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Evaluation of Stability Parameters for Discrimination of Stable, Adaptable and High Flower Yielding Landraces of *Rosa damascena*

B. Yousefi[1*], S. R. Tabaei-Aghdaei[2], M. H. Assareh[2], and F. Darvish[1]

ABSTRACT

In order to determinate appropriate stability parameters, six statistics were studied for flower yield stability of 35 *Rosa damascena* landraces in 8 locations over two years (2007-8) in Iran, using a randomized complete blocks design with 3 replications. A positive correlation between environmental variance (S^2) and flower yield suggested that only low yield landraces develop a similar phenotype over a range of environments. The stable and adaptable landraces using the environmental coefficient of variation (CV) produced a flower yield about average for landraces or higher. Although all of the stable landraces by S^2 produced very low yield, some of adaptable ones by CV (e.g. YZ2) showed high flower yield and stability simultaneously. A negative correlation was observed between *CV* and flower yield. The regression coefficient of yield over environments (b) was positively correlated with flower yield; the regression coefficients of all studied landraces were statistically different from zero therefore were not stable with static stability concept (b equal to zero). The stable and adaptable landraces according to dynamic stability concept (b equal to unity and Sd^2 or variance due to deviation from regression equal to zero) produced a flower yield higher than average for landraces or near it. The superiority index (P) determined some of the highest flower yield as adaptable landraces. The stable landraces with the least variance of years within places ($MS_{Y/P}$) produced the least flower yield; because of a mixing of effects (year with plant age), $MS_{Y/P}$ isn't a favourable parameter for flower yield in perennial plants. Some high flower yield landraces were found (e.g. YZ2 and IS5) showing stability and adaptability with varying statistics such as CV, b, Sd^2 and P. It could be concluded that a genotype can demonstrate both static and dynamic stability with high flower yield. In addition, the coefficient of variation (CV), dynamic view statistics (b equal to unity and Sd^2 equal to zero) and superiority index (P) are proposed as desirable parameters for evaluation of flower yield stability with different concepts in Damask rose genotypes.

Keywords: Adaptation, Flower yield, *Rosa damascena* Mill., Stability parameter.

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INTRODUCTION

Genotype×Environment interaction (GE) is a differential genotypic expression across different environments (Basford and Cooper, 1998). According to Ramagosa and Fox (1993), GE interaction reduces association between phenotypic and genotypic values of a genotype. This may cause promising selections from one environment to perform poorly in another environment, forcing plant breeders to examine genotypic adaptation. A desirable landrace is one that not only yields well in its area of initial selection, but also maintains its high yielding ability over a wide range of environments within its intended area of production. Plant breeders and agronomists often ignore GE

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[1] Research Center of Agricultural and Natural Resources of Kurdistan, P. O. Box: 66169-36311, Sanandaj, Islamic Republic of Iran.

[*] Corresponding author, e-mail: bayzidyousefi@gmail.com

[2] Department of Natural Resources Biotechnology, Research Institute of Forests and Rangelands, P.O. Box: 13185-116,Tehran, Islamic Republic of Iran.

interactions and usually select genotypes based on their mean performance across environments. When all the test environments fall within some defined target environment, combining yield performance with yield stability across environments has received very little attention for practical use but could be advantageous when the target environment encompasses a wide range of environmental conditions (Kang, 1993). Stability of yield is the ability of a genotype to avoid substantial fluctuations in yield over a range of environmental conditions (Heinrich *et al.,* 1983). The adaptability or stability of a landrace often relates to physiological, morphological and phenological mechanisms. Accumulation of tolerance to a number of stresses is the key to wide adaptation and, consequently, selection in multiple environments is the best way to breed stable genotypes (Ramagosa and Fox, 1993). There are two concepts of stability, static and dynamic. Genotypes that are buffered against environmental variation and develop a similar phenotype over a range of environments possess a "biological" or "static" stability. This type is seldom a desired feature of crop landraces, since no response is to improve the growing conditions which would be expected. In contrast, "agronomic" or "dynamic" stability permits a predictable response to environments (Becker and León, 1988). Researchers need a statistic that provides a reliable measure of stability or consistency the performance across a range of environments. Numerous stability parameters have been developed but their use in selecting the high-yielding and stable genotypes are limited (Kang, 1993). Lin *et al.* (1986) investigated the statistical relationship between nine stability statistics and identified three types of stability:

Type 1: Stable genotype that is characterized by a small variance across all environments. This type of stability is useful when the environments considered are not very diverse and is equivalent to the static concept of stability (Becker and León, 1988).

