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Shrikant Sahu
Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Samir Kumar Tamrakar
Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Ritu R Saxena
Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Gaurav Sharma
Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Shrikant Sahu
Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Estimation of performance in marigold genotypes based on vegetative growth, reproductive and yield traits

Shrikant Sahu, Samir Kumar Tamrakar, Ritu R Saxena and Gaurav Sharma

Abstract
In the Indian economy the marigold flower has a key role because it is an essential landscaping crop and economically important loose flower. The wide uses of marigold depend on the variable performance of different genotypes. The evaluation of the performance of the different marigold genotypes was carried out on a set thirteen traits. The highest plant height at 30, 60 and 90 DAT was reported by marigold genotype Pusa Arpita. The lowest plant height observed in CGFM-2 at 30 DAT while the genotype CGFM-1 reported lowest plant height at 60 and 90 DAT. At 60 and 90 DAT, the highest plant spread of east-west and north-south was recorded by CGFM-3 whereas, the lowest reported by Chaindani Gainda and CGWM-1 at 60 and 90 DAT respectively. The highest primary branches per plant at 30 and 60 DAT reported by genotype CGFM-3 while at 90 DAT, Pusa Arpita showed maximum primary branches per plant. The highest number of secondary branches per plant was observed in genotype CGFM-1 and CGFM-3 at 60 and 90 DAT respectively. At 30 and 60 DAT number of leaves per plant was highest in genotype CGWM-1 but at 90 DAT it was present in Pusa Arpita. The lowest days required for first bud appearance and days for 50% reported by genotype CGWM-1 and Chaindani Gainda respectively. The significantly highest number of flowers per plant and flower diameter was observed in the genotype CGFM-1 and CGWM-1 respectively. The highest yield of flower per plant and per hectare was witnessed in the genotype CGFM-1. It has been observed that the value of high GCV, PCV and heritability along with high genetic advance as percentage of mean were recorded for the traits such as plant height (cm), number of secondary branches per plant, number of leaves per plant, days to first bud appearance, days to 50% flowering, number of flowers per plant, flower diameter (cm), flower yield/ plant (g) and flower yield (q/ha). It has been observed that the greater value of GCV and PCV was present for a trait that much affected by environmental factors. It has been observed that the higher genetic advance along with higher heritability can be most applicable for effective improvement of any kind of traits through selection in simple manner.

Keywords: Marigold, variability, genetic advance, heritability

Introduction
In the world India holds rank first for area and production of marigold (*Tagetes spp*.) and there are more than 50 species of genus *Tagetes* was reported. Marigold belongs to family Asteraceae and is native to the South and Central America [5]. Marigold is usually grown for cut flowers, making garlands, landscape gardening, decoration during pooja and religious functions. Also, marigold is being grown as an important source of carotenoid pigments (xanthophyll) [2]. In India, during 2020, the cultivation area of marigold was 64 thousand hectare along with production of 608.97 thousand metric tons. In Chhattisgarh state, the area under cultivation of marigold was 4129 hectare with the production of 29 thousand metric tons [3]. The studies on evaluation of the performance of marigold genotypes based on vegetative and flowering parameters along with genetic constitution has paramount importance for crop improvement programme [1]. Determining genetic diversity through variation between genotypes, genotype groups or populations is most important breeding tool to select better genotypes for improvement in desired traits [4]. Genotypic or phenotypic variation in a species is the main source of any breeding programme for development of new varieties that withstand with environmental changes coming in future. During experiment estimation of type of variation in germplasm required for plant breeder because the most of the traits influencing yield and they are having polygenetic nature [17]. Marigold is a heterozygous crop and it gaining considerable importance hence it exploiting increased variations as present in open pollinated crops [30].

In the present investigation the study of vegetative growth and flowering parameters of marigold genotypes was carried out because it is prerequisite source for any breeding programme for developing suitable varieties. Before embarking on any selection programme, it is imperative to have knowledge on the magnitude of variability and the extent of heritable variation present in the material for the desired characters [14]. In the current investigation the vegetative growth and flowering parameters was studied by estimating phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance that provide proper information of variability present in a group of population and lead to the successful development of a new cultivar [15]. Coefficient of variation (GCV and PCV) provides the estimate about the amount of variability present in the available genotypes based on vegetative growth and flowering parameters [24]. In the flower breeding programme the estimation of heritability providing information regarding transmission of characters from one generation to another because the consistency of genotype performance for selection totally rely on heritable portion of the variability, thus it helps breeders for proper selection of elite genotypes [32]. Heritability along with genetic advance increases the efficiency of selection in a breeding programme by assessing the influence of environmental factors and additive gene action. [38]. The selection of elite genotypes mostly required heritability together with genetic advances because the alone use of heritability is not pre-requisite for any kind of breeding programmes [3]. In Chhattisgarh, also marigold is one of the dominating flowers which fetches high price in the local market. Moreover, by studying vegetative growth and flowering parameters the diverse marigold available in the different agro-climatic condition of Chhattisgarh, there is a scope of finding remarkable variations in the growth and flowering in the locally available marigold flowers. Keeping these points in view, the present investigation was undertaken to study the performance of different marigold genotype by considering vegetative growth, reproductive and yield parameters.

