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FLOWERS QUALITY IN RELATION TO PLANTING PERIOD IN SOME HYACINTH CULTIVARS

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Abstract

The study evaluated the quality of flowers in nine cultivars of Hyacinthus orientalis L. according to planting time and forcing period. Biological material was represented by nine Hyacinth cultivars: 'Carnegie' (Car), 'Blue Jacket' (B J), 'Blue Star' (B S), 'China Pink' (C P), 'Fondante' (Fon), 'Gipsy Queen' (G Q), 'Pink Pearl' (P P), 'Rembrandt' (Rem), 'Miss Saigon' (M S). A mixture of leaf soil and sand represented the growth substrate. The planting was done on three different calendar dates: November 10 (P I), November 24 (P II), and December 12 (P III) 2018, respectively. Forcing period (FP: FP I, FP II, FP III), flower stem length (FS: FS I, FS II, FS III) and flowering duration (FD: FD I, FD II, FD III) were evaluated. 'Blue Jacket' (B J) cultivar showed the highest values for flower stem (FS), with statistically assured differences for LSD 0.01% (FS I and FS II) and for LSD 5% (FS III), respectively. Differences statistically ensured for LSD5% were also recorded in 'Carnegie' (Car), 'Fondante' (Fon) cultivars (FS I and FS II), and in 'Gipsy Queen' (G Q) cultivar (FS I, FS II and FS III), respectively. The variation of the FS parameter in relation to FP, was described by a polynomial equation of degree 3 under conditions of R^2=0.839, p=0.045 for FP I, and by a polynomial equation of degree 2 under conditions of R^2=0.923, p=0.0016 for FP II. The flowering duration (FD) according to the forcing period (FP) was described by a polynomial equations of degree 2, under conditions of R^2=0.873, p=0.0057 for FP I, and in conditions of R^2 = 0.621, p=0.085 for FP II, respectively. PCA explained 58.498% of variance for PC1 and 30.622% of variance for PC2, in relation to the forcing period (FP); explained 58.052% of variance for PCI, and 34.78% of variance for PC2 in relation to flowering duration (FD), and explained 93.882% of variance for PC1 and 4.1988% of variance for PC2, respectively, in relation to flower stem (FS). Cluster analysis (two way) facilitated the grouping of the cultivars based on affinity in relation to FP, FD and FS, under statistical safety conditions (Coph. corr = 0.849).

Key words*: cluster analysis, flower quality, flowering period, Hyacinth, PCA.*

INTRODUCTION

Hyacinthus orientalis L. (*Asparagaceae*) has its origin in the Eastern part of the Mediterranean region. From Turkey it was introduced to Eastern Europe and a number of genotypes were improved to obtain and grow varieties with new decorative qualities (Hosokawa, 1999). During the Victorian period, there were about 2000 varieties in cultivation, and at present, it is estimated that 187 are registered in the International Register (Stebbings, 1996; Hosokawa, 1999), of which about 70 are most commonly cultivated as garden flowers, or in pots. The varieties differ by the size of the plants, the color of the flowers (white, yellow, pink, red, purple, blue), the type of petals (single or double), perfume. Anthocyanin compounds are an important factor for flower color and over 20 anthocyanins have been identified and isolated in hyacinth flowers (Harborna, 1964; Hosokawa et al. 1995a-c, 1996a,b, 1999).

It is a species cultivated for large-scale ornamental purposes in the Northern Hemisphere (Hosokawa, 1999; Nazari et al., 2011; Souza and Lorenzi, 2012; Alexandre et al., 2017). Individual flowers, as cut flowers, can also be use in indoor flower arrangements for different festive times, or for obtaining essential oils in the perfume and cosmetics industry (Hosokawa and Fukunaga, 1995; Nazari et al., 2011).

The importance of some species in ecosystem (Patoka et al., 2016; Jones et al., 2018), relationships with cultivation conditions (Addai, 2011; Smigielska et al., 2014; Karagöz et al., 2019), sensitivity to pathogens, genetic transformations in cultivated varieties and transmission of pathogens through propagation methods (Koetle et al., 2015; Patoka et al., 2016; Alexandre et al., 2017), the potential for transfer of pathogens to the international flower market (Santos et al., 2006; Çiğ and Başdoğan, 2016; Patoka et al., 2016) and obtaining forms resistant to pathogens (Popowich et al., 2007), have been analyzed by numerous studies and researches.

