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Growth and flowering of African marigold (*Tagetes erecta* L.) as influenced by spacing and pinching

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Abstract
The present investigation entitled, growth and flowering of African marigold (*Tagetes erecta* L.) as influenced by spacing and pinching was conducted during October, 2021 to February, 2022 at College Farm, College of Horticulture, S. D. Agricultural University, Jagudan, Dist. Mehsana, Gujarat. Experiment was comprised of two factors which included three spacing 60 cm × 30 cm (s_1), 60 cm × 45 cm (s_2) and 45 cm × 45 cm (s_3) and four pinching levels no pinching (p_0), pinching at 25 DAT (p_1), pinching at 40 DAT (p_2) and double pinching at 25 and 40 DAT (p_3). Growth and flowering parameters were observed and statistically analyzed in Split Plot Design. Treatment s_1 recorded maximum plant height (31.17, 49.12 and 63.93 cm), while s_2 gave maximum number of primary branches (4.91, 9.63 and 13.00) and plant spread [N-S (15.60, 26.21 and 44.33 cm) and E-W (15.92, 25.73 and 43.41 cm)] at 25, 40 and 90 DAT, respectively, secondary branches (15.85 and 40.55) at 40 and 90 DAT, diameter of flower (4.91 cm) and number of flowers per plant (82.43).$p_0$showed maximum plant height (50.77 and 64.62 cm at 40 and 90 DAT), number of pickings (10.82) and diameter of flower (5.21 cm), while p_3 gave maximum primary (9.67 and 12.40) and secondary branches (16.42 and 44.13) at 40 and 90 DAT, respectively, plant spread [N-S (43.60 cm) and E-W (43.71 cm)] at 90 DAT, number of flowers per plant (91.24), minimum days to bud initiation (22.69) and days to first picking (41.36). Treatment $s_2p_0$gave maximum plant height (70.06 cm at 90 DAT) and diameter of flower (5.68 cm) while s_2p_3 showed highest number of secondary branches (48.73 at 90 DAT).

Keywords: Growth, African marigold, spacing, pinching, *Tagetes erecta* L.

Introduction
Marigold (*Tagetes erecta* L.) a member of Asteraceae family which is most commonly grown for loose and cut flower in India. It is also used for making garlands, wreaths, religious offering and as cut flowers. So far as commercial cultivation of marigold is concerned, the climatic factors are beyond the control of humans but growth and production of marigold can be improved to a large extent by the judicious use of fertilizers, variety, planting time, cultural operations like gap filling, weeding, irrigation, appropriate spacing and pinching etc. The flower production is affected to a large extent when plants are not placed at relevant pacing. Apart from this, pinching also plays an important role in plant growth and flowering production. Therefore, in the light of above facts the present investigation was undertaken to assess, refine and standardize spacing and pinching for optimum growth and flowering in marigold.

Material and Methods
The experiment entitled, growth and flowering of African marigold (*Tagetes erecta*L.) as influenced by spacing and pinching was taken on marigold cv. Pusa Narangi Gainda, comprising three factors of spacing 60 cm × 30 cm (s_1), 60 cm × 45 cm (s_2) and 45 cm × 45 cm (s_3) and four levels of pinching no pinching (p_0), pinching at 25 DAT (p_1), pinching at 40 DAT (p_2) and double pinching at 25 and 40 DAT (p_3). Total twelve treatment combinations were tested in Split Plot Design with three replications. The mean data recorded on growth parameters plant height, number of branches (primary and secondary), plant spread (North-South and East-West) at 25, 40 and 90 DAT, while flowering parameters days to bud initiation, days to first picking, number of pickings, diameter of flower, flower weight and number of flowers per plant was subjected to statistical analysis following analysis of variance technique (Panse and Sukhatme, 1985) [13].

Results and Discussion

Growth parameters

Effect of spacing (Table 1)

Inspection of data showed maximum plant height (31.17, 49.12 and 63.93 cm) was observed at 25, 40 and 90 DAT, respectively in treatment s_1, which was at par with s_3 at 40 and 90 DAT. Higher plant height at closest spacing might be due to massive competition between plants for light, which resulted in elongation of main stem and also might be due to the fact that the plants tend to grow vertically when they are crowded owing to shadowing effect of the plants on one another. These results are in conformity with the finding of Ahirwar *et al*. (2012) [1] and Rolaniya *et al*. (2017) [15] in African marigold.

