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QUALITY OF FLOWERS TO DAFFODILS BASED ON VEGETATIVE AND FLORAL INDICES

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Abstract

The study aimed to evaluate the quality of flowers in daffodils (Narcissus pseudonarcissus L.) in relation to physiological indices and parameters and floral indices. The biological material was represented by five varieties of daffodils: 'Carlton', 'Ice Follies', 'St. Patrick', 'Dick Wilden' and 'Salome'. A series of physiological indices and parameters, and floral indices were evaluated that described the status of plants (plant height - PH, number of leaves - LN, length of leaves - LL), vegetation period (VP), flowering period (FP), and flowers size (FS). The flowering period (FP) expressed in days, recorded the values: FP = 13 days for 'Carlton', FP = 18 days for 'Ice Follies', FP = 9 days for 'St. Patrick', FP = 10 days for 'Dick Wilden', and respectively FP = 11 days for 'Salome'. Correlation analysis revealed very high, positive, correlations between FS and LN (r = 0.968), and between plant height (PH) and leaf length (LL) (r = 0.915). The variation of FS according to LN was described by a polynomial equation of degree 2, under conditions of R^2 = 0.938, p << 0.01. A 3D model of FS variation with respect to LN and FP was obtained, and a graphical representation in the form of isoquant, expressed a possible combination of LN and FP for optimum of FS. Principal Component Analysis (PCA) led to the distribution of the studied varieties in relation to the main quality parameters considered (VP, FP and FS). PC1 explained 43.701% of variance, and PC2 explained 39.003% of variance. Cluster analysis led to the grouping of daffodils varieties based on affinity with respect to flower quality indices (FP and FS) under statistical safety conditions, Coph.corr. = 0.924.

Key words: *daffodils, cluster analysis, flowers quality, isoquant, PCA*

INTRODUCTION

Narcissus is a genus of perennial plants, predominantly spring, which belongs to the Family *Amaryllis*, *Amaryllidaceae* [27]. Daffodils (*Narcissus pseudonarcissus* L.) are one of the most popular ornamental plants in the world [2], [44], [9], [18], [5], [15], [3].

Narcissus species, for the most part, are synanthous, which means that the leaves and flower stems appear at the same time [15], [6]. Some studies have evaluated the characteristics of different varieties of daffodils compared to wild taxa in order to establish the degree of connection between cultivated varieties and wild plants from different areas around the World [37]. Phylogeny studies in Narcissus were also conducted [46].It is known the use of daffodil flowers, but also of other plants of the Family *Amaryllidaceae*, in the popular practice for treating some diseases, and studies and researches have identified a series of compounds with specific pharmaceutical and medicinal action [25]. Studies on a number of active principles and their usefulness in the pharmaceutical field have been carried out on different parts of *Narcissus* plants [34], [22], [36].

Obtaining quality biological material is of interest for the production of ornamental plants of daffodils with aesthetic and economic value, in this sense being carried out studies on the methods of daffodils multiplication [42].

Soil or different growth media are used for the cultivation of ornamental plants, and the relationship of plants with soil or growing media is important for obtaining quality ornamental plants [39]. Some studies have evaluated the relationships of daffodil plants with salinity conditions in order to evaluate the response to saline stress conditions [45]. The relationships of daffodil plants with soil and nutrients were studied under different cultivation conditions as ornamental plants, an important aspect being the period of nitrogen application [6].

The leaves of daffodils have been studied in relation to the level of bulb development, and to the methods and techniques of propagation [28]. The study of the leaves in daffodils was approached in different genotypes in relation to the vegetation and flowering period, in relation to growth bioregulatory substances [7], as well to other aspects [8], for the study of the leaf area being proposed different models and applications [40], [10]. Also the leaves were studied in relation to the vegetation conditions, especially with the variation of the temperatures that had an influence on the elongation of the leaves and the development of the flowers [24]. Some studies at the leaf level have evaluated the relationship with different pathogens and treatment methods [16], the rapid and accurate evaluation of the degree of attack of some pathogens being facilitated by software applications [11].

The quality of flowers and the variation of the flowering period in daffodils was studied in relation to different varieties, cultivation conditions, soil conditions, but also with their pharmaceutical potential [35], [25], [6].

The daffodils were also a model for studying the distribution of carotenoid pigments, involved in determining the color of yellow and orange, because the daffodils are predisposed to the phenomenon of "color break", and in the daffodils the phenomenon of "brocken" in white spots was identified [18].

