Exploring Growth Responses and Performance of Endemic Iranian Narcissus Genotypes

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Abstract

Narcissus, a prominent perennial ornamental bulbous plant, serves both aesthetic and practical purposes as a cut flower. This study aimed to assess the impact of climatic conditions on flower yield in native narcissus populations in Ahvaz. The experiment was designed as a randomized complete block with three replications, conducted between 2020 and 2022 at Chamran University's research farm in Ahvaz, Iran. Native narcissus genotypes collected from diverse regions of the country were cultivated and subjected to a comprehensive evaluation of morphological indices. The analysis of variance (ANOVA) underscored significant differences in all morphological parameters at a 1% probability level, showcasing the diversity among the genotypes. Phenotypic correlations unveiled robust positive associations between most traits, underscoring their interdependence. Principal component and cluster analyses offered a holistic perspective on the dataset. The first three principal components encapsulated 87.15% of the total variability, with the primary component (PC1) spotlighting the most influential traits driving genotype divergence. Cluster analysis delineated the eleven genotypes into three distinct clusters, indicative of notable variations in morphological attributes among the genotypes. This study furnishes valuable insights into the intricate relationships between diverse traits and flower numbers in daffodil genotypes, providing a foundation for informed breeding decisions. Comprehending the complex interplay of these traits through correlation and multivariate analyses is pivotal for advancing daffodil breeding programs and enhancing multiplication capacity. These findings not only inform daffodil breeding initiatives in Iran but also lay a groundwork for similar studies in other plant species.

Keywords: bulb, climate, daffodil, endemic, morphology, Narcissus

Mirzaei, S., M. Chehrazi, and H. Zeinalzadeh-Tabrizi. 2024. 'Growth response and performance of endemic Iranian narcissus genotypes'*. Iranian Journal of Plant Physiology 14*(2), 5003-5015.

Introduction

Narcissus tazetta belongs to the Amaryllidaceae family (Okubo and Sochacki, 2013), and it is one of the most important ornamental bulbous flowers that is loved all over the world. Native narcissus flowers in Iran are genotypes of the *Narcissus tazetta* L. species (Mozafarian, 2015, Ghahraman, 2019). Also, narcissus is one of the most important fragrant flowers in the world with more than 65 species and 20,000 varieties and hybrids, which

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Received: January, 2024
Accepted: March, 2024

are spread over a wide area of tropical and cold regions of the world. It is widely used as an outdoor perennial, for cut flower production in open fields, and as a cut or pot flower in greenhouse production. It is also playing an increasing role in medicine (Tarakemeh et al., 2019, Breiterová et al., 2020). Some cultivars of narcissus since the 20th century, have been cultivated as ornamental plants, and because of their essential oil, they are so desirable. The importance of daffodils is due to the fact that the flowers of some of their varieties are suitable for commercial picking; they are also planted in front of shrubs, evergreen plants, or green spaces (AL-Fatlawi et al., 2022). Regarding its application in landscaping, the cultivation of narcissus is typically suitable for natural-style gardens, where it is commonly planted in basins and flower circles alongside various herbal flowers. Most members of the genus Narcissus flower in spring; their active growth occurs in the spring, along with their flowering. They go dormant in summer when it is warm and the soil is dry, and then grow again in the autumn. The growth rate of the above-ground parts and the speed of flowering (start, prolongation, durability) depend on temperature. Leaves remain active after flowering and their early removal reduces bulb yield. Its flowering period is in the spring and produces one flowering stem (Gul et al., 2018). It has high potential in horticultural aspects (Misra and Misra, 2017). Furthermore, narcissus serves as a popular ornamental plant in parks and gardens (Kebeli and Çelikel, 2013). Its long stems make it particularly well-suited as a cut flower, and it is commonly employed in floral arrangements. Additionally, narcissus finds utility as an indoor potted plant, contributing to its versatility in various horticultural applications (Demir and Çelikel, 2019). It is essential to identify the morphological characteristics and understand the capacity for post-harvest flower storage. This knowledge is crucial for enhancing both cultivation practices and the export process. Kizil et al., (2013) showed that the time of planting bulbus plants has an effect on several parameters, including the height of the plant and the number of daughter bulbs. The post-harvest indices of narcissus depend on several factors, of which the most important is low temperature. Because the growth rate of pests and diseases, as well as metabolic activities, were reduced, the signs of aging were delayed (Gul and Tahir, 2015). According to results of researches, the fresh weight of *Narcissus tazetta* cv. Kashmir is 0.049 g and its dry weight was 0.042 g (Gul and Tahir, 2015). Narcissus flower life has been reported as 2.7 and 9 days. The diameter of narcissus flower is 1.5 cm, the fresh weight is 0.29 g, and the dry weight is 0.23 g (Gul et al., 2015).

This study postulates that climatic conditions significantly influence flower yield in native narcissus populations, with particular emphasis on morphological traits such as bulb weight and bulb length playing pivotal roles in determining flower number. The primary aim of this research is to comprehensively analyze and understand the impact of climatic conditions on flower yield in native narcissus populations, specifically in Ahvaz, Iran, by investigating the direct and indirect effects of various morphological and bulbous characteristics on flower number. By identifying key traits that are crucial for determining flower yield and unraveling the interrelationships between morphological traits, this study aspires to provide valuable insights for informed breeding decisions in the context of narcissus and to contribute to enhancing multiplication capacity in daffodil breeding programs.

