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# Effect of planting date, fertigation and mulch on flowering and yield of African marigold (*Tagetes erecta* L.)

**Toran Lal Sahu, LS Verma, SK Tamrakar and Jitendra Sinha**

**Abstract**
The experiment was carried out to "Study the effect of planting date, fertigation and mulch on flowering and yield of African marigold (*Tagetes erecta* L.)" at experimental farm Pendri, Pt. Kishori Lal Shukla, College of Horticulture and Research Station, Rajnandgaon (C.G.) during *Rabi* 2019-20 and 2020-21. The study consisted of three transplanting dates (15 October, 15 November and 15 December) as factor A, two levels of mulch (black plastic mulch and reusable plastic bag mulch) as factor B along with three levels of fertigation (55, 70 and 85% RDF) and application of 100% RDF through soil application as factor C having 24 treatments combinations. The goal of this study is to define the suitable outcome of different planting dates, mulches and fertigation levels influencing flowering and yield of African marigold.
The results of investigation indicated that the flowering and yield characters were significantly influenced by various treatments of planting date, mulch and fertigation level. The 15 October planting date, black plastic mulch and fertigation with 85% RDF had progressive influence in the flowering and yield characters such as bud appearance, first flowering, 50% flowering, blooming period, flower diameter, fresh and dry weight of flower per plant, with highest and flower yield per hectare.

**Keywords:** African marigold**,** fertigation, mulch and planting date

## Introduction
African marigold (*Tagetes erecta* L.) belongs to the family asteraceae is the most important conventionally exploited flower which is widely cultivated for aesthetic and religious purposes and has a high economic value in both rural and urban parts of the country. Easy growing nature, wider adoptability in different soil & climatic condition make marigold popular. Marigold covers approximately two-third of the total area under loose flowers category in India. The major marigold producing states are Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal and Maharashtra. In Chhattisgarh, area under flower crops is 13,493 hectare with 76,219 MT productions. Marigold is a leading flower crop of Chhattisgarh; it is cultivated in an area of about 5,245 hectares with a production of 42,451 MT (Anonymous, 2020). Marigold production is varied with agro-climatic regions and package of practices opted. The aim of this study is to choose the suitable planting date, mulching material and optimum level of fertilizers application through fertigation for production in Chhattisgarh plain. Planting time is the most important factor which ensures growth and quality of marigold flower. Time of planting is a considerable factor to meet out the demand in particular time for special occasion to fetch higher income. Mulching is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development and efficient crop production. Fertigation is the application of nutrients along with water to the root zone of the plant in small but frequent quantities through the drippers. The main advantages of fertigation are to reduce fluctuations of nutrient availability in the root zone, enhanced nutrient use efficiency, reduced nutrient leaching-loss, saving of time, labor and cost of application.

## Material and Methods
The field experiment was carried out at experimental farm Pendri, Pt. Kishori Lal Shukla, College of Horticulture and Research Station, Rajnandgaon (C.G.) during *Rabi* 2019-20 and 2020-21. There were twenty-four treatments which were the combinations of three planting dates (15 October, 15 November and 15 December), two type of mulches (black plastic mulch and reusable plastic bag mulch) and four fertigation treatments (application of 55, 70 and 85% RDF through fertigation and 100% RDF through soil application). Split- split plot design with three replications was used for study in which planting dates were allotted in the main plots,

mulch in sub-plot and fertigation treatments were assigned in sub-sub plots. Rajnandgaon is located in a dry sub-humid agro-climatic region. The experimental area is situated at 21.10°N latitude and 81.03°E longitudes at an altitude of 307 meters above the mean sea level.

**Treatment detail**

| | | |
|---|---|---|
| | **Main plot – Planting date** | |
| 1. | $D_1$ | 15 October |
| 2. | $D_2$ | 15 November |
| 3. | $D_3$ | 15 December |
| | **Sub plot –Mulches** | |
| 1. | $M_1$ | Black plastic mulch |
| 2. | $M_2$ | Reusable plastic bag mulch |
| | **Sub- sub plot –Fertigation** | |
| 1. | $F_1$ | Fertigation with 55% RDF |
| 2. | $F_2$ | Fertigation with 70% RDF |
| 3. | $F_3$ | Fertigation with 85% RDF |
| 4. | $F_4$ | Soil application with 100% RDF |

## Result and Discussion

### Days to bud appearance

Earlier bud appearance was recorded when seedling were transplanted on 15 October ($D_1$); whereas, more days required for first bud emergence on 15 December transplanting ($D_3$). As regard to the different treatments of mulch, significantly earlier bud appearance was observed in black plastic mulch ($M_1$) than reusable plastic bag mulch ($M_2$). It is evident from data that there was a significant influence in the bud appearance due to fertigation. As regard to fertigation, earliest bud appearance observed with application of 85% RDF through fertigation ($F_3$); however, late bud initiation was found in fertigation with 55% RDF ($F_1$) during 2019-20, 2020-21.

The interaction effect between planting date and fertigation was showed significant during both the years. The treatment combination of 15 October planting with application of 85% RDF through fertigation ($D_1 \times F_3$) registered significantly earliest bud appearance; while, the maximum days taken to bud appearance in 15 December planting with application of 55% RDF by means of fertigation ($D_3 \times F_1$) during 2019-20 and 2020-21.

### Days to first flowering

The 15 October planting gave earliest first flowering followed by 15 November planting; whereas, delayed flowering on 15 December planted crop. In case of mulch, significantly earlier flowering was recorded in black plastic mulch as compared to reusable plastic bag mulch. Considering the fertigation treatments minimum period from transplanting to first flowering was noted in fertigation with 85% RDF ($F_3$); while, delayed first flowering recorded with application of 55% RDF ($F_1$) through fertigation during both the years of experiment.

