**Assessing the suitability of exotic African marigold hybrids (*Tagetes erecta* L.) under south Gujarat conditions, India**

**ABSTRACT:**

**Aims:** To evaluate the performance of 34 exotic marigold hybrids during winter, a study assessed their flowering, plant development, and total production. The ultimate goal was to identify the best hybrid suited for the agroclimatic conditions of south Gujarat.

**Study design:** The experiment was arranged in Randomized Complete Block Design with 34 marigold hybrids and 3 replications.

**Place and Duration of Study:** The research was executed at Jarvi Seeds Private Limited, Bharadia, Bharuch, Gujarat, during the winter season of 2024-2025.

**Methodology:** Seeds of the marigold hybrids were raised using a standard package of practices and observations on flowering, plant growth, and yield were recorded using scientific protocols.

**Results:** Among 34 hybrids of marigold, Yellow#0068, Marigold#074, Marigold#078, Yellow#0065 and Marvel yellow were found promising for cultivation in south Gujarat region in terms of yield attributes.

**Conclusion:** Yellow#0068' is the top recommended marigold hybrid for commercial use in south Gujarat. It excelled in flower yield (638.30g/plant), flower diameter (5.75 cm), and number of flowers (96.07/plant), while matching other high-performing varieties for key flowering and growth traits.

**KEYWORDS:** Exotic Hybrids, Flowering, Growth, Marigold, south Gujarat, Yield

**1. INTRODUCTION:**

The African marigold (*Tagetes erecta* L., 2n = 2x = 24) is a multipurpose cross-pollinated annual ornamental flower crop plant in the Asteraceae family that is native to the Americas, primarily in Mexico and Central America. It is an annual herb with upright, densely branched stems that grow up to 1.4 m tall and produce big yellow to orange blooms [1]. It is the hardiest annual crop, grown in a variety of agroclimatic situations. It is a prominent loose flower crop among ornamentals, growing commercially in all Indian states. It became famous among crops because of its ease of cultivation and tolerance to a variety of agro-climatic situations. It is highly valued for its therapeutic qualities [2]. It is widely grown throughout Europe, the United States, China, India, and Africa.

African marigold is commonly used as a bedding plant, loose flower, insect and worm deterrent, and nutrient addition for poultry feed [3]. The flower juice is used as a treatment for bleeding piles. African marigold is commercially grown as an important supplier of fat-soluble carotenoid pigments derived from its petals [4]. The carotenoids obtained from the flowers are used as a natural food colouring to brighten egg yolks and poultry feathers. Lutein has been successfully used professionally to color fabrics [5]. Xanthophyll is recognized to help fight cancer and boost immune system performance [6].

The marketable flower is in double form, usually male-sterile, and has a high financial worth. American marigolds feature a standard head flower made up of two morphologically different types: ray (sterile) florets on the periphery and disk (fertile) florets in the center [7]. Marigold seeds are in high demand globally, accounting for around 10,000 kg per year. Marigold seeds continue to be widely produced in the northern region, particularly in Chiang Mai. The seeds are transported to India, Vietnam, and China [8].

The shift from traditional, genetically impure varieties to hybrid types is crucial in floriculture, particularly for crops like marigold, due to the low-yielding potential of older cultivars and their inability to meet contemporary market demands [9]. In recent years, the exploitation of heterosis, also known as hybrid vigor, has emerged as the most viable and successful technology for significantly increasing agricultural productivity and overall production [10]. Hybrid varieties offer several distinct advantages over open-pollinated varieties, making them highly desirable in commercial cultivation. These benefits include earliness in flowering, profuse and uniform blooms, increased flower weight and size, elongated flower stalks, and a longer overall flowering duration [11]. These traits directly contribute to higher market value and improved profitability for growers.

Even though there are many marigold hybrids on the market right now, their performance can differ greatly according to the local climate. The best hybrids for the south Gujarat region in terms of flowering, growth, and yield have not yet been determined and confirmed by experimentation. In order to evaluate the performance of 34 marigold exotic hybrids throughout the winter, a special experiment was carried out. The purpose of the study was to assess how they perform for important factors like flowering, plant development, and total production. Finding the best marigold hybrid that was especially suited to south Gujarat's agroclimatic conditions was the final objective.

