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Morpho-agronomic Characterization of Marigold (*Tagetes erecta* L.) Varieties Cultivated in Eastern India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Marigold occupies the topmost position in loose flower production, and variability in productivity is attributed to genetic differences and genotype-environment interactions. This study evaluates the performance of ten flowering plant varieties (T1 to T10) over two years (2023 and 2024) based on morphological and yield attributes characters in randomized block design at the North-eastern Ghat Zone of Odisha. The experiment was conducted to identify varieties with superior traits for commercial floriculture. Results indicate significant variability among varieties, with T5-A. Vibha exhibiting the highest yield (34.2 q ha^{-1}) and largest flower diameter (6.6cm) among tested varieties. The maximum shelf-life was observed in A. Vibha (6.40 days) with vibrant yellow and orange blooms. A. Vibha produced 3.4 times higher yield compared to GFM-1 with the higher net return of Rs. 200000 ha^{-1} respectively. A. Vibha not only produced good quality flowers but also provided a higher B:C ratio of 3.8, helping farmers to double their income. These findings provide valuable insights for selecting high-performing varieties and optimizing cultivation practices in floriculture.

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Keywords: Marigold; floweral diameter; yield; economy; B:C ratio.

1. INTRODUCTION

Floriculture is a vital sector of modern agriculture, driven by the demand for ornamental plants with desirable traits such as large flower size, high yield, and robust growth (Titisari, 2025). Marigold (*Tagetes erecta* L.), a member of the *Asteraceae* family, is one of the most important commercial annual flower crops in India. It is widely cultivated and holds traditional significance, making it the most popular flower across the country. Marigolds are known for their excellent keeping quality and adaptability to diverse growing conditions, making them more versatile than many other annual flowering plants. In addition to their widespread use in landscape gardening, marigolds are grown for ornamental purposes and marketed in various forms such as cut flowers, loose flowers sold in bulk, garlands, and decorations for religious and cultural events. Marigolds also play a significant role in integrated pest management; they suppress soil nematode populations and act as a trap crop to control fruit borers in tomato cultivation (Parihar et al., 2025). Furthermore, they show potential in phytoremediation due to their pollutant-absorbing abilities. The crop's year-round availability, ease of cultivation, and broad adaptability have contributed to its rising popularity across India. Marigolds are often referred to as the "poor man's crop" because they provide a good return even when cultivated on a small scale, such as in backyard gardens (Linderman & Davis, 2004). Despite this, the currently available varieties tend to have lower yields, reduced vigor, and are more prone to lodging, highlighting the need for the development of genetically stable, high-yielding, semi-tall genotypes (Kumar et al., 2022). Genetic variability plays a critical role in plant breeding, as it determines the potential for selecting superior genotypes. Since marigold is a cross-pollinated crop, the development of high-yielding varieties with specific desirable flower colours can significantly enhance farmer income (Sharma et al., 2024). The vibrant marigold flowers are also rich in xanthophyll, a natural pigment used in poultry feed to enhance the colour of egg yolks and chicken skin, and in the textile industry for fabric dyeing. This varietal performs well across different locations, seasons, and varying environmental conditions, maximizing its potential for successful adoption by farmers. To meet the growing demand and breeding objectives, research has been carried out to assess variability among marigold genotypes for traits of economic importance. Odisha, with its diverse agro-climatic zones, is well-suited for the cultivation of a wide range of horticultural crops, including fruits, vegetables, flowers, and spices. Given that high-value horticultural crops offer better economic returns per unit area than traditional field crops, it is essential to focus on their development (Reddy, 2013). In this context, ten African marigold cultivars were evaluated under the North-eastern Ghats Zone of Odisha to identify promising types that could enhance production, productivity, and profitability for farmers in the region.

