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# Efficacy of plant growth retardants and their time of application on yield and economics of African marigold

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**Abstract**
In order to evaluate the efficacy of plant growth retardant (paclobutrazol and cycocel) and their time of application on yield and economics of marigold an investigation was carried out. The experiment was carried in two seasons i.e., years in Factorial Randomized Block Design (FRBD) with three replications having twenty one treatment combinations of two plant growth retardants with three doses each *i.e.* Paclobutrazol (PBZ) @ 50, 100 and 150 ppm and Cycocel (CCC) @ 500, 750 and 1000 ppm along with water spray (control) as factor A and three time of application *viz.*, 30 DAT, 45 DAT and 30 and 45 DAT as factor B. The maximum flower yield, gross income net return and B:C ratio was noted with treatment $G_3$: paclobutrazol (PBZ) @ 150 ppm under during both the years (2018-19 and 2019-20) and on mean basis, respectively. The result revealed that among the time of application of plant growth retardants, treatment $D_1$: application at 30 DAT registered maximum flower yield, maximum gross income, net return and B:C ratio was recorded under treatment $D_1$:application at 30 DAT during both the years (2018-19 and 2019-20) and on mean basis, respectively.

**Keywords:** Cycocel (CCC), marigold, paclobutrazol (PBZ) plant growth retardants and Time of application

## Introduction
Floriculture is a branch of ornamental horticulture that deals with the cultivation, marketing of flowers and ornamental plants as well as with flower arrangement. The total area under floriculture production in India was 283 thousand hectares with a production of 2295 thousand tonnes loose flowers and 833 thousand tonnes cut flowers (Anonymous, 2021-22) [1]. Marigold is native to Central and South America, especially Mexico, spreads globally in the 16$^{th}$ century. Marigold is a hardy plant with a height of over 150 cm and a lifespan of 120-150 days, with a good shelf-life. It can be grown in different agro-climatic conditions. It also has the advantage of being cultivated in all season. The market offers both loose flowers and garlands that have been made from them. Marigold, a versatile flower, is ideal for beautification, landscape planning, and bedding plants in herbaceous borders and shrubbery due to its variable height and color. The economic yield is significantly affected by different factors. Beside this, Plant growth retardant also plays an important role in plant growth development and flowering production. Therefore, it was decided to conduct experiment trials to evaluate, improve and standardize suitable plant growth retardants with the best dose at the right time for the maximum flower production with improved floral quality in Marigold Pusa Narangi Gainda.

## Materials and Methods
Experiment was carryout at the Horticulture Research cum Instructional Farm, Department of Floriculture and Landscape Architecture, College of Agriculture, IGKV, Raipur (C.G.) during *rabi* season of the year 2018-19 and 2019-20. The experiment was conducted in Factorial Randomized Block Design (FRBD) with three replications having twenty one treatment combinations of two plant growth retardants with three doses each *i.e.* Paclobutrazol (PBZ) @ 50, 100 and 150 ppm and Cycocel (CCC) @ 500, 750 and 1000 ppm along with water spray (control) as factor A and three time of application *viz*. 30 DAT, 45 DAT and 30 and 45 DAT as factor B.

## Results and Dissuasion

### Response of growth retardants

The data on cost of cultivation, gross income, net income and benefit: cost ratio (B:C ratio) of African marigold as influenced by plant growth retardants and their time of application and data are presented in Table 1 and 2.

### Response of plant growth retardants

The data on yield of flowers ha$^{-1}$ of African marigold as influenced by different plant growth retardants are given in Table 1. Among different treatments of plant growth retardants, treatment $G_3$: PBZ 150 ppm observed significantly maximum yield of marigold flowers ha$^{-1}$ but it was statistically similar to treatment $G_2$: PBZ 100 ppm during second year (2019-20) and treatment $G_6$: CCC 1000 ppm during 2018-19 & 2019-20 as well as on mean basis, respectively. Whereas, the minimum yield of flowers ha$^{-1}$ was noted with treatment $G_0$: water spray during both the years and on mean basis, respectively. The maximum cost of cultivation was noted under treatment $G_6$: CCC 1000 ppm followed by treatment $G_5$: CCC 750 ppm and treatment $G_4$: CCC 500 ppm during both the years and on mean basis, respectively. Whereas, maximum gross income was recorded with treatment $G_3$: PBZ 150 ppm followed by treatment $G_6$: CCC 1000 ppm and treatment $G_2$: PBZ 150 ppm during both the years and on mean basis, respectively. The maximum net income was noticed with treatment $G_3$: PBZ 150 ppm followed by treatment $G_6$: CCC 1000 ppm and treatment $G_2$: PBZ 150 ppm during both the years and on mean basis, respectively and maximum B:C ratio was noted under treatment $G_3$: PBZ 150 ppm followed by treatment $G_6$: CCC 1000 ppm and treatment $G_2$: PBZ 150 ppm during both the years and on mean basis, respectively.

