The Pharma Innovation Journal 2023; 12(4): 2246-2254

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 2246-2254

www.thepharmajournal.com
Received: 07-02-2023
Accepted: 11-03-2023

Manjunath S Halagi
Department of Horticulture, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Rajendra P Maurya
Department of Horticulture, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

MK Bundela
Department of Horticulture, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

MK Jat
Department of Plant Pathology, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Corresponding Author:
Manjunath S Halagi
Department of Horticulture, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Effect of plant spacing and pinching interval on growth, yield and flower quality of African marigold (*Tagetes erecta* L.) under semi-arid conditions

Manjunath S Halagi, Rajendra P Maurya, MK Bundela and MK Jat

Abstract
The present investigation was carried out at Agricultural Research Farm, Department of Horticulture, Suresh Gyan Vihar University, Jagatpura, Jaipur (Rajasthan) to study the effect of plant spacing and pinching time on plant growth, flower quality characters and yield attributes in African marigold under semi-arid condition during winter season of the year 2019-20. The experiment was laid down in Factorial Randomized Block Design with three replications which comprises of sixteen treatment combinations included four different levels of plant spacing (40x10 cm, 40x20 cm, 40x40 cm and 40x60 cm) and four pinching stages as well (no pinching, pinching at 20 DAT, pinching at 30 DAT and pinching at 40 DAT). The maximum chlorophyll (9.70 mg g^{-1}FW), primary branches plant^{-1} (11.16), bud size (1.40 mm), flower diameter (6.53 cm), flowers plant^{-1} (47.16) and heaviest fresh flower weight (10.40 g) were recorded under the widest plant spacing (40x 60 cm). Whereas, the highest plant height (65.45 cm), longest (66.00 days) blooming period and the highest yield ha^{-1} (127.33 q) were recorded under plant spacing of 40x20 cm. The pinching at 30 days after transplanting performed significant effect on highest plant height (67.50 cm), primary branches plant^{-1} (12.83), bud size (1.39 mm), flower diameter (7.00 cm), heaviest fresh flower weight (10.58 g), blooming period (67.66 days) and maximum flowers plant^{-1} (57.18) and yield quintal ha^{-1} (358.35 q). The interaction effect of plant spacing 40x20 cm and pinching at 30 DAT significantly influenced the highest plant height (68.52 cm), maximum leaves (146.67), stem diameter (1.73 cm), primary branches (13.91), bud size (1.40 mm), flower diameter (7.60 cm), the heaviest fresh flower (11.66 g), dry flower weight (4.80 g), longest pedicel length (8.16 cm), blooming period (71.67 days), vase life (7.42 days), highest flower yield plant^{-1} (60.50 g), yield quintal ha^{-1} (132.83 q) and a B: C ratio of 3.03. It is, therefore, concluded from the present study that the treatment combination consists of plant spacing 40 x 20 cm and pinching at 30 days after transplanting were found to be best and showed a significant effect on vegetative growth, yield and flower quality of African marigold.

Keywords: Plant spacing, pinching interval, growth, yield, flower quality, *Tagetes erecta* L.

Introduction
African marigold (*Tagetes erecta* L.) is a native to central and South America, especially Mexico (Oviedo *et al*., 2012) [16], from where it spread to different parts of the world during the early 16th century. In India, marigold was introduced by Portuguese. It grows both as an annual or perennial crop and is mostly herbaceous plant, belongs to sunflower family *Asteraceae*.

It became popular and spread quickly because of its easy cultivation, adaptability under varied soil and agro-climatic conditions and easy transportation. It can be grown almost throughout the year. The flowers are beautiful with a long blooming period and have excellent vase-life. The variable flower size and colours make marigold an ideal flower for decoration as well as for landscape gardening. It is commercially used for making garlands, floral decoration, flower baskets, religious offerings, potting, bedding, edging, and also for making different products (Swaroop *et al.*, 2007) [28]. It plays an important role in the preparation of garlands, bouquets and for floral decoration at the time of marriages and other ceremonies.

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 present area under African marigold cultivation is 66, 130 ha with a production of 6, 03, 180 MT (GOI, 2017). It is also used as a potential source for the production of natural products and pharmaceutical components. It is suitable for pigment extraction, meal production, natural colorant preparation, oil extraction etc., which can help the farmers for maximizing their farm

income. Now-a-days many industries are interested in marigold cultivation owing to its potential in value addition.

The leaves and flowers of marigold have got medicinal value too. The juice extracted from leaves is used for getting relief from boils, carbuncles and ear ache. Flower extract is considered as a blood purifier and a good remedy for eye diseases and ulcers. Good quality of perfumes can also be made from its essential oils. Its petals are used for deriving food colours and commercially used as poultry feed.

Besides these, marigold is planted to control the soil nematodes. The earliest report about the resistance of *Tagetes* to control root-knot nematodes (*Meloidogyne* spp.) infestation was reported by Tyler (1938) [30] and Steiner (1941) [27] in a field experiment. All species of marigold are resistant to and can be used in control of *Meloidogyne incognita* in highly infected areas (Warden and Windrich, 1974) [31]. Marigold also produces thiophenes, which are naturally occurring biocides that active against nematodes. Water extract prepared from green leaves of *Tagetes erecta* shows different fungicidal effect. The oil extracted from *Tagetes* species is used in perfumery industries and due to a specific odour; it also acts as a repellant to flies.

Rajasthan is blessed with many natural advantages like abundant sunshine, favorable temperature for growth of marigold in different seasons and its location for marigold cultivation. Therefore, in plains under different agro-climatic conditions, marigold is grown as summer, rainy and winter season crop. Its production should be planned according to the need of the market. So, small or marginal farmers can earn a good profit per unit area.

In most of the flower crops, the flower yield mainly depends on the number of flowers bearing branches which can be manipulated by checking vertical growth of plants and encouraging side shoots by means of apical bud pinching. But studies on the influence of pinching of apical bud in African marigold and its effect on flower yield and quality are meager.

The African marigold is taller and an annual with profuse branching habit. It produces large-sized quality flowers of different colours, which fetches high prices in the market. But apical dominance delay in flowering and long and weak stems are some of the problems, which results in poor yield/economic returns. As far as favorable climatic conditions are concerned, they are beyond the control of human intervention. However, judicious cultural operations, balanced nutrition and physiological manipulations like plant spacing and pinching will definitely improve the flower yield and quality of the crop. In marigold cultivation, plant spacing and pinching time are the key factors, which contribute flower quality, and total yield.

