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EVALUATION OF THE ORNAMENTAL ASPECT ON CROCUS BASED ON FLOWERS SIZE

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Abstract

The present study evaluated the size of crocus flowers as an element of ornamental quality, depending on the biometric parameters of the plants, against the background of different growing substrates. Two types of crocus were studied: "Queen of the Blues" crocus and "Yellow" crocus. The plants were evaluated in terms of height (Ph, cm) at the beginning of flowering (Ph B-Flo) and at the end of flowering (Ph E-Flo). The size of the flowers (Fs) was evaluated based on the diameter (Fs, cm). Three different substrates were used: sand (V1), mixture of sand and compost (V2) and soil (V3). The bulbs were planted at t1 - mid-October (a), t2 - early November (b), and t3 - mid-November (c). There were 9 experimental variants: V1a - sand at t1; V2a - sand and compost at t1; V3a - soil at t1; V1b– sand at t2; V2b - sand and compost at t2; V3b - soil at t2; V1c - sand at t3; V2c - sand and compost at t3; V3c - soil at t3. The size of the flowers (Fs) varied between 3.97 cm (V1c) and 5.07 cm (V2a) in "Queen of the Blue", respectively between 3.83 cm (V1c) and 4.07 cm (V2b) in "Yellow" crocus. 3D models and in the form of isoquants graphically represented the variation of Fs depending on the physiological parameters (Ph B-Flo and Ph E-Flo). The fs estimation safety was quantified by evaluating the degree of fit between the true values (RFs) and the predicted values (PFs). PC1 explained 79.234% of variance, and PC2 explained 19.046% of variance in the case of the "Queen of the Blues" crocus, and in the case of Yellow crocus, PC1 explained 88.851% of variance, and PC2 explained 8.8951% of variance.

Key words: *crocus, flower size, model, ornamental aspect, physiological parameter*

INTRODUCTION

The genus Crocus, Family *Iridaceae*, includes approx. 100 different plant species, throughout the world [26], many of which are found in culture, especially for pharmaceutical and medicinal purposes, but also for food industry (eg aroma, color, flavor), and in the fabric and paper coloring industry [14], [4], [1], [21], [7].

Crocus has been studied from various perspectives, such as genetic diversity and physiological specificity [3], [20], evolutionary aspects and botany, taxonomy, cytology, cultural, economic, phytopharmaceutical importance [24], [29], [13], [25].

The biology of crocus flowers has been studied in relation to various ecological factors of influence, such as thermal conditions and water regime [17], [29].

In relation to the field of interest, the quality of crocus flowers has been studied in relation to the content of bioactive compounds [27], [18].

The improvement of crocus quality has been studied for medicinal and pharmaceutical purposes, in relation to the content of active principles, under the influence of various treatments and biopreparations applied to the plants, as elements in cultivation technology [21].

The plant growth media has a significant importance on plants, in relation to soil or substrate type, and morphological, physicochemical and biological properties, respectively different factors of influence [23].

The processes of physiological growth and corm formation in crocus have been studied in relation to certain substrates in protected space conditions (greenhouse), and a significant influence of the substrate has been found [28]. The study authors reported the favorable, significant influence of manure on flower size and stigma weight, and the results as a whole confirmed the great importance of the substrate on flower formation in crocus. Corm quality and some morphological aspects of crocus were evaluated in relation to the soil and perlite substrate as plant cultivation media [11]. The authors recorded the differentiated influence of the substrate, in relation to certain parameters analyzed in plants.

Other studies have looked at fresh crocus flowers and stigmas from a production perspective in relation to bulb size and production cycle (1 to 3 years) [6].

Corm size, cultivation conditions, and stress factors (eg water stress) were elements in relation to which photosynthesis and crocus biomass production were evaluated during the vegetation period [22].

The production and quality of saffron flowers were also evaluated in relation to different systems and methods of cultivation [2] and agro-climatic conditions [15].

Various studies have been carried out for plant breeding in crocus, for ornamental purposes have followed the quality of plants, flowers in terms of color, shape, size, duration of flowering [10]. The quality of flowers in terms of color in yellow crocus species, compared to purple and white were studied in relation to UV models [16].

The present study evaluated the size of the flowers, as an element of ornamental quality in the crocus, depending on the biometric parameters of the plants, on the background of different growth substrates.

