2. REVIEW OF LITERATURE

The survey of published literature revealed that very limited published information is available in seed production of flowering annuals particularly on seed yield contributing characters and seed quality attributes of marigold. However, whatever literature is available on planting time, spacing and pinching on seed yield and quality in African marigold (Tagetes erecta L.) are presented in this chapter. Besides the marigold the relevant literature from the other crops are also included.

2.1 Effect of planting time on seed yield and seed quality attributes

2.1.1 Effect of planting time on seed yield contributing characters

Chanda and Roy choudhury (1991) recorded that plant height, number of primary branches, number of flowers and flower yield/plant were higher at the wider spacing but yield/ha was highest at the closer spacing. Highest number of flowers/plant (47.7-51.0) was obtained with planting on 15 March whereas highest yield/plant (213.2-240.3 g) and yield/ha (23.7-15.0 t) were obtained with planting on 15 June.

Mohanty et al. (1993) recorded that planting in May produced a higher number of secondary branches, and increased plant height and spread. September planting produced a higher number of larger flowers per plant and per plot. The widest spacing encouraged the greatest vegetative growth.

Mohanty et al. (1993) recorded that the maximum number of flowers/plot
was obtained with the closest spacing and spacing had no effect on flower size. The most profitable crop was obtained from a September planting at 40 x 30 cm spacing.

Mohanty et al. (1997) found that May and July planting gave the highest number of branches per plant, plant height and stem thickness. Flower buds appeared earlier when cuttings were planted in November or January, but flower yield was highest in the September planting, followed by July and November. Fresh weight per flower and stem thickness both increased significantly as plant spacing increased. The highest flower yield per plant was achieved by planting on 1st September at a spacing of 40 x 30 cm.

Mishra (1998) reported that September or October planting gave higher number of flowers per plant (77.17 and 68.50, respectively) and flower yields (118.98 and 106.25 q/ha, respectively) than the other planting dates.

Samantaray et al. (1999) observed that the September planting was optimum for flower yield/plant closely followed by July planting. January and November plantings hastened the appearance of flower bud.

Cruz and Mendez (2002) observed that date of transplanting had an effect on several plant characteristics such as plant height, stem internodes number, length of basal and top lateral branches, number of flowers per plant and time to flowering decreased. Early (75 days), intermediate (95 days) and late (110-120 days) flowering responses corresponded to June-July, May and March-April transplanting dates, respectively, showing a photoperiodic response of the genotype.

Rao and Reddy (2002) conducted field experiment on African marigold (Tagetes erecta) cv. Pusa Narangi Gainda to determine the optimum time of
planting for flower and seed production with year round production of marigold flowers. June planting was the best for maximum flower and seed yield. It was also observed that irrespective of planting in the month of June, July or August, the maximum flower production was recorded during September and October months only, which coincided with the short day lengths confirming that short day lengths are more congenial for flower bud induction and flowering in African marigold.

Rao and Reddy (2002) further recorded that June planting produced the highest dry matter/plant followed by July, March, September and October plantings. The number of days required to first flower opening was reduced from August to February because of short day lengths coupled with low night temperatures. While in the case of March planting, flowering was delayed due to high diurnal temperatures, flower induction was low in July due to long day lengths coupled with low light intensity because of frequent rains and clouds. The study revealed that the marigold flowers can be produced throughout the year except in May and June in red sandy loam soils of Hyderabad region of Andhra Pradesh.

Jadhav et al. (2002) recorded significant effects of interactions of spacing and N levels for diameter of flowers and weight of 100 flowers per plant, while non-significant in respect of the rest of flowering and yield characters. In general closer spacing gave early flowering, where as flower quality was better under wider spacing.

Dubey et al. (2002) has observed that the interaction between time of planting and spacing for seed-yield was significant. However, non-significant interaction for plant height, number of branches per plant, days to first flowering, number of flowers per plant were noted.
Dubey et al. (2002) has observed that among the planting dates 15th August was found to be the best over May and July planting for plant height. The number of flowers per plant was found to be maximum under 15th August planting while minimum under 15th June planting in cosmos.

Sharma et al. (2003) noted that planting time significantly affected the vegetative growth and flower yield of marigold. The highest flower yield (10.73 tonnes/ha) was recorded in August-planted crop, followed by September-planted (8.48 tonnes/ha) crop, and the minimum (2.61 tonnes/ha) in January-planted crop. The highest net return (Rs.1,12,115/ha) was obtained from August-planted crop, with benefit cost ratio of 3.29, followed by September-planted crop (Rs.78, 380/ha), with benefit cost ratio 2.60.

