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Variability of some morphological parameters in crocus plants in relation to growing conditions

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Abstract
The study analyzed the variation of some parameters of the crocus plants in relation to the growing conditions. The experimental variants were generated through three growing substrates and three moments of planting the crocus bulbs, and resulted in nine variants. Plant height (PH) was the studied parameter. Moderate variability was recorded within the V2T2 variant (CV = 23.2726), and low variability was recorded within the other variants. Cluster analysis facilitated the grouping of variants based on similarity (Coph.corr. = 0.834). The experimental variants were positioned differently in relation to the calculated mean value. The V3T1 variant presented negative differences, at the $p<0.01$ level (oo), the V2T2 variant presented positive differences, at the $p<0.01$ level (**), the V1T3 variant presented positive differences at the $p<0.05$ level (*), and the V2T3 variant presented negative differences, at the level of $p<0.05$ (o). In the case of the other variants, the differences did not show statistical safety. The recorded results showed which growth substrate and planting time led to more vigorous plants, with influence for the ornamental appearance in the current crop cycle, as well as for the next crop cycle.

Keywords: cluster analysis, crocus, growth conditions, plant parameters, substrate

Introduction

Ornamental bulbous plants include a series of species with different characteristics in terms of the shape and color of the flowers, the flowering period, other indices of floral quality that recommend them [14].

Bulbous ornamental plants are of interest, primarily as ornamental in open or indoor spaces, and as resources for various industries, such as the food industry, the perfume industry, in pharmacy, medicine, cosmetics, etc. [1]. Ornamental bulbous plants are cultivated in different systems (open field, protected spaces, indoor spaces), but they lend themselves to pots or for cut flowers [13]. Bulbous plants create a "table effect", a fact that recommends them for certain ornamental arrangements in open spaces [6].

Bulbous ornamental plants present a very dynamic industry, with extensive changes in production systems [23]. The growing techniques of bulbous plants have diversified, in order to improve plant quality indices [17]. The authors studied the contribution of rhizobacteria in different growth substrates, with positive effects on the vegetative, plant growth and development indices.

For the cultivation of ornamental plants, different growing substrates have been studied, and more recently "soilless" crop systems have been promoted with important results [5], [9].

In the case of substrates based on solid components, different combinations of ingredients were studied, with variable proportions of participation in the mixtures [18]. Different components have been studied when making growing substrates, in relation to the crop system of ornamental plants [12]. Professional substrates, which include various "environmentally friendly" components, such as coconut fiber, wood fiber, green compost, etc. are increasingly promoted [3].

In order to ensure the environment for the growth of ornamental plants, substrates were studied in homogeneous mixtures, with different proportions of the components, but also stratified substrates, with differentiated functionalities of the components [10]. The influence of fertilizers, bioregulatory substances, in classical form or nanoparticle conditioning, was studied in relation to the way of application to plants of interest [11], [20], [21]. Different species of the genus Crocus are of interest in the field of ornamental plants, and have been studied in relation to the acclimatization process, with indices of ornamental quality, with different types

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of substrate and growing conditions [15], [16], [19].

The present study evaluated the variation of some parameters of the crocus plants in relation to the growing conditions, provided by different substrates and the moment of planting the crocus bulbs.

Material and Method

The study analyzed the variation of plant height in *Crocus sativus* L., in open field crop conditions, in different substrates. The experiment took place in open field conditions, in the area of the Padureni locality, during the period 2023-2024.

The planting material (9/10 size) contained 500 bulbs, with bulb diameter between D = 2.86 cm and D = 3.18 cm.

The land was prepared by working with the motor cultivator. The experiment included nine experimental variants, with the size of the variant of L = 1.3 m, W = 1m. Among the variants were access lanes of 0.20 m. The growth substrate was made of garden soil (V1), a mixture of soil with sand, in a 1:1 ratio (V2), respectively a mixture of soil with peat (Klasmann TS 3, pH=6) in a 1:1 ratio (V3).