The combined effect of planting date and fertigation showed significant difference, 15 October planting with application of 85% RDF through fertigation registered significantly minimum number of days taken for first flowering; while, delayed flowering in 15 December planting with application of 55% RDF through fertigation during 2019-20 and 2020-21.

### Days to 50% flowering

The perusal of data presented on Table 3 illustrated that 15 October planting recorded minimum days taken to complete 50% flowering followed by 15 November planting; whereas, maximum period on 15 December planting. Among the mulch treatments, significantly earlier 50% flowering was recorded with black plastic mulch as compared to reusable plastic bag mulch. As respect to the fertigation treatments, application of 85% RDF *via* fertigation ($F_3$) resulted significantly minimum period from transplanting to 50% flowering; while, fertigation with 55% RDF ($F_1$) recorded for late completion of 50% flowering during both the years.

The interaction of 15 October planting with application of 85% RDF by means of fertigation ($D_1 \times F_3$) was found significant minimum number of days for 50% flowering; while, the maximum duration for first flowering was registered in 15 December planting with application of 55% RDF through fertigation ($D_3 \times F_1$) during 2019-20 and 2020-21.

The interaction effects between planting date and mulch, mulch and fertigation and combined effect of all three factors (planting date, mulch and fertigation) on bud appearance, days to first flowering and 50% flowering was found non-significant during both the years.

The reason might October planting experienced short day conditions established much earlier and could complete essential vegetative growth redound reproductive phase within a short time. However, delayed flowering observed when crop planted during December. These results are in close conformity with the findings of Singh and Arora, (1988) [31], Mohanty *et al*. (2015) [21], Samantaray *et al*. (1999) [27] and Lakshmi *et al*. (2014) [20] while working in African marigold.

The plants mulched with the black polythene sheet took minimum time for flowering which might be due to the fact that coloured polythene has more capacity to regulate soil temperature which promotes faster vegetative growth especially during early period and ultimately leading to earliness in flowering. Similar result presented by Hooda *et al*. (1999) [12] in tomato and Kumar *et al*. (2010) [18] in rose.

The nutritional status of the plant directly controls the flowering pattern and timing. High C:N ratio promotes flowering whereas, high availability of nitrogen i.e. low C:N ratio resulting in the promotion of vegetative growth. Raper *et al*. (1988) [25] and Rideout *et al*. (1992) [26] hypothesized that an imbalance in the endogenous availability of carbohydrates and nitrogen in the shoot apical meristem stimulates the floral transition. Hence, 85% RDF fertigation application had significantly influenced all flowering parameters. Similar results were reported by Ganesh *et al*. (2014) [8] in chrysanthemum and Kurakula *et al*. (2018) [19] in marigold.

It is evident from the data that the combination 15 October planting with 85% RDF fertigation responded positively to number of days taken for first flower opening. This might be due to better growth and subsequent differentiation might have contributed to reduce the leaching loss of fertilizer and increases the nutrient use efficiency by accumulating the fertilizer near the root zone. This result is in conformity with Abou El-Magd (2019) [1] in kohlrabi.

### Period of bloom (days)

The blooming period affected by planting date treatments, 15 October planting recorded significantly maximum duration of bloom; while, the minimum duration of bloom was observed on 15 December planting. Due to the effect of mulch significantly maximum blooming period was recorded in black plastic mulch as compared to reusable plastic bag mulch. The differences in responses under fertigation treatment was significantly influenced, the maximum blooming period was recorded with application of 85% RDF

through fertigation; while, fertigation with 55% RDF recorded for minimum duration of bloom during both the years.

Interaction effect between planting date and fertigation was also found significant, 15 October planted marigold with application of 85% RDF through fertigation had maximum blooming period; while, 15 December planted crop with application of 55% RDF *via* fertigation exhibited significantly minimum blooming period during 2019-20 and 2020-21.

The interaction effects between planting date and mulch, mulch and fertigation and combined effect of all three factors i.e. planting date, mulch and fertigation on blooming period was found non-significant duration of bloom during both the years of experiment.

Maximum blooming period was obtained in 15 October planted marigold and least duration was recorded when the seedlings planted in 15 December. This might be due to the best possible climatic situation during its vegetative as well as flowering phases accessible for the crop planted on 15 October. The result conforms to the findings of Ghosh and Pal (2008) [10], Lakshmi *et al*. (2014) [20] in African marigold and Sharma *et al*. (2015) [29] in gaillardia.

The result obtained due to the application of mulch could be credited to superior uptake of nutrients which might be due to enhanced root growth and more availability of nutrients as effects of black polythene mulching in moderating the soil temperature and preventing leaching loss of nutrients as well as checking weed growth which helps to increase the chlorophyll content, production of photosynthates and translocation of food materials from source to sink. This result is supported by reports of earlier workers who found the maximum flowering duration of crossandra with black polythene mulch (Murugan and Gopinath, 2001) [23].

Among the different examined fertigation doses, application of 85% RDF fertigation system had significantly increased the blooming period and this might be due to the optimum dose of NPK which was responsible for vegetative growth of plant and had a significant effect on the quantity and quality of flowering (Gurav *et al*., 2004) [11]. Fertigation reduced the leaching loss of fertilizer and increased the fertilizer use efficiency by accumulating the fertilizer near the root zone area which increased the absorption of nutrients by the plant. These results were supported by Ganesh *et al*. (2014) [8] in chrysanthemum and Kurakula *et al*. (2018) [19] in marigold.

Maximum blooming period was obtained in the treatment combination of 15 October planting with application of 85% RDF through fertigation. This might be due to the best possible climatic situation and optimum nutrient availability in the root zone of marigold plants. These results were supported by Khan *et al*. (1996) [14] and Sandhu *et al*. (2014) [28] in potato.

