**Original Research Article**

# Genetic variability studies on morphological characterization for floral, vegetative and corm attributes of saffron (*Crocus sativus* L.)

## Abstract

A study on genetic variability among selected lines of saffron was conducted at Advanced Research Station for Saffron and Seed Spices (ARSSSS), Dusso Konibal, Pampore, SKUAST-Kashmir during cropping season 2017-18. The "Saffron (*Crocus sativus* L.)" germplasm was evaluated to collect data on genetic variability for 18 floral, vegetative and corm traits and data were recorded on 10 randomly selected and tagged competitive plants. The traits studied are given as; number of flowers corm$^{-1}$line$^{-1}$, number of days to 50% flowering, fresh flower weight corm$^{-1}$line$^{-1}$, inner tepal length, outer tepal length, inner tepal width, outer tepal width, anther length, anther width, style length, stigma length, fresh pistil weight corm$^{-1}$line$^{-1}$, dry pistil weight corm$^{-1}$line$^{-1}$, leaf length, number of leaves corm$^{-1}$, number of days to 50% sprouting, Big Corm Index, Multiplication Index. It was observed that there were significant variations among populations for all the traits studied, number of flowers corm$^{-1}$line$^{-1}$ (5.04-37.67), fresh pistil weight corm$^{-1}$line$^{-1}$ (106.78- 1301.12mg), stigma length (2.66-4.26cm), leaf length (17.11-38.15cm), multiplication index (3.08-5.01), number of leaves corm$^{-1}$line$^{-1}$ (7.06-12.45), fresh flower weight corm$^{-1}$line$^{-1}$(1.89-13.37mg) indicating presence of high level of variability and therefore imply considerable scope for saffron improvement through clonal selection. Estimates of genotypic variance were higher than the corresponding estimates of phenotypic variance, and the genotypic coefficient of variation (GCV) was greater than the phenotypic coefficient of variation (PCV) thereby revealing minimum influence of environment in the expression of the traits studied except dry pistil weight and stigma length ( actual economic part) which reveals higher phenotypic variance and phenotypic coefficient of variation (PCV) thereby revealing strong influence of these environment on these two parameters Therefore, the selection of ecotypes based on phenotypic values can be a perfect criterion for selection for genetic advancement and therefore needs to be more focused and made selection based on these two parameters could be a good idea in economic point of view. Based on variability studies, it can be paramount in understanding the extent of variability and possibilities of its future utilization in subsequent breeding programme.

**Keyword:** *Crocus sativus* L., variability divergence, genetic, variability.

### Introduction

Saffron (*Crocus sativus* L.) which belongs to family *Iridaceae* is the most expensive spice in the world and is popularly known as the "Golden Condiment". In India it is a legendary crop of Jammu and Kashmir, produced on well drained karewa soils, where ideal climatic conditions are available for good shoot growth and flower production. The genus *Crocus* includes native species from Europe, North Africa and temperate Asia, and is especially well represented in arid countries of south-eastern Europe and Western and Central Asia. Dried stigmas of saffron flowers compose the most expensive spice which has been valuable since ancient times for its odoriferous, coloring and medicinal properties (Plessner *et al*., 1989). Saffron is a sterile triploid plant that is propagated by corms as the propagation through seed is impossible due to non setting of seeds. The possibility of saffron genetic improvement is indicated through clonal selection from the available germplasm resources.

Identification of these elite genotypes with distinct superiority in yield and corm attributes can be used as a source for further improvement and development of high yielding varieties which would be beneficial for saffron industry in Jammu and Kashmir. Development of varieties from the identified germplasm resources, exhibiting high yielding potential and quality will boost the production and productivity of saffron in Jammu and Kashmir and improve the socio-economic condition of the people associated with this important commercial crop. Development of varieties from the identified germplasm resources, exhibiting high yielding potential and quality will boost the production and productivity of saffron in Jammu and Kashmir and improve the socio-economic condition of the people associated with this important commercial crop.

## Materials and methods

Saffron corms weighing 5g to 16g were planted in Augmented Block Design, for daughter corm production under annual planting cycle. Corms were planted under each category supplemented with adequate nutrients as per the recommendations of SKUAST-K, Shalimar. The present investigation was carried out at Advanced Research Station for Saffron and Seed Spices (ARSSSS), Dusso Konibal, Pampore, SKUAST-Kashmir during cropping season 2017-18. The experimental site is located at $34^0$N latitude, $74^0$E longitude and about 1650 m a.s.l and 29 km away from main campus of the University at Shalimar, Srinagar. The material for study comprised of 50 saffron germplasm lines collected from different saffron growing areas of Kashmir and abroad. The pedigree details of all the 50 corm samples was recorded and subsequently planted in Augmented Block Design with a row length of 3m, width 2m and inter and intra-row spacing of 20 and 10 cms, respectively. Observations were recorded on 10 randomly selected and tagged competitive plants from each line for all the traits.