In natural conditions, daffodils are present in certain favorable areas in the form of large specific plant associations, managed as Protected Areas (Nature Reserves), and imaging analysis is a useful tool for the study and management of such areas [17], [33]. Several Daffodils' Glade are known in Romania, some of them Protected Area and Nature Reserves, such as: "Negrileasa" and "Țecnești" Alba County, "Rovina" and "Susag" Arad County, "Negrași" Argeș County, "Goronișteе" and "Oșorhei" Bihor County, "Șesul Mogoșenilor" and "Șesul Văii Budacului" Bistrita-Năsăud County, "Dumbrava Vadului" Brașov County, "Zervești" Caras-Severin County, "Șardu" Cluj County, "Lunca Neajlovului" Dâmbovița County, "Dealul Ciocârlău" Gorj County, "Dumbrava Harghitei" Harghita County, "Nucșoara", Hunedoara County, "Gurghiu" Mures County, "Racâș-Hida" Sălaj County, "Șuvara Sașilor" Sibiu County, "Bătești" Timis County [26]. In the traditional symbolism, the daffodil is considered as a "flower of rebirth", and associated with some Daffodils Nature Reservation, cultural events are held, such as "Daffodils' Festival" (Nature Reservation "Dumbrava Vadului", Brasov County). This also highlights the tourism potential of the respective areas, having as central subject the daffodils. Tourism, in fact, has been the subject of valuable studies that have contributed to the enhancement of some tourist objectives or opened new trends in tourism science [20], [30], [31], [32].

The present study evaluated the quality of flowers in five varieties of daffodils (*Narcissus pseudonarcissus* L.) in relation to the vegetation period, flowering period and flower size.

MATERIALS AND METHODS

The study aimed to evaluate the quality of flowers in daffodils, in relation to physiological indices and floral indices.

The biological material was represented by five varieties of daffodils: 'Carlton', 'Ice Follies', 'St. Patrick', 'Dick Wilden' and 'Salome'. The control variant was represented by trials average value. A series of physiological indices, and parameters and floral indices were evaluated that described the status of plants (plant height - PH, leaf number - LN, length of leaves - LL), vegetation period (VP), flowering period (FP), and flowers size (FS). For analysis and interpretation of experimental data, variant analysis, correlation analysis, regression analysis, principal component analysis (PCA), and cluster analysis (CA) were used.

As the parameters of the statistical safety, the values of the significance limit of differences (LSD), correlation and regression coefficients (r, R^2), the cophenetic coefficient (Coph.corr), similarity and distances indices (SDI) were used.

PAST software [14], and Wolfram Alpha software [49] were used to analyze the experimental data.

RESULTS AND DISCUSSIONS

The five varieties of daffodils were evaluated in terms of vegetation indices and parameters, and floral indices. In terms of vegetation period (VP), expressed in days, the studied varieties recorded the following values: VP = 80 days for 'Carlton', VP = 101 days for 'Ice Follies', VP = 125 days for 'St. Patrick', VP = 98 days for 'Dick Wilden', and respectively VP = 71 days for 'Salome'.

The flowering period (FP) expressed in days, recorded the values: FP = 13 days for 'Carlton', FP = 18 days for 'Ice Follies', FP = 9 days for 'St. Patrick', FP = 10 days for 'Dick Wilden', and respectively FP = 11 days for 'Salome'.

With regard to plant height, the five genotypes showed mean values between 14.75 ± 0.42 cm in the 'Ice Follies' variety and 31.83 ± 1.43 in the 'Carlton' variety, where the differences from the average of the experience showed statistical significance for LSD 0.1%, Table 1.

Table 1. Variation of the plants height in daffodils according to the studied varieties

Cultivars	Average value (cm)	Relative value (%)	Differences
'Carlton'	31.83±1.43	140.03	9.10***
'Ice Follies'	14.75±0.42	64.88	-7.98^{00}
'St. Patrick'	22.00±2.78	96.77	-0.73
'Dick Wilden'	23.25±0.80	102.27	0.52
'Salome'	21.83±0.67	21.83	-0.90
Control	22.73±0.62	100.00	-
LSD values	LSD 5%=4.733; LSD 1%=6.410; LSD 0.1%=8.569		

Source: original data, resulted from our experiments.

The number of leaves, as an index and parameter of vegetation, showed average values between 4.20 ± 0.71 cm in the 'Carlton' variety and 6.40 ± 0.75 in the 'Dick Wilden' variety, where the differences from the average of the experience showed statistical significance for LSD 0.1%, Table 2.