**Flower diameter (cm)**

The data showed that the flower diameter was significantly influenced by planting date, mulch and fertigation treatments. Marigold planted on 15 October planting ($D_1$) recorded maximum flowers diameter; while, the minimum flower diameter in 15 December planting ($D_3$). Due to effect of mulch significantly maximum flower diameter was recorded in black plastic mulch ($M_1$) as compared to reusable plastic bag mulch ($M_2$). Fertigation levels also affected the flower diameter, fertigation with 85% RDF ($F_3$) exhibited significantly highest flower diameter; while, application of 55% RDF *via* fertigation ($F_1$) recorded for lowest flower diameter during 2019-20 and 2020-21.

It is clear from the data that an interaction among planting date and fertigation brings significant difference on flower diameter, 15 October planting with application of 85% RDF through fertigation exhibited significantly maximum flower diameter; however, minimum flower diameter was registered in 15 December planting with application of 55% RDF by means of fertigation during both the years.

The interaction effects between planting date and mulch, mulch and fertigation and combined effect of all factors in respect with flower diameter was found non-significant during both the years of study.

The increase in flower diameter when planted on 15 October could be attributed to favorable temperature prevailing during the crop development period and consequently, resulted in increased photosynthesis as well as and translocation of photosynthates from source (leaf) to the sink (flowers) thereby leading to increased flower size. Similar results were reported by Ghosh and Pal (2008) [10] and Lakshmi *et al*. (2014) [20] in African marigold.

The bigger size of flower registered with the use of black polythene mulch because black color polythene sheet has more capacity to regulate soil temperature than other mulch materials. In addition to this, no weed infestation was seen under black polythene mulch treatment, besides creating a more favorable microclimate, better soil environment with the application of mulches, which might have resulted in better uptake of the nutrients by the plants. Similar results were reported by Gavahane *et al*. (2004) [9] in African marigold, Kumar *et al*. (2010) [18] in rose and Bajad (2017) [4] in China aster also recorded maximum flower diameter.

The diameter of the flower was significantly improved by the application of 85% RDF fertigation as they boost the overall vegetative growth. The increase in the flower diameter could be attributed to the accelerated rate of photosynthesis which could have further led to the better partitioning of assimilates. Higher value observed for this trait with fertigation treatments might be due to higher fertilizer use efficiency and higher uptake of nutrients *viz*., N, P and K. Obviously, the diameter of the flower is contributed by the number of petals, petal length and width of the flower. This is well supported by Ashok and Rangaswami (1999) [2], Pawar *et al*. (2002) in rose and Anthurium, Ganesh *et al*. (2014) [8] in chrysanthemum, Babu *et al*. (2018) [3] and Kurakula *et al*. (2018) [19] in marigold.

Bigger size flowers was obtained in the treatment combination of 15 October planting with 85% RDF fertigation in marigold could be attributed to favorable temperature prevailing and accurate dose of nutrient placement at the root zone of plant during the crop development period and consequently, resulted in increased photosynthesis as well as and translocation of photosynthates from source to the sink thereby leading to increased flower size. Similar reports presented by Jain and Gupta (2004) [13] and Kill-Shahrbabaki *et al*. (2014) [15] in pot marigold.

**Number of flowers per plant**

The number of flowers per plant was significantly affected by different planting dates. The 15 October planting recorded maximum number of flowers per plant followed by treatment $D_2$; while, the minimum number of flowers in 15 December planting. Due to the effect of mulch significantly maximum number of flowers per plant was recorded in black plastic mulch as compared to reusable plastic bag mulch. Among the fertigation treatments, plants fertigated with 85% RDF had

recorded maximum number of flowers per plant; whereas, minimum number of flowers was recorded with application of 55% RDF through fertigation during both the years.

The data on number of flowers per plant were significantly influenced by combine effect of planting date and fertigation. 15 October planting coupled with application of 85% RDF through fertigation ($D_1 \times F_3$) registered significantly maximum number of flowers per plant; while, minimum number of flowers per plant was registered in 15 December planting with application of 55% RDF *via* fertigation ($D_3 \times F_1$) during 2019-20 and 2020-21.

**Flower yield per hectare (q)**

It is evident from the data that the effect of planting dates, mulches, fertigation levels and their interaction on flower yield per hectare was noted significant difference, marigold seedlings planted on 15 October ($D_1$) exhibited the maximum flower yield $ha^{-1}$; while, minimum flower yield per hectare was observed in 15 December planting ($D_3$). Irrespective of planting date, black plastic mulch ($M_1$) also had significantly higher yield $ha^{-1}$ as compared to reusable plastic bag mulch. Among the fertigation treatments, application of 85% RDF through fertigation ($F_3$) had recorded significantly maximum flower yield $ha^{-1}$; while, fertigation with 55% RDF ($F_1$) recorded for minimum flower yield $ha^{-1}$ during 2019-20 and 2020-21.

Interaction effect between planting dates and fertigation levels gave significantly maximum flower yield. The highest flower yield per hectare was noticed in 15 October planting with application of 85% RDF by means of fertigation followed by 15 November planting with application of 85% RDF *via* fertigation; while, minimum flower $ha^{-1}$ was registered in 15 December planting with application of 55% RDF through fertigation during both the years.

The combine effect between planting date and mulch, mulch and fertigation and combined effect of all three factors i.e. planting date, mulch and fertigation were found to be non-significant during both the years and on mean basis with respect to number of flower per plant and flower yield per hectare.

The highest number of flowers per plant and flower yield per hectare was recorded with 15 October planting. This might be due to the reason that the crop planted on 15 October have more vegetative growth i. e. number of primary and secondary branches per plant that have produced more flower buds which finally contributed to more number of flowers per plant in marigold. Similar findings were reported by Kulkarni and Reddy (2010) [17] in Chrysanthemum and Sharma *et al.* (2015) [29] in gaillardia.

Black plastic mulch increases the number of flowers per plant and flower yield per hectare due to direct effect on suppressing weed flora and indirect effect on uptake of nutrients under the improved conditions of the soil, particularly concerning moisture availability and moderation of soil temperature making it more favorable microclimate for the development of the plant. Murugan and Gopinath had (2001) [23] in crossandra, Abu-Bakr and Mustafa (2003) in okra and Kumar *et al.* (2010) [18] in rose reported that plants mulched with black polyethylene mulch had produced more flowers per plant.

