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A Study of Morphological Variations and Their Relationship with Flower Yield and Yield Components in *Rosa damascena*

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ABSTRACT

***Rosa damascena* has attracted considerable attention in horticulture, biochemistry and in pharmacology because of the fragrance of the flowers and the high content of its biologically active substances. There is limited information available on factors controlling flower yield and its components. The present study reports an investigation on flower yield and the various factors affecting it, in Iranian *Rosa damascena* using sixteen genotypes collected from different regions in Iran. These genotypes were planted at Isfahan Agriculture Research Center, using a randomized complete block design with three replications in 2005. Twelve yield determining characters including flower yield per plant, number of flowers per plant, fresh flower weight, plant height, canopy diameter, length and width of bud, number of petal per flower, length and width of receptacle, fresh weight of petal as well as flowering period were recorded. *Rosa damascena* genotypes significantly varied for all the traits except for the fresh weight of petals per flower. Phenotypic and genotypic coefficients of variation for flower yield per plant (48.03%, 36.49%), number of flowers per plant (40.65%, 26.99%), number of petals per flower (37.56%, 32.31%) were higher than the coefficients for other tested traits. Cluster analysis revealed that Khuzestan and Shiraz 2 genotypes were the most related ones, while the most independent ones were the western and eastern Azerbaijan genotypes. Results of stepwise regression analysis showed that 90 percent of total variation of flower yield per plant could be explained by the number of flowers per plant. This suggested that number of flowers per plant is the most important component determining flower yield per plant. According to principle component analysis, parents with a high standing of the following traits: fresh weight of flower, number of petals per flower and bud width, may well be employed for hybridization in a breeding program. Regression and cluster analyses proved to be the appropriate multivariate analyses for an identification of *Rosa damascena* genotypes possessing the desirable characters for hybridization to develop improved cultivars.**

Keywords: Cluster analysis, Hybridization, Receptacle, *Rosa damascena*, Stepwise regression.

INTRODUCTION

Genus *Rosa* includes around 140 species, widely scattered in Europe, Asia, the Middle East and North America (Cairns, 2003). Rose is grown widely in gardens for the beauty of the flowers as well as for the fruits (Kutbay and Kilinc, 1996). Twenty five rose species have been reported to be grown in Iran for production of rose petals, as well as for extraction of rose water (Mozaffarian, 1996). Iran is believed as the center of origin and therefore the genetic resource for many rose species.

Recently rose extracted oil has been used as a component in pharmaceutical preparations (ointment and lotions) besides its previously being used as a fragrance ingredient in perfumes, creams and soaps. About 0.2% of rose oil is also being used in beverages, frozen

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dairy, desserts, sweets, baked gelatins as well as in puddings (Rangahau, 2001).

Currently, emphasis is being laid on conserving plant germplasm, especially the medicinal and aromatic plants, as valuable bioresources regarding their beneficial genes which could provide means of dealing with diseases, control of insects, and control of environmental stresses as constrains to crop production (Khanuja *et al.*, 2000). An identification of genetic variation between and within genotypes for a high level of oil content, flower yield and other desirable characteristics provides an effective tool to be employed by *Rosa* breeders.

Cluster analysis has been employed to assess similarities among genotypes in plant breeding programs. When genotypic and phenotypic repetition of several characters are found among a set of populations, lines or accessions, parents are then selected from among them for hybridization (Wilson *et al.,* 1990). Debener *et al.* (1996) used RAPD markers to assess the variation among cultivated and wild rose species and found the two *dog* rose species *R. sherardii* and *R. villosa* as closely related and included in a common cluster with several wild and cultivated rose species. Debener *et al.* (1997) later used *R. sherardii* as pollen parent in an interspecific cross with another member of section 'Caninae', i.e. *R. obtusifolia* Desv, to prove hybridization in the progeny plants they employed for molecular markers. The resultant interspecific compatibility revealed the relatively close relatedness of the species of this section. The section 'Caninae' is well separated from other sections in the genus *Rosa,* indicated by both differentiation in morphological characters as well as molecular markers (Grant, 1971; Millan, 1996). The *'Dog*' rose species are morphologically distinct with their reproductive and vegetative morphological characters revealing differences among the investigated taxa, with the exception of two subspecies of *R. dualism* namely: subsp. *corifoliia* and subsp. *dumalis* (Werlemark, 2000). Millan *et al.* (1996) also used RAPD markers to show that Spanish *dog* rose species are closely related to each other and to *R.*×*Alba*, the presumed cross between species from section *Caninae* and section *Gallicane.*

There is limited information available on flower and yield components' related traits of *Rosa damascena* genotypes in Iran. The objectives of this study were (1) to evaluate the variation among 16 Iranian *Rosa damascena* for flower yield, yield components and other morphological traits, and (2) to assess the relationship among the studied traits.