The methods, conditions and factors that influence the propagation of *Hyacinthus* genotypes, and bulblet induction (Krause, 1980; Cheesman et al., 2010), as well as the relationship with the growth substrates (Nazari et al., 2011), or the response to stress conditions (Türkoglu et al., 2011; Koksal et al., 2014) were studied.

Providing optimal conditions during the forcing period in relation to *Hyacinthus* varieties is very important, so the influence of factors such as temperature, humidity, light etc., have been studied on the evolution of plants and on the flowers quality (Dole, 2003; Addai and Scott, 2011). Flowers quality depends on the genotype and a number of factors such as forcing period, vegetation conditions (temperature, light through spectrum and intensity, growth medium etc.) (Nazari et al., 2011; Śmigielska et al., 2014).

The present study evaluated the influence of planting date and forcing period on flower quality in nine cultivars of *Hyacinthus orientalis* L.

MATERIAL AND METHODS

The study evaluated the quality of flowers in nine cultivars of *Hyacinthus orientalis* L. according to the time of planting and the forcing period. Biological material was represented by nine cultivars: 'Carnegie' (Car), 'Blue Jacket' (B J), 'Blue Star' (B S), 'China Pink' (C P), 'Fondante' (Fon), 'Gipsy Queen' (G Q), 'Pink Pearl' (P P), 'Rembrandt' (Rem), 'Miss Saigon' (M S).

The bulbs showed a high degree of uniformity in the case of each cultivar: 82.2 ± 1.38 g at 'Carnegie' (Car), 79.6 ± 1.43 g at 'Blue Jacket' (B J), 64.6 ± 1.29 g at 'Blue Star' (B S), 77.2 ± 1.98 g at 'China Pink' (C P), 77.4 ± 1.83 g at 'Fondante' (Fon), 87.4 ± 1.91 g at 'Gipsy Queen' (G Q), 63.1 ± 1.09 g at 'Pink Pearl' (P P), 73.8 ± 1.2 g at 'Rembrandt' (Rem), and 67.2 ± 1.95 g at 'Miss Saigon' (M S), respectively.

A mixture of leaf soil and sand represented the growth substrate, growt medium suitable for Hyacinth (Sala, 2011).

The planting was done on three different calendar dates: first planting (P I) on 10 November; second planting (P II) on 24 November and third planting (P III) on 8 Deccember 2018. The duration of the forcing period (FP), from the time of planting to flowering, was evaluated. Depending on the date of planting, three forcing periods were recorded: FP I in case of P I, FP II in case of P II and FP III in case of P III.

In order to evaluate the flowers quality, the length of the flower stem (FS) and the flowering duration (FD) were determined for the nine cultivars, in relation to the planting date and the forcing period.

To obtain the values for limit of significance of differences (LSD) the analysis of variance was used. In order to evaluate the degree of interdependence between the variables studied (FP, FD, FS), the correlation analysis was used. The behavioral models of some variables, as well as the statistical safety coefficients, were obtained by regression analysis. Principal Component Analysis and Cluster Analysis were used to evaluate the level of variance according to the main components, as well as to obtain the classification and association of the experimental variants. For the statistical certainty of the results, the correlation coefficients r and R^2, and p and F parameters were used. For the statistical analysis and processing of the experimental data, EXCEL and PAST programmes were used (Hammer et al., 2001).

RESULTS AND DISCUSSIONS

Depending on the time of planting (P I, P II, P III) the plants within the nine cultivars have undergone different periods of forcing (FP I, FP II, FP III) until the time of flowering. In the case of P I planting, there was a forcing period between 69 days in the 'Fondante' (Fon) and 'Gipsy Queen' (G Q) cultivars, and 76 days in the 'Rembrandt' (Rem) cultivar. For P II planting, the forcing period ranged from 85 days in 'Fondante' (Fon) cultivar and 89 days in 'Blue Jacket' (B J) and 'Gipsy Queen' (G Q) cultivars. In the case of P III planting, the forcing period varied between 83 days in the 'Carnegie' (Car) cultivar and 94 days in the 'Fondante' (Fon) cultivar (Table 1).

As a result of the planting times and the forcing period, three flowering durations (FD) were recorded (FD I, FD II and FD III). Flowering duration FD I varied between 10 days in 'China Pink' (C P) cultivar and 21 days in 'Gipsy Queen' (G Q) cultivar. Flowering duration FD II varied between 19 days in 'Blue Star' (B S) cultivar and 28 days in 'Blue Jacket' (B J) cultivar. Flowering duration FD III varied between 5 days in 'China Pink' (C P) cultivar and 18 days in 'Miss Saigon' (M S) cultivar (Table 1).

