



## Effect of pinching and spacing on growth, flowering and yield of African marigold (*Tagetes erecta* L.) under semi-arid conditions of Haryana

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**Abstract:** The present study was conducted at experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar (Haryana), India with a view to optimize pinching time and spacing in African marigold for achieving better growth, flowering and yield. Design of the experiment was factorial Randomized Block Design with three replications. Experiment comprises of two levels of pinching (no pinching & pinching at 28 DAT i.e. Days After Transplanting) and three levels of spacing (40 x 40 cm, 40 x 30 cm & 30 x 30 cm) in all possible combinations. Maximum number of branches/plant (12.11), plant spread (63.59 cm), fresh weight of plant (358.79 g), number of buds/plant, duration of flowering (53.95 days), number of flowers/plant (54.54), stalk length and flower yield/plant (403.68 g) and flower yield/hectare (33.33 t) were significantly recorded in plants pinched at 28 DAT at 5% level of significance, whereas, maximum plant height (73.52 cm), flower diameter (6.38 cm), fresh weight of flower (8.93 g) was obtained in un-pinched plants. In case of spacing, maximum plant spread (64.01 cm), primary branches/plant (11.42), fresh weight of plant (370.20 g), number of buds/plant, number of flowers/plant (51.43), duration of flowering (53.98 days), flower diameter (6.42 cm), fresh weight of flower (9.03 g), flower yield/plant (460.42 g) was recorded at 40 x 40 cm, whereas, maximum plant height (71.76 cm), stalk length, flower yield/hectare (36.34 t) was observed with 30 x 30 cm. Results revealed that plants pinched at 28 DAT with widest spacing (40 x 40 cm) were found best for better growth, flowering and yield of African marigold.

**Keywords:** Growth and Flowering, Marigold, Pinching, Spacing, Yield

### INTRODUCTION

Floriculture has caught the eyes of the farmers as an enterprise which can yield higher returns per unit area due to the emphasis shifting on diversification of agriculture in the recent years. Marigold is a native of Mexico and belongs to the family Asteraceae. It is used commercially for making garlands, wreaths, religious offering and as cut flowers. Its habit of free flowering, short duration, attractive colour, shape, size, good keeping quality and easy transportation attracts the attention of flower growers and traders. In India, the total area under marigold cultivation is 255 thousand hectares with production of 1754 thousand MT loose flowers and 543 thousand MT cut flowers. In Haryana, the area under floriculture is 6.5 thousand hectares with a production of 65.5 thousand MT of loose flower and 11.3 thousand MT cut flowers, out of which 5.69 thousand hectares is covered under marigold cultivation with a loose flower production of 64.62 thousand MT (Saxena and Gandhi, 2014). Pinching is done to stimulate early emergence of side branches which ultimately produces more number of flowers with good quality and uniform size. Shoot pinching at 30 DAT improved plant spread, number of leaves, weight of flowers per plot (3745.95 g) and flower yield per hectare (13873.0 kg) (Mohanty

*et al.*, 2015). The maximum number of branches/plant (22.99) and number of flowers/plant (34.91) was recorded in double pinching at 60 DAT followed by pinching at 30 DAT (19.28) and (31.97), respectively (Meena *et al.*, 2015). A wider spacing increases the photosynthetic area and reduces the competition for nutrients, while the reverse is true for closer spacing. The wider spacing of 30 x 60 cm resulted in to highest number of branches/plant (19.87) and number of flowers/plant (34.67) followed by 30 x 45 cm (18.33 & 31.59, respectively) and 30 x 30 cm (17.05 & 29.55, respectively) (Meena *et al.*, 2015). Wider spacing (50 x 50 cm) recorded the maximum flower yield per plant (0.42 kg), while maximum flower yield per hectare (205.19 q/ha) was obtained in closer spacing (50 x 40 cm) (Chauhan and Ambast, 2014). The successful commercial production of marigold depends upon many factors such as variety, planting time, fertilizer, spacing and cultural practices like gap filling, pinching, weeding, irrigation etc. However, some aspects of the production technology of marigold in agro-climatic conditions of Haryana have not been standardized so far. Therefore, in the light of above facts the present investigation was planned with the objective to study the effect of pinching and spacing on growth, flowering and yield of African marigold under semi arid con-

ditions of Haryana.