MATERIALS AND METHODS

Plant materials comprising of 16 *Rosa damascena* genotypes, collected from different regions of Iran (Isfahan 1, 2, 7, 9, 10; Fars 1, 2; Khuzestan; Eilam; Qum; East and West Azerbaijan; Hamedan; Tehran, Ardabil and Zanjan Provinces) were accounted for in this study. These genotypes were planted in a randomized complete block design with three replications at the Agriculture Research Farm of Isfahan Agricultural Research Center, in February, 2005. The inter-row and intra-plant spacings were both chosen as 3 m. Plants were selected for recording observations on 12 quantitative characters including flower yield per plant, number of flowers per plant, fresh weight of flower, plant height, canopy diameter, length and width of bud, number of petals per flower, length and width of receptacle, fresh weight of petal and finally the flowering period.

Data were subjected to analysis of variance, mean comparison being conducted through Duncan's multiple range test using SAS statistical package (SAS Institute, 1996). Genotypic and phenotypic coefficients of variation, the square root of the genetic and phenotypic variance expressed in percent of the mean, were calculated according to the method of Burton and DeVane (1953). Heritability in the broad sense may be defined as the proportion of the total variance due to genetic effects.

Cluster analysis was conducted with 16 clone means of variables according to Ward's minimum variance method using the cluster procedure of SAS computer software (SAS

Institute, 1996). The clone means were standardized with a mean of zero along with a standard deviation of one (Cardi, 1998).

Variance and relationship between traits of the *Rosa damscena* genotypes were further studied by using the principal component analysis concerned with explaining the variance-covariance structure through a few linear combinations of the original variables. The variables were standardized and the principal component given as described by Ouendeba (1991). Stepwise regression analysis was done for flower yield per plant as dependent variable and the rest of the traits as independent variables. Correlation coefficients were calculated according to the method proposed by Hayes *et al.* (1955).

RESULTS AND DISCUSSION

The mean comparisons of 16 *R. damascena* genotypes for the 12 morphological traits are presented in Table 1. Flower yield per plant varied from 949.6 for Tehran genotype to 173.7 g for West Azerbaijan genotype. Number of flowers per plant varied from 468.2 for Tehran genotype to 139.1 for Zanjan genotype. The highest and the lowest fresh weight of flower were observed for Ardabil genotype with 2.4 g and West Azerbaijan genotype with 1.0 g. Plant height stood in a range of 97.5 cm for Ardabil genotype to 62.2 cm for Tehran genotype. The highest length and the highest width of bud belonged to Tehran genotype with 13.1 mm and 10.5 mm, respectively. Number of petals per flower varied from 82.5 for Zanjan genotype to 31.2 for East Azerbaijan genotype. The maximum and the minimum flowering periods were respectively observed for Esfahan 7 genotype (25.3 days) and West Azerbaijan genotype (17.7 days) (Table 1). Tabaei-aghdaei *et al*. (2004) reported the fresh weight of flower in *Rosa damascena* genotypes ranging from 1.54 to 2.74 g and the length and width of bud varying from 5 to 20 and from 4 to 16 mm, respectively. The results of the present study were consistent with the mentioned report in view of the genotypic variations for the studied traits.

The *Rosa damascena* genotypes differed significantly for all the traits with the exception of fresh weight of petal per flower (Table 2). Tabaei-aghdaei *et al.* (2004) *and* Tabaei-aghdaei *et al.* (2005) also compared genotypes of *R. damascena* based on flower yield and morphological characteristics and showed significant differences in terms of the measured traits. The genotypic and phenotypic coefficients of variations are given in Table 2. Phenotypic and genotypic coefficients of variation for flower yield per plant (48.03%, 36.49%), number of flower per plant (40.65%, 26.99%), number of petal per flower (37.56%, 32.31%) were found to be high. The lowest values of phenotypic and genotypic coefficients of variation belonged to length and width of bud (Table 2). Differences among the genotypic and phenotypic coefficients of variation in fresh weight of flower, length and width of receptacle and of bud were found as relatively low. Hence, these characters were not much influenced by the environmental factors under these experimental conditions. In general, phenotypic coefficients of variation were higher than the corresponding genotypic coefficients of variation (Table 2). As for heritability, it was shown (Table 2) that the highest and the lowest heritability belonged to width of receptacle and fresh weight of petals, respectively. Heritability of flower yield per plant, fresh weight of flower, bud length, number of petals of flower and length of receptacle traits were higher as compared with other characters (Table 2). The high estimates of heritability of traits would enable plant breeders to base their selection programs on the phenotypic performance of characters.

