emergent
Life Sciences Research

Research Article

Corm size determination and genetic variability studies in Saffron (*Crocus sativus* L.)

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Abstract

The objective of the current study was laid in augmented block design at ARSSSS Pampore, to examine the optimal corm size, and genetic divergence and to observe the phenotypic and genotypic variability (PCV, GCV) for corm attributes. The genetic divergence among selected lines was thoroughly investigated for the identification of elite divergent traits showing economic gains along with their contribution towards yield. Significant differences were observed among populations for all traits, including the multiplication index (MI) (3.0-5.0) with a mean of 3.8, the number of days to 50% sprouting (22-134) with a mean of 128 days, and the Big Corm Index (BCI) (6-15) with a mean of 10.42g, indicating the presence of a high level of variability and therefore imply considerable scope for saffron improvement via proper corm selection. Bigger corm size (8-12cm) indicates earlier and more persistent flowering, as well as big flower size, implying a direct effect on saffron yield, however, there was no effect on saffron quality. It was also observed that phenotypic variance estimation was greater than corresponding estimates of genotypic variance, indicating an environmental influence on trait expression. Genetic variability studies are critical for understanding the degree of variability and the potential for its future use in subsequent breeding programs.

Keywords big corm index, genetic divergence, genetic variability, multiplication index, phenotypic variability

Received: 23 October 2022
Accepted: 25 November 2022
Online: 01 December 2022

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Emer Life Sci Res (2022) 8(2): 186-191

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2022.82186191

Introduction

Saffron (*Crocus sativus* L.) belongs to the family Iridaceae, is globally the most expensive spice, and is commonly referred to as the "Golden Condiment." It is a legendary crop of Jammu and Kashmir, grown on well-drained karewa soils with climatic conditions conducive to obtaining higher yield. In previous studies, it has been observed that mature and bigger corms produced more flowers and daughter corms as described by Molina et al., [1], De Juan et al., [2]. Furthermore, Turhan et al., [3], Renau-Morata et al., [4], and Mollafilabi [5] ascertained that corm size is an important factor in determining to flower, even if the corm does not reach its original size. According to Amirnia et al., [6] and Siracusa et al., [7] the environment and origin of corm have a significant impact on the number of flowers and stigma yield. Researchers such as Molina et al., [1, 8], Gresta et al., [9], and Maggi et al., [10] found that climatic factors (e.g., temperature, soil water content) had a significant impact on the quantitative and qualitative traits of saffron.

Singh et al., [11] described that genetic variability provides breeders with an accurate picture of the genetic diversity of various traits for use in breeding programs. Saffron production relies heavily on the selection of corms for propagation. The determination of the best corm size would help with cultivation practices and ultimately, yield and quality as it is sterile and reproduces only by vegetative means. Abdulhabip et al., [12] revealed that larger corm size flowered earlier than the small corms and was also found that it continue to flowering for a longer period than small corms.

This study was conducted to determine the best corm size for saffron and corm yield to meet the global demand which is rising continuously for the last few decades due to poor quality corms. On average, most of the geophytes show a low rate of propagation, and therefore biotechnological techniques such as in vitro cultural methods aid in the propagation of several important and economically important plants to mitigate this issue. Clonal selection from available germplasm resources suggests the potential for saffron genetic improvement. The identification of such elite genotypes with discrete superiority in yield and corm attributes could then be utilized as a source for further improvement, benefiting the global saffron industry.

Methodology

The current study was conducted during the cropping season of 2017-18, at the Advanced Research Station for Saffron and Seed Spices (ARSSSS) Pampore which is located at 34°N latitude, 74°E longitude, and approximately 1650amsl. Saffron corms of each category were planted and supplemented with adequate nutrients according to SKUAST-K, Shalimar recommendation. The study material consisted of 140 saffron accessions taken from various saffron-growing regions of Kashmir and abroad. The pedigree details of all accessions were recorded and corms weighing from 5g to 15g, measuring 4cm to 12cm were planted in Augmented Block Design (ABD) with a row length of 3m, a width of 2m, and inter and intra-row spacing of 20 and 10 cm, respectively. Observations were recorded on ten randomly selected and tagged competitive plants from each line for all traits.

Corm characteristics

No. of days to 50% sprouting, Big Corm Index (BCI) (measured via vernier caliper scale), Multiplication index (MI) (MI data is recorded by counting the number of daughter corms produced from mother corm).

Data analysis

Mean values for all the characters were estimated for analysis of variance [13-14] and Character association at the genotypic and phenotypic level given by Al Jibouri [15]. Data were analyzed by taking the help of R software. And Tukey's test was used for multiple comparison procedures.