Maximum number of primary branches (4.91, 9.63 and 13.00) at 25, 40 and 90 DAT, respectively and secondary branches (15.85 and 40.55) at 40 and 90 DAT, respectively was observed in s_2. This might be attributed to availability of space, nutrition and air. These results are confirmed with Ahirwar *et al*. (2012) [1] and Chauhan and Ambast (2014) [3] in African marigold.

Treatment s_2 showed in maximum plant spread (N-S) (15.60, 26.21 and 44.33 cm) while treatment s_1 resulted in minimum (13.53, 22.78 and 38.58 cm) at 25, 40 and 90 DAT, respectively. Treatment s_3 was found at par when observed at 25 DAT.

Maximum plant spread (E-W) (15.92, 25.74 and 43.42 cm) was observed in $s_2$at 25, 40 and 90 DAT. Treatment s_3 (45 cm × 45 cm) was found at par when observed at 25 and 40 DAT. This increase in plant spread may be attributed to availability of more space, nutrition and air at widest spacing as compare to closest spacing. Similar findings were also reported by Ahirwar *et al*. (2012) [1], Chauhan and Ambast (2014) [3] and Nain *et al*. (2017) [12] in African marigold.

Effect of pinching (Table 1)

Maximum plant height (50.77 and 64.62 cm) at 40 and 90 DAT was observed in p_0 which was at par with p_2. The reduction in the plant height in double pinched plant was mainly due to the removal of apical meristematic tissue which suppresses the apical dominance and diverted plant metabolites from vertical to horizontal growth. These results are in line with the findings of Baskaran and Abirami (2017) [2] in African marigold.

Significantly maximum number of primary branches (9.67 and 12.40) and secondary branches (16.42 and 44.13) at 40 and 90 DAT, respectively was noticed in p_3. When the apical buds are pinched, the lowering in concentration of IAA encourages the lateral buds to grow and produces new shoots and branches which can be relate to the fact that decrease in IAA overcome apical dominance (Singh *et al*. 2017) [16]. These results are in line with the findings of Baskaran and Abirami (2017) [2], Singh *et al*. (2017) [16] and Jyothi *et al*. (2018) [4] in marigold.

Significantly maximum plant spread (N-S) (43.60 cm) was found in p_3, whereas minimum (40.07 cm) was recorded with p_0 at 90 DAT. Maximum plant spread (E-W) (43.71 cm) was found in p_3, whereas minimum value (40.46 cm) was recorded with p_0 (no pinching) at 90 DAT which was at par with treatment p_1. These results are in conformity with Maharnor *et al*. (2011) [9], Mohanty *et al*. (2015) [11] and Jyothi *et al*. (2018) [4] in African marigold.

Interaction effect (Table 2)

Maximum plant height (70.06 cm) at 90 DAT was recorded in s_1p_0 which was at par with s_1p_2. These results are found in agreement with the findings of Nain *et al.* (2017) [12] in African marigold. Significantly maximum number of secondary branches (48.73) at 90 DAT was observed in s_2p_3 whereas, minimum secondary branches (31.87) were found in s_1p_0. Similar results were obtained by Kour *et al.* (2012) [6] and Meena *et al*. (2015) [10] in marigold.

Flowering parameters

Effect of spacing (Table 3)

The data concerned with effect of spacing on diameter of flower decreased with every decrease in spacing. Maximum (4.91 cm) diameter of flower was found in s_2 which was at par with s_3. In widest spacing, more vegetative growth had occurred and due to late flowering, which in turn resulted in bigger size flower (Poudel *et al*. 2017) [14]. Same results are in close accordance with Ahirwar *et al*. (2012) [1] and Nain *et al*. (2017) [12] in marigold.

It is evident from the data that there was increase in number of flowers with the increase in plant spacing. Maximum number of flowers (82.43) was observed with s_2 (60 cm × 45 cm) which was at par with the treatment s_3. This is might be due to increased number of branches and as a result a greater number of flowers per plant were obtained. These results are closely supported by the findings of Ahirwar *et al*. (2012) [1], Chauhan and Ambast (2014) [3], Katiyar and Batra (2016) [5], Nain *et al*. (2017) [12], in marigold.

Effect of pinching (Table 3)

Among different levels of pinching, p_0 resulted in earlier bud initiation by taking minimum number of days (22.69) which was at par with the treatment p_2. This is 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 which would have ultimately resulted in delayed initiation of bud and shortest duration of flowering (Singh *et al*., 2017) [16]. These results are in line with the findings of Singh *et al*. (2017) [16] in marigold crop.

Minimum days to first picking (41.36) was observed in $p_0$which was at par with p_2. 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 (Meena *et al*., 2015) [10]. These results are supported by the findings of Baskaran and Abirami (2017) [2] and Jyothi *et al*. (2018) [4] in marigold.