Materials and Methods

The present investigation was carried out at Agricultural Research Farm, Department of Horticulture, Suresh Gyan Vihar University, Jagatpura, Jaipur, Rajasthan during winter season of the year 2019–20. The field experiment was laid out in Factorial Randomized Block Design (RBD) with 16 treatments and three replications. The treatments were randomized at the time of transplanting of seedlings and pinching also done accordingly. The size of the net plot was 1.6 m x 2.4 m. The African marigold cv. 'Pusa Narangi Gainda' was chosen for the experiment and seeds were collected from Pusa New Delhi. There were the four spacings namely 40 cm x 10 cm (S_1), 40 cm x 20 cm (S_2), 40 cm x 40 cm (S_3), 40 cm x 60 cm (S_4) and four pinching treatments *viz*. No Pinching (P_0), Pinching at 20 DAP (P_1), Pinching at 30 DAP (P), Pinching at 40 DAP (P_3). The soil of the experimental field was sandy loam in texture and had pH 8.2 and EC 0.48 dSm-1, organic carbon (0.45%). Seeds were sown on 25th July, 2019 on raised nursery beds. One month old healthy and uniform seedlings were transplanted at different levels of spacing on 8th September, 2019. A basal dose of well rotten FYM @ 5 kg/m^2 was uniformly mixed in the soil 15 days before transplanting. Half dose of nitrogen (10 g/m^2), full dose of phosphorus (20 g/m^2) and potassium (10 g/m^2) 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^2) was applied at 30 DAT. Different intercultural practices like gap filling, irrigating, staking, weeding etc. were performed as per crop requirement. The data were recorded for various growth, flowering and yield parameters in African marigold during the course of investigation subjected to statistical analysis by using factorial RBD for analysis of variance (ANOVA) as suggested online opstat software by Sheoran *et al.* (1998) [23].

Results and Discussion

Vegetative growth parameters

Plant height (cm)

The highest plant height (65.45 cm) was recorded at (40×20 cm) spacing whereas, the lowest plant height (58.72 cm) was recorded at widest plant spacing (40×60 cm) and plant height at spacing (40×20 cm) was at par. The increased plant height with closer spacing of (40×20 cm) may be due to competition for light under inadequate spacing. These results are found in agreement with the findings of Chauhan and Ambast (2014) [6] and Meena *et al.* (2015) [13]. The pinching treatment significantly increased the plant height at 20, 40 and 80 DAT while at 60 DAT there was no significant effect observed. The highest plant height (67.50 cm) was recorded on pinching at 30 DAT and the lowest plant height (64.17 cm) in non-pinching treatment. 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) [3] and Meena *et al.* (2015) [13] in African marigold. The interaction effect of plant spacing and pinching showed significant effect on plant height at all periodic growth stages 20, 40, 60 and 80 DAT. The highest plant height (68.52 cm) was observed in plant spacing (40×20 cm) and pinching at 30 DAT and the lowest plant height (57.17 cm) was recorded in plant spacing (40×10 cm) with no pinching treatment. However, spacing (40×60 cm) and pinching at 30 DAT showed the plant height (64.88 cm) at par with the highest plant height (68.52 cm) in plant spacing (40×20 cm) and pinching at 30 DAT. A perusal at the response exhibited by the pinching treatment revealed that pinching at 30 days after transplanting produced significantly taller plants, as pinching plays an important role in vegetative development, photosynthesis and cell division. Simultaneously, it increases metabolic activities, cell size and division of cells. The cumulative effect of pinching on above activities might have increased the plant height. These findings are in close conformity with the observations

recorded by Sehrawat *et al.* (2003) [19]; Badge *et al.* (2014) [3] and Sharma *et al*. (2016) [21].

Average number of leaves plant $^{-1}$

It is evident from the data presented in Table 1 that the significant difference was observed among all treatments at 80 DAT. The maximum (150.25) leaves plant^{-1} was observed with wider spacing (40×60 cm) and the lowest (101.54) leaves plant $^{-1}$ in closer spacing (40×10 cm), which was reduced significantly. The wider spacing (40×60 cm) favoured for production of more number of leaves plant^{-1}. This might be due to greater availability of plant nutrients, water and better sunlight exposure under wider spacing, which favours more lateral growth of plants. The present findings are in close conformity with the report of Yadav *et al.* (2004) [32] and Mohanty *et al*. (2015) [14].

The pinching at 40 days after transplanting produced significantly maximum number of (144.55) leaves plant^{-1} followed by leaves in pinching at 30 DAT and minimum (103.34) leaves was observed under the treatment of non-pinching plants. The increase in number of leaves plant^{-1} was noticed significantly with pinching at 40 days after transplanting. The possible reason for higher number of leaves plant $^{-1}$ in different interval of pinching may be due to the increase in metabolic activities, photosynthetic activity and increased cell division (Mohanty *et al*., 2015) [14]. The interaction effect between plant spacing and pinching also played significant role on production of number of leaves plant $^{-1}$ and the maximum leaves plant^{-1} (146.67) was recorded in spacing (40x20 cm) and pinching at 30 DAT whereas, minimum leaves plant^{-1} (97.33) was recorded in spacing (40x10 cm) and un-pinched plants (Chauhan and Ambast, 2014 and Meena *et al*., 2015) [6, 13] in African marigold.

Table 1: Effect of Spacing and pinching on vegetative growth parameters of African marigold (*Tagetes erecta* L.).