On the basis of cluster analysis, the sixteen *Rosa damascena* genotypes were grouped into four clusters (Figure 1). Cluster I, II, III, and IV had each 9, 3, 1 and 3 genotypes, respectively (Figure 1). Babaei *et al*. (2007) used molecular markers to assess the variation of 40 Iranian *R. damascene* genotypes from different regions and observed genotypic polymorphism, while some other studies of genetic diversity in *R. damascene* species did not reveal any polymorphism among *R. damascene* genotypes

Table 1. Mean comparisons of 16 *Rosa damascena* genotypes for 12 morphological traits using Duncan test.

Genotype	Flower yield per plant (g)	Number of flower per plant	Fresh weight of flower (g)	Plant height (cm)	Canopy diameter (cm)	Length of bud(mm)	Width of bud(mm)	Number of petal per flower	Width of receptacle (cm)	Length of receptacle (cm)	Fresh weight of petal (g)	Flowering time (day)
1 [a]	173.7 [gf]	167.7[c]	1.0[d]	74.1[ab]	77.6[ab]	11.8[abc]	9.7[abc]	55.1[bc]	7.3[a]	7.7[f]	0.9[a]	17.7[b]
2 [b]	619.6 [abc]	332.5[abc]	1.9[bc]	85.7[ab]	103.3[ab]	12.3[ab]	9.7[abc]	31.2[d]	7.6[a]	9.2[bcdef]	1.1[a]	20.0[ab]
3 [c]	705.2[ab]	307.7[abc]	2.4[a]	97.5[a]	121.0[a]	12.7[ab]	10.1[ab]	43.5[bcd]	7.5[a]	8.5[def]	1.2[a]	22.0[ab]
4 [d]	503.4 [bcd]	265.8[abc]	1.9[bc]	64.8[b]	84.3[ab]	12.6[ab]	8.9[bc]	38.5[cd]	5.1[c]	8.5[ef]	1.1[a]	22.3[ab]
5 [e]	623.3[abc]	352.5[abc]	1.8[bc]	73.5[ab]	105.8[ab]	12.7[a]	8.8[c]	33.5[d]	5.[c]	9.9[bcd]	1.1[a]	23.7[ab]
6 [f]	562.5[abcd]	307.4[abc]	1.8[bc]	76.4[ab]	102.2[ab]	12.5[ab]	9.3[abc]	34.0[d]	5.3[bc]	10.3[bcd]	1.2[a]	24.7[ab]
7 [g]	949.6[a]	468.2[a]	2.0[ab]	62.2[b]	101.8[ab]	13.1[a]	10.5[a]	31.9[d]	7.1[a]	12.7[a]	1.3[a]	25.0[a]
8 [h]	634.4[abc]	403.4[ab]	1.6[bc]	75.8[ab]	108.4 [ab]	12.9[a]	9.3[bc]	34.9[d]	5.7[bc]	9.8[bcde]	1.0[a]	24.3[ab]
9 [i]	640.0[abc]	359.8[abc]	1.7[bc]	84.6[ab]	107.6[ab]	11.9[abc]	8.9[bc]	32.8[d]	5.1[c]	10.8[b]	1.1[a]	24.3[ab]
10 [j]	202.2[d]	139.1[c]	1.4[cd]	88.4[ab]	73.8[b]	10.4[cd]	9.1[bc]	82.5[a]	6.5[ab]	8.6[cdef]	1.2[a]	19.7[ab]
11 [k]	529.8[bcd]	284.0[abc]	1.9[bc]	85.9[ab]	98.2[ab]	9.8[d]	10.1[ab]	32.6 [d]	7.6[a]	8.6[cdef]	1.1[a]	19.0[ab]
12 [l]	648.9[abc]	338.6[abc]	1.9[bc]	83.6[ab]	97.4[ab]	12.3[ab]	8.6[c]	36.4 [cd]	5.3[bc]	10.5[bc]	1.1[a]	25.3[a]
13 [m]	257.9[cd]	160.2[c]	1.6[bc]	88.3[ab]	69.2[b]	10.9[bcd]	9.4[abc]	59.9[b]	7.4[a]	7.9[ef]	1.1[a]	22.7[ab]
14 [n]	359.4[bcd]	215.7[c]	1.6[bc]	72.3[ab]	94.8[ab]	13.1[a]	9.3[abc]	35.1[d]	5.1[c]	10.7[b]	1.0[a]	22.3[ab]
15 [o]	388.8[cdb]	232.3[bc]	1.7[bc]	76.9[ab]	99.9[ab]	12.7[ab]	9.0[bc]	34.1[d]	5.[c]	9.3[bcdef]	1.0[a]	22.7[ab]
16 [p]	351.4[bcd]	223.6[bc]	1.6[bc]	70.1[ab]	109.2[ab]	12.4[ab]	9.1[bc]	34.7[d]	5.1[c]	9.7[bcde]	1.1[a]	25.3[a]