Maximum number of pickings (10.82) was observed from the treatment p_0 which was at par with p_2. This might be due to the fact that by removing the apical portion of the plants, new shoots which emerge on the pinched plants takes more time for bud initiation and mature. These results are in line with the findings of Kour (2012) [6] and Nain *et al*. (2017) [12] in marigold.

Significantly maximum diameter (5.21 cm) of flower was recorded in p_0. This decrease in flower diameter might be attributed to the fact that in pinched plants, 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. These results are in conformity with findings of Nain *et al*. (2017) [12] and Poudel *et al*. (2017) [14] in marigold.

The perusal of data indicated that, pinching significantly influenced number of flowers per plant which was found maximum (91.24) in p_3. 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 a greater number of uniform flowers. Our resultsare in closely conformity with Nain *et al.* (2017) [12] in marigold.

Interaction effect (Table 4)

The interaction between different levels of spacing and pinching has significant impact on diameter of flower. Among the interaction, maximum diameter of flower (5.68 cm) was recorded in s_2p_0, whereas, minimum (3.89 cm) was recorded in s_1p_3. These results are in line with the findings of Kour *et al*. (2012) [6] in marigold.

Table 1: Effect of spacing and pinching on growth parameters

Treatment	Plant height (cm)			Number of branches per plant					Plant spread (cm)					
				Primary			Secondary		(N-S)			(E-W)		
	25 DAT	40 DAT	90 DAT	25 DAT	40 DAT	90 DAT	40 DAT	90 DAT	25 DAT	40 DAT	90 DAT	25 DAT	40 DAT	90 DAT
s_1	31.17	49.13	63.93	3.80	8.38	10.78	13.53	36.48	13.53	22.78	38.58	13.53	23.00	40.39
s_2	27.80	45.20	57.26	4.91	9.63	13.00	15.85	40.55	15.60	26.21	44.33	15.92	25.74	43.42
s_3	28.50	46.77	59.68	4.05	8.75	11.18	14.82	37.97	14.35	23.28	41.43	14.45	25.02	40.90
S.Em ±	0.44	0.73	1.03	0.20	0.23	0.36	0.41	0.64	0.34	0.62	0.67	0.44	0.49	0.60
C. D. %	1.71	2.87	4.05	0.80	0.90	1.41	1.59	2.53	1.33	2.44	2.64	1.75	1.93	2.37
C. V. %	5.18	5.39	5.92	16.65	8.91	10.64	9.54	5.83	8.08	8.92	5.63	10.53	6.93	5.03
p_0	28.48	50.77	64.62	3.96	8.21	10.60	12.78	35.53	14.45	23.57	40.07	13.63	24.35	40.46
p_1	29.89	44.14	58.16	4.17	9.44	12.09	15.56	37.60	14.64	24.19	41.13	15.02	24.99	41.64
p_2	28.27	49.42	60.96	4.31	8.36	11.53	14.18	36.07	14.12	23.55	41.00	14.62	23.50	40.47
p_3	29.99	43.80	57.43	4.58	9.67	12.40	16.42	44.13	14.76	25.04	43.60	15.25	25.51	43.71
S.Em ±	1.27	1.62	1.25	0.24	0.72	0.36	0.556	0.72	0.55	1.04	0.82	0.61	0.67	1.26
C. D. %	NS	4.80	3.70	NS	NS	1.08	1.68	2.15	NS	NS	2.43	NS	NS	NS
C. V. %	13.05	10.30	6.20	16.83	14.01	9.38	11.50	5.66	11.38	12.99	5.93	12.49	8.22	5.24

