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# VARIATION OF FLOWERING TIME IN CROCUS IN RELATION TO THE PLANTING PERIOD AND THE GROWING SUBSTRATE

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***Abstract***

*The flowering period of the crocus was studied in relation to the planting period and the growing substrate. The "Queen of the Blues" variety was used as biological material. Sand (Gs1), a mixture of sand and compost (Gs2) and garden soil (Gs3) were used as growing substrate. Crocus bulbs were planted on three different dates in 2020: October 20 (PD1), November 3 (PD2), and November 17 (PD3), simultaneously on each of the three types of substrate used. Flowering time (FT) was assessed in the spring of the following year (2021). By planting the bulbs on the three substrates at three different times, the whole experiment recorded flowering in the spring between March 2 and April 1, 2021, but differentiated depending on the planting date and substrate. The earliest flowering (March 2) was recorded in the case of planting on PD1Gs2 conditions. The latest flowering (March 22) was recorded in the case of planting on PD2Gs3 condition. The longest flowering time was recorded in the case of planting on PD1Gs2 condition, with a period of 29 days, between March 2 and March 30. Regression analysis facilitated the obtaining of models that described the variation of FT in relation to the time from the date of planting (PD) to the beginning of flowering (B-Flo), considered as T1, and the time from the date of planting (PD) to at the end of flowering (E-Flo), considered as T2. According to PCA, PC1 explained 81.613% of variance, and PC2 explained 18.387% of variance.*

***Key words:*** *crocus, floral attributes, flowering time, growth substrate, model, open field, regression analysis*

## INTRODUCTION

The ornamental aspect of open spaces, public or private, can be ensured by a large number of methods, techniques, models, etc., which are composed of natural and / or artificial elements, of different categories of representation (ecological, economic, socio-cultural, historical, etc.), or combinations thereof [7], [9], [5], [8], [14], [26], [3].

The ornamental elements, of vegetal category, of an open space are in close connection with the topoclimates conditions that characterize the locality [25].

Green spaces have been studied and analyzed often in relation to the desired spatial patterns [25], with building types [24], historical texture [3], sustainable urban strategies [24] and other elements, for a balance of the urban ecosystem.

In the conditions of the use of vegetal components in the open ornamental spaces, are taken into account vegetative aspects or attributes [16], [15], [35], and floral attributes [36], [23], [28], [20], [32].

In urban ecosystems, some studies have evaluated physiological and parametric biometric indices of plants in response to urban habitats [10], and other studies have evaluated plants relative to soil suitably in urban open space [34].

The importance and social significance of green systems have also been considered in studies in relation to urban ecosystems [11].

Ornamental plants, as components for open spaces, have been studied in relation to planting conditions, such as planting data, growth substrates and other elements that determine the growth and ornamental appearance of plants [22], [17], [31], [2], [37], [21], [27]. Numerous components of organic, mineral, and organo-mineral category are known that can be used singly or in mixtures (variable proportion) to make suitable substrates for plant growth [4], [18], [30], [1]. Noninvasive techniques have been promoted

for the study of plants, which can be used to evaluate ornamental plants without affecting the ornamental attributes of plant organs [12], [13], [16], [29].
Some studies on urban ecosystems have evaluated the floristic composition of green spaces, ornamental, and highlighted the absence of some species from late winter - early spring (eg. Crocus, Galanthus) [6].
The present study analyzed the ornamental aspect of the crocus, through the flowering time in relation to the date of planting and the growing substrate, in open space conditions.

## MATERIALS AND METHODS

The study evaluated the variation of the flowering time of the crocus, "Queen of the Blues", depending on the planting date and the growing substrate. The planting of crocus bulbs, "Queen of the Blues", was done in the fall of 2020, at three different dates (planting date - PD), October 20 (PD1), November 3 (PD2) and November 17 (PD3), Figure 1.


Fig. 1. Aspects from the crocus experiment, "Queen of the Blues"
Source: Original figure, author's photo.