[a] West Azarbayijan; [b] East Azarbayijan; [c] Ardabil; [d] Esfahan 9; [e] Esfahan 10; [f] Eilam; [g] Tehran; [h] Qum; [I] Khozestan; [J] Zanjan; [K] Shiraz 1; [L] Shiraz; [m] Hamadan; [n] Esfahan1; [o] Esfahan 2, [p] Esfahan 7.

*Means with the same letter are not significantly different.

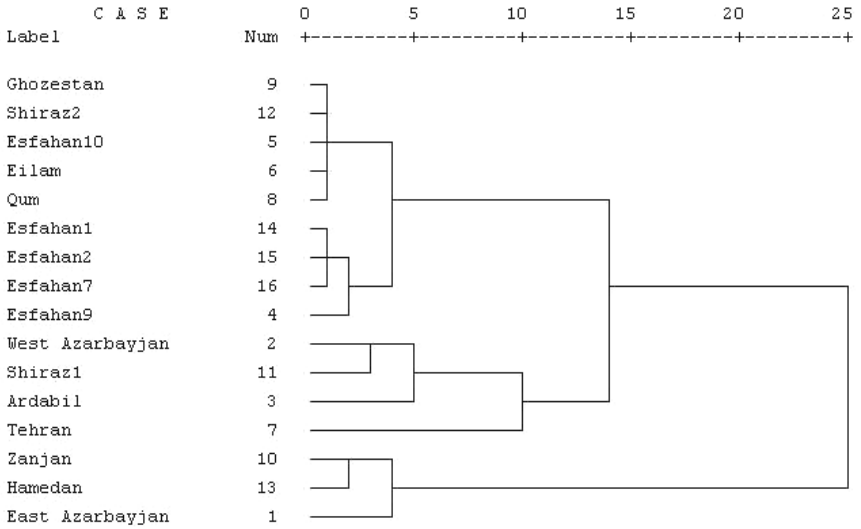

Figure 1. Dendrogram of the similarities among 16 *Rosa damascena* genotypes using Ward's minimum variance method of cluster analysis.

collected from various regions in Turkey and Bulgaria (Baydar *et al* 2004; Rusanov *et al*. 2005). Therefore, the results of present study and those from Babaei *et al*. (2007) and Tabaei- Aghdaei *et al.* (2004 and 2005) indicate that Iranian gene pool of *R. damascene* contains a greater diversity than those from other countries. Also, the wide range of variation detected through multivariate statistics for the characters studied, was in agreement with that of previous studies using Tehran, and Kashan *Rosa damascena* germplasm (Tabaei-aghdaei *et al*., 2003 and 2004). In the present study, the collected genotypes from Isfahan with the exception of Isfahan 10 are included in cluster I. This indicates that genotypes collected from Isfahan may have been originated from a single common ancestor and then mainly vegetatively propagated in these regions. Cluster III included only one clone from Tehran genotype. The highest similarity was observed between Khuzestan and Shiraz 2 genotypes and the lowest observed between West and East Azerbaijan genotypes (Figure

Table 2. Mean squares, phenotypic and genotypic coefficients of variability and heritability of 12 studied traits using 16 *Rosa damascena* genotypes.

Characters	MST[a]	MSE[b]	GCV[c]	PCV[d]	ECV[e]	Heritability%
Flower yield per plant (g)	128996.5**	25312.1	36.49	48.03	31.23	57.7
Number of flowers per plant	25247.9**	7500.2	26.99	40.65	30.39	44.1
Fresh weight of flower (g)	0.25**	0.04	15.46	18.92	10.90	63.6
Plant height (cm)	269.1*	132.3	8.58	16.94	14.60	25.6
Canopy diameter (cm)	599.2*	272.8	10.73	20.10	16.99	28.5
Bud length (mm)	2.84**	0.51	7.27	9.34	5.85	60.4
Bud width (mm)	0.85**	0.23	4.85	7.05	5.11	47.3
Number of petals per flower	578.8**	60.63	32.31	37.56	19.14	74.1
Width of receptacle (mm)	3.66**	0.24	17.52	19.03	8.09	82.6
Length of receptacle (mm)	4.71**	0.57	12.21	14.51	7.84	70.7
Fresh weight of petal (g)	0.02ns	0.02	11.73	25.20	13.48	13.6
Flowering period (day)	17.05*	7.22	8.02	14.36	11.91	31.3

[a] Mean squares of treat; [b] Mean squares of error; [c] Genotypic Coefficients of Variation, [d] Phenotypic Coefficients of Variation, [e] Environmental Coefficients of Variation.
*, ** Significant at the 5% and 1 % probability levels respectively.
ns: Non significant.