MATERIALS AND METHODS

The ornamental aspect of the crocus was evaluated based on the size of the flowers, in relation to the physiological parameters of the plants. Two types of crocus were studied: "Queen of the Blues" crocus and "Yellow" crocus, Figure 1.

Fig. 1. Aspects of crocus plants under cultivation conditions, spring 2021
Source: Original figure, authors' photo.

The plants were evaluated in terms of height (Ph, cm) at the beginning of flowering (Ph B-Flo) and at the end of flowering (E-Flo).

Flower size (Fs) was evaluated based on flower diameter (Fs, cm).

Crocus bulbs were planted on three different substrates: sand (V1), a mixture of sand and compost (V2) and soil (V3). Planting was done at three different times: t1 - mid-October (a), t2 - early November (b) and t3 - mid-November (c). From the combination of the two elements, given by the substrate and the moment of planting, resulted 9 experimental variants: V1a - sand at t1; V2a - sand and compost at t1; V3a - soil at t1; V1b– sand at t2; V2b - sand and compost at t2; V3b - soil at t2; V1c - sand at t3; V2c - sand and compost at t3; V3c - soil at t3.

Experimental data were processed statistically appropriately to assess the presence of the variance, the degree of statistical safety (p, R^2), and the differences between the variants, on each type of crocus studied. PAST software [9] and Wolfram Alpha [30] application were used.

RESULTS AND DISCUSSIONS

By planting crocus bulbs in the two types studied, "Queen of the Blues" crocus and "Yellow" crocus, on substrates and at different times, the biological material benefited from different growth conditions. In the spring, the height of the plants was determined at the beginning of flowering (Ph B-Flo) and at the end of flowering (Ph E-Flo). The size of the flowers (Fs) on each variant was also determined. The data on vegetative parameters and flower quality are presented in Table 1.

Table 1. Average values of vegetative parameters and crocus flower size

Experimental Variant	"Queen of the Blues"			"Yellow"		
	Ph		Fs	Ph		Fs
	(cm)					
	B-Flo	E-Flo	BC-Fs	B-Flo	E-Flo	YC-Fs
V1a	10.14	15.03	4.26	10.69	15.24	3.93
V2a	11.69	15.17	5.07	11.83	16.15	4.01
V3a	11.65	15.08	5.00	11.58	15.78	3.96
V1b	10.50	14.63	4.18	10.40	14.93	3.92
V2b	11.39	15.01	4.76	11.28	16.07	4.07
V3b	11.15	14.85	4.44	11.22	15.49	3.95
V1c	10.48	14.19	3.97	10.28	14.45	3.83
V2c	11.29	14.91	4.69	11.17	15.17	3.96
V3c	11.07	14.25	4.58	10.97	14.73	3.91

Source: Original data from experimental conditions.

The graphical representation of the flower size, as average values, in direct relation with Ph B-Flo and Ph E-Flo, for the two types of crocus studied, is shown in Figures 2 and 3.

Regression analysis was used to evaluate the variation of flower size (Fs) in relation to the vegetative parameters of the plants considered, respectively the height of the plants before flowering (Ph B-Flo) and the height of the plants at the end of flowering (Ph E-Flo).

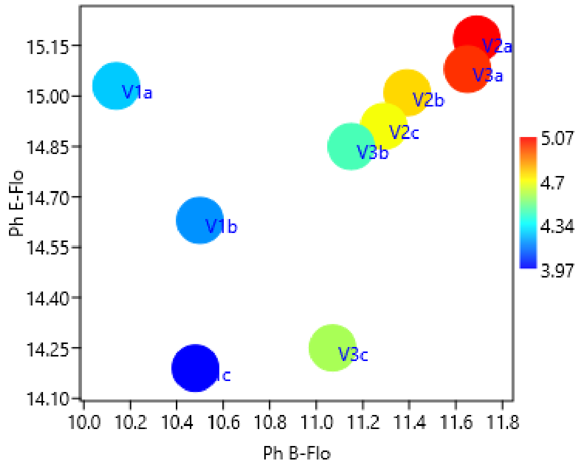

Fig. 2. Flower size of "Queen of the Blues" crocus (average values) in relation to Ph B-Flo (x-axis) and Ph E-Flo (y-axis)
Source: Original figure, based on data analysis.