**2. MATERIALS AND METHODS:**

The experiment took place at Jarvi Seeds Private Limited, Bharadia, Bharuch, Gujarat, during the winter season of 2024-2025. It involved 34 exotic African marigold hybrids collected from Thailand and China; their detailed descriptions are provided in Table 1. The experiment began by raising the seeds of these hybrids in a nursery seedbed for 30 days. After this period, the seedlings were transplanted into the main experimental fields. These fields were set up in a randomized complete block design with three replications, using ridges that measured 10.00 m in length and 1.00 m in width. Plant of 30 cm and a row spacing of 1 m was maintained. Pinching was carried out 45 days after transplanting. Fertilization involved a basal application of 150:100:100 kg ha⁻¹ NPK, made 8 days post-transplanting, and a top dressing of 45 kg N ha⁻¹ applied 45 days after transplanting. The first irrigation was given immediately after transplanting, with subsequent irrigations occurring weekly. All other necessary cultural practices were performed as required. Various observations concerning flowering, plant growth, and yield were recorded adhering to standard methodologies.

**Table 1: Detailed Description of Variety**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name of Hybrid/ Advanced Breeding Hybrids** | **Name of Company** | **Name of Country from where it is collected** | **Code** | **Flower colour** |
| 1 | 264 Plus | AGA Agro Marigold Seeds | Thailand | MAR264SK | Yellow |
| 2 | Chandra Yellow | AGA Agro Marigold Seeds | Thailand | MAR289SK | Yellow |
| 3 | Vang Ving Orange | AGA Agro Marigold Seeds | Thailand | MAR005SS | Orange |
| 4 | White Star | AGA Agro Marigold Seeds | Thailand | MAR055SS | White |
| 5 | Bengal Orange | AGA Agro Marigold Seeds | Thailand | MAR070SS | Orange |
| 6 | Supernova Deep Orange | AGA Agro Marigold Seeds | Thailand | MAR343SS | Orange |
| 7 | Tall Orange#P01 | Home Seeds Co. Ltd. | Thailand | P01 | Orange |
| 8 | Tall Orange#P09 | Home Seeds Co. Ltd. | Thailand | P09 | Orange |
| 9 | Tall Orange#P10 | Home Seeds Co. Ltd. | Thailand | P10 | Orange |
| 10 | Marigold#074 | Home Seeds Co. Ltd. | Thailand | MAR074 | Orange |
| 11 | Marigold#078 | Home Seeds Co. Ltd. | Thailand | MAR078 | Yellow |
| 12 | Narangi | Home Seeds Co. Ltd. | Thailand | MAR089 | Orange |
| 13 | Marigold#102 | Home Seeds Co. Ltd. | Thailand | MAR102 | Yellow |
| 14 | Marigold#103 | Home Seeds Co. Ltd. | Thailand | MAR103 | Yellow |
| 15 | Yellow#003 | Target Genetics Pvt. Ltd, | Thailand | TGE003 | Yellow |
| 16 | Yellow#009 | Target Genetics Pvt. Ltd, | Thailand | TGE009 | Yellow |
| 17 | Yellow#018 | Target Genetics Pvt. Ltd, | Thailand | TGE018 | Yellow |
| 18 | Orange#002 | Target Genetics Pvt. Ltd, | Thailand | TGE002 | Orange |
| 19 | Orange#003 | Target Genetics Pvt. Ltd, | Thailand | TGE003 | Orange |
| 20 | Tall Orange#004 | Target Genetics Pvt. Ltd, | Thailand | TGE004 | Orange |
| 21 | Yellow#071 | Target Genetics Pvt. Ltd, | Thailand | TGE22SR-STY-71YL | Yellow |
| 22 | Yellow#023 | Target Genetics Pvt. Ltd, | Thailand | TGE23SR-Y-23YL | Yellow |
| 23 | Yellow#0068 | Target Genetics Pvt. Ltd, | Thailand | TGE24WT-0068 | Yellow |
| 24 | Yellow#0065 | Target Genetics Pvt. Ltd, | Thailand | TGE24WT-0065 | Yellow |
| 25 | Kolkata Orange | JYK Seed Co. Ltd. | China | 1504H30-24-001 | Orange |
| 26 | Kolkata Primrose | JYK Seed Co. Ltd. | China | 1504H30-24-002 | Yellow |
| 27 | Marvel yellow | JYK Seed Co. Ltd. | China | 1504H30-24-003 | Yellow |
| 28 | Marvel Orange | JYK Seed Co. Ltd. | China | 1504H30-24-004 | Orange |
| 29 | Marvel Gold | JYK Seed Co. Ltd. | China | 1504H30-24-005 | Yellow |
| 30 | P8 Orange | JYK Seed Co. Ltd. | China | 1504H30-24-006 | Orange |
| 31 | Sonata Yellow | JYK Seed Co. Ltd. | China | 1504H30-24-007 | Yellow |
| 32 | Sonata Orange | JYK Seed Co. Ltd. | China | 1504H30-24-008 | Orange |
| 33 | JYK24 Orange | JYK Seed Co. Ltd. | China | 1504H30-24-009 | Orange |
| 34 | JYK25 Orange | JYK Seed Co. Ltd. | China | 1504H30-24-010 | Orange |

