Eco. Env. & Cons. 28 (January Suppl. Issue) : 2022; pp. (S200-S205)
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ISSN 0971–765X

http://doi.org/10.53550/EEC.2022.v28i01s.029

Effect of spacing and pinching on growth, flowering and seed yield traits in African marigold (*Tagetes erecta*) cultivar Pusa Narangi Gainda under semi-arid conditions of Haryana, India

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(Received 10 August, 2021; Accepted 2 September, 2021)

ABSTRACT

The present investigation was carried out at Horticulture Demonstration Farm, Department of Horticulture, SGT University, Gurugram (Haryana), India during the year 2020-21 with a view to optimize spacing and pinching time in African marigold cultivar Pusa Narangi Gainda for achieving better growth, flowering and seed yield. Experiment comprises of three levels of spacing (30 x 30 cm, 30 x 45 cm and 30 x 60 cm) and two levels of pinching (no pinching, pinching at 30 DAT (Days After Transplanting) and pinching at 60 DAT) in nine treatment combinations. This experiment was conducted in a split plot design (Factorial) replicated thrice. It was noted that wider spacing (30 x 60 cm) and pinching at 60 DAT had significant effect on plant growth, flowering and seed yield. Wider spacing (30 x 60 cm) recorded maximum number of branches (23.31), diameter of main stem (1.30 cm), number of flowers per plant (40.02), flower diameter (9.58 cm), seed yield per plant (30.03 g), whereas, maximum plant height (49.53 cm) and earliest flowering (59.54 days) was recorded in closer spacing (30 x 30 cm). Similarly, pinching at 60 DAT resulted in maximum number of branches (21.17), diameter of main stem (1.23 cm), number of flowers per plant (73.53), flower diameter (40.14 cm), seed yield per plant (28.93 g), whereas, no pinching recorded maximum plant height (48.64 cm) and earliest flowering (69.79 days). Significant interaction between spacing and pinching recorded maximum flower yield/ per plant (949.00 g), flower yield/ per plot (10.10 kg), seed yield/ per flower (0.844 g) and seed yield/ per plot (367.67 g) with wider spacing and pinching at 60 DAT

Key words : *Pinching, Spacing, Marigold, Growth, Flowering, Seed*

Introduction

Marigold (*Tagetes erecta* L.) is one of the important loose flower crops grown commercially in different states of India especially in the plains. Marigold belongs to the family Asteraceae and used commercially for making garlands, wreaths and in religious offering. It is a short duration, hardy crop which contains medicinal and nematocidal property. Because of its attractive flower colour, shape size, easy transportation with good vase life, marigold attracts the attention of flower growers and traders.

In India, the total area under marigold cultivation is 66.13 thousand hectares with production of 603.18

thousand MT (NHB, 2017). In Haryana, the area under marigold cultivation is 5288.4 hectares with a production of 71470.5 MT. The major district cultivating marigold are Gurugram, Sonipat, Rewari, Kurukshetra, Mewat, Yamunanagar, Narnaul, Palwal, etc (Hort Department GOH, 2018-19).

Successful commercial cultivation of marigold depends on factors like variety, planting time, spacing and cultural practices like pinching, weeding etc. A wider spacing increases the photosynthetic area and reduces the competition for nutrients (Chauhan and Ambast, 2014), whereas, Pinching stimulates early emergence of side branches which ultimately produces more number of uniform good quality flowers (Mohanty *et al.*, 2015). The number of side branches are directly positively correlated the yield of flower in African marigold (Singh *et al.*, 2019).

In India, maximum cultivated areas covered by the traditional varieties which are genetically impure and low yielders. Therefore, to cover more area with high yielding variety like PusaNarangiGainda there is a need to ensure the quality seed which is in short supply due to lack of standardized seed production practices. Thus, the present investigation efforts have been made to standardize the spacing, time of pinching and their interaction effect to improve the availability of quality flower and seed.

