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Assessment of marigold genotypes for flowering and yield attributes

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Abstract
A field experiment was conducted to assess the fourteen genotypes of marigold for promising flowering and yield attributes at Experimental Orchard of Department of Horticulture, CCS HAU, Hisar during the winter season of 2018-19. This experiment was laid out in Randomized Block Design with three replications. All genotypes exhibited significant variation in terms of various flowering and yield attributes. Statistical analysis of data revealed that flowers having maximum diameter (11.50 cm) and fresh weight (13.40 g) were recorded in African genotype MGH 133-1-2-1, whereas, the maximum number of flowers per plant (164.0) were obtained from French genotype Hisar Jafri-2. The highest yield in terms of flower yield per plant (902.48 g), flower yield per m^2 (5.641 kg) and flower yield per plot (21.659 kg) was also recorded from Hisar Jafri-2. From the present experiment, it may be concluded that African marigold genotype MGH 133-1-2-1 and French genotype Hisar Jafri-2 were found promising for various floral and yield attributes.

Keywords: Marigold, assessment, genotype, flowering and yield

1. Introduction
Marigold popularly known as *gainda* is native to Mexico and belongs to the Asteraceae family. African marigold (*Tagetes erecta* L.) and French marigold (*Tagetes patula* L.) are two commercially important species of marigold, mainly grown in India. African marigold is a tall, hardy and ornamental plant having large globular flowers of different shades of yellow, golden, orange and white color. French marigold is a dwarf plant and generally bears small flowers of yellow, orange, rusty red or a combination of these colors. Loose flowers of marigold are mainly used for various decorative purposes during festivals, religious, social and political functions, whereas, cut flowers are used for floral decoration and display purposes. Marigold is extensively used in landscape gardening for bedding, window boxes, hanging basket, rockery, edging and herbaceous borders. It is also used for the extraction of essential oil and perfume making in the perfume industry.

Marigold is a rich source of carotenoid pigments and has diverse use in poultry, pharmaceutical, food and textile industries. Marigold flower extract is widely used as an additive in poultry feed for increasing the xanthophyll contents in eggs as compared to commercially used synthetic carotenoids. Egg production increased when the hen's diet was supplemented with 150 mg/kg marigold flower extract, while lutein and zeaxanthin content in egg yolk increased after the addition of 350 mg/kg marigold flower extract (Skřivan *et al*., 2015) [13]. The addition of 15 ppm marigold flower extract in the poultry diet improved production performance and egg quality by reducing egg cholesterol and enhancing the egg yolk colour of *Coturnix coturnix japonica* laying quail (Nuraini *et al*., 2017) [9]. Marigold has been traditionally used as an antioxidant, antiseptic and anti-inflammatory for the treatment of various diseases like stomach problems, ulcers and kidney troubles. Lutein extracted from marigold flowers has a strong antioxidant property and plays an important role in treating age-related macular degeneration and thus maintaining normal eye vision. Lutein-rich powder prepared from freeze-dried African marigold and French marigold petals may be used as a functional food ingredient to enhance the color as well as antioxidant properties of bread (Alotaibi *et al*., 2021) [1]. Marigold flowers can also be used as a natural colorant for dyeing of raw fibers in the textile industry. Roots of marigold have nematicidal, insecticidal, antifungal, antibacterial and mosquito repellent properties due to the presence of the α-terthienyl compound.

Marigold is commercially grown as loose flower crop throughout India due to its easy culture, short duration, hardy nature, round the year cultivation and wide adaptability to varied agro-

climatic conditions. It is also grown for cut flowers in some regions like Assam, Jammu and Kashmir and Chhattisgarh. Marigold is mainly grown in Haryana for loose flower production. More than 60% area of floriculture is covered under marigold cultivation in Haryana. It is commercially grown mainly in Kurukshetra, Sonipat, Gurgaon and Palwal districts of Haryana on a large scale. A wide range of variation is available mainly in terms of various floral and yield attributes like flower color, flower diameter, fresh weight of flower, number of flowers per plant and flower yield in marigold. This variation can be utilized for the identification of promising genotypes of marigold for increasing net return per unit area and thus improving the economic status of flower growers. These genotypes can be further utilized in crop improvement programs for flower production and landscaping purpose.