The dimensions of the flower stems (FS) varied according to cultivar, time of planting and forcing period (Table 2).

Table 1. Forcing period (FP) and flowering duration (FD) depending on the date of planting

Hyacinth cultivars	Values for forcing period (FP) and flowering duration (FD) depending on the date of planting					
	P I (10 11 2018)		P II (24 11 2018)		P III (8 12 2018)	
	FP I	FD I	FP II	FD II	FP III	FD III
	(days)					
'Carnegie' (Car)	71	18	88	26	83	14
'Blue Jacket' (B J)	75	19	89	28	90	16
'Blue Star' (B S)	73	14	85	19	92	11
'China Pink' (C P)	74	10	87	21	91	5
'Fondante' (Fon)	69	20	85	27	94	11
'Gipsy Queen' (G Q)	69	21	89	23	91	8
'Pink Pearl' (P P)	72	13	86	20	86	14
'Rembrandt' (Rem)	76	13	86	22	89	10
'Miss Saigon' (M S)	74	13	88	22	88	18

P – time of planting (P I – first planting; P II – second planting; P III – third planting); FP – forcing period; FP I – forcing period for first planting (P I); FP II – forcing period for second planting (P II); FP III – forcing period for third planting (P III); FD – flowering duration; FD I – flowering duration I (associated with P I and FP I); FD II – flowering duration II (associated with P II and FP II); FD III – flowering duration III (associated with P III and FP III)

Table 2. Size of the flower stem in the Hyacinth cultivars studied, in relation to the forcing period

Hyacynth cultivars	Floral stem length (cm) depending on the date of planting								
	P I (10 11 2018)			P II (24 11 2018)			P III (8 12 2018)		
	FS I Mean values	Diferences	Signification	FS II Mean values	Diferences	Signification	FS III Mean values	Diferences	Signification
'Carnegie' (Car)	11	1.67	*	10.66	0.89	-	8.33	-0.32	-
'Blue Jacket' (B J)	12.33	3	***	13.66	3.89	***	11	2.34	*
'Blue Star' (B S)	7.33	-1.99	0	7.33	-2.44	0	7.66	-0.99	-
'China Pink' (C P)	7.66	-1.66	0	8.66	-1.11	-	8.33	-0.32	-
'Fondante' (Fon)	11.33	2	*	11	1.33	-	10	1.34	-
'Gipsy Queen' (G Q)	11	1.67	*	11.66	1.89	*	10.66	2	*
'Pink Pearl' (P P)	8	-1.33	-	7.33	-2.44	0	6.66	-1.99	0
'Rembrandt' (Rem)	7	-2.33	0	8	-1.77	0	7.66	-0.99	-
'Miss Saigon' (M S)	8.33	-0.99	-	9.66	-0.11		7.66	-0.99	-
Control	9.33			9.77			8.66		
Limit of significance of differences (LSD)	LSD5%=1.53; LSD1%=2.10; LSD0.1%=2.86			LSD5%=1.54; LSD1%=2.12; LSD0.1%=2.88			LSD5%=1.83; LSD1%=2.51; LSD0.1%=3.42		

FS I – flower stem in P I conditions; FS II – flower stem in P II conditions; FS III – flower stem in P III conditions

The quality of the flowers, based on the size of the flower stem (FS), a parameter that varied in relation to forcing period (FP), was evaluated. Larger flowers have higher quality and are more appreciated. The values for flower stem (FS I) ranged between 7.00 cm in 'Rembrandt' (Rem) cultivar and 12.33 cm in 'Blue Jacket' (B J) cultivar, in the case of FP I forcing period. The length of the flower stem (FS II) was between 8.00 cm in 'Rembrandt' (Rem) cultivar and 13.66 cm in 'Blue Jacket' (B J) cultivar in the case of FP II forcing period. The floral stems (FS III) had dimensions between 6.66 cm in 'Pink Pearl' (P P) cultivar and 11.00 cm in 'Blue Jacket' (B J) cultivar in the case of FP III forcing period.

The 'Blue Jacket' cultivar presented the highest values for the flower stem in all three flowering periods, with statistically assured differences for LSD 0.01% (P I and P II planting period) and LSD 5% (P III planting period). 'Carnegie', 'Fondante' (P I and P II planting periods) and 'Gipsy Queen' cultivars (P I, P II, P III planting periods) were also evidenced.

In the case of the first planting (P I), the variation of flower stem length, depending on the forcing period (FP I), was described by a polynomial equation of degree 3, relation (1), under conditions of $R^2 = 0.839$, $p = 0.045$.