Table 2. Variation in the leaves number per plant in daffodils depending on the studied varieties

Cultivars	Average value (no)	Relative value (%)	Differences
'Carlton'	4.20±0.71	81.08	-0.98
'Ice Follies'	5.00±0.71	96.53	-0.18
'St. Patrick'	4.80±0.58	92.66	-0.38
'Dick Wilden'	6.40±0.75	123.55	1.22*
'Salome'	5.50±0.68	106.18	0.32
Control	5.18±0.18	100.00	-
LSD values	LSD 5%=1.210; LSD 1%=1.656; LSD 0.1%=2.245		

Source: original data, resulted from our experiments.

The length of the leaves, as a vegetation index, showed average values between 17.48 ± 2.00 cm in 'Ice Follies' variety, and 30.08 ± 1.79 cm in 'Carlton' variety. There were positive differences compared to the control in the 'Carlton' variety, in conditions of statistical significance for LSD 0.1%, and in the case of the 'Ice Follies' variety, there were negative differences compared to the control variant, in statistical safety conditions for LSD 5%, Table 3.

Table 3. Variation of leaf length per plant in daffodils depending on the studied varieties

Cultivars	Average value (cm)	Relative value (%)	Differences
'Carlton'	30.08±1.79	134.10	7.65**
'Ice Follies'	17.48±2.00	77.93	-4.95^{0}
'St. Patrick'	21.33±1.95	95.10	-1.10
'Dick Wilden'	19.73±1.75	87.96	-2.70
'Salome'	23.68±0.86	105.57	1.25
Control	22.43±0.71	100.00	-
LSD values	LSD 5%=4.557; LSD 1%=6.172; LSD 0.1%=8.252		

Source: original data, resulted from our experiments.

The size of the flowers, as a quality floral index, showed average values between 5.47 ± 0.44 cm in the 'Carlton' variety and 6.88 ± 0.36 in the 'Dick Wilden' variety, where the difference from the average of the experience showed statistical significance for LSD 5 %, Table 4.

The correlation analysis revealed very high correlations between FS and LN, r = 0.968, and between plant height (PH) and leaf length (LL), r = 0.915.

The variation of FS according to LN was described by a polynomial equation of degree 2, equation (1), under conditions of R^2=0.938, $p << 0.01$.

Table 4. Variation of flower size in daffodils depending on the studied varieties

Cultivars	Average value (cm)	Relative value (%)	Differences
'Carlton'	5.47±0.44	89.67	-0.63
'Ice Follies'	5.92±0.40	97.05	-0.18
'St. Patrick'	5.67±0.32	92.95	-0.43
'Dick Wilden'	6.88±0.36	112.79	0.78*
'Salome'	6.55±0.18	107.38	0.45
Control	6.10±0.12	100.00	-
LSD values	LSD 5%=0.771; LSD 1%=1.045; LSD 0.1%=1.397		

Source: original data, resulted from our experiments.

$$FS = -0.0373LN^2 + 1.0979LN + 1.4327 \quad (1)$$

The size of the flowers is a character

determined by the genotype and variety, but influenced to a certain extent by the vegetation conditions, as well as by physiological indices that express the state of nutrition and vegetation of the plants.

For the five daffodils studied varieties, the variation of FS according to the number of leaves (LN) and the flowering period (FP), was described by equation (2), in condition of R^2= 0.998, p<0.01, F=1052.53.

The graphical distribution of FS variation in relation to LN and FP is presented in Figs. 1 and 2.

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

where: x – LN, y – FP;
a, b, c, d, e, f - the equation (2) coefficients;
a=-0.0387082896905585;
b=-0.0114516062373491;
c=0.977471228080841;
d= 0.240217612718943;
e=0.0153681411034134;
f=0.

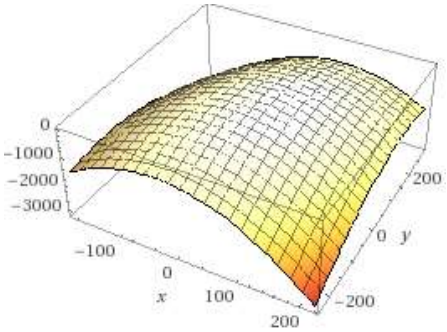

Fig. 1. Graphical distribution of FS values in relation to LN and FP; a - 3D graph for FS distribution in relation to LN and FP (x=LN; y=FP)
Source: original graph, based on our experimental data; graph was generated using Wolfram Alpha software (49).