Rao and Moon (2005) conducted field experiment to determine the effects of sowing dates on the seed production and flower yield of African Marigold (T. erecta). April, May and June sowing resulted in highest flower and seed yields. The highest flower production was recorded during September and October which coincided with the short day length. The number of days required to first flower opening was reduced from April to August because of short day length coupled with low night temperature. March sowing resulted in delayed flowering due to high variation in diurnal temperature, long day length coupled with low light intensity, frequent rains and cloudiness.

Raju et al. (2006) planted French marigold (Tagetes patula) variety Selection-2 in different months, i.e. May, June, July and August, to study the effect of planting time on growth and flowering parameters. He observed that the bud initiation occurred in October among all the plantings and that indicated a short-day photoperiodic requirement of French marigold. Flower yield per plant was maximum (173 g) in June planting where as flower diameter
(5.12 cm) and weight (6.84 g) were highest in August planting and lowest (3.80 cm and 3.57 g, respectively) in June planting. July planting was found to be the best for seed production of fresh marigold Selection-2.

Sreekanth et al. (2007) recorded early flower initiation in December planting whereas highest number of flowers per plant and flower diameter was recorded in October planting.

Singh et al. (2008) investigated the variability among 29 lines of African marigold for growth, flowering and seed attributes. The TEG -26 recorded maximum plant height, weight of seed per peduncle and seed yield per plant. TEG-17 was recorded maximum number of secondary branches per plant, second highest number of seeds per peduncle.

2.1.2 Effect of planting time on seed quality attributes

Dubey et al. (2002) has recorded the effect of time of planting on germination percentage and viability. The best germination percentage and viability was noted under 15th August and 15th July planting in cosmos respectively.

Mor et al. (2006) found that spring planting resulted highest test weight (3.20 g), seed germination (57.97%), seedling length (13.01 cm), dry matter per 10 seedlings (2.24 mg), vigour index (134.93), field emergence index (9.24), and seedling establishment (50.55%), whereas planting in the summer registered the lowest values for these parameters. Among the genotypes, MG-1 was superior in terms of test weight (3.70 g) and seedling height (7.05 cm), whereas MG-2 was superior with regard to seed germination (80.50%), seedling dry weight (2.77 mg), vigour (215.10), field emergence index (16.00), and seedling establishment (74.0%).
2.2 Effect of Spacing

2.2.1 Effect of spacing on seed yield contributing characters

Attempt has been made to review the research work reported by various workers on the effect of plant spacing in numerous ornamental crops. Since, plant density per unit area is one of the important factors in the crops production governing the growth of plant and yield of flowers. However, the available literature on ornamental crops amounts little but exhibits that proper spacing differs considerably with the variability in variety, soil fertility, kind of planting material and mechanization. Spacing generally affects the yield not only through plant density but also through performance of individual plant.

Monch (1962) reported that the flower production in carnation per m$^2$ of William Sim was higher with closer planting (13 x 24 cm or 32 plants/m$^2$ than the wider spacing (22 x 24 cm or 28 plants/m$^2$). The percentage of first quality flowers from the wide spaced plants was higher than that from the closer-spaced plants, but more number of first quality flowers were produced from close plants than from wide spaced plants.

Yokol and Hosaka (1962) recommended that spacing of 30 x 20 cm or 30 x 15 cm is optimum for maximum quality and yield of flower in variety Otaki of China aster. Pei (1962) compared the planting of *Anemone coronaria* at 25 x 5 cm, 35 x 5 cm and 35 x 10 cm and noted the number of flowers and seed-heads/ m$^2$ decreased as the plants were more widely spaced. But flowers and seed heads per plant increased with wider spacing. The seed yield per sq. m. was the lowest at wider spacing.

Pringle (1963) suggested that the highest number of chrysanthemum blooms per unit area was obtained with spacing at 7 inch x 7 inch, compared
with spacing at 5.9 and 12 inch.

Skalsa (1964) recommended wider spacing (30x30 cm) between the rows and closer spacing within the rows (15x15 cm) for commercial Begonia production. According to Quagliotti and Gullino (1962), plant growth and flower quality were not significantly affected in Dahlia variety Grazilla by any of the four spacing viz. 35 x 50 cm, 45 x 65 cm, 55 x 80 cm and 65 x 85 cm. The number of flower head/plant, however, increased by increasing the spacing between the plants, whereas the number of flower per sq. m. decreased. Rees et al. (1968) noted that over the density range 1 to 14 plants per sq. ft., the flower number increased from 2 to 12 per sq. ft. and the stem length from 29 cm to 35 cm.

