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# Effect of Pinching on Growth, Flowering, and Yield of African Marigold (*Tagetes erecta* L.) cv. Calcutta Local

**Ranjana Sedhai [1] ✉, Shambhu Katel [2], Anju Adhikari [3]**

[1] Nepal Polytechnic Institute (NPI), Chitwan, Nepal

[2] G.P. Koirala College of Agriculture and Research Centre (GPCAR), Gothgaun, Morang, Purbanchal University, Nepal

[3] Agriculture and Forestry University, Chitwan, Nepal

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**Correspondence**

Ranjana Sedhai

✉: ranzusedhai333@gmail.com

**ABSTRACT**

The single factor field experiment was laid out in a Randomized Complete Block Design (RCBD) with 5 treatments (T1-no pinching, T2-pinching at 10 DAT, T3-pinching at 20 DAT, T4-pinching at 30 DAT, and T5- pinching at 40 DAT) and four replications. Five plants were randomly selected from each treatment to record growth, flowering parameters, and yield of marigold. Among the treatments, T1 (no pinching) recorded the maximum plant height (89.05 cm), earliest bud initiation (29.75 days), the earliest appearance of the first flower (40.25 days), and minimum days to 50% flowering (50 days). Similarly, the maximum flower diameter (5.53 g), fresh weight (5.08 g), and dry weight of the flower (2.11 g) were also recorded with this treatment. Further, the highest number of primary branches per plant (19.25), secondary branches per plant (46.25), plant spread (59.20 cm), and the highest number of flowers (124.96), flower yield per plant (549.9 g), flower yield per plot (8.25 kg) and total flower yield (229.14 q/ha) were recorded at T5 (pinching at 40 DAT). Hence, it can be concluded that pinching at 40 DAT is the most effective practice for yield and number of flowers and no pinching can be recommended if early and large sized flowers are required.



## 1. Introduction

Marigold is one of the most significant commercial flower crops cultivated both globally and in Nepal (Ghosh, et al., 2018). The marigold is a hardy, hairy, free-flowering, short-lived, evergreen crop in genus *Tagetes* and belongs to class Magnoliopsidae, family Compositae. The two most common species of marigold are french marigold, and african marigold, native to South Africa and Mexico, respectively. African marigolds are tall, upright plants that grow to a height of over 100 cm during their lifetime. Cuttings and seeds spread it. Propagation from seeds is preferred over cuttings because plants grown from seeds are tall, diverse, and heavy yielders. The flower, ranging from yellow to orange in color, has numerous ray florets along the edges and disc florets in the center. The mature seed is small, with a striking jet-black color, and is referred to as an achene (Zhang et al., 2005; Regmi & Acharya, 2022; Acharya, et al., 2021). Marigold plants are grown in open, sunny conditions and require lots of sunshine and a mild climate for lush growth and abundant flowering. Marigold is associated with religious ceremonies and celebrations because of its diverse and varied germplasm (Kumar, et al., 2012; Kumar & Senthil, 2011). Marigold flowers are valuable on festival days, particularly in Tihar. Flowers are always in demand for variety of occasions, including weddings, festivals, and floral arrangements. At religious and social gatherings, flowers are offered to gods and goddesses and are also used to make garlands (Pun, 2004). The marigold flower has held significant importance since ancient times often considered the favorite bloom of the gods. It has gained popularity among gardeners due to its easy cultivation, wide adaptability, and quick production of marketable flowers (Arora & Khanna, 1986) Many farmers grow marigold at the commercial level, and some farmers have benefitted economically from their cultivation during normal and off seasons (Adhikari and Pun, 2011). A popular annual flower crop, marigolds are grown for their beauty in gardens, pots, bedding plants, and herbaceous borders. They are also used commercially to make garlands, wreaths, religious offerings, cut flowers, and other items

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like oil extraction (mostly xanthophyll) (Singh et al., 2017). Recently, marigold has emerged as a natural source of carotenoid pigments. The principle pigment in the flower is xanthophyll particularly lutein which contains more than 80-90 % and is present in the form of esters of palmitics and myristic acid. Marigold carotenoids are the major source of pigment for poultry industry as a feed additive to intensify the yellow color of egg yolks, and broiler skin (Scott et al., 1968). After harvesting, flowers are silage, dried, and extracted to get lutein, which is a carotenoid pigment found mainly in marigold flower. About 90% (w/w) of carotenoids are present in dry petals of marigold (Kumar et al, 2014). At present use of lutein is increasing worldwide because natural lutein is a nutritional supplement that protects skin from sun damage, prevents low density lipid cholesterol from oxidizing and possesses lower risks of heart diseases (Singh and Karki, 2004). Lutein which is a major constituent of xanthophyll is used for coloring food stuffs, purified extracts of marigold petals containing lutein di-palmitate is marked as an ophthalmologic agent under the name adaptinol (Singh, 2006). Hence, marigold carotenoids are also used in pharmaceuticals, food supplements, cosmetics (Hadden et al., 1999) as well as in human food, stuffs since they are nutritious in nature (Shetty et. al., 2006).