Type 2: A genotype that is stable if its response to environments is parallel to the mean response of all genotypes in the trial. This type is equivalent to the dynamic concept of stability (Becker and León, 1988).

Type 3: A genotype that is stable when the variance due to deviation from regression (Sd^2) is small (smaller deviation from regression). This type of stability is also dynamic and the method of Eberhart and Russell (1966) can be used for its estimation.

Furthermore, Lin and Binns (1988) defined a fourth type of stability as: a genotype that is stable when variance due to years within locations of the genotype is small (smaller variance due to years within locations). They also defined the landrace performance measure or superiority index (P). Lin and Binns (1988) defined the *P* of a genotype as mean squares of the distance between a given genotype and genotypes with the maximum response in the locations. The smaller distance to the genotypes with maximum yield, the smaller the value of *P*, and the better the genotype.

Damask rose (*Rosa damascena* Mill.) is widely cultivated for its essential oil, medicinal properties and ornamental aspects in many areas of the world e.g. Bulgaria, Turkey, India and Iran (Tabaei-Aghdaei *et al*., 2006). Flowers are the main part of the Damask rose and, thus, flower yield is the most important trait in this crop. Considerable variation among Iranian Damask rose populations has been reported for many traits such as flower yield, oil content (Tabei-Aghdaei *et al.,* 2004; 2007), molecular markers (Pirseyedi *et al.,* 2005; Babaei *et al.,* 2007; Tabei-Aghdaei *et al.,* 2006). Flower yield is highly influenced by many genetic as well as environmental factors. Therefore, evaluating genotypes' potential in different environments (location and years), especially in countries such as Iran with high ecological variation, is an

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important step in Damask rose breeding programs before selecting desirable ones.

In this study, 35 landraces of Damask rose were evaluated for flower yield under sixteen environments (2 years×8 locations). The overall objectives were to determine which stability statistics or methods can be recognized as more suitable in determination of stable, adaptable and high yielding landraces and to evaluate correlations among stability statistics and flower yield.

MATERIALS AND METHODS

Thirty-five landraces of Damask rose were evaluated for flower yield stability in eight locations (Sanandaj, Hamedan, Arak, Kashan, Dezful, Stahban, Kerman and Mashhad) with different environmental conditions (Table 1) over two years (2007-8) in Iran. Safe and uniform (about 40 cm hieght) annual saplings of the landraces provided from the experimental field of the Research Institute of Forests and Rangelands of Iran were planted in each location in March 2004 using randomized complete block design with three replications. Plant spacing was 3 m×3 m and each plot comprised of three plants. Normal cultural practices were followed as and when necessary in each location. Flower yield was collected during the appropriate time (early to late spring) related to environmental (year×location) conditions. Complete fresh flowers of each plant were collected for each of the replications and landraces separately in each environment daily. After the harvest, fresh flowers were weighed and flower yield data recorded. Combined analysis of variance was used to the estimate mean square of landraces, environments and landrace×environmental interactions. Landrace stability was evaluated on the basis of landrace×location and landrace×environment (year×location) interactions by following the main procedures in different concepts and types of stability.

Table 1. Some environmental characteristics of the research locations.

Locations(Provinces)	Longitude (E)	Latitude (N)	Altitude (meter)	Average temperature (Centigrade degree)			Relative humidity (Percent)	Annual rainfall (mm)	Number of freezing days	Annual evaporation (mm)	Total sunny hours
				T_{Min}	T_{Max}	T_{Opt}					
Sanandaj(Kurdistan)	47° 00′	35 ° 20′	1373	5.4	21.4	16	47	462	106	1340	2860
Hamedan(Hamedan)	48 ° 32′	34 ° 51′	1749	3.3	19.1	15.8	54	317	125	1500	2929
Arak(Markazi)	49 ° 46′	34 ° 60′	1708	6.9	20.7	13.8	46	342	91	1750	2973
Kashan(Isfahan)	51 ° 27′	33 ° 59′	982	12.1	26.1	14	40	139	44	2526	2906
Dezful(Khuzestan)	48 ° 25′	32 ° 16′	83	15.8	32	16.2	48	344	2	2334	3066
Stahban(Fars)	53 ° 41′	28 ° 58′	1288	10.9	27.7	16.8	39	293	34	2196	3370
Kerman(Kerman)	56 ° 58′	30 ° 15′	1754	6.9	24.7	17.8	32	154	89	1800	3165
Mashhad(Khorasan)	59 ° 38′	36 ° 16′	999	7	21.1	14.1	55	255	91	1720	2888