Three growing substrates were used, represented by sand (Gs1), mixtures of sand and compost (Gs2), and respectively garden soil (Gs3), Figure 1. All substrates were used at each planting date, so that from the combination of the two factors (planting date and substrate) resulted in 9 experimental variants.
The time of beginning of flowering (B-Flo), the flowering time (FT), the time of the end of flowering (E-Flo), the time from the date of planting (PD) to the beginning of flowering (T1), and the time from the date of planting (PD) to the end of flowering (T2) were recorded. Determinations were made for each variant.
The data obtained were analyzed in terms of statistical certainty and the presence of the variance (ANOVA test). To evaluate the FT variation according to the time parameters considered (T1, T2), regression analysis was used. PCA was used to obtain the distribution diagram of the variants in relation to the variables considered (PD, Gs) and the elements of ornamental interest, with reference to flowering (T1, T2 and FT).
The safety of the results was assessed based on the statistical parameters $R^2$, p, F-test.
PAST software [19] and Wolfram Alpha (2020) [33] were used for statistical data analysis and graph generation.

## RESULTS AND DISCUSSIONS

By planting on three different dates (PD1, PD2, PD3) the biological material of the crocus (bulbs), 'Queen of the Blues', on the three substrates considered (Gs1, Gs2, Gs3), was registered in the spring of 2021, between March 2 and April 1, the variation of flowering, in terms of the beginning of flowering (B-Flo), the end of flowering (E-Flo) and the flowering time (FT).
In relation to the planting date (PD), a longer flowering time interval was recorded in the case of planting on October 20 (PD1).

The substrate also had a differentiated influence on the beginning and end moments of flowering (B-Flo, E-Flo), as well as on the flowering time (FT).

The substrate consisting of the mixture of sand and compost (Gs2) provided the most suitable substrate for crocus ('Queen of the Blues'), under the study conditions, and on this substrate (Gs2) a longer flowering time was recorded, in all the three planting dates (PD1, PD2, PD3).

During the planting on October 20 (PD1), on the Gs2 substrate, a flowering period of 29 days was registered, the longest of all the experimental variants.

Long flowering time were also recorded in the case of planting variants on October 20 (PD1), on the soil substrate (Gs3), and in the planting variant on November 17 (PD3), on the sand and compost substrate (Gs2). The flowering diagram is presented in Figure 2.