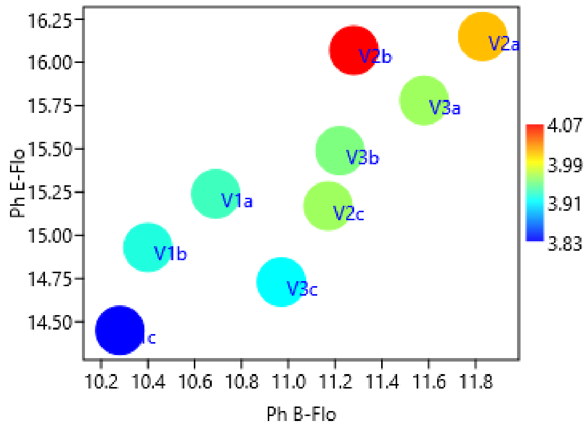

Fig. 3. Flower size of "Yellow" crocus (average values) in relation to Ph B-Flo (x-axis) and Ph E-Flo (y-axis)
Source: Original figure, based on data analysis

Thus, the variation in flower size was described by equation (1) for "Queen of the Blues" crocus, and equation (2) for "Yellow" crocus, in general statistical safety conditions ($R^2 = 0.999$, $p < 0.001$).

The graphical distribution regarding the Fs variation in relation to the physiological parameters of the plants (Ph B-Flo, and Ph E-Flo) is shown in the form of 3D model and in the form of isoquants in figures 4 and 5 for "Queen of the Blues" crocus, and respectively in figures 6 and 7 for "Yellow" crocus.

$$Fs_{QB} = a\,x^2 + b\,y^2 + c\,x + d\,y + e\,xy + f \qquad (1)$$

where: Fs_{QB} - flower size of the "Queen of the Blues" crocus (cm);
x – plant height at the beginning of flowering (Ph B-Flo);
y – plant height at the end of flowering (Ph E-Flo);
a, b, c, d, e, f – coefficients of the equation (1);
a = 0.53218659
b = 0.21095152
c = -1.24302600
d = 0.95127036
e = -0.65479873
f = 0

$$Fs_{Y} = a\,x^2 + b\,y^2 + c\,x + d\,y + e\,xy + f \qquad (2)$$

where: Fs_Y - flower size of the "Yellow" crocus (cm);
x – plant height at the beginning of flowering (Ph B-Flo)
y – plant height at the end of flowering (Ph E-Flo);
a, b, c, d, e, f – coefficients of the equation (2);
a = 0.26431630
b = 0.20766234
c = 1.68881901
d = -0.81194304
e = -0.49207633
f = 0

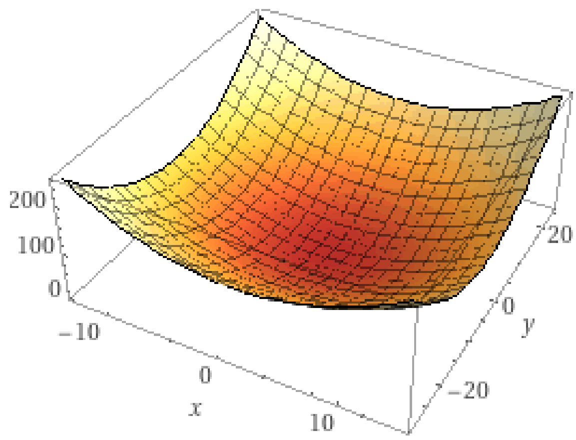

Fig. 4. 3D model of flower size variation in relation to Ph B-Flo (x-axis) and Ph E-Flo (y-axis), "Queen of the Blues" crocus
Source: Original figure generated based on experimental data.