Pinching is the technique of removing the plant's apical portion (Pandey, et al., 2021). Pinching delays flowering and increases flower yield in marigold plants, making it a crucial cultural operation for plant growth and flower production. The quantity of branches that bear flowers determines the amount of flowering and yield, and monitoring the plants' vertical growth can control this and promoting side shoots by pinching the apical bud (Sasikumar et al., 2015). The main purpose of pinching is to encourage branching to produce a bushy growth and or the production of more flowers and flower yield (Singh et al., 2017). It is safe alternative treatment, which could be a potential substitute to use plant growth retardants application, which widely used in recent years for compacting growth and producing more branches. Results of Omar et al., (1997) on *Hibiscus sabdariffa* showed that pinching increased the number of branches and flowers. Also, Pushkar and Singh (2012) indicated that pinching increased the flower yield of African marigold. Pinching, the terminal portion of shoots is removed early, the emergence of side branches starts earlier and production of large number of primary branches resulting in well spread bushy plant and more number of flowers of good quality and uniform size are produced flowers. To fulfill the demand of industrialists and local market, it is necessary to increase the production through pinching to accelerate growth, induce lateral buds and to increase flower yield.

## 2. Materials and Methods

### 2.1. Experiment site and treatment details

The experiment was conducted in Khairahani, Chitwan, Nepal. Geographically, it is located at 27.571 ° N latitude and 84.571 ° E longitude. Chitwan has a tropical monsoon climate with high humidity throughout the year. The monsoon starts in mid-June and eases off in late September. Summer temperatures exceed 37°C whereas winter temperature range from 7°C to 23°C. The average annual temperature is 24°C. The average rainfall is 1993 mm.

### 2.2. Experimental design and treatment details

The experiment was laid out in Randomized Complete Block Design (RCBD) with five treatments and four replications in which row to row distance is 60 cm and plant to plant distance is 40 cm. The total area is 126 $m^2$ with a single plot area is 3.6 $m^2$. For this experiment, Marigold plants were pinched on different days after transplanting and the details of treatments are given below.

Table 1. Different treatments used for marigold production

| # | Treatment | Time of pinching |
|---|---|---|
| 1 | Control | No Pinching (T1) |
| 2 | First Pinching | 10 days after Transplanting (T2) |
| 3 | Second Pinching | 20 days after Transplanting (T3) |
| 4 | Third Pinching | 30 days after Transplanting (T4) |
| 5 | Fourth Pinching | 40 days after Transplanting (T5) |

### 2.3. Cultural operations

#### *2.3.1. Field Preparation*

With a Mouldboard plough, the field was prepared for cultivation. Harrowing broke up the clods. The field was leveled after clearing away the grasses, weeds, and remnants of previous crops. Measurement tape, rope, and bamboo pegs were used to help with the experiment's layout.

#### *2.3.2. Manures and fertilizers*

Due to its rapid growth, marigold needs a high nitrogen dose along with a moderate amount of phosphorous and potash for healthy root development and high-quality flowers. The application of well-decomposed FYM@20 Mt/ha occurred during the land preparation phase. The fertilizer dose of 160:60:60 kg NPK/ha was applied in two splits, meaning that half of the N dose and the full doses of P and K were applied at the time of transplanting, and the remaining 2.9 half doses of N were applied a month later. Urea, single super phosphate, and muriate of potash were used to apply nitrogen, phosphorus, and potash, respectively.

#### *2.3.3. Transplanting of seedlings*

The 30 days old seedlings were transplanted during the evening hours at a spacing of 60 cm; row to row and 40 cm; plant to plant.

#### *2.3.4. Gap filling*

About 16.6% of gap filling was done as the plants died due to the excessive rainfall after 1 week of transplanting to maintain the desired plant population number of plants. Total 50 numbers of seedlings were used for gap filling.

### 2.3.5. Irrigation

Due to continuous rainfall, first irrigation was given after 45 days after transplanting. The plants were given regular irrigation at an interval of 6-8 days.

### 2.3.6. Pinching

Pinching was done to promote vegetative growth and create multi-stemmed plants. The single pinch method was used in this experiment. Using one hand to hold the main plant without causing any disturbance to the root zone, pinching was done early in the morning when the plants were extremely turgid. In accordance with the days specified in the treatments, 4-5 cm terminal growing tips made up of 3–4 pairs of leaves were removed.