The graphical distribution of the FS parameter values according to the forcing period (FP), for the planting variant P I, is presented in Figure 1.

$$y = 0.02207x^3 - 4.746x^2 + 339.3x - 8056 \qquad (1)$$

where: y - flower stem - FS I (cm); x - forcing period - FP I (days).

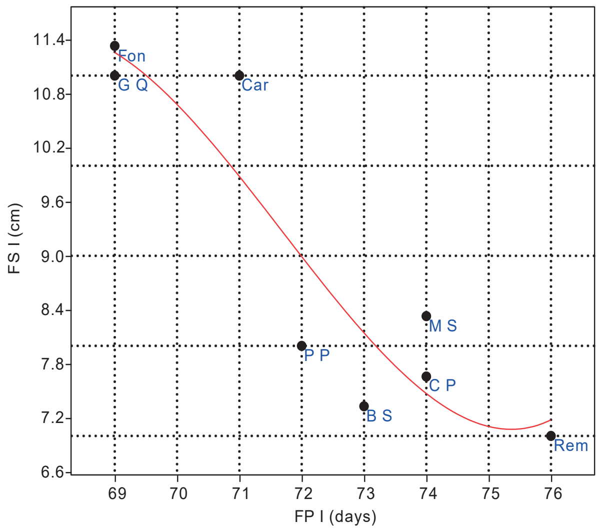

Figure 1. Flower stem (cm) in relation to forcing period (FD I) in condition to P I planting (analysis without 'Blue Jacket' cultivar)

In the case of P II plantations, the length of the flower stem (FS) according to the forcing period (FP II) was described by a polynomial equation of degree 2, relation (2), in conditions of $R^2=0.923$, $p=0.0016$. The graphical distribution of the FS parameter values, according to the forcing period (FP II), for the planting variant P II, is presented in Figure 2.

$$y = 0.3544x^2 - 60.36x + 2577 \qquad (2)$$

where: y - flower stem - FS II (cm); x - forcing period - FP II (days).

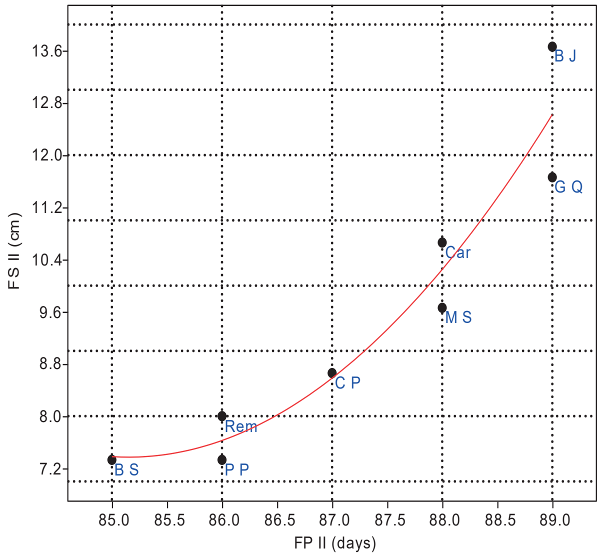

Figure 2. Flower stem in relation to forcing period in condition of P II planting (analisys without 'Fondante' cultivar)

The length of the flower stem presented a high variability in relation to forcing period FP III (CV = 17.5502). As a result, the analysis of the data did not lead to obtaining a model of variation of the parameter FS III in relation to FP III, under statistical safety conditions.

Flowering duration also has a high importance regarding the quality of flowers, both from a practical and economic point of view.

For the first planting period (P I) the highest flowering duration was recorded in the 'Gipsy Queen' (G Q) cultivar (21 days), followed by 'Fondante' (Fon) (20 days), 'Blue Jacket' (B J) (19 days) and 'Carnegie' (Car) (18 days), and the shortest period of flowering was recorded at 'China Pink' (C P) (10 days).

In case of P II planting, the highest values of flowering duration were recorded in the 'Blue Jacket' (B J) cultivar (28 days), followed by 'Fondante' (Fon) (27 days), and 'Carnegie' (Car) (26 days), and the lowest value was recorded in the 'Blue Star' (B S) cultivar (19 days). In the case of P III planting, the highest flowering duration was recorded in the 'Miss

Saigon' (M S) cultivar (18 days) followed by 'Blue Jacket' (B J) (16 days), the other cultivars having shorter flowering durations, and the shortest was at 'China Pink' (C P) (5 days). The comparative analysis regarding the flowering duration for the three planting periods, highlighted the P II planting period during which the highest flowering duration in the studied cultivars was recorded. The total flowering duration (TFD) calculated as $TFD = FDI + FDII + FDIII$, led to the graphical representation in Figure 3.