Very little work has been done to assess the marigold genotypes under Haryana conditions; mainly for commercially important attributes like attractive flower color, big flower and high yield potential. Keeping in view the rising demand for marigold flowers for their multipurpose uses; it has become necessary to identify superior marigold genotypes well suited to agro-climatic conditions of Haryana. So, the present experiment entitled "Assessment of marigold genotypes for flowering and yield attributes" was planned to find out suitable genotypes of marigold with promising flower size and high yield potential.

2. Materials and Methods

A field experiment was conducted to assess marigold genotypes for promising flowering and yield attributes at Experimental Orchard of Department of Horticulture, CCS HAU, Hisar in the winter season of 2018-19. It consisted of fourteen genotypes of marigold; twelve genotypes of African type namely; MGH 160-8-3-3-1, MGH 160-8-3-3-2, MGH 160-8-3-3-3, MGH 160-8-3-3-4, MGH 160-8-3-3-5, MGH 160-8-3-3-6, MGH 133-1-1-1, MGH 133-1-1-2, MGH 133-1-1-3, MGH 133-1-2-1, MGH 133-1-2-2, MGH 133-1-2-3 and two genotypes of French type i.e. Hisar Beauty and Hisar Jafri-2 (Table 1). All these genotypes were taken from marigold germplasm maintained at Experimental Orchard of Department of Horticulture, CCS HAU, Hisar.

Table 1: Description of marigold genotypes

Sr. No.	Genotype	Type	Flower Colour	Flower Size*
1.	MGH 160-8-3-3-1	African	Orange	Big
2.	MGH 160-8-3-3-2	African	Orange	Medium
3.	MGH 160-8-3-3-3	African	Orange	Small
4.	MGH 160-8-3-3-4	African	Golden	Big
5.	MGH 160-8-3-3-5	African	Golden	Medium
6.	MGH 160-8-3-3-6	African	Golden	Small
7.	MGH 133-1-1-1	African	Lemon Green	Big
8.	MGH 133-1-1-2	African	Lemon Green	Medium
9.	MGH 133-1-1-3	African	Lemon Green	Small
10.	MGH 133-1-2-1	African	Lemon Red	Big
11.	MGH 133-1-2-2	African	Lemon Red	Medium
12.	MGH 133-1-2-3	African	Lemon Red	Small
13.	Hisar Beauty	French	Dark Red with yellow margin	Small
14.	Hisar Jafri-2	French	Orange	Small

*Flower size: Small: < 5.50 cm; Medium: 5.50 cm – 7.50 cm; Large: >7.50 cm

This experiment was laid out in a Randomized Block Design with three replications. Healthy and vigorous seeds of all genotypes were sown in raised nursery beds during September-October 2018 and transplanted in the experimental plots of 2.4 m × 1.6 m size at a spacing of 40 cm × 40 cm during October-November 2018. All intercultural practices were adopted uniformly for successful raising of all the genotypes. Five competitive plants were randomly selected from each experimental plot to record data on various flowering attributes and yield attributes. Various flowering attributes *viz*., flower color, flower diameter, fresh weight of flower and number of flowers per plant were recorded at the full bloom stage. Yield attributes like flower yield per plant, flower yield per m^2 and flower yield per hectare were also recorded at full bloom stage. The average fresh weight of flower was multiplied by average number of flowers per plant to record the flower yield per plant and mean was computed and expressed in gram. Flower yield per plant was converted to square meter basis, which reflected the flower yield per m^2 and expressed in kilogram. Average flower yield per plant was also multiplied by number of plants in the plot and recorded in kilogram to compute flower yield per plot. All recorded data pertaining to flowering and yield attributes were subjected to statistical analysis by using randomized block design (RBD) as suggested by Panse and Sukhatme (1985) [10].

3. Results and Discussion

3.1 Flower colour

Flower color varied from orange, yellow, golden, lemon green, lemon red to dark red among different genotypes of marigold as depicted in Table 1. African genotypes *viz*., MGH 160-8-3-3-1, MGH 160-8-3-3-2, MGH 160-8-3-3-3 and French genotype Hisar Jafri-2 produced orange colored flowers. However, golden color is exhibited by African genotypes namely MGH 160-8-3-3-4, MGH 160-8-3-3-5 and MGH 160-8-3-3-6. Flowers of lemon green color were obtained from MGH 133-1-1-1, MGH 133-1-1-2 and MGH 133-1-1-3, whereas, flowers of lemon red color were produced by MGH 133-1-2-1, MGH 133-1-2-2 and MGH 133-1-2-3; all African genotypes. Hisar Beauty; French genotype had dark red petals with yellow margin. Flower color is a qualitative character and variation in it is governed by genes present in the hereditary material of each genotype. Similar observations were reported by Namita *et al*. (2013) [8], Bharathi and Jawaharlal (2014) [2] and Dahal *et al*. (2021) [4] in marigold.