### 2.3.7. Weeding

Weeding is a major problem in marigold during rainy season. So, the experimental field was kept weed free by hand weeding and hoeing at regular intervals. These practices not only help to manage the weed population but also enhance soil aeration.

### 2.3.8. Stalking

Due to excessive vegetative growth, some plants continue the upright growth and at the end become very tall which results in the bending of the plants and thus need stalking to support the plant.70 -80 cm long wooden sticks did staking and the plants were kept erect. It was done after 7 weeks of transplanting.

### 2.3.9. Disease and Pests

Damping off, powdery mildew, thrips, mites, and caterpillars were observed in the experimental site and were controlled through different chemical measures.

### 2.3.10. Harvesting

Fully-opened flowers were plucked in the morning, manually. In marigolds, flowering is not synchronized. So, the harvesting was done at weekly intervals when the central whorls of petals were fully open. The field was irrigated before plucking to maintain the turgidity of flowers and better post-harvest life.

## 2.4. Observation recorded

Five plants were selected from each treatment randomly and were tagged for the purpose of recording data on various parameters.

### 2.4.1. Vegetative growth parameters

#### Plant height (cm)

Five plants were taken as sample plants from each plot and tagged. Plant height was measured from the ground level up to the terminal portion of the plant with the help of a reference scale at an interval of 15, 30, 45, 60, 75, and 90 days after transplanting. The average height was calculated by dividing the summation with five.

#### Number of primary branches per plant

All the branches, which come out from the main stem, were counted from five sample plants of each plot. Then, average numbers of branches were calculated.

#### Number of secondary branches per plant

All the branches, which came out from the primary branches, were counted from five sample plants of each plot. The average was then calculated by dividing the summation with five.

#### Plant spread (cm)

The plant spread was determined by averaging the distance between the outermost side shoots from east to west and from north to south. The average value was then worked out.

### 2.4.2. Flowering and yield parameters

#### Days to bud initiation (days)

The appearance of first bud in each sample plants were recorded and days taken were counted from the date of transplanting.

#### Days to flowering initiation (days)

The numbers of days taken from the date of transplanting to first flower opening were recorded.

#### Days to 50 % flowering (days)

Days to 50% flowering were recorded when 50% plants came into flowering in each plot. This observation was taken with reference to the date of transplanting.

#### Diameter of the flower (cm)

In each treatment, five flowers were selected at the full bloom stage. The flower diameter was recorded in cm and their mean values were calculated.

#### Fresh weight of flower (g)

Five flowers were plucked randomly from each sample plant, and then average weight was recorded in gram with the help of electronic balance.

#### Dry weight of flower (g)

Flowers, which were taken for fresh weight, were dried in hot air oven. After oven drying, dry weight of the selected flowers were taken and expressed in gram.

### *Number of flowers per plant*

Total number of flowers per plant was recorded from each sample plant at each harvest. After the final harvest, the number of flowers of every picking was counted and then average was worked out.

### *Flower yield per plant (g)*

It was calculated by multiplying total number of flowers per plant and average fresh weight of flower in each treatment and was expressed in gram.

### *Flower yield per plot (kg)*

It was calculated by multiplying average flowers yield per plant and number of plants in the plot and was expressed in kg.

### *Total Flower yield (q/ha)*

The total flower yield of the whole experiment was expressed in quintal per hectare (q/ha).

### 2.5. Data entry and analysis

The collected data were entered, tabulated and processed in Microsoft Excel. The recorded data on different parameters were analyzed by using GENSTAT software and the mean was calculated using Duncan's Multiple Range Test (DMRT).

### 2.6. Economics of marigold cultivation

The total cost and benefit of the marigold cultivation was calculated for this experiment. The cost of cultivation was calculated by recording the total expenditure made under different headings right from the land preparation to harvesting stage. The total benefit obtained was recorded on the basis of its sale. Both garland and loose flowers were sold for different purposes.

## 3. Results and Discussion

### 3.1. Plant height

The plant height was recorded from 15 days after transplanting at 15 days intervals up to 90 days. The average plant height at successive stages of growth (15, 30, 45, 60, 75 and 90) days after transplanting is presented in Table 2. Pinching resulted in a significant effect on plant height as compared to un-pinched plants at 5% level of significance. At 15 days after transplanting, the maximum plant height (26.05 cm) was found under no pinching and minimum plant height (19.60 cm) was observed in pinching at 10 days after transplanting likewise, at 30 days after transplanting, the maximum plant height (39.15 cm) was found under no pinching and the minimum plant height (33.75 cm) was observed in pinching at 30 days after transplanting. Similarly, at 45 days after transplanting, the maximum plant height (54.30 cm) was found under the no pinching, and the minimum plant height (44.55 cm) was found in pinching at 20 days after transplanting additionally, at 60, 75, 90 days after transplanting the maximum plant height (66.55 cm, 77.60 cm, and 89.05 cm) was found under no pinching and the minimum plant height (55.20 cm, 68.55 cm, and 80.75 cm) was found under pinching at 40 days after transplanting.