Treatments	Plant height (cm)				Number of leaves plant-1				Chlorophyll Content (mg g^{-1} FW)
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	
Spacing (cm)									
40 x 10 (S_1)	23.98	34.42	54.00	61.97	12.50	31.50	73.50	101.54	9.58
40 x 20 (S_2)	24.62	36.09	54.69	65.45	13.19	32.19	77.50	116.40	7.70
40 x 40 (S_3)	24.09	34.48	53.20	64.38	13.74	34.34	74.50	121.17	8.20
40 x 60 (S_4)	23.67	34.15	51.83	58.72	14.93	35.83	78.83	150.25	9.70
SE (m) ±	0.32	0.73	0.76	0.36	0.16	0.44	0.67	0.50	0.31
CD at 5%	NS	NS	NS	1.29	0.58	1.56	2.37	1.78	1.12
Pinching (P)									
No pinching (P_0)	23.15	33.50	52.03	64.17	11.54	29.18	81.33	103.34	8.48
Pinching at 20 DAT (P_1)	26.67	35.17	52.84	66.33	15.08	32.97	84.80	108.57	12.17
Pinching at 30 DAT (P_2)	32.00	36.17	55.35	67.50	15.48	35.78	89.17	133.70	10.60
Pinching at 40 DAT (P_3)	31.00	32.67	52.33	66.83	16.08	36.32	89.33	144.55	10.23
SE (m) ±	0.56	0.30	0.74	0.54	0.31	0.40	1.22	0.05	0.24
CD at 5%	1.99	1.05	NS	1.92	1.12	1.42	4.31	0.17	0.85
Interaction (Spacing x Pinching)									
Spacing 40 x10 cm and no Pinching (S_1P_0)	23.30	33.01	45.50	57.17	10.83	26.66	72.15	97.33	12.72
Spacing 40 x20 cm and no Pinching (S_2P_0)	22.76	33.95	47.30	59.77	12.35	30.53	74.27	98.33	13.10
Spacing 40 x 40 cm and no Pinching (S_3P_0)	23.67	35.71	53.26	65.13	11.33	34.04	83.61	106.53	12.92
Spacing 40 x60 cm and no Pinching (S_4P_0))	23.76	35.08	54.24	66.50	11.50	38.62	91.37	124.72	13.42
Spacing 40 x10 cm and Pinching at 20DAT (S_1P_1)	22.77	35.80	50.94	64.39	12.00	28.96	78.64	106.17	6.43
Spacing 40 x20 cm and pinching at 20 DAT (S_2P_1)	23.32	35.17	54.34	67.31	13.50	34.32	78.03	102.98	13.50
Spacing 40 x40 cm and pinching at 20 DAT (S_3P_1)	24.52	35.23	52.08	64.34	13.00	33.79	83.98	133.52	10.81
Spacing 40 x60 cm and pinching at 20 DAT (S_4P_1)	25.20	36.46	56.17	63.33	11.50	30.26	75.04	123.00	11.01
Spacing 40 x10 cm and Pinching at 30DAT (S_1P_2)	32.83	38.17	56.72	62.10	15.17	35.17	91.33	111.00	12.93
Spacing 40 x20 cm and pinching at 30 DAT (S_2P_2)	34.08	39.33	57.83	68.52	15.58	41.76	92.83	146.67	14.85
Spacing 40 x40 cm and pinching at 30 DAT (S_3P_2)	33.26	37.86	55.77	67.67	15.18	37.17	86.75	137.39	13.17
Spacing 40 x60 cm and pinching at 30 DAT (S_4P_2)	31.00	38.40	55.98	64.88	15.08	35.75	88.73	135.50	11.35
Spacing 40 x10 cm and Pinching at 40DAT (S_1P_3)	24.62	34.43	54.59	60.00	12.33	34.67	85.67	139.67	11.95
Spacing 40 x20 cm and pinching at 40 DAT (S_2P_3)	25.32	34.43	50.50	58.42	15.60	35.75	86.83	134.21	12.98
Spacing 40 x40 cm and pinching at 40 DAT (S_3P_3)	25.56	36.21	53.10	59.23	14.75	35.05	85.33	139.67	11.02
Spacing 40 x60 cm and pinching at 40 DAT (S_4P_3)	24.81	36.39	55.67	64.14	18.50	37.00	85.75	141.50	10.92
SE (m) ±	0.41	0.85	1.19	1.37	0.37	0.42	0.82	0.94	0.47
CD at 5%	1.19	NS	3.45	3.98	1.08	1.22	2.39	2.74	1.38

Chlorophyll content (mg g^{-1} FW)

The highest chlorophyll (9.70 mg g^{-1} FW) was observed in plant spacing (40×60 cm) followed by (9.58 mg g^{-1} FW) in spacing (40x10 cm) whereas, the lowest chlorophyll (7.70 mg g^{-1} FW) was observed in spacing (40×20 cm). It might be due to greater availability of plant nutrients, water and better sunlight that plays an important role in metabolic activities of the plant resulting in the synthesis of chlorophyll and

cytochromes, which are essential for photosynthesis and respiration process in the plants (Thanapornpoonpong *et al.*, 2008) [29]. Further, it is known as an important component of many important structural, genetic and metabolic compounds in plant cells (Macadam *et al.*, 1989) [12].

The highest chlorophyll (12.17 mg g^{-1} FW) content was recorded in pinching at 20 DAT followed by (10.60 mg g^{-1} FW), (10.23 mg g^{-1} FW) in pinching at 30 DAT and 40 DAT, respectively. The pinching at 20 DAT showed highly significant effect on chlorophyll content over non-pinching treatment. This might be due to the removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal growth which might have favoured in increasing the chlorophyll content. Sarkar *et al.* (2018) [18] also recorded the total chlorophyll content (1.36 mg g^{-1} FW) in marigold. The interaction effect between spacing and pinching revealed that the plant spacing (40×20 cm) with pinching at 30 DAT produced highest chlorophyll (14.85 mg g^{-1} FW). It might be due to greater availability of plant nutrients, water and better sunlight that plays an important role in metabolic activities as well as removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal growth which might have favoured in increasing the chlorophyll content (Sarkar *et al.*, (2018) [18].

Average stem diameter (cm)

The thickest stem diameter (1.64 cm) was observed in spacing (40×60 cm), whereas thinnest stem diameter (1.48 cm) was oberved in spacing (40×10 cm) at 80 DAT. The stem diameter increased continuously as getting age of plants up to 80 DAT. The increased thickness of stem could be ascribed to a better availability of nutrients, water and better sunlight exposure per unit area due to sufficient space resulting in less competition among the plants. The results are in accordance with the findings of Dixit (2004) [7] and Yadav *et al.* (2004) [32]. The maximum stem diameter (1.66 cm) was recorded in pinching at 40 DAT and minimum stem diameter (1.50 cm) was recorded in non-pinching plants at 80 DAT. The pinching treatment was significantly increased the stem diameter over non-pinching plants at different period of growth of marigold plants. This increase in stem diameter is might be due to removal of apical dominance by pinching could be attributed to promote cell division, cell enlargement and ultimately increased cell size of stem. Khandelwal *et al.* (2003) [9] also recorded the maximum (2.56 cm) stem diameter with pinching at 20 days after transplanting in marigold. The significant interaction effect on maximum stem diameter (1.73 cm) was also observed in plant spacing (40×20 cm) and pinching at 30 DAT whereas, minimum (1.25 cm) stem diameter was recorded in spacing (40x10 cm) and non-pinching plants at 80 DAT. However, the age of plants also played important role on stem diameter. The youngest plants at 20 DAT had low stem diameter (1.25 cm) and matured plants had bigger stem diameter (1.73 cm) at 80 DAT. Similar findings were also reported by Chauhan and Ambast (2014) [6] in African marigold.