**Floral attributes**: Number of flowers corm$^{-1}$line$^{-1}$, number of days to 50% flowering, fresh flower weight corm$^{-1}$line$^{-1}$ (mg), inner tepal length (cm), outer tepal length (cm), inner tepal width (cm), outer tepal width (cm), anther length (cm), anther width (mm), style length (cm), stigma length (cm), fresh pistil weight corm$^{-1}$line$^{-1}$ (mg), dry pistil weight corm$^{-1}$line$^{-1}$ (mg).

**Vegetative parameters**: Leaf length (cm), No. of leaves corm$^{-1}$ line$^{-1}$.
[The length and weight of above given traits for floral and vegetative attributes were measured with the help of measuring scale and small digital weighing balance. Similarly for other traits like number of flowers corm$^{-1}$line$^{-1}$ (data were recorded early in the morning at flowering period) and number of leaves corm$^{-1}$ line$^{-1}$ (at 80% maturity stage) was counted and averaged to single plant basis].

**Corm attributes**: No. of days to 50% sprouting, Big Corm Index, Multiplication Index.
[Big Corm Index data was recorded by taking the weight of daughter corms (g) for all the tagged plants and averaged to single corm basis, similarly multiplication Index was recorded by counting the

number of daughter corms produced by the representative tagged mother plants and was averaged to single corm basis].

Mean values for all the characters were estimated for analysis of variance (Verma *et al.* 1987; Singh and Chaudhary, 1985) and Character association at genotypic and phenotypic level (Al Jibouri, *et al*., 1958).

