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COMPARATIVE ANALYSIS OF SOME GLADIOLUS VARIETIES IN RELATION TO VEGETATIVE INDICES AND FLORAL QUALITY PARAMETERS

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Abstract

The present study aimed to analyze and characterize five gladiolus varieties, based on flower quality parameters in relation to some vegetation indices. The studied gladiolus varieties were: 'Plumtart' (Plu), as control variant (Mt), 'Flower Song' (Flo_S), 'Tequendame' (Teq), 'Princess Margaret Rose' (PMR), and 'Praha' (Pra). For the comparative analysis of the five gladiolus varieties, vegetation indices and flower quality parameters were used: vegetation period until flowering (VPuF), plant height (PH), floral stem number (FSN), inflorescences length (IL), flowers number (FN), flowering time (FT), and total vegetation period (TVP). Inflorescences length (IL) recorded values between 30.33 cm for the 'Praha' (Pra) variety and 64.00 cm for the 'Flower Song' (Flo_S) variety. The flowers number (FN) in the inflorescence registered values between 12.50 for the 'Praha' (Pra) variety, and 19.17 for the 'Flower Song' (Flo_S) variety. Flowering time (FT) varied between 24 days for 'Praha' and 'Flower Song' varieties, and 28 days for 'Princess Margaret Rose' and 'Plumtart' varieties. The regression analysis facilitated the obtaining of equations that described the variation of the flowers number (FN) in relation to the flower stem number (FSN), and inflorescence length (IL), respectively the variation of FT in relation to VPuF and FSN, under statistical safety conditions. According to PCA, PC1 explained 90.243% of variance, and PC2 7.3695% of variance. Cluster analysis facilitated the grouping of the studied gladiolus varieties based on similarities in relation to the vegetative indices and floral quality parameters, in conditions of statistical safety (Coph.corr = 0.955).

Key words: *floral quality parameters, flowering time, gladiolus, models, vegetation indices*

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.), are part of the Iridaceae Family, with over 250 known species. They are bulbous plants, cultivated for ornamental purposes, over 150 endemic species, originating from South Africa [23], [18].
Different species of gladiolus have been studied in order to diversify and enrich the palette of ornamental flowers for cut flowers, gardening or green spaces [15]. Some studies have analyzed different varieties of gladiolus in order to characterize them based on phenolic profile and molecular markers [26].
For ornamental purposes, a quality biological material is necessary, so that numerous studies on gladioli have analyzed the multiplication process and have been carried out in relation to corms production for the production of cut flowers [30], [6], [7], [31].
Some studies have analyzed the relationship and response of gladioli to vegetation conditions, water regime, and bioactive substances [25].
Vegetative growth, plant development and flower quality in gladioli were analyzed in relation to different growth media as well as in relation to climatic conditions [19], [33].
The growth and development of plants and the quality of flowers in different gladiolus genotypes and cultivars, have been studied in relation to various fertilizing, mineral and organic resources, as well as in relation to certain nutrients, such as nitrogen, phosphorus, potassium, etc. [1], [3], [12], [9], [20], [35]. The stages of growth and development, respectively the quality of flowers in gladiolus, were evaluated in relation to the fertilization rate [2].
Given the demand for flowers on the market and their quality, some studies have analyzed the growth and development of gladiolus in relation to commercial fertilizers, in nutrient

film growth systems [24].
The flowering period of gladiolus is genotype dependent, but is also influenced by climatic and technological factors [28]. Studies on the behavior of some varieties of gladiolus, in relation to the period and duration of flowering were performed and communicated by Cantor et al. [8].
The behavior of some gladiolus varieties in relation to the planting period, flower production, physiological and flower quality indices, as well as genetic factors were studied [4], [5].
Some studies have approached the use of gladiolus as cut flowers, in order to ensure the quality of flowers in different market conditions [21].
The behavior of gladioli and the level of tolerance in relation to different stress factors (eg. saline, water, etc.) were also studied [10].
Simulation models regarding the development of gladiolus were developed in some studies, in relation to different factors [32].
The present study aimed to analyze and characterize some gladiolus varieties based on floral quality parameters in relation to vegetation indices.