## MATERIALS AND METHODS

This study was conducted at experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar (Haryana), India in factorial RBD during winter season of 2013-14 to optimize the pinching time and spacing in African marigold cv. Local Selection. Present experiment consists of two levels of pinching (no pinching & pinching at 28 DAT) and three levels of spacing (40 x 40 cm, 40 x 30 cm & 30 x 30 cm) in six treatment combinations replicated thrice. The soil of the experimental field was sandy loam in texture and had pH (8.2), E.C. (0.48 dSm<sup>-1</sup>) [1:2 soil water suspension (Jackson, 1967)], organic carbon (0.45 %) [Walkley and Black's rapid titration method (Piper, 1966)] and 137.4 kg/ha available N [Alkaline permanganate method (Subbiah and Asija, 1956)], 25 kg/ha available P<sub>2</sub>O<sub>5</sub> [Olsen's method (Olsen *et al.*, 1954)], 449.5 kg/ha available K<sub>2</sub>O [Flame photometric method (Jackson, 1973)]. Seeds were sown on 16<sup>th</sup> August, 2013 on raised nursery beds. One month old healthy and uniform seedlings were transplanted at different levels of spacing on 19<sup>th</sup> September, 2013. A basal dose of well rotten Farm Yard Manure @ 5 kg/m<sup>2</sup> was uniformly mixed in the soil 15 days before transplanting. Half dose of nitrogen (10 g/m<sup>2</sup>), full dose of phosphorus (20 g/m<sup>2</sup>) and potassium (10 g/m<sup>2</sup>) was supplied through urea, single super phosphate and muriate of potash, respectively as basal application at transplanting time. Remaining half dose of nitrogen (10 g/m<sup>2</sup>) was applied at 30 DAT. Different intercultural practices like gap filling, irrigating, staking, weeding etc. were performed as per crop requirement. Observations were recorded for various growth, flowering and yield parameters in African marigold. The data recorded during the course of investigation were subjected to statistical analysis by using factorial RBD for analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1995).

## RESULTS AND DISCUSSION

### Growth parameters

**Plant height (cm):** Pinching resulted in to significant decrease in plant height as compared to un-pinched plants at 5% level of significance (Table 1). Maximum plant height (73.52 cm) was reported in un-pinched plants, while minimum (63.13 cm) was recorded in plants pinched at 28 DAT. This reduction in the plant height in pinched plant was mainly due to the removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal growth. Similar decrease in plant height was reported by Badge *et al.* (2014) and Meena *et al.* (2015) in African marigold. Plant height increased significantly with every decrease in level of

spacing (Table 1). Maximum plant height (71.76 cm) was recorded at closer spacing (30 × 30 cm), while minimum (64.58 cm) was observed in wider spacing (40 × 40 cm). The increase in plant height with closer spacing may be due to competition for light under inadequate spacing. These results are found in agreement with the findings of Chauhan and Ambast (2014) and Meena *et al.* (2015) in African marigold. The interaction effect between pinching and spacing was found significant. Maximum plant height (78.70 cm) was recorded in un-pinched plants planted at 30 x 30 cm spacing, whereas, minimum plant height (61.67 cm) was observed at wider (40 x 40 cm) spacing.

**Plant spread (cm):** Pinching exerted a significant effect on increasing plant spread at 5% level of significance (Table 1). Maximum plant spread (63.59 cm) was recorded when plants were pinched at 28 DAT, while minimum (63.59 cm) was recorded in un-pinched plants. Similar results were also recorded by Maharnor *et al.* (2011) and Mohanty *et al.* (2015) in African marigold. Different levels of spacing had significant effect on increasing plant spread except at S<sub>1</sub> (40 × 40 cm) level followed by S<sub>2</sub> (40 x 30 cm) at 5% level of significance. Maximum plant spread (64.01 cm) was reported at S<sub>3</sub> (40 × 40 cm) level followed by S<sub>2</sub> (40 x 30 cm) level, whereas, minimum plant spread (57.30 cm) was observed at S<sub>3</sub> (30 x 30 cm) level. This increase in plant spread may be attributed to availability of more space, nutrition and air at wider spacing. Similar findings were also reported by Ahirwar *et al.* (2012) and Chauhan and Ambast (2014) in African marigold. The interaction effect between various pinching and spacing was found non-significant.