Fertigation with 85% of RDF recorded highest number of flowers per plant and flower yield per hectare than other treatments might be due to optimum dose of NPK, reduced nutrient leaching losses and efficient use of nutrients through fertigation attributed to the nature of the interaction of physiological and growth parameters by the way of enhanced synthesis of hormones like auxins and gibberellins and dry matter production which conforms with the findings of Banker and Mukhopadhayay (1990) [5] in tuberose, Krishna *et al.* (1999) in carnation and Kurakula *et al.* (2018) [19] in marigold.

15 October planting with 85% RDF fertigation recorded significantly higher number of flowers per plant. It might be due to congenial environmental condition and optimum dose of NPK, reduced nutrient leaching losses and efficient use of nutrients through fertigation attributed to the nature of the interaction of physiological and growth parameters by the way of enhanced synthesis of hormones resulting more vegetative and reproductive growth of crops. Similar findings were reported by Chanda and Roychoudhary (1991) [7] in African marigold, Ganesh *et al.* (2014) [8] in chrysanthemum and Yazdanpanah *et al.* (2018) [32] in rossel.

**Table 1:** Effect of planting date, mulch and fertigation on days to bud appearance of African marigold

| Treatment | | 2019-20 | | | | | 2020-21 | | | | | Mean | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean |
| $D_1$ | $M_1$ | 33.73 | 29.73 | 20.53 | 31.73 | 28.93 | 35.27 | 31.08 | 20.84 | 33.17 | 30.09 | 34.50 | 30.41 | 20.69 | 32.45 | 29.51 |
| | $M_2$ | 33.94 | 30.30 | 23.63 | 32.16 | 30.01 | 35.48 | 31.68 | 23.42 | 33.63 | 31.05 | 34.71 | 30.99 | 23.53 | 32.90 | 30.53 |
| | Mean | 33.84 | 30.02 | 22.08 | 31.95 | 29.47 | 35.38 | 31.38 | 22.13 | 33.40 | 30.57 | 34.61 | 30.70 | 22.11 | 32.67 | 30.02 |
| $D_2$ | $M_1$ | 34.94 | 30.79 | 24.84 | 32.30 | 30.72 | 36.53 | 32.20 | 26.69 | 33.77 | 32.30 | 35.73 | 31.49 | 25.76 | 33.04 | 31.51 |
| | $M_2$ | 35.17 | 30.94 | 26.75 | 32.34 | 31.30 | 36.77 | 32.34 | 27.97 | 33.81 | 32.72 | 35.97 | 31.64 | 27.36 | 33.07 | 32.01 |
| | Mean | 35.05 | 30.87 | 25.79 | 32.32 | 31.01 | 36.65 | 32.27 | 27.33 | 33.79 | 32.51 | 35.85 | 31.57 | 26.56 | 33.05 | 31.76 |
| $D_3$ | $M_1$ | 39.28 | 30.97 | 28.19 | 33.17 | 32.90 | 38.23 | 32.38 | 29.48 | 34.68 | 33.69 | 38.76 | 31.67 | 28.84 | 33.92 | 33.30 |
| | $M_2$ | 41.47 | 31.66 | 29.70 | 33.59 | 34.11 | 41.95 | 33.10 | 31.05 | 35.02 | 35.28 | 41.71 | 32.38 | 30.37 | 34.31 | 34.69 |
| | Mean | 40.38 | 31.32 | 28.95 | 33.38 | 33.50 | 40.09 | 32.74 | 30.26 | 34.85 | 34.49 | 40.23 | 32.03 | 29.60 | 34.11 | 33.99 |
| M × F | $M_1$ | 35.98 | 30.50 | 24.52 | 32.40 | 30.85 | 36.67 | 31.88 | 25.67 | 33.87 | 32.03 | 36.33 | 31.19 | 25.10 | 33.14 | 31.44 |
| | $M_2$ | 36.86 | 30.97 | 26.69 | 32.70 | 31.80 | 38.07 | 32.38 | 27.48 | 34.15 | 33.02 | 37.46 | 31.67 | 27.09 | 33.43 | 32.41 |
| | Mean | 36.42 | 30.73 | 25.61 | 32.55 | 31.33 | 37.37 | 32.13 | 26.58 | 34.01 | 32.52 | 36.90 | 31.43 | 26.09 | 33.28 | 31.92 |

| Factor | SEm± | | | CD (P = 0.05) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Mean | 2019-20 | 2020-21 | Mean |
| D | 0.37 | 0.43 | 0.39 | 1.47 | 1.68 | 1.52 |
| M | 0.27 | 0.26 | 0.25 | 0.92 | 0.91 | 0.88 |
| F | 0.43 | 0.42 | 0.40 | 1.23 | 1.20 | 1.14 |
| D×M | 0.46 | 0.46 | 0.44 | NS | NS | NS |
| D×F | 0.74 | 0.73 | 0.69 | 2.13 | 2.08 | 1.98 |

| | | | | | | |
|---|---|---|---|---|---|---|
| M×F | 0.61 | 0.59 | 0.56 | NS | NS | NS |
| D×M×F | 1.05 | 1.03 | 0.97 | NS | NS | NS |