2. MATERIAL AND METHOD

The experimental trials were conducted at the Regional Research and Technology Transfer Station, G. Udayagiri, located at 20.5472° N latitude and 84.2286° E longitude. Due to its position in the north-eastern corner of the Deccan Plateau, the district enjoys a milder climate compared to the main deccan region. The area receives an average annual rainfall of 1427.9 mm, with approximately 74 rainy days per year (defined as days with at least 2.5 mm of rainfall). The climate is broadly categorized into four seasons: the hot summer season (March to May), the southwest monsoon season (June to September), the post-monsoon season (October to November), and the winter season (December to February). Fig. 1 presents the average monthly weather parameters recorded during the cropping period. The soil at the experimental site was classified as sandy loam in texture. The bulk density (BD) of the soil was recorded at 1.51 g cm^{-3}, indicating a moderately compacted structure. The soil exhibited a slightly acidic reaction, with a pH of 5.8. The electrical conductivity (EC) measured at 25°C was 1.10 dS m^{-1}, which falls within the normal range for crop cultivation, suggesting non-saline conditions. The organic carbon content of the soil was 5.72 g kg^{-1}, reflecting a moderate level of organic matter. The soil was found to have available nitrogen (N) content of 220 kg ha^{-1}, available phosphorus (P) of 12 kg ha^{-1}, and available potassium (K) of 180 kg ha^{-1}, indicating a medium fertility status in terms of macronutrients essential for crop growth. The experiment involved ten marigold varieties A. Abhi, A. Subha, B. Kaligendu, BM-4, A. Vibha, GFM-1, P. Arpita, Punjab Gaindu, BM-2, and P. Deep arranged in a randomized block design (RBD) with three replications (Fig. 2). Standard

agronomic practices were followed throughout the trial. Observations were recorded on morphological traits such as plant height, number of primary and secondary branches per plant, and plant spread at 60 and 90 days after transplanting (DAT). Yield attributes included the number of days to 50% flowering, number of flowers per plant, flower diameter, average flower weight per plant, total flower yield, and number of flower head colours. The benefit-cost ratio was calculated following the methodology described by Mohapatra et al. (2023).

$$\text{Benefit -Cost ratio} = \frac{Gross\ Income}{Cost\ of\ cultivation}$$

2.1 Statistical Analysis

All parameters data were measured in triplicate (n=3), and the results were presented based on statistical analysis using methodology of Gomez and Gomez (1984). The data underwent one-way analysis of variance (ANOVA), and significant differences between treatments were assessed using Fisher's protected least significant difference (LSD) at a significance level of $P < 0.05$, utilizing R Studio software (Doebioresearch package).

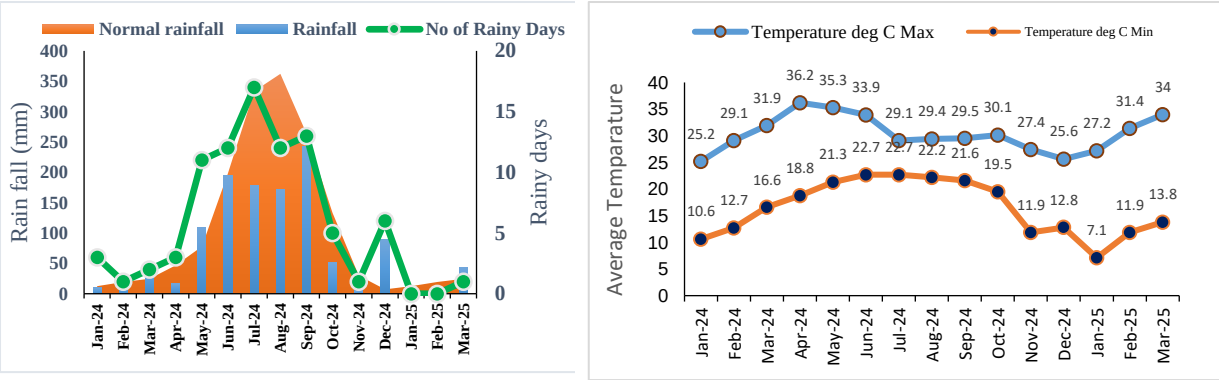

Fig. 1. Climatic data during cropping period

Fig. 2. Experimental photo of field trails and Morphological characteristics of different varieties flowers