45 bulbs were planted on each variant, in five rows. The planting was done in September, 2023, at three different time points: September 5, 2023 (T1), September 12, 2023 (T2), and September 19, 2023 (T3). Aspects of the experiment are presented in figure 1.

Figure 1. Aspects from the experiment (authors' original figure)

In relation to the purpose of the study, the height of the plants (PH, cm) was determined for each experimental variant.

The recorded data were analyzed mathematically and statistically to quantify the presence of variance, the reliability of the data and the differences between the variants. The data analysis was done in EXCEL and the PAST software [8].

Results and Discussion

The morphological parameter, plant height (PH) in Crocus was determined on each experimental variant associated with the growth substrate (V1, V2, V3), at the three time points (T1, T2, T3). The data series were analyzed and are represented graphically, as a box-plot format, in figure 2. From the analysis of the data series, the Anova Test confirmed the reliability of the experimental results and the presence of variance in the data series, table 1.

Moderate variability for PH was recorded in the case of the V2T2 variant (CV = 23.2726), and in the case of the other variants low variability was recorded (CV = 9.2805 in the case of the V3T3 variant, up to CV = 18.2106 in the case of V3T2). Through graphic analysis, the diversity profile was determined, figure 3, which confirmed the variability of the results in the case of the PH parameter, in relation to the experimental variants.

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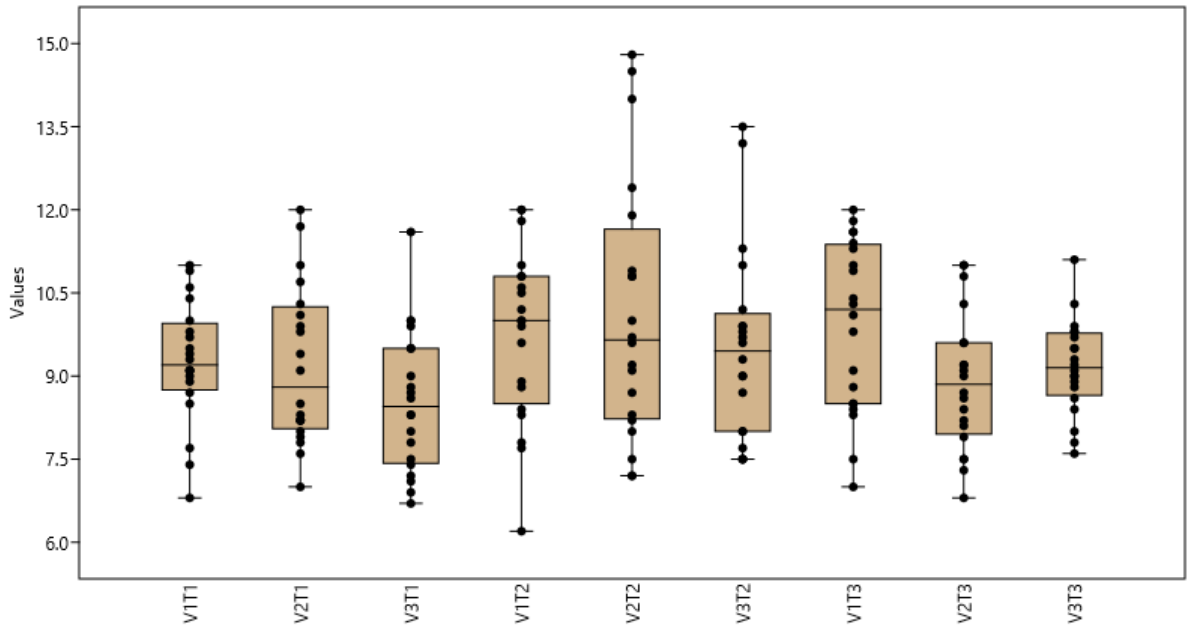

Figure 2. Graphic representation of experimental data in box-plot format

Table 1. Anova Test results

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	41.561	8	5.195125	2.276981	0.024356	1.9929
Within Groups	390.151	171	2.281585			
Total	431.712	179				