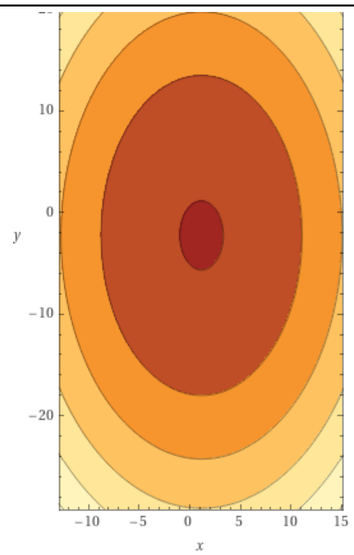

Fig. 5. Model of flower size variation, in the form of isoquants, in relation to Ph B-Flo (x-axis) and Ph E-Flo (y-axis), "Queen of the Blues" crocus
Source: Original figure generated based on experimental data

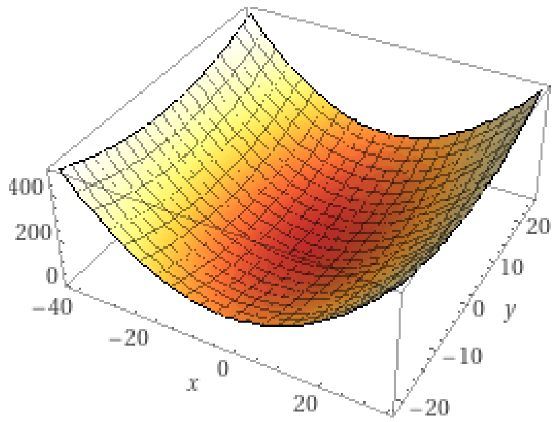

Fig. 6. 3D model of flower size variation in relation to Ph B-Flo (x-axis) and Ph E-Flo (y-axis), "Yellow" crocus
Source: Original figure generated based on experimental data.

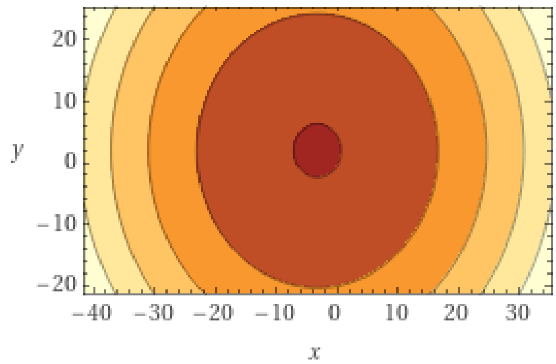

Fig. 7. Model of flower size variation, in the form of isoquants, in relation to Ph B-Flo (x-axis) and Ph E-Flo (y-axis), "Yellow" crocus
Source: Original figure generated based on experimental data.

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The safety of estimating Fs was analyzed by assessing the degree of fit between the actual values (RFs) and the estimated values (PFs) for each of the two types of crocus studied.

In the case of "Queen of the Blues" crocus, the linear equation (3) described the fit between the two data series (average values), and the graphical representation is shown in Figure 8.

$$PFs = 0.9815 \cdot RFs + 0.084 \tag{3}$$

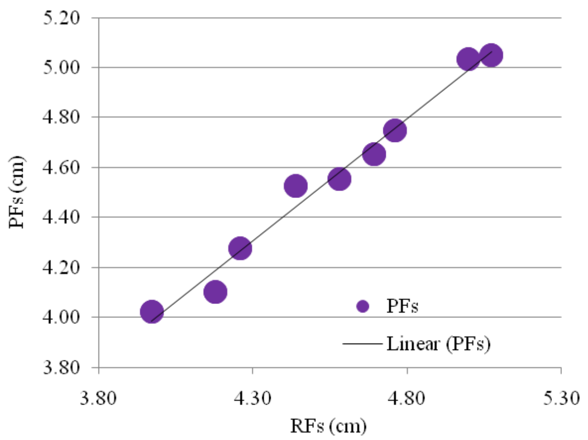

Fig. 8. The fit line between RFs and PFS in the case of the "Queen of the Blues" crocus
Source: Original figure generated based on experimental data.

In the case of "Yellow" crocus, the linear equation (4) described the fit between the two data series RFs and PFs (average values), and the graphical representation is shown in Figure 9.

$$PFs = 0.9576 \cdot RFs + 0.1674 \tag{4}$$

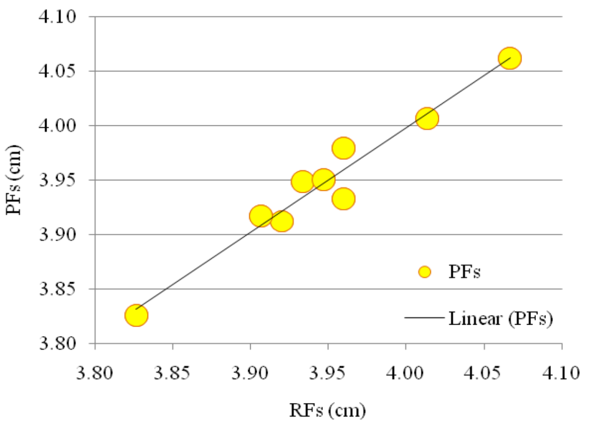

Fig. 9. The fit line between RFs and PFS in the case of the "Yellow" crocus
Source: Original figure generated based on experimental data.