Environmental Variance (S^2)

Landraces with the smaller S^2 are the more stable. S^2 estimated as:

$$Si^2 = \frac{\sum \left(Yij - \overline{Yio}\right)^2}{q-1} \qquad (1$$

where q is number of environments, Y_{ij} is yield of the *i*th landrace in the jth environment and $\bar{Y}_{io}$ is yield mean of the *i*th landrace in all environments.

Environmental Coefficient of Variation (CV)

Landraces with the smaller *CV* are the more stable (Francis and Kannenberg, 1973). *CV* is estimated as

$$CVi = \frac{Si^2}{\overline{Yio}} \times 100 \qquad (2$$

where S_i^2 is environmental variance of *i*th landrace and $\bar{Y}_{io}$ is yield mean of the *i*th landrace in all environments.

Regression Coefficient of Yield over Environmental Index (b)

Finlay and Wilkinson (1963) proposed that a regression coefficient approaching zero indicates stable performance. Regression coefficients approximating 1.0 indicate average stability. Regression values increasing above 1.0 describe genotypes with increasing sensitivity to environmental change (below average stability) and greater specificity of adaptability to high yielding environments. Regression coefficients decreasing below 1.0 provide a measure of greater resistance to environmental change (above average stability) and, therefore, increasing specificity of adaptability to low yielding environments. We used their absolute consideration of stability that described landraces with a regression coefficient (b) equal to zero as stable ones. As described by Finlay and Wilkinson (1963) and Singh and Chaudhary (1977) $bi = \frac{\sum YijIj}{\sum Ij}$ (3

where Y_{ij} is yield of the *i*th landrace in the *j*th environment and I_j is environmental index and $I_j = \bar{Y}_{oj} - \bar{Y}_{oo}$.

Dynamic Concept (b and Sd^2 or Deviation from Regression)

Eberhart and Russell (1966) considered a stable genotype to have a slope (b value) equal to unity and deviation from regression (Sd^2) equal to zero. The stable genotypes will be those having mean yield higher than the average yield of all the genotypes under test. As described by Eberhart and Russell (1966), Singh and Chaudhary (1977)

$$bi = \frac{\sum YijIj}{\sum Ij} \text{ and } Sd^2 i = \frac{\left(\sum \sigma^2 ij\right)}{q-2} \text{ that}$$

$$\sum \sigma^2 ij = \frac{\left(\sum Y^2 ij - Y^2 io\right)}{q} - \frac{\left(\sum jYijIj\right)^2}{\sum jIj^2} \qquad (4$$

where q is the number of environments, $\Sigma\sigma^2_{ij}$ is sum of squares (SS) of deviations, $(\Sigma_j Y_{ij}^2 - Y_{io}^2/q)$ is total SS and $(\Sigma_j Y_{ij} I_j)^2 / \Sigma_j I_j^2$ is the *SS* of regression. Regression coefficients of genotypes (b_i) were tested using the *t*-test with an assumed value ($\beta = 0$ in Finlay and Wilkinson and $\beta = 1$ in Eberhartand Russell model) as

$$t = \frac{b-\beta}{\frac{Mse}{\sum Ij^2}} \qquad (5$$

where *Mse* is the pooled error and I_j is the environmental index.

Variance Due to Years within Locations (MSY/P)

After arranging a year-location flower yield table for each landrace, *MSY/P* was estimated as

SSY/P = SSTotal – SSPlaces and

$$MSY/P = \frac{SSY/P}{(y-1)l} \qquad (6$$

where *MSY/P* is variance due to years within locations, *y* and *l* are the number of years and locations, respectively.