3. RESULTS AND DISCUSSION

3.1 Plant Height

Morphological attributes: The height of a marigold variety is important for planning planting geometry, ensuring each plant has enough room to grow and thrive. The evaluation of ten marigold varieties over two consecutive years (2023 and 2024) revealed significant variations in morphological attributes are presented in Table 1. The maximum plant height was recorded in treatment T1 (*A. Abhi*) with heights of 53.0 cm and 55.0 cm in 2023 and 2024. In contrast, T6 (*GFM-1*) and T9 (*BM-2*) consistently recorded the lowest plant height across both years, with values ranging from 13.0 to 17.0 cm. Plant height is a varietal trait, and the observed variation among marigold varieties can be attributed to genetic differences and genotype-environment interactions (Sumalatha, 2025). Additionally, improved root development and vigorous vegetative growth under favorable conditions may have contributed to increased plant height by enhancing photosynthetic activity. Furthermore, the favourable effects of nitrogen availability and higher chlorophyll content in the leaves may have promoted the synthesis of carbohydrates and amino acids, thereby supporting enhanced vegetative growth (Lahkar et al., 2024). Taller plants can improve plant ability to resist weed infestation and higher nutrient and solar radiation use efficiency and enhance overall productivity. More importantly, it creates a visually aesthetic ecosystem service for the viewers (Singh, 2017). There is a general positive correlation between plant morphology, physiological efficiency, and biomass, ultimately contributing to higher productivity (Sumalatha, 2025). A similar outcome in terms of variation in plant height was also reported by Sharma and Jadagoudar (2021) in marigold.

Yield attributes: The yield attributes characters like average number of effective buds at the time of ploughing, numbers of ploughing, flowers diameter, Fresh flower yield are presented in the Table 1. Significant variation in number of effective buds per plant among the treatments was found and ranged between 16 to 54 per plant. The maximum number of buds was found in A. vibha which as 100 to 184 percent higher over A. Abhi. The variation in the number of buds per plant may be attributed to the genetic traits of the different varieties. An increase in the number of branches per plant could lead to a higher number of buds. Furthermore, differences in photosynthetic efficiency among varieties may enhance food accumulation, promoting better plant growth and, consequently, a higher number of flowers per plant. Similar findings have also been reported by Dedhia et al., (2024). The frequency of plucking varied slightly among treatments. Most genotypes required four to six ploughings, with T5 (*A. Vibha*) and T3 (*B. Kaligendu*) needing the highest (six), whereas T6 (*GFM-1*), T7 (*P. Arpita*), and T9 (*BM-2*) required the fewest (2-3 times). The frequency of plucking was closely linked to the duration of the flowering period and the timing of bud opening. Variations in the number of pluckings may be attributed to the genetic traits of the varieties, environmental conditions, and management practices (Parashar et al., 2021; Lahkar et al., 2024)). Similar difference in the number of buds per plant among the genotypes was also recorded earlier in marigold by Netam et al. (2019). Similarly, the maximum flower diameter was recorded at A. Vibha during both year 2023, 2024 respectively, followed closely by T4 (*BM-4*) and T2 (*A. Subha*). The observed variation in this parameter can be attributed to the genetic makeup of the varieties and their interaction with environmental factors. Additionally, greater dry matter accumulation under favorable climatic conditions may have contributed to the increased flower diameter. The differences in flower diameter among marigold varieties are likely influenced by the genetic characteristics inherent to each variety (Lahkar et al., 2024). The smallest flowers were observed in T6 (*GFM-1*) and T7 (*P. Arpita*), ranging between 3.0 and 3.2 cm. Similar results were observed by Narsude et al. (2010) and Deepa et al. (2016) in marigold (Table1). The fresh flower yield varied significantly among the treatments. The highest yields were obtained from T5 (*A. Vibha*) at 34.0 q ha^{-1} (2023) and 34.2 q ha^{-1} (2024), followed by T2 (*A. Subha*) and T3 (*B. Kaligendu*) which was 3.4 times higher over T6 (GFM-1) and T7 (P. Arpita). The lowest yields were recorded in T6 (*GFM-1*) and T7 (*P. Arpita*), with values below 10.0 q ha^{-1}. Higher flower weight and a greater number of flowers per plant for certain varieties, along with ideal temperature and photoperiod conditions during the flowering season, may be the causes of the rise in flower production per hectare (Chandel et al.,2023; Lahkar et al., 2024). Deepa et al. (2016) and Shilpa et al. (2022) similarly observed similar outcomes in marigold. The variation in flower yield is due to the genetic variability of the genotype and agroclimatic condition reported by Shilpa et al., (2022); and Pratheeksha et al., (2024). A. Vibha perform better yield contributing character and

productivity also reported by (Ahmad et al., 2023; Singh et al., 2023).