3.2 Flower Diameter (cm)

Various genotypes performed differently with respect to flower diameter and it varied from 2.13 cm to 11.50 cm as evident from the data given in Table 2. The maximum flower diameter (11.50 cm) was attained by flowers of African genotype MGH 133-1-2-1 and it varied significantly from all other genotypes. However, the minimum flower diameter (2.13 cm) was recorded in the French genotype Hisar Beauty. This variation in flower diameter may be attributed to the different genetic material of genotypes and their interaction with the prevailing environment during the period of experimentation. These results are in accordance with the findings of Bharathi and Jawaharlal (2014) [2], Gupta *et al*. (2016) [5], Manik and Sharma (2016) [6], Naik *et al*. (2019) [7], Sharma *et al*. (2019) [12], Srinivas and Rajasekharam (2020) [14], Thirumalmurugan *et al*. (2020) [15], Dahal *et al*. (2021) [4],

Sharma and Jadagoudar (2021) [11] and Cicevan *et al*. (2022) [3] in marigold.

Table 2: Assessment of marigold genotypes for various flowering attributes

Sr. No.	Genotype	Flower Diameter (cm)	Fresh weight of flower (g)	Number of flowers per plant
1.	MGH 160-8-3-3-1	8.23	7.99	20.0
2.	MGH 160-8-3-3-2	6.28	6.09	35.7
3.	MGH 160-8-3-3-3	4.64	4.55	58.3
4.	MGH 160-8-3-3-4	8.17	8.48	29.0
5.	MGH 160-8-3-3-5	6.48	6.49	47.4
6.	MGH 160-8-3-3-6	4.27	4.75	84.7
7.	MGH 133-1-1-1	8.83	8.28	20.3
8.	MGH 133-1-1-2	6.67	7.32	30.0
9.	MGH 133-1-1-3	4.90	4.32	57.5
10.	MGH 133-1-2-1	11.50	13.40	26.0
11.	MGH 133-1-2-2	6.13	7.56	45.2
12.	MGH 133-1-2-3	4.46	4.03	36.3
13.	Hisar Beauty	2.13	1.80	20.2
14.	Hisar Jafri-2	4.40	5.50	164.0
	CD at 5%	0.671	0.81	7.48

3.3 Fresh weight of flower (g)

All genotypes varied with respect to the fresh weight of flower among each other as apparent from the data presented in Table 2. The fresh weight of flower ranged from 1.80 g to 13.40 g among different genotypes of marigold. African genotype MGH 133-1-2-1 attained the maximum fresh weight of flower (13.40 g) and it differed significantly from the rest of the genotypes. Though, the minimum fresh weight of flower (1.80 g) was recorded in the French genotype Hisar Beauty. This difference in fresh weight of flower among different genotypes might be resulted due to a wide range of variability in their flower diameter. It can also arise due to the varied performance of different genotypes and prevailing environmental conditions. Similar variation in terms of fresh weight of flower was reported by Bharathi and Jawaharlal (2014) [2], Sharma *et al*. (2019) [12], Thirumalmurugan *et al*. (2020) [15] and Dahal *et al*. (2021) [4] in marigold.

3.4 Number of flowers per plant

All genotypes differed from each other in terms of number of flowers per plant as revealed by data given in Table 2. The number of flowers per plant ranged from 20.0 to 164.0. The highest number of flowers per plant (164.0) was recorded from French genotype Hisar Jafri-2 significantly followed by African genotype MGH 160-8-3-3-6 (84.7). It also differs significantly from the rest of the genotypes. However, the minimum number of flowers per plant (20.0) was obtained in African marigold genotype MGH 160-8-3-3-1 which was found at par with French genotype Hisar Beauty (20.2) and African genotypes MGH 133-1-1-1 (20.3) and MGH 133-1-2-1 (26.0). This difference in the number of flowers per plant among genotypes may be due to their genetic makeup. These results are in consonance with the findings of Bharathi and Jawaharlal (2014) [2], Gupta *et al*. (2016) [5], Manik and Sharma (2016) [6], Sharma *et al*. (2019) [12], Srinivas and Rajasekharam (2020), Thirumalmurugan *et al*. (2020) [15], Dahal *et al*. (2021) [4], Sharma and Jadagoudar (2021) [11] and Cicevan *et al*. (2022) [3] in marigold.