Results and Discussion

Genetic variability

Genetic variability is extremely useful in determining the extent of genetic diversity for different traits in a population as described by Singh et al., [11]. The components of phenotypic and genotypic variability revealed that all attributes had a wide range of variability. Big corm index (BCI) (6.00-15.33) with an average value of 10.42, multiplication index (MI) (3.00-5.00) with an overall mean of 3.80 as shown in Figure 1, and 50% sprouting (22.00-134.00) with an average value of 128.16 are all shown in (Table 1). These findings agree with those of Sheikh et al., [16], Latto and Dhar [17], Zargar [18], Gohill [19], Zargar [20], and Makhdoomi et al., [21] which indicate that corms with bigger size and weight can give more number of daughter corms with proper size and weight and thereby can bear flowers in next cropping season. So, by considering these findings it is concluded that there is plenty of room for saffron genetic improvement by selecting superior genotypes from heterogeneous saffron populations.

Corm size effect

Corms with a size of 4 cm and less than 8 gm did not produce flowers usually; however, corms sized greater than 8 cm produced large, earlier, and persistent flowers. Table 2, shows the saffron yield (g/m^2) observed

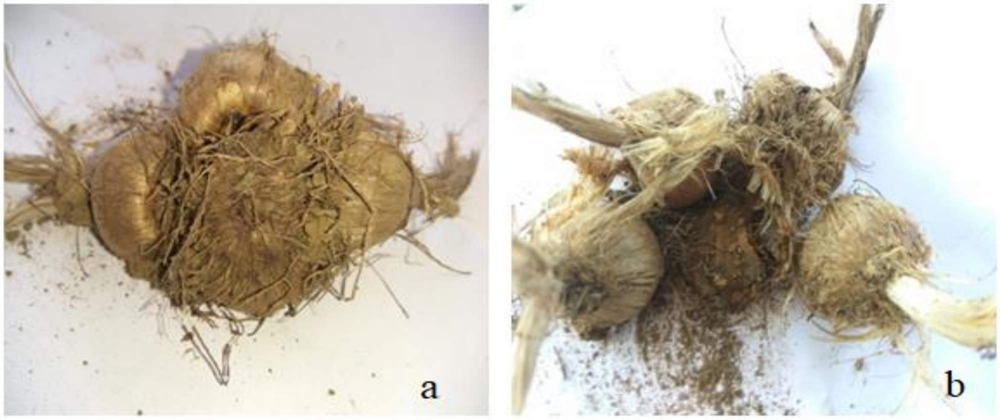

Figure 1. (A) Mother corm (B) Mother corm reduces to give rise to 4 daughter corms

Table 1. Magnitude of variability for different corm attributes in saffron (Crocus sativus L.).

SN.	Characters	Range	Mean	C.V	S.E	C.D@ 5%
1	Big corm index (g)	6.00-15.33	10.42	12.53	0.75	2.09
2	Multiplication index	3.00-5.00	3.80	30.84	0.67	1.08
3	50% sprouting	22.00-134.00	128.16	0.92	0.68	1.89

during the cropping season 2017-2018. The findings revealed that corm size has a significant impact on saffron yield and there is no flowering observed in smaller corms in either year. These findings are inconsistent with those of Molina et al., [8] and Gresta et al., [22] who found that corm size is an important factor in determining a bulbous plant's ability to flower and produce a higher yield. It is heavily influenced by corm dimension, as large corms with appropriate spacing and management practices increased flower number and yield significantly. Large corm size (8-12cm) yields 1.81g/m^2 in the first season and 1.53g/m^2 in the second season, with yield decreasing as corm size decreases.

Table 2. Saffron yield (g/m^2) result values during cropping season 2017-18

Corm Size(cm)	2017	2018	Combined values
8-12	1.81 a	1.53 a	1.67
6-8	0.28 b	0.26 b	0.27
4-6	0.00 c	0.00 c	0.00
Mean	1.90	0.60	
LSD (5%)	0.076**	0.076**	

Significance at a level of 1%

Corm yield (g/m^2)

Corm size had a positive impact on yield and it was discovered that a large corm index (8-12cm size) remarkably increased both the number of corms as well as saffron yield. Mother corms typically give rise to 4-6 daughter corms of adequate size, if properly nourished with fertilizers and managed by following the proper guidelines of cultural practices of saffron production given by SKUAST Kashmir. Corm size has a significant impact on yield and varies in coming years as shown in Table 3. The corm size (8-12cm) gives the maximum yield, followed by the subsequent small-sized corms, and size gradually decreases in both growing seasons. Corm yield of 3426g/m^2 was obtained in the first growing season from a big corm size of 8-12cm, followed by 3108g/m^2 in the second growing season. Corm yields of 2217g/m^2 and 2101g/m^2

were obtained from small corm sizes (6-8 cm). As shown in table 2, the lowest yield there was obtained from

