 ppm promoted flowering in both Gold Benz tall (31.40 days) and Maxima yellow (32.40 days). This might be due to synergetic effect of auxins with gibberellins generally obtained in short day plants. The delayed flowering in marigold with the application of MH might be due to lesser mitotic activity and preservation of biosynthesis of gibberellic acid like substances. The present results are in agreement with the findings of Sen and Maharana (1971) and Dutta *et al.* (1993) in chrysanthemum.

The treatment of $GA_3$ @ 150ppm in both Gold Benz tall (30.13 and 406.21 g) and Maxima yellow (33.16 and 402.83 g) recorded maximum number of flowers per plant and flower yield per plant as compared to control. The plant sprayed with of $GA_3$ @ 150ppm registered the maximum number of flowers per plant (31.80) and flower yield per plant (404.52 g) as compared to control. The increase in number of flowers might be due to production of large number of laterals at early stage, which had sufficient time to accumulate reserve carbohydrates for proper flower bud differentiation.

The increase in flower yield by $GA_3$ @ 150 ppm treatment was due to increased number of branches which led to increased number of flowers and improvement in individual flower weight. These findings are in accordance with Kumar and Ugherja (1998), Gupta and Dutta (2000), Rakesh *et al.* (2003) and Singhrot *et al.* (2004) in chrysanthemum.

Among all interaction treatments, $V_1T_3$ (Gold Benz tall $GA_3$ @150 ppm) recorded the highest yield (406.21 g) per plant followed by $V_2T_3$ (Maxima yellow $GA_3$ @ 150 ppm) (402.83 g) per plant. The gibberellin is well known for its promoter effects on cell division and cell elongation. Therefore an increase in single flower weight obtained with the application of $GA_3$ @ 150 ppm might be due to increase in GA activity in the floral buds. Since, the alar is an anti-auxins and also possibly anti-gibberellins too would have reduced the flower size and stalk length. Similar results were also reported by Girwani *et al.* (1990), Gowda and Jayanthi (1991) in marigold, Vijai Ananth and Anburani (2010) and Kumar and Haripriya (2010) in nNerium and Ragaa and Taha (2012) in iris.

Marigold flower production is governed by the extent of which the applied growth regulators are translocated to these floral parts to obtain higher yield of flowers and ultimately xanthophyll yield. Xanthophyll yield was maximum with the treatment $GA_3$ @ 150 ppm and minimum in control ($T_{14}$). Based on the above facts and results of the present studies on growth regulator treatments and pinching on different varieties of marigold, it is revealed that foliar spray of $GA_3$ @ 150 ppm was found to be superior in increasing yield of flowers in both varieties.

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