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Influence of planting time and spacing on flower yield of African marigold

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Abstract
African marigold cultivation for loose flower markets depends heavily on getting two things right: when to plant and how far apart to space the transplants. This research evaluated three planting dates (15 June, 1 July, and 15 July) and three spacing levels (30×30 cm, 30×45 cm, and 45×45 cm) in a factorial randomized block design for their effects on growth, flower yield, and quality of African marigold (*Tagetes erecta* L. cv. Pusa Narangi Gainda) at Swarnim Gujarat Agricultural University, Gandhinagar, during the kharif seasons of 2022 and 2023. The 1 July planting at 30×45 cm spacing produced the highest flower yield of 12.34 t/ha, flower diameter of 7.82 cm, and carotenoid content of 184.6 µg/g fresh weight. The earliest planting (15 June) suffered from excessive vegetative growth with reduced flower number, while the latest date (15 July) had a shortened growing period that limited cumulative flower production. Closer spacing (30×30 cm) gave the highest plant population but smaller flowers due to competition. These results recommend 1 July transplanting at 30×45 cm spacing as the optimum combination for maximizing both flower yield and quality in the Gujarat plains.

Keywords: Planting time, spacing, African marigold, *Tagetes erecta*, flower yield, floriculture, carotenoid content, loose flower, Gujarat, kharif season

Introduction
Walk through any Indian flower market during the festival season and you will find African marigold in every shade from lemon yellow to deep orange, piled in enormous heaps that are sold by weight for garlands, religious offerings, and decorations. India is the world's largest producer of marigold, cultivating roughly 3.5 lakh hectares with an output exceeding 18 lakh tonnes of loose flowers annually [1]. In Gujarat, marigold is grown mainly during kharif and rabi seasons, with kharif plantings timed to produce peak flowering during the Navratri and Diwali festival period from September through November [2].

Planting date and spacing are among the simplest management decisions available to growers, yet they strongly influence the balance between vegetative and reproductive growth, light interception, air circulation, and ultimately the number and size of marketable flowers [3]. Too early a planting can push the crop into excessive vegetative growth before the shorter days and cooler nights trigger flower initiation, while too late a planting truncates the flowering window [4]. Spacing affects competition for light, water, and nutrients among plants; closer spacing increases plant density and potentially total yield per hectare, but may reduce individual flower size and increase disease incidence [5]. This research tested combinations of three planting dates and three spacing levels to identify the optimal package for African marigold under Gujarat plains conditions.

Crop Growth Stage Documentation
Seedlings were raised in pro-trays filled with cocopeat and transplanted to the main field at the 4-5 true leaf stage (about 28 days after sowing). First flower bud appearance was recorded at 32-38 days after transplanting depending on the planting date and spacing. First harvest of fully opened flowers began at 58-65 days after transplanting. Peak flowering occurred between 75 and 95 days after transplanting for the 1 July planting. Total harvesting spanned 45-55 days across multiple pickings at 3-4 day intervals. The crop was terminated when fewer than 10 marketable flowers per plot were available per picking [6].

Material and Methods

Material: The experiment was conducted at the Research Farm of Swarnim Gujarat Agricultural University, Gandhinagar, Gujarat (23.22° N, 72.68° E, elevation 81 m), during kharif 2022 and 2023. The soil was sandy loam with pH 7.4 and organic carbon 0.52%. African marigold cv. Pusa Narangi Gainda was used. A factorial RBD with three planting dates (D1: 15 June, D2: 1 July, D3: 15 July) and three spacings (S1: 30×30 cm, S2: 30×45 cm, S3: 45×45 cm) gave nine treatment combinations replicated three times. Plot size was 4 m × 3 m [7]. A uniform dose of 120:80:80 kg N:P_2O_5:K_2O per hectare was applied.

Methods

Observations were recorded on plant height, branches per plant, days to first flower, flowers per plant, flower diameter, individual flower weight, flower yield per plot and per hectare, shelf life of harvested flowers, and carotenoid content (by spectrophotometric estimation at 450 nm after petroleum ether extraction) [8]. Flower yield was computed from the cumulative weight of all harvested flowers across all pickings. Data were pooled over two seasons and analyzed by factorial ANOVA at P = 0.05 with Duncan's test for mean separation.

Results

Table 1: Effect of planting time and spacing on growth and flower yield of African marigold (pooled, 2022-2023)

Treatment	Plant Ht. (cm)	Flowers/ plant	Flower Dia. (cm)	Flower Yield (t/ha)	Carotenoid (µg/g)
D1S1	68.4	24.6	6.42	8.42	162.4
D1S2	72.6	28.4	7.14	10.86	174.8
D1S3	76.8	26.2	7.48	9.24	178.2
D2S1	64.2	28.8	6.84	9.18	172.6
D2S2	68.4	34.6	7.82	12.34	184.6
D2S3	72.2	30.4	8.12	10.68	188.4
D3S1	58.6	22.4	6.28	7.86	156.8
D3S2	62.4	26.8	6.94	9.42	168.4
D3S3	66.8	24.2	7.24	8.12	172.6
SEm(±)	2.14	1.42	0.18	0.48	4.86
CD (P=0.05)	6.42	4.26	0.54	1.44	14.58

The 1 July planting at 30×45 cm spacing (D2S2) produced the highest flower yield at 12.34 t/ha with excellent flower diameter (7.82 cm) and carotenoid content (184.6 µg/g) (Table 1). The 15 June planting gave taller plants but fewer flowers per plant. The 15 July planting consistently underperformed.