Rees et al. (1969) investigated the effect of five plants densities by employing 10 cm x 20 cm, 10 cm x 7.5 cm, 10 cm x 5 cm and 5 cm x 7.5 cm on leaf growth and bulb yield of some tulip cultivars. It was noted that the leaf area index was directly proportional to the plant densities.

Bakker (1970) noted the heaviest yield of tulip bulbs in all grades with a planting density of 76 per m², regardless of seasonal differences in climate. According to Cocozza (1970), raising the planting densities from 80 to 200 corms of Frasaria refracta/m² slightly reduced the number of flowering spikes per plant but doubled the number of spikes per unit area. It had a favorable effect on the stem length and number of secondary spikes also. However, the plants density did not show any effect on the duration of flowering. Nevertheless, weight and number of corms produced per original corm was the lowest. The plant density also affected the size distribution of the harvested corms in this investigation.

Timmer et al. (1973) reported that the weight of tulip bulbs harvested per plant increased from 14.9 g at the closest spacing (5 cm x 5 cm) to 40.8 g
at the widest spacing (24 cm x 24 cm).

Ferodades et al., (1975) reported that the highest daughter bulb yield of tulip was obtained by planting the bulb 15 cm deep in the row 20 cm, apart. Corms of *Gladiolus grandiflorus* cv. Friendship were planted at 200,000 to 600,000/ha in rows spaced 0.60 m apart and observed that decreased spacing reduced the corm-weight, the number of corm lets formed and also floral spike length.

Sousa et al. (1981) worked on the carnation (cv. Scania Red Sim type) and planted, at densities of 233333, 176000 or 116667 plants/ha and recorded that with the increased density the number of flowers/ha with a perfect calyx increased and there were reduction in split-calyx flower per plant, weight of flowers +flower stalk and size of carolla.

Deswal et al. (1983) compared the effect of plant spacing on growth, flowering and corm production in gladiolus and noted that the corms spaced at 30 cm x 45 cm produced the tallest (/ 1.6 cm) plants which produced the greatest number of florets per spike.

Manik Chandra (1985) suggested that the corm of gladiolus should be planted 20 cm apart in the rows spaced at 40 cm for better plant growth, flowering and cormel production.

Gowda and Jayanthi (1986) noted that increasing the planting distance in African marigold (*Tagetes erecta* L.) resulted in the highest flower yield (17.07 t/ha) with wider spacing of 20 x 50 cm followed by 20 x 30 cm (12.23 t/ha).

Gowda and Jayanthi (1986) recorded that due to interaction effect of sowing and spacing the highest yield of flowers (21.68 t/ha) was recorded un-
der September sown plants with 20 x 50 cm spacing and least (1.41 t/ha) was in January sown plants with 20 x 30 cm spacing.

Ravindran et al. (1986) conducted a trial in red sandy soil with three levels of spacing in African marigolds (Tagetes erecta L.) and found that the yield of flowers was the maximum in the closest (30 x 30 cm) and medium (40 x 30 cm) spacing. Bhati and Chitkara (1987) recorded that plants of different cultivars of marigold were taller under close spacing whereas, flower yield per plant were higher at wider space but yield per unit area was highest with the closest spacing.

Yaduvanshi (1987) recommended that the corms of gladiolus should be planted at 30 x 20 cm for higher corms yield.

Chanda and Roychoudhury (1991) reported that plant height, plant spread (Canopy), number of primary branches, number of flowers and flower yield/plant were higher at the wider spacing but yield/ha was highest at the closer spacing. Highest number of flowers/plant (47.7-51.0) was obtained with planting on 15 March, whereas highest yield/plant (213.2-240.3 g) and yield/ha (23.7-15.0 t) were obtained with planting on 15 June.

Kobza (1993) reported an influence of plant density on seed yield in varieties of marigold. He planted tall cultivars of (T. erecta) at a spacing of 40 x 40cm, 40 x 30cm or 40 x 20cm and short cultivars of (T. patula) at 30 x 30 cm, 30 x 20 cm, 30 x 11.5cm or 30 x 10 cm. He found that increase in the plant density among the T. erecta cultivars register an increase of 30-100% whereas in T. patula cultivars a 56% and 200% rise in plant numbers increased seed yields by 20 and 35%, respectively. The increasing of yield had no significant effect on seed quality.
Mohanty et al. (1993) observed that the widest spacing encouraged the greatest vegetative growth. The maximum number of flowers/plant was obtained with the closest spacing; spacing had no effect on flower size. The most profitable crop was obtained from a September planting at 40 x 30 cm spacing.