Average number of primary and secondary branches plant^{-1}

In Table 2 showed that the maximum (11.16) primary branches and (30.50) secondary branches plant^{-1} were observed in the widest plant spacing (40x60 cm) whereas, the minimum (7.43) primary branches and (24.16) secondary branches plant $^{-1}$ were recorded in the closest plant spacing (40×10 cm). Remarkably higher numbers of primary branches plant^{-1} were observed in wider spacing as compared to closer spacing. This may be due to greater availability of plant nutrients, water and better sunlight exposure under wider spacing, which favours more lateral growth of plant. The results are in agreement with the findings of Dixit (2004) [7]; Yadav *et al.* (2004) [32] and Meena *et al.* (2015) [13]. The maximum (12.83) primary branches and (31.83) secondary branches plant^{-1} were recorded in plants pinched at 30 DAT whereas, the minimum (7.30) primary branches and (24.00) secondary branches plant $^{-1}$ were recorded in non-pinched plants. The all pinching treatments showed significant effect on number of primary branches plant^{-1} over un-pinched plants. It might have resulted due to enhanced cell division, increased cell size as well as higher leaf area and thus greater photosynthesis activity. The removal of apical dominance also stimulates lateral branches (Chauhan *et al.*, 2005) [5].

The interaction effect between spacing and pinching significantly influenced number of primary branches and the maximum (13.91) primary branches and (40.83) secondary branches plant^{-1} were observed in spacing (40×20 cm) and pinching at 30 DAT treatment while, the minimum (9.51) primary branches and (24.00) secondary branches plant^{-1} were observed in spacing (40x60 cm) and non-pinching plants. This may be due to greater availability of plant nutrients, water and better sunlight exposure and in pinched plants more energy is utilized for the development of side branches (Yadav *et al.;* 2004; Kumar *et al*., 2012 and Meena *et al.;* 2015) [32, 11, 13].

Average days to first bud emergence (days)

The wider spacing of 40×60 cm required maximum (42.16) days as compared to plant spacing of 40x20 cm required minimum period (36.66 days) for first bud emergence. It might be due to closer spacing creates microclimate for reproductive phase of plants and resulted in early onset of flower bud emergence (Nain *et al.* 2017) [15].

The pinched plants took more number of days to first bud emergence as compare to non-pinched plants. There was a significant difference was observed in pinching and non-pinching plants and interaction of spacing and pinching also showed significant effect in days to first bud emergence (Table 2). It might be due to different vegetative growth pattern as a result of various pinching treatments which prolonged vegetative growth and resulted in delayed onset of reproductive phase. These findings are in accordance with the report by Kumar *et al.* (2002) [11] and Pathania *et al.* (2000) [17].

Table 2: Effect of spacing and pinching on vegetative growth parameters and flower bud emergence of African marigold (*Tagetes erecta* L.)

Treatments	Stem diameter (cm)				Number primary branches plant^{-1}	Number secondary branches plant^{-1}	Days to first bud emergence	Days to 50% Flowering
	20 DAT	40 DAT	60 DAT	80 DAT				
Spacing (S)								
40 x 10 (S_1)	0.52	0.82	1.24	1.48	7.43	24.16	38.00	41.83
40 x 20 (S_2)	0.56	0.83	1.32	1.57	9.28	24.83	36.66	44.33
40 x 40 (S_3)	0.56	0.82	1.33	1.57	10.85	27.50	40.33	44.33
40 x 60 (S_4)	0.62	0.89	1.32	1.64	11.16	30.50	42.16	45.66
SE (m) ±	0.09	0.010	0.015	0.02	0.26	1.05	0.70	1.35
CD at 5%	0.03	0.03	0.05	0.10	0.95	3.70	2.47	NS
Pinching (P)								
No pinching (P_0)	0.56	0.82	1.48	1.50	7.30	24.00	40.16	41.00
Pinching at 20 DAT (P_1)	0.62	0.84	1.57	1.57	11.50	30.00	43.16	50.83
Pinching at 30 DAT (P_2)	0.61	0.83	1.57	1.58	12.83	31.83	44.00	53.16
Pinching at 40 DAT (P_3)	0.63	0.90	1.64	1.66	12.75	31.33	45.00	52.66
SE (m) ±	0.015	0.010	0.029	0.023	0.41	0.35	0.93	0.46
CD at 5%	NS	0.037	0.104	0.081	1.44	1.25	3.29	1.65
Interaction (Spacing x Pinching)								
Spacing 40 x10 cm and no Pinching (S_1P_0)	0.54	0.74	1.23	1.25	11.25	25.00	43.00	49.67
Spacing 40 x20 cm and no Pinching (S_2P_0)	0.62	0.79	1.24	1.46	11.76	24.50	43.00	52.67
Spacing 40 x 40 cm and no Pinching (S_3P_0)	0.52	0.82	1.34	1.54	12.50	24.00	44.33	54.67
Spacing 40 x60 cm and no Pinching (S_4P_0))	0.56	0.80	1.35	1.62	9.51	26.16	44.67	50.83
Spacing 40 x10 cm and Pinching at 20DAT (S_1P_1)	0.56	0.76	1.28	1.37	10.36	23.33	46.17	51.00
Spacing 40 x20 cm and pinching at 20 DAT (S_2P_1)	0.53	0.82	1.35	1.61	9.51	26.50	48.17	55.00
Spacing 40 x40 cm and pinching at 20 DAT (S_3P_1)	0.62	0.86	1.37	1.56	13.50	27.76	50.17	53.17
Spacing 40 x60 cm and pinching at 20 DAT (S_4P_1)	0.56	0.83	1.31	1.66	10.29	29.33	51.67	56.67
Spacing 40 x10 cm and Pinching at 30DAT (S_1P_2)	0.63	0.82	1.43	1.68	12.33	39.50	52.33	53.67
Spacing 40 x20 cm and pinching at 30 DAT (S_2P_2)	0.74	0.90	1.47	1.73	13.91	40.83	40.83	45.83
Spacing 40 x40 cm and pinching at 30 DAT (S_3P_2)	0.71	0.84	1.44	1.54	13.25	39.83	52.17	54.67
Spacing 40 x60 cm and pinching at 30 DAT (S_4P_2)	0.71	0.87	1.44	1.46	12.58	40.66	52.17	55.67
Spacing 40 x10 cm and Pinching at 40DAT (S_1P_3)	0.68	0.85	1.37	1.57	10.91	35.83	50.33	55.50
Spacing 40 x20 cm and pinching at 40 DAT (S_2P_3)	0.70	0.85	1.36	1.65	12.00	35.83	50.33	55.67
Spacing 40 x40 cm and pinching at 40 DAT (S_3P_3)	0.69	0.86	1.41	1.53	12.25	37.33	49.33	53.67
Spacing 40 x60 cm and pinching at 40 DAT (S_4P_3)	0.69	0.84	1.39	1.55	11.83	37.83	51.33	52.17
SE (m) ±	0.013	0.014	0.014	0.013	0.39	0.54	0.93	1.02
CD at 5%	0.038	0.040	0.041	0.037	1.14	1.56	2.70	2.98