**Results and Discussion**

Genetic variability assists a great deal in detecting the range of genetic diversity for various traits in population (Singh *et al*., 2004). Components of phenotypic and genotypic variability indicated that a wide range of variability existed for all the traits studied. Outer tepal length ranged from (4.19-5.35cm) with a mean value of 4.77, inner tepal length (3.54-3.98cm), with a mean value of 3.76, outer tepal width (3.55-3.99cm) with a mean value of 3.77, inner tepal width (1.65-2.11cm) with a mean value of 1.74, anther length (1.44-3.12cm) with a mean value of 2.28 and anther width (1.65-4.18mm) with a mean value of 2.92, these results were found in conformity with the reports of Latto and Dhar (1999), Zargar (1999), Gohill (1999). Similarly for stigma length the values ranged from (2.66-4.26cm) with a mean value of 3.46, style length (2.45-7.23cm) with a mean value of 4.184, leaf length (17.11-38.15cm) with a mean value of 27.63, similar results were found by Zargar (2002) and Sheikh *et al* (2014). Number of leaves corm$^{-1}$line$^{-1}$ (7.06-12.45) with a mean value of 9.75, number of flowers corm$^{-1}$ line$^{-1}$ (5.04-37.67) with a mean value of 21.35, fresh flower weight corm$^{-1}$ line (1.89-13.37g) with a mean value of 7.63, fresh pistil weight corm$^{-1}$line$^{-1}$ (106.78-1301.12mg) with a mean value of 703.95, dry pistil weight corm$^{-1}$line$^{-1}$ (26.99-987.35mg) with a mean value of 507.17, 50% flowering (72.32-78.25) with a mean value of 75.29. These results are in conformity with the report of Makhdoomi *et al.* (2010). Corm traits like Big corm index ranges from (6.02-14.39) with a mean value of 10.21, multiplication index (3.08-5.01) with a mean value of 4.54 and 50% sprouting (23.03-138.01) with a mean value of 80.52 and all these above given traits are shown in (Table 2). The study suggests that there is an ample scope for saffron genetic improvement through selection of superior genotypes from the heterogeneous saffron populations. For floral attributes viz, outer tepal length, inner tepal length, outer tepal width, inner tepal width, anther length, anther width indicates less range of variability and this fact is supported by the data as the estimates of genotypic variances ($\sigma^2$g) and genotypic coefficient of variation (GCV) values are a bit higher than phenotypic variances ($\sigma^2$p) and phenotypic coefficient of variation (PCV) values. As GCV is higher, it means the environmental influence is very minimal. Hence their range is narrow. However for other traits like Stigma length and Dry pistil weight shows higher phenotypic coefficient of variation than genotypic coefficient of variation, thereby revealing a strong influence of environment in the expression of these two (2) traits studied. Estimates of phenotypic and genotypic correlation coefficient among the characters have been found useful in planning and evaluating breeding programme (Johnson *et al*., 1955; Al-Jibouri *et al.*, 1958). Genotypic correlation coefficient measures genetic association among the characters to identify characters that could be useful in selection programme. At phenotypic and genotypic level, dry pistil weight (economic part) exhibited a significant positive correlation with all the traits studied. The results clearly reveal a scope for simultaneous improvements of this important trait through selection. If we talk about yield, it is influenced by environmental conditions and shows complex mode for inheritance and has low heritability (Bo´canski *et al.*, 2009). However, most of the yield components which naturally leads to using some other trait that is highly correlated with yield and has a much higher heritability through selection of the best progenies for more reliability (Bekavac *et al.*, 2008, Vasic *et al.*, 2001). In this study, to assess the phenotypic and genotypic coefficient of variation between studied traits, as shown in (Table 1) results showed that the saffron yield is strongly influenced by these traits. These findings are in conformity with Gresta *et al.*, 2009. Therefore, any increase in the yield components improved saffron yield directly and indirectly. It was notable in this study that in most cases the genotypic coefficients of variation (GCV) were larger than the phenotypic coefficient of variation (PCV) except two traits stigma length and dry pistil weight. This finding is in agreement with the results of previous studies of Singh *et al.* (2003, 2004). Saffron under temperate conditions of Kashmir Valley reported wide spectrum of variability for floral, vegetative and corm attributes and the results implied a great scope for saffron improvement. Fresh flower weight, number of flowers corm$^{-1}$ and saffron recovery per flower were observed to help as selection index for increasing saffron yield. Valley exhibited highest range of variability in saffron germplasm. It has been observed from available germplasm under study that some flowers have four and five stigmas. The presence of higher number of stigmas per flower may be due to physiological or developmental irregularities leading to four or five stigmas. These results are in conformity with Nehvi *et al.* (2003, 2004 and 2006). The phenotypic and genotypic variations between different saffron ecotypes and the phenotypic/genotypic relationships between yield and yield components of saffron were measured such as: fresh pistil weight, dry pistil weight and stigma length. The results showed that genetic variances were much higher than phenotypic variances for most of the traits. And also these traits show highest genetic diversity. Therefore, with the phenotypic selection of saffron ecotypes in respect of these traits the saffron yield can be increased. These findings are in agreement with the results of previous studies of Bayat *et al.* (2016).

**Table 1. Estimates of Phenotypic variance ($\delta^2$ p), genotypic variance($\delta^2$ g), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) for morphological and corm attributes of Saffron (*Crocus sativus* L.)**

| S. No. | Characters | Phenotypic variance ($\delta^2$ P) | Genotypic variance ($\delta^2$g) | Phenotypic coefficient of variation (PCV) | Genotypic coefficient of variation (GCV) |
|---|---|---|---|---|---|
| 1 | **Outer tepal length** | **0.017** | **0.054** | **3.32** | **6.34** |
| 2 | **Inner tepal length** | **0.018** | **0.021** | **4.01** | **4.13** |
| 3 | **Outer tepal width** | **0.015** | **0.017** | **3.35** | **3.55** |
| 4 | **Inner tepal width** | **0.014** | **0.018** | **6.98** | **7.03** |
| 5 | **Stigma length** | **0.22** | **0.29** | **13.61** | **12.93** |
| 6 | **Style length** | **0.56** | **0.59** | **15.74** | **16.10** |
| 7 | **Leaf length** | **10.78** | **12.88** | **13.31** | **13.96** |
| 8 | **Number of leaves per corm** | **0.99** | **2.98** | **13.67** | **21.23** |
| 9 | **Number of flowers per corm per line** | **32.81** | **35.68** | **37.66** | **39.45** |
| 10 | **Fresh Flower weight corm$^{-1}$ line$^{-1}$** | **8.058** | **9.65** | **44.67** | **45.89** |
| 11 | **Big corm index** | **6.37** | **8.069** | **23.27** | **26.67** |
| 12 | **Multiplication index** | **0.19** | **1.54** | **11.56** | **31.12** |
| 13 | **Fresh pistil weight** | **48854.13** | **49342.78** | **47.28** | **47.87** |
| 14 | **Dry pistil weight** | **6858.67** | **9854.25** | **92.23** | **72.94** |
| 15 | **Anther length** | **0.096** | **0.099** | **14.87** | **14.94** |
| 16 | **Anther width** | **0.315** | **0.39** | **25.67** | **26.87** |
| 17 | **50% flowering** | **2.34** | **4.890** | **2.34** | **2.98** |
| 18 | **50% sprouting** | **2.78** | **12.11** | **2.56** | **2.87** |