Economic Analysis: The economic feasibility of different chrysanthemum genotypes was evaluated based on gross return, net return, and benefit-cost (B:C) ratio across two consecutive years (2023 and 2024) (Table 2). Among all treatments, T5 (*A. Vibha*) recorded the highest gross return of ₹2,72,000 in 2023 and ₹273600 in 2024, followed by T2 (*A. Subha*) and T3 (*B. Kaligendu*). Conversely, the lowest gross returns were observed in T6 (*GFM-1*) and T7 (*P. Arpita*), with values below ₹80,000 in both years. A similar trend was observed for net return. T5 (*A. Vibha*) outperformed all other treatments, providing a net return of ₹2,00,000 in 2023 and ₹2,01,600 in 2024. Treatments T2 (*A. Subha*) and T3 (*B. Kaligendu*) also recorded high net returns above ₹1,20,000 in both years. In contrast, the lowest net returns were observed in T6 (*GFM-1*) and T7 (*P. Arpita*), both under ₹10,000 in 2023. The highest B:C ratio was obtained in T5 (*A. Vibha*), with values of 3.78 and 3.80 in 2023 and 2024, respectively, indicating excellent profitability. T2 (*A. Subha*) and T3 (*B. Kaligendu*) also recorded economically viable B:C ratios, ranging from 2.71 to 2.88. On the other hand, T6 (*GFM-1*) and T7 (*P. Arpita*) reported the lowest B:C ratios (< 2), suggesting these treatments were economically less viable. Overall, *A. Vibha* (T5) emerged as the most economically profitable genotype across both years, followed by *A. Subha* (T2) and *B. Kaligendu* (T3), considering all three economic indicators gross return, net return, and B:C ratio. Kaur et al. (2022) also reported the similar result of doubling farmers income with the cultivation of suitable marigold varieties. The expansion of marigold cultivation can significantly boost employee productivity, create jobs in floral production, and increase the profitability of farmers who grow marigolds.

Table 1. Effect of different marigold varieties on morphological characters and yield

Treatment	Effective Plant height		no. of effective bud per plant		Frequency of Plucking		flower diameter (Cm)		Fresh flower yield (q ha^{-1})	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
T1-A. Abhi	53	55	16	19	5	4	5.5	5.4	14.9	15.7
T2-A. Subha	40.5	44.2	20	22	6	5	5.5	5.6	25.2	25.9
T3-B. Kaligendu	31	32	26	32	6	5	4	4	24.6	24.4
T4-BM-4	32		23	24	4	3	5.5	5.8	17.6	17.7
T5-A. Vibha	47	52	32	54	6	5	6.5	6.6	34.0	34.2
T6-GFM-1	13	15	23	24	3	3	3.0	3.2	9.8	10.0
T7-P. Arpita	42.5	45	18	20	3	3	3.0	3.1	9.81	9.92
T8-Punjab Gaindu	48	51	20	26	4	4	5.0	5.4	16.9	17.5
T9-BM-2	16	17	15	18	3	2	4.0	4.2	12.6	12.7
T10-P. Deep	28	31	32	29	4	5	4.0	3.8	17.2	17.3
CD									3.45	3.85
SEM									1.25	1.33

Table 2. Effect of different marigold varieties on farmer's economy

Treatment	Cost of cultivation	Gross Return		Net return		B: C ratio	
		2023	2024	2023	2024	2023	2024
T1-A. Abhi	72000	119200	125600	47200	53600	1.66	1.74
T2-A. Subha	72000	201600	207200	129600	135200	2.8	2.88
T3-B. Kaligendu	72000	196800	195200	124800	123200	2.73	2.71
T4-BM-4	72000	140800	141600	68800	69600	1.96	1.97
T5-A. Vibha	72000	272000	273600	200000	201600	3.78	3.80
T6-GFM-1	72000	78400	80000	6400	8000	1.09	1.11
T7-P. Arpita	72000	78480	79360	6480	7360	1.09	1.10
T8-Punjab Gaindu	72000	135200	140000	63200	68000	1.88	1.94
T9-BM-2	72000	100800	101600	28800	29600	1.4	1.41
T10-P. Deep	72000	137600	138400	65600	66400	1.91	1.92
CD		1624	1752	548	764	0.15	0.19
SEM		15.42	13.42	7.02	5.64	0.02	0.02

4. CONCLUSION

The experiment was based on a comparative assessment of marigold varieties as per their morphological and yield attributes. The result obtained among the French marigold genotypes was that A. Vibha was found to be better with regard to vegetative growth, flower productivity, and economy among marigold varieties. This information will contribute to the selection of the best marigold variety suitable for an agroclimatic zone. This information will also assist the government and policymakers in including the best-performing marigold varieties in the varietal release cycle under the floriculture mission in the North Eastern Ghat Zone. Furthermore, this study contributes to improving farmers' livelihoods by supporting efforts to double farm income.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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