Table 3. Corm yield (g/m^2) values obtained during cropping seasons 2017-18

Corm Size(cm)	2017	2018	Combined values
8-12	3426 a	3108 a	3267
6-8	2217 b	2101 b	2159
4-6	1765 c	1634 c	1699.5
Mean	2469.33	2281	
LSD (5%)	137.7**	139.4**	

Significance at a level of 1%

corm sizes of 4-6cm, 1765g/m^2 (in 2017), and 1634g/m^2 (in 2018). These findings are consistent with those of Mohammad et al., [23] who reported that a big corm index gives rise to a large number of daughter corms with adequate size and a higher saffron yield. According to Gresta et al., [22] big mother corms increase the total weight of daughter corms by 16.6%.

Big corm Inde

The number of corms produced by a mother corm depends on its size during each cropping season. In both cropping seasons, the maximum number of corms (8-12cm) are produced, then a reduction in number as the size is reduced. Table 4 shows that corm sizes of 4-6cm yielded the lowest number of corms (1-2) with low weight.

Table 4. Big corm index values obtained during cropping season 2017-18

Corm Size(cm)	2017	2018	Combined values
8-12	5.32 a	4.71 a	5.01
6-8	3.12 b	2.87 b	2.99
4-6	1.67 c	1.37 c	1.52
Mean	3.34	2.98	
LSD (5%)	0.31**	139.4**	

Significance at a level of 1%

The phenotypic variance estimates were higher than the genotypic variance estimates, indicating a strong influence of environment on the expression of the studied traits. Estimates of phenotypic and genotypic coefficients among characters are useful in the planning and evaluation of breeding programs described by Johnson et al., [24] and Al-Jibouri et al., [15]. Yield is affected by environmental factors and has a complex mode of inheritance with low heritability. However, most yield components are highly correlated with yield, which naturally leads to higher yield and has significantly higher heritability through the selection of the best progenies for greater reliability. Saffron grown in the temperate conditions of Kashmir Valley showed a wide range of variability in corm attributes, implying that there is a lot of scope for saffron improvement. The data recorded for variability in saffron germplasm due to geographical distribution shows that saffron germplasm collected from the valley had the greatest range of variability present. Some accessions were observed that their flowers bear 4 and 5 stigmas but were entirely devoid of style and anthers. And the reason for the presence of more stigmas per flower is due to physiological or developmental anomalies. Furthermore, it has been observed that the larger the corm size, the bigger the flower, which implies maximum pistil length and therefore results in a higher saffron yield. These findings are consistent with Nehvi et al., [25-27]. The coefficient of variation, based on phenotypic and genotypic values was calculated in this study and it has been observed that any improvement in the yield component enhances saffron yield directly or indirectly as a genotypic coefficient of variation was consistently greater than the phenotypic coefficient of variation as shown in Table 5.

In general, based on the studied objectives and assessments of the genotypic coefficient of variation as well as genetic parameters, it can be concluded that traits like the big corm index (BCI), and multiplication index (MI) were the most effective and had the greatest positive impact on saffron yield. As a result, the phenotypic selection of saffron ecotypes for this trait will increase saffron yield to a greater extent. This finding is consistent with the findings of earlier studies by Bayat et al., [28].

Table 5. Estimation of Phenotypic, genotypic variability for corm attributes of Saffron (*Crocus sativus* L.) during cropping season 2017-18

SN.	Characters	Phenotypic variance (δ2 P)	Genotypic variance (δ2g)	Phenotypic coefficient of variation (PCV)	Genotypic coefficient of variation (GCV)
1	Big corm index (g)	6.00-15.33	10.42	12.53	0.75
2	Multiplication index	3.00-5.00	3.80	30.84	0.67
3	50% sprouting	22.00-134.00	128.16	0.92	0.68

Conclusion

According to the findings, a wide range of variability exists in the natural population of saffron, as illustrated by the amplitude of performance, and phenotypic and genotypic coefficient of variation implying the significant potential for saffron improvement through clonal selection. Big corm index and multiplication index are critical attributes to consider when selecting for higher saffron yield. Such characteristics, which can be used as selection criteria, could be utilized as a source of elite genetic resources for crop improvement.

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