**3. RESULTS AND DISCUSSION:**

 Results pertaining to various flowering, growth and yield characteristics of 34 exotic marigold hybrid along with statistical analysis were given in Table 2 & 3.

**3.1 Days to First Bud Initiation**

 Considering all tested hybrids, a significant difference was noted in the days to first bud initiation. The earliest bud initiation, at 40.00 days, was observed in 'Sonata Yellow', which performed similarly to 'Marigold#074', 'Orange#003', 'Yellow#0068', 'Yellow#0065', 'Sonata Orange', 'JYK24 Orange', and 'JYK25 Orange'. In contrast, 'Tall Orange#P01' was the latest to initiate buds, requiring 51.00 days. This divergence in bud initiation time is largely a consequence of the genetic variability present within different marigold genotypes [12]. Our findings corroborate similar observations reported by Lohar *et al*. (2018) [13].

**3.2 Days to 50 % Flowering**

Significant differences were observed among the marigold hybrids in days to 50% flowering. 'Sonata Yellow' recorded the earliest flowering at 51.00 days, statistically on par with 'White Star', 'Marigold#074', 'Marigold#078', 'Narangi', 'Orange#002', 'Orange#003', 'Yellow#0068', 'Yellow#0065', 'Kolkata Orange', and 'Sonata Orange'. Conversely, 'Marvel Gold' exhibited the latest flowering, reaching 50% bloom in 70.33 days. This variation is primarily due to the genetic control over flowering time inherent in the hybrids [14], a finding consistent with studies by Jian *et al.* (2020) [15] and Naik *et al.* (2019) [16].

**3.3 Duration of Flowering**

Duration of flowering among all these hybrids was found significant and it ranges between 48.33-62.67 days. Marigold#074 and Orange#003 recorded the highest duration of flowering (62.67 days) which was found at par with Bengal Orange, Supernova Deep Orange, Yellow#003, Yellow#023, Yellow#0068, Yellow#0065, Kolkata Orange, Marvel Gold, P8 Orange and Sonata Yellow. The lowest duration of flowering was observed in Orange#002 (48.33 days). The observed result is might be due to genetic control of these characters and modification in their expression due to environmental conditions [17]. The observed results are in line with Shibuya & Ichimura (2016) [18] and Kumar *et el.* (2020) [19].

**3.4 Plant Height (cm)**

 Significant variation in plant height was recorded across all marigold hybrids. 'Tall Orange#P01' achieved a maximum height of 116.00 cm, statistically equivalent to 'Tall Orange#P09' and 'Tall Orange#004'. Meanwhile, 'Bengal Orange' exhibited a minimum plant height at 70.73 cm. This observed phenotypic diversity is fundamentally attributed to genetic factors that regulate cell elongation, cell division, and the comprehensive development of the stem [14]. These results are consistent with previous research, including those reported by Patel *et al.* (2020) [20].