3.5 Flower yield per plant (g)

A significant variation was recorded among genotypes for flower yield per plant as revealed by data shown in Table 3. It ranged from 36.23 g to 902.48 g among all genotypes. The maximum flower yield (902.48 g) per plant was obtained in French genotype Hisar Jafri-2 significantly followed by MGH 160-8-3-3-6 (401.80 g) and it was found significantly superior to all other genotypes. Although the minimum flower yield per plant (36.23 g) was recorded in the French genotype Hisar Beauty. Various genetic and environmental factors might be responsible for this difference in flower yield per plant. It may also be due to variation in fresh weight of flower and number of flowers per plant among all genotypes. These findings are in harmony with the results obtained by Bharathi and Jawaharlal (2014) [2], Gupta *et al*. (2016) [5], Sharma *et al*. (2019) [12], Thirumalmurugan *et al*. (2020) [15] and Sharma and Jadagoudar (2021) [11] in marigold.

3.6 Flower yield per m^2

All genotypes performed differently for flower yield per m^2 as revealed by data presented in Table 3. It ranged from 0.226 kg to 5.641 kg among all genotypes. The maximum flower yield per m^2 (5.641 kg) was recorded in French genotype Hisar Jafri-2 significantly followed by MGH 160-8-3-3-6 (2.511 kg) and it was found significantly superior to all other genotypes. The minimum flower yield per m^2 (0.226 kg) was recorded in the French genotype Hisar Beauty. This difference in flower yield per m^2 might be due to the cumulative effect of genotype and environment. These findings confirm the reports of Gupta *et al*. (2016) [5] and Sharma *et al*. (2019) [12] in marigold.

3.7 Flower yield per plot (kg)

All genotypes varied among each other in influencing flower yield per plot as shown by data given in Table 3. It varied from 0.870 kg to 21.659 kg. The maximum flower yield per plot (21.659 kg) was recorded from French genotype Hisar Jafri-2 significantly followed by African genotype MGH 160-8-3-3-6 (9.643 kg). Hisar Jafri-2; French genotype was also found significantly superior to the rest of the genotypes in terms of flower yield per plot. However, the minimum flower yield per plot (0.870 kg) was recorded from Hisar Beauty; a French genotype. These results are in consonance with the findings of Manik and Sharma (2016)[6] in marigold.

Table 3: Assessment of marigold genotypes for various yield attributes

Sr. No.	Genotype	Flower yield per plant (g)	Flower yield per m^2 (kg)	Flower yield per plot (kg)
1.	MGH 160-8-3-3-1	158.74	0.992	3.810
2.	MGH 160-8-3-3-2	217.53	1.360	5.221
3.	MGH 160-8-3-3-3	265.37	1.659	6.369
4.	MGH 160-8-3-3-4	247.50	1.547	5.940
5.	MGH 160-8-3-3-5	307.98	1.925	7.392
6.	MGH 160-8-3-3-6	401.80	2.511	9.643
7.	MGH 133-1-1-1	167.63	1.048	4.023
8.	MGH 133-1-1-2	219.22	1.370	5.261
9.	MGH 133-1-1-3	248.42	1.553	5.962
10.	MGH 133-1-2-1	349.04	2.182	8.377
11.	MGH 133-1-2-2	342.00	2.137	8.208
12.	MGH 133-1-2-3	146.42	0.915	3.514
13.	Hisar Beauty	36.23	0.226	0.870
14.	Hisar Jafri-2	902.48	5.641	21.659
	CD at 5%	51.29	0.321	1.231

4. Conclusion

From the present study, it may be concluded that African marigold genotype MGH 133-1-2-1 and French marigold genotype Hisar Jafri-2 exhibited better performance in terms of flower diameter and flower yield.

All genotypes performed differently with respect to various flowering and yield attributes. African genotype MGH 133-1-2-1 produced flowers having the largest diameter and maximum flower weight, whereas, the highest values for flower yield per plant, flower yield per m^2 and flower yield per plot were recorded from the French genotype Hisar Jafri-2.

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