The PCA led to the distribution diagrams of the variants shown in Fig. 10 for the "Queen of the Blues" crocus and in Figure 11 for the "Yellow" crocus.

In the case of the "Queen of the Blues" crocus, figure 10, PC1 explained 79.234% of variance, and PC2 explained 19.046% of variance. In the case of "Yellow" crocus, Figure 11, PC1 explained 88.851% of variance, and PC2 explained 8.8951% of variance.

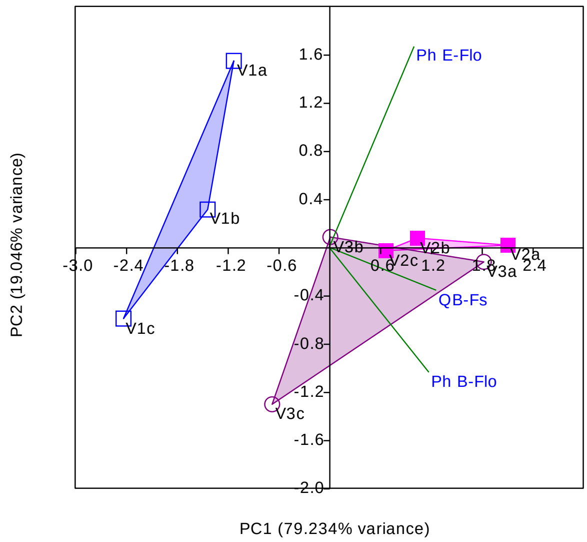

Fig. 10. PCA diagram, Correlation matrix, "Queen of the Blues" crocus in relation to physiological parameters of plants and Fs
Source: Original diagram generated based on experimental data.

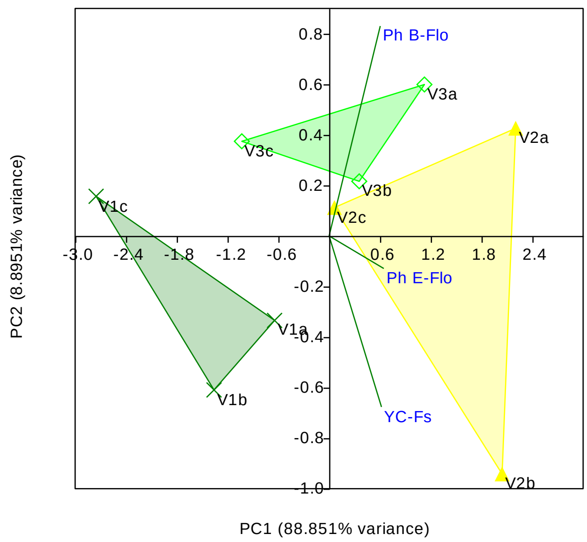

Fig. 11. PCA PCA diagram, Correlation matrix, "Yellow" crocus in relation to physiological parameters of plants and Fs
Source: Original diagram generated based on experimental data.

A comparative presentation of the average values of the flower size for the two types of crocus, under the study conditions, is represented in Figure 12.

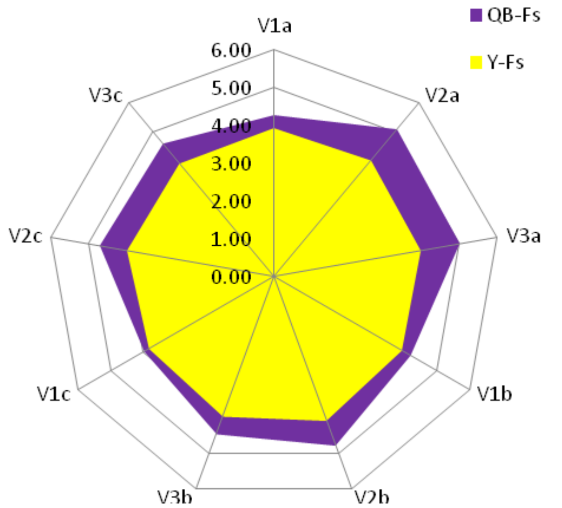

Fig. 12. Comparative graphical representation of flower size (Fs) of the two types of crocus under experimental conditions
Source: Original figure generated based on recorded data.