Alpha = 0.05

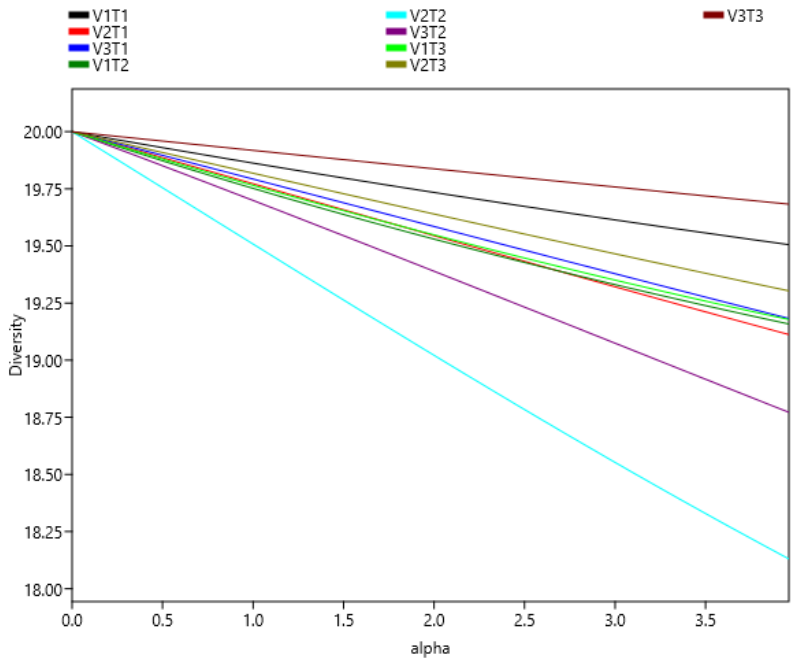

Figure 3. Diversity profile for the PH parameter of crocus plants

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The cluster analysis led to the diagram in figure 4, under conditions of Coph.corr. = 0.834. The grouping of the variants in two distinct clusters was found. Only one variant, V2T2, was included in the C1 cluster, which presented an obvious differentiation. The other variants were grouped in the C2 cluster, in two sub-clusters. Subcluster C2-A included two variants (V1T3 and V3T3). The other variants were grouped in the C2-B subcluster.

The degree of similarity at the level of the variants was quantified based on the SDI values, table 2. A high level of similarity was recorded at the level of the variants V1T1 and V3T3, with SDI = 7.2457. The ranking of the variants was done in relation to the height of the plants, and the result is presented in figure 5.