MATERIALS AND METHODS

The study aimed at the comparative evaluation of five gladiolus varieties, to assess their value in relation to certain flowering parameters associated.
The biological material was represented by the following gladiolus varieties: 'Plumtart' (Plu), as control variant (Mt), 'Flower Song' (Flo_S), 'Tequendame' (Teq), 'Princess Margaret Rose' (PMR), and 'Praha' (Pra), (Figure 1).
'Plumtart' (Plu) is a semi-early variety with a flower stem of 100 cm, with an inflorescence of 70-80 cm; cyclamen flowers color. It is recommended for cut flowers.

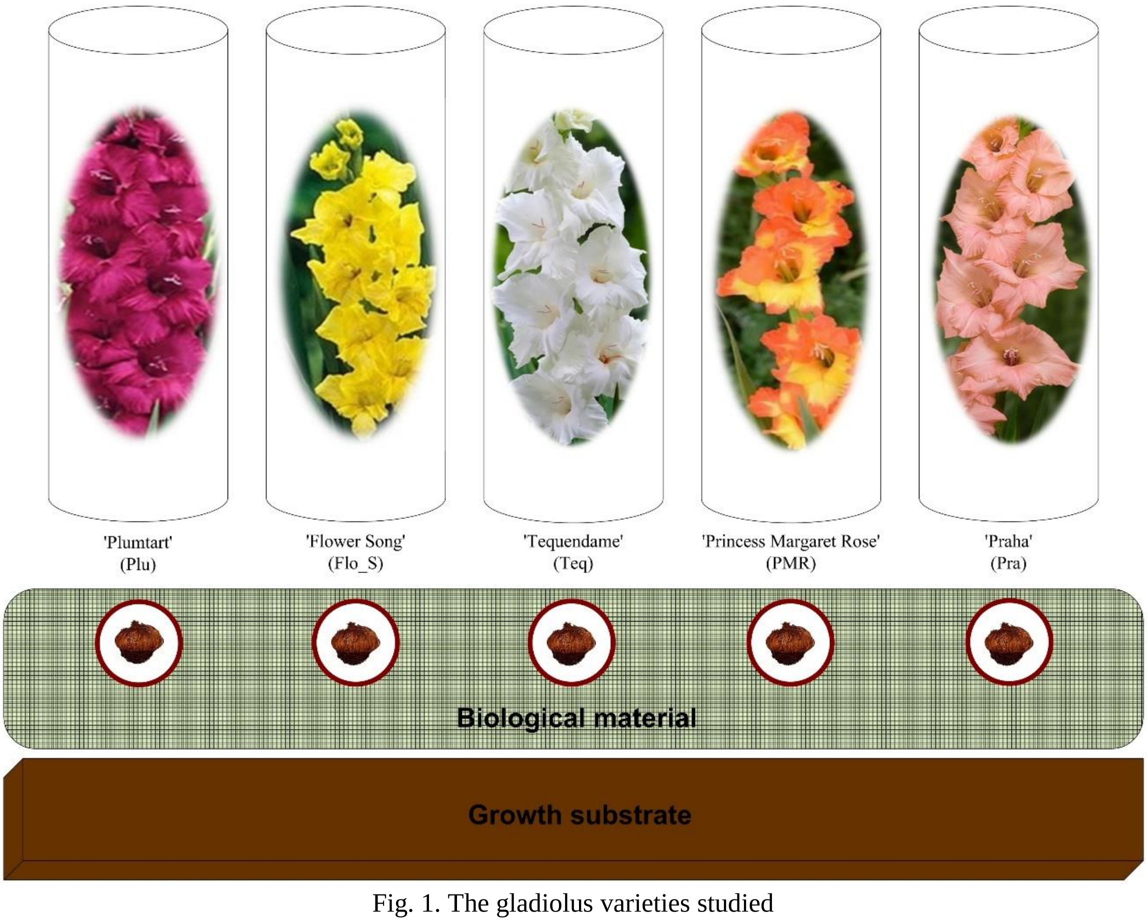

Fig. 1. The gladiolus varieties studied
Source: Original.