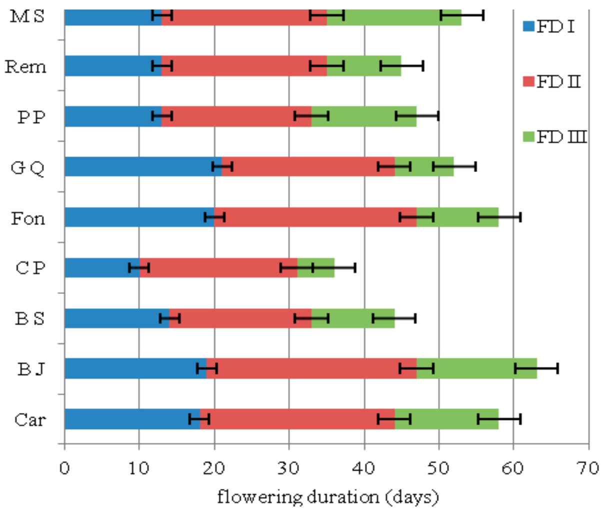

Figure 3. TFD diagram for Hyacinth cultivars according to planting period

In relation to TFD, there were four classes of 10 days each. In class C1 (TFD = 30-40 days) C P cultivar was classified; in class C2 (TFD = 40-50 days) B S, P P and Rem cultivars were included; in class C3 (TFD = 50-60 days) Car, Fon, G Q and M S cultivars were classified, and in class C4 (TDF> 60 days) the B J cultivar was included.

The possibility of flowering duration (FD) estimating was tested according to the forcing period (FP), variable that depended on the planting times (P I, P II, P III).

In the case of the P I planting time, estimation of flowering duration (FD I) was possible based on a polynomial equation of degree 2, relation (3), under conditions of $R^2 = 0.873$, $p = 0.0057$, graphical distribution being presented in Figure 4.

$$y = 0.2466x^2 - 36.97x + 1397 \qquad (3)$$

where: y - flowering duration - FD (days); x - forcing period - FP (days).

For the P II planting variant, the flowering duration (FD II) according to the FP II forcing period was described by a polynomial equation of degree 2, relation (4), under conditions of $R^2 = 0.621$, $p = 0.085$, graphical distribution being presented in Figure 5.

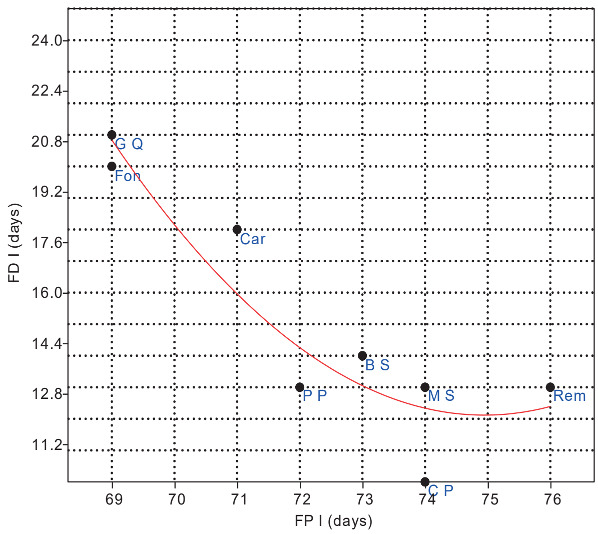

Figure 4. Graphical distribution of flowering duration (FD) according to the forcing period (FP), in case of P I planting variant

$$y = 0.08503x^2 - 13.22x + 528.7 \qquad (4)$$

where: y - flowering duration - FD (days); x - forcing period - FP (days).