Landrace Performance Measure or Superiority Index (P)

As described by Lin and Binns (1988)

$$Pi = \frac{(\bar{Y}ij - \bar{Y}j\max)^2}{2l} \qquad (7$$

that where $\bar{Y}_{ij}$ is the yield mean of the *i*th landrace in the *j*th location, $\bar{Y}_{jmax}$ is the yield mean of the landrace with maximum yield in the *j*th location and l is the number of locations.

Flower yield means of landraces were compared with the overall mean of landraces ($\bar{Y}_{oo}$) *via* the *t*-test as $t = \frac{(\bar{Y}i - \bar{Y}oo)}{\frac{\sum Sdi^2}{q}}$ (8

where $\bar{Y}_i$ is the flower yield mean of the *i*th landrace, ΣSd^2_i is the pooled deviations and *q* is the number of environments.

In order to determine the degree of associations between flower yield and stability parameters, Pearson's coefficients were used.

RESULTS

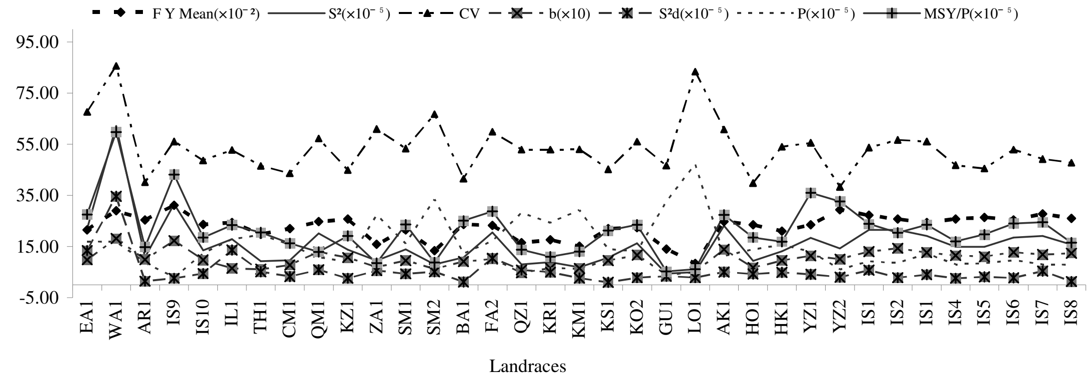
Significant differences at the P≤ 0.01 level were observed for flower yield among landraces (G), locations (L), environments (E) and for landrace×location (GL) and landrace×environment (GE) interactions (Table 2) and stability parameters for landraces were estimated (Table 3). The landraces GU1, LO1, SM2, KM1 and QZ1 showed the least environmental variance (S^2) and, thus, were stable for GE (landrace×environment) interaction. The landraces GU1, LO1, KM1, TH1 and BA1 were stable for GL (landrace×location) interaction for flower yield (Table 5). The stable landraces with the S^2 parameter produced very low flower yield (Table 3). Environmental variance (S^2) was positively correlated with flower yield in both environments and locations (Table 4 and Figure 1). The landraces AR1, HO1, YZ2, KZ1 and IS5 showed the least environment coefficient of variation (CV) and, thus, were stable for GE and the landraces YZ2, BA, HO1, TH1 and KS1 were stable for GL for flower yield (Table 5). The stable landraces with the *CV* parameter produced flower yield about average for landraces or higher (Table 3). The relationship between the environmental coefficient of variation (CV) with flower yield was negatively significant

Table 2. Pooled analysis of variance for stability of flower yields over 8 locations and 2 years for a total of 16 different environments.

Sources of variation	Environments			Locations		
	df	Sum of squares	Mean squares	df	Sum of squares	Mean squares
Total	559	1236448029.64	-	279	326027442.52	-
G^a	34	131408329.21	3864950.85**	34	65230461.33	1918542.89**
E^b	15	735327253.32	49021816.89**	7	145536521.11	20790931.57**
GE^c	510	369712447.11	724926.37**	238	115260460.08	484287.65**
E+GE	525	1105039700.43	2104837.52**	245	260796981.19	1064477.47**
$E(L)^d$	1	738956756.38	738956756.38**	1	145536521.42	145536521.42**
$GE(L)^e$	34	66054227.53	1942771.4**	34	22455589.05	660458.5^{ns}
$Sd_i^2\sum^f$	490	305445454.00	623358.07**	210	92804415.00	441925.79**
Pooled error	1088	310027050.67	284951.33	544	104836597.33	192714.33

** and ^{ns}, Denote significant at P≤ 0.01 and non significant respectively.

^{a} Landraces, ^{b} Environments, ^{c} Landraces×Environments, ^{d} Environment(Linear), ^{e} Landraces×Environments (Linear), ^{f} Pooled deviation from regression.