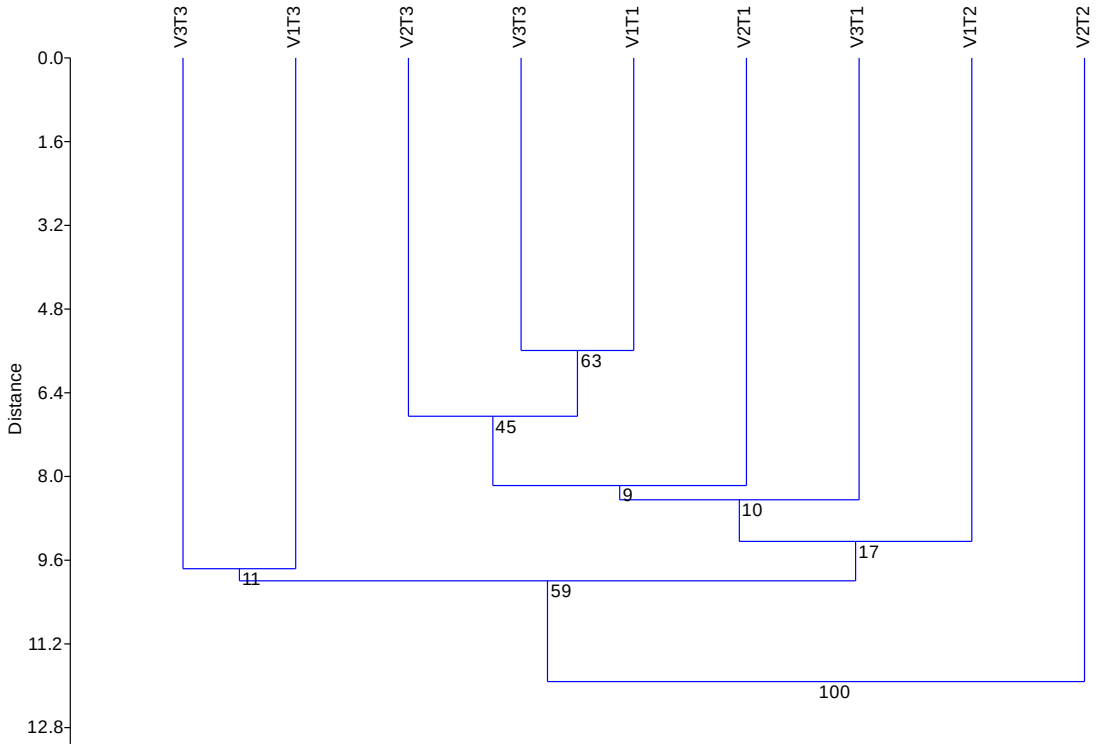

Figure 4. Cluster grouping of the variants in relation to the values of the PH parameter

Table 2. SDI values of the experimental variants, in relation to the PH parameter

	V1T1	V2T1	V3T1	V1T2	V2T2	V3T3	V1T3	V2T3	V3T3
V1T1		8.8668	9.0769	8.6937	12.0150	7.2457	9.3531	7.5888	5.5911
V2T1	8.8668		8.2468	10.7540	10.4790	8.8431	9.8934	8.0839	7.5670
V3T1	9.0769	8.2468		10.2850	12.4300	9.6866	10.1620	8.2207	8.2359
V1T2	8.6937	10.7540	10.2850		11.8100	12.4560	10.8670	9.6193	6.8557
V2T2	12.0150	10.4790	12.4300	11.8100		11.0800	11.5940	13.4710	12.4850
V3T3	7.2457	8.8431	9.6866	12.4560	11.0800		9.7632	11.2670	9.2607
V1T3	9.3531	9.8934	10.1620	10.8670	11.5940	9.7632		11.4130	9.4868
V2T3	7.5888	8.0839	8.2207	9.6193	13.4710	11.2670	11.4130		6.1066
V3T3	5.5911	7.5670	8.2359	6.8557	12.4850	9.2607	9.4868	6.1066	

The mean value of the PH parameter was calculated at the level of the experiment, in the amount of PH_m = 9.373±0.385 cm. The value of the PH parameter was analyzed for each variant, in relation to the mean value of the experiment. Variations of the growth increase (ΔPH) were recorded, between ΔPH = -0.833 cm, 91.11% (V3T1), and ΔPH = 0.767 cm (108.18%) in the case of the V2T2 variant, table 3, figure 6.