Comparing the Fs values recorded with the average of the experiment, for each of the two types of crocus studied, positive or negative differences were found, in relation to the experimental variants.

The graphical distribution of the calculated difference values, compared to the average value of Fs, are shown in Figure 13 for the "Queen of the Blues" crocus and in Figure 14 for the "Yellow" crocus.

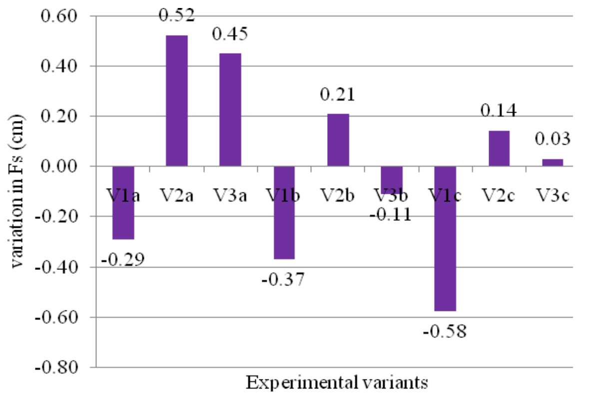

Fig. 13. Fs variation given by the experimental variants in relation to the average value of the experience, "Queen of the Blues" crocus
Source: Original figure generated based on data.

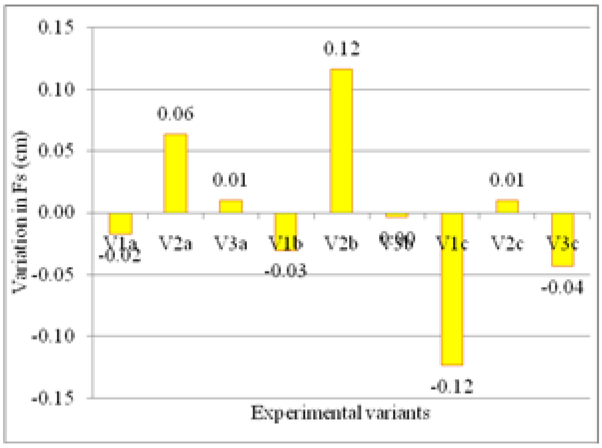

Fig. 14. Fs variation given by the experimental variants in relation to the average value of the experience, "Yellow" crocus
Source: Original figure generated based on data.

In the case of "Queen of the Blues" crocus, compared to the average value (4.55 cm) of flower size, positive values were found for V2a, V3a, V2b, V2c and V3c, and negative values for V1a, V1b , V3b and V1c.

In the case of "Yellow" crocus, compared to the average value (3.95 cm), positive values were recorded for V2a, V3a, V2b, V2c and negative values for V1a, V1b, V1c and V3c.

In both types of crocus studied, it was found that the V1 variant (sand substrate), generated lower values of flower size, regardless of the period of planting the bulbs. Although it is an affordable substrate, it does not offer the best results alone.

The size of crocus flowers is of interest and has been studied in relation to production targets for the phytopharmaceutical, food and dye industry [1], [25]. At the same time, the size of the flowers is interesting from an ornamental perspective.

Physiological indices and biometric parameters of plants express the environmental and living conditions of plants, and the relationship of plants with habitat [19], [12], [5], [26]. Some non-destructive methods, based on imaging analysis, can provide information on the health of plants, very useful methods and applicable to ornamental plants, in order not to harm plants by sampling [7].

Therefore, in the case of cultivating crocuses for ornamental purposes, by using quality biological material, and by directing plant density, substrate quality, water regime, the plants will have a better growth and thus larger flowers can be obtained, which will ensure a high quality ornamental look.

In conditions if crocus is cultivated for ornamental purposes, mixed with other early spring bulbous species (eg *Galanthus*, *Scilla*), in competition with these species for space, water and nutrients, it is possible that the size of the flowers is close to the lower limit, and the ornamental aspect will depend on the whole floral carpet and not on singular plants.

