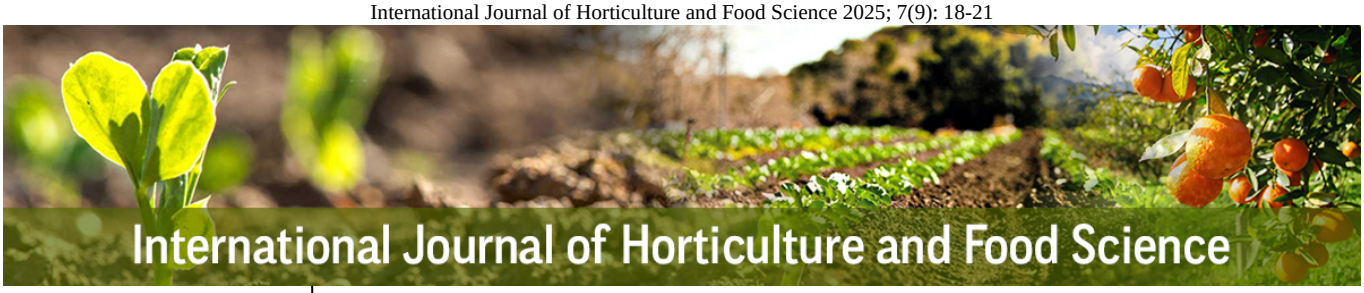

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Influence of planting dates and spacing on flowering and yield of African marigold (*Tagetes erecta* L.) cv. Punjab Genda No. 1 under Semi-Arid conditions of Rajasthan

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Abstract
A field experiment was conducted at Crop Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan during *rabi*, 2024-25 on sandy loamy soil. The experiment was laid out in Factorial Randomized Block Design, Replicated thrice, consisting of fifteen treatments. planting dates *i.e.*, D_1 (10th November), D_2 (20th November), D_3 (30th November), D_4 (10th December) and D_5 (20th December) and spacing *i.e.*, S1 (30 x 30 cm), S2 (30 x 40 cm) and S3 (30 x 50 cm) The results revealed that the treatment combination D_1S_3 (10th November + 30 cm x 50 cm spacing) significantly outperformed all other treatments. This combination recorded the earliest flower bud formation (43.26 days) and flowering (52.33 days). D_1S_3 also showed the longest flowering duration (78.11 days), largest flower diameter (6.80 cm), maximum flower weight per plant (434.44 g), and the highest flower yield per hectare (17066.67 kg/ha). These findings suggest that planting African marigold on 10th November at a spacing of 30 cm x 50 cm is the most suitable for achieving optimum growth, enhanced flowering, and maximum flower yield in semi-arid regions.

Keywords: Marigold, spacing, planting dates, Yield attributes, growth, yield, Rabi

1. Introduction
African marigold (*Tagetes erecta* L.), a member of the Asteraceae family, is renowned for its bold and colorful blooms, which typically range from bright yellow to deep orange hues. Though originally native to Central and South America, it has become a globally cultivated ornamental due to its wide adaptability and decorative appeal (Singh *et al.*, 2022) [12]. This vigorous, annual herbaceous plant features upright stems, pinnately divided leaves, and a capitulum-type inflorescence. In addition to its ornamental significance, African marigold is also appreciated for its therapeutic and biopesticidal uses, making it a valuable crop in floriculture and related sectors (Tirkey *et al.*, 2023) [17].

African marigold is a commercially significant flower crop cultivated extensively across the globe, particularly in countries such as India, Mexico, and the United States. Among these, India stands out as a leading producer, with states like Rajasthan playing a key role in national production, largely due to its favorable agro-climatic conditions (Kumar *et al.*, 2020) [4]. In Rajasthan, marigold farming has become increasingly important, catering to both domestic demand and export markets. The crop's productivity is affected by several factors, including varietal selection, environmental conditions, and cultural practices. Recent research has emphasized the importance of refining planting schedules and plant spacing to enhance both flower yield and quality (Tirkey *et al.*, 2024) [16].

Planting time is a critical factor influencing the growth, flowering behavior, and yield of African marigold. Variations in planting season can significantly impact vegetative development, flowering onset, and overall productivity. Studies conducted between 2019 and 2021 revealed that sowing marigold during the rabi (October-November) or kharif (July-August) seasons resulted in superior growth and higher flower yield when compared to summer planting, which is often hindered by heat-induced stress (Tirkey *et al.*, 2024) [16]. Early sowing within the suitable season enables the crop to benefit from optimal temperature

and photoperiod, thereby promoting greater flower output and extended blooming periods (Kumar *et al.*, 2020) [4].
Plant spacing is a vital agronomic factor that significantly affects the growth dynamics and flower yield of African marigold. Recent research highlights that closer spacing (such as 30 × 30 cm) can enhance flower yield per hectare by maximizing plant population density. However, this may lead to reduced individual plant performance due to increased competition for light, nutrients, and space (Srivastava *et al.*, 2023) [15]. On the other hand, wider spacing (e.g., 40 × 40 cm or 50 × 50 cm) tends to support better vegetative growth, larger blooms, and more branching, though it may result in a lower overall yield per unit area. Furthermore, integrating pinching practices with appropriate spacing has proven effective in enhancing branching and flower production, underscoring the importance of comprehensive crop management strategies (Nain *et al.*, 2017) [17].