**3.5 Branches per Plant**

 The marigold hybrids showed a significant difference in branches per plant. 'Yellow#0065' recorded the highest number of branches at 22.73, statistically on par with 'Marigold#074', 'Marigold#078', and 'Yellow#0068'. In contrast, 'Chandra Yellow' had the lowest number of branches at 11.60. These variations are primarily due to genetic factors that regulate axillary bud outgrowth, apical dominance, and overall plant architecture [21]. This outcome aligns with findings reported by Vishnupriy *et al.* (2015) [22].

**Table 2: Genetic variability in 34 marigold hybrids for growth and its attributing traits**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Hybrids** | **Days to first bud Initiation** | **Days to 50 % Flowering** | **Duration of Flowering** | **Plant Height (cm)** | **Branches per plant** | **Flowers per plant** | **Flower Weight (g)** | **Flower Diameter (cm)** | **Flower yield per plant (g)** |
| 1 | 264 Plus | 49.00 | 63.67 | 56.00 | 87.27 | 13.93 | 41.80 | 6.41 | 3.73 | 270.05 |
| 2 | Chandra Yellow | 46.00 | 60.00 | 52.00 | 96.27 | 11.60 | 35.00 | 5.78 | 3.93 | 201.86 |
| 3 | Vang Ving Orange | 49.33 | 63.33 | 49.00 | 90.47 | 13.27 | 43.53 | 6.13 | 4.42 | 266.80 |
| 4 | White Star | 42.67 | 55.33 | 61.33 | 93.13 | 19.27 | 80.60 | 5.82 | 4.10 | 468.76 |
| 5 | Bengal Orange | 45.33 | 59.33 | 57.33 | 70.73 | 16.47 | 56.47 | 4.94 | 4.53 | 279.19 |
| 6 | Supernova Deep Orange | 48.67 | 63.00 | 57.67 | 73.80 | 13.93 | 38.40 | 4.61 | 4.19 | 175.69 |
| 7 | Tall Orange#P01 | 51.00 | 64.33 | 52.00 | 116.00 | 16.20 | 58.60 | 6.24 | 4.92 | 365.98 |
| 8 | Tall Orange#P09 | 50.00 | 62.67 | 59.33 | 111.00 | 16.73 | 58.80 | 5.98 | 5.02 | 350.90 |
| 9 | Tall Orange#P10 | 48.67 | 59.33 | 59.67 | 105.73 | 14.73 | 49.07 | 5.67 | 5.73 | 278.38 |
| 10 | Marigold#074 | 42.33 | 55.00 | 62.67 | 71.07 | 20.73 | 93.60 | 6.15 | 5.24 | 575.23 |
| 11 | Marigold#078 | 42.67 | 56.33 | 60.00 | 96.87 | 21.87 | 89.73 | 6.10 | 5.47 | 547.08 |
| 12 | Narangi | 43.33 | 53.33 | 60.67 | 91.40 | 15.67 | 53.33 | 5.66 | 4.62 | 303.02 |
| 13 | Marigold#102 | 44.00 | 58.67 | 53.00 | 83.27 | 15.40 | 61.73 | 5.02 | 4.41 | 310.31 |
| 14 | Marigold#103 | 43.33 | 57.33 | 59.67 | 87.07 | 16.40 | 59.80 | 5.39 | 4.80 | 320.92 |
| 15 | Yellow#003 | 48.33 | 61.67 | 57.67 | 92.33 | 13.60 | 39.20 | 5.47 | 4.58 | 214.48 |
| 16 | Yellow#009 | 49.33 | 61.67 | 54.00 | 99.20 | 16.33 | 55.60 | 4.46 | 4.00 | 247.61 |
| 17 | Yellow#018 | 46.00 | 60.67 | 62.33 | 99.87 | 17.67 | 68.47 | 5.28 | 4.04 | 361.36 |
| 18 | Orange#002 | 43.33 | 52.33 | 48.33 | 99.00 | 17.20 | 65.20 | 5.02 | 4.36 | 326.95 |
| 19 | Orange#003 | 41.33 | 51.67 | 62.67 | 78.73 | 14.53 | 48.80 | 3.30 | 4.56 | 162.06 |
| 20 | Tall Orange#004 | 50.33 | 63.33 | 53.33 | 108.00 | 17.80 | 62.80 | 6.63 | 5.36 | 415.90 |
| 21 | Yellow#071 | 47.33 | 61.67 | 54.33 | 91.40 | 14.33 | 52.27 | 6.14 | 5.06 | 320.86 |
| 22 | Yellow#023 | 43.33 | 60.00 | 60.67 | 85.60 | 16.53 | 58.93 | 5.43 | 4.52 | 320.44 |
| 23 | Yellow#0068 | 41.33 | 53.00 | 61.67 | 88.73 | 21.53 | 96.07 | 6.62 | 5.75 | 638.30 |
| 24 | Yellow#0065 | 40.67 | 52.33 | 62.00 | 88.93 | 22.73 | 93.73 | 5.52 | 5.56 | 516.58 |
| 25 | Kolkata Orange | 44.00 | 56.33 | 58.67 | 87.60 | 16.87 | 68.53 | 5.44 | 4.51 | 372.14 |
| 26 | Kolkata Primrose | 47.00 | 60.67 | 54.00 | 81.47 | 14.27 | 51.00 | 5.03 | 4.34 | 256.34 |
| 27 | Marvel yellow | 47.67 | 59.00 | 49.33 | 68.93 | 18.40 | 73.80 | 6.40 | 5.34 | 472.36 |
| 28 | Marvel Orange | 50.67 | 62.67 | 54.33 | 72.07 | 17.33 | 63.27 | 5.75 | 4.96 | 362.14 |
| 29 | Marvel Gold | 47.67 | 70.33 | 59.33 | 87.07 | 17.53 | 62.73 | 5.41 | 4.42 | 339.91 |
| 30 | P8 Orange | 47.33 | 59.00 | 58.67 | 87.87 | 12.27 | 33.07 | 4.05 | 4.14 | 134.32 |
| 31 | Sonata Yellow | 40.00 | 51.00 | 58.00 | 80.53 | 13.60 | 35.47 | 5.24 | 4.74 | 185.78 |
| 32 | Sonata Orange | 41.33 | 53.67 | 57.00 | 85.27 | 15.93 | 43.00 | 5.16 | 4.87 | 221.78 |
| 33 | JYK24 Orange | 41.33 | 59.33 | 52.33 | 98.13 | 15.13 | 44.87 | 6.03 | 5.03 | 270.47 |
| 34 | JYK25 Orange | 42.00 | 57.33 | 54.67 | 90.33 | 14.27 | 39.07 | 3.71 | 4.27 | 144.56 |
| **S.Em. ±** | 0.87 | 1.93 | 1.99 | 2.92 | 1.01 | 2.25 | 0.18 | 0.21 | 16.62 |
| **C.D. at 5%** | 2.45 | 5.45 | 5.62 | 8.24 | 2.85 | 6.35 | 0.51 | 0.60 | 46.93 |
| **C.V. %** | 3.31 | 5.69 | 6.07 | 5.64 | 10.72 | 6.70 | 5.68 | 7.87 | 8.90 |