Table 3. Analysis of variance and mean comparison of clusters for 15 tested traits of *Rosa damascena* genotypes.

Character	Mean squares	Mean of clusters [a]			
		Cluster I	Cluster II	Cluster III	Cluster IV
Flower yield per plant (g)	165915**	523.6^{bc}	618.2^{b}	949.6^{a}	211.3^{c}
Number of flowers per plant	29113.7**	299.9^{ab}	308.07^{ab}	468.22^{a}	155.67^{b}
Fresh weight flower (g)	0.268**	1.7^{ab}	2.1^{a}	2.0^{a}	1.4^{b}
Plant height (cm)	270.59**	75.3^{ab}	89.7^{a}	62.2^{b}	83.6^{a}
Canopy diameter (cm)	717.30**	101.1^{a}	107.5^{a}	101.8^{a}	73.6^{b}
Length of bud (mm)	2.46^{ns}	12.6^{a}	11.6^{a}	13.1^{a}	11.0^{a}
Width of bud (mm)	1.16**	9.0^{c}	9.9^{ab}	10.5^{a}	9.4b^{c}
Number of petals per flower	783.79**	34.9^{b}	35.8^{b}	31.9^{b}	65.8^{a}
Width of receptacle (mm)	5.79**	5.2^{b}	7.6^{a}	7.1^{a}	7.0^{a}
Length of receptacle (mm)	6.85**	10.1^{b}	8.8^{bc}	12.7^{b}	8.1^{c}
Fresh weight of petal (g)	0.009^{ns}	1.1^{a}	1.1^{a}	1.3^{a}	1.1^{a}
Flowering period (day)	18.76**	23.9^{ab}	20.3^{b}	25.0^{a}	20.0^{b}

*, ** Significant at the 5% and 1 % probability levels, respectively.
ns: Non significant.
[a] In each column means with similar letter are not significantly different.

1). The clustering pattern of the genotypes revealed that geographic diversity was greatly correlated to genetic diversity, though there were exceptions like Eilam in cluster I and Shiraz1 in cluster II (Figure 1). This could be due to the exchange of germplasm in the regions located all over Iran. Analysis of variance among clusters revealed the significant differences for all tested traits with the exception of fresh weight of petal per flower (Table 3). These traits were the major source of diversity among *Rosa damascena* genotypes. Mean comparison among clusters on 12 traits is shown in Table 3. Genotypes from East Azerbaijan, Shiraz 1 and Ardabil 1 placed in cluster II were superior to other genotypes for fresh weight of flower, plant height and canopy diameter traits. Cluster III was only allocated to Tehran genotype which had the highest values for flower yield per plant, number of flowers per plant, and flowering period traits. This genotype hence could be considered as the superior Iranian rose genotype. Genotypes from Zanjan, Hamedan and West Azerbaijan in cluster IV had the lowest flowers yield, number of flowers per plant, fresh weight of flower, canopy diameter, length of bud as well as flowering period

Table 4. Principal component coefficients of 12 tested traits in 16 *Rosa damascena* genotypes.

Characters	Prin1	Prin2	Prin3	Prin4
Flower yield per plant (g)	0.37	0.27	0.06	0.08
Number of flowers per plant	0.38	0.18	0.08	-0.01
Fresh weight of flower per plant (g)	0.28	0.31	-0.11	0.35
Plant height (cm)	-0.17	0.33	-0.37	0.54
Canopy diameter (cm)	0.32	0.15	-0.42	-0.01
Length of bud (mm)	0.32	-0.19	-0.14	-0.30
Width of bud (mm)	0.01	0.52	0.16	-0.45
Number of petals per flower	-0.35	-0.02	0.15	0.20
Width of receptacle (mm)	-0.17	0.54	0.13	-0.16
Length of receptacle (mm)	0.36	-0.11	0.32	-0.01
Fresh weight of petal (g)	0.11	0.05	0.69	0.40
Flowering period (day)	0.33	-0.23	-0.08	0.22
Percent variation	%45	%21	%11	%09
Cumulative percent of total variance	%45	%66	%77	%86

(Table 3). These genotypes hence could be considered as the inferior Iranian rose genotypes. These differentiating results of *Rosa damascena* genotypes could be beneficial for selecting diverse parents with desirable characters for hybridization to develop improved cultivars, synthetics as well as hybrids. The results of the present study are in agreement with those obtained by Tabaei-aghdaei *et al.* (2004, 2005) who reported the Iranian gene pool of *Rosa damascene* as the rich resources in possessing the genetic variations for morphological traits. Tabaei-aghdaei *et al*. (2004) using cluster analysis on eleven genotypes of *Rosa damascene* indicated 3 clusters and also reported genotypes in cluster I to be superior for productivity as well as for other characters.