The removal of apical meristematic tissue, which prevented apical dominance and redirected plant metabolites from vertical growth to horizontal growth, was the primary cause of the pinched plant's reduction in height. These results were in agreement with the finding of Sarkar et al. (2018), Nain et al. (2017), Rathore et al. (2011), Badge et al. (2014) and Meena et al. (2015).

### 3.2. Plant spread

The plant spread was recorded from 15 days after transplanting at 15 days interval up to 90 days. The average plant spread at successive stages of growth (15, 30, 45, 60, 75 and 90) days after transplanting is presented in Table 3. Pinching exerted a significant effect on plant spread at 5 % level of significance. At 15 days after transplanting, the maximum plant spread (11.87 cm) was found under the pinching at 40 days after transplanting. The minimum plant spread (10.27cm) was observed in pinching at 10 days after transplanting. At 30 days after transplanting, the maximum plant spread (27.74 cm) was found under the pinching at 20 days after transplanting. The minimum plant spread (21.91cm) was observed in pinching at 30 days after transplanting. At 45, 60, 75 and 90 days after transplanting, plant spread was maximum in pinching at 40 days after transplanting (34.41cm, 44cm, 52.99cm and 59.20cm) whereas minimum plant spread was noticed in no pinching (27.66cm, 34.65cm, 40.60cm and 44.73cm).

A greater number of lateral and secondary branches per plant may have resulted from cell elongation and pinching, which slowed the apical growth of the stem and, in turn, increased plant spread under various pinching treatments. Similar results were reported by Sharma et al. (2006), Rajbeer et al. (2009), and Raut et al. (2011) and Nain et al. ( 2017).

### 3.3. Number of primary branches

The number of primary branches was recorded from 15 days after transplanting at 15 days interval up to 90 days. Effect of pinching on number of primary branches per plant is presented in Table 4. The data observed that different level of pinching on African marigold was found to be statistically significant within the treatments. The result revealed that, at 15 days after transplanting, the maximum number of primary branches (5.1) was found under no pinching and the minimum number of primary branches (4.6) was observed in pinching at 10 days after transplanting likewise, at 30 days after transplanting the maximum number of primary branches (8.55) was found under the pinching at 10 days after transplanting. The minimum number of primary branches (7.7) was observed in pinching at 30 days after transplanting and at 45 days after transplanting, the maximum number of primary branches (11.95) was found under pinching at 40 days after transplanting. The minimum number of primary branches (9.6) was observed in no pinching. Similarly

result, was obtained in 60, 75 and 90 days after transplanting.

The axillary buds on the main shoot may have grown more freely from correlative inhibition, which had been suppressed by the apical dominance phenomenon, after the apical portion of the plant was removed. Alternatively, the increase in primary branch count could be the result of enhanced cell division, larger cells, larger leaf areas, and therefore higher photosynthesis activity. The present finding agree with the views of Mohanty et al. (2015), Kumar et al. (2012) and Sharma et al. (2006).

### 3.4. Number of secondary branches

The data on effect of pinching on number of secondary branches have been presented in Table 5 was recorded from 15 days after transplanting at 15 days interval up to 90 days. At 15 days after transplanting, the maximum number of secondary branches (5.75) was found under pinching at 10 days after transplanting and the minimum number of secondary branches (4.1cm) was observed in pinching at 40 days after transplanting. At 30 days after transplanting, the maximum number of secondary branches (13.85) was found under the pinching at 20 days after transplanting and the minimum number of primary branches (11) was observed in no pinching. At 45 days after transplanting, the maximum number of secondary branches (21.70) was found under the pinching at 30 days after transplanting and the minimum number of primary branch (17.35) was observed in no pinching additionally result, noticed at 60, 75 and 90 days after transplanting.

Pinching resulted in increased number of secondary branches per plant may be due to cell elongation, which finally results in more number of secondary branches per plant. Similar, result were reported by Meena et al. (2015) and Sarkar et al. (2018).

### 3.5. Days to bud initiation (days)

In this experiment, days to bud initiation were significantly influenced by various pinching treatments. The data recorded on days to first bud initiation is presented in Table 6. In the present study the average days taken to bud initiation was significant within the treatments. The result revealed that plant without pinching induced early bud (29.75 days) in comparison with pinching at 40 days after transplanting (51 days).