**Table 3: Analysis of variance for different for different growth and its attributing traits**

|  |  |  |
| --- | --- | --- |
| **Sources of Variation** | **D.F.** | **MSS** |
| **Days to first bud Initiation** | **Days to 50 % Flowering** | **Duration of Flowering** | **Plant Height (cm)** | **Branches per plant** | **Flowers per plant** | **Flower Weight (g)** | **Flower Diameter (cm)** | **Flower yield per plant (g)** |
| **Replication** | 2 | 6.37 | 12.36 | 20.72 | 72.19 | 0.69 | 2.02 | 0.26 | 0.21 | 1551.63 |
| **Treatment** | 33 | 1121.49 | 1981.75 | 51.27 | 389.90 | 21.32 | 911.33 | 1.85 | 0.849 | 45922.55 |
| **Error** | 66 | 149.63 | 738.61 | 11.908 | 25.55 | 3.05 | 15.17 | 0.10 | 0.14 | 829.04 |
| **S.Em. ±** | 0.87 | 1.93 | 1.99 | 2.92 | 1.01 | 2.25 | 0.18 | 0.21 | 16.62 |
| **C.D. at 5%** | 2.45 | 5.45 | 5.62 | 8.24 | 2.85 | 6.35 | 0.51 | 0.60 | 46.93 |
| **C.V. %** | 3.31 | 5.69 | 6.07 | 5.64 | 10.72 | 6.70 | 5.68 | 7.87 | 8.90 |