Principal component analysis revealed four components, which explained 86 percent of the total variation among traits (Table 4). Principal component 1 (PC1 same as Prin1 in Table 4) justified 45 percent of the total variation and was equally associated with yield of flower per plant, number of flowers per plant, canopy diameter, length of bud, length of receptacle as well as flowering period. PC2 consisted of fresh weight of flower, plant height, width of bud and width of receptacle, and accounted for 21 percent of total variance. PC3 explained 11 percent of the total variations and was mainly associated with fresh weight of petal. PC4 accounted for 9 percent of the total variance and consisted of fresh weight of flower and of petal, as well as plant height. Furthermore, these principal components revealed intra-correlations among traits. For example, PC1 showed that flower yield per plant, number of flowers per plant, canopy diameter, length of receptacle and flowering period had positive intra-correlations, while number of petals per flower was in a negative intra-correlation with them. A study of the relationships among traits could be beneficial to the breeders in their breeding programs, and the estimated PCs reveal how the characters affect each other (Table 4).

Results of stepwise regression analysis for flower yield per plant, as dependent variable, and the rest of the traits, as independent variables, showed that number of flowers per plant accounted for 90 percent of the total variation in flower yield per plant. These results imply that the number of flowers per plant is the most important component of flower yield per plant (Table 5). Fresh weight of flower, number of petals per flower and width of bud entered into the model followed by the number of flowers per plant, justifying 7, 0.2 and 0.01 percent of the total variation of flower yield per plant, respectively (Table 5). Relationships among traits also indicated that the number of flowers per plant had the highest correlation with flower yield per plant (r= 0.95). Correlation between flower yield per plant and fresh weight of flower (r= 0.57), canopy diameter (r= 0.58), length of receptacle (r= 0.54), and flowering period (r= 0.43) was positive and significant (P< 0.01) while with the number of petals per flower, the correlation was a negative and significant one. These relationships along with the positive and significant correlations shown between flower yield and other morphological traits

Table 5. Stepwise regression analysis for 12 studied traits of *Rosa damascena* genotypes using flower yield per plant as a dependent variable.

Variable entered	Partial R**2	Model R**2	Intercept	Regression coefficients			
				b_1	b_2	b_3	b_4
Number of flowers per plant	0.905	0.905**	-65.89**	2.02**			
Fresh weight of flower (g)	0.077	0.982**	-375.0**3	1.82**	209.85**		
Number of petals per flower	0.004	0.986**	-442.66**	1.87**	218.60**	0.92**	
Width of bud (mm)	0.001	0.987**	-558.18**	1.87**	211.27**	14.13**	0.86**

*, ** Significant at the 5% and 1 % probability levels, respectively.

Table 6. Phenotypic correlations among 12 morphological characters assessed on 16 *Rosa damascena* genotypes.

Characters	Flower yield per plant	Number of flowers per plant	Fresh weight flower	Plant height	Canopy diameter	Length of bud	Width of bud	Number of petals per flower	Width of receptacle	Length of receptacle	Fresh weight of petal
Flower yield per plant	1										
Number of flower per plant	0.95**	1									
Fresh weight flower	0.54**	0.32*	1								
Plant height	0.11	0.08	0.14	1							
Canopy diameter	0.57**	0.54**	0.41**	0.50**	1						
Length of bud	0.31*	0.29*	0.21	-0.21	0.27	1					
Width of bud	0.20	0.10	0.24	0.19	0.20	0.14	1				
Number of petal of flower	-0.50**	-0.51**	-0.36**	0.16	-0.47**	-0.41**	-0.03	1			
Width of receptacle	0.04	-0.03	0.10	0.32*	-0.06	-0.41**	0.57**	0.31*	1		
Length of receptacle	0.54**	0.51**	0.29*	-0.37**	0.22	0.44**	-0.04	-0.45**	-0.46**	1	
Fresh weight of petal	-0.05	-0.09	0.08	-0.06	-0.17	-0.01	0.11	-0.06	-0.01	0.18	1
Flowering time	0.43**	0.46**	0.11	0.25	0.51**	0.33*	-0.06	-0.31*	-0.28*	0.33**	0.11

*, ** Significant at the 5% and 1 % probability levels, respectively.

and in particular number of flowers per plant would be useful in the development of a cultivar with improved flower yield potential (Table 6). Tabaei-aghdaei *et al*. (2003, 2004) showed that flower yield was in a highly positive correlation with fresh weight of flower and with number of flowers per plant, this result being in agreement with the results obtained in the present study.