Palasri (1996) reported that spacing had no effect on seed yield, seed germination and germination index in both cultivars, but plants grown in narrow spacing had tendency to produce the highest seed yield per unit area. Orange No. 1 produced better seed yield and quality than Giant Flower Bicolor.

Mohanty et al. (1997) noted that fresh weight per flower and stem thickness both increased significantly as plant spacing increased. The highest flower yield per plant was achieved by planting on 1 September at a spacing of 40 x 30 cm.

Samantaray (1999) observed fresh weight of individual flowers and flower yield/plant increased with wider row spacing. The highest yield of flowers/plant was obtained with September planting at the spacing of 40 x 30 cm.

Hameed and Sekar (1999) observed that the maximum stem length of flowers, flower diameter, single flower weight and yield per plant were observed in both cultivars treated with 150 kg N/ha + 120 kg P₂O₅/ha. The same treatment produced the earliest 50% flowering in both Dindigul (42.66 days) and Salem (43.33 days).

Dubey et al. (2002) was recorded highest seed yield/m² (24.48 g) under closest plant spacing (30x20 cm) in cosmos.

Poonam et al. (2002) observed that the plant spacing influence plant growth, flowering and seed yield significantly. The maximum plant height
(52.64 cm), spread (34.83 cm), number of branches (10.56) per plant and seed yield (2.61 g/m²) were observed under 40x30 cm spacing which was significantly better than 40x20 cm, 30x30 cm and 30x20 cm spacing.

Srivastava et al. (2002) investigated the effect of row spacing and pinching in marigold cv. Pusa Narangi Gainda growth, flowering and yield during 2000-01 in Uttar Pradesh, India. Treatments comprised: 3 spacing (40 x 40, 40 x 50 and 40 x 60 cm (S1, S2 and S3, respectively) and 4 pinching treatments (no pinching, pinching at 20, 30 and 40 days after transplanting (P0, P1, P2 and P3, respectively). Plant height was maximum under S1. The number of secondary branches per plant was maximum under S3. Pinching reduced the plant height significantly, with the maximum recorded under P1. The number of days required for initiation of flowers and duration of flowering were maximum under P3. The average size and weight of flowers were maximum under S3. The average size and weight of flowers were minimum under S1. The size and weight of flower were maximum under P0S3, and minimum under the P1S1. The number of flowers per plant were maximum under S3. The flower yield was maximum under S1. The flowers per plant were maximum under P2S3. The flower yield was maximum under P3S1, followed by P2S1 combination. The S2 and P3 combination was the optimum treatment for a high marigold flower yield with high-quality flowers.

Natarajan and Vijayakumar (2002) obtained highest number of flowers per plant, number of seeds per flower, seed yield per plant and plot, 100-seed weight, germination percentage, root and shoot lengths, dry matter production, and vigour index with N:P:K @125:125:50 kg/ha and a row spacing of 60x40 cm. The interaction effect was not significant for dry matter production.

Yadav et al. (2004) recorded greatest plant height under 40x30 cm spac-
ing (67.13 cm). The greatest stem diameter (1.64 cm), plant spread (43.82 cm), and number of leaves (147.92), number of primary (14.54) and secondary (64.11) branches, fresh weight (306.54 g), number of flowers (22.89) and flower yield per plant (231.75 g) were obtained under 60x45 cm spacing.

Karuppaiah and Krishna (2005) recorded the maximum value of growth characters at spacing 30x30 cm viz., plant height, number of primary and secondary branches, number of leaves, leaf area and dry matter production and flower characters in marigold viz., number of flowers, single flower weight, flower diameter, flower stalk length and carotenoid content and the treatment was considered as superior treatment.

Sreekanth et al. (2006) recorded among the 3 spacing viz. 40x30, 50x30 and 60x30 cm, the closer spacing of 40x30 cm had given maximum flower diameter, yield per plant and yield/ha in marigold.

Sunitha et al. (2007) revealed that the wider spacing (60x60 cm) recorded more number of branches (11.6), flowers (59.6), seed yield per plant (15.4 g) and per hectare (453.5 kg) than closer spacing of 60x40 cm. However, an application of vermin-compost as 50% RDN along with 50% RDF recorded significantly higher plant height (100.3 cm), maximum number of primary branches (13.1), flowers (66.2), seed yield per plant (18.6 g) and per hectare (499.00 kg) and recorded higher 1000-seed weight (3.7 g), root length (6.2 cm), shoot length (5.5 cm) and vigour index (1047) compared to RDF alone.

