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# EVALUATION OF AFRICAN MARIGOLD (*Tegetes erecta L.*) GENOTYPES UNDER RAIN SHELTER AND OPEN FIELD CONDITIONS AT GODAWARI, LALITPUR

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## ABSTRACT

The growing season of African Marigold coincides with the monsoon season bringing down the quality and post-harvest life of flowers. This study evaluated nine African Marigold Genotypes- Karma-111 Orange, Mayan Orange, Oriental Orange, Karma-444 Orange, Karma-555 Orange, Calcuttia Orange, Sonata, Karma-888 Orange, and Thai—under both open field and rain shelter conditions at the Floriculture Development Centre, Godawari, using a two-factor factorial RCBD with three replications. Vegetative, floral, yield, and post-harvest attributes were measured. Under rain shelters, Karma-555 Orange produced the tallest plants (126.41 cm) and the most flowers per plant (282.25), while Karma-111 had the thickest stems (22.84 cm). Calcuttia Orange under shelter showed the widest canopy (99.04 cm) and the longest garland post-harvest life (8.22 days). In open field, Sonata flowered the earliest (28.08 days to bud, 53.83 days to flower) and achieved the highest yield per plant (5991.6 g), and Karma-444 produced the largest florets (105.74 cm) with the heaviest fresh flowers (37.69 g). No significant genotype × environment interaction was observed for stem diameter, number of flowers per garland, or garland fresh weight. Rain shelters generally improved plant height (87.80 cm) and flower count (196.6 per plant). Calcuttia Orange had the longest post-harvest life while Karma-111 had the shortest and Garlands from rain shelter-grown flowers lasted longer than open field. Considering flower quality, yield, and storage life, Karma-555 and Calcuttia Orange under shelter are recommended; Sonata and Mayan Orange suit open-field conditions due to their early flowering and high yield.

**Key word:** *Flower yield and quality, marigold, Monsoon, post-harvest, variety*

## INTRODUCTION

Marigolds are hardy annual or perennial commercially grown flowering plants belonging to the family Asteraceae and genus *Tagetes* comprising of more than 50 wild and cultivated species worldwide (Soule, 1994). In Nepal, the flower is commonly known as "Sayapatri". It is native to Central and South America especially Mexico (Singh et al., 2019) and is cultivated extensively in Asia, India, China, and other countries with a tropical climate. Mostly cultivated types of Marigolds include African Marigold (*Tagetes erecta* L., 2n = 24) and French Marigold (*Tagetes patula* L., 2n = 48) (Poudel et al., 2017). African Marigold is popular bedding plant around the world and take longer to reach flowering stage than French Marigold (Adhikari & Pun, 2011, Priyanka et al., 2013). Both French and African Marigold are popular in Nepal.

Marigold has wide adaptability in various soil and climate. Marigold cultivation can successfully be done from 150 to 2000 masl altitude in Nepal (Dhital & Mishra, 2016). Commercial cultivation can be done all round the year but the area must be frost free (Khanal, 2014). Marigold flowers hold a religious and cultural importance during major festivals and wedding occasions (Dhakal & Bhattarai, 2017). Flowers are also used in welcoming guest, garland-making, religious offering, bouquets, floral arrangements and hall decoration. The use of Marigold flowers as cut flowers is also increasing. The habit of profuse flowering, short duration to produce marketable flowers, wide spectrum of attractive colors, shape, size, good keeping quality, easy cultivation, hardy nature and wider adaptability of the crop (Arora, 1998) have increased popularity of African Marigold in Nepal. Commercial cultivation during both off season and normal season has been practiced in Nepal and farmers has been benefitted economically. Pradhan (2016) found that the BCR ratio for Marigold cultivation was found to be the highest (1.63) compared to Rose and Chrysanthemum indicating Marigold a good substitute economic crop because of its good per unit returns.

In Nepal, Marigold flower has a potentiality for year-round flower production. But the production is limited for June to October due to limited knowledge and technology for Winter-Spring season production (Dhakal & Bhattarai, 2017). Production beyond Autumn season, i.e., throughout the Winter and Spring seasons, has not yet been successful. This is because of low winter temperatures, low light intensity, and no suitable variety for Winter climate (Dhakal et al., 2021). Variety selection is the most important decision farmer has to make considering not only the yield and quality but also other varietal characteristics and management practices suitable to the region. In case of African Marigold, the demand for uniform, medium sized, compact bright color flowers with longer shelf life is very high in domestic flower market. Yet very little research work had been done towards varietal evaluation in order to recommend a suitable African Marigold variety for a particular area. Thus, farmers are compelled to grow local and low yielding varieties without being aware of their potential yield and quality. Also, the local varieties found in Godawari could not meet the market's demand of high-quality flowers. The main season for Marigold cultivation in Nepal coincides with the monsoon season. In Godawari, the intensity of rainfall is higher as compared to the Kathmandu valley. This reduces the flower and post-harvest quality of flowers. Hence, there is the need of location based varietal trial to find out the suitable varieties of Marigold and growing conditions for enhancement of both quality and yield in Godawari condition.