The delays in emergence of flower bud may be due to the fact that, it might have suppressed the bud initiation process by way of inhibition in cell division in the sub apical meristem during the period when the floral stimulus was present, thus preventing the expression of the stimulus in flower primordial, which would have ultimately resulted in delayed emergence of first flower bud. The finding are agree with the view of Sarkar et al. (2018).

### 3.6. Days to flower initiation (days)

A keen observation of data shown in Table 6. It reported that different pinching treatments had a significant effect on initiation of flower. The total period from transplanting to first flowering was comparatively less (40.25 days) in no pinching while, comparatively more (59.50) period for first flowering was noted under pinching at 40 days after transplanting. The pinching at 40 days after transplanting was recorded maximum days to open first flower and it might be due to the fact that pinching of apical bud suppresses the bud initiation process by inhibiting cell division in the lateral meristem resulting in prevention of flower primordial development in the meantime. The present finding agree with the views of Parhi et al. (2016) , Singh et al. (2017), Rajbeer et al. (2009) and Shrivastava et al. (2005).

### 3.7. Number of days taken for 50% flowering

Various levels of pinching give striking effect on number of days taken for 50% flowering in Table 6. The data revealed that number of days taken for 50% flowering was significantly affected by the pinching treatments. From the table it is evident that (50 days) earliest flowering is found in no pinching. The maximum delays in 50 % flowering (68.25 days) were noticed in pinching at 40 days after transplanting. The possible reason for maximum delays in 50 % flowering in pinched plant may be due to fact that during the process of pinching, physiological mature portion of the shoot was removed and new shoots which emerged out from the pinched plant took more time to become physiologically mature to bear flower. These results are in close conformity with earlier reports of Rathore et al. (2007), Kumar et al. (2012), Jyothi et al. (2018), Prakash (2015) and Srivastav et al. (2005).

### 3.8. Flower diameter (cm)

The data with concerned to flower diameter as affected by various levels of pinching was statistically significant in Table 6. Pinching has significantly affect flower diameter. It was observed that the larger size of flower (5.53cm) was under no pinching and smaller size of flower (4.84cm) was under pinching at 40 days after transplanting. It can be inferred that pinching at 40 days after transplanting among all the treatments was found lowest diameter. This decrease in flower diameter might be attributed to the fact that in pinched plant the developing side branches share energy, while in case of un-pinched paints the energy sharing is limited to the flower developing on main branch only. These results are in close conformity with result Nain et al. (2017), Palekar et al. (2018) and Kumar et al. (2012).

### 3.9. Fresh weight of flower (g)

Statistical analysis of the data is presented in Table 6, showed that different pinching treatments had a significant effect on fresh weight of flower. The maximum fresh weight (5.08g) was obtained in no pinching while; the minimum fresh weight of flower (4.46g) was noticed pinching at 40 days after transplanting. The reason of increased weight of the flower with no pinching may be due to availability of more food material and better allocation of energy pertaining to lesser number of flowers. The finding are agree with the views of Palekar et al. ( 2018) and Singh et al. (2017).

Table 2. Effect of pinching on plant height of African marigold

| Treatments | Plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT |
| $T_1$-no pinching | 26.05$^{a}$ | 39.15$^{a}$ | 54.30$^{a}$ | 66.55$^{a}$ | 77.60$^{a}$ | 89.05$^{a}$ |
| $T_2$-pinching at 10 DAT | 19.60$^{b}$ | 34.05$^{b}$ | 48.05$^{b}$ | 58.60$^{b}$ | 72.35$^{b}$ | 84.55$^{b}$ |
| $T_3$-pinching at 20 DAT | 24.75$^{a}$ | 33.85$^{b}$ | 44.55$^{c}$ | 58.55$^{b}$ | 72.35$^{b}$ | 83.20$^{b}$ |
| $T_4$-pinching at 30 DAT | 26.00$^{a}$ | 33.75$^{b}$ | 45.00$^{bc}$ | 56.30$^{c}$ | 69.05$^{c}$ | 81.50$^{c}$ |
| $T_5$-pinching at 40 DAT | 26.55$^{a}$ | 38.30$^{a}$ | 44.9bc | 55.20$^{c}$ | 68.55$^{c}$ | 80.75$^{c}$ |
| Grand mean | 24.59 | 35.82 | 47.36 | 59.04 | 71.98 | 83.81 |
| CV (%) | 5.8 | 6.2 | 4.3 | 2 | 2.1 | 1.3 |
| SEM (±) | 0.717 | 1.107 | 1.011 | 0.58 | 0.74 | 0.76 |
| $LSD_{0.05}$ | 2.210*** | 3.412*** | 3.11*** | 1.8*** | 2.3*** | 1.65*** |