($P \leq 0.05$) in environments (Table 4 and Figure 1). There was no stable landrace (for GE) using Finlay and Wilkinson's (1963) consideration (b or regression coefficient of yield over environmental index equal to zero) for flower yield and only a low flower yield landrace (QZ1) was stable for GL interaction. The regression coefficient of flower yield over environmental index (b value) showed a significant ($P \leq 0.01$) positive correlation with flower yield both in environments and locations (Table 4 and Figure 1). The landraces YZ2, IS5, IS8, IS4, KZ1, AR1, IS1 and BA1 were stable and YZ2, IS5, IS8, IS4, KZ1, AR1, IS6, IS1, BA1, IS10 and YZ1 were adaptable for flower yield according to Eberhart and Russell's (1966) considerations (b equal to unity, Sd^2 or variance due to deviation from regression equal to zero and mean of flower yield about average of landraces or higher than it) (Table 5). Regression coefficient (b) had correlated significantly with flower yield in both environments and locations (r= 0.878** and r= 0.694**, respectively). Sd^2 showed a positive but not significant correlation with flower yield in two conditions (Table 4 and Figure 1). Among the studied landraces, IS9, YZ2, IS8, IS7, IS4, IS5 and IS2 with the highest flower yield, respectively, (Tables 3 and 5) showed the least landrace performance measurement or Lin and Binns (1988) superiority index (P_i); therefore, these were stable and adaptable. Superiority index (P_i) had negatively correlated (r= -0.947**) with flower yield (Table 4 and Figure 1). The landraces GU1, LO1, ZA1, SM2 and KR1 with the least flower yield (Table 3) showed the least variance of the years within places (MSY/P) and, thus, were stable (Table 5). Variance of the years within places (MSY/P) showed a significant positive correlation (r= 0.689**) with flower yield (Table 4 and Figure 1).

DISCUSSION

Kempton and Fox (1997) described adaptation as yield stability in spatial dimension thus; we can define the stable landraces for landrace×location interaction as adaptable and compatible ones. The stable and adaptable landraces with the S^2 parameter produced a very low flower yield. The significant positive correlation between S^2 and flower yield suggests that only low flower yield landraces develop a similar phenotype over a range of environments and locations. Environmental variance (S^2) measures "biological" or "static" stability. This type of stability is seldom a desired feature of crop cultivars, since no response to improved growing conditions would be expected (Becker and León, 1988). Because of the lowest flower yield of the stable landraces with S^2, this statistic is not a suitable parameter for evaluating flower yield stability in Damask rose, especially in wide variated ecological conditions such as the studied areas and is not recommended.

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Table 3. Studied stability parameters and mean of flower yield ($\bar{Y}$) for Damask rose landraces over 16 environments and 8 locations.