### Response of time of application of plant growth retardants

Different application time of growth retardants showed significant impact on yield of marigold flower during both the years as well as on mean basis and data are presented in Table1. The significantly maximum yield of flowers ha$^{-1}$ was recorded with treatment $D_1$: application at 30 DAT, but it was at par to treatment $D_3$: application at 30 and 45 DAT during 2018-19 & 2019-20 as well as on mean basis, respectively. However, treatment $D_2$: application at 45 DAT, noted minimum yield of marigold flowers ha$^{-1}$ during 2018-19 & 2019-20 as well as on mean basis, respectively. The maximum cost of cultivation was noted under treatment $D_3$: application at 30 and 45 DAT as compared to rest of the others treatments during 2018-19 & 2019-20 as well as on mean basis respectively. Whereas maximum gross income was recorded with treatment $D_1$: application at 30 DAT followed by treatment $D_3$: application at 30 and 45 DAT during both the years and on mean basis, respectively, maximum net income was noticed with treatment $D_1$:application at 30 DAT followed by treatment $D_3$:application at 30 and 45 DAT during 2018-19 & 2019-20 as well as on on mean basis, respectively and maximum B:C ratio was noted under treatment $D_1$: application at 30 DAT followed by $D_3$: application at 30 and 45 DAT during 2018-19 & 2019-20 as well as on mean basis, respectively.

### Interaction effect

The interaction effects between plant growth retardants and their time of application was found non-significant with regards to yield of flower ha$^{-1}$ in African marigold during 2018-19 & 2019-20 as well as on mean basis. The maximum cost of cultivation was noted under interaction between $G_6 \times D_3$: application of CCC @ 1000 ppm at 30 and 45 DAT followed by interaction $G_5 \times D_3$: application of CCC @ 750 ppm at 30 and 45 DAT during 2018-19 & 2019-20 as well as on mean basis, respectively. Whereas, maximum gross income was recorded with interaction between $G_3 \times D_1$: application of PBZ @ 150 ppm at 30 DAT followed by interaction between $G_3 \times D_3$: application of PBZ @ 150 ppm at 30 and 45 DAT and interaction between $G_6 \times D_1$: application of CCC @ 1000 ppm at 30 DAT during 2018-19 & 2019-20 as well as on mean basis, respectively. The maximum net income was noticed with interaction between $G_3 \times D_1$: application of PBZ @ 150 ppm at 30 DAT followed by interaction between $G_3 \times D_3$: application of PBZ @ 150 ppm at 30 and 45 DAT and interaction between $G_6 \times D_1$: application of CCC @ 1000 ppm at 30 DAT during both the years and on mean basis, respectively and the maximum B:C ratio was noted under interaction between $G_3 \times D_1$: application of PBZ @ 150 ppm at 30 DAT followed by interaction between $G_3 \times D_3$: application of PBZ @ 150 ppm at 30 and 45 DAT and interaction between $G_6 \times D_1$: application of CCC @ 1000 ppm at 30 DAT during both the years and on mean basis, respectively.

This might be due to the fact that the foliar application of plant growth retardants and their time of application response might have improved the yield and quality of African marigold flowers. Plant growth retardants exhibited their significant yield of flowers ha$^{-1}$ (t). Treatment PBZ at 150 ppm observed maximum yield of flowers ha$^{-1}$ (t). The increase in number and weight of flower may be due to, fact that PBZ suppressed apical dominance, increasing leaf and branch production, resulting in maximum leaf area and more photosynthates diverted to flowers, leading to increased flower size, weight, and yield. Similar findings are noticed by Naik *et al.* (2005) [7] in African marigold. The positive effects of PBZ in increasing flower yield ha$^{-1}$ conformity with the findings of, Atteya and Gendy (2018) [2] in *Tagetes patula*, Nellipalli and Pal (2018) [8] in tuberose, Hamza *et al.* (2019) [3] in Kalanchoe and El-Deen (2020) in Ruellia simplex.