## MATERIALS AND METHODS

The field experiment was conducted at the Floriculture Development Center, Godawari, Lalitpur (27°35′26″ N, 85°22′46″ E; 1551 masl) from July 15, 2023, to January 2, 2024. The site has a mean annual temperature of 20.3 °C, and average annual rainfall of 699 mm. Soil analysis (Central Agriculture Laboratory, Hariharbhawan) showed that under rain shelter conditions, soil was acidic (pH 5.35) with medium organic matter (3 %), medium total N (0.15 %), high $P_2O_5$ (590 kg ha$^{-1}$), and high $K_2O$ (1149.6 kg ha$^{-1}$). In open field conditions, soil was near neutral (pH 6.52) with medium organic matter (3.22 %), medium total N (0.16 %), and medium levels of $P_2O_5$ (297.7 kg ha$^{-1}$) and $K_2O$ (599 kg ha$^{-1}$). Climatic data (Department of Hydrology and Meteorology) indicated the highest average monthly temperature in June (Tmax 27.8 °C; Tmin 20 °C) and the lowest in January (Tmax 19.6 °C; Tmin 3.5 °C). Rainfall peaked in May (127.6 mm) and was lowest in November (0.8 mm). Relative humidity was highest in August (91.69 %) and lowest in December (72.88 %). The experiment followed a two-factor Randomized Complete Block Design (RCBD) with nine genotypes (Factor A) and two growing conditions: open field and rain shelter (Factor B). Each treatment was replicated three times, totaling 54 plots. Treatment details are presented in Table 1.

**Table 1: Factor A representing nine genotypes of African Marigold with varietal characteristics and factor B representing two growing conditions.**

| **Factor A** | | | |
|---|---|---|---|
| **Genotypes** | **Height** | **Flower size** | **Color** |
| Karma-111 Orange (T1) | Tall | Large | Orange |
| Mayan Orange (T2) | Tall | Small | Orange |
| Oriental Orange (T3) | Dwarf | Large | Orange |
| Karma-444 Orange (T4) | Semi-Tall | Medium | Orange |
| Karma-555 Orange (T5) | Tall | Small | Orange |
| Calcuttia Orange (T6) | Semi-Tall | Medium | Orange |
| Sonata (T7) | Semi-Tall | Medium | Gold |
| Karma-888 Orange (T8) | Tall | Large | Orange |
| Thai (T9) | Semi-Tall | Medium | Orange |
| Factor B (Growing conditions) | | | |
| Open field condition | | | |
| Rain shelter condition | | | |

The total experimental area was 187.11 m² (18.9 × 9.9 m) for each growing condition. Each block was separated by a 50 m margin, with 50 cm spacing between plots. Each plot measured 4.48 m² (1.6 × 2.8 m) and accommodated 20 plants (5 plants × 4 rows) with row-to-row spacing of 60 cm and plant-to-plant spacing of 40 cm. Nursery raising began on June 17, 2023, by sowing seeds in cocopeat-filled trays placed in a high-tech tunnel. Seedlings were transplanted into polybags after 2 weeks, and into the field at the 3–4 leaf stage (4 weeks after sowing). Fertilization included 20–25 t $ha^{-1}$ of farmyard manure and 200:100:100 kg $ha^{-1}$ NPK (Urea, DAP, MOP). Full doses of compost, P, K, and one-third of N were applied as basal; the remaining N was top-dressed at 30 and 60 DAT. Standard intercultural practices (weeding, hoeing, irrigation as required) were followed. Pinching was done at 15 DAT by removing the apical 3–4 cm above the third node. Insect-pest and disease control was done using chemical pesticides. Harvesting was carried out in the evening when 75 % of petals were unfolded. Six plants per plot were sampled for data collection. Vegetative parameters included plant height (20, 40, 60, 80 DAT), basal stem diameter, and plant spread (at harvest). Flowering and yield parameters included days to bud initiation, days to first flowering, flower size, fresh flower weight, average flower weight (12-sample basis), and total flower yield per plant. Post-harvest parameters included number of flowers per standard 1 m garland, garland fresh weight, and vase-life or shelf life (days until petal withering under ambient storage). The environmental conditions for the evaluation of postharvest of the garland as given below. Data were analyzed using R for RCBD and Duncan's Multiple Range Test (DMRT) at 5 % significance, with tables and graphs prepared in SPSS 16.0.