**3.6 Flowers per Plant**

 The results for flowers per plant showed significant variation across the different marigold hybrids. 'Yellow#0068' exhibited the highest flower count, averaging 96.07 flowers per plant, a result comparable to 'Marigold#074' and 'Yellow#0065'. In contrast, 'P8 Orange' produced the fewest flowers, with an average of 33.07 per plant. This observed difference is largely attributable to genetic factors that govern the plant's floral meristem identity, subsequent flower development, and overall reproductive potential [7]. These findings are consistent with earlier research, such as that conducted by Choudhary *et al.* (2017) [23].

**3.7 Flower Weight (g)**

 The experimented marigold hybrids exhibited statistically significant variation in flower weight. 'Tall Orange#004' produced the heaviest flowers at 6.63g, a result statistically equivalent to '264 Plus', 'Vang Ving Orange', 'Tall Orange#P01', 'Marigold#074', 'Yellow#071', 'Yellow#0068', and 'Marvel Orange'. On the other hand, 'Orange#003' recorded the minimum flower weight at 3.30g. This disparity is primarily driven by genetic factors that dictate flower size, petal development, and the allocation of biomass to floral structures [14]. These findings are in line with other studies, such as those by Choudhary *et al.* (2017) [23] and Tejashwini *et al*. (2022) [24].

**3.8 Flower Diameter (cm)**

 The flower diameter varied significantly among the marigold hybrids. 'Yellow#0068' recorded the largest diameter at 5.75 cm, statistically on par with 'Tall Orange#P10', 'Marigold#074', 'Marigold#078', 'Tall Orange#004', 'Yellow#0065', and 'Marvel Yellow'. Conversely, '264 Plus' showed the smallest flower diameter at 3.73 cm. This variation is primarily due to genetic factors that control the development, growth, and expansion of floral organs [25]. These findings are consistent with results reported by Sukwiwat *et al.* (2023) [26].

**3.9 Flower Yield per Plant (g)**

 A significantly superior result was observed in terms of flower yield per plant for the marigold hybrids. 'Yellow#0068' recorded the highest yield at 638.30g, while 'P8 Orange' noted the lowest at 134.32g. This considerable variation is a direct consequence of the complex interplay of multiple genetically controlled traits that contribute to overall plant productivity [27]. These findings are consistent with results reported by Choudhary *et al.* (2017) [23], Tejashwini *et al*. (2022) [24], and Sukwiwat *et al.* (2023) [26].

Fig 1 : Among 34 hybrids of marigold, Yellow#0068, Marigold#074, Marigold#078, Yellow#0065 and Marvel yellow found promising for cultivation in south Gujarat

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| **Yellow#0068** | **Marigold#074** | **Marigold#078** | **Yellow#0065** | **Marvel yellow** |

**CONCLUSION:**

Based on the evaluation of 34 marigold hybrids, 'Yellow#0068' stands out as the most suitable for commercial application. It exhibited statistically superior performance in key yield-contributing traits, including flower yield per plant (638.30g), flower diameter (5.75 cm), and flowers per plant (96.07). Moreover, for other vital parameters like flower weight, days to first bud initiation, days to 50% flowering, duration of flowering, and branches per plant, 'Yellow#0068' consistently matched the highest performers. Collectively, these findings make 'Yellow#0068' an excellent recommendation for higher yield and improved flowering characteristics in the south Gujarat region.

**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 the writing or editing of this manuscript.

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