**Number of branches per plant:** Number of branches per plant increased significantly with pinching at 5% level of significance (Table 1). Maximum number of branches per plant (12.11) was recorded with pinching at 28 DAT, while minimum (9.34) was recorded in un-pinched plants. Similar results were reported by Badge *et al.* (2014) and Meena *et al.* (2015) in African marigold. Spacing was found non-significant in increasing number of branches per plant (Table 1). However, maximum number of branches per plant (11.42) was found at wider spacing of 40 × 40 cm and minimum (9.81) at 30 x 30 cm spacing. Similar findings were also reported by Chauhan and Ambast (2014) and Meena *et al.* (2015) in African marigold. The interaction effect among various pinching and spacing treatments was found non-significant.

**Fresh weight of plant (g):** Pinching played a significant role in increasing fresh weight of the plant at 5% level of significance (Table 1). Maximum fresh weight of plant (358.79 g) was recorded in plants pinched at 28 DAT, while minimum (327.45 g) was observed in un-pinched plants. Fresh weight of plant increased significantly with respect to various levels of spacing at 5% level of significance. Maximum fresh weight of

**Table 1.** Effect of pinching and spacing on growth and yield of African marigold.

Treatment	Plant height (cm)	Plant Spread (cm)	No. of branches/plant	Fresh weight of plant (g)	Dry weight of plant (g)	Flower yield/plant (g)	Flower yield/hectare (t)
Pinching							
No pinching	73.52	58.88	9.34	327.45	32.37	387.49	32.26
Pinching at 28DAT	63.13	63.59	12.11	358.79	36.40	403.68	33.33
CD (5%)	1.14	1.74	1.07	3.29	1.37	2.33	0.85
Spacing (cm)							
40 × 40	64.58	64.01	11.42	370.20	37.99	460.42	28.77
40 × 30	68.63	62.38	10.94	346.32	34.61	399.21	33.27
30 × 30	71.76	57.30	9.81	312.83	30.54	327.12	36.34
CD (5%)	1.39	2.13	NS	4.03	1.68	2.85	1.04
P × S							
P <sub>0</sub> S <sub>1</sub>	67.50	61.45	10.40	350.00	35.00	441.80	27.61
P <sub>0</sub> S <sub>2</sub>	74.37	59.75	9.75	331.84	33.86	392.26	32.69
P <sub>0</sub> S <sub>3</sub>	78.70	55.43	7.88	300.50	28.25	328.41	36.49
P <sub>1</sub> S <sub>1</sub>	61.67	66.58	12.44	390.40	40.99	479.04	29.94
P <sub>1</sub> S <sub>2</sub>	62.89	65.01	12.14	360.81	35.37	406.17	33.85
P <sub>1</sub> S <sub>3</sub>	64.83	59.18	11.75	325.16	32.84	325.83	36.20
CD (5%)	1.97	NS	NS	5.71	2.37	4.04	NS

**Table 2.** Effect of pinching and spacing on flowering parameters of African marigold.

Treatment	No. of buds/plant	No. of flowers/plant	Duration of flowering (days)	Diameter of flower (cm)	Stalk length (cm)	Fresh weight of flower (g)	Dry weight of flower (g)
Pinching							
No pinching	50.31	43.23	49.08	6.38	4.66	8.93	0.88
Pinching at 28 DAT	67.81	54.54	53.95	5.91	4.90	7.36	0.75
CD (5%)	1.06	1.51	0.82	0.07	0.18	0.12	0.01
Spacing (cm)							
40 × 40	63.03	51.43	53.98	6.42	4.61	9.03	0.89
40 × 30	60.96	49.88	51.91	6.19	4.74	8.13	0.81
30 × 30	53.17	45.33	48.15	5.81	4.98	7.28	0.73
CD (5%)	1.30	1.85	1.00	0.09	0.22	0.15	0.01
P × S							
P <sub>0</sub> S <sub>1</sub>	54.57	45.50	52.43	6.61	4.48	9.71	0.94
P <sub>0</sub> S <sub>2</sub>	50.75	43.20	49.61	6.42	4.67	9.08	0.91
P <sub>0</sub> S <sub>3</sub>	45.60	41.00	45.20	6.10	4.83	8.01	0.78
P <sub>1</sub> S <sub>1</sub>	71.50	57.37	55.53	6.23	4.75	8.35	0.85
P <sub>1</sub> S <sub>2</sub>	71.17	56.57	54.21	5.96	4.81	7.18	0.71
P <sub>1</sub> S <sub>3</sub>	60.75	49.67	51.10	5.53	5.13	6.56	0.68
CD (5%)	1.84	2.61	1.42	NS	NS	0.21	0.02