**Table 2: Environmental conditions of garland**

| Date | Morning (8 am) | | Day (12pm) | | Afternoon (4 pm) | |
|---|---|---|---|---|---|---|
| | Temperature (°C) | RH (%) | Temperature (°C) | RH (%) | Temperature (°C) | RH (%) |
| October 14 | 13.2 | 85 | 20.5 | 69 | 17.1 | 67 |
| October 15 | 14.5 | 88 | 20.7 | 55 | 17.5 | 61 |
| October 16 | 14.9 | 92 | 21.1 | 57 | 18.5 | 56 |
| October 17 | 15.3 | 84 | 20.3 | 47 | 18.1 | 59 |
| October 18 | 15.1 | 86 | 21.7 | 44 | 16.4 | 68 |
| October 19 | 14.9 | 89 | 20.1 | 64 | 17.8 | 73 |
| October 20 | 14.7 | 90 | 21.8 | 51 | 16.8 | 70 |
| October 21 | 16.2 | 82 | 20.7 | 59 | 16.6 | 66 |
| October 22 | 15.3 | 91 | 19.8 | 52 | 16.4 | 60 |

## RESULTS AND DISCUSSION

### Vegetative parameters

Plant height, stem diameter, and plant spread were significantly influenced by genotype, growing condition, and (except for stem diameter) their interaction. Karma-555 Orange produced the tallest plants at all stages 20 DAT (30.63±1.33 cm), 40 (51.50±0.74 cm), 60 (84.29±5.29 cm), and 80 DAT (112.83±6.65 cm) while Oriental Orange remained the shortest (57.16 cm). Height was unaffected by growing condition at 20 DAT, greater in the open field at 40 DAT, and higher in the rain shelter at 60 and 80 DAT, with the final height significantly greater under rain shelter (87.68±4.28 cm) due to favorable microclimate and temperature that enhanced photosynthesis and nutrient uptake, consistent with Van Iersel & Seymour (2002) and Jhon & Khan (2003). The tallest plants overall were observed in Karma-555 Orange under rain shelter (126.41 cm), indicating genotype-specific responses to environment (Salve et al., 2016; Sarkar & Ghimiray, 2004; Sarkar & Sharma, 2016). Stem diameter was highest in Karma-111 (22.84±0.41 mm), statistically similar to Oriental Orange, Karma-888 Orange, and Karma-444 Orange, and the lowest in the Thai genotype (17.60±0.72 mm). Plants in the open field (21.81±0.39 mm) had thicker stems than those in the rain shelter (19.78±0.37 mm), likely due to greater spread and light interception that enhanced photosynthate accumulation (Budiarto & Marwoto, 2009). The interaction effect was non-significant. Plant spread was the widest in Calcuttia Orange (98.25±0.89 cm) and narrowest in Oriental Orange (60.91±1.51 cm). Spread was greater in the open field (80.18±2.28 cm) than in the rain shelter (78.43±2.61 cm), possibly due to uninterrupted light and higher soil moisture during main-season cultivation, consistent with earlier reports (Dhakal et al., 2021; Altmann & Streitz, 1995; Talukdar et al., 2006). The maximum spread was recorded in Calcuttia Orange under rain shelter (99.04 cm), statistically similar to its performance in the open field (97.45 cm).