'Flower Song' (Flo_S) is an early variety, with a flower stem of 100 cm and inflorescences of 60-70 cm length. The flowers are yellow. It is used for cut flowers.

'Tequendame' (Teq) is a midseason variety, with a floral stem of 100 cm, and an inflorescence of 70-80 cm length. The flowers are white. It is used alone or in combination with other species in floral arrangements or bouquets.

'Princess Margaret Rose' (PMR) is a late (very late) variety, with a flower stem of 90 cm and inflorescences of 60-70 cm length. The flowers are yellow with a red border, which gives it the appearance of embers.

'Praha' (Pra) is a late (very late) variety, with a flower stem of 90 cm and inflorescences of 60 - 70 cm length; light pink flowers. It is recommended for cut flowers.

For the comparative analysis of the five varieties of gladiolus, vegetation indices and flower quality parameters were used: Vegetation period until flowering (VPuF), Plant height (PH), Floral stem number (FSN), Inflorescences length (IL), Flowers number (FN), Flowering time (FT), total vegetation period (TVP).

The experimental data were analyzed by appropriate statistical methods, in relation to the proposed objectives (variance analysis, correlation analysis, regression analysis, Principal Component Analysis, Cluster analysis). To estimate the significance of differences between varieties, the significance limits of differences (LSD) were calculated for the statistical thresholds of 5%, 1% and 0.1% respectively.

PAST software [16], and Wolfram Alpha software [34] respectively were used for data analysis and processing.

RESULTS AND DISCUSSIONS

After planting the bulbs, the five varieties of gladiolus were studied from the perspective of some vegetation indices and flower quality parameters. The floral stems number (FST) recorded average values between 1.50 for 'Plumtart' and 3.50 for the 'Princess Margaret Rose' variety (Table 1). The differences compared to the control variant (Plu) presented the statistical safety in conditions of LSD5% in the case of Teq and Pra variants, respectively in conditions of LSD0.1% for the PRM variant.

Table 1. Floral stem number in the studied gladiolus varieties

Variety	Average values	Relative value (%)	Differences and significance
'Plumtart' (Mt)	1.50	100.00	-
'Flower Song'	2.17	144.44	0.67
'Tequendame'	2.33	155.56	0.83^{*}
'Princess Margaret Rose'	3.50	233.33	2.00^{***}
'Praha'	2.33	155.56	0.83^{*}
LSD	LSD5%=0.76; LSD1%=1.03; LSD0.1%=1.40		

Source: Original data from experiment.

The five gladiolus varieties had variable plant height, in accordance with the biological specificity of each. Thus, the plant height varied between 83.17 cm in the case of the 'Praha' variety (Pra) and 127.50 cm in the case of the 'Tequendame' (Teq) variety (Table 2). Compared to the control variant (Plu), a hight variety, the differences in plant height showed differences in statistical safety conditions in the Flo_S variant (LSD1%) and in the PRM and Pra variants (LSD0.1%).

Table 2. Plant height in the studied gladiolus varieties

Variety	Average values	Relative value (%)	Differences and significance
'Plumtart' (Mt)	126.67	100.00	-
'Flower Song'	115.67	91.32	-11.00^{oo}
'Tequendame'	127.50	100.66	0.83
'Princess Margaret Rose'	92.83	73.29	-33.83^{ooo}
'Praha'	83.17	65.66	-43.50^{ooo}
LSD	LSD5%=6.72; LSD1%=9.13; LSD0.1%=12.38		

Source: Original data from experiment.