### Response of time of application of plant growth retardants

The results indicated yield of flowers ha$^{-1}$ (t) was recorded maximum under application at 30 DAT. the reason for maximum yield might be due to the more number of branches and maximum plant spread in this treatment had accumulated more carbohydrates through photosynthesis ability since the juvenile phase as well as better absorption of nutrient through improved growth leading to development of higher C: N ratio resulting increasing the flower yield. These results are agreement with the findings, Vaghasia and Polara (2015) [9] in Chrysanthemum, Majeed *et al.* (2017) [6] in marigold, Khan *et al.* (2012) [4] in marigold and Kumar (2017) [5] in marigold cv. 'Pusa Narangi Gainda'.

**Table 1:** Response of plant growth retardants and their time of application on yield of flowers ha$^{-1}$ (t) of African marigold

| Treatment | Yield of flowers ha$^{-1}$(t) | | |
|---|---|---|---|
| | 2018-19 | 2019-20 | Mean |
| **Plant growth retardant (G)** | | | |
| $G_1$ | 19.35 | 22.05 | 20.70 |
| $G_2$ | 21.07 | 23.52 | 22.29 |
| $G_3$ | 24.86 | 26.73 | 25.80 |
| $G_4$ | 19.30 | 20.38 | 19.84 |
| $G_5$ | 20.85 | 23.19 | 22.02 |
| $G_6$ | 23.00 | 25.37 | 24.19 |
| $G_0$ | 17.04 | 17.77 | 17.41 |
| S.Em± | 0.90 | 1.18 | 0.71 |
| CD (P=0.05) | 2.56 | 3.36 | 2.02 |
| **Time of application (D)** | | | |
| $D_1$ | 21.93 | 24.34 | 23.13 |
| $D_2$ | 19.23 | 20.41 | 19.82 |
| $D_3$ | 21.19 | 23.39 | 22.29 |
| S.Em± | 0.59 | 0.77 | 0.46 |
| CD (P=0.05) | 1.68 | 2.20 | 1.32 |
| **Interaction** | | | |
| $G_1D_1$ | 21.11 | 23.06 | 22.08 |
| $G_1D_2$ | 18.14 | 20.29 | 19.21 |
| $G_1D_3$ | 18.81 | 22.80 | 20.81 |
| $G_2D_1$ | 21.96 | 26.20 | 24.08 |
| $G_2D_2$ | 19.67 | 20.05 | 19.86 |
| $G_2D_3$ | 21.59 | 24.29 | 22.94 |
| $G_3D_1$ | 26.69 | 29.34 | 28.02 |
| $G_3D_2$ | 22.12 | 23.47 | 22.79 |
| $G_3D_3$ | 25.77 | 27.39 | 26.58 |
| $G_4D_1$ | 20.12 | 21.14 | 20.63 |
| $G_4D_2$ | 18.22 | 19.09 | 18.66 |
| $G_4D_3$ | 19.58 | 20.90 | 20.24 |
| $G_5D_1$ | 21.62 | 24.85 | 23.23 |
| $G_5D_2$ | 19.52 | 21.67 | 20.60 |
| $G_5D_3$ | 21.39 | 23.04 | 22.22 |
| $G_6D_1$ | 24.47 | 27.41 | 25.94 |
| $G_6D_2$ | 20.70 | 21.72 | 21.21 |
| $G_6D_3$ | 23.85 | 26.98 | 25.41 |
| $G_0D_1$ | 17.56 | 18.37 | 17.96 |
| $G_0D_2$ | 16.24 | 16.61 | 16.42 |
| $G_0D_3$ | 17.32 | 18.34 | 17.83 |
| S.Em± | 1.55 | 2.03 | 1.22 |
| CD (P=0.05) | NS | NS | NS |