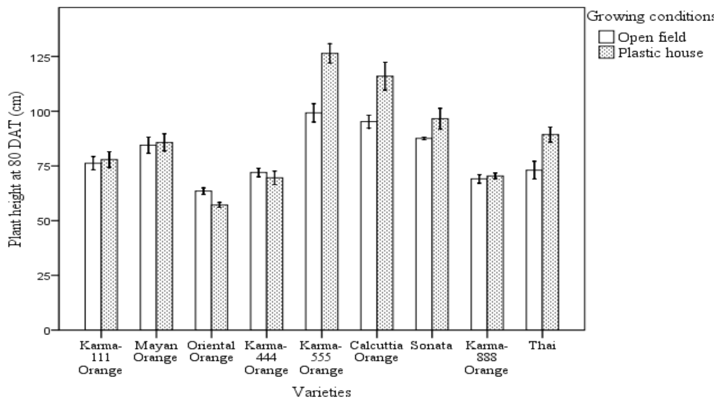


**Figure 1: Effect of interaction between genotypes and growing conditions on plant height at 80 days after transplanting of African Marigold.**

**Flowering parameters**

Significant variation was observed among genotypes, growing conditions, and their interaction for days to first bud appearance, days to first flowering, flower size, and fresh weight of flowers. Oriental Orange consistently required the longest duration for bud initiation (38.25±0.52 days) and flowering (72.37±0.17 days), whereas Sonata was the earliest to bud (28.16±0.08 days) and flower (54.41±0.28 days), statistically similar to Thai and Mayan Orange. Genotypic differences likely explain this variability, as also reported in Marigold, China Aster, and other ornamentals (Mehta, 2022; Dhatt, 2014; Munikrishnappa et al., 2013; Khanal, 2014). Growing conditions alone had limited influence, but interactions were significant: Oriental Orange under open field took the longest time to bud (39 days) and flower (72.16 days), while Sonata and Mayan Orange under open field flowered the earliest (54 days).

Flower traits also varied notably. Karma-888 Orange produced the largest flowers (104.21±0.74 mm), while Calcuttia Orange had the smallest (64.71±1.72 mm). Flowers were generally larger in open field (89.25±2.60 mm) than under rain shelter (86.48±2.15 mm), possibly due to greater light intensity and natural fluctuations favoring growth (Chiang et al., 2020; Gantait & Pai., 2011 and Saud & Talukdar 1999). Among interactions, Karma-444 Orange under open field produced the largest blooms (105.74 mm), while Calcuttia Orange under the same condition had the smallest (60.96 mm). Similarly on the fresh weight, Karma-444 Orange recorded the highest (31.16±2.92 g), closely followed by Karma-888 Orange (29.97±1.46 g), whereas Calcuttia Orange produced the lowest (14.68±0.45 g). Flowers were heavier in open field (26.67±1.26 g) compared to rain shelter (19.22±0.86 g), with the maximum weight observed in Karma-444 Orange under open field (37.69 g) and the minimum in Calcuttia Orange under rain shelter (13.66 g).

Overall, variation in flowering behavior and flower traits was largely governed by genotypic differences, (Deepa et al., 2016; Gotz 1983; and Panwar et al., 2013) while growing conditions and their interactions further influenced performance. Open-field conditions generally favored earlier flowering, larger blooms, and higher fresh weight, likely due to improved light and environmental dynamics enhancing photosynthesis and carbohydrate accumulation (Malhotra & Kumar, 2000; Gantait & Pai, 2011) but contrast with John & Khan (2003) and Blanchard & Runkle (2011) in tulip.

**Yield and yield attributing parameters**

Genotypes, growing conditions, and their interaction significantly influenced both the number and weight of flowers per plant. Sonata produced the highest number of flowers (256.87±9.83), while Oriental Orange had the lowest (112.12±2.80), highlighting the strong role of genetic factors in flower production, as also noted by Shivakumar et al. (2014) in African Marigold. Rain shelter conditions yielded more flowers (191.68±11.58) than open field (165.68±8.61), likely due to the favorable microclimate that enhanced photosynthesis and growth. Similar findings in Chrysanthemum under protected cultivation were reported by Gaikwad et al. (2002), Mukherjee (1992), and Saud & Talukdar (1999). The genotype × environment interaction showed that Karma-555 Orange under rain shelter produced the most flowers (282.25), comparable to Sonata (276.33), whereas Oriental Orange under open field recorded the fewest (107.91) (Figure 2). Significant variation was also observed in flower weight per plant. Karma-555 Orange produced the highest flower weight (5522.38±104.73 g), statistically similar to Sonata (5499.73±293.04 g), while Oriental Orange had the lowest (2067.30±147.16 g), consistent with genetic differences reported by Dhatt (2014) and Dhakal et al. (2021). Unlike flower number, open field conditions favored higher flower weight (4389.97±273.29 g) compared to rain shelter (3616.41±221.31 g), likely due to larger flower size under open environments. The interaction effect revealed that Sonata under open field produced the maximum flower weight (5991.60 g), whereas the minimum was recorded in Karma-333 Orange under rain shelter (1753.56 g). The higher number of flowers per plant under rain-shelter conditions may be due to reduced environmental stress and improved flower retention, whereas the heavier flowers produced in the open field likely result from lower flower numbers, greater light availability, and increased assimilate allocation to individual flowers, indicating a difference between flower number and flower size as similar in Wei et al. (2025) and Zhang et al. (2005).