CONCLUSIONS

The size of crocus flowers (Fs) varied in close connection with the physiological parameters represented by the height of the plants at the beginning of flowering (Ph B-Flo) and at the end of flowering (Ph E-Flo) at the two types of crocus studied.

Models in the form of 3dD and isoquants, described the Fs variation in relation to the physiological parameters considered, and linear models confirmed the high degree of fit between predicted values (PFs) and real values (RFs) of flower size.

By properly managing the vegetation factors that contribute to the growth and development of crocus plants, and organizing the cultivation system (especially growth substrate), plants with variable flower sizes can be obtained, in relation to the proposed objectives, such as ornamental (simple or mixed culture), food or industrial.

REFERENCES

[1]Abu-Izneid, T., Rauf, A., Khalil, A.A., Olatunde, A., Khalid, A., Alhumaydhi, F.A., Aljohani, A.S.M., Sahab Uddin, M., Heydari, M., Khayrullin, M., Shariati, M.A., Aremu, A.O., Alafnan, A., Rengasamy, K.R.R., 2020, Nutritional and health beneficial properties of saffron (*Crocus sativus* L): A comprehensive review, Crit. Rev. Food Sci. Nutr., 17:1-24.

[2]Aghhavani-Shajari, M., Fallahi, H.R., Sahabi, H., Kaveh, H., Branca, F., 2021, Production systems and methods affect the quality and the quantity of saffron (*Crocus sativus* L.), Span. J. Agric. Res., 19(1):e0901.

[3]Alsayied, N.F., Fernández, J.A., Schwarzacher, T., Heslop-Harrison, J.S., 2015, Diversity and relationships of *Crocus sativus* and its relatives analysed by inter-retroelement amplified polymorphism (IRAP), *Ann. Bot.*, 116(3):359-368.

[4]Bagur, M.J., Salinas, G.L.A., Jiménez-Monreal, A.M., Chaouqi, S., Llorens, S., Martínez-Tomé, M., Alonso, G.L., 2017, Saffron: An old medicinal plant and a potential novel functional food, Molecules (Basel, Switzerland), 23(1):30.

[5]Datcu, A.-D., Sala, F., Ianovici, N., 2017, Studies regarding some morphometric and biomass allocation parameters in the urban habitat on *Plantago major*, Res. J. Agric. Sci., 49(4):96-102.

[6]Douglas, M.H., Smallfield, B.M., Wallace, A.R., McGimpsey, J.A., 2014, Saffron (*Crocus sativus* L.): The effect of mother corm size on progeny multiplication, flower and stigma production, Sci. Hortic., 166:50-58.

[7]Drienovsky, R., Nicolin, A.L., Rujescu, C., Sala, F., 2017, Scan Sick & Healthy Leaf – A software application for the determination of the degree of the leaves attack, Res. J. Agric. Sci., 49(4):225-233.

[8]García-Blázquez, A., Moratalla-López, N., Lorenzo, C., Salinas, M.R., Alonso, G.L., 2021, Effect of *Crocus sativus* L. stigmas microwave dehydration on picrocrocin, safranal and crocetin esters, Foods, 10:404.

[9]Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001, PAST: Paleontological statistics software package for education and data analysis, Palaeontol. Electron., 4(1):1-9.

[10]Haspolat, G., Kunter, B., Ozzambak, M.E., 2016, Some changes in mutant *Crocus* plants, Acta Hortic., 1127:389-394.

[11]Hosseini, S.M., Sorooshzadeh, A., Modares Sanavi, S.A.M., 2015, Effects of substrate culture, axillary bud removing and mother corm size on daughter corm production and morphological traits in the saffron plant (*Crocus Sativus* L.), Iranian Journal of Medicinal and Aromatic Plants, 31, 2(70):194-203.

[12]Hou, Y., Lou, A., 2011, Population genetic diversity and structure of a naturally isolated plant species, Rhodioladumulosa (Crassulaceae), PLoS ONE, 6:e24497.