Materials and Methods

The present study was carried out at, Indira Gandhi Krishi Vishwavidyalaya, College of Agriculture, Raipur during the year 2017. Experimental material consisted of six genotypes of marigold *viz*., CGFM-1, CGFM -2, CGFM -3, CGWM-1, Chaindani Gainda and Pusa Arpita collected from different places Chhattisgarh. The experiment was laid out in Randomized Block Design (RBD) with four replications. For planting of plot was prepared at the dimension of 1.20 × 1.60 m and before planting, the seed were treated with fungicides. The treated seed were planted at 4 cm depth at a spacing of 30 x 30 cm between the plant and row as per the standard recommendation. Uniform cultural practices were followed throughout the experimentation. The data were recorded on five random plants from each genotype in each replication for thirteen characters which includes vegetative (plant height, primary branches per plant, number of secondary branches per plant, plant spread and number of leaves per plant), reproductive (days to 50% flowering, days to first bud appearance and duration of flowering) and yield parameters (flower yield/plant, flowers per plant, flower diameter and flower yield q/ha). Data were subjected to statistical analysis as per method given by Panse and Sukhatme (1954) [23]. Genetic parameters like genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated according to Singh and Chaudhary (1979) [33] and heritability in broad sense as suggested by Falconer (1981) [10] and genetic advance was calculated using the formula given by Johnson *et al.* (1995) [12].

Results and Discussion

Performance of marigold genotypes for vegetative parameters

The evaluation of the performance of the different marigold genotypes was carried out on a set five vegetative traits. Where, the statistical analysis has been shown that the marigold genotypes used in study are significantly different for all five vegetative traits considered at different stages *viz.* 30, 60 and 90 days after transplantation (DAT) (Table 1). The highest plant height at 30 DAT was reported by marigold genotype Pusa Arpita (51.60 cm) and lowest by CGFM-2 (34.82 cm). In case of 60 DAT plant height depicting that the maximum plant height was observed in genotype Pusa Arpita (92.55 cm) and least plant height was recorded in genotype CGFM-1 (56.28 cm). At 90 DAT the marigold genotype Pusa Arpita showed maximum plant height (137.35 cm), whereas lowest plant height was observed in genotype CGFM-1 (67.52 cm). Several researchers also found the variation in the trait like plant height among the different marigold genotypes [16, 11]. The character was mostly affected due to plant genetic constitution and it is attributed to be a significant nature of cultivars [27], The distinction in plant height among the different genotypes might be due to genotypic variation in the phenotypic expression of plant height and also variations in a different genotype may be due to environmental interaction effects on plant height [11].

At 60 DAT, the highest plant spread (east-west) was recorded by CGFM-3 (52.40 cm) which was at par with other genotypes. Whereas, the lowest plant spread (east-west) was reported in Chaindani Gainda (40.25 cm). Similarly, at 90 DAT, the genotype CGFM-3 (59.50 cm) reported maximum plant spread (east-west) which was at par as compare to remaining 5 marigold genotypes while the minimum plant spread (east-west) was observed in genotype CGWM-1 (44.28 cm). At 60 DAT, the highest plant spread (north-south) was recorded by CGFM-3 (57.19 cm) which was at par. Whereas, lowest plant spread (north-south) was reported in Chaindani Gainda (40.19 cm). Similarly, at 90 DAT, the genotype CGFM-3 (64.73 cm) was reported maximum plant spread (north-south) while the minimum plant spread (north-south) was observed in genotype CGWM-1 (39.98 cm). In case of plant spread east-west (EW) and north-south (NS), the result showing that the current finding is consistent with earlier findings on the marigold genotypes for evaluation of superior genotypes in advanced breeding programme [22]. Raghuvanshi and Sharma, (2011) [26] and also reported the similar kind of variation among different marigold genotypes**.**

The highest primary branches per plant at 30 DAT was reported by marigold genotype CGFM-3 (6.70/plant) and lowest by CGWM-1 (3.20/plant). In case of 60 DAT, maximum primary branches per plant were observed in genotype CGFM-3 (17.00/plant) and genotype CGWM-1 reported the lowest primary branches per plant (10.50/plant). At 90 DAT the marigold genotype Pusa Arpita showed maximum primary branches per plant (25.03/plant), whereas lowest was observed in genotype CGWM-1 (14.30/plant). Several researchers also found the variation in the trait like primary branches per plant among the different marigold

genotypes [19, 37].