**Table 3: Flowers yield attribute character of different genotype and growing conditions**

| | Yield Attributing Characteristics | |
|---|---|---|
| **Treatments** | **Number of flowers per plant** | **Weight of flowers per plant (g)** |
| Genotypes (Factor A) | | |
| Karma-111 | $163.66^{d}\pm4.31$ | $4465.43^{c}\pm238.87$ |
| Mayan Orange | $226.45^{b}\pm4.62$ | $4930.84^{b}\pm452.66$ |
| Oriental Orange | $112.12^{g}\pm2.80$ | $2067.30^{f}\pm147.16$ |
| Karma-444 Orange | $130.04^{f}\pm1.45$ | $4033.38^{d}\pm338.98$ |
| Karma-555 Orange | $244.29^{a}\pm17.31$ | $5522.38^{a}\pm104.73$ |
| Calcuttia Orange | $189.87^{c}\pm13.44$ | $2760.82^{e}\pm126.17$ |
| Sonata | $256.87^{a}\pm9.83$ | $5499.73^{a}\pm293.04$ |
| Karma-888 Orange | $139.12^{ef}\pm3.68$ | $4156.63^{cd}\pm179.61$ |
| Thai | $145.70^{e}\pm6.26$ | $2592.18^{e}\pm184.49$ |
| $LSD_{0.05}$ | 12.63 | 336.34 |
| p-value | *** | *** |
| Growing Conditions (Factor B) | | |
| Open field | $165.68^{b}\pm8.61$ | $4389.97^{a}\pm273.29$ |
| Rain shelter | $191.68^{a}\pm11.58$ | $3616.41^{b}\pm221.31$ |
| $LSD_{0.05}$ | 5.95 | 158.55 |
| p-value | *** | *** |
| CV | 6.02 | 7.16 |
| Grand mean | 178.68 | 4003.19 |

**Post-harvest parameters**

The number of flowers needed to prepare a one-meter garland varied significantly among genotypes, while growing conditions and their interaction with genotype had no significant effect. The Thai genotype required the highest flowers (40.50±0.20), whereas Karma-888 Orange required the fewest (31.44±0.16), statistically similar to Karma-444 Orange (31.44±0.23), likely reflecting differences in flower size. Fresh weight of garlands also differed significantly among genotypes. Karma-888 Orange produced the heaviest garlands (604.94±25.91 g), while Calcuttia Orange had the lightest (435.16±21.49 g), consistent with genotypic differences in individual flower weight. Growing conditions influenced garland weight, with higher weights under open field (562.88±11.96 g) than rain shelter (459.93±11.03 g), possibly due to larger flowers under open conditions. The genotype × growing condition interaction was not significant.

Post-harvest life showed significant variation among genotypes, growing conditions, and their interaction. Calcuttia Orange had the longest post-harvest life (7.44±0.38 days), while Karma-111 had the shortest (5.61±0.15 days). Garlands from rain shelter-grown flowers lasted longer (7.59±0.15 days) than those from the open field (6.27±0.09 days), likely due to optimal temperature and light promoting photosynthesis and starch accumulation, consistent with Petunia studies (Shvarts et al., 1997). The maximum life (8.22 days) was observed for Calcuttia Orange under rain shelter, statistically similar to Karma-444 Orange, whereas the shortest (5.44 days) occurred in Karma-111 under open field, comparable to Mayan Orange (5.55 days). Similar trends have been reported in Chrysanthemum under polyhouse conditions (Gantait & Pai, 2011). Higher fresh weight of garlands under rain shelter conditions is due to a favorable microclimate with higher humidity and reduced environmental stress that enhances water retention and biomass accumulation, whereas garlands produced in open-field conditions exhibit longer post-harvest life because exposure to natural stresses results in firmer tissues with lower moisture content, slower respiration, and delayed senescence (Li et al., 2014).