**Table 2:** Effect of planting date, mulch and fertigation on days to first flowering of African marigold

| Treatment | | 2019-20 | | | | | 2020-21 | | | | | Mean | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean |
| $D_1$ | $M_1$ | 40.64 | 36.64 | 26.44 | 38.64 | 35.59 | 41.70 | 37.51 | 26.94 | 39.60 | 36.44 | 41.17 | 37.08 | 26.69 | 39.12 | 36.01 |
| | $M_2$ | 40.85 | 37.21 | 29.54 | 39.07 | 36.67 | 41.91 | 38.11 | 30.52 | 40.08 | 37.66 | 41.38 | 37.66 | 30.03 | 39.58 | 37.16 |
| | Mean | 40.75 | 36.93 | 27.99 | 38.86 | 36.13 | 41.81 | 37.81 | 28.73 | 39.84 | 37.05 | 41.28 | 37.37 | 28.36 | 39.35 | 36.59 |
| $D_2$ | $M_1$ | 41.85 | 37.70 | 32.44 | 39.21 | 37.80 | 42.96 | 38.63 | 33.12 | 40.20 | 38.73 | 42.40 | 38.16 | 32.78 | 39.71 | 38.26 |
| | $M_2$ | 42.08 | 37.85 | 33.66 | 39.25 | 38.21 | 43.20 | 38.77 | 34.40 | 40.24 | 39.15 | 42.64 | 38.31 | 34.03 | 39.74 | 38.68 |
| | Mean | 41.96 | 37.78 | 33.05 | 39.23 | 38.00 | 43.08 | 38.70 | 33.76 | 40.22 | 38.94 | 42.52 | 38.24 | 33.40 | 39.72 | 38.47 |
| $D_3$ | $M_1$ | 45.48 | 37.88 | 35.10 | 40.08 | 39.63 | 44.66 | 38.81 | 35.91 | 41.11 | 40.12 | 45.07 | 38.34 | 35.51 | 40.59 | 39.88 |
| | $M_2$ | 46.71 | 38.57 | 36.61 | 40.41 | 40.58 | 48.38 | 39.53 | 37.48 | 41.45 | 41.71 | 47.55 | 39.05 | 37.04 | 40.93 | 41.14 |
| | Mean | 46.10 | 38.23 | 35.86 | 40.24 | 40.10 | 46.52 | 39.17 | 36.69 | 41.28 | 40.92 | 46.31 | 38.70 | 36.27 | 40.76 | 40.51 |
| M × F | $M_1$ | 42.65 | 37.41 | 31.33 | 39.31 | 37.67 | 43.10 | 38.31 | 31.99 | 40.30 | 38.43 | 42.88 | 37.86 | 31.66 | 39.81 | 38.05 |
| | $M_2$ | 43.21 | 37.88 | 33.27 | 39.58 | 38.48 | 44.50 | 38.81 | 34.13 | 40.59 | 39.51 | 43.85 | 38.34 | 33.70 | 40.08 | 39.00 |
| | Mean | 42.93 | 37.64 | 32.30 | 39.44 | 38.08 | 43.80 | 38.56 | 33.06 | 40.45 | 38.97 | 43.37 | 38.10 | 32.68 | 39.95 | 38.52 |

| Factor | SEm± | | | CD (P = 0.05) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Mean | 2019-20 | 2020-21 | Mean |
| D | 0.40 | 0.43 | 0.40 | 1.58 | 1.69 | 1.57 |
| M | 0.20 | 0.27 | 0.23 | 0.69 | 0.93 | 0.80 |
| F | 0.38 | 0.42 | 0.38 | 1.10 | 1.20 | 1.09 |
| D×M | 0.34 | 0.46 | 0.40 | NS | NS | NS |
| D×F | 0.66 | 0.73 | 0.66 | 1.90 | 2.09 | 1.89 |
| M×F | 0.54 | 0.59 | 0.54 | NS | NS | NS |
| D×M×F | 0.94 | 1.03 | 0.93 | NS | NS | NS |

**Table 3:** Effect of planting date, mulch and fertigation on days to 50% flowering of African marigold

| Treatment | | 2019-20 | | | | | 2020-21 | | | | | Mean | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean |
| $D_1$ | $M_1$ | 64.71 | 58.34 | 42.10 | 61.53 | 56.67 | 62.24 | 55.87 | 39.63 | 59.06 | 54.20 | 63.47 | 57.11 | 40.86 | 60.29 | 55.43 |
| | $M_2$ | 65.04 | 59.25 | 47.04 | 62.22 | 58.39 | 62.57 | 56.78 | 42.72 | 59.75 | 55.46 | 63.81 | 58.01 | 44.88 | 60.98 | 56.92 |
| | Mean | 64.88 | 58.79 | 44.57 | 61.87 | 57.53 | 62.41 | 56.32 | 41.18 | 59.40 | 54.83 | 63.64 | 57.56 | 42.87 | 60.64 | 56.18 |
| $D_2$ | $M_1$ | 66.63 | 60.03 | 51.65 | 62.43 | 60.19 | 64.16 | 57.56 | 49.18 | 59.96 | 57.72 | 65.40 | 58.80 | 50.42 | 61.20 | 58.95 |
| | $M_2$ | 67.00 | 60.26 | 53.60 | 62.49 | 60.84 | 64.53 | 57.79 | 51.13 | 60.02 | 58.37 | 65.76 | 59.03 | 52.36 | 61.26 | 59.60 |
| | Mean | 66.81 | 60.15 | 52.62 | 62.46 | 60.51 | 64.34 | 57.68 | 50.15 | 59.99 | 58.04 | 65.58 | 58.91 | 51.39 | 61.23 | 59.28 |
| $D_3$ | $M_1$ | 72.41 | 60.31 | 55.89 | 63.81 | 63.11 | 69.94 | 57.84 | 53.42 | 61.34 | 60.64 | 71.18 | 59.07 | 54.66 | 62.58 | 61.87 |
| | $M_2$ | 74.38 | 61.42 | 58.29 | 64.34 | 64.61 | 72.58 | 58.95 | 55.82 | 61.87 | 62.30 | 73.48 | 60.18 | 57.05 | 63.11 | 63.46 |
| | Mean | 73.40 | 60.86 | 57.09 | 64.08 | 63.86 | 71.26 | 58.39 | 54.62 | 61.61 | 61.47 | 72.33 | 59.63 | 55.86 | 62.84 | 62.66 |
| M × F | $M_1$ | 67.92 | 59.56 | 49.88 | 62.59 | 59.99 | 65.45 | 57.09 | 47.41 | 60.12 | 57.52 | 66.68 | 58.33 | 48.65 | 61.36 | 58.75 |
| | $M_2$ | 68.81 | 60.31 | 52.97 | 63.02 | 61.28 | 66.56 | 57.84 | 49.89 | 60.55 | 58.71 | 67.68 | 59.07 | 51.43 | 61.78 | 59.99 |
| | Mean | 68.36 | 59.94 | 51.43 | 62.80 | 60.63 | 66.00 | 57.47 | 48.65 | 60.33 | 58.11 | 67.18 | 58.70 | 50.04 | 61.57 | 59.37 |