**Table 2. Magnitude of variability for different floral, vegetative and corm attributes in saffron (*Crocus sativus* L.).**

| S. No. | Characters | Range | Mean | C.V. | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|
| 1 | Outer tepal length (cm) | 4.19-5.35 | 4.77 | 4.83 | 0.12 | 0.34 |
| 2 | Inner tepal length (cm) | 3.54-3.98 | 3.76 | 0.53 | 0.02 | 0.04 |
| 3 | Outer tepal width (cm) | 3.55-3.99 | 3.77 | 0.44 | 0.03 | 0.03 |
| 4 | Inner tepal width (cm) | 1.65-2.11 | 1.74 | 1.12 | 0.02 | 0.04 |
| 5 | Stigma length (cm) | 2.66-4.26 | 3.46 | 4.05 | 0.09 | 0.25 |
| 6 | Style length (cm) | 2.45-7.23 | 4.84 | 0.73 | 0.03 | 0.06 |
| 7 | Leaf length (cm) | 17.11-38.15 | 27.63 | 3.72 | 0.61 | 1.69 |
| 8 | Number of leaves corm$^{-1}$line$^{-1}$ | 7.06-12.45 | 9.75 | 16.01 | 0.83 | 2.32 |
| 9 | Number of flowers corm$^{-1}$ line$^{-1}$ | 5.04-37.67 | 21.35 | 8.78 | 0.79 | 2.19 |
| 10 | Fresh Flower weight corm$^{-1}$ line$^{-1}$ | 1.89-13.37 | 7.63 | 7.52 | 0.32 | 0.89 |
| 11 | Big corm index (g) | 6.02-14.39 | 10.21 | 12.51 | 0.77 | 2.12 |
| 12 | Multiplication index | 3.08-5.01 | 4.54 | 30.71 | 0.69 | 1.09 |
| 13 | Fresh pistil weight corm$^{-1}$line$^{-1}$ (mg) | 106.78-1301.12 | 703.95 | 4.86 | 13.84 | 38.66 |
| 14 | Dry pistil weight corm$^{-1}$line$^{-1}$ (mg) | 26.99-987.35 | 507.17 | 58.69 | 38.94 | 108.39 |
| 15 | Anther length (cm) | 1.44-3.12 | 2.28 | 1.03 | 0.03 | 0.07 |
| 16 | Anther width (mm) | 1.65-4.18 | 2.92 | 6.95 | 0.11 | 0.29 |
| 17 | 50% flowering | 72.32-78.25 | 75.29 | 1.83 | 0.79 | 2.23 |
| 18 | 50% sprouting | 23.03-138.01 | 80.52 | 0.91 | 0.69 | 1.94 |

## Conclusion

Based on the results of the investigation, wide range of variability exists in the natural population of saffron as indicated by the magnitude of performance, phenotypic and genotypic coefficient of variation, implying considerable scope for saffron improvement through clonal selection. Number of flowers corm$^{-1}$ and stigma length are the important traits for which due emphasis should be given while selecting for high saffron yield with better quality. Therefore, such characters can be taken as criteria in selection for divergent lines and could be used as a source of elite genetic resource for of new varieties.

## References


Al-Jibouri, H. A., Miller, P. A. and Robinson, H. F. (1958). Genetic and environmental variances and co- variances in an upland cotton cross of interspecific origin. *Agronomy Journal***50**: 633- 636.

Bayat, Mahdi., Reza, Amirnia. and Mehdi, Rahimi. (2016). Phenotypic and genotypic relationship between traits in saffron (*Crocus sativus* L.) as revealed by path analysis. *Journal of Applied Research on Medicinal and Aromatic Plants* 5: 33-40.

Bekavac, G., Purar, B. and Jockovic, D. (2008). Relationships between line per se and testcross performance for agronomic traits in two broad-based populations of maize. *Euphytica***162**: 363-369.