The length of the inflorescences (IL) registered values between 30.33 cm for the 'Praha' variety (Pra) and 64.00 cm for the 'Flower Song' variety (Flo_S) (Table 3). The differences registered in relation to the control variant (Plu) presented statistical safety to the variety 'Tequendame' (Teq) in conditions of LSD 5%, for 'Princess Margaret Rose' (PRM) variety in conditions of LSD1%, and for 'Flower Song' (Flo_S) respectively 'Praha' (Pra) varieties in conditions of 0.1%.

Table 3. The length of the inflorescences in the studied gladiolus varieties

Variety	Average values	Relative value (%)	Differences and significance
'Plumtart' (Mt)	49.17	100.00	-
'Flower Song'	64.00	130.17	14.83^{***}
'Tequendame'	52.83	107.46	3.67^{*}
'Princess Margaret Rose'	43.33	88.14	-5.83^{oo}
'Praha'	30.33	61.69	-18.83^{ooo}
LSD	LSD5%=3.30; LSD1%=4.48; LSD0.1%=6.07		

Source: Original data from experiment.

The number of flowers in the inflorescence (FN) registered values between 12.50 for the 'Praha' variety (Pra), and 19.17 for the 'Flower Song' variety (Flo_S) (Table 4). The differences between the variants, in relation to the control variant (Mt), presented statistical safety in conditions of LSD1% for the 'Flower Song' and 'Princess Margaret Rose' varieties, respectively in conditions of 0.1% for the 'Praha' variety. With higher values was the 'Flower Song' (Flo_S) variety, and with negative differences were the 'Princess Margaret Rose' (PMR) and 'Praha' (Pra) varieties.

Table 4. Number of flowers in inflorescence in the studied gladiolus varieties

Variety	Average values	Relative value (%)	Differences and significance
'Plumtart' (Mt)	17.00	100.00	-
'Flower Song'	19.17	112.75	2.17^{**}
'Tequendame'	17.50	102.94	0.50
'Princess Margaret Rose'	14.67	86.27	-2.33^{oo}
'Praha'	12.50	73.53	-4.50^{ooo}
LSD	LSD5%=1.47; LSD1%=2.00; LSD0.1%=2.71		

Source: Original data from experiment.

The five gladiolus varieties were planted on April 27. As a result of the biology specific to each variety, they had a different period of vegetation until flowering, with values between 73 days for the 'Flower Song' (Flo_S) variety, and 103 days for the 'Praha' (Pra) variety (Table 5). The flowering period, on all the studied varieties, was registered between July 10 (Flo_S) and September 3 (PRM), with a variation specific to each variety (Table 5, Figure 2).

Table 5. Vegetation and flowering period for the studied gladiolus varieties

Variety	Date og planting	Vegetation period until flowering (VPuF)	Beginning of flowering	End of flowering	Flowering Time (days)	Total vegetation period (TVP)
'Plumtart' (Mt)	27 April	74	11 July	7 August	28	102
'Flower Song'		73	10 July	2 August	24	97
'Tequendame'		81	18 July	12 August	26	107
'Princess Margaret Rose'		101	7 August	3 September	28	129
'Praha'		103	9 August	1 September	24	127

Source: Original data from experiment.

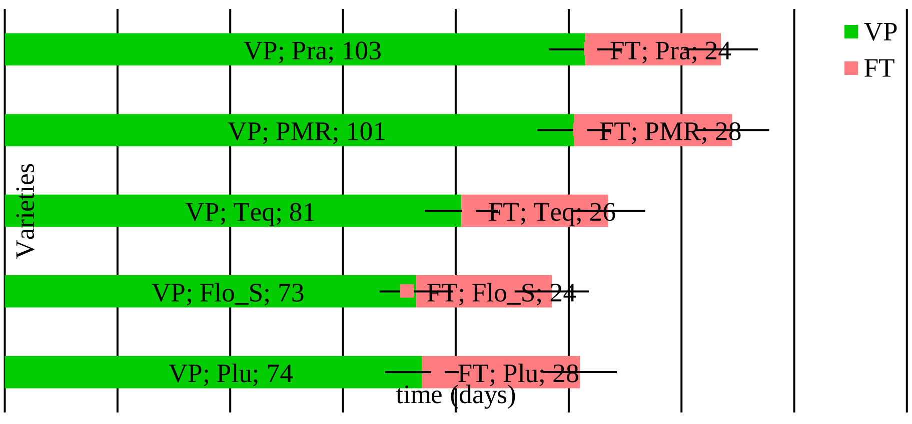

Fig. 2. Graphic distribution of vegetation period under flowering (VPuF), and flowering time (FT) in gladiolus varieties studied
Source: Original graph based on experimental data.