| Factor | SEm± | | | CD (P = 0.05) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Mean | 2019-20 | 2020-21 | Mean |
| D | 0.64 | 0.73 | 0.69 | 2.52 | 2.88 | 2.70 |
| M | 0.32 | 0.33 | 0.32 | 1.09 | 1.16 | 1.12 |
| F | 0.61 | 0.61 | 0.61 | 1.75 | 1.75 | 1.74 |
| D×M | 0.55 | 0.58 | 0.56 | NS | NS | NS |
| D×F | 1.06 | 1.06 | 1.05 | 3.03 | 3.04 | 3.02 |
| M×F | 0.86 | 0.86 | 0.86 | NS | NS | NS |
| D×M×F | 1.50 | 1.50 | 1.49 | NS | NS | NS |

**Table 4:** Effect of planting date, mulch and fertigation on period of bloom (days) of African marigold

| Treatment | | 2019-20 | | | | | 2020-21 | | | | | Mean | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean |
| $D_1$ | $M_1$ | 59.21 | 74.26 | 83.86 | 65.35 | 70.67 | 59.86 | 75.26 | 84.73 | 66.14 | 71.50 | 59.53 | 74.76 | 84.30 | 65.74 | 71.08 |
| | $M_2$ | 58.26 | 73.41 | 82.87 | 63.28 | 69.45 | 58.89 | 74.38 | 83.38 | 64.02 | 70.17 | 58.58 | 73.89 | 83.13 | 63.65 | 69.81 |
| | Mean | 58.73 | 73.84 | 83.37 | 64.31 | 70.06 | 59.38 | 74.82 | 84.06 | 65.08 | 70.83 | 59.05 | 74.33 | 83.71 | 64.70 | 70.45 |
| $D_2$ | $M_1$ | 57.23 | 69.45 | 80.14 | 60.86 | 66.92 | 57.83 | 70.33 | 81.27 | 61.55 | 67.75 | 57.53 | 69.89 | 80.71 | 61.21 | 67.33 |
| | $M_2$ | 55.79 | 67.46 | 77.65 | 60.60 | 65.37 | 56.37 | 68.30 | 78.72 | 61.28 | 66.17 | 56.08 | 67.88 | 78.18 | 60.94 | 65.77 |
| | Mean | 56.51 | 68.45 | 78.90 | 60.73 | 66.15 | 57.10 | 69.31 | 79.99 | 61.42 | 66.96 | 56.80 | 68.88 | 79.44 | 61.07 | 66.55 |
| $D_3$ | $M_1$ | 49.01 | 67.26 | 75.99 | 60.38 | 63.16 | 49.43 | 68.10 | 77.03 | 61.06 | 63.90 | 49.22 | 67.68 | 76.51 | 60.72 | 63.53 |
| | $M_2$ | 41.40 | 66.27 | 75.33 | 59.66 | 60.66 | 41.65 | 67.09 | 76.34 | 60.32 | 61.35 | 41.52 | 66.68 | 75.84 | 59.99 | 61.01 |
| | Mean | 45.20 | 66.77 | 75.66 | 60.02 | 61.91 | 45.54 | 67.59 | 76.69 | 60.69 | 62.63 | 45.37 | 67.18 | 76.17 | 60.35 | 62.27 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M × F | $M_1$ | 55.15 | 70.32 | 80.00 | 62.19 | 66.92 | 55.71 | 71.23 | 81.01 | 62.91 | 67.72 | 55.43 | 70.78 | 80.50 | 62.55 | 67.32 |
| | $M_2$ | 51.82 | 69.05 | 78.62 | 61.18 | 65.16 | 52.30 | 69.92 | 79.48 | 61.88 | 65.89 | 52.06 | 69.48 | 79.05 | 61.53 | 65.53 |
| | Mean | 53.48 | 69.68 | 79.31 | 61.69 | 66.04 | 54.00 | 70.57 | 80.25 | 62.40 | 66.80 | 53.74 | 70.13 | 79.78 | 62.04 | 66.42 |

| Factor | SEm± | | | CD (P = 0.05) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Mean | 2019-20 | 2020-21 | Mean |
| D | 0.91 | 0.98 | 0.94 | 3.56 | 3.85 | 3.70 |
| M | 0.49 | 0.52 | 0.50 | 1.68 | 1.82 | 1.75 |
| F | 0.87 | 0.90 | 0.89 | 2.51 | 2.58 | 2.54 |
| D×M | 0.84 | 0.91 | 0.87 | NS | NS | NS |
| D×F | 1.52 | 1.56 | 1.53 | 4.35 | 4.46 | 4.40 |
| M×F | 1.24 | 1.27 | 1.25 | NS | NS | NS |
| D×M×F | 2.14 | 2.20 | 2.17 | NS | NS | NS |