Landrace	$\bar{Y}^a$(kg ha^{-1}) (H_0: $\bar{Y}_i = \mu$)		$S^{2\,b}$		CV^c		$b^d(H_0 : b_i = 0)$		$b(H_0 : b_i = 1)$		$Sd^{2\,e}$ (H_0: $Sd_i^2 = 0$)		P^f	$MS_{Y/P}{}^g$
	E^h	L^i	E	L	E	L	E	L	E	L	E	L		
AK1	2477.30^{ns}	2477.30^{ns}	2989091.8	1635445.8	69.79	51.62	1.330**	1.441**	1.330**	1.441*	534232.50*	469032.67*	1131502.2	2742517
AR1	2547.37^{ns}	2547.37^{ns}	1445564.5	717746.8	47.2	33.01	0.952**	1.031**	0.952^{ns}	1.031^{ns}	182076.64^{ns}	101465.50^{ns}	865245.86	1480305
BA1	2371.83^{ns}	2371.83^{ns}	1736724.8	411984	55.56	27.36	1.060**	0.767**	1.060^{ns}	0.767^{ns}	167365.57^{ns}	72424.50^{ns}	1223519.8	2509384
CM1	2199.81^{ns}	2199.81^{ns}	1381973	552555.2	53.44	33.79	0.865**	0.691**	0.865^{ns}	0.691^{ns}	351938.64^{ns}	313817.00^{ns}	1554699.7	1624228
EA1	2160.03^{ns}	2160.03^{ns}	2874016.2	1506179.1	78.48	56.82	0.994**	0.979**	0.994^{ns}	0.979^{ns}	1590898.29**	1093415.17**	1701245.4	2752967
FA2	2323.66^{ns}	2323.66^{ns}	2769666	1322386.6	71.62	48.12	1.095**	0.937**	1.095^{ns}	0.937^{ns}	1160080.00**	934014.17**	1712217.3	2878947
GU1	1407.28**	1407.28**	567674.6	312609.4	53.54	39.68	0.320**	0.447*	0.320**	0.447**	453464.29^{ns}	226567.33^{ns}	3245798.5	524945
HA1	2099.58^{ns}	2099.58^{ns}	1740438.7	898208.9	62.83	45.14	0.904**	1.007**	0.904^{ns}	1.007^{ns}	631433.29**	344904.33^{ns}	1563850.5	1691457
HO1	2350.74^{ns}	2350.74^{ns}	1419779.2	462998.1	50.69	28.95	0.826**	0.522*	0.826^{ns}	0.522*	493370.71*	351446.00^{ns}	1383986.1	1851839
IL1	2438.33^{ns}	2438.33^{ns}	2372031.3	1204321.5	63.16	42.19	0.852**	0.442*	0.852^{ns}	0.442**	1448024.43**	1269940.50**	1787969.6	2339996
IS1	2716.92*	2716.92^{ns}	2729778	1590448.3	60.81	46.55	1.255**	1.347**	1.255*	1.347^{ns}	548994.64*	598807.50**	924393.99	2381428
IS2	2572.80^{ns}	2572.80^{ns}	2643498.6	1667628.4	63.2	50.19	1.274**	1.598**	1.274*	1.598**	385887.79^{ns}	176739.83^{ns}	855390.39	2038210
IS3	2438.62^{ns}	2438.62^{ns}	2499261.7	1333825.9	64.83	47.36	1.226**	1.301**	1.226^{ns}	1.301^{ns}	411437.57^{ns}	383641.17^{ns}	1216463	2351920
IS4	2579.91^{ns}	2579.91^{ns}	1903506.5	1071837.1	53.48	40.13	1.072**	1.227**	1.072^{ns}	1.227^{ns}	305863.29^{ns}	207535.83^{ns}	807133.52	1693360
IS5	2639.12^{ns}	2639.12^{ns}	1974504.6	988779.2	53.24	37.68	1.087**	1.116**	1.087^{ns}	1.116^{ns}	333141.79^{ns}	290214.67^{ns}	845785.78	1971833
IS6	2539.98^{ns}	2539.98^{ns}	2455271	1255246	61.69	44.11	1.242**	1.323**	1.242*	1.323^{ns}	303294.07^{ns}	251931.50^{ns}	967089.42	2406953
IS7	2769.15**	2769.15*	2520600.2	1295812.3	57.33	41.11	1.199**	1.175**	1.199^{ns}	1.175^{ns}	533507.86*	555757.17**	803872.3	2458454
IS8	2602.75^{ns}	2602.75^{ns}	1970107.9	1168560.6	53.93	41.53	1.132**	1.351**	1.132^{ns}	1.351^{ns}	177128.43^{ns}	98194.83^{ns}	788541.72	1648971
IS9	3120.63**	3120.63**	4242220.4	2078304.8	66	46.2	1.683**	1.776**	1.683**	1.776**	272707.79^{ns}	238217.50^{ns}	293799.89	4317130
IS10	2355.74^{ns}	2355.74^{ns}	1818016.6	887894.3	57.24	40	0.981**	0.970**	0.981^{ns}	0.970^{ns}	498022.64*	383205.00^{ns}	1230534.8	1854966