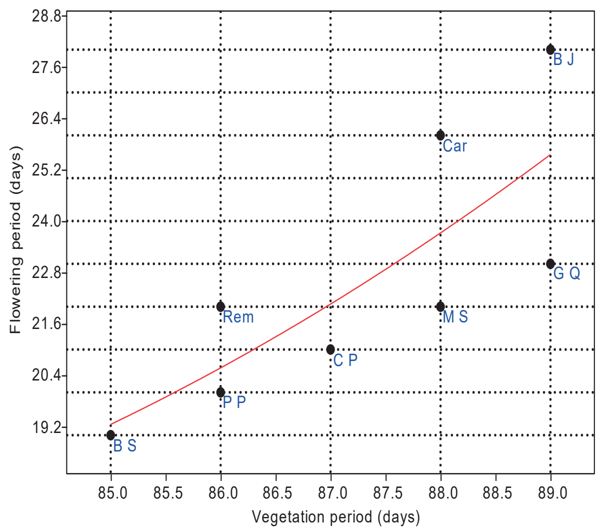

Figure 5. Graphical distribution of flowering duration FD II according to the FP II forcing period, in case of P II planting variant

For the planting period P III, the flowering duration (FD III) showed a high variability (CV = 34.0224), and by analyzing the data in relation to the FP III forcing period, a model describing the FD III variation in relation to FP III was not obtained under statistical safety conditions.

PCA was used to evaluate the distribution and association of cultivars in relation to the three forcing periods (FP I, FP II, FP III), flowering durations (FD I, FD II, FD III), and flower stem (FS I, FS II, FS III). PCA analysis explained 58.498% of variance for PC1 and 30.622% of variance for PC2, in relation to the forcing period (FP), Figure 6.

PCA diagram (Figure 6) show how the cultivars M S, Rem and B J were associated with the biplot FP I; Carp and P P cultivars were associated with FP II biplot, and C P and B S cultivars were associated with FP III biplot.

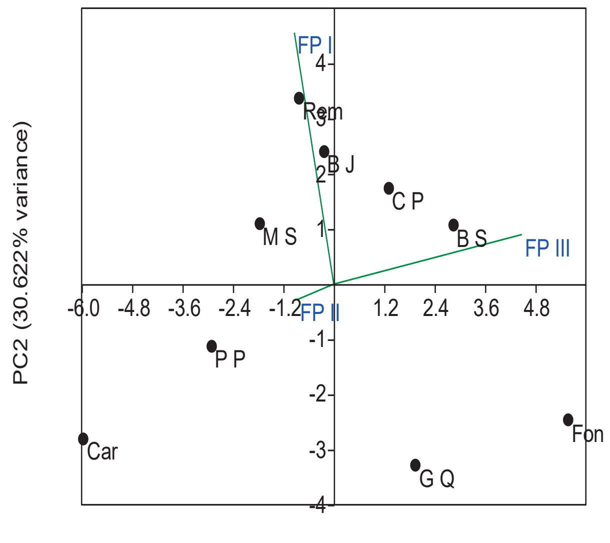

Figure 6. PCA diagram in relation to forcing period (FP) for Hyacinth cultivars studied

In relation to flowering duration (FD), PCA explained 58.052% of variance for PCI, and 34.78% of variance for PC2. From the PCA diagram shown in Figure 7, were found the association of G Q and Fon cultivars with FD I and FD II biplots, respectively the association of M S, Car and B J cultivars with FD III biplot.

In relation to flowers stem (FS), PCA explained 93.882% of variance for PC1 and 4.1988% of variance for PC2, respectively. From the PCA diagram shown in Figure 8, were found the association of Car and Fon cultivars with FS I biplot, and the association of G Q and B J cultivars with FS II and FS III biplots.

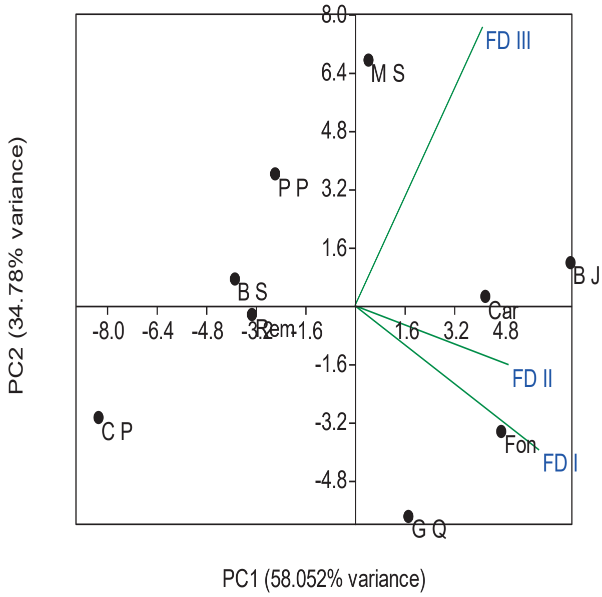

Figure 7. PCA diagram in relation flowering duration (FD) for Hyacinth cultivars studied