**Table 5:** Effect of planting date, mulch and fertigation on flower diameter (cm) of African marigold

| Treatment | | 2019-20 | | | | | 2020-21 | | | | | Mean | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean |
| $D_1$ | $M_1$ | 4.48 | 5.50 | 7.19 | 4.96 | 5.53 | 4.81 | 5.91 | 7.73 | 5.33 | 5.95 | 4.65 | 5.70 | 7.46 | 5.14 | 5.74 |
| | $M_2$ | 4.32 | 5.25 | 7.12 | 4.80 | 5.37 | 4.65 | 5.64 | 7.69 | 5.17 | 5.79 | 4.49 | 5.44 | 7.41 | 4.98 | 5.58 |
| | Mean | 4.40 | 5.37 | 7.16 | 4.88 | 5.45 | 4.73 | 5.78 | 7.71 | 5.25 | 5.87 | 4.57 | 5.57 | 7.43 | 5.06 | 5.66 |
| $D_2$ | $M_1$ | 4.12 | 5.24 | 6.71 | 4.67 | 5.19 | 4.43 | 5.63 | 7.22 | 5.03 | 5.58 | 4.28 | 5.43 | 6.96 | 4.85 | 5.38 |
| | $M_2$ | 3.80 | 5.22 | 6.67 | 4.65 | 5.08 | 4.09 | 5.61 | 7.17 | 5.00 | 5.47 | 3.95 | 5.41 | 6.92 | 4.83 | 5.28 |
| | Mean | 3.96 | 5.23 | 6.69 | 4.66 | 5.14 | 4.26 | 5.62 | 7.19 | 5.01 | 5.52 | 4.11 | 5.42 | 6.94 | 4.84 | 5.33 |
| $D_3$ | $M_1$ | 3.79 | 5.11 | 6.38 | 4.55 | 4.95 | 4.07 | 5.49 | 6.86 | 4.89 | 5.33 | 3.93 | 5.30 | 6.62 | 4.72 | 5.14 |
| | $M_2$ | 3.40 | 4.98 | 5.96 | 4.49 | 4.71 | 3.69 | 5.35 | 6.41 | 4.83 | 5.07 | 3.55 | 5.16 | 6.18 | 4.66 | 4.89 |
| | Mean | 3.59 | 5.04 | 6.17 | 4.52 | 4.83 | 3.88 | 5.42 | 6.63 | 4.86 | 5.20 | 3.74 | 5.23 | 6.40 | 4.69 | 5.01 |
| M × F | $M_1$ | 4.13 | 5.28 | 6.76 | 4.73 | 5.22 | 4.44 | 5.68 | 7.27 | 5.08 | 5.62 | 4.28 | 5.48 | 7.01 | 4.90 | 5.42 |
| | $M_2$ | 3.84 | 5.15 | 6.58 | 4.65 | 5.05 | 4.14 | 5.54 | 7.09 | 5.00 | 5.44 | 3.99 | 5.34 | 6.84 | 4.82 | 5.25 |
| | Mean | 3.99 | 5.21 | 6.67 | 4.69 | 5.14 | 4.29 | 5.61 | 7.18 | 5.04 | 5.53 | 4.14 | 5.41 | 6.92 | 4.86 | 5.33 |

| Factor | SEm± | | | CD (P = 0.05) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Mean | 2019-20 | 2020-21 | Mean |
| D | 0.08 | 0.08 | 0.08 | 0.31 | 0.32 | 0.31 |
| M | 0.05 | 0.05 | 0.05 | 0.16 | 0.17 | 0.16 |
| F | 0.05 | 0.06 | 0.06 | 0.15 | 0.17 | 0.16 |
| D×M | 0.08 | 0.09 | 0.08 | NS | NS | NS |
| D×F | 0.09 | 0.10 | 0.10 | 0.26 | 0.29 | 0.28 |
| M×F | 0.07 | 0.08 | 0.08 | NS | NS | NS |
| D×M×F | 0.13 | 0.14 | 0.14 | NS | NS | NS |

**Table 6:** Effect of planting date, mulch and fertigation on number of flowers per plant of African marigold

| Treatment | | 2019-20 | | | | | 2020-21 | | | | | Mean | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean |
| $D_1$ | $M_1$ | 58.44 | 71.37 | 83.85 | 69.05 | 70.68 | 56.30 | 69.16 | 81.71 | 66.91 | 68.52 | 57.37 | 70.26 | 82.78 | 67.98 | 69.60 |
| | $M_2$ | 58.07 | 71.32 | 80.66 | 65.64 | 68.92 | 55.93 | 69.04 | 78.52 | 63.50 | 66.75 | 57.00 | 70.18 | 79.59 | 64.57 | 67.83 |
| | Mean | 58.26 | 71.34 | 82.26 | 67.35 | 69.80 | 56.11 | 69.10 | 80.11 | 65.20 | 67.63 | 57.18 | 70.22 | 81.19 | 66.28 | 68.72 |
| $D_2$ | $M_1$ | 56.07 | 71.11 | 77.01 | 62.02 | 66.55 | 53.93 | 68.97 | 74.87 | 59.21 | 64.24 | 55.00 | 70.04 | 75.94 | 60.61 | 65.40 |
| | $M_2$ | 52.31 | 70.79 | 76.41 | 59.76 | 64.82 | 50.16 | 68.64 | 74.26 | 57.61 | 62.67 | 51.24 | 69.72 | 75.34 | 58.69 | 63.74 |
| | Mean | 54.19 | 70.95 | 76.71 | 60.89 | 65.68 | 52.05 | 68.81 | 74.57 | 58.41 | 63.46 | 53.12 | 69.88 | 75.64 | 59.65 | 64.57 |
| $D_3$ | $M_1$ | 47.82 | 70.67 | 75.12 | 59.52 | 63.28 | 45.68 | 68.53 | 72.97 | 57.38 | 61.14 | 46.75 | 69.60 | 74.05 | 58.45 | 62.21 |
| | $M_2$ | 44.09 | 69.66 | 73.40 | 58.93 | 61.52 | 42.28 | 67.52 | 71.25 | 56.78 | 59.46 | 43.19 | 68.59 | 72.33 | 57.86 | 60.49 |
| | Mean | 45.96 | 70.17 | 74.26 | 59.22 | 62.40 | 43.98 | 68.03 | 72.11 | 57.08 | 60.30 | 44.97 | 69.10 | 73.19 | 58.15 | 61.35 |
| M × F | $M_1$ | 54.11 | 71.05 | 78.66 | 63.53 | 66.84 | 51.97 | 68.88 | 76.52 | 61.16 | 64.63 | 53.04 | 69.97 | 77.59 | 62.35 | 65.74 |
| | $M_2$ | 51.49 | 70.59 | 76.82 | 61.44 | 65.09 | 49.46 | 68.40 | 74.68 | 59.30 | 62.96 | 50.47 | 69.50 | 75.75 | 60.37 | 64.02 |
| | Mean | 52.80 | 70.82 | 77.74 | 62.49 | 65.96 | 50.71 | 68.64 | 75.60 | 60.23 | 63.80 | 51.76 | 69.73 | 76.67 | 61.36 | 64.88 |