Materials and Methods

The study was conducted between the years 2020 and 2022 in the research field of Chamran University, located in Ahvaz, Iran. The geographical coordinates of the researclh site are 48°40′E longitude, 31°20′N latitude, and an elevation of 22.5 meters above mean sea level.

The city of Ahvaz, where the research farm is located, is classified as a dry and semi-arid region based on its climatic conditions. Based on the 50-year meteorological data, it has been observed that the maximum monthly temperature in July reaches 47°C, but the minimum monthly temperature lowers to 7°C in December. The region experiences an average yearly precipitation of roughly 212 millimeters, as determined by a long-term 50-year average. Additionally, the daily average relative humidity in the area is recorded at 44%. Meteorological data for the experimental location are shown in Table 1.

number of bulbs from each genotype were kept for the experiment and sterilized in a fungicide solution (Carbendazim 2%). Thereafter, the bulbs

Table 1
Meteorological data for the experimental location

Month	Relative humidity (%)	Precipitation (mm)	Evaporation (mm)	Sunny hours (h)	Temperature (°C)		
					Average	Maximum	Minimum
2019							
March	71.55	0.90	7.53	8.77	16.69	33.09	24.89
April	61.00	0.76	10.16	7.97	21.57	36.45	29.01
May	37.32	0.00	20.42	11.09	27.78	45.70	36.74
June	37.42	0.00	21.73	11.88	28.78	48.29	38.54
July	38.00	0.00	21.02	11.41	27.86	47.42	37.64
August	61.32	0.00	10.96	10.60	26.56	46.62	36.59
September	59.37	1.53	9.33	8.90	22.04	40.71	31.37
October	87.63	1.41	3.31	6.12	16.23	26.71	21.47
November	95.57	2.60	1.92	5.06	11.93	21.27	16.60
December	92.03	0.83	1.82	4.22	8.38	17.50	12.94
January	90.50	1.35	2.67	6.58	8.82	20.11	14.46
February	87.30	0.56	4.16	8.64	9.09	22.79	15.94
2020							
March	79.90	1.03	5.33	7.06	15.95	29.32	22.64
April	66.19	0.01	10.09	10.29	19.55	36.33	27.94
May	52.06	0.00	15.84	12.27	26.30	46.03	16.36
June	50.74	0.00	17.88	12.25	26.83	46.32	36.58
July	54.97	0.00	15.25	11.54	27.18	45.77	36.47
August	65.68	0.00	15.25	11.54	24.79	43.63	34.21
September	73.63	0.01	7.42	8.79	22.51	39.90	31.20
October	78.63	2.00	5.50	6.67	14.89	29.22	22.06
November	91.00	3.30	1.33	3.96	11.13	20.47	15.80
December	87.87	0.07	1.79	6.91	8.62	19.77	14.19
January	85.00	0.76	2.80	7.13	7.49	19.83	13.66
February	84.50	1.10	3.61	7.02	12.12	25.89	19.01

Table 2
Soil properties of the research experiment field

Soil depth (cm)	pH	EC (ds/cm)	Organic matter (%)	N (mg/kg)	P (mg/kg)	K (mg/kg)
0-30	8.77	7.03	0.6	0.018	85.73	82

The soil properties of the research experiment field are shown in Table 2.

Bulbs of native narcissus genotypes were collected from different parts of nature in Iran (Dil aro, Behbahan, Birjand, Shiraz, Mazandaran, Ilam, Ahvaz, Noorabad, Kazeron, Dare shahr and Khafr). Bulbs were removed from cotton bags, damaged and infected bulbs were separated and healthy bulbs were kept in a dry and cool area for a few days to prevent fungus growth. Then the same

of each genotype were cultivated in a 4 square meter area in three replications, at 5 - 6 cm depth and spacing of 20×20 cm2, in September. The well-rotten cow manure was applied to the top layer of soil after cultivation. The first irrigation was at the time of cultivation. Thereafter, irrigation was done every 20 days interval. During plant growth, all the recommended packages of practices were adapted uniformly to all genotypes, to raise high-quality plants. In order to evaluate the quality of floral and vegetative display of endemic narcissus plants, the morphological traits were evaluated, including bulb diameter (BD), bulb length (BL), bulb weight (BW), number of leaves (LN), leaf width (LW), leaf length (LL), leaf area (LA), scape length (FSL), number of flower (FN) and flower diameter (FD) during January and February (Fig. II, Fig. III).

Measuring method

Bulb Diameter (BD): Bulbs were kept in the accurate digital caliper from the round portion, and the amount of bulb diameter was recorded in centimeter units.

Bulb Length (BL): Bulbs were kept in the accurate digital caliper from tip to bottom portion, and the amount of bulb length was recorded in centimeter units.

Bulb Weight (BW): After cleaning the underground parts (bulbs) from the soil substrate, each bulb was kept on the accurate weight scale (Brand: Sartorius- Accurancy: 0.0001) and the bulb's weight was recorded in grams.

Number of Leaves (LN): All the leaves in each bush were counted and recorded.