[13]Jafari-Ghanavati, M., Saket, S., 2020, Chapter 1 - Saffron and folklore. Editor(s): Alireza Koocheki, Mohammad Khajeh-Hosseini, In Woodhead Publishing Series in Food Science, Technology and Nutrition, Saffron, Woodhead Publishing, pp. 3-13,

[14]Khazdair, M.R., Boskabady, M.H., Hosseini, M., Rezaee, R., Tsatsakis, A.M., 2015, The effects of *Crocus sativus* (saffron) and its constituents on nervous system: A review, Avicenna J. Phytomed., 5(5):376-391.

[15]Kothari, D., Thakur, M., Joshi, R., Kumar, A., Kumar, R., 2021, Agro-climatic suitability evaluation for saffron production in areas of Western Himalaya, Front. Plant Sci., 12:657819.

[16]Lunau, K., Konzmann, S., Bossems, J., Harpke, D., 2016, A matter of contrast: Yellow flower colour constrains style length in *Crocus* species, PLoS ONE, 11(4):e0154728.

[17]Molina, R.V., Valero, M., Navarro, Y., Guardiola, J.L., Garcia-Luis, A., 2005, Temperature effects on flower formation in saffron (*Crocus sativus* L.), Sci. Hortic., 103:361-379.

[18]Moratalla-López, N., Sánchez, A.M., Lorenzo, C.,

López-Córcoles, H., Alonso, G.L., 2020, Quality determination of *Crocus sativus* L. flower by high-performance liquid chromatography. J. Food Compost. Anal., 93:103613.
[19]Norbak, R., Brandt, K., Nielsen, J.K., Orgaard, M., Jacobsen, N., 2002, Flower pigment composition of Crocus species and cultivars used for a chemotaxonomic investigation, Biochem. Syst. Ecol., 30:763-791.
[20]Pastor-Férriz, T., De-los-Mozos-Pascual, M., Renau-Morata, B., Nebauer, S.G., Sanchis, E., Busconi, M., Fernández, J.-A., Kamenetsky, R., Molina, R.V., 2021, Ongoing evolution in the genus crocus: Diversity of flowering strategies on the way to hysteranthy, Plants, 10:477.
[21]Prisa, D., 2020, Improving quality of *Crocus sativus* through the use of *Bacillus subtilis*. Int. J. Sci. Res. Multidiscip. Stud., 6(2):9-13.
[22]Renau-Morata, B., Nebauer, S.G., Sánchez, M., Molina, R.V., 2014, Effect of corm size, water stress and cultivation conditions on photosynthesis and biomass partitioning during the vegetative growth of saffron (*Crocus sativus* L.). Ind. Crops Prod., 39:40-46.
[23]Sala, F., 2011, Agrochemistry (Agrochimie), Eurobit Publishing House, Timisoara, (In Romanian), pp. 148-163.
[24]Saxena, R.B., 2010, Botany, taxonomy and cytology of *Crocus sativus* series. Ayu, 31(3):374-381.
[25]Shahnoushi, N., Abolhassani, L., Kavakebi, V., Reed, M., Saghaian, S., 2020, Chapter 21 - Economic analysis of saffron production, Editor(s): Alireza Koocheki, Mohammad Khajeh-Hosseini, In Woodhead Publishing Series in Food Science, Technology and Nutrition, Saffron, Woodhead Publishing, ISBN 9780128186381, Pages 337-356,
[26]Sheidai, M., Tabasi, M., Mehrabian, M.-R., Koohdar, F., Ghasemzadeh-Baraki, S., Noormohammadi, Z., 2018, Species delimitation and relationship in *Crocus* L. (*Iridaceae*), Acta Bot. Croat., 77(1):10-17.
[27]Srivastava, R., Ahmed, H., Dixit, R.K., Dharamveer, Saraf, S.A., 2010, *Crocus sativus* L.: A comprehensive review. Pharmacognosy reviews, 4(8):200-208.
[28]Turhan, H., Kahriman, F., Egesel, C.O., Gul, M.K., 2007, The effects of different growing media on flowering and corm formation of saffron (*Crocus sativus* L.), Afr. J. Biotechnol., 6(20):2328-2332.
[29]Valijonovich, M., 2017, Bioecological features and anatomical structure of *Crocus korolkovii* Regel & Maw in the introduction of Uzbekistan, Am. J. Plant Sci., 8:471-481.
[30]Wolfram, Research, Inc., 2020, Mathematica, Version 12.1, Champaign, IL (2020).