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

Table 3. Effect of pinching on plant spread of African marigold

| Treatments | Plant spread (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT |
| $T_1$-no pinching | 11.25$^{a}$ | 21.97$^{b}$ | 27.66$^{b}$ | 34.65$^{d}$ | 40.60$^{d}$ | 44.73$^{d}$ |
| $T_2$-pinching at 10 DAT | 10.27$^{b}$ | 23.74$^{b}$ | 29.85$^{ab}$ | 39.03$^{c}$ | 45.35$^{cd}$ | 52.86$^{c}$ |
| $T_3$-pinching at 20 DAT | 11.70$^{a}$ | 27.74$^{a}$ | 32.59$^{ab}$ | 40.71$^{bc}$ | 47.19$^{bc}$ | 54.40$^{bc}$ |
| $T_4$-pinching at 30 DAT | 11.82$^{a}$ | 21.91$^{b}$ | 34.41$^{a}$ | 43.03$^{ab}$ | 50.41$^{ab}$ | 57.91$^{ab}$ |
| $T_5$-pinching at 40 DAT | 11.87$^{a}$ | 22.01$^{b}$ | 31.44$^{ab}$ | 44$^{a}$ | 52.99$^{a}$ | 59.20$^{a}$ |
| Grand Mean | 11.38 | 23.47 | 31.19 | 40.28 | 50.04 | 54.56 |
| CV (%) | 4.2 | 5.1 | 10.8 | 4.4 | 6.6 | 5 |
| SEM (±) | 0.237 | 0.6 | 5.2 | 0.89 | 1.564 | 1.9 |
| $LSD_{0.05}$ | 0.731*** | 1.18*** | 1.75** | 2.741*** | 4.819*** | 4.165*** |

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation.

Table 4. Effect of pinching on number of primary branches of African marigold

| Treatments | Number of primary branches | | | | | |
|---|---|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT |
| $T_1$-no pinching | 5.1$^{a}$ | 7.55$^{b}$ | 9.6$^{c}$ | 11.50$^{c}$ | 13.20$^{c}$ | 14.25$^{c}$ |
| $T_2$-pinching at 10 DAT | 4.6$^{b}$ | 8.55$^{a}$ | 11$^{b}$ | 13.55$^{b}$ | 16$^{b}$ | 18.05$^{b}$ |
| $T_3$-pinching at 20 DAT | 4.95$^{a}$ | 8.35$^{a}$ | 11.45$^{ab}$ | 14.15$^{ab}$ | 16.30$^{b}$ | 18.20$^{b}$ |
| $T_4$-pinching at 30 DAT | 4.95$^{a}$ | 7.7$^{b}$ | 11.35$^{ab}$ | 14.25$^{ab}$ | 16.45$^{b}$ | 18.40$^{ab}$ |
| $T_5$-pinching at 40 DAT | 5.1$^{a}$ | 7.7$^{b}$ | 11.95$^{a}$ | 14.60$^{a}$ | 17.35a | 19.25$^{a}$ |
| Grand Mean | 4.94 | 7.97 | 11.07 | 13.61 | 15.86 | 17.63 |
| CV (%) | 4.3 | 4.1 | 4.1 | 3.6 | 3.1 | 3.3 |
| SEM (±) | 0.10 | 0.23 | 0.321 | 0.245 | 0.23 | 0.3 |
| $LSD_{0.05}$ | 0.33** | 0.5*** | 0.699*** | 0.76*** | 0.77*** | 0.9*** |

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

Table 5. Effect of pinching on number of secondary branches of African marigold

| Treatments | Number of secondary branches (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT |
| $T_1$-no pinching | 4.45$^{a}$ | 11$^{b}$ | 17.35$^{b}$ | 25.55$^{e}$ | 28.60$^{e}$ | 30.10$^{e}$ |
| $T_2$-pinching at 10 DAT | 5.75$^{a}$ | 13.30$^{a}$ | 20.45$^{a}$ | 28.85$^{d}$ | 31.80$^{d}$ | 33.80$^{d}$ |
| $T_3$-pinching at 20 DAT | 4.05$^{b}$ | 13.85$^{a}$ | 20.70$^{a}$ | 31.30$^{c}$ | 35$^{c}$ | 37.70$^{c}$ |
| $T_4$-pinching at 30 DAT | 4.2$^{b}$ | 11.25$^{b}$ | 20.70$^{a}$ | 34.80$^{b}$ | 38.05$^{b}$ | 41.60$^{b}$ |
| $T_5$-pinching at 40 DAT | 4.1$^{b}$ | 11.60$^{b}$ | 21.10$^{a}$ | 39.50$^{a}$ | 43.45$^{a}$ | 46.25$^{a}$ |
| **Grand mean** | 4.5 | 12.20 | 20.06 | 32.00 | 35.38 | 37.89 |
| **CV (%)** | 8.2 | 4.3 | 2.3 | 3.1 | 2.8 | 2.1 |
| **SEM (±)** | 0.19 | 0.27 | 0.23 | 0.5 | 0.5 | 0.4 |
| **$LSD_{0.05}$** | 0.57*** | 0.8*** | 0.71*** | 1.54*** | 1.53*** | 1.21*** |