Average days to 50% flowering (days)

The non-significant difference was observed plant spacing but significant difference was observed in pinching and non-pinching plants on number of days taken in 50% flowering. The maximum (53.16) days in plants pinched at 30 DAT whereas, minimum (41.00) days observed in non-pinched plants. Un-pinched plants showed less number of days in 50% flowering and pinched plants took long duration in 50% flowering. The pinching significantly delayed the days to 50% flowering and it is due to the induction of vegetative phase after the break of apical dominance. Similar views have also been expressed by Srivastava *et al.* (2005) [26]. The maximum (56.67) days in spacing (40×60 cm) and pinching at 20 DAT and minimum (49.67) days took in spacing (40x10 cm) with no pinching and. A significant difference was noticed due to interaction between pinching and different spacing on number of days taken to 50% flowering. These results are in close agreement with the findings of Srivastava *et al.* (2005) [26]; Nain *et al.* (2017) [15] and Sheena *et al.* (2017) [22].

Floral Quality Parameters

Average bud size (mm) and flower diameter (cm)

It apparent from the data presented in Table 3 the bud size increased significantly due to various spacing and pinching treatments. The maximum 1.40 mm bud size were recorded in the widest plant spacing (40×60 cm) followed by in spacing (40×40 cm) and the minimum 1.23 mm bud size were found in the closest spacing (40×10 cm). The increased thickness of flower bud could be ascribed to a better availability of nutrients, water and better sunlight exposure per unit area due to sufficient space resulting in less competition among the plants (Dixit, 2004) [7] and Yadav *et al.*, 2004) [32]. The maximum size of bud were recorded in pinching at 30 DAT whereas, the minimum bud size was noted under in non-pinching treatment which showed non-significant effect on bud size. The non- significant effect was found under different spacing, pinching and interaction between plant spacing and pinching in flower diameter under pinching treatment.

Average fresh and dry weight of flower (g)

The maximum fresh (10.40 g) and fry (3.90 g) flower weight were observed in the widest spacing of (40×60 cm) which was found significantly the heaviest flower than other spacing treatments i.e. 40x10 cm, 40x20 cm and 40×40 cm whereas, minimum fresh (7.33 g) and dry (3.60 g) flower weight were recorded in the closest spacing (40×10 cm). The heaviest fresh weight of flower with wider spacing might be due to higher plant spread, more number of branches, leaves and increased girth of stem. The large number of leaves and high chlorophyll content helps in photosynthesis that increased the fresh flower weight (Singh *et al.*, 2018) [24]. The pinching at 30 DAT was found significantly better than the rest of the pinching levels for increasing fresh weight of plants. The

heaviest fresh (10.58 g) and dry (4.45 g) flower weight were recorded with pinching at 30 DAT whereas, the lowest fresh flower weight (9.33 g) and dry (3.56 g) flower weight were recorded in non-pinching plants. The interaction between spacing and pinching were found significant for this attribute and spacing (40×20 cm) with pinching at 30 DAT produced the heaviest fresh (11.66 g) and dry (4.80 g) flower weight in comparison to other treatment combinations. This increase in fresh flower weight under pinching treatment might be due to the reason that extra energy diverted into the production of more reproductive parts instead of vegetative parts (Ahirwar *et al.*, 2012) [1].

Average pedicel length (cm)

The longest pedicel length (7.26 cm) was observed in the widest spacing (40×60 cm) whereas, the smallest pedicel length were (6.80 cm) observed in the closest spacing (40×10 cm). The data on the effect of pinching revealed that the longest pedicel length (7.70 cm) was observed with pinching at 30 DAT treatment followed by pinching at 40 DAT whereas the, smallest pedicel length (6.73 cm) was noticed in non-pinching treatment. However, the interaction effect between spacing and pinching had non-significant effect on pedicel length. The possible reasons are the pinching plays an important role in vegetative development, photosynthesis and cell division. Simultaneously, it increases metabolic activities, cell size and division of cells. The cumulative effect of pinching on above activities might have increased the plant height. These findings are in close conformity with the findings of Sehrawat *et al.* (2003) [19]; Badge *et al.* (2014) [3] and Sharma *et al*. (2016) [21].

Average period of bloom (days)

The data (Table 3) showed that the non-significant effect was observed under different spacing treatments on the longest period of bloom. The pinching at 20 DAT had the longest blooming period (67.66 days) followed by (67.00 days) in pinching at 30 DAT, both are at par whereas, the shortest blooming period was observed in un-pinched plants. The interaction had significant effect of spacing and pinching the longest blooming period 71.67 was recorded in spacing (40×20 cm) and pinching at 30 DAT followed by 70.50 days in plant spacing (40x40 cm) with pinching at 20 DAT. The possible reason for long period of bloom under different pinching treatments may be due to the fact that after removal of apical portion of the plant, the plant enters into the vegetative phase and the new shoots took longer time to get physiological maturity, thereby resulting longest duration of flowering (Srivastava *et al.*, 2005) [26].