Materials and Methods

The present research experiment was conducted at the Horticultural Demonstration Farm, Department of Horticulture, SGT University, Gurugram (Haryana) During the year 2020-21. The experimental site situated at latitude of 28°47''N and longitude 76°16''E and at an altitude of 217 m above mean sea level. It has semi-arid climate with high variation between summer and winter temperatures and precipitation. The seed of marigold variety Pusa Narangi Gainda was procured from Seed Production Unit, IARI, New Delhi and seedlings were grown on the raised seed beds in the nursery. One month old seedlings of 4-6 leaf stage transplanted on with three different spacing, i.e. 30 cm × 30 cm (S_1), 30 cm × 45 cm (S_2), 30 cm × 60 cm (S_3) in main plot. The pinching operation was practiced in sub-plot with three different ways, i.e. no pinching (P_1), pinching at 30 DAT (Days After Transplanting) (P_2) and double pinching at 60 DAT (P_3). The split plot design was followed with three replications. The observations are recorded for vegetative growth, flowering and seed traits, viz. plant height at maturity (cm), number of the branches, diameter of main stem (cm), days to first flowering, number of flower per plant, flower diameter, flower yield per plant (g), flower yield per plot (kg) seed yield per flower (g), seed yield per plant (g), seed yield per plot (g) were recorded on 10 randomly selected plants from each plot. Data was subjected to analysis of variance (ANOVA) to determine significant differences and comparison of mean at a significant level of 5 %.

Results and Discussion

Growth traits

Perusal of data (Table 1) showed that all growth parameters were significantly affected by different spacing and pinching treatments, whereas, the interaction among pinching and spacing was found non-significant for all. The plant height increased significantly with every decrease in level of spacing. The maximum plant height (49.53 cm) was recorded under close spacing (S_1) followed by S_2 (45.72 cm) and S_3 (42.78 cm). The increase in plant height with

Table 1. Effect of spacing and pinching on growth traits in African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda

Spacing (S)	Plant height at Maturity (cm)				Number of Branches				Diameter of main stem (cm)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
S_1 30x30 cm	52.40	49.77	46.43	49.53	13.00	14.00	15.33	14.11	1.04	1.08	1.11	1.08
S_2 30x45 cm	47.97	45.93	43.26	45.72	19.33	21.00	23.00	21.11	1.15	1.21	1.26	1.21
S_3 30x60 cm	45.57	42.27	40.50	42.78	21.33	23.43	25.17	23.31	1.28	1.29	1.32	1.30
Mean	48.64	45.99	43.40		17.89	19.48	21.17		1.16	1.19	1.23	
CD (P=0.05)												
Spacing (S)	2.63	1.53	0.22									
Pinching (P)	2.63	1.53	0.22									
SxP	N/A	N/A	N/A									

*S_1-30 cm × 30 cm, S_2-30 cm × 45 cm, S_3-30 cm × 60 cm, **P_1- No pinching, P_2-Pinching at 30 DAT, P_3-Pinching at 60 DAT

closer spacing may be due to competition for light under inadequate spacing. The maximum plant height (48.64 cm) was observed under no pinching treatment (P_1), whereas, the minimum plant height (43.40 cm) was recorded under double pinching at 60 DAT (P_3). 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 Chauhan and Ambast (2014), Badge *et al.* (2014) and Meena *et al.* (2015) in African marigold.

Among the different spacing levels, the maximum number of branches per plant (23.31) was recorded at wider spacing (S_3), while the closer spacing (S_1) recorded minimum number of branches per plant (14.11) which was due to better light intensity and less competition for inputs. Maximum number of branches per plant (21.17) was found under P3, followed by P_2 (19.48) and P_1 (17.89). Increase in number of branches per plant is due to supply of more plant assimilates towards the side branching after the pinching process. The similar results reported by Meena *et al.* (2015), Nain *et al.* (2017) and Baskaran and Abirami (2017).

Wider spacing (S_3) showed maximum diameter of main stem (1.30 cm) followed by treatments S_2 (1.21 cm) and S_1 (1.08 cm). The increased thickness of main stem could be ascribed to a better availability of nutrients per unit area due to sufficient space resulting in less competition among the plants. Similarly, P_3 produced significantly higher diameter of main stem (1.23 cm) as compared to P_2 (1.19 cm) and P_1 (1.16 cm). The increase in stem diameter due to pinching could be attributed to promoted cell division, cell enlargement and ultimately increases cell size of stem and are in accordance with the reports of Yadav *et al*. (2004) and Rathore (2007).