The experimental data at 60 DAT showing that the secondary branches per plant was the highest in CGFM-1 (5.15/plant) lowest in Pusa Arpita (0.10/plant). Similarly, at 90 DAT, the genotype CGFM-3 (61.60/plant) reported maximum secondary branches per plant and minimum was observed in genotype Pusa Arpita (1.80/plant). The enhanced number of secondary branches in several genotypes may be attributed to the genetic constitution of the genotypes. The number of secondary branches per plant was significantly increased after 30 days after transplantation in all genotypes which may be attributed to pinching of a plant which might have enhanced the auxiliary buds to flourish well. In the last decades, Khanvilkar *et al*. (2003) [16] reported a similar result was recorded in marigold, where they found that the high diversity or variation in secondary branches per plant and they also found that the secondary branches per plant were increased after 30 days after transplantation in many marigold genotypes.

At 30 DAT, the experimental data representing that the number of leaves per plant was highest (27.65/plant) and lowest (17.50/plant) in genotype CGWM-1 and CGFM-2 respectively. In case of experimental data at 60 DAT, maximum number of leaves per plant was observed in genotype CGWM-1 (31.10/plant) and least number of leaves per plant was recorded in genotype CGFM-2 (23.00/plant). At 90 DAT the genotype Pusa Arpita showed maximum number of leaves per plant (52.65/plant), whereas lowest was observed in genotype CGFM-2 (30.40/plant). The production of an increased number of leaves might be attributed to the production of a higher number of branches per plant [37]. Similar difference in the number of leaves per plant among the genotypes was also recorded earlier in marigold by Singh and Misra (2008) [30].

Performance of marigold genotypes for reproductive parameters

The performance of marigold genotypes was studied on three reproductive traits and mean value along with statistical data is given in Table 2. The analysis of variance has been shown significant variation for three reproductive traits. The highest days required for first bud appearance at 90 DAT was reported by genotype Pusa Arpita (113.85 days) and lowest by CGWM-1 (61.85 days). Significantly earliest days for 50% flower bud opening was reported by Chaindani Gainda (76.50 days) followed by CGFM-1 (78.50 days). Both the genotypes were at par but significantly superior to the all the other genotypes. The highest number of days for 50% flowering was recorded in genotype Pusa Arpita (126.25 days). The time required for days taken to first flower bud appearance is an essential genotypic character that might be principally governed by the genetic constitution of the genotypes [27]. The variation in flowering might be due to the different time period taken by the various genotypes because of their different genetic makeup. The results recorded were in line with earlier findings of Nair and Shiva (2003) [20] in gerbera; and Suvija *et al.* (2016) [35] in chrysanthemum.

The significantly longest duration of flowering was observed in the genotype Chaindani Gainda (48.00 days) which was superior to all the other genotypes and the minimum duration of flowering was observed in CGWM-1 (42.50 days). Longer duration of flowering could be due to high dry matter assimilation because of more nitrogen incorporation and other nutrients uptake in addition to a prevailing favorable environment, Rao *et al.,* (2005) [27]**.** The genetic control of these characters and alteration in their expression due to environmental conditions might be the probable causes of recorded variation. Similar result was recorded by Khanvilkar *et al.,* (2003) [16].

Performance of marigold genotypes for yield parameters

In present investigation four yield related traits was studied and analysis of variance indicating that the data was significantly different (Table 2). The significantly highest number of flowers per plant was observed in the genotype CGFM-1 (156.25) which was statistically not similar to other genotypes used in study and significantly superior to the rest of the genotypes. The minimum number of flowers per plant was observed in CGWM-1 (82.25). The difference in the number of flowers per plant may be because of the hereditary traits of the genotypes. Increased number of branches leads to more production of flower per plant [18]. The results are in close conformity with Choudhary *et al.*, (2014) [7] Singh *et al.*, (2008) [31] in marigold. In addition, diverse photosynthetic efficiency of genotypes may have increased food synthesis resulting in enhanced plant growth and consequently increased number of flowers per plant [34].

The maximum flower diameter was witnessed in the genotype CGWM-1 (4.55 cm) followed by Chaindani Gainda (3.36 cm). Genotype CGWM-1 was significantly superior over the rest of the genotypes in case of flower diameter. The minimum flower diameter was observed in the genotypes CGFM-3 (2.44 cm). The distinction in the diameter of the flower might be because of the genetic constitution of the genotypes and their interaction with an existing environment. The highest number of leaves which influences in increased dry matter production leads to increased accumulation of photosynthates that may have contributed to the production of larger sized flowers [36]. Similar results were observed by Narsude *et al.,* (2010) [22] and Deepa *et al.,* (2016) [8] in marigold crop.