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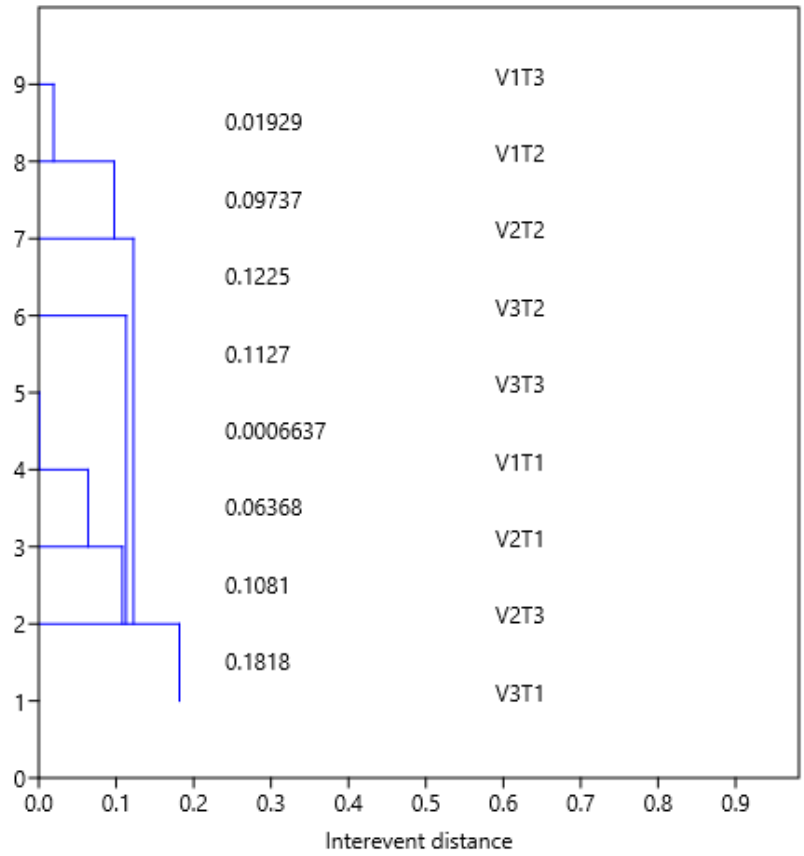

Figure 5. Scaling dendrogram of experimental variants in crocus

Table 3. Plant height values in relation to the average of the experiment

Variants	PH	Mean value	Differences	
	(cm)	(cm)	(cm)	(%)
V1T1	9.245±0.246	9.373±0.385	-0.128	98.63
V2T1	9.185±0.322		-0.188	97.99
V3T1	8.540±0.285		-0.833	91.11
V1T2	9.765±0.348		0.392	104.18
V2T2	10.140±0.528		0.767	108.18
V3T2	9.515±0.387		0.142	101.51
V1T3	9.915±0.346		0.542	105.78
V2T3	8.890±0.247		-0.483	94.85
V3T3	9.165±0.190		-0.208	97.78

The significance of the differences and the degree of statistical certainty on experimental variants were analyzed, in relation to the mean value at the level of the experiment. The results are the values shown in table 4.

The registered differences showed statistical certainty in the case of the V3T1 variant, at the level of $p<0.01$ (oo), in the case of the V2T2 variant, at the level of $p<0.01$ (**), in the case of the V1T3 variant, at the level of $p<0.05$ (*), and respectively in the case of the V2T3 variant, at the level of $p<0.05$ (o). In the case of the other variants, the differences did not show statistical certainty.

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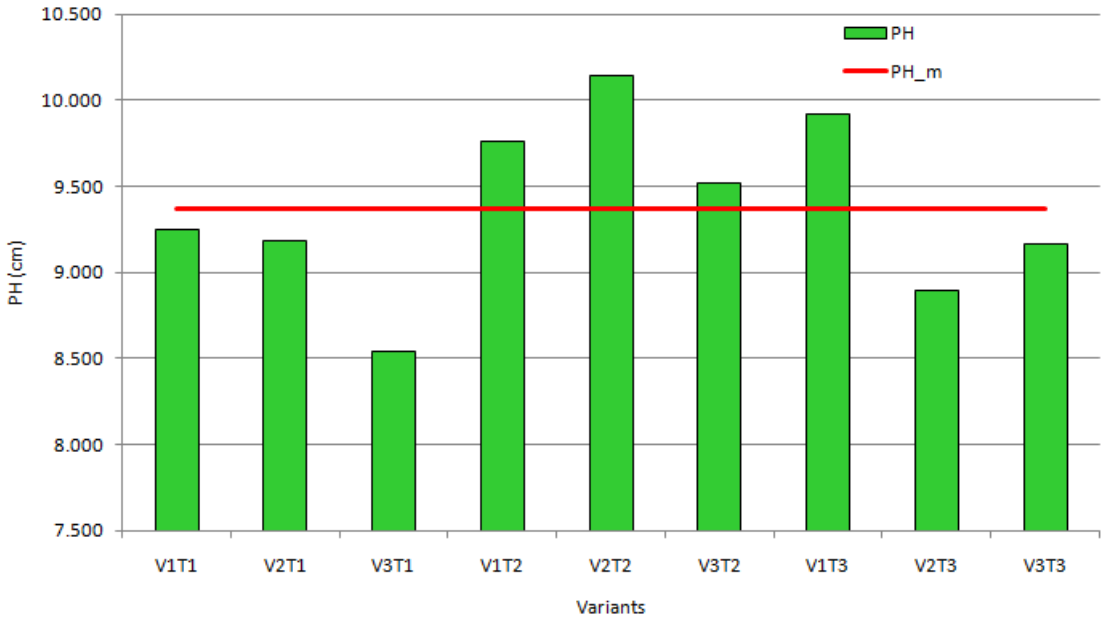