2. Materials and Methods
The experiment was conducted at the experimental farm of the Department of Floriculture and Landscaping, Jaipur National University, from November 2024 to April 2025. The farm is geographically located at 75°51'44" E longitude and 26°48'35" N latitude, at an altitude of 431 meters above mean sea level, approximately 17 km from Jaipur city. The soil at the experimental site was sandy loam in texture and contained 0.87% organic carbon, with available nitrogen (225 kg/ha), phosphorus (41.8 kg/ha), and potassium (261.2 kg/ha). The area falls under a subtropical climatic zone.Weeding and hoeing operations were carried out as and when required throughout the crop cycle. The major weed species observed during the growing season included *Oxalis* spp., *Cyperus rotundus*, *Gallinsoga parviflora*, and *Ageratum* spp., which was manually controlled using hand hoes.Irrigation was applied daily from December to April, while from June onwards, the frequency was reduced due to the onset of the monsoon season. Specifically, during December and January, irrigation was provided twice a week. Data on various growth parameters were recorded using standard agronomic procedures at the time of harvest. Similarly, observations related to flowering and yield was also collected on the harvest day. All collected data were subjected to statistical analysis using the analysis of variance (ANOVA) technique, following the method described by Gomez and Gomez (1984) [2].

3. Result and Discussion:
3.1 Days taken to bud formation
Result pertaining to the days to taken bud formation is presented in Table 3 shows the effect of planting dates and spacing significantly affected days to bud formation at harvest over control. Minimum days to taken bud formation (43.26) was reported with planting dates (10th November) and for spacing treatments minimum days to bud formation (46.35) was reported with spacing of 30 cm x 50 cm. Combined the application of planting dates (10th November) + 30 cm x 50 cm spacing recorded the minimum days to taken bud formation which was significantly superior over other treatment. It can be attributed to ideal environmental conditions and reduced competition, which accelerate plant growth and development. This combination enables plants to reach the budding stage more quickly than other treatments, reflecting enhanced physiological efficiency. (Singh *et al.*, 2024) [14] and (Mehta *et al.*, 2022) [6] resulted the same.

3.2 Days to flowering
Result pertaining to the days to flowering is presented in Table 3 shows the effect of planting dates and spacing significantly affected days to flowering at harvest over control. Minimum days to flowering (52.33) was reported with planting dates (10th November) and for spacing treatments minimum days to days to flowering (56.20) was reported with spacing of 30 cm x 50 cm. Combined the application of planting dates (10th November) + 30 cm x 50 cm spacing recorded the minimum days to flowering which was significantly superior over other treatment. It is due to optimal temperature, light, and resource availability, which promote faster plant growth and earlier reproductive development. This favourable combination allows plants to transition to flowering more quickly and efficiently than other treatments. (Singh and Verma, 2020) [13] and (Khan and Jain, 2021) [3] have the similar experimental results.

3.3 Duration of flowering
Result pertaining to the duration of flowering is presented in 3 shows the effect of planting dates and spacing significantly increased duration of flowering at harvest over control. Highest duration of flowering (78.11) was reported with planting dates (10th November) and for spacing treatments highest duration of flowering (71.77) was reported with spacing of 30 cm x 50 cm. Combined the application of planting dates (10th November) + 30 cm x 50 cm spacing recorded the highest duration of flowering which was significantly superior over other treatment. It is likely due to optimal environmental conditions and adequate space, which support sustained plant vigor and prolonged reproductive activity. This combination ensures continuous resource availability, allowing plants to maintain flowering for a longer period compared to other treatments.These results are supported by (Lal and Sharma, 2023) [5] and (Rao and Kulkarni, 2024) [10].