The relationship between flowers number (FN) and inflorescence length (IL) was described by a degree 2 equation, equation (1), in statistical safety conditions (R^2 = 0.973, p = 0.026, F = 36.14).

$$FN = -0.001103 \cdot IL^2 + 0.3105 \cdot IL + 3.957 \quad (1)$$

Principal Component Analysis led to the diagram in Figure 3, in which the spatial distribution of the gladiolus varieties was obtained, in relation to the vegetation indices and flowers quality parameters of the studied flowers.

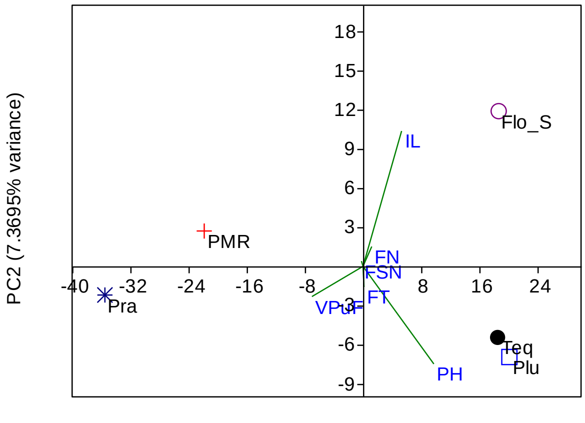

Fig. 3. PCA diagram with the distribution of gladiolus varieties in relation to vegetation and flower quality parameters, as biplot
Source: Original graph based on experimental data.

PC1 explained 90.243% of variance, and PC2 explained 7.3695% of variance. The distribution of the Flo_S variant in relation to IL, of the Teq and Plu variants in relation to PH, of the Pra variant with VP, and an independent position in the case of the PMR variant was found.

The cluster analysis led to the grouping of the studied gladiolus varieties, based on similarity, in relation to the physiological and floral parameters studied, in conditions of statistical safety (Coph.corr = 0.955). A high degree of similarity were presented by the variants Teq and Plu (SDI = 8.2476). They were followed, with lower values, the variants Pra and PMR (SDI = 16.982), the variants Teq and Flo_S (SDI = 18.318) and Flo_S with Plu (SDI = 19.055).

Gladioli are ornamental plants with flowers. Thus, the variation of the flower number in relation to flowers stem number (FSN) and inflorescence length (IL) was analyzed.

Regression analysis was used to evaluate the variation of the number of flowers in relation to the indices and parameters studied. For the accuracy of the calculations, the values of the coefficients of the equations were used with up to 16 decimals.

The variation of the flowers number (FN) in relation to the flower stem number (FSN) and inflorescence length (IL) was described by equation (2), in statistical safety conditions (R^2 = 0.998, p <0.001).

$$FN = ax^2 + by^2 + cx + dy + exy + f \quad (2)$$

where: FN - flowers number
x – FSN - flower stem number;
y –IL – inflorescence length;
a, b, c, d, e, f – coefficients of the equation (2);
a= -0.3710560;
b= -0.0023982;
c= 1.6873838;
d= 0.4427256;
e= -0.0090402;
f= 0.

The ANOVA test confirmed the statistical safety for the values of the coefficients of equation (2), p <0.001. The graphical distribution of the FN variation in relation to FSN (x-axis) and IL (y-axis) is shown in 3D form in Figure 4, and in the form of isoquants in Figure 5.