Figure 6. Graphical distribution of PH values in relation to the experimental mean value

Tabelul 4. The significance of the differences at the level of the experimental variants in relation to the PH mean value

Statistical parameters	Experimental variants								
	V1T1	V2T1	V3T1	V1T2	V2T2	V3T2	V1T3	V2T3	V3T3
Given mean:	9.245	9.185	8.540	9.765	10.140	9.515	9.915	8.890	9.165
Sample mean:	9.373	9.373	9.373	9.373	9.373	9.373	9.373	9.373	9.373
95% conf. interval:	(8.9816 9.7651)	(8.9816 9.7651)	(8.9816 9.7651)	(8.9816 9.7651)	(8.9816 9.7651)	(8.9816 9.7651)	(8.9816 9.7651)	(8.9816 9.7651)	(8.9816 9.7651)
Difference:	0.12833	0.18833	0.83333	0.39167	0.76667	0.14167	0.54167	0.48333	0.20833
95% conf. interval:	(-0.26342 0.52009)	(-0.20342 0.58009)	(0.44158 1.2251)	(-9.0702E-05 0.78342)	(0.37491 1.1584)	(-0.25009 0.53342)	(0.14991 0.93342)	(0.091576 0.87509)	(-0.18342 0.60009)
t :	0.7554	1.1086	4.9052	-2.3054	-4.5128	-0.83388	-3.1884	2.845	1.2263
p (same mean):	0.47166	0.29982	0.00118	0.05004	0.00196	0.42854	0.01283	0.02164	0.25495
Significance of differences	ns	ns	oo	ns	**	ns	*	o	ns

Ornamental plants were studied in relation to different substrates, and a differentiated response to the substrate and growth conditions was recorded, in relation to the plant species [11], [17], [18]. The behavior of crocus plants in relation to the substrate and growing conditions was also communicated in other studies, highlighting the favorable conditions given by the type of substrate, the time of planting, management practices [2], [4], [7], [22].

In the study conditions, the crocus plants showed differential vigor, in terms of the height of the plants, in relation to the substrate but also to the time of planting. At the T2 time of planting, all three substrates ensured good plant growth conditions, with values of the PH parameter above the average of the experiment. Substrates with a lighter, more aerated texture were, less favorable in relation to the T1 and T3 planting times, in study conditions.

Conclusions

The three substrates differentially influenced plant growth and the values of the analyzed morphological parameters, respectively plant height (PH). In the conditions of the substrate represented by garden soil (V1), the plants registered greater vigor, at all three planting times.

In relation to the time of planting, all growth substrates ensured good conditions associated with the T2 time of planting.

Compared to the mean value of the PH parameter at the experiment level, the V1T2, V2T2, V3T2 and V1T3 variants generated values above the mean, with statistical certainty in the case of the V2T2 and V1T3 variants. Negative differences were recorded, under statistical safety conditions, in the case of the V3T1 and V2T3 variants.

The results provide information regarding the interaction of the substrate with the planting date of the crocus bulbs, in order to obtain vigorous plants, with a good ornamental quality, in the study conditions. This information can be useful for ornamental crocus crops, under similar conditions.

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