**Table 2:** Response of plant growth retardants and their time of application on economic of African marigold

| Treatment | Cost of cultivation (Rs ha$^{-1}$) | | | Gross income (Rs ha$^{-1}$) | | | Net income (Rs ha$^{-1}$) | | | B:C Ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018-19 | 2019-20 | Mean | 2018-19 | 2019-20 | Mean | 2018-19 | 2019-20 | Mean | 2018-19 | 2019-20 | Mean |
| $G_1$ | 1,35,060 | 1,40,339 | 1,37,700 | 2,90,300 | 3,96,900 | 3,43,600 | 1,55,239 | 2,56,560 | 2,05,899 | 2.15 | 2.83 | 2.49 |
| $G_2$ | 1,35,294 | 1,40,573 | 1,37,933 | 3,16,100 | 4,23,240 | 3,69,670 | 1,80,805 | 2,82,666 | 2,31,736 | 2.34 | 3.01 | 2.67 |
| $G_3$ | 1,35,527 | 1,40,806 | 1,38,167 | 3,72,900 | 4,81,200 | 4,27,050 | 2,37,372 | 3,40,393 | 2,88,883 | 2.75 | 3.42 | 3.08 |
| $G_4$ | 1,36,794 | 1,42,073 | 1,39,433 | 2,89,600 | 3,66,780 | 3,28,190 | 1,52,805 | 2,24,706 | 1,88,756 | 2.12 | 2.58 | 2.35 |
| $G_5$ | 1,37,777 | 1,43,056 | 1,40,417 | 3,12,650 | 4,17,360 | 3,65,005 | 1,74,872 | 2,74,303 | 2,24,588 | 2.27 | 2.92 | 2.59 |
| $G_6$ | 1,38,760 | 1,44,039 | 1,41,400 | 3,45,100 | 4,56,660 | 4,00,880 | 2,06,339 | 3,12,620 | 2,59,479 | 2.49 | 3.17 | 2.83 |
| $G_0$ | 1,34,827 | 1,40,106 | 1,37,467 | 2,55,600 | 3,19,920 | 2,87,760 | 1,20,772 | 1,79,813 | 1,50,293 | 1.90 | 2.28 | 2.09 |
| $D_1$ | 1,35,925 | 1,41,204 | 1,38,565 | 3,28,992 | 4,38,094 | 3,83,543 | 1,93,067 | 2,96,889 | 2,44,978 | 2.42 | 3.10 | 2.76 |
| $D_2$ | 1,35,925 | 1,41,204 | 1,38,565 | 2,88,450 | 3,67,457 | 3,27,953 | 1,52,524 | 2,26,252 | 1,89,388 | 2.12 | 2.60 | 2.36 |
| $D_3$ | 1,37,023 | 1,42,302 | 1,39,663 | 3,17,807 | 4,21,045 | 3,69,426 | 1,80,783 | 2,78,742 | 2,29,763 | 2.32 | 2.96 | 2.64 |