Yield Parameters

Average number of flowers plant $^{-1}$

The maximum (47.16) flowers plant^{-1} were recorded in spacing (40×40 cm) followed by (46.33) flowers plant^{-1} in 40x60 cm spacing treatment while, minimum (39.91) flowers plant^{-1} were recorded in plant spacing (40×20 cm). The spacing treatments had significant effect on number of flowers plant $^{-1}$. This increase in flower number plant $^{-1}$ under wider spacing might be attributed to less competition for food and water among the plants. The production of more number of primary and secondary branches plant^{-1} which ultimately produced more number of flowers plant $^{-1}$ is another reason (Yadav *et al.*, 2004 and Chauhan and Ambast, 2014) [32, 6]. The pinching at 30 DAT had produced the maximum (57.18) flowers plant^{-1} followed by (57.16) flowers plant^{-1} in pinching at 40 DAT whereas, minimum (52.00) flowers plant $^{-1}$ was recorded in pinching at 20 DAT. It might be due to removal of apical dominance by pinching stimulating lateral branches. The increase in number of primary and secondary branches under pinching might have resulted due to higher leaf area and thus greater photosynthesis activity. These results are in close conformity with results of Chauhan and Ambast (2014) [6] and Meena *et al.* (2015) [13].

Average weight of flowers plant^{-1}

Table 3 revealed that the widest plant spacing (40x60 cm) produced maximum (295.57g) flowers plant^{-1} whereas, spacing (40×20cm) produced the minimum (279.50 g) flowers plant^{-1}. This may be due to favorable conditions, like availability of nutrients, sun light and soil moisture to individual plant at wider spacing, which ultimately increased the weight of flowers (Chauhan and Ambast, 2014) [13]. Amongst the various pinching treatments, pinching at 30 DAT was found significantly superior in producing (358.35 g) flowers plant^{-1} as compare to other pinching treatments. Whereas, the minimum (314.47 g) flowers plant^{-1} was recorded under non pinched plants. This might be due to the removal of apical dominance enhanced extra energy diverted into the production of more reproductive parts instead of vegetative parts (Ahirwar *et al.* (2012) [1]. The interaction effects were also found to be significant for this attribute. The maximum (373.97 g) flowers plant^{-1} was recorded in spacing (40×20 cm) and pinching at 30 DAT whereas, the minimum (309.74 g) flowers plant^{-1} was recorded in spacing (40×10 cm) and non-pinching plants (Chauhan and Ambast, 2014) [6] and Meena *et al.*, 2015) [13].

Average flower yield ha $^{-1}$ (q)

The data presented Table 3 that the highest (127.33 q) yield ha^{-1} were recorded in plant spacing (40×20 cm) whereas, the lowest (112.33 q) yield ha^{-1} was recorded in wider spacing (40×60 cm). Maximum flower yield per ha may be due to accommodation of more number of plants in per ha area and production of more number of primary and secondary branches per plant which ultimately produced more flower yield ha^{-1}, which increased the weight of flowers and ultimately flower yield ha^{-1}. Similar findings have also been reported by Yadav *et al.* (2004) [32]; Beniwal *et al.* (2005) [4] and Singh *et al.* (2018) [24]. The pinching treatments also significantly influenced the flower yield ha^{-1}. The maximum flower (141.16 q) yield ha^{-1} was recorded on pinching at 30 DAT whereas, the lowest (132.16 q) yield ha $^{-1}$ were recorded in non-pinching treatment. It might be due to removal of apical dominance which diverted the extra energy into the production of more reproductive parts instead of vegetative parts (Ahirwar *et al.*, 2012) [1]. However, the highest flower (132.83 q) yield ha^{-1} was recorded in plant spacing (40×20 cm) and pinching at 30 DAT. It was observed that interaction effects between spacing and pinching had significant difference on flower yield ha $^{-1}$. These results are in close conformity with the findings of Kumar *et al.* (2012) [11] and Sharma *et al.* (2012) [20] Kour *et al.* (2012) [10] also obtained maximum (248.12 q/ha) flower yield under close spacing (40× 40 cm) with delayed pinching (40 DAT).

Average vase life of flower (days)

The maximum (6.82 days) vase-life of flowers were recorded in flower produced in spacing (40×20 cm) whereas, minimum (6.28 days) vase-life was recorded in flower produced in the closest spacing (40×10 cm). The data showed that the maximum (7.48 days) vase-life of cut flower was observed in pinching at 40 DAT followed by (6.84 days) in pinching at 30 DAT and in pinching at 20 DAT treatment whereas, the minimum (5.57 days) was recorded in non-pinching treatment. The pinching treatment had significant effect over non-pinching treatment. The significant increase in vase-life of flowers may be due to the effect of pinching that helped in improving the lusture and keeping quality of flower. The pinching accelerates most of the physiological attributes, which results in increased cell division and cell elongation. The cell enlargement occurs as a result of plasticity of cell wall. This reduces the wall pressure around the cell wall and turgor pressure caused by osmotic forces in the vascular sap which lead to entry of water into the cell resulting in cell enlargement and thereby enhancing the vase-life of flowers. The present findings are in accordance with the report of Singh *et al.* (2005) [25] and Anuradha *et al.* (2017) [2]. The interaction between spacing and pinching was significantly influence the vase-life of flowers. The maximum (7.42 days) vase-life was recorded in spacing (40×20 cm) and pinching at 30 DAT whereas, the minimum (5.33 days) was recorded in spacing (40×40 cm) and pinching at 40 DAT followed by in spacing (40×10 cm) and pinching at 20 DAT (Table 3).

In this study, the highest benefit-cost ratio 3.03 was recorded in spacing 40×20 cm with pinching at 30 DAT. It might be due to that this treatment produced the highest yield in per unit area with quality produce. The calculated B: C ratio (3.03) is gives valuable information to farmers or growers in semi-arid climatic conditions to improve socio-economic status and livelihood of growers.

Table 3: Effect of spacing and pinching on floral quality and yield parameters of African marigold (*Tagetes erecta* L.)