A 3D model of variation of FS with respect to LN and FP was obtained (Fig. 1), and a graphical representation in the form of an isoquant, expressed a possible combination of LN and FP for optimum values of FS (Fig. 2).

Principal Component Analysis (PCA) led to the diagram in Fig. 3, in which the studied daffodils varieties were distributed in relation to the main quality parameters analyzed (VP, FP and FS).

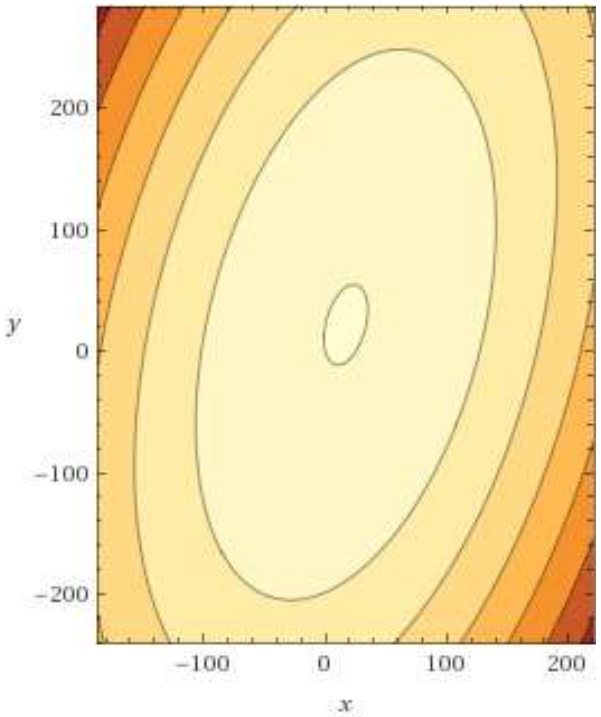

Fig. 2. Graphical distribution of FS values in relation to LN and FP; Isoquant distribution model for FS optimum value in relation to LN and FP (x=LN; y=FP)
Source: original graph, based on our experimental data; graph was generated using Wolfram Alpha software (49).

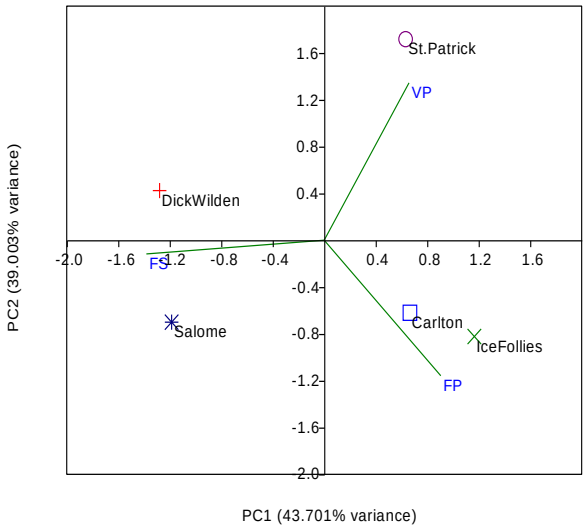

Fig. 3. PCA distribution diagram of daffodil varieties in relation to VP, FS and FP (VP – vegetation period; FS – flower size; FP – flower period)
Source: original graph, based on our experimental data; graph was generated using PAST software (14).

PC1 explained 43.701% of variance, and PC2 explained 39.003% of variance. The 'St. Patrick' variety was associated with biplot VP, this variety having the highest vegetation period (125 days).

The varieties 'Dick Wilden' and 'Salome' were

associated with the biplot FS (flower size), being the genotypes with the largest flower sizes (6.88 at 'Dick Wilden' and 6.55 cm respectively at 'Salome').
The varieties 'Ice Follies' and 'Carlton' were associated with the biplot FP, the respective varieties having the highest flowering period (18 days in the 'Ice Follies' variety, respectively 13 days in the 'Carlton' variety).
Cluster analysis resulted in the dendrogram in Fig. 4, under statistical safety conditions, Coph.corr = 0.924. The five varieties of daffodils were distributed in relation to the most important quality parameters taken into consideration, FS and FP, and two clusters were formed.
A cluster containing the variety 'Ice Follies', in a solitary position, with the highest value for flowering period, FP = 18 days. In the second cluster were associated, with high affinity, the varieties 'Salome' and 'Dick Wilden', with the value of similarity and distances indices (SDI), SDI = 1.053, table 5.