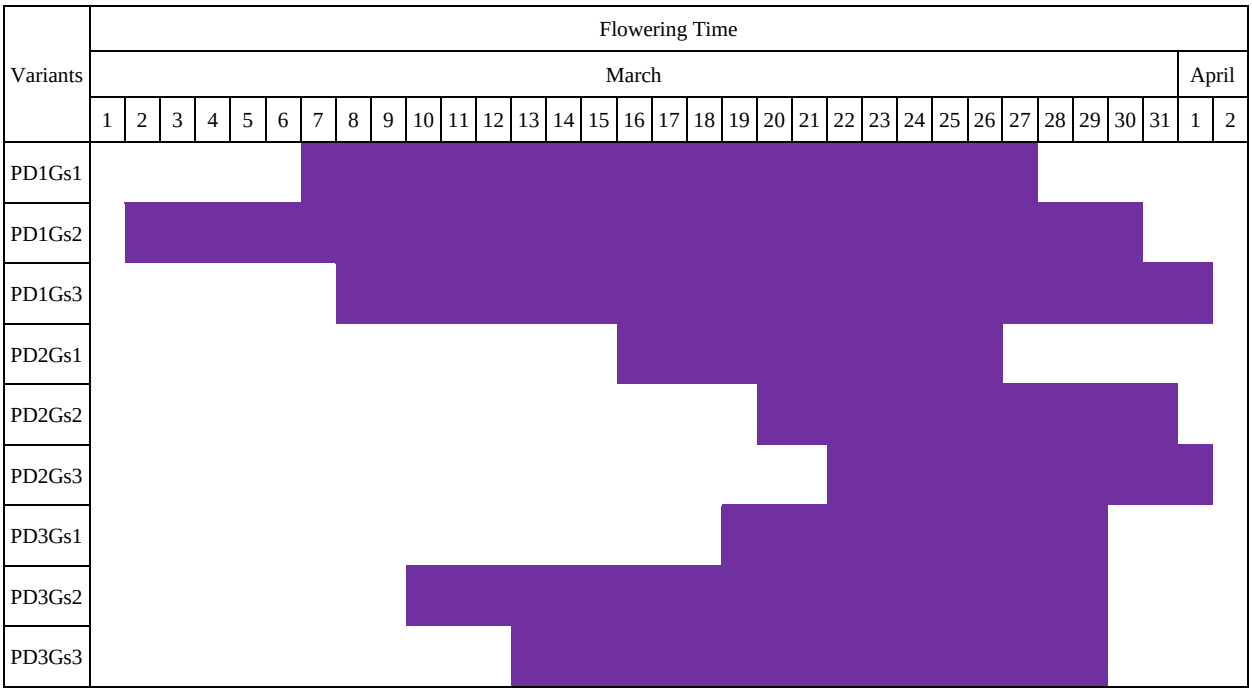


Fig. 2. Crocus flowering diagram, 'Queen of the Blues' in relation to the planting date (PD) and substrate (Gs)
Source: Original diagram, based on experimental data.

Regression analysis was used to evaluate the variation of flowering time (FT) as a function of time T1 (PD to B-Flo) and T2 (PD to E-Flo).

The variation of flowering time (FT) in relation to T1 and T2 was described by equation (1), under conditions of $R^2 = 0.999$, $p < 0.001$. The graphical distribution of the FT variation in relation to T1 and T2 is shown in figure 3 as a 3D plot model respectively in figure 4 as Contour plot.

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

where: FT – flowering time (days);

*x* – the time from the planting date to the beginning of flowering (T1, days);

*y* – the time from the planting date to the end of flowering (T2, days);

a, b, c, d, e, f – coefficients of the equation (1);
a= -3.18658711069832E-16;
b=-2.51611368586273E-16;
c= -1;
d= 1;
e= 5.69575914870252E-16;
f=0.

Based on PCA, the diagram in Figure 5 was obtained. PC1 explained 81.613% of variance, and PC2 explained 18.387% of variance.

According to the PCA diagram, the PD1Gs1, PD1Gs2 and PD1Gs3 variants had an orientation and distribution associated with FT and T2 as bi-plot. The PD1Gs1, PD2Gs2 and PD2Gs3 variants were closely associated with T1 as a bi-plot.

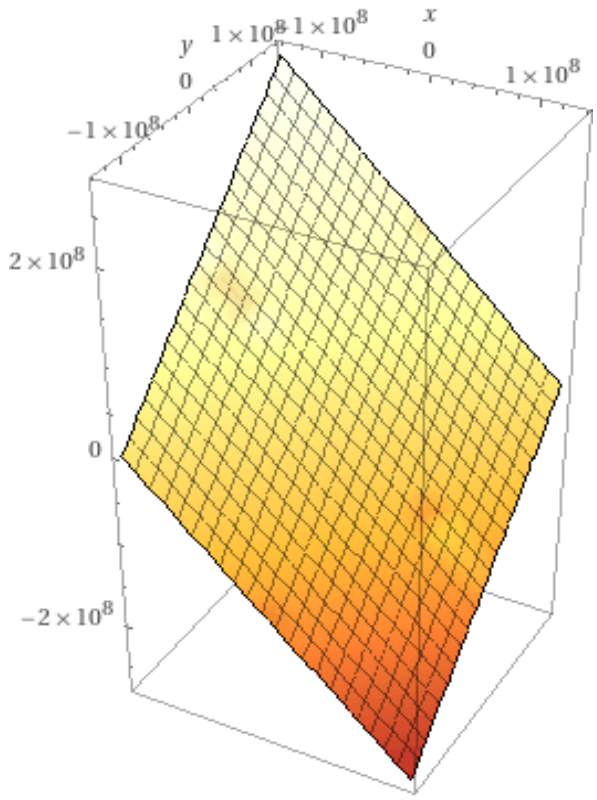


Fig. 3. 3D plot model for variation of flowering time (FT) in relation to T1 (x-axis) and T2 (y-axis) in crocus, 'Queen of the Blues'
Source: Original graph generated based on data.