plant (370.20 g) was observed at wider spacing of S<sub>1</sub> (40 × 40 cm) treatment and minimum (312.83 g) was recorded in S<sub>3</sub> (30 × 30 cm) treatment. This increase in fresh weight of plant may be due to the lesser competition between the plants for food and water at wider spacing. Pinching and spacing interaction was found significant in influencing dry weight of the plant at 5% level of significance. The interaction effect between various pinching and spacing treatments was found significant at 5% level of significance (Table 1). Maximum fresh weight of plant (390.40 g) was obtained at a wider spacing of 40 × 40 cm with pinching done at 28 DAT, whereas, the minimum (300.50 g) was recorded at closer spacing of 30 × 30 cm without pinching.

**Dry weight of plant (g):** Plants pinched at 28 DAT significantly increased dry weight of plant at 5% level of significance (Table 1). Maximum dry weight of

plant (36.40 g) was recorded in plants pinched at 28 DAT, while minimum (32.37g) was recorded in un-pinched plants. Spacing had significant influence on dry weight of plant at 5% level of significance (Table 1). Maximum dry weight of plant (37.99 g) was observed at wider spacing (40 × 40 cm) and minimum (30.54 g) in closer spacing (30 × 30 cm). The interaction effect between various pinching and spacing treatments was found significant in influencing dry weight of plant at 5% level of significance (Table 1). Maximum dry weight of plant (40.99 g) was observed at a spacing of 40 × 40 cm with pinching at 28 DAT, whereas, the minimum dry weight (28.25 g) of plant was recorded at a spacing of 30 × 30 cm without pinching.

#### Floral parameters

**Number of bud per plant:** The data presented in

Table 2 reveal that number of buds per plant increased significantly with pinching at 5% level of significance. The maximum number of buds per plant (67.81) was recorded when plants were pinched 28 DAT, whereas, minimum (50.31) was found in un-pinched plants. This increase in number of buds per plant under pinching treatment might be due to the reason that extra energy divert into the production of more reproductive parts instead of vegetative parts. Number of buds per plant decreased significantly with every decrease in spacing at 5% level of significance. Maximum number of buds per plant (63.03) was found in S<sub>1</sub> (40 × 40 cm) treatment and minimum (53.17) was recorded in S<sub>3</sub> (30 × 30 cm) treatment. The interaction effect between various spacing and pinching was found significant in increasing number of buds per plant. Maximum number of buds per plant (71.50) was observed when plants were planted at a spacing of 40 × 40 cm with pinching 28 DAT, whereas, minimum (45.60) was recorded in a spacing of 30 × 30 cm without pinching.

**Number of flowers per plant:** Pinching had played a significant role in influencing number of flowers per plant at 5% level of significance (Table 2). Maximum (54.54) number of flowers per plant was recorded with pinching at 28 DAT, while minimum (43.23) was obtained in plants without pinching. Increase in number of flowers may be due to the fact that pinched plant induces production of large number of axillaries shoots resulting in well-shaped bushy plants bearing more number of uniform flowers. Pushkar and Singh (2012), Badge *et al.* (2014) and Meena *et al.* (2015) also reported similar findings in African marigold. Number of flowers per plant decreased significantly with every decrease in spacing except at S<sub>2</sub> (40 × 30 cm) treatment followed by S<sub>1</sub> (40 × 40 cm) treatment at 5% level of significance (Table 2). Maximum number (51.43) of flowers per plant was found at 40 × 40 cm spacing and minimum number (45.33) of flowers per plant was recorded at 30 × 30 cm spacing. Meena *et al.* (2015) also reported similar finding in African marigold cv. Pusa Narangi Gainda. The interaction effect among various pinching and spacing treatments was found significant at 5% level of significance. Maximum (57.37) number of flowers per plant was observed when plants were planted at a spacing of 40 × 40 cm with pinching done at 28 days after transplanting, whereas, minimum (41.00) was obtained at a spacing of 30 × 30 cm in un-pinched plants.