Flower traits

The data presented in Table 2 showed a significant difference in all flowering traits due to plant spacing and pinching treatments. The interaction effect among various spacing and pinching treatments was found non- significant except for flower yield per plant and flower yield per plot.The closer spacing (S_1) recorded lesser number of days for first flowering (59.54), whereas, the wider spacing (S_3) had taken a greater number of days to first flowering (93.38) due to the more vegetative growth. The

Table 2. Effect of spacing and pinching on flower traits in African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda

Spacing (S)	No. of Days to First Flowering				No. of Flowers per plant				Flower Diameter (cm)				Flower Yield/Plant (g)				Flower Yield/Plot (kg)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
S_1 30x30 cm	57.67	59.57	61.38	59.54	28.97	33.17	36.13	32.76	6.90	7.23	7.50	7.21	494.33	563.67	649.00	569.00	5.03	5.77	6.33	5.71
S_2 30x45 cm	60.37	62.47	64.20	62.34	35.33	38.83	41.00	38.39	8.20	8.67	9.23	8.70	596.67	748.67	844.67	730.00	6.07	7.63	8.73	7.48
S_3 30x60cm	91.33	93.80	95.00	93.38	36.43	40.33	43.30	40.02	9.03	9.63	10.07	9.58	755.33	883.33	949.00	862.56	7.73	9.13	10.10	8.99
Mean	69.79	71.94	73.53		33.58	37.44	40.14		8.04	8.51	8.93		615.45	731.89	814.22		6.28	7.51	8.39	
CD (P=0.05)																				
Spacing (S)	1.84	1.44	0.36	26.03	0.26															
Pinching (P)	1.84	1.44	0.36	26.03	0.26															
SxP	N/A	N/A	N/A	45.08	0.45															

*S_1-30 cm × 30 cm, S_2-30 cm × 45 cm, S_3-30 cm × 60 cm, **P_1- No pinching, P_2-Pinching at 30 DAT, P_3-Pinching at 60 DAT

double pinching (P_3) has taken maximum (94.85) days for first flowering followed by P_2 (77.12) and P_1 (71.35). The pinching has significantly delayed the days to first flowering and it is due to the induction of vegetative phase after the break of apical dominance and the finding corroborated well with the previous observations of Rathore (2007).

The wider spacing (S_3) has given significantly highest number of flowers per plant (40.02), whereas, lowest recorded under S_1 (32.76) which had attributed to the higher number of branches per plant and better growth and less competition for water, nutrients and light under wider spacing. The maximum (40.14) number of flowers per plants was recorded in double pinching at 60 DAT (P3) followed by P_2 (37.44) and P_1 (33.58) which was due to the more number of branches per plant and the result of this investigation is in agreement with Bhat and Shephered (2007) and Nain *et al.* (2017).

Maximum flower diameter (9.58 cm) was recorded at wider spacing (S_3) and the minimum (7.21 cm) was recorded under closer spacing (S_1). Similarly, P3 produced significantly higher flower diameter (8.93 cm) as compared to P_2 (8.51 cm) and P_1 (8.04 cm) and are in accordance with the reports of Yadav *et al*. (2004).

Similarly, maximum value for flower yield per plant (862.56 g) and flower yield per plot (8.99 kg) was obtained with wider spacing (S_3), whereas, the minimum value for flower yield per plant (569.00 g) and flower yield per plot (5.71 kg) was obtained under closer spacing (S_1). This increase in flower yield per plant and per plot under wider spacing might be attributed to less competition for food and water among the plants and are in accordance with the reports of Chauhan and Ambast (2014) in African marigold. Between pinching, maximum value for flower yield per plant (814.22 g) and flower yield per plot (8.39 kg) was obtained from double pinching at 60 DAT (P_3), while, minimum value for flower yield per plant (615.45 g) and flower yield per plot (6.28 kg) was obtained under no pinching treatment (P_1). Maximum flower yield per plant (949.00 g) and flower yield per plot (10.10 kg) was observed in plants planted at wider spacing (S_3) with double pinching at 60 DAT (P_3), whereas, the minimum flower yield per plant (494.33 g) and flower yield per plot (5.03 kg) was recorded at closer spacing (S_1) with no pinching treatment (P_1).