**Table 3:** Interaction effect of plant growth retardants and their time of application on economic of African marigold

| Treatment | Cost of cultivation (Rs ha$^{-1}$) | | | Gross income (Rs ha$^{-1}$) | | | Net income (Rs ha$^{-1}$) | | | B:C Ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018-19 | 2019-20 | Mean | 2018-19 | 2019-20 | Mean | 2018-19 | 2019-20 | Mean | 2018-19 | 2019-20 | Mean |
| $G_1D_1$ | 1,35,003 | 1,40,282 | 1,37,642 | 3,16,650 | 4,15,080 | 3,65,865 | 1,81,648 | 2,74,799 | 2,28,223 | 2.35 | 2.96 | 2.65 |
| $G_1D_2$ | 1,35,003 | 1,40,282 | 1,37,642 | 2,72,100 | 3,65,220 | 3,18,660 | 1,37,098 | 2,24,939 | 1,81,018 | 2.02 | 2.60 | 2.31 |
| $G_1D_3$ | 1,35,178 | 1,40,457 | 1,37,817 | 2,82,150 | 4,10,400 | 3,46,275 | 1,46,973 | 2,69,944 | 2,08,458 | 2.09 | 2.92 | 2.50 |
| $G_2D_1$ | 1,35,178 | 1,40,457 | 1,37,817 | 3,29,400 | 4,71,600 | 4,00,500 | 1,94,223 | 3,31,144 | 2,62,683 | 2.44 | 3.36 | 2.90 |
| $G_2D_2$ | 1,35,178 | 1,40,457 | 1,37,817 | 2,95,050 | 3,60,900 | 3,27,975 | 1,59,873 | 2,20,444 | 1,90,158 | 2.18 | 2.57 | 2.38 |
| $G_2D_3$ | 1,35,528 | 1,40,807 | 1,38,167 | 3,23,850 | 4,37,220 | 3,80,535 | 1,88,323 | 2,96,414 | 2,42,368 | 2.39 | 3.11 | 2.75 |
| $G_3D_1$ | 1,35,353 | 1,40,632 | 1,37,992 | 4,00,350 | 5,28,120 | 4,64,235 | 2,64,998 | 3,87,489 | 3,26,243 | 2.96 | 3.76 | 3.36 |
| $G_3D_2$ | 1,35,353 | 1,40,632 | 1,37,992 | 3,31,800 | 4,22,460 | 3,77,130 | 1,96,448 | 2,81,829 | 2,39,138 | 2.45 | 3.00 | 2.73 |
| $G_3D_3$ | 1,35,878 | 1,41,157 | 1,38,517 | 3,86,550 | 4,93,020 | 4,39,785 | 2,50,673 | 3,51,864 | 3,01,268 | 2.84 | 3.49 | 3.17 |
| $G_4D_1$ | 1,36,303 | 1,41,582 | 1,38,942 | 3,01,800 | 3,80,520 | 3,41,160 | 1,65,498 | 2,38,939 | 2,02,218 | 2.21 | 2.69 | 2.45 |
| $G_4D_2$ | 1,36,303 | 1,41,582 | 1,38,942 | 2,73,300 | 3,43,620 | 3,08,460 | 1,36,998 | 2,02,039 | 1,69,518 | 2.01 | 2.43 | 2.22 |
| $G_4D_3$ | 1,37,778 | 1,43,057 | 1,40,417 | 2,93,700 | 3,76,200 | 3,34,950 | 1,55,923 | 2,33,144 | 1,94,533 | 2.13 | 2.63 | 2.38 |
| $G_5D_1$ | 1,37,040 | 1,42,319 | 1,39,680 | 3,24,300 | 4,47,300 | 3,85,800 | 1,87,260 | 3,04,981 | 2,46,121 | 2.37 | 3.14 | 2.75 |
| $G_5D_2$ | 1,37,040 | 1,42,319 | 1,39,680 | 2,92,800 | 3,90,060 | 3,41,430 | 1,55,760 | 2,47,741 | 2,01,751 | 2.14 | 2.74 | 2.44 |
| $G_5D_3$ | 1,39,253 | 1,44,532 | 1,41,892 | 3,20,850 | 4,14,720 | 3,67,785 | 1,81,598 | 2,70,189 | 2,25,893 | 2.30 | 2.87 | 2.59 |
| $G_6D_1$ | 1,37,778 | 1,43,057 | 1,40,417 | 3,67,050 | 4,93,380 | 4,30,215 | 2,29,273 | 3,50,324 | 2,89,798 | 2.66 | 3.45 | 3.06 |
| $G_6D_2$ | 1,37,778 | 1,43,057 | 1,40,417 | 3,10,500 | 3,90,960 | 3,50,730 | 1,72,723 | 2,47,904 | 2,10,313 | 2.25 | 2.73 | 2.49 |
| $G_6D_3$ | 1,40,728 | 1,46,007 | 1,43,367 | 3,57,750 | 4,85,640 | 4,21,695 | 2,17,023 | 3,39,634 | 2,78,328 | 2.54 | 3.33 | 2.93 |
| $G_0D_1$ | 1,34,828 | 1,40,107 | 1,37,467 | 2,63,400 | 3,30,660 | 2,97,030 | 1,28,573 | 1,90,554 | 1,59,563 | 1.95 | 2.36 | 2.16 |
| $G_0D_2$ | 1,34,828 | 1,40,107 | 1,37,467 | 2,43,600 | 2,98,980 | 2,71,290 | 1,08,773 | 1,58,874 | 1,33,823 | 1.81 | 2.13 | 1.97 |
| $G_0D_3$ | 1,34,828 | 1,40,107 | 1,37,467 | 2,59,800 | 3,30,120 | 2,94,960 | 1,24,973 | 1,90,014 | 1,57,493 | 1.93 | 2.36 | 2.14 |

## Conclusion

Based on the results obtained from the experiments conducted under Chhattisgarh plains the following conclusions can be drawn:

Among the different treatments of plant growth retardants application of paclobutrazol (PBZ) @ 150 ppm registered significantly flowers yield$^{-1}$, gross return, net return and B:C ratio of African marigold during both the years and on mean basis, respectively and cost of cultivation during both the years (2018-19 and 2019-20) and on mean basis, respectively.

As regards to the time of application of plant growth retardants, at 30 DAT performed best with regard yield of flowers ha$^{-1}$ maximum gross return, net return and B:C ratio during both the years (2018-19 and 2019-20) and on mean basis, respectively. The maximum yield of flowers ha$^{-1}$ was registered under interaction between $G_3 \times D_1$: application of PBZ @ 150 ppm at 30 DAT, followed by interaction between $G_3 \times D_3$: application of PBZ @ 150 ppm at 30 and 45 DAT and interaction between $G_6 \times D_1$: application of CCC @ 1000 ppm at 30 DAT during both the years (2018-19 and 2019-20) and on mean basis, respectively.

The maximum net income and B:C ratio (Rs 2.96, 3.76 and 3.36 ha$^{-1}$) was noticed with interaction between $G_3 \times D_1$: application of PBZ @ 150 ppm at 30 DAT followed by interaction between $G_3 \times D3$: application of PBZ @ 150 ppm at 30 and 45 DAT with net income and B:C ratio of 2.84, 3.49 and 3.17 during both the years (2018-19 and 2019-20) and on mean basis, respectively.

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