**Duration of flowering (days):** The data presented in Table 2 reveal that duration of flowering increased significantly at 5% level of significance with pinching. Maximum duration of flowering (53.95 days) was recorded in plants pinched at 28 DAT, while minimum (49.08 days) was observed in un-pinched plants. Similar findings were also observed by Kour *et al.* (2012) and Kumar *et al.* (2012) in African marigold cv. Pusa Narangi Gainda. Duration of flowering decreased sig-

nificantly with every decrease in spacing at 5% level of significance (Table 2). Maximum duration of flowering (53.98 days) was found in 40 × 40 cm spacing and minimum duration of flowering (48.15 days) was recorded at 30 × 30 cm spacing. More flowering period at wider spacing may be due to the fact that wider spaced plants have less competition for nutrient, water and light without any shedding effect resulted in increased spike weight with increasing levels of spacing. Similar findings were also reported by Kumar *et al.* (2012) and Chauhan and Ambast (2014) in African marigold. Interaction between pinching and spacing was found significant in influencing flowering duration at 5% level of significance (Table 2). Maximum duration of flowering (55.53 days) was observed at a spacing of 40 × 40 cm with pinching done at 28 days after transplanting and minimum duration of flowering (45.20 days) was recorded at a spacing of 30 × 30 cm without pinching. Kumar *et al.* (2012) recorded similar finding in African marigold cv. Pusa Narangi.

**Diameter of flower (cm):** Diameter of flower decreased significantly with pinching at 5% level of significance (Table 2). Maximum diameter (6.38 cm) of flower was recorded in un-pinched plants, while minimum (5.91 cm) was observed in plants pinched at 28 DAT. This decrease in flower diameter might be attributed to the fact that in pinched plant energy is shared by the developing side branches, while in case of un-pinched plants the energy sharing is limited to the flower developing on main branch only. Diameter of flower decreased significantly with every decrease in spacing at 5% level of significance (Table 2). Maximum (6.42 cm) diameter of flower was found at 40 × 40 cm spacing and minimum (5.81 cm) was recorded at 30 × 30 cm spacing. Similar trend was also reported by Ahirwar *et al.* (2012) in African marigold. The interaction effect between various pinching and spacing levels was found non-significant in influencing diameter of flower.

**Stalk length (cm):** The data presented in Table 2 reveal that stalk length of flower increased significantly with pinching at 5% level of significance. Maximum stalk length (4.90 cm) was recorded in plants pinched at 28 DAT and minimum (4.66 cm) was observed in un-pinched plants. Flower stalk length increased significantly with every decrease in spacing at 5% level of significance (Table 2). Maximum stalk length of flower (4.98 cm) was found in 30 × 30 cm and minimum (4.61 cm) at 40 × 40 cm followed by S<sub>2</sub> (40 × 30 cm) treatment (4.74 cm). Interactional effect between various pinching and spacing treatments was found non-significant in affecting flower stalk length.

#### **Yield parameters**

**Fresh weight of flower (g):** The data presented in Table 2 show that fresh weight of flower decreased significantly with pinching at 5% level of significance. Maximum (8.93g) fresh weight of flower was recorded