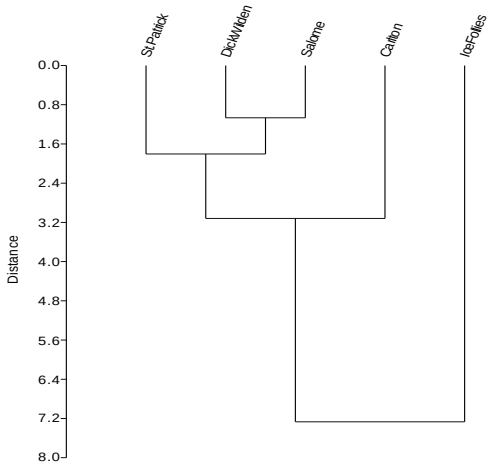

Fig. 4. Cluster diagram of daffodil varieties according to studied parameters (FS and FP)
Source: original graph, based on our experimental data; graph was generated using PAST software (14).

In the grouping of the two varieties, the 'St. Patrick' variety was associated, who presented the value SDI = 1.5697 in relation to the 'Dick Wilden' variety, and respectively the value SDI = 2.185 in relation to 'Salome' variety. With a more distant position to this subcluster was attached the 'Carlton' variety (SDI = 2.273 in relation to 'Salome'). The data for similarity and distances index for the five varieties are presented in Table 5.

Table 5. Similarity and distances indices between the daffodils genotypes in relation to FS and FP

	Carlton	IceFollies	St.Patrick	Dick Wilden	Salome
Carlton		5.0202	4.005	3.3148	2.273
IceFollies	5.0202		9.0035	8.0574	7.0283
St.Patrick	4.005	9.0035		1.5697	2.185
DickWilden	3.3148	8.0574	1.5697		1.053
Salome	2.273	7.0283	2.185	1.053	

Source: original data, resulted from our experimental results calculation.

Studies on the quality of flowers in narcissus are justified in relation to different factors, such as genotype, cultivation conditions, form of use (flowers in pots, cut flowers, in the field, spontaneous flora, etc.), and for some of these aspects many approaches are still needed [1], [4].
Variation of flower size and number of flowers were studied in daffodils in relation to different species, populations and plants at individual level [47].
The obtained results showed the correlation of the size of the flowers (FS) with the number of leaves (LN), possibly due to the fact that a larger number of leaves ensure the accumulation of a greater quantity of reserve substances in bulbs and more vigorous bulbs. Positive correlations between leaf number and size, bulbs size and flower quality were recorded in lachenalia cultivars [21]. Comparative studies on leaves and flowers at different ornamental plants with different symbolic values were also carried out by [19].
The vegetation period did not significantly influence the size of the flowers, but contributed to the accumulation of bulb reserve substances for the next vegetation cycle. Relations of interdependence between bulbs and flowers in daffodils were communicated by [29]. They found a positive correlation between bulb size and flowering period.
At *Narcissus tazetta* quality parameters for cut flowers (RFW - relative fresh weight, and WU - water uptake) were obtained by using a solution of 300 μL l^{-1} 8-HQC and 2% sucrose, and the lifetime of cut flowers extended from 6 to 9 days [1]. Thus, the commercial potential of flowers cut into *Narcissus tazetta* was emphasized through the use of appropriate

nutritional solutions. The study of cut flowers in relation to different substances in water (glutamine, essential oil, salicylic acid, silver nanoparticles) has been studied in other species [23], the influence of nanoparticles in metabolic and physiological processes in plants being known [38], [41].

Some studies have evaluated the quality of flowers in narcissus in relation to the mineral elements, the most studied being nitrogen, phosphorus and potassium, provided by different assortments of fertilizers [12], [48], [13].

Also the quality of flowers in narcissus has been studied in relation to different pathogens and protective methods [43].

The results regarding the quality of the flowers in the five daffodils varieties studied are in accordance with the references literature consulted and which was the basis of the present study.

The models of the flower size variation (FS) in relation to the leaf number (LN) and the flowering period (FP), are useful in adjustment some elements of daffodils growing technology in order to ensure the quality of the flowers.

CONCLUSIONS

The comparative analysis of the quality of flowers in the five varieties of daffodils highlighted the qualities of flowers for each variety in relation to specific physiological and vegetation indices and parameters.

A polynomial equation of degree 2 to, as a model to describe the variation of flower sise (FS) according to the number of leaves (LN) was obtained, under statistical security conditions.

A model was found that described the variation of FS depending on LN and FP in terms of statistical safety, and facilitated the representation of the optimal range of these parameters in order to reach the optimal FS, in the form of a 3D graph, and in the form of isoquant representation.

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