The highest yield of flower per plant was witnessed in the genotype CGFM-1 (283.75 g) which was significantly superior to all the other genotypes including CGFM -2, CGFM -3, CGWM-1, Chaindani Gainda and Pusa Arpita. The least yield was recorded in genotype Chaindani Gainda (137.50 g). The variation in genotypes may be due to genetic and environmental interaction. The maximum number of leaves has a positive effect on the increased accumulation of photosynthesis that may have contributed to the production higher yield in genotypes. The results are similar to findings of Choudhary *et al.,* (2014) [7] and Singh *et al.,* (2008) [30] in marigold. The increased number of flowers per plant might be due to cell elongation and rapid cell stimulation. Similar results were also noticed by Choudhary *et al.,* (2014) [7] and Bharathi and Jawaharlal (2014) [6] in African marigold.

The highest yield of flower per hectare was recorded in the genotype CGFM-1 (141.50 q/ha) which was significantly superior over other genotypes, whereas the lowest yield was reported by genotype Chaindani Gainda (69.75 q/ha). The distinction in yield of flowers per hectare might be attributed to more number of leaves and plant spread which might have influenced in increased photosynthesis and assimilation of higher photosynthesis resulting in the production of higher yield. Flower diameter, the weight of flower and number of flower per plant also influence the yield of flowers. The genetic constitution of the genotypes and interaction with the environment also decides the yield factor. In marigold

genotypes the analogous results were also recorded by Deepa *et al.*, (2016) [8] and Poornachandragowda *et al.*, (2016) [25].

Estimation of genetic parameters (GCV, PCV, Heritability and genetic advance)

The results of the genetic parameters (GCV and PCV) of 13 traits in marigold genotypes are presented in Table 3. The results indicate that magnitude of phenotypic coefficient of variation is greater than the genotypic coefficient of variation. This tells us that the apparent variation is not only due to genotypes but also due to influence of environmental factors. The high magnitude of PCV coupled with high GCV observed in traits such as plant height (cm), number of secondary branches per plant, number of leaves per plant, days to first bud appearance, days to 50% flowering, number of flowers per plant, flower diameter (cm), flower yield/ plant (g) and flower yield (q/ha); except plant spread (EW) and plant spread (NS) showed moderate to low and high to moderate PCV coupled with GCV. The trait like duration of flowering recorded the low value of these genetic parameters. The results obtained from this study can be linear with the earlier finding of Panwar *et al.* (2013) [24] and Sharma *et al.* (2014) [28] in Marigold plant. The results of this study also indicating the presence of sufficient genetic variability that can be exploited during advanced breeding programme [13].

The study on vegetative growth and flowering parameters of marigold genotypes was carried to find out genetic advance as a per cent of mean, genetic advance and heritability while the regarding data given on Table 3. In present investigation a set of 13 vegetative growth and flowering parameters was studied for heritability, genetic advance and genetic advance as percentage of mean. Days to first bud appearance shows high magnitude for broad sense heritability. Rest of all the traits showed high heritability except plant spread (NS) reported moderate heritability. The plant spread (EW) and duration of flowering showed the low value of heritability. For genetic advance as per percent mean (GA %), the traits number of secondary branches per plant recorded highest value. Rest of all the traits also exhibited the highest value of GA % except plant spread (EW) showed moderate and duration of flowering recorded low value of GA %. The number of secondary branches per plant showed high value for PCV, GCV coupled with heritability and GA %.

This investigation can be prove that the study of heritability and genetic advance provides better ideals for genetic potential because it is based on the characters which has highly phenotypic and heritable values but it does not mean a genetic gain with high in nature. It has been observed that the higher genetic advance along with higher heritability can be most applicable for effective improvement of any kind of traits through selection in simple manner [29]. In the advanced breeding programme the selection can be improve by using additive gene effect that can be achieved by high genetic advance combined with high heritability. In last decade in various types marigold genotypes evaluated on the basis of genetic advance as a per cent of mean, genetic advance and heritability for successful breeding programme that finding was similar with current investigation [13, 29, 9].

Conclusion

From the various aspects of genetic parameters (GCV, PCV, heritability and genetic advance expressed as percentage of mean), studied in this experiment, nine characters *viz.*, plant height (cm), number of secondary branches per plant, number of leaves per plant, days to first bud appearance, days to 50% flowering, number of flowers per plant, flower diameter (cm), flower yield/ plant (g) and flower yield (q/ha) were identified for primary selection as they had high GCV, PCV, high heritability along with genetic advance. Considering these characters, the genotype CGFM-1 which showed significantly superiority in mean performance were identified for further purification and multiplication for their commercial exploitation.

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