Table 2: Economics of African marigold production under different planting time and spacing combinations

Treatment	Gross Income (₹/ha)	Cost of Cultivation (₹/ha)	Net Income (₹/ha)	B:C Ratio
D1S2	2,17,200	86,400	1,30,800	2.51
D2S1	1,83,600	92,800	90,800	1.98
D2S2	2,46,800	88,600	1,58,200	2.79
D2S3	2,13,600	82,400	1,31,200	2.59
D3S2	1,88,400	86,400	1,02,000	2.18

D2S2 gave the highest net income (₹1,58,200/ha) and B:C ratio (2.79) (Table 2). The closer spacing D2S1 had higher cultivation cost due to more seedlings and labor but lower returns per rupee invested.

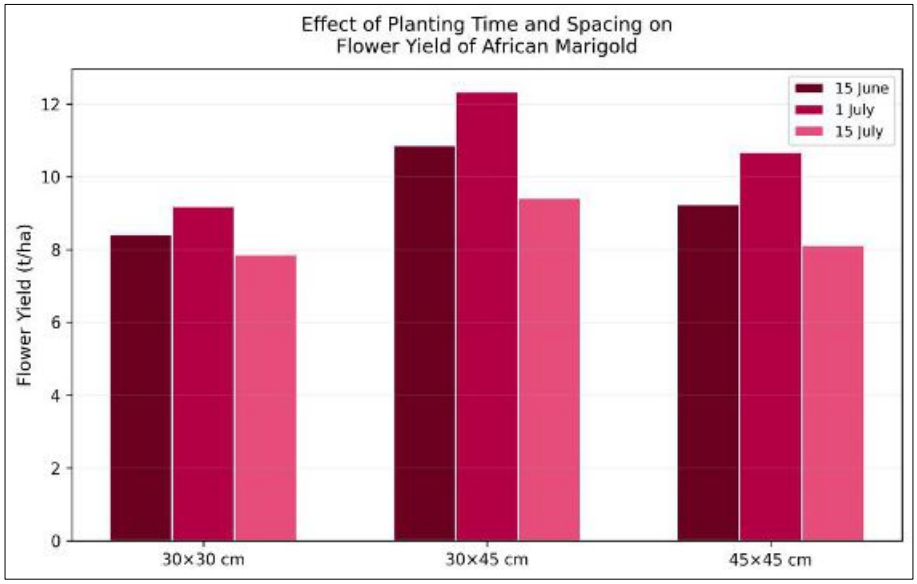

Fig 1: Effect of planting time and spacing on flower yield of African marigold across nine treatment combinations

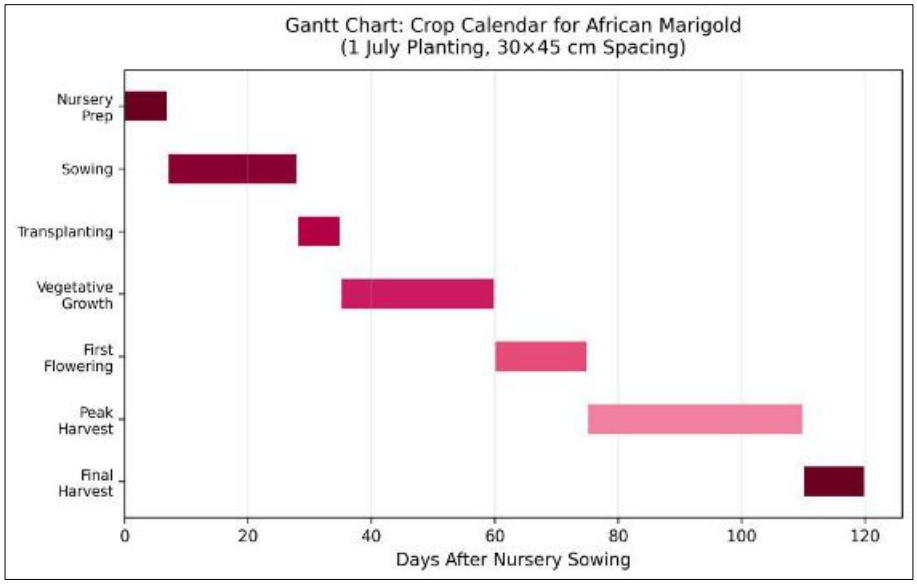

Fig 2: Gantt chart showing the crop calendar for African marigold under the recommended 1 July planting at 30×45 cm spacing

Comprehensive Interpretation

The interaction between planting date and spacing was significant ($p< 0.05$) for flower yield, flower diameter, and carotenoid content. The 1 July date optimized the vegetative-to-reproductive transition by ensuring that plants reached the flower initiation stage during the declining daylength period of August-September, while the 30×45 cm spacing provided sufficient space for lateral branching without wasting land area.

Discussion

The superiority of the 1 July planting reflects the favorable synchronization between the plant's developmental requirements and the seasonal pattern of temperature and photoperiod in Gujarat [2, 4]. The 15 June planting experienced longer days during early growth, which promoted excessive stem elongation at the expense of flower bud initiation. The 15 July planting, while avoiding this problem, simply ran out of time before the onset of cool, dry weather in late November curtailed growth [3].

At the 30×45 cm spacing, the plant population of approximately 74,000 per hectare balanced individual plant productivity with population density. The wider 45×45 cm spacing (49,000 plants/ha) produced the largest individual flowers but lower total yield per hectare because fewer plants couldn't compensate for the bigger blooms. The highest carotenoid content in wider spacings may reflect better light penetration into the canopy, as carotenoid biosynthesis is light-dependent [5, 8].

Conclusion

Planting African marigold on 1 July at 30×45 cm spacing is the optimum combination for the Gujarat plains, producing the highest flower yield (12.34 t/ha), good flower quality, and the best economic returns (B:C 2.79). Growers targeting the Navratri-Diwali festival market should adopt this package to maximize both yield and profit. Earlier planting wastes the vegetative potential on stem growth, while later planting shortens the productive harvest window.

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