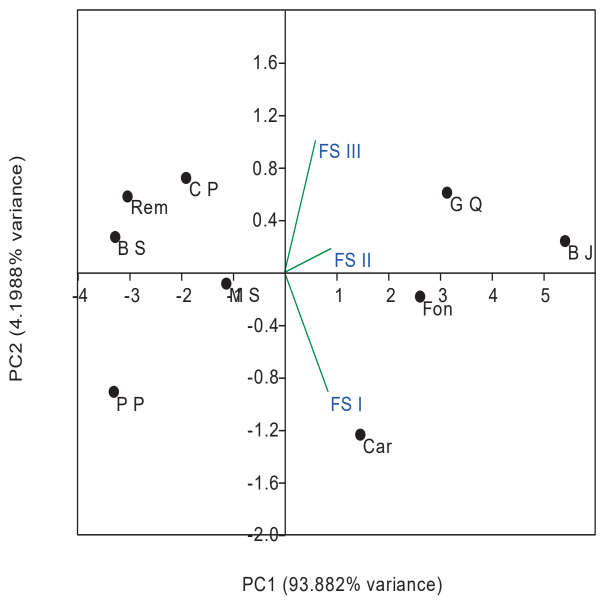

Figure 8. PCA diagram in relation to flowers stem (FS) for Hyacinth cultivars studied

Cluster analysis (two way) facilitated the grouping of cultivars on the basis of affinity with respect to the forcing period (FP) and flower stem (FS), under statistical safety conditions, Coph. corr. = 0.849 (Figure 9).

From the dendrogram analysis shown in Figure 9, were found high affinity between FP II and FP III (common subcluster) and high affinity between FS I and FS II (common subcluster).

Regarding the grouping of cultivars in relation to the two parameters (FP and FS), two distinct clusters were formed with several sub-clusters each. In the CI cluster, 'Fondante' (Fon) and

'Gipsy Queen' (G Q) cultivars were grouped with similar results (common subcluster), and 'Blue Jacket' (B J) cultivar being associated with the respective sub-cluster.

In C2 cluster, two sub-clusters with high affinity (B S and C P, respectively Rem and M S) were identified, to which the P P cultivar is attached, followed by the Car cultivar.

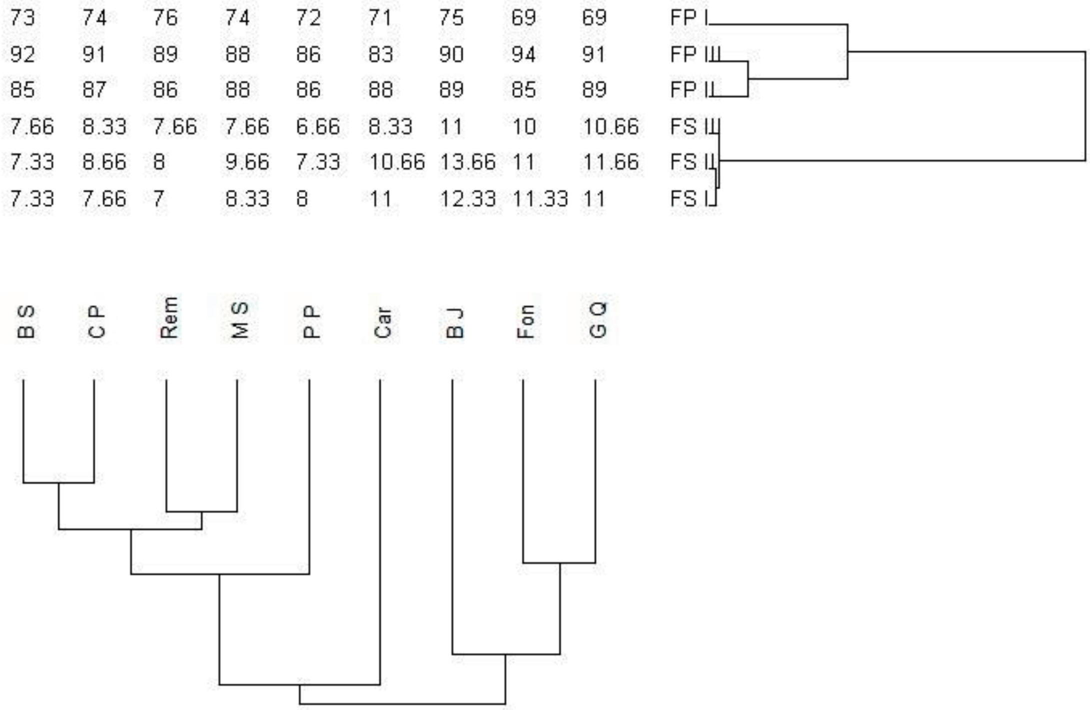

Figure 9. Dendrogram based on Cluster analysis, two way, on the nine Hyacinth cultivars in relation to FP and FS

Ornamental plants are important both by the decorative effect and by the functional role at the level of natural or urban ecosystem (Baiyewu et al., 2005; Acar et al., 2007; Mohamad et al., 2013; Dragoș et al., 2018).