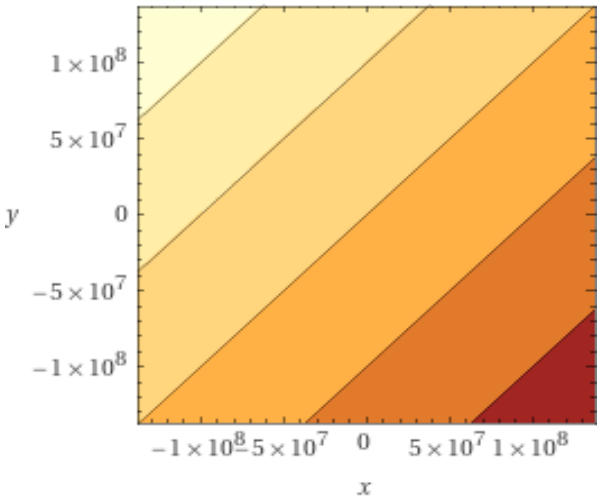


Fig. 4. Representation model as a Contour plot of the FT variation in relation to T1 (x-axis) and T2 (y-axis) in the crocus, 'Queen of the Blues'
Source: Original graph generated based on data.

The cluster analysis led to the grouping of variants in relation to the degree of similarity, in relation to the element of floral attributes, flowering time (FT). It was found the formation of two distinct clusters, in conditions of statistical safety condition, Coph.corr. = 0.787, figure 6.

A C1 cluster comprises variants with low values for FT (PD2Gs1, PD2Gs3, PD3Gs1, PD2Gs2), and cluster C2 comprised two subclusters; C2-1 with intermediate values for FT (PD1Gs2, PD1Gs3), and C2-2 with the highest values high for FT (PD1Gs1, PD3Gs2 and PD3Gs3).

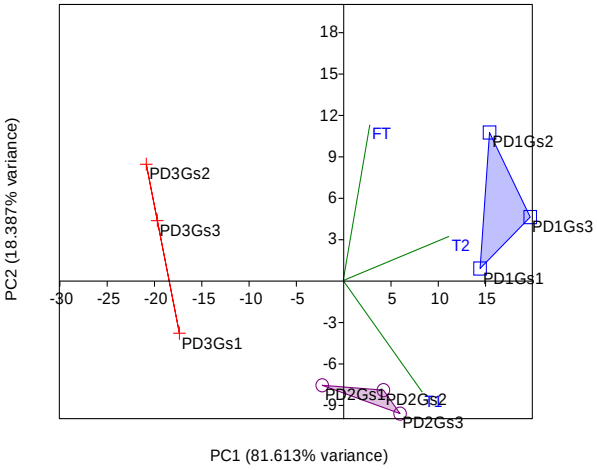


Fig. 5. PCA diagram of crocus FT, 'Queen of the Blues' in relation to planting date (PD) and growth substrate (Gs)
Source: Original figure, generated based on experimental data.

The variation of the flowering time generated by the planting date (PD) in relation to each type of growing substrate (Gs) was analyzed, as well as the variation of the flowering time generated by the growing substrate (Gs) in relation to each planting date (PD).
For this, the average values were calculated in relation to the two basic criteria (PD, Gs) taken into account, and the differences from the experimental variants were also calculated.
The average values (days) in relation to PD1 was T1 = 136.67, T2 = 161.67, FT = 25; the average values (days) in relation to PD2 was T1 = 136.33, T2 = 147.67, FT = 11.33, and the average values (days) in relation to PD3 was T1 = 117.00, T2 = 133.00, FT = 16.00.
The average values (days) in relation to the growth substrate Gs1 was T1 = 131.00, T2 = 145.33, FT = 14.33. The average values (days) in relation to Gs2 was T1 = 127.67, T2 = 148.00, FT = 20.33, and the average values (days) in relation to Gs3 was T1 = 131.33, T2 = 149.00, FT = 17.67.