in un-pinched plants, while minimum (7.36g) fresh weight of flower was recorded in plants pinched at 28 DAT. Similar results were also obtained by Rathore *et al.* (2011) in African marigold cv. Pusa Basanti Gaiinda. The reduction in fresh flower weight in pinching treatment might be attributed to the fact that pinched treatment increased the number of flowers per plant hence; the developing flowers might have been supplied with comparatively lesser quantities of plant bio-regulators and food reserve resulting ultimately in reduction of fresh and dry flower weight. Fresh weight of flower decreased significantly with every decrease in level of spacing at 5% level of significance (Table 2). Maximum (9.03g) fresh weight of flower was found at 40 × 40 cm spacing and minimum (7.28 g) was obtained at 30 x 30 cm spacing. Ahirwar *et al.* (2012) also noticed similar results in African marigold. The interaction effect between various pinching and spacing treatments was found significant in increasing fresh weight of flower at 5% level of significance. Maximum (9.71g) fresh weight of flower was observed at a spacing of 40 x 40 cm without pinching, whereas, the minimum (6.56 g) was recorded at a spacing of 30 x 30 cm with pinching done at 28 DAT.

**Dry weight of flower (g):** The data presented in Table 2 reveal that dry weight of flower decreased significantly with pinching at 5% level of significance. Maximum (0.88 g) dry weight of flower was recorded in un-pinched plants and minimum (0.75 g) was recorded in plants pinched at 28 DAT. Similar results were also obtained by Rathore *et al.* (2011) in African marigold cv. Pusa Basanti Gaiinda. Dry weight of flower decreased significantly at 5% level of significance with every decrease in spacing. Maximum (0.89 g) dry weight of flower was found at 40 × 40 cm spacing and minimum (0.73 g) was recorded at 30 x 30 cm spacing. The interaction effect between various pinching and spacing treatments was found significant at 5% level of significance (Table 2). Maximum dry weight of flower (0.94 g) was observed in plants planted at a spacing of 40 x 40 cm with no pinching, whereas, the minimum dry weight of flower (0.68 g) was recorded at a spacing of 30 x 30 cm with pinching done at 28 DAT.

**Flower yield per plant (g):** Flower yield per plant increased significantly at 5% level of significance with pinching (Table 1). Maximum flower yield per plant (403.68 g) was found in plants pinched at 28 DAT and minimum (387.49 g) was recorded in un-pinched plants. These results are in conformity with the findings of Maharnor *et al.* (2011) and Pushkar and Singh (2012) in African marigold. Flower yield per plant decreased significantly at 5% level of significance with every decrease in spacing (Table 1). Maximum flower yield per plant (460.42 g) was found in 40 × 40 cm spacing and minimum flower yield per plant (327.12 g) was reported at 30 x 30 cm spacing. This increase in flower yield per plant under wider spacing might be

attributed to less competition for food and water among the plants. Similar findings were also noticed by Chauhan and Ambast (2014) in African marigold. The interaction effect between various pinching and spacing treatments was found significant in influencing flower yield per plant at 5% level of significance (Table 1). Maximum flower yield per plant (479.04 g) was observed in plants planted at a spacing of 40 x 40 cm with pinching done at 28 DAT, whereas, the minimum flower yield per plant (325.83 g) was recorded at a spacing of 30 x 30 cm with pinching at 28 DAT. Similar results were recorded by Kumar *et al.* (2012) in African marigold.

**Flower yield per hectare (t):** The data presented in Table 1 show that pinched plants significantly increased flower yield per hectare at 5% level of significance. Maximum flower yield per hectare (33.33 t) was recorded in plants pinched at 28 DAT, while minimum flower yield per hectare (32.26 t) was found in un-pinched plants. Similar results were also obtained by Sharma *et al.* (2012), Kour *et al.* (2012) and Mohanty *et al.* (2015) in African marigold. Flower yield per hectare increased significantly with every decrease in spacing at 5% level of significance (Table 1). Maximum flower yield per hectare (36.34 t) was found with 30 × 30 cm spacing and minimum (28.77t) was reported at 40 x 40 cm spacing. These results were found in agreement with the findings of Kumar *et al.* (2012) in African marigold cv. Pusa Narangi. Pinching and spacing interaction effect was found non- significant in influencing flower yield per hectare.

## Conclusion

From the present study, it may be concluded that African marigold cv. Local Selection plants pinched at 28 DAT with widest spacing (40 x 40 cm) attained maximum fresh weight of plant (390.40 g), number of buds per plant (45.60), number of flowers per plant (57.37), duration of flowering (55.53 days) and flower yield per plant (479.04 g). It is a new germplasm of African marigold which was identified for release and suitable for summer and winter season cultivation.

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