Seed traits

Data presented (Table 3) showed that all seed yield traits of marigold cv. Pusa Narangi Gainda were significantly influenced by different spacing and pinching treatments. The interaction effect between various spacing and pinching treatments was found significant for all seed traits except seed yield/ per plant. The wider spacing (S_3) produced significantly higher seed yield per flower, per seed yield per plant and seed yield per plot i.e., 0.754 g, 30.03 g and 334.22 g, respectively as compared to closer spacing (S_1) i.e., 0.540 g, 17.43 g and 193.56 g, respectively. The pinching at 60 DAT (S_3) had given maximum seed yield per flower, per seed yield per plant and per seed yield per plot i.e., 0.730 g, 28.93 g and 315 g, respectively as compared to closer spacing (S_1) i.e., 0.573 g, 19.73 g and 224.67 g, respectively. The interaction between spacing and pinching were recorded for seed yield per flower and seed yield per plot. Maximum seed yield per flower (0.844 g) and per seed yield per plot (367.67 g) was recorded in plants planted at wider spacing (S_3) with double pinching at 60 DAT (P_3). Whereas, the minimum seed yield per flower (0.482 g) and seed yield per plot (141.67

Table 3. Effect of spacing and pinching on seed traits in African marigold (*Tagetes erecta*) cv. PusaNarangiGainda

Spacing (S)	Seed Yield/Flower (g)				Seed Yield/Plant (g)				Seed Yield/Plot (g)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
S_1 30x30 cm	0.482	0.530	0.607	0.540	13.47	17.60	21.23	17.43	141.67	181.67	257.33	193.56
S_2 30x45 cm	0.577	0.608	0.740	0.641	20.40	23.63	30.50	24.84	225.00	284.33	320.00	276.45
S_3 30x60cm	0.661	0.756	0.844	0.754	25.33	29.70	35.07	30.03	307.33	327.67	367.67	334.22
Mean	0.573	0.631	0.730		19.73	23.64	28.93		224.67	264.56	315.00	
CD (P=0.05)												
Spacing (S)	0.017	1.278	10.27									
Pinching (P)	0.017	1.278	10.27									
SxP	0.029	N/A	17.79									

*S_1-30 cm × 30 cm, S_2-30 cm × 45 cm, S_3-30 cm × 60 cm, **P_1- No pinching, P_2-Pinching at 30 DAT, P_3-Pinching at 60 DAT

Table 4. Returns from African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda cultivation (Rs./ha)

Treatment combinations	Yield (kg/ha)	Total cost	Gross return	Net return	Net Benefit Cost Ratio
S_3P_3	6313	47100	157813	110713	2.35
S_3P_2	5700	47221	142500	95279	2.02
S_2P_3	5456	47555	136406	88851	1.87
S_3P_1	4831	47900	120781	72881	1.52
S_2P_2	4769	48873	119219	70346	1.44
S_1P_3	3956	48965	98906	49941	1.02
S_2P_1	3794	49111	94844	45733	0.93
S_1P_2	3606	49370	90156	40786	0.83
S_1P_1	3144	50139	78594	28455	0.57

*Market sale rate of marigold- Rs. 25/kg.

g) was recorded at closer spacing (S_1) with no pinching treatment (P_1) which could be attributed to more number of branches/ per plant, more number of flower/ per plant, seed yield/ per flower and seed yield/ per plant and seed yield per plot. The finding corroborated well with the previous observations of Baskaran and Abirami (2017).

Returns from African marigold (*Tagetes erecta*) cultivar Pusa Narangi Gainda cultivation

The data presented in Table 4 showed the levels of total cost and returns per hectare of various treatment combinations between different plant spacing and pinching. Total cost refers to the cost incurred for raising marigold and gross return denotes the value of the total product. The per hectare gross return from marigold cv. Pusa Narangi Gainda cultivation ranged from Rs. 78594 in case of S_1P_1 to Rs. 157813 in case of S_3P_3. The highest cost was incurred of Rs. 50139 in case of S_1P_1, whereas, the lowest was of Rs. 47100 in case of S_3P_3. Thus, the highest net cost benefit ratio was calculated for S_3P_3 and lowest was for S_1P_1 treatment combination. Therefore, the treatment combination S_3P_3 proved to be the most beneficial.

Conclusion

Keeping in view of the results obtained from the research experiment, it can be recommended that marigold cultivarPusaNarangiGainda should be transplanted at the spacing of 30 cm × 60 cm with double pinching at 60 DAT should be practiced to obtain higher flower and seed yield under semi-arid conditions of Haryana

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