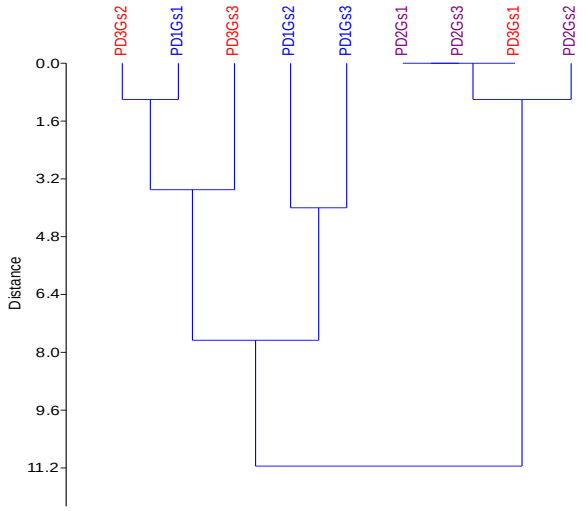


Fig. 6. Variant grouping dendrogram in relation to FT for crocus, 'Queen of the Blues'
Source: Original figure, generated based on experimental data.

The differences calculated on each variant, in relation to the average values, are presented graphically in figure 7 (in relation to PD) and in figure 8 (in relation to Gs).
Compared to the calculated average value, in relation to the planting date (PD), there were positive differences (days) for flowering time (FT) in the PD1Gs2 variant (4.00 days), in the PD2Gs2 variant (0.67 days), in the PD3Gs2 variant (4.00 days), and in the PD3Gs3 variant (1.00 days). Negative differences for FT, compared to the mean value in this case, were recorded in PD1Gs1, PD2Gs1, PD2Gs3 and PD3Gs1.

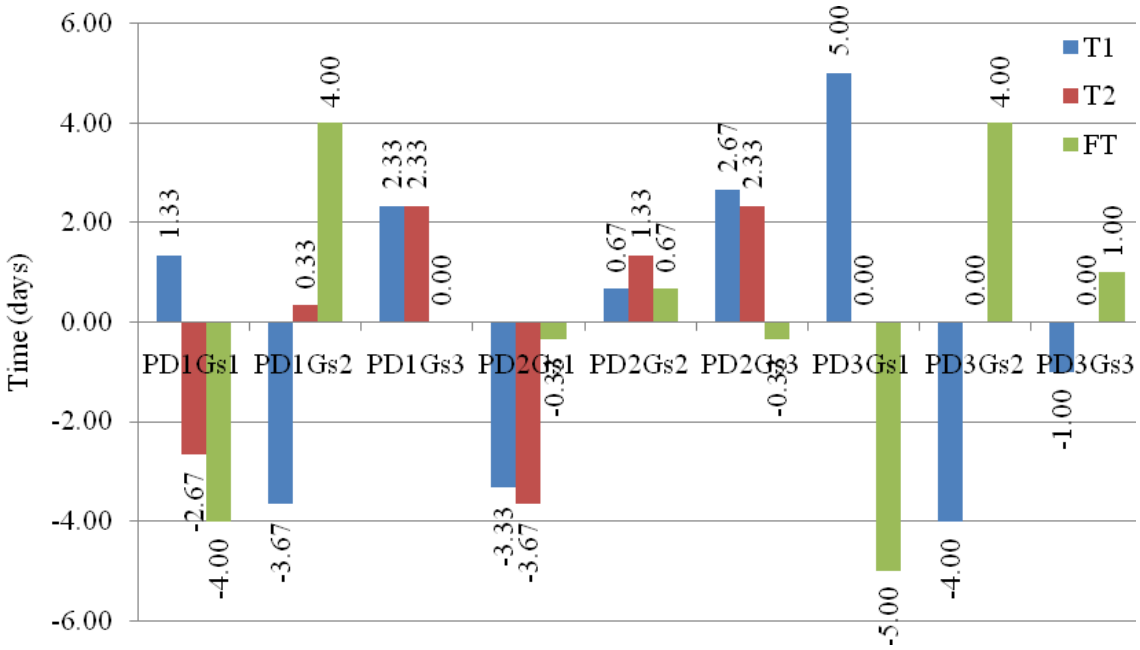


Fig. 7. Graphical representation of the differences (days) generated by planting date (PD) in relation to growth substrates (Gs), crocus 'Queen of the Blues'
Source: Original graph generated based on calculated values.