### 2.2.2 Effect of spacing on seed quality attributes

Palasri (1996) reported that spacing had no effect on seed germination and germination index in both cultivars, but plants grown in narrow spacing had tendency to produce the highest seed yield per area. Orange No. 1 produced
better seed yield and quality than Giant Flower Bicolor.

Singh et al (2008) observed variation in 29 lines of marigold for 1000 seed weight. The 1000 seed weight among the lines varies from 0.164 – 0.910 gm with the maximum 1000 seed weight in TEG – 28 and minimum in TEG – 7.

2.3. Effect of Pinching

2.3.1 Effect of pinching on seed yield contributing characters

Arora and Khanna (1986) observed that pinching at 20, 30 and 40 days after transplanting did not show significant increased in flower production but it delayed flower production by 10-20 days over non-pinched plants. The delay could be useful for regulating the flower production and to avoid glut in the market.

Sehrawat et al. (2003) reported that pinching increased the number of branches (except with 10 g N/m2), number of days to flower bud initiation, number of days to 50% flowering, and flowering duration. Pinching significantly reduced plant height, especially when conducted at 30 DAPS. The highest number of flowers per plant (30.17) and flower yield (322.68 g per plant) were obtained with pinching at 30 DAP (30.17).

Srivastava et al. (2004) conducted trial to investigate the effect of row spacing and pinching on growth, flowering and yield in marigold (cv. Pusa Basanti Gainda). Treatments comprised: three spacing (40x40, 40x50 and 40x60 cm (S1, S2 and S3, respectively)) and four pinching treatments (no pinching, pinching at 20, 30 and 40 days after transplanting (P0, P1, P2 and P3, respectively)). Plant height was higher in S1. The number of secondary branches per plant was higher under S3. Pinching reduced the plant height...
significantly, with the maximum recorded under P1. The number of secondary branches per plant was maximum under P3. The reduction in plant height was more under P1S3. The number of secondary branches per plant was maximum under P3S3. The number of days required for initiation of flowers and duration of flowering were maximum under P3. The average size and weight of flowers were maximum under S3. The average size and weight of flowers were minimum under S1. The size and weight of flower were maximum under P0S3, and minimum under the P1S1. The number of flowers per plant were maximum under S3. The flower yield was maximum under S1. The flowers per plant were maximum under P2S3. The flower yield was maximum under P3S1, followed by P2S1 combination. The S2 and P3 combination was the optimum treatment for a high marigold flower yield with high-quality flowers.

Tomar et al. (2004) observed that the double pinching (at 30 days & 55 days after transplanting) had produced highest number of flowers/plants (48.34 & 62.00) and seed yield/plant (17.71 & 20.94) in African marigold, cultivar Pusa Narangi Gainda and Pusa Basanti Gainda respectively.

Sharma et al. (2006) noted that pinching at 40 DAT had recorded maximum growth and flower production under Jabalpur (Madhya Pradesh) conditions.

Bhat and Shepherded (2007) reported that single pinching at 35 days after transplanting gave the tallest plant height (83.14 cm), lesser number of days to first flowering (47.85), higher plant spread (43.30 cm), higher number of branches per plant (11.90), number of flowers per plant (63.81), seed yield per plant (17.70 g), and flower size (5.05 cm). The seed quality attributes viz. 1000-seed weight (2.88 g) and germination percentage (71.04%), root length (3.76 cm) and shoot length (4.11 cm) was highest at single pinching 35 days
after planting.

Sunitha et al. (2007) observed that pinching significantly increased the number of primary branches (12.0), number of flowers per plant (61.8), and seed yield per plant (18.2 g) and seed yield per hectare (473.7 kg) over no pinching. Spraying of GA3 @ 200 ppm had been recorded for higher plant height (101.2 cm), number of primary branches (14.4) and flowers (68.6) per plant, seed yield per plant (20.6 g) and seed yield per hectare (531.5 kg). The 1000-seed weight (3.3 g), germination (90%), field emergence (77.1%), root length (6.3 cm), shoot length (5.4 cm), seedling dry weight (11.4 mg) and vigour index (1059) were also higher when the GA3 was sprayed followed by NAA @ 60 ppm.

2.3.2 Effect of pinching on seed quality attributes

Tomar et al. (2004) investigated the effect of pinching on seed quality characters in two varieties of marigold Pusa Narangi Gainda and Pusa Basanti Gainda and it is observed that control & single pinching 30 days after transplanting was at par for vigour index in variety Pusa Narangi Gainda and similar trend was observed in Pusa Basanti Gainda for vigour index.