Leaf Width (LW): leaves were kept in the accurate digital caliper from the width portion and recorded in centimeter units.

Leaf Length (LL): leaves were measured with a ruler from the substrate surface to the tip of the leaf and recorded in centimeter units.

Leaf Area (LA): Each leaf was kept on the area meter (Brand: ADC- Model: AM100) and recorded in cm2 units.

Scape Length (FSL): Scape length was measured with a ruler from the soil rim to the top of the scape and recorded in centimeters.

Number of Flower (FN): All the flowers in each bush were counted and recorded.

Flower Diameter (FD): In each flower, petals were opened, kept in the accurate digital caliper, and recorded in centimeter units.

Statistical Analysis

Prior to conducting the analysis of variance, the data were tested for outliers and normality using the Grubbs test and the Shapiro-Wilk test, respectively, with the STAR software (IRRI, 2013). SPSS 24.0 statistical software (IBM Corporation, 2016) was employed to conduct stepwise regression analysis, and perform path analysis. To compute Pearson correlation coefficients, Principal Component Analysis (PCA) and cluster analysis were executed using JMP 16 statistical software (JMP®Version16, 2021).

Result

Analysis of variance (ANOVA) for recorded data was presented in Table 3. All morphological parameters exhibited significance at a 1% probability level.

Bulb diameter

Analysis of variance for recorded data showed that the effect of genotype on bulb diameter was significant at 1% level of significance (Table 3). The analysis of mean comparisons for recorded bulb diameter data revealed a significant difference in bulb diameter among various genotypes, as depicted in Fig. (Ia). Specifically, genotypes from Ahvaz and Ilam exhibited the largest bulb diameters, measuring 4.96 and 4.93 cm, respectively. In contrast, the smallest bulb diameter was observed in the Khafr genotype, measuring 2.90 cm.

Bulb length

The analysis of variance for the recorded data indicated a significant effect of genotype on bulb length at the 1% level of significance, as presented in Table 3. The results concerning the length of bulbs among different genotypes revealed that Mazandaran genotypes had the largest size, with a length of 5.16 cm, while the smallest bulb size was recorded for the Khafr genotypes, measuring 3.50 cm. Further examination through mean comparisons for bulb length data demonstrated that all other genotypes exhibited a significant difference when compared to the genotype with the highest bulb length, as depicted in Fig. (Ib).