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

### 3.10. Dry weight of flower (g)

Effect of pinching on dry weight of flower is presented in Table 6. Different pinching levels on African marigold significantly influenced on dry weight. No pinching (2.11g) showed the maximum dry weigh while, minimum (1.6g) was recorded in pinching at 40 days after transplanting. As fresh weight of flower was recorded maximum in no pinched plant, so it is obvious that dry weight of the respective flower should be maximum Similar results were also obtained by Singh et al. (2017), Sharma et al. (2006) and Rathore et al. (2011).

### 3.11. Number of flowers

Effect of pinching on number of flowers is presented in Table 6. Different levels of pinching on Africa marigold cv. Calcutta local was found statistically significant in number of flowers. In the present experiment though pinching at 40 days after transplanting, number of flowers was found higher (124.96) compared to no pinching (58.34). This might be due to the fact that pinched plant induces the production of large number of axillaries shoots resulting in well-shaped bushy plants bearing more number of uniform flowers. Similar results were reported by Jyothi et al. ( 2018), Sarkar et al. ( 2018) , Pushkar et al. *(*2012) and Meena et al. (2015).

### 3.12. Flower yield

The flower yield was recorded under different treatments are presented in Table 7. The data conclude that different pinching levels on African marigold cv. Calcutta Local was found to be statistically on yield of flowers. Higher flower yield per plant (549.9 g) was recorded in pinching at 40 days after transplanting in comparison with no pinching (296.4 g). Similarly, significantly higher yield per plot (8.25 kg) was observed in pinching at 40 days after transplanting, as compared to lower yield per plot (4.45 kg) was observed in no pinching and maximum flower yield (229.14 ton/ha) was noticed in plant pinched at 40 days after transplanting whereas, the minimum yield was recorded in no pinching (123.48 ton/ha). Minimum yield was observed in no pinching may be due to less number of flowers per plant than in plant pinched 10, 20, 30 and 40 days after transplanting and the increase in yield of flowers under pinching treatments might be due to the increase in yield of flower under pinching treatments may be due to the fact that pinching checked the apical dominance and diverted extra metabolites into the production of more number of flowers. Gain of extra energy in the production of more number of flowers per plant and ultimately surge in flower yield. Similar result were reported by Sarkar et al. (2018), Palekar et al. (2018), Singh et al. (2017), Prakash et al. (2015) and Anuradha et al. (2017).

### 3.13. Economics Analysis

#### *3.13.1. Cost of marigold cultivation*

The cost of marigold cultivation is shown in Table 8. The total cost of production of marigold was NRs. 7371.1. The major inputs were seedling, labor charge and land preparation. It was clearly seen from the table that seedling involved the maximum cost on total cost of production which accounted NRs. 3200.Labor charge was second significant cost involved (NRs 2000) of the total expenditure. The cost of land preparation by harrowing was found to be the third costlier input regarding the marigold production. It accounted NRs 800.The overall income is shown in Table 9.

#### *3.13.2. Total income*

From the Table 10, it indicated that the total income of marigold was Rs.21900. The overall cost of cultivation was Rs.7371 and the B: C ratio was 2.97 which show that for each rupee invested the profit obtained was 2.97.

Table 6. Effect of pinching on days to bud initiation, days to flower initiation, days taken for 50% flowering, flower diameter, fresh weight and dry weight of flower, number of flowers of African marigold