3.4 Flower diameter (cm)
Result pertaining to the flower diameter is presented in Table 4 shows the effect of planting dates and spacing significantly increased flower diameter at harvest over control. Highest flower diameter (6.80 cm) was reported with planting dates (10th November) and for spacing treatments highest days to flower diameter (6.19 cm) was reported with spacing of 30 cm x 50 cm. Combined the application of planting dates (10th November) + 30 cm x 50 cm spacing recorded the highest flower diameter which was significantly superior over other treatment. Beyond simply optimizing growth parameters, the combination of the 10th November planting date and 30 cm x 50 cm spacing may also influence the plant's physiological processes, such as hormone balance and stress tolerance. These factors can further contribute to enhanced flower size, as plants experience less environmental stress and can invest more energy in reproductive structures, resulting in superior floral development. (Patel *et al.*, 2021) [9] and (Chaudhary and Joshi, 2022) [1] have the similar findings.

3.5 Weight of flowers per plant (g)
Result pertaining to the weight of flowers per plant is presented in Table 5 shows the effect of planting dates and

spacing significantly increased weight of flowers per plant at harvest over control. Maximum weight of flowers per plant (434.44 g) was reported with planting dates (10th November) and for spacing treatments maximum weight of flowers per plant (376.94 g) was reported with spacing of 30 cm x 50 cm. Combined the application of planting dates (10th November) + 30 cm x 50 cm spacing recorded the maximum weight of flowers per plant which was significantly superior over other treatment. It can be attributed to optimal environmental conditions and sufficient spacing, which enhance nutrient uptake, photosynthetic efficiency, and overall plant vigor. This combination allows plants to develop more and larger flowers, resulting in a significantly higher total flower weight compared to other treatments. (Rashmi, 2023) [11] and (Nain *et al.*, 2021) [18] resulted the same.

3.6 Flower yield (kg/ha): Result pertaining to the flower yield is presented in Table 5 shows the effect of planting dates and spacing significantly increased flower yield at harvest over control. Maximum flower yield (17066.67 kg/ha) was reported with planting dates (10th November) and for spacing treatments maximum flower yield (14460 kg/ha) was reported with spacing of 30 cm x 50 cm. Combined the application of planting dates (10th November) + 30 cm x 50 cm spacing recorded the maximum flower yield which was significantly superior over other treatment. It is attributed to the optimal alignment of planting time and plant population, which together create favourable environmental conditions and reduce intra-plant competition. This combination ensures efficient utilization of light, nutrients, and moisture, leading to robust plant growth and significantly higher flower yield compared to other treatments. (Singh and Yadav, 2024) [14] and (Mehta *et al.*, 2022) [6] have the similar findings.

Table 1: Effect of planting dates and spacing on flowering of African Marigold CV. Punjab Genda No. 1

Treatments	Days to bud formation	Days to flowering	Duration of flowering
Planting date (D)			
10th November	43.26	52.33	78.11
20th November	45.32	55.00	74.98
30th November	47.38	57.00	70.97
10th December	49.44	60.00	65.61
20th December	51.50	62.00	61.59
SEm±	0.86	0.96	1.38
CD	2.49	2.79	3.99
CV (%)	5.45	5.05	5.88
Spacing (S)			
30x30 cm	48.41	58.40	68.82
30x40 cm	47.38	57.20	70.16
30x50 cm	46.35	56.20	71.77
SEm±	0.67	0.75	1.07
CD	1.93	2.16	3.09
CV (%)	5.45	5.05	5.88

Table 2: Effect of planting dates and spacing on yield of African Marigold Punjab Genda No. 1

Treatments	Flower diameter (cm)	Weight of flowers per plant (g)	Flower yield (kg/ha)
Planting date (D)			
10th November	6.80	434.44	17066.67
20th November	6.46	405.17	15566.67
30th November	6.01	368.32	13800.00
10th December	5.61	320.37	12466.67
20th December	5.20	298.22	11300.00
SEm±	0.10	6.28	258.20
CD	0.30	18.20	747.86
CV (%)	5.15	5.16	5.52
Spacing (S)			
30x30 cm	5.82	352.92	13600.00
30x40 cm	6.04	366.05	14060.00
30x50 cm	6.19	376.94	14460.00
SEm±	0.08	4.87	200.00
CD	0.23	14.10	579.29
CV (%)	5.15	5.16	5.52

4. Conclusion

On the basis of findings of the present experiment, the following conclusion may be drawn:

The experiment consisted of 15 treatments of combinations consisting of 5 planting dates (10th Nov, 20th Nov, 30th Nov, 10th Dec, and 20th Dec) and 3 plant spacings (30×30 cm, 30×40 cm, and 30×50 cm), of which with respect to plant spacing, 10th November and spacing (30×50 cm) recorded minimum days to bud formation, minimum days to flowering, longest flowering duration, largest flower diameter and flower yield per hectare in semi-arid zone of Rajasthan is recommended as the best agronomic practices

of African marigold planting on 10th November and suitable plant spacing was 30×50 cm.

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