Bulb weight

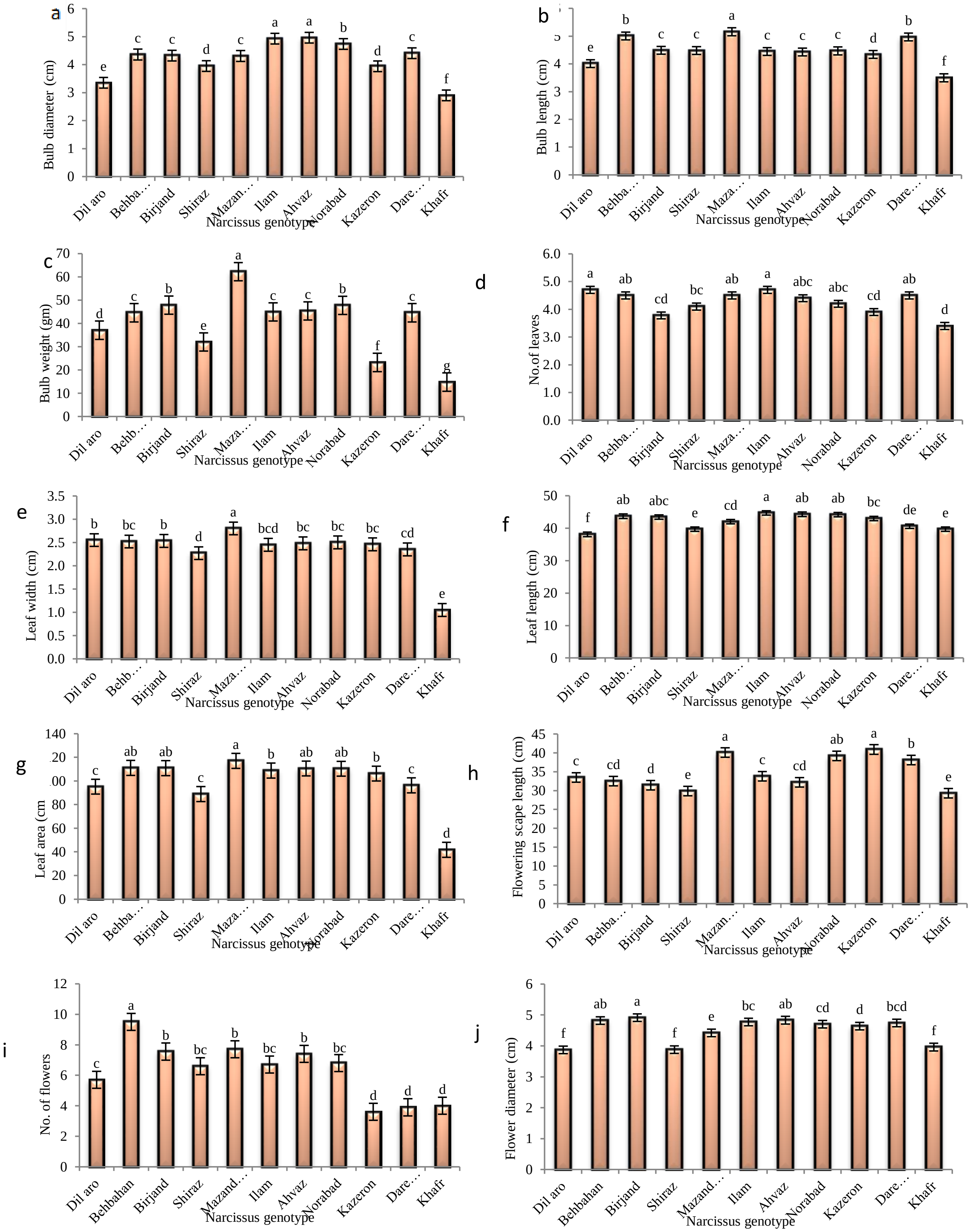

Fig. I. Comparison of mean morphological traits in various native narcissus genotypes; a: bulb diameter (BD); b: bulb length (BL); c: bulb weight (BW); d: number of leaves (LN); e: leaf width (LW); f: leaf length (LL); g: leaf area (LA); h: scape length (FSL); i: number of flower (FN) and j: flower diameter (FD). * similar letters are not significantly different at 5% using the LSD test.

revealed a significant effect of genotype on bulb weight at the 1% level of significance, as shown in Table 3. The results concerning the weight of bulbs across different genotypes indicated that the Mazandaran genotypes had the highest weight, with an average of 62.20 g, while the smallest bulb weight was observed in the Khafr genotypes, measuring 14.81 g. Further examination through mean comparisons for bulb weight data demonstrated that all other genotypes exhibited a significant difference when compared to the genotype with the highest bulb weight, as illustrated in Fig. (Ic). that all other genotypes

exhibited a significant difference when compared to the genotype with the highest bulb weight (Fig. I, c).

Number of leaves

The analysis of variance for recorded data showed that the effect of genotype on the number of leaves was significant at the 1% level of significance (Table 1). The results on the number of leaves in different genotypes showed that genotypes of Dillaro and Ilam with 4.70 leaves had the highest number of leaves. The lowest amount was recorded for genotypes of Khafr with 3.40 leaves. The mean comparison of recorded data for the number of leaves showed that the genotypes of Behbahan, Mazandaran, Ahvaz, and Dare shahr also didn’t have a significant difference with the highest number of leaves (Fig. Id).

Leaf width

The analysis of variance for the recorded data indicated a significant effect of genotype on leaf width at the 1% level of significance, as presented in Table 3. The results concerning leaf width among different genotypes showed that the Mazandaran genotypes exhibited the highest leaf width, measuring 2.80 cm, while the lowest leaf width was recorded for the Khafr genotypes, with a width of 1.05 cm. Mean comparisons of the recorded data for leaf width revealed that genotypes Dillaro, Behbahan, Birjand, and Norabad did not exhibit a significant difference when compared to the genotype with the highest leaf width, as shown in Fig. (Ie).

Leaf length

The analysis of variance for the recorded data indicated a significant effect of genotype on leaf length at the 1% level of significance, as detailed in Table 3. The results pertaining to leaf length across different genotypes revealed that the Ilam genotypes had the highest leaf length, measuring 44.70 cm, while the lowest leaf length was recorded for the Dilaro genotypes, with a length of 38.10 cm. Mean comparisons of the recorded data for leaf length demonstrated that genotypes Behbahan, Birjand, Ahvaz, Norabad, and Kazeron did not exhibit a significant difference when compared to the genotype with the highest leaf length, as depicted in Fig. (If).

Leaf area

The analysis of variance for the recorded data demonstrated a significant effect of genotype on leaf area at the 1% level of significance, as indicated in Table 3. The results pertaining to leaf area among different genotypes revealed that the Mazandaran genotypes exhibited the highest leaf area, measuring 116.91 cm^2, while the smallest leaf area was recorded for the Khafr genotypes, with an area of 41.80 cm^2. Mean comparisons of the recorded data for leaf area indicated that genotypes Behbahan, Birjand, Ilam, Ahvaz, Norabad, and Kazeron did not display a significant difference when compared to the genotype with the highest leaf area, as illustrated in Fig. (Ig).

Flowering scape length

The analysis of variance for the recorded data revealed a significant effect of genotype on flowering scape length at the 1% level of significance, as presented in Table 3. The results concerning the flowering scape length among different genotypes showed that the Mazandaran genotypes had the highest scape length, measuring 40.10 cm, while the shortest scape length was recorded for the Khafr genotypes, with a length of 29.30 cm. Mean comparisons of the recorded data for scape length indicated that genotypes Norabad, Kazeron, and Dareshahr did not exhibit a significant difference when compared to the genotype with the highest scape length, as depicted in Fig. (Ih).