**Table 4: Garland character of different genotype and growing conditions**

| Treatments | Garland Characteristics: Number of flowers needed to make a garland | Fresh weight of a garland (g) | Post-harvest life of a garland (days) |
|---|---|---|---|
| Genotypes (Factor A) | | | |
| Karma-111 | $35.16^{d}$±0.14 | $561.33^{c}$±22.75 | $5.61^{e}$±0.15 |
| Mayan Orange | $36.94^{c}$±0.15 | $474.94^{f}$±22.16 | $6.33^{d}$±0.35 |
| Oriental Orange | $34.00^{e}$±0.22 | $472.33^{f}$±21.25 | $7.22^{abc}$±0.20 |
| Karma-444 Orange | $31.44^{f}$±0.23 | $592.27^{b}$±23.64 | $7.38^{ab}$±0.37 |
| Karma-555 Orange | $35.72^{d}$±0.18 | $521.38^{d}$±25.12 | $7.05^{bc}$±0.29 |
| Calcuttia Orange | $40.33^{a}$±0.12 | $435.16^{h}$±21.49 | $7.44^{a}$±0.38 |
| Sonata | $38.38^{b}$±0.38 | $488.77^{e}$±23.36 | $7.27^{abc}$±0.33 |
| Karma-888 Orange | $31.44^{f}$±0.16 | $604.94^{a}$±25.91 | $7.00^{c}$±0.35 |
| Thai | $40.50^{a}$±0.20 | $451.55^{g}$±22.53 | $7.05^{bc}$±0.38 |
| $LSD_{0.05}$ | 0.63 | 7.23 | 0.31 |
| p-value | *** | *** | *** |
| Growing Conditions (Factor B) | | | |
| Open field | $36.06^{a}$±0.64 | $562.88^{a}$±11.96 | $6.27^{b}$±0.09 |
| Rain shelter | $35.92^{a}$±0.61 | $459.93^{b}$±11.03 | $7.59^{a}$±0.15 |
| $LSD_{0.05}$ | 0.27 | 3.40 | 0.15 |
| p-value | NS | *** | *** |
| CV | 1.49 | 1.20 | 3.92 |
| Grand mean | 35.99 | 511.41 | 6.93 |

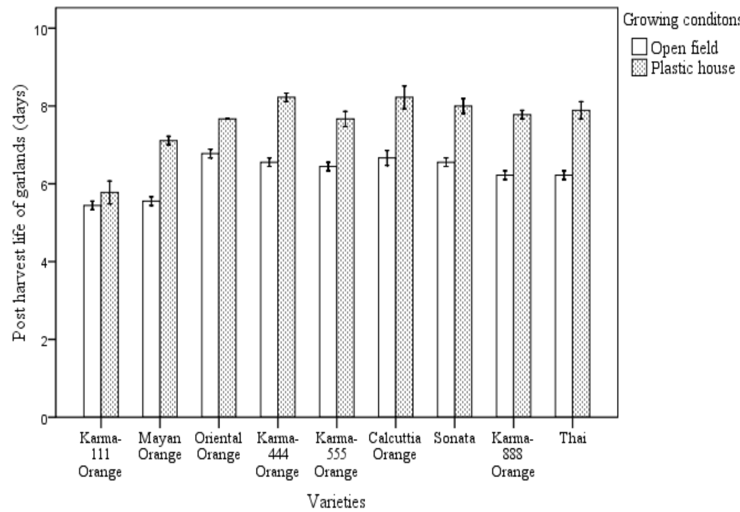


**Figure 3: Effect of interaction between genotypes and growing conditions on post-harvest life of standard garlands of African Marigold**

## CONCLUSION

The study on the evaluation of African Marigold genotypes under rain shelter and open field conditions at Godawari, Lalitpur, highlights the significant role of genotypic differences and environmental conditions in shaping the growth, yield, and post-harvest quality of Marigold flowers. The results demonstrate that rain shelter conditions promote better plant height and number of flower yield, with Karma-555 Orange and Calcuttia Orange being particularly suitable for higher flower numbers and extended post-harvest life. These genotypes also exhibited optimal characteristics for garland production, making them ideal for farmers looking to improve flower quality and longevity. On the other hand, open field conditions favor earlier flowering and higher yield per plant (weight), with Sonata and Mayan Orange genotypes standing out for their commercial potential due to their early blooming and substantial flower production. Although the findings are based on a single growing season, the study provides valuable insights for farmers in the Godawari region, suggesting that appropriate genotype selection and growing conditions can greatly improve Marigold production. To confirm these results and further refine recommendations, additional trials across multiple seasons are necessary. This research serves as a critical step toward enhancing Marigold cultivation practices and boosting flower yield and quality in the region.

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