For the qualitative appreciation of the ornamental plants through the leaves, a series of elements such as the shape, dimensions and spatial distribution of the leaves are important (Di Benedetto et al., 2006; Li et al., 2014; Santagostini et al., 2014).

In addition, the leaf surface, for which different estimation methods were elaborated (Sala et al., 2015; Drienovsky et al., 2017; Cândea-Crăciun et al., 2018), the health and intensity of the leaf color (Kim et al., 2012; Bayat et al., 2018), are parameters which, moreover, contributes to the plants functioning, and in decorative and contrasting effect of ornamental plants.

For ornamental plants through flowers, morphological description and qualitative assessment was made on the basis of parameters, descriptors and qualitative indices of flowers (shape, size, color, flowering duration, perfume etc.), as well as the flowers/leaves proportion and balance, and the plants as whole (Dobrilovič, 2010; Kuligowska et al., 2015; Huss et al., 2018).

The quality of the flowers at Hyacinth was evaluated based on several parameters that concern the plant as a whole. It presented interest especially the height of the plant, the length of the inflorescence, the length of the leaves, the diameter and the circumference of the inflorescence, the number of flowers in inflorescence, the petals arrangement, flowering duration, color, perfume (Addai, 2011; Śmigielska et al., 2014; Çiğ and Koçak, 2019).

Flowers dimensions (length of the flower stem, diameter, circumference) and the number of inflorescences were studied and appreciated as important elements in the qualitative assessment at Hyacinth (Addai, 2011).

The colors of leaves and flowers in plants in general, and especially in ornamental plants have been intensively studied and have been found to be of particular importance for the management of species and genotypes (Kendal et al., 2013; Zhao and Tao, 2015; Noman et al., 2017).

Flower color is genotype specific, and anthocyanin profiles were studied in flower petals in different genotypes of *Hyacinthus orientalis* and grape hyacinth (*Muscari* ssp.) (Tao et al., 2015; Lou et al., 2017). At the same time, the color of the flowers is influenced in intensity, by the pH of the soil or the growth substrate, and certain mineral salts (Sala, 2011, 2018; Yang et al., 2012; Zhao and Tao, 2015).

The perfume complements the spatial architectural ensemble and creates a special atmosphere through elegant notes (Fenske and Imaizumi, 2016; Noman et al., 2017).

Flowering duration is also important in *Hyacinthus* and has been studied in relation to planting periods, forcing periods, genotypes, growing conditions, mycorrhizal relationships and so on. (Śmigielska et al., 2014; Xie and Wu, 2017). The estimation of the flowering period and duration, has already been performed in other ornamental species, based on polynomial or smoothing spline models (Băla et al., 2018).

The prolonged stress induces disturbances of physiological indices in the ornamental plants and the reduction of the anthocyanin content, which affects the leaves and flowers colors of the ornamental plants (Li et al., 2009; Zhao and Tao, 2015).

Alterations of physiological indices and flower quality in Hyacinthus were recorded under alkaline pH conditions and high concentrations of mineral salts, such as Na (Türkoglu et al., 2011; Koksal et al., 2014).

The results communicated are in accordance with the data and the results presented by the specialized literature that was the basis for the documentation of this study.

CONCLUSIONS

The nine cultivars of *Hyacinthus orientalis* L. had different behavior in terms of vegetation period (VP), flowering duration (FD) and flower stem (FS) as a flower quality element, under similar growing conditions. 'Blue Jacket' (B J) was differentiated by the largest size of the flower stem, followed by 'Fondante', (Fon) 'Carnegie' (Car), and 'Gipsy Queen' (G Q), with statistically assured differences from the control.

Models of polynomial equations of degree 2 and 3 were obtained, to estimate the size of the flower stem (FS) and the flowering duration (FD) in relation to the vegetation period, under statistic safety conditions.

Principal Component Analysis and Cluster Analysis approaches explained the variance and the association of the cultivars in relation to variables studied, under statistical safety conditions.

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