Number of flowers

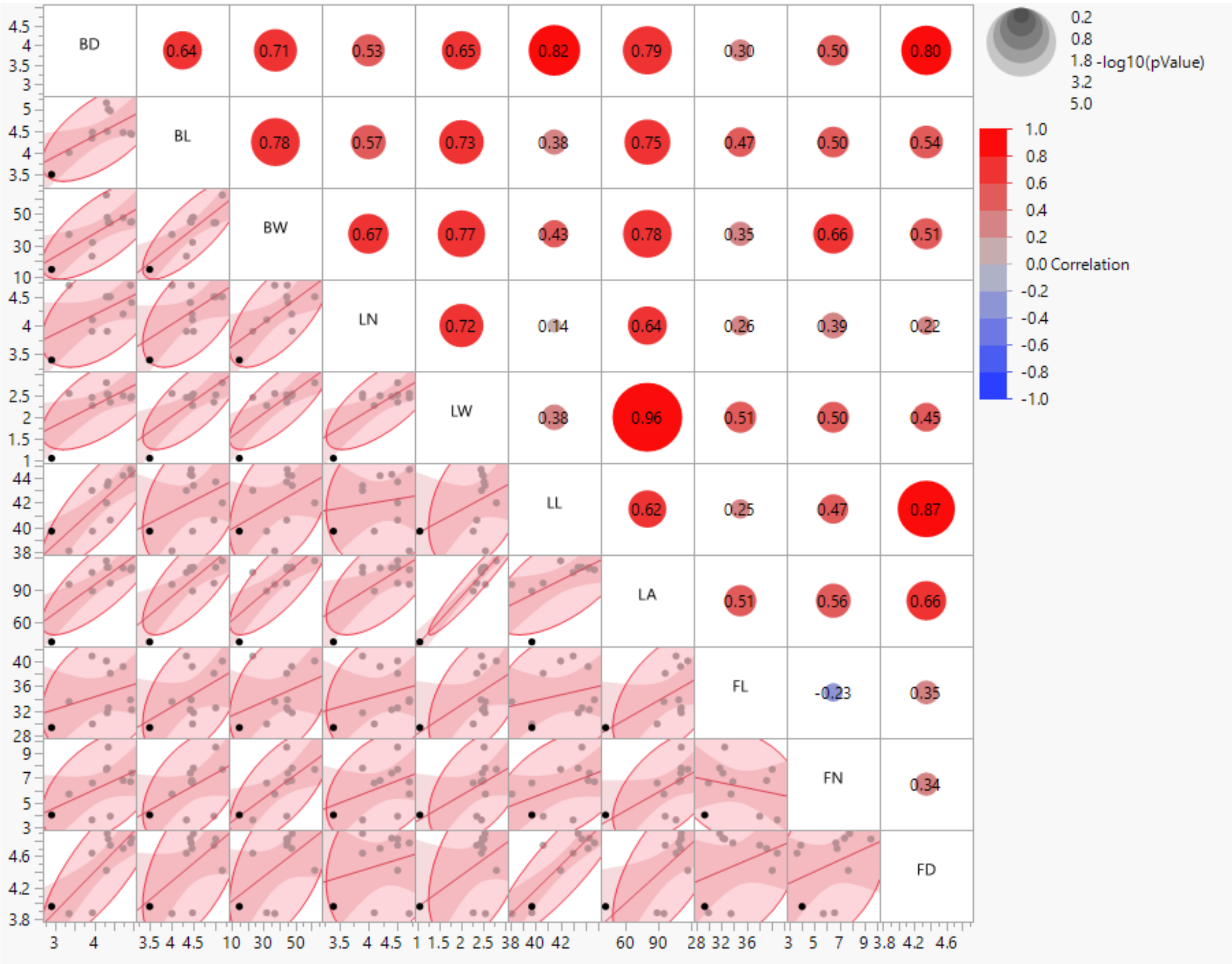

Fig. II. Phenotypic association coefficients pertaining to several morphological traits observed in narcissus genotypes

The analysis of variance for the recorded data indicated a significant effect of genotype on the number of flowers at the 1% level of significance, as detailed in Table 3. The results regarding the number of flowers among different genotypes showed that the Behbahan genotypes had the highest number of flowers, totaling 9.50 on average. The lowest number of flowers was recorded for the Kazeron genotypes, with an average of 3.60. Mean comparisons of the recorded data for the number of flowers revealed that genotypes Birjand, Mazandaran, and Ahvaz did not exhibit a significant difference when compared to the genotype with the highest number of flowers, as illustrated in Fig. (Ii).

Flower diameter

. Analysis of variance for the recorded data demonstrated a significant effect of genotype on flower diameter at p<0.01 (Table 3). The results regarding flower diameter among different genotypes showed that Birjand genotypes had the largest flower diameter (4.91 cm). Minimum flower diameter (3.87 cm) was recorded for the Dillaro genotypes. Comparison of mean flower diameters indicated that genotypes of Behbahan, Ilam, Ahvaz, and Dareshahr were not significantly different from the genotype with the maximum flower size (Fig. I, j).