Table 2: Interaction effect of spacing and pinching on growth parameters

Treatment Combination	Plant height (cm)			Number of branches per plant					Plant spread (cm)					
				Primary			Secondary		(N-S)			(E-W)		
	25 DAT	40 DAT	90 DAT	25 DAT	40 DAT	90 DAT	40 DAT	90 DAT	25 DAT	40 DAT	90 DAT	25 DAT	40 DAT	90 DAT
s_1p_0	33.63	55.73	70.07	3.80	7.03	10.07	12.33	31.87	14.81	23.50	37.20	11.44	22.62	40.50
s_1p_1	30.22	44.10	59.27	3.53	8.80	11.07	14.07	37.13	12.05	21.00	36.93	14.19	23.47	41.40
s_1p_2	29.47	51.61	65.00	3.60	7.80	10.60	12.87	36.47	13.16	23.53	37.40	13.45	21.80	37.27
s_1p_3	31.37	45.07	61.40	4.27	9.87	11.40	14.87	40.47	14.11	23.10	42.80	15.03	24.10	42.40
s_2p_0	23.75	46.59	63.27	5.07	9.40	11.27	13.93	37.80	15.48	25.00	41.13	15.07	25.19	42.33
s_2p_1	30.78	44.70	58.80	4.70	10.73	13.33	17.00	39.07	16.38	27.47	46.60	16.77	26.10	42.07
s_2p_2	27.00	45.60	57.07	4.93	9.13	12.60	14.33	36.60	15.31	24.86	43.93	15.59	24.87	44.27
s_2p_3	29.68	43.89	49.90	4.93	9.27	14.80	18.13	48.73	15.22	27.50	45.67	16.26	26.80	45.00
s_3p_0	28.07	49.98	60.53	3.00	8.20	10.47	12.07	36.93	13.07	22.21	41.87	14.39	25.23	38.53
s_3p_1	28.67	43.61	56.40	4.27	8.80	11.87	15.60	36.60	15.49	24.10	39.87	14.10	25.40	41.47
s_3p_2	28.34	51.05	60.80	4.40	8.13	11.40	15.33	35.13	13.88	22.27	41.67	14.83	23.83	39.87
s_3p_3	28.93	42.45	61.00	4.53	9.87	11.00	16.27	43.20	14.97	24.53	42.33	14.47	25.62	43.73
S.Em ±	2.20	2.80	2.16	0.41	0.72	0.63	0.98	1.25	0.95	1.81	1.42	1.05	1.17	1.26
C. D. %	NS	NS	6.41	NS	NS	NS	NS	3.72	NS	NS	NS	NS	NS	NS
C. V. %	13.05	10.30	6.20	16.83	14.01	9.38	11.50	5.66	11.38	12.99	5.93	12.49	8.22	5.24

Table 3: Effect of spacing and pinching on flowering parameters

Treatments	Days to bud initiation	Days to first picking	Number of pickings	Diameter of flower (cm)	Flower weight (cm)	Number of flowers per plant
s_1	25.22	43.37	9.9	4.48	4.48	71.80
s_2	26.47	46.13	10.2	4.91	4.90	82.43
s_3	25.87	44.59	10.1	4.72	4.62	76.67
S.Em ±	0.38	1.74	0.15	0.07	0.12	1.88
C. D. %	NS	NS	NS	0.28	NS	7.37
C. V. %	5.16	13.46	5.11	5.26	8.68	8.44
p_0	22.69	41.36	10.8	5.21	5.51	68.62
p_1	28.64	47.31	9.9	4.73	4.54	72.49
p_2	22.78	42.11	10.4	4.63	4.39	75.51
p_3	29.29	48.01	9.0	4.26	4.23	91.24
S.Em ±	0.67	1.60	0.23	0.08	0.11	3.01
C. D. %	1.98	4.75	NS	0.24	NS	8.95
C. V. %	7.75	10.74	6.78	5.10	7.26	11.74

Table 4: Interaction effect of spacing and pinching on flowering parameters

Treatments Combination	Days to bud initiation	Days to first picking	Number of pickings	Diameter of flower (cm)	Flower weight (cm)	Number of flowers per plant
s_1p_0	22.53	43.07	10.00	4.90	5.07	61.13
s_1p_1	27.00	45.00	9.87	4.47	4.69	71.20
s_1p_2	22.53	41.67	10.53	4.67	4.59	70.53
s_1p_3	28.80	43.73	9.00	3.89	4.83	84.33
s_2p_0	22.20	40.47	11.53	5.68	4.56	72.07
s_2p_1	29.60	51.07	9.67	4.88	4.58	70.67
s_2p_2	23.33	42.07	10.47	4.53	4.58	80.73
s_2p_3	30.73	50.93	8.93	4.55	5.23	106.27
s_3p_0	23.33	40.53	10.93	5.03	4.70	72.67
s_3p_1	29.33	45.87	10.13	4.83	4.49	75.60
s_3p_2	22.47	42.60	10.07	4.71	4.84	75.27
s_3p_3	28.33	49.37	9.13	4.33	4.40	83.13
S.Em ±	1.16	2.77	0.39	0.14	0.20	5.22
C. D. %	NS	NS	NS	0.41	NS	NS
C. V. %	7.75	10.74	6.78	5.10	7.26	11.74

Conclusion

From the present investigation it can be concluded that wider spacing and double pinching gives higher number of primary and secondary branches and flowers per planting African marigold.

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