Treatments	Bud size (mm)	Flower diameter (cm)	Fresh weight of flower (g)	Dry weight of flower (g)	Pedicel length (cm)	Period of bloom (days)	Number of flowers plant^{-1}	Number of flowers plot^{-1}	Weight of flowers plant–1 (g)	Weight of flowers plot^{-1}(kg)	Yield ha^{-1} (q)	Vase life of flowers (days)	B:C Ratio
Spacing (S)													
40 x 10 (S_1)	1.23	6.23	7.33	3.63	6.80	66.33	43.66	293.50	289.90	5.60	112.33	6.28	2.54
40 x 20 (S_2)	1.23	6.47	8.33	3.60	6.90	65.33	39.91	286.33	279.50	4.43	127.33	6.82	2.77
40 x 40 (S_3)	1.32	6.42	9.16	3.68	7.20	63.33	47.16	285.17	287.10	3.97	116.66	6.58	2.77
40 x 60 (S_4)	1.40	6.53	10.40	3.90	7.26	66.00	46.33	280.17	295.57	3.50	117.83	6.52	2.45
SE (m) ±	0.03	0.10	0.08	0.07	0.18	0.86	1.03	0.65	2.94	0.09	1.73	0.10	
CD at 5%	0.12	NS	0.29	0.27	NS	NS	3.63	2.30	10.40	0.33	6.11	0.35	
Pinching (P)													
No pinching (P_0)	1.21	6.18	9.33	3.56	6.73	61.66	53.33	347.00	305.03	6.47	132.16	5.57	2.96
Pinching at 20 DAT (P_1)	1.25	6.40	10.50	3.76	7.13	67.66	52.00	354.00	314.47	5.70	141.16	6.68	2.82
Pinching at 30 DAT (P_2)	1.39	7.00	10.58	4.43	7.70	67.00	57.18	422.00	358.33	4.75	134.50	6.84	2.40
Pinching at 40 DAT (P_3)	1.38	6.78	10.20	4.45	7.60	65.66	57.16	397.00	358.35	3.93	136.33	7.48	1.95
SE (m) ±	0.42	0.28	0.29	0.05	0.10	1.14	0.85	7.17	6.10	0.09	1.51	0.08	
CD at 5%	NS	NS	NS	0.20	NS	NS	3.12	25.32	21.52	0.32	5.35	0.30	
Interaction (Spacing x Pinching)													
Spacing 40 x10 cm and no Pinching (S_1P_0)	1.26	6.30	9.26	3.60	6.63	68.67	50.83	304.09	309.74	6.40	131.16	5.62	2.75
Spacing 40 x20 cm and no Pinching (S_2P_0)	1.21	6.17	9.16	3.73	7.30	68.67	50.66	388.50	315.12	4.60	125.23	5.69	3.03
Spacing 40 x 40 cm and no Pinching (S_3P_0)	1.28	6.15	9.33	3.40	8.00	65.33	49.66	360.20	331.47	3.60	114.00	6.79	2.71
Spacing 40 x60 cm and no Pinching (S_4P_0))	1.15	6.32	10.53	4.40	7.23	66.67	49.66	270.96	328.15	2.43	103.83	6.74	2.75
Spacing 40 x10 cm and Pinching at 20DAT (S_1P_1)	1.25	7.00	10.23	3.23	6.86	67.00	46.34	342.27	322.00	6.50	128.66	5.41	2.82
Spacing 40 x20 cm and pinching at 20 DAT (S_2P_1)	1.20	7.16	9.80	3.55	7.20	70.00	47.00	358.70	321.07	4.43	119.45	6.49	2.75
Spacing 40 x40 cm and pinching at 20 DAT (S_3P_1)	1.29	7.23	9.40	4.27	7.13	70.50	46.50	327.93	332.40	3.47	102.83	7.26	2.57
Spacing 40 x60 cm and pinching at 20 DAT (S_4P_1)	1.26	7.00	9.50	3.93	7.36	68.83	45.27	315.21	315.60	2.68	86.18	6.70	2.48
Spacing 40 x10 cm and Pinching at 30DAT (S_1P_2)	1.36	7.55	11.41	4.67	7.26	68.83	59.33	488.50	365.70	6.53	122.00	5.82	2.75
Spacing 40 x20 cm and pinching at 30 DAT (S_2P_2)	1.40	7.60	11.66	4.80	8.16	71.67	60.50	502.50	373.97	6.77	132.83	7.42	3.03
Spacing 40 x40 cm and	1.35	7.47	11.08	4.50	8.13	68.50	57.18	482.48	356.78	6.30	127.16	6.95	2.71

pinching at 30 DAT (S_3P_2)													
Spacing 40 x60 cm and pinching at 30 DAT (S_4P_2)	1.36	7.50	10.46	4.47	8.03	67.33	57.16	489.17	363.24	4.73	129.51	6.53	2.75
Spacing 40 x10 cm and Pinching at 40DAT (S_1P_3)	1.37	6.77	9.75	4.07	6.86	67.33	45.84	314.09	314.47	6.26	124.00	5.33	2.82
Spacing 40 x20 cm and pinching at 40 DAT (S_2P_3)	1.34	6.73	9.91	4.03	7.63	65.67	48.14	348.58	314.50	4.30	117.24	6.93	2.75
Spacing 40 x40 cm and pinching at 40 DAT (S_3P_3)	1.34	6.65	10.70	4.60	7.80	66.33	48.83	480.31	318.23	4.03	108.14	6.62	2.57
Spacing 40 x60 cm and pinching at 40 DAT (S_4P_3)	1.36	7.23	10.50	4.10	7.53	65.67	43.50	398.31	325.80	2.33	101.83	6.50	2.48
SE (m) ±	0.02	0.18	0.32	0.08	0.23	0.73	0.80	8.43	3.72	0.14	2.99	0.13	
CD at 5%	NS	NS	0.93	0.24	NS	2.13	2.34	24.48	10.80	0.40	8.67	0.37	