Phenotypic correlations

Fig. (IV) displays the phenotypic association coefficients pertaining to several growth traits observed in narcissus genotypes. The majority of the traits exhibited positive and statistically significant associations with one another. The study revealed a strong positive correlation between LA and LW, with a correlation coefficient of 0.96**. This was the strongest correlation recorded. Additionally, a substantial correlation

Table 4
Summary of trait effects on flower number: stepwise regression and path analysis

Response Variable	Predictor Variables	Adjusted R^2	Tolerance	VIF	Direct Effect	Indirect Effect via	
						BW	FL
FN	BW	0.607	0.874	1.144	0.850**	-	-0.188
	FL		0.874	1.144	-0.533*	0.300	-

coefficient of 0.87** was found between FD and LL, followed by a correlation coefficient of 0.80** b D, L, and W were positively correlated with each other, which revealed a highly significant and positive correlation with FN. These results demonstrated that improvement for any of these traits could lead to an increase in FN. The findings from the correlation study indicated that there existed solely a negative correlation coefficient (-0.23) between FN and FL, which was not statistically significant (Fig. IV). Results also revealed that FL had the weakest interrelationship with the other traits studied. The present study observed a strong correlation coefficient among morphological traits, indicating that it was challenging to ascertain the specific impact of each component on FN due to the presence of combined or confounding effects. The utilization of path analysis is recommended for comprehending the extent and orientation of the direct and indirect influences of component attributes on FN, as correlation coefficients alone do not provide a comprehensive depiction when the causal elements are interrelated and interdependent. The multiplication rate seen in narcissus exhibits a significant degree of underperformance.

The results of the stepwise regression analysis indicate significant findings. BW demonstrates a noteworthy positive direct effect (0.850**) on FN, while FL exhibits a significant negative direct effect (-0.533*) on FN. Interestingly, despite the FL trait's negative direct effect, it exerts a positive indirect effect (0.300) on FN through the BW trait. Conversely, a negative indirect effect of BW via FL (-0.188) is also evident. These findings collectively suggest that the selection for FN in Narcissus should prioritize BW rather than FL (Table 4).

Principal component and cluster analyses

Table 5
Analysis of 10 traits, including component loadings, eigenvalues, the proportion of total variance explained by the first four principal components (PC), and the cumulative variance observed across eleven narcissus genotypes

	PC1	PC2	PC3
BD	0.88368	0.29807	0.00281
BL	0.83301	-0.21986	0.03945
BW	0.87594	-0.21071	-0.17567
LN	0.67502	-0.52123	-0.15719
LW	0.87788	-0.34355	0.03847
LL	0.69455	0.68382	0.06565
LA	0.95342	-0.08441	0.05958
FL	0.47003	-0.23055	0.81019
FN	0.62533	0.09038	-0.71073
FD	0.74660	0.55604	0.20371
Eigenvalue	6.0292	1.4165	1.2695
Percent	60.292	14.165	12.695
Cumulative Percent	60.292	74.457	87.152
Chi Square	130.743	83.654	66.795
DF	40.163	40.934	33.968
Prob > Chi Sq	<.0001*	<.0001*	0.0007*

In the current study, it was shown that the first three principal components, which had eigenvalues greater than one, accounted for a cumulative variability of 87.15% among the eleven genotypes that were assessed for 10 morphological and bulbous characteristics (Table 5). The first principal component explained 60.29% of the variance, whilst the second component accounted for 14.16% of the overall variability. The third principal components accounted for a variability of 12.69%. Hence, it can be deduced that the primary characteristics of the dataset were captured in the initial three principal components. The traits LA (0.953), BD (0.884), BW (0.876), BL (0.833), and LW (0.878) accounted for

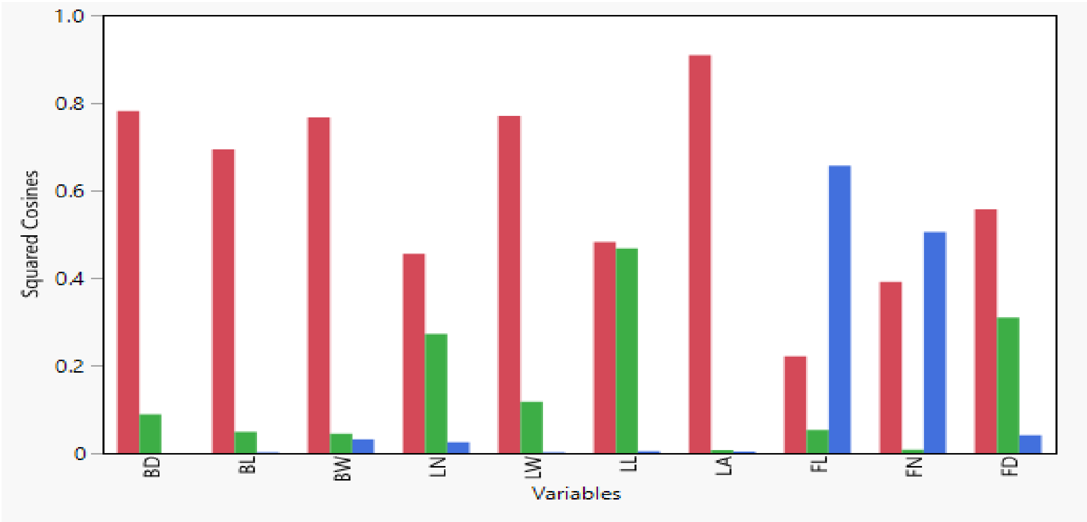

Fig. III. Principal component analysis; dominant traits in eleven genotypes are comprised of the most significant traits, as determined by the first three principal components