REFERENCES

1. Babaei, A. R., Tabaei-Aghdaei, S. R., Khosh-Khui, M., Omidbaigi, R., Naghavi, M. R., Esselink, G. D. and Smulders, M. J. M. 2007. Microsatellite Analysis of Damask Rose (*Rosa damascena* Mill.) Accessions from Various Regions in Iran Reveals Multiple Genotypes. *BMC Plant Biol*. **10**: 7-12.
2. Baydar, N., Baydar, H. and Debener, T. 2004. Analysis of Genetic Relationships among *Rosa Damascena* Plants Grown in Turkey by Using AFLP and Microsatellite Markers. *J. Biotechnology*. **111**: 263-267.
3. Burton, G. W. and DeVane, E. H. 1953. Estimating Heritability in Tall Fescue from Replicated Clonal Material. *Agron. J*. **45**: 478-481.
4. Cairns, T. 2003. Horticultural Classification Schemes, In: *"Encyclopedia of Rose Science*", Roberts, A. V., Debener, T. and Gudin, S. (Eds.). Vol. 1, Elsevier. PP.117-124
5. Cardi, T. 1998. Multivariate Analysis of Variation among *Solanum Commersonii* x *S. tuberosum* Somatic Hybrids with Different Ploidy Levels. *Euphytica*, **99**: 35-41.
6. Debener, T., Bartels C. and Mattiesch, L. 1996. RAPD Analysis of Genetic Variation between Groups of Rose Cultivars and Selected Wild *Rose* Species. *Mol. Breed.*, **2**: 321-327.
7. Debener, T., Bartels C. and Spehtmann, W. 1997. Parentage Analysis in Interspecific Crosses between Rose Species with RAPD Markers. *Gartenbauwissenschaft*, **62**: 180-184.
8. Grant, V. 1971. *Plant Speciation.* Columbia University Press, New York. **161**: 13-21.
9. Hayes, H. K., Immer F. R. and Smith, D. C. 1955. *Methods of Plant Breeding*. Mc Graw-Hill. New York.
10. Khanuja, S. P. S., Shasanj A. K., Srivastava A. and Kumar, S. 2000. Assessment of Genetic Relationship in *Mentha* Species. *Euphytica*, **111**: 121-125.
11. Kutbay, H. G. and Kilinc, M. 1996. Taxonomic Properties of *Rose* Hip Species. In: *Rose hip symposium, Gumushane*. p. 75-83.
12. Millan, T., Osuna, F., Cobos, S., Torres A., and Cubero, J. 1996. Using RAPD to Study Phylogenetic Relationships in *Rosa*. *Theor. Appl. Genet.*, **92**: 273-277.
13. Mozaffarian, V. 1996. *A Dictionary of Iranian Plant Names*. Farhang Moaser. Tehran, Iran.
14. Nilson, O. 1997. *Rosa*, In: *"Flora of Turkey and the East Aegean Island"*, Davis P. H. (Ed.), Vol. 4, Edinburg University Press, Edinburg. PP. 106-128.
15. Ouendeba, B. 1991. Diversity, Combining Ability and Heterotic Patterns among African Pearl Millet (Landrace). Ph.D. Dissertation, University of Georgia, Athens. USA.
16. Rangahau, M. K. 2001. *Rose-Rosa damascena* Trigintipetala. *Crop and Food Res.,* **29**: 35-38.
17. Rusanov, K., Kovacheva, N., Vosman, B., Zhang, L., Rajapakse, S., Atanassov, A. and Atanssov, I., 2005. Microsatellite Analysis of *Rosa damascene* Mill. Accessions Reveals Genetic Similarity between Genotypes Used for Rose Oil Production and Old Damask Rose Varieties. *Theor. Appl. Genet*., **111**: 804-809.
18. Statistical Analysis System Institute. 1996. *SAS/ STAT User's Guid.* Ver. 6.4, SAS Insititue Inc., Cary, NC.
19. Tabaei-aghdaei, S. R. and Rezaee, M. B. 2003. Study of Flower Yield Variation in *Rosa Damascena* L. Genotypes of Kashan. *Iranian Rangelands and Forests Plant Breeding and Genetic Research*, **9**: 99-110.
20. Tabaei-aghdaei, S. R. and Rezaee, M. B. 2004. Study of Flower Yield Variation in *Rosa Damascene* Mill. From Western Regions of Iran. *Iranian Journal of Medicinal and Aromatic Plants*, **20**: 333-344.
21. Tabaei-aghdaei, S. R., Rezaee, M. B. and Jebelly, M., 2004. Flower Yield and Morphological Characterististics in Some Genotypes of *Rosa Damascena* Mill. *Iranian Journal of Medicinal and Aromatic Plants*, **20**: 111-122.
22. Tabaei-aghdaei, S. R., Sahebi, M., Jafari, A. A. and Rezaee, M. B. 2004. Evaluation of Flower Yield and Morphological Characteristics of 11 *Rosa Damascene* Mill. Genotypes Using Multivariate Analysis. *Iranian Journal*