| Factor | SEm± | | | CD (P = 0.05) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Mean | 2019-20 | 2020-21 | Mean |
| D | 0.85 | 0.85 | 0.85 | 3.33 | 3.33 | 3.33 |
| M | 0.45 | 0.45 | 0.45 | 1.56 | 1.56 | 1.56 |
| F | 0.86 | 0.86 | 0.86 | 2.48 | 2.46 | 2.47 |
| D×M | 0.78 | 0.78 | 0.78 | NS | NS | NS |
| D×F | 1.50 | 1.48 | 1.49 | 4.29 | 4.25 | 4.27 |
| M×F | 1.22 | 1.21 | 1.22 | NS | NS | NS |
| D×M×F | 2.12 | 2.10 | 2.11 | NS | NS | NS |

**Table 7:** Effect of planting date, mulch and fertigation on flower yield per hectare (q) of African marigold

| Treatment | | 2019-20 | | | | | 2020-21 | | | | | Mean | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean | $F_1$ | $F_2$ | $F_3$ | $F_4$ | Mean |
| $D_1$ | $M_1$ | 163.33 | 199.46 | 234.02 | 192.99 | 197.45 | 165.12 | 201.25 | 235.81 | 194.78 | 199.24 | 164.23 | 200.35 | 234.92 | 193.89 | 198.35 |
| | $M_2$ | 162.30 | 199.33 | 226.43 | 183.46 | 192.88 | 164.09 | 201.12 | 228.56 | 185.25 | 194.75 | 163.19 | 200.22 | 227.50 | 184.35 | 193.82 |
| | Mean | 162.82 | 199.39 | 230.23 | 188.22 | 195.17 | 164.61 | 201.18 | 232.19 | 190.01 | 197.00 | 163.71 | 200.29 | 231.21 | 189.12 | 196.08 |
| $D_2$ | $M_1$ | 156.71 | 198.74 | 216.31 | 173.33 | 186.27 | 158.50 | 200.53 | 218.10 | 175.12 | 188.06 | 157.60 | 199.64 | 217.21 | 174.22 | 187.17 |
| | $M_2$ | 146.19 | 197.84 | 212.78 | 167.01 | 180.96 | 144.32 | 199.63 | 214.57 | 168.80 | 181.83 | 145.25 | 198.73 | 213.67 | 167.91 | 181.39 |
| | Mean | 151.45 | 198.29 | 214.55 | 170.17 | 183.61 | 151.41 | 200.08 | 216.34 | 171.96 | 184.95 | 151.43 | 199.19 | 215.44 | 171.07 | 184.28 |
| $D_3$ | $M_1$ | 132.98 | 197.52 | 210.61 | 166.35 | 176.87 | 133.44 | 199.31 | 212.40 | 168.14 | 178.32 | 133.21 | 198.42 | 211.50 | 167.25 | 177.59 |
| | $M_2$ | 123.23 | 194.70 | 205.13 | 164.69 | 171.94 | 125.02 | 195.82 | 206.26 | 166.48 | 173.40 | 124.13 | 195.26 | 205.69 | 165.59 | 172.67 |
| | Mean | 128.11 | 196.11 | 207.87 | 165.52 | 174.40 | 129.23 | 197.57 | 209.33 | 167.31 | 175.86 | 128.67 | 196.84 | 208.60 | 166.42 | 175.13 |
| M × F | $M_1$ | 151.01 | 198.57 | 220.31 | 177.56 | 186.86 | 152.35 | 200.36 | 222.10 | 179.35 | 188.54 | 151.68 | 199.47 | 221.21 | 178.45 | 187.70 |
| | $M_2$ | 143.91 | 197.29 | 214.78 | 171.72 | 181.92 | 144.48 | 198.86 | 216.46 | 173.51 | 183.33 | 144.19 | 198.07 | 215.62 | 172.61 | 182.63 |
| | Mean | 147.46 | 197.93 | 217.55 | 174.64 | 184.39 | 148.41 | 199.61 | 219.28 | 176.43 | 185.93 | 147.94 | 198.77 | 218.42 | 175.53 | 185.16 |

| Factor | SEm± | | | CD (P = 0.05) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Mean | 2019-20 | 2020-21 | Mean |
| D | 2.37 | 2.33 | 2.34 | 9.29 | 9.13 | 9.19 |
| M | 1.40 | 1.46 | 1.43 | 4.84 | 5.07 | 4.94 |
| F | 2.47 | 2.44 | 2.45 | 7.10 | 6.99 | 7.03 |
| D×M | 2.42 | 2.54 | 2.47 | NS | NS | NS |
| D×F | 4.28 | 4.22 | 4.24 | 12.29 | 12.11 | 12.17 |
| M×F | 3.50 | 3.45 | 3.46 | NS | NS | NS |
| D×M×F | 6.06 | 5.97 | 6.00 | NS | NS | NS |

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