References

1. Ahirwar MK, Ahirwar K, Shukla M. Effect of plant densities, nitrogen and phosphorus levels on growth, yield and quality of African marigold Ana. Pl. & Soil Res. 2012;14(2):153-155.
2. Anuradha RW, Sateesh RP, Priyanka TK, Kumar N, Kulakarni BS. Effect of Growth Regulators and Pinching on Vegetative Growth, Flowering and Flower Yield Parameters in African marigold cv. Culcatta Orange, Int. J Pure App. Biosci. 2017;5(5):989-994.
3. Badge S, Panchbhai DM, Dod VN. Response of pinching and foliar application of gibberellic acid on growth and flower yield in summer African marigold, Research on Crops. 2014;15(2):394-397.
4. Beniwal BS, Ahlawat VP, Rakesh. Studies on the effect of spacing and pinching on growth and flower production of chrysanthemum cv. Flirt, Haryana J of Horticultural Sci. 2005;32(3&4):228-229.
5. Chauhan S, Singh CN, Singh AK. Effect of vermicompost and pinching on growth and flowering in marigold cv. Pusa Narangi Gainda, Indian J of Horticulture. 2005;37(2):419-422.
6. Chauhan SK, Ambast SK. Effect of salinity levels and plant spacing on growth and flowering behaviour of marigold. Ann. Pl. & Soil Res. 2014;16(2):125-127.
7. Dixit A. Effect of plant spacing and nitrogen on growth, flowering and yield of annual chrysanthemum cv. local white. Orissa J Hort. 2004;32(2):55-56.
8. Government of India. Horticultural Statistics: At a Glance, Ministry of Agriculture and Farmers Welfare, Government of India, Chandu Press, New Delhi, India; c2017. p. 481.
9. Khandelwal SK, Jain NK, Singh P. Effect of growth retardants and pinching on growth and yield of African marigold (*Tagetes erecta* L.) J. of Ornamental Horticulture. 2003;6(3):271-273.
10. Kour R, Khajuria S, Sharma M, Sharma A. Effect of spacing and pinching on flower production in marigold cv. Pusa Narangi Gainda in mid-Hills of J&K State, The Asian J of Horticulture. 2012;7(2):1307-1309.
11. Kumar V, Singh HK, Kumar A, Singh AK, Bhanupratap. Effect of planting distance and pinching on growth and flowering behaviour of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda, in Rainy Season, Curr. Adv. Agril. Sci. 2012;4(1):79-81.
12. Macadam JW, Nelson CJ, Volenec JJ. Effects of nitrogen on mesophyll cell division and epidermal cell elongation in tall fescue leaf blades. Plant Physiol. 1989;89:549-556.
13. Meena Y, Sirohi HS, Tomar BS, Kumar S. Effect of planting time, spacing and pinching on growth and seed yield traits in African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. Indian J Agril. Sci. 2015;85(6):797-801.
14. Mohanty CR, Mohanty A, Parhi R. Effect of planting dates and pinching on seed traits in African marigold cv. Sirakole, Agriculture Science Digest. 2015;35(4):285-289.
15. Nain S, Beniwal BS, Dalal RPS, Sheoran S. Effect of Pinching and Spacing on Growth, Flowering and Yield of African Marigold (*Tagetes erecta* L.) under Semi-Arid Conditions of Haryana. J of Appl. and Natural Sci. 2017;9(4):2073-2078.
16. Oviedo Prieto R, Herrera Oliver P, Caluff MG. National list of invasive and potentially invasive plants in the Republic of Cuba - 2011. 2012.
17. Pathania NS, Sehgal OP, Gupta YC. Pinching for flower regulating in sim Carnation. J of Ornamental Hort. 2000;3(2):114-117.
18. Sarkar D, Saud BK, Mahanta P, Kalita P, Neog B, Talukdar MC. Response of pinching and gibberellic acid on growth and physiological characteristics of African marigold. Int. J Curr. Microbiol. App. Sci. 2018;7(3):1666-1672.
19. Sehrawat SK, Dahiya DS, Singh S, Rana GS. Effect of nitrogen and pinching on growth, flowering and yield of marigold (*Tagetes erecta* L.) cv. African Giant Double Orange. Haryana J Hort. Sci. 2003;32(1&2):59-61.
20. Sharma AK, Chaudhary SVS, Bhatia RS. Effect of spacing and pinching on regulation of flowering in African marigold (*Tagetes erecta* L.) under submontane low hill conditions of Himachal Pradesh, Indian J of Agricultural Sciences. 2012;12(2):331-336.
21. Sharma RK, Pandey RK, Laishram N, Singh A. Effect of pinching and plant growth regulators on flower regulation in African marigold (*Tagetes erecta* L.), J of Ornamental Horticulture. 2016;19(3&4):80-86.
22. Sheena N, Beniwal BS, Dalal RPS, Sonu S. Effect of pinching and spacing on growth, flowering and yield of African marigold (*Tagetes erecta* L.) under semi-arid conditions of Haryana, J. Applied and natural science

foundation. 2017;9(4):2073-2078.
23. Sheoran OP, Tonk DS, Kaushik LS, Hasija RC, Pannu RS. Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications by D.S. Hooda & R.C. Hasija Department of Mathematics Statistics, CCS HAU, Hisar; c1998. p. 139-143.
24. Singh H, Singh J, Ahirwar GK. Effect of spacing and pinching on growth and flowering in African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda, J of Pharmacognosy and Phytochemistry. 2018;7(2):1764-1766.
25. Singh S, Rathore SVS, Singh GK. Effect of pinching, levels of nitrogen and concentration of cytozyme on yield and yield attributes of flowers of African marigold (*Tagetes erecta* L.) during spring summer season. South Indian Hort. J. 2005;53(1-6):157-162.
26. Srivastava SK, Singh HK, Srivastava AK. Spacing and pinching as factors for regulating flowering in marigold, Haryana J. of Horticultural Science. 2005;34(2):75-77.
27. Steiner G. Nematodes parasitic on and associated with roots of marigolds (Tagetes hybrids). Proc. of the Biol. Soc., Washington. 1941;54:31-34.
28. Swaroop K, Singh KP, Raju DVS. Vegetative growth, flowering and seed characters of African marigold (*Tagetes erecta* L.) as Influenced by Different Growth Substances during mild off seasons. J Ornam. Horticulture. 2007;6(2):134-136.
29. Thanapornpoonpong S, Vearasilp S, Pawelzik E, Gorinstein S. Influence of various nitrogen applications on protein and amino acid profiles of amaranth and quinoa. J Agric. Food Chem. 2008;56:11464-11470.
30. Tyler J. Proceedings of the root-knot nematode conference held at Atlanta, Georgia, February 4, 1938. Plant Disease Reporter Supplement. 1938;109:133-151.
31. Warden WW, Windrich WA. Studies on nematological problem in horticulture. Agriculture Co-operation Project, Indonesia; c1974. p. 393-402
32. Yadav RM, Dubey P, Asati BS. Effect of spacing and nitrogen levels on growth, flowering and flower yield of marigold (*Tagetes erecta* L.). Orissa J Hort. 2004;2(1):41-45.