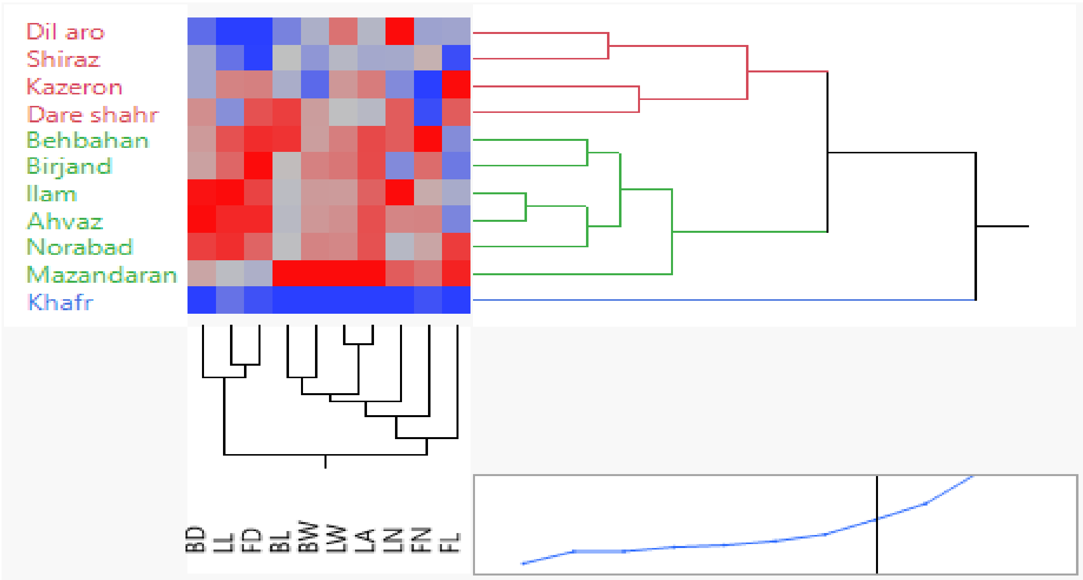

Fig. IV. Hierarchical cluster analysis and classification of eleven narcissus genotypes under study

the highest amount of variance in the first principal component (PC1). Principal Component 2 (PC2) contributed to 14.16% of the overall variance and exhibited greater variances for LL (0.684), FD (0.556), and LN (-0.521), indicating their significant relevance in the context of narcissus. The third principal component (PC3) exhibited notable loading values for traits such as FL (0.810) and FN (-0.711) (Table 5). Moreover, the loading of various traits, as determined by the first three principal components, revealed that the primary component (PC1) of divergence among the eleven genotypes are comprised of the most significant traits. Conversely, the other traits made relatively less contributions to the overall divergence (Fig. V).

The hierarchical cluster analysis resulted in the classification of eleven narcissus genotypes into three distinct clusters, as depicted in Fig (VI). The initial cluster consisted of a single genotype, specifically the Khafr genotype. The second cluster consisted of two sub-clusters, wherein the first sub-cluster (Mazandaran) contained one genotype, while the second sub-cluster (Norabad, Ahvaz, Ilam, Birjand, and Behbahan) comprised five genotypes. The third cluster consisted of two sub-clusters, with the first sub-cluster containing two genotypes (Dare shahr and Kazeron) and the second sub-cluster containing two genotypes (Shiraz and Dil aro). Based on the findings of the cluster analysis, it was shown that genotypes belonging to the second cluster had elevated values for significant morphological traits in narcissus. This clustering pattern was consistent with the results obtained through Principal Component Analysis (PCA), reinforcing the robustness of the morphological evaluation. Hence, the identification of clustering patterns within the dendrogram would aid in the determination of appropriate cultivars for prospective narcissus breeding initiatives in Iran.

Discussion

Reports have shown a range of sizes for narcissus bulbs size. For instance, Dhiman et al., (2019) reported sizes ranging from 2.58 to 4.22 cm. In a different study, Slezák et al., (2020) reported varying sizes for Narcissus Poeticus, spanning from 10.6 to 21.7 mm. Also, Dhiman et al., (2019) reported a bulb diameter of 2.58 to 4.22 cm for different genotypes of narcissus. However, a bigger bulb size has also been reported, which was around 12 cm for Narcissus tazetta subsp. tazetta L. under the conditions of Harran Plain (Özel and Erden, 2018). Although initial bulb size effects bulb yield and quality (Kapczynska, 2019). Additionally, Slezák et al., (2020) reported different weight ranges for Narcissus Poeticus bulbs, spanning from 0.8 to 6.3 g. Khan et al., (2013) also reported 37.74 g for narcissus bulb weight. Fresh weight and the circumference of bulbs have a positive correlation with vegetative growth in bulbous plants. However, the possession of a large bulb has little overall advantage for growth and development. Because after the 50 g bulb size, the results look markedly similar. In general, plants produced from large bulbs grow faster to complete their life cycle than those produced from medium and small bulbs (Kapczynska, 2014, Manimaran et al., 2017). Also, Babarabie et al., (2018) and Khan et al., (2013) reported mean values of 2.56 and 3.98 for the number of leaves in narcissus. Dhiman et al., (2019) reported 0.58 to 1.57 cm of leaf width for different genotypes of narcissus. Miller and Olberg (2016) reported a mean value of 30.5 cm for narcissus leaf length. Dhiman et al., (2019) reported 13.47 to 23.83 cm of leaf length for different genotypes of narcissus. Also, Jezdinská Slezák et al., (2021) reported a leaf length of 24.91 ± 1.21 cm in narcissus. Other researchers reported a mean value of 18.40 cm for narcissus leaf length (Demir and Çelikel, 2019). Babarabie et al., (2018), Miller and Olberg (2016), reported mean values of 13.81cm for scape length in Narcissus tazetta and 35.7 cm in Narcissus pseudonarcissus, which are shorter than the scape length of all studied genotypes in our research. Also, Demir and Çelikel (2019) for narcissus tazetta scape length and Jezdinská Slezák et al., (2021) reported the stem length of N. poeticus plants was 23.53 ± 3.38 cm. In the reports, 3.47 to 5.98 leaves have been recorded for narcissus (Dhiman et al., (2019). Babarabie et al., (2018) reported 194.54 cm for the narcissus flower diameter. In other report, 3.72 to 8.37 cm of flower diameter has been recorded for narcissus (Dhiman et al., (2019). On the base of observations, in many varities, flower number varies negatively with flower diameter among Narcissus species.