Compared to the average value calculated in relation to the growth substrate (Gs), there were positive differences (days) for flowering time (FT) in the PD1Gs1 variant (6.67 days), in the PD1Gs2 variant (8.67 days), and in the PD1Gs3 variant (7.33 days). Negative differences for FT, compared to the mean value in this case, were recorded in PD2Gs1, PD3Gs1, PD2Gs2, PD2Gs3 and PD3Gs3.
From the evaluation of the values of differences, compared to the calculated averages, we can appreciate the result generated by each variant, and in relation to the concrete conditions of the 'Queen of the Blues' crocus cultivation space for ornamental purposes, we can choose the variant that corresponds best, based on the present study conditions.
In all conditions, the 'Queen of the Blues' crocus provides a suitable ornamental appearance, but, in association with other ornamental plants, with the general and

specific context of the place, one variant may be more appropriate than another

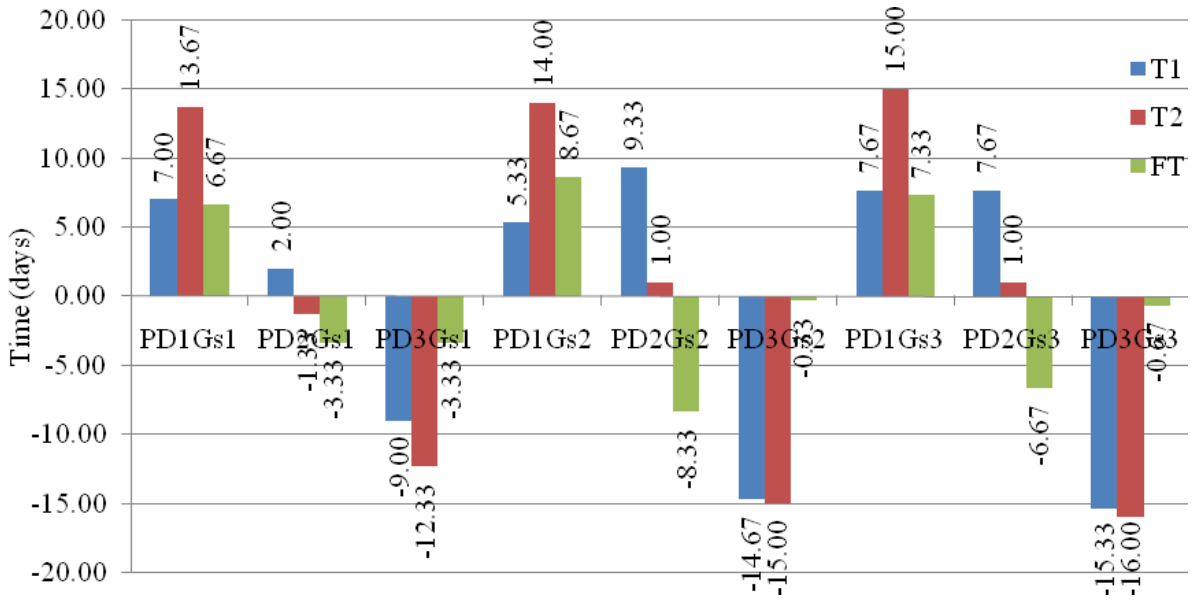


Fig. 8. Graphical representation of the differences (days) generated by growth substrates (Gs) in relation to planting date (PD), crocus 'Queen of the Blues'
Source: Original graph generated based on calculated values.

## CONCLUSIONS

The flowering time (FT) of the 'Queen of the Blues' crocus recorded a specific variation in relation to the date of planting (PD) and the growing substrate used (Gs).

The PD1 planting date associated with Gs2 provided the longest flowering time under the study conditions, and the short flowering time was recorded in PD2 with all 3 substrates, respectively in PD3 and Gs1.

The mathematical and statistical methods and tools used highlighted the differences between the variants, in relation to the evaluated floral attribute (FT), so that the choice of variants given by PD and Gs is safe in relation to the purpose for a certain ornamental area, open space.

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