of Medicinal and Aromatic Plants, **20**: 199-213.
23. Tabaei-aghdaei, S. R., Soleimani, E. and Jafari, A. A. 2005. Evaluation of Genetic Variation for Flowering Duration and Morphological Characters in 8 *Rosa Damascena* Mill. Genotypes. *Iranian Rangelands and Forests Plant Breeding and Genetic Research,* **12**: 266-280.
24. Werlemark, G. 2000. Genetic Variability and Reproductive Strategies in Nordic Dogroses, Rosa Section 'Caninae'. Doctoral Dissertation, The Swedish University of Agricultural Sciences, SE-29194 Kristianstad, Sweden.
25. Wilson, J. P., Burton G. W., Zongo J. D. and Oiko, I. O. 1990. Diversity among Pearl Millet Landraces Collected in Central Burkina Faso. *Crop Sci.*, 30: 40-43.

مطالعه تنوع مورفولوژیکی و روابط بین عملکرد گل و اجزاء عملکرد در گل محمدی

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چکیده

گل محمدی به طور قابل ملاحظه ای در باغبانی، بیوشیمی و داروسازی، به خاطر داشتن عطر و مواد فعال بیولوژیکی در گلهای آن جلب توجه کرده است. اطلاعات قابل دسترس کمی در باره عملکرد گل و اجزاء گل آن وجود دارد. این مطالعه به منظور بررسی عملکرد گل و اجزاء آن با استفاده از ۱۶ ژنوتیپ که از سرتاسر ایران جمع آوری شدند انجام شد. دوازده صفت مورفولوژیکی شامل عملکرد گل در هر گیاه، تعداد گل در هر گیاه، وزن تر گل، ارتفاع گیاه ، قطر تاج پوشش، طول و عرض غنچه، تعداد گلبرگ در هر گل، طول و عرض نهنج، وزن تر گلبرگ در هر گل و زمان گل دهی اندازه گیری شدند. ژنوتیپ های گل محمدی به طور معنی داری از لحاظ کلیه صفات بجز وزن تر گلبرگ در هر گل تفاوت معنی داری را نشان دادند. ضرایب تنوع فنوتیپی و ژنوتیپی برای عملکرد گل در هر گیاه (۴۸/۰۳ و ۳۲/۳۱ در صد)، تعداد گل در هر گیاه (۴۰/۶۵ و ۲۶/۹۹ در صد)، تعداد گلبرگ در هر گل (۳۷/۵۶ و ۳۲/۳۱ در صد) از کلیه صفات دیگر بیشتر بودند. تجزیه خوشه‌ای نشان داد که بیشترین تشابه بین ژنوتیپ های خوزستان و شیراز و کمترین تشابه بین ژنوتیپ آذربایجان شرقی و غربی وجود داشت. نتایج تجزیه رگرسیون مرحله ای برای عملکرد گل در هر گیاه به عنوان متغیر وابسته نشان داد که تعداد گل در هر گیاه به تنهایی ۹۰ در صد کل تنوع عملکرد گل در در هر گیاه را توجیه نمود. این مطلب پشنهاد می کند که تعداد گل در هر گیاه می تواند به عنوان مهمترین جزء عملکرد گل در هر گیاه باشد. وزن تر گل ، تعداد گلبرگ در هر گل و عرض غنچه به ترتیب بعد از عملکرد گل در هر بوته وارد مدل شدند . از آنجاییکه انتخاب والدین برای دو رگ گیری یا بهبود محصول بایستی بر اساس تنوع ژنتیکی و صفات خاص جالب باشد، بنابراین، تجزیه رگرسیون و تجزیه کلاستر در برنامه های اصلاحی می توانند به منظور شناسایی ژنوتیپ های گل محمدی که برای دو رگ گیری جهت ایجاد ارقام بهبود یافته، ساختگی سود مند باشند.