| Treatments | Bud initiation (days) | Flower initiation (days) | 50% Flowering (days) | Flower diameter (cm) | Fresh weight (g) | Dry weight (g) | Number of flowers |
|---|---|---|---|---|---|---|---|
| $T_1$-no pinching | 29.75$^{e}$ | 40.25 | 50$^{e}$ | 5.53$^{a}$ | 5.08$^{a}$ | 2.11$^{a}$ | 58.34$^{e}$ |
| $T_2$-pinching at 10 DAT | 34.50$^{d}$ | 45 | 54.25$^{d}$ | 5.3$^{b}$ | 4.9$^{b}$ | 1.9$^{b}$ | 72.38$^{d}$ |
| $T_3$-pinching at 20 DAT | 40$^{c}$ | 51.50 | 60$^{c}$ | 5.17$^{c}$ | 4.8$^{c}$ | 1.83$^{bc}$ | 79.77$^{c}$ |
| $T_4$-pinching at 30 DAT | 44.50$^{b}$ | 53.50 | 63$^{b}$ | 5.04$^{d}$ | 4.73$^{c}$ | 1.73$^{c}$ | 96.43$^{b}$ |
| $T_5$-pinching at 40 DAT | 51$^{a}$ | 59.50 | 68.25$^{a}$ | 4.84$^{e}$ | 4.46$^{d}$ | 1.6$^{d}$ | 124.96$^{a}$ |
| Grand Mean | 39.95 | 49.95 | 59.10 | 5.5175 | 4.803 | 1.83 | 86.38 |
| CV (%) | 2.3 | 3 | 3.2 | 0.6 | 1.7 | 4.8 | 1.6 |
| SEM (±) | 0.5 | 0.747 | 0.94 | 0.02 | 0.04 | 0.061 | 0.703 |
| $LSD_{0.05}$ | 1.42*** | 2.302 | 2.89*** | 0.05*** | 0.12*** | 0.134*** | 2.16*** |

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

Table 7. Effect of pinching on flower yield of African marigold

| Treatments | Flower yield/plant | Flower yield/plot | Total flower yield (q/ha) |
|---|---|---|---|
| $T_1$ (no pinching) | 296.4$^{e}$ | 4.45$^{e}$ | 123.48$^{e}$ |
| $T_2$ (pinching at 10 DAT) | 357.5$^{c}$ | 5.36$^{d}$ | 148.94$^{d}$ |
| $T_3$ (pinching at 20 DAT) | 383.5$^{c}$ | 5.58$^{c}$ | 159.78$^{c}$ |
| $T_4$ (pinching at 30 DAT) | 452.8$^{b}$ | 6.79$^{b}$ | 188.65$^{b}$ |
| $T_5$ (pinching at 40 DAT) | 549.9$^{a}$ | 8.25$^{a}$ | 229.14$^{a}$ |
| Grand Mean | 408 | 6.12 | 170 |
| CV (%) | 2.3 | 2.3 | 2.3 |
| SEM (±) | 4.63 | 0.07 | 1.93 |
| $LSD_{0.05}$ | 14.28*** | 0.21*** | 5.95*** |

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation

Table 8. Cost of marigold cultivation

| # | Particulars | Inputs | Rate (Rs.) | Amount (Rs.) |
|---|---|---|---|---|
| 1. | **Land Preparation (126 $m^2$)** | | | |
| i. | Harrowing | 40 min | 800 | 800 |
| **2.** | **Labour charges** | No. of labours | | |
| i. | Preparation of plots, bunds and irrigation channel | 1 for 2 days | 1000 $day^{-1}$ | 2000 |
| **3.** | **Cost of inputs** | | | |
| i. | Cost of seedling | 400 | 8/seedling | 3200 |
| ii. | Cost of FYM | 150kg | 2/kg | 300 |
| iii. | Irrigation charge | | | 500 |
| iv. | Cost of fertilizers | | | |
| a. | Urea | 1.37 kg | 60 $kg^{-1}$ | 82.2 |
| b. | Single Super Phosphate | 0.93 kg | 50 $kg^{-1}$ | 46.5 |
| c. | Muriate of potash | 0.72kg | 45 $kg^{-1}$ | 32.4 |
| v | Cost of insecticides & pesticides | | | 150 |
| **4.** | Miscellaneous | | | 300 |
| **5** | **Total Cost** | | | 7371.1 |

Table 9. Total income from marigold cultivation

| Product | Quantity (No.) | Rate (Rs.) | Total Amount (Rs.) |
|---|---|---|---|
| Flower | 4600 | 1.5/ flower | 6900 |
| Garland | 250 | 60/ garland | 15000 |
| Total Income | | | 21900 |
| Net Revenue | | | 14528.9 |

Table 10. Yield and Economic Returns from Marigold Cultivation

| Particular | Land Holding (124 $m^2$) |
|---|---|
| Total Income (Rs.) | 21900 |
| Total Cost (Rs.) | 7371.1 |
| B: C Ratio (Rs.) | 2.97 |

## 4. Conclusion

Based on the results, it can be concluded that pinching 40 days after transplanting was the most effective for achieving a higher yield and a greater number of flowers. Number of pinching can be recommended if early and big sized flowers are required and finally planting marigold is highly beneficial because of its high B: C ratio.

## Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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