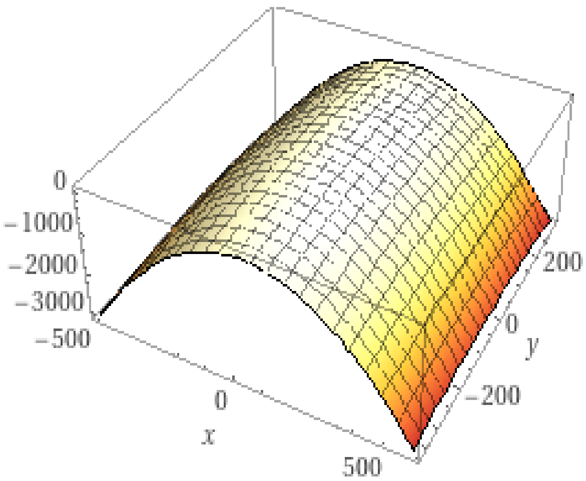

Fig. 4. 3D graphical distribution of FN parameter values in relation to FSN (x-axis) and IL (y-axis)
Source: Original graph, generated based on experimental data.

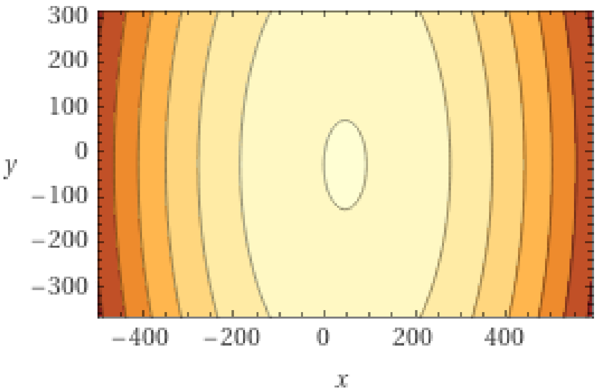

Fig. 5. Graphic distribution in the form of isoquants of the values of the FN parameter in relation to FSN (x-axis) and IL (y-axis)
Source: Original graph, generated based on experimental data.

From the data analysis, as well as from the 3D graphic distribution (3D graphic model), it was found a very small variation of the number of flowers in relation to IL (inflorescence length), specific to each variety. Instead, the number of flowers varied widely in relation to FSN. This indicates that the number of flowers can be directed through the flower stem number. This aspect is given either by the use of large, developed bulbs, or by using a larger number of medium-sized bulbs. From the analysis of the obtained data, optimal values for FSN (x_{opt} = 1,176) and IL (y_{opt} = 90.08 cm) were found.

The regression analysis facilitated the evaluation of the FT (flowering time) variation in relation to VPuF and FSN, equation (3), in safety statistical conditions, according to $R^2 = 0.998$, $p < 0.001$.

$$FT = ax^2 + by^2 + cx + dy + exy + f \quad (3)$$

where: FT - flowering time;
x – VPuF – vegetation period until flowering;
y – FSN – flower stem number;
a, b, c, d, e, f – coefficients of the equation (3);
a= -0.0182723;
b= -5.2777201;
c= 1.6051579;
d= -38.8113120;
e= 0.7150408;
f= 0.

The ANOVA test confirmed the statistical safety for the values of the coefficients of equation (3), p <0.001. The graphical distribution of FT values in relation to VPuF (x-axis) and FSN (y-axis) is shown in figure 6, in 3D form, and in Figure 7 as isoquants format.

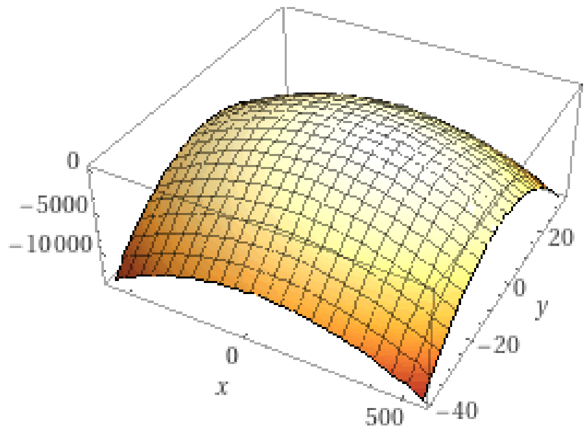

Fig. 6. 3D graphical distribution of FT values in relation to VPuF (x-axis) and FSN (y-axis)
Source: Original graph, generated based on experimental data.