Positive correlations between various vegetative and reproductive characteristics were also reported by (Rezaei et al., 2019). Hence, the process of selecting traits based on their growth characteristics can be undertaken without hesitation till the manifestation of those growth traits.

D, L, and W were positively correlated with each other, which revealed a highly significant and positive correlation with FN. This findings were similar with those of (Dhiman et al., 2019). These results demonstrated that improvement for any of these traits could lead to an increase in FN. Previous studies by Bhatia et al., (2013) have documented analogous patterns of correlations between bulbous characteristics in tulips.

Enhancing the understanding of the interconnectedness between various traits through correlation analysis is a crucial factor in facilitating efficient selection processes (Dhiman et al., 2019). The findings from the correlation study indicated that there existed solely a negative correlation coefficient (-0.23) between FN and FL, which was not statistically significant (Fig. IV).

Similar result was also reported by (Dhiman et al., 2019). Results also revealed that FL had the weakest interrelationship with the other traits studied. The propagation of Narcissus occurs through the use of bulbs in commercial settings. Nevertheless, the multiplication rate in narcissus exhibits a significant deficiency. There exists a necessity to enhance the multiplication capacity, either by selecting genotypes with a high bulb number coefficient or through indirect enhancement of the qualities that contribute to the number of bulbs per plant (Dhiman et al., 2019). Simon et al., (2015) found that flower size was positively correlated with all traits, while flower shape, which was positively correlated with tube width at the junction, was negatively correlated with tube width at the base of the flower, tepal length, and corona width at the mouth. A positive correlation has been observed in Liu et al., (2017) study between the flowering stem number and the flower number which was not in accordance with the current study. The present study observed a strong correlation coefficient among morphological traits, indicating that it was challenging to ascertain the specific impact of each component on FN due to the presence of combined or confounding effects. The utilization of path analysis is recommended for comprehending the extent and orientation of the direct and indirect influences of component attributes on FN, as correlation coefficients alone do not provide a comprehensive depiction when the causal elements are interrelated and interdependent. The multiplication rate seen in narcissus exhibits a significant degree of underperformance. There is a requirement to enhance the multiplication capacity, either by choosing genotypes with a high bulb production coefficient or through indirect enhancement of the features that contribute to the number of bulbs per plant (Dhiman et al., 2019).

Our finding in the stepwise regression analysis was in accordance with (Dhiman et al., 2019) study who reported highly significant and positive relationship of with weight of bulb (0.825).

The quantification of flower count per bulb or per weight of bulbs holds significance for bulb manufacturers operating in the commercial sector. The study conducted by Özel and Erden (2018) investigated the associations among three variables: the quantity of bulbs and flowers per metric ton of bulbs, the number of bulb units per individual bulb, and the number of flowers per bulb unit. One of the primary factors contributing to the variability in flower production was the quantity of bulb units per unit weight found in larger bulbs. This factor was only partially offset by an increase in the number of bulb units per individual bulb. However, it is worth noting that the number of bulb units per metric ton remained rather stable throughout the study.

Also, Bhatia et al., (2017) in tulip and Dhiman et al., (2019) in narcissus also documented comparable findings pertaining to principal component analysis. Bhatia et al., (2017) and Dhiman et al., (2019) have revealed similar findings in the context of tulip and narcissus, respectively. The convergence of data from both cluster analysis and PCA emphasizes the reliability of the identified clusters and highlights their potential significance in guiding the selection of appropriate cultivars for future narcissus breeding initiatives in Iran.

Conclusion

This study conducted a comprehensive analysis of morphological traits in eleven daffodil genotypes, focusing on their effects on flower number. Significant differences were observed among genotypes, with bulb weight showing a notable positive direct effect on flower number, contrary to bulb length's negative direct effect. Interestingly, bulb length indirectly influenced flower number positively through bulb weight. Principal component and cluster analyses revealed significant variability among genotypes, with three distinct clusters identified. These findings provide valuable insights for daffodil breeding, emphasizing the importance of bulb weight in selecting for flower number and offering a framework for similar studies in other plant species.

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