Bo' Canski, J., Sreckov, Z. and Nastasic, A. (2009). Genetic and phenotypic relationship between grain yield and components of grain yield of maize (*Zea mays* L.). *Genetika* **41**: 145-154.

F. A. Sheikh, M. I. Makhdoomi, Gowher Ali, F. a. Nehvi, Ajaz, A. Lone., Gul, Zaffar and Asif, M. Iqbal (2014). Genetic variability in saffron (*Crocus sativus* L.) clones. *Medicinal Plants* **6**(3).

Gohill, R. N. (1999). Need for Analysis and Generating Genetic Variability in Saffron. *Proceedings of National Symposium on Saffron*. November 25-26, RRL Jammu. pp 42.

Gresta, F., Avola, G., Lombardo, G., Siracusa, L. and Ruberto, G. (2009). Analysis of Flowering: Stigma Yield and Qualitative Traits of Saffron (*Crocus sativus* L.) as affected by environmental conditions. *Scientia Horticulturae* **119**: 320-324.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. (1955). Estimation of Genetic and Environmental Variability in Soybeans. *Agronomy Journal*. **47**: 314-318.

Latto, S. K. A. and Dhar, A. K. (1999). Studies on Saffron in Kashmir, Variation Pattern in Floral Characters in Saffron. *Proceedings of National Symposium on Saffron*. November 25-26, RRL Jammu. pp 38.

Makhdoomi, M. I., Nehvi, F. A. and Wani. S. A. (2010). Genetic Divergence in Saffron. Proceedings of International Seminar on Saffron. *Acta Horticulturae* **850**: 79-81.

Nehvi, F. A. (2003). Problems and Prospects of Saffron improvement in India. *In: Proceedings of the Second International Seminar on Industrial use of Biotechnology,* 27th September-1st October, Iran , 14pp.

Nehvi, F. A. (2004). Success stories of Saffron Research under temperate conditions of Kashmir. National Agriculture Technology Project (NATP) report, SKUAST-K, India, 28pp.

Nehvi, F. A., Wani, S. A., Dar, S. A., Makhdoomi, M. I., Allie, B. A. and Mir, Z. A. (2006). New Emerging Trends on Production Technology of Saffron. *Proceedings of the Second International Symposium on Saffron Biology and Biotechnology* 28-30 October 2006. Islamic Republic of Iran, pp. 401-408.

Plessner, O., Negbi, M., Ziv, M. and Baske, D. (1989). Effect of temperature on flowering of saffron crocus (*Crocus sativus* L.): induction of hysteranthy. *Israel Journal of Botany* **38**: 1-7.

Singh, R. K. and Chaudhary, B. D. (1985). Biometrical methods in quantitative genetic analysis. Kalyani Publishers, Ludhiana, New Delhi, pp 54-57.

Singh, R. K., Sharma, R. K., Singh, A. K., Singh, V. P., Singh, N. K., Tiwari, S. P. and Mohapatra, T. (2004). Suitability of Mapped Sequence tagged Microsatellite site Markers for establishing Distinctness, Uniformity and Stability in Aromatic Rice. *Euphytica* **135**: 135-143.

Singh., Mahak., Srivastava., R. I. Prasad, Lata, and Dixit, R. K. (2003). Studies on Heritability and Genetic Advance in Indian Mustard (*Brassica juncea*). *International Journal of Advanced Science and Research* **16**: 263-266.

Vasic, N., Ivanovic, M., Peternelli, L., Jockovic, D., Stojakovic, M. and Bocanski, J., (2001). Genetic Relationships between Grain Yield and Yield Components in a Synthetic Maize Population and their Implications in Selection. *Acta Agronomica* Hung **49**: 337-342.

Verma, P. R., Yikbarek, S. M. and Morrall, R. A.(1987). Anastomosis groups, Pathogenicity and Specificity of *Rhizoctonia solani* isolates from seedling and adult rapeseed/canola plants and soils in Saskatchewan. *Journal of Plant Pathology* **9**: 6-13.

Zargar, G. H. (1999). Status of Saffron Cultivation in Kashmir and Strategies for Improving Productivity through Crop Improvement. *Proceedings of National Symposium on Saffron*. November 25-26, RRL Jammu. pp 26.

Zargar, G. H. (2002). Genetic variation in saffron and importance of quality seed corms. National Seminar cum Workshop Srinagar, August, 2002.