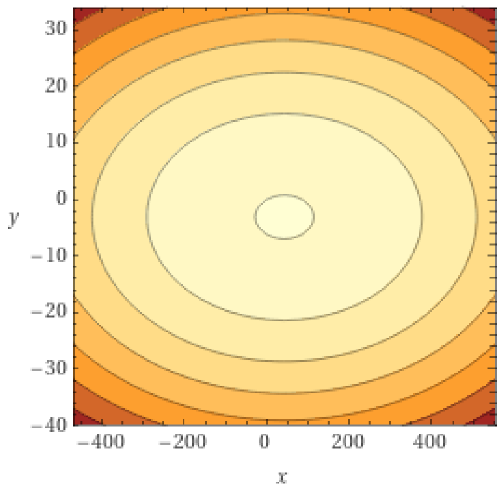

Fig. 7. Graphic distribution in the form of isoquants of the values of the FT index in relation to VPuF (x-axis) and FSN (y-axis)
Source: Original graph, generated based on experimental data

Starting from equation (3), the optimal values for VPuF and FSN in relation to flowering time (FT) were calculated. The values x_{opt} = 86.09 days (VPuF), and y_{opt} = 2.15 (FSN) were obtained.

FSN adjustment can be achieved by using vigorous, well-developed, healthy bulbs. Ensuring a fertile substrate and maintaining the plants during the vegetation period through watering works are also adequate cultivation measures. Controlling the number of flower stem number, by eliminating some competing or poorly developed ones, if necessary, can also help control the number of flowers, the quality of flowers and the duration of flowering.

It is recommended to maintain the gladiolus plants after flowering, by watering and fertilizing, for a period of 4-5 weeks, to result in vigorous bulbs for the next crop cycle.

Cantor et al. (2010) [8] presented classes of vegetation periods in gladiolus. In relation to these, among the varieties analyzed in the present study, 'Flower Song' (Flo_S) and 'Plumtart' (Plu) had an early period, 'Tequendame' (Teq) was in midseason, and the varieties 'Princess Margaret Rose' (PMR) and 'Praha' (Pra) they had a very late period.

Gladioli have high requirements for the growing substrate, as a nutrition media, whether it is represented by the soil or by various organo-mineral components, as mixtures [27].

The evaluation of the state of vegetation and plant health, as a general aspect, at the foliar level or of some expressive organs, is important in order to direct some influencing factors or to establish prophylactic measures [29], [13], [14].

Green spaces, with an ornamental and agreement role, are essential components in the urban ecosystems, strongly anthropized and influenced by climatic conditions, buildings, and other specific urban elements [17]. Urban habitats were studied in relation to different influencing factors and some specific indicators at the level of some plant species, considered as indicator plants [11]. In the context of the specificity of urban areas, gladioli may be of interest as ornamental garden plants [22], [5].

The results of this study are in line with the research direction on the use of ornamental plant species for decorative purposes or as market products

CONCLUSIONS

The studied gladiolus varieties showed a specific variation of vegetation indices and flower quality indices, and the differences registered, compared to the control variant, presented statistical certainty.

Models were found that described the variation of some flowers parameters in relation to vegetation indices, which allows the formulation of vegetation management measures in gladiolus crops order to obtain high floral quality parameters.

The clusters analysis and PCA facilitated the grouping of the studied varieties based on similarity in relation to the vegetative and floral parameters studied, which allows the choice of appropriate genotypes, in relation to the purpose of cultivating and capitalizing the flowers.

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