KM1	1516.11**	1516.11**	1023876.3	354717.3	66.74	39.28	0.704**	0.585**	0.704*	0.585^{ns}	350011.36^{ns}	176464.83^{ns}	2920324.4	1299013
KO2	2236.96^{ns}	2236.96^{ns}	2215407.8	1033124.2	66.54	45.44	1.162**	1.182**	1.162^{ns}	1.182^{ns}	338803.50^{ns}	237192.33^{ns}	1319518.8	2345922
KR1	1758.24*	1758.24*	1161132.5	611398	61.29	44.47	0.674**	0.643**	0.674**	0.643^{ns}	559238.43*	426697.17*	2432269.1	1107177
KS1	2200.10^{ns}	2200.10^{ns}	1613027.1	518752	57.73	32.74	1.022**	0.897**	1.022^{ns}	0.897^{ns}	151973.07^{ns}	47804.17^{ns}	1395029.2	2116610
KZ1	2566.42^{ns}	2566.42^{ns}	1850899.7	885740.2	53.01	36.67	1.064**	1.069**	1.064^{ns}	1.069^{ns}	275657.79^{ns}	242176.50^{ns}	901545.66	1920392
LO1	842.54**	842.54**	654990.9	353662.8	96.06	70.58	0.483**	0.527*	0.483**	0.527*	350224.71^{ns}	219747.83^{ns}	4720121.5	609198
QM1	2472.32^{ns}	2472.32^{ns}	2298038.8	1726860.4	61.32	53.15	1.057**	1.523**	1.057^{ns}	1.523*	776195.93**	406985.33*	1083671.2	1286817
QZ1	1651.55**	1651.55**	1153312	454180.9	65.03	40.76	0.583**	0.364^{ns}	0.583**	0.364**	723874.57**	437960.33*	2815523	1370548
SM1	2160.00^{ns}	2160.00^{ns}	1990397.1	785087.5	65.32	41.35	1.045**	0.872**	1.045^{ns}	0.872^{ns}	486080.21*	389335.17^{ns}	1614560.8	2358091
SM2	1331.75**	1331.75**	1018965.5	590905.4	75.8	57.72	0.452**	0.801**	0.452**	0.801^{ns}	784291.79**	244654.33^{ns}	3350907.9	876476
TH1	1977.73^{ns}	1977.73^{ns}	1466695	398072.9	61.24	31.9	0.748**	0.479*	0.748*	0.479*	727972.14**	305668.83^{ns}	1964140.5	2053425
WA1	2894.62**	2894.62**	7466077.9	4945498.7	94.4	76.83	1.599**	2.022**	1.599**	2.022**	3994398.79**	2935837.67**	1689490.9	5974893
YZ1	2354.32^{ns}	2354.32^{ns}	2764963.6	909787.3	70.63	40.51	1.288**	0.993**	1.288*	0.993^{ns}	461055.71^{ns}	378372.67^{ns}	1303654.8	3592179
YZ2	2941.63**	2941.63**	2280741.2	575637.6	51.34	25.39	1.152**	0.861**	1.152^{ns}	0.861^{ns}	443532.57^{ns}	158119.33^{ns}	602066.46	3269024
ZA1	1594.08**	1594.08**	1154801	750513.7	67.41	54.35	0.644**	0.737**	0.644**	0.737^{ns}	611351.64**	499113.83*	2726413.9	851853

**, * and ^{ns}; Denote significant at $P \leq 0.01$, $P \leq 0.05$ and non significant respectively.

^{a} Flower yield mean; ^{b} Environmental variance; ^{c} Environmental coefficient of variation; ^{d} Regression coefficient of yield over environmental index; ^{e} Variance due to deviation from regression; ^{f} Superiority index; ^{g} Variance of the years within places; ^{h} Environments, ^{i} Locations.

Table 4. Correlation coefficients between studied stability parameters and mean of flower yield ($\bar{Y}$) in environments and locations.

	S^2		CV		b		Sd^2		P	MSY/P
	Envir.	Loc.	Envir.	Loc.	Envir.	Loc.	Envir.	Loc.		
Flower mean yield($\bar{Y}$)	0.65**	0.533^{**}	-0.352^{*}	-0.234^{ns}	0.878^{**}	0.694^{**}	0.128^{ns}	0.208^{ns}	-0.947^{**}	0.689^{**}

**, * and ^{ns}; Denote significant at P≤ 0.01, P≤ 0.05 and non significant respectively.

Table 5. Stable (for environments) and adaptable (for locations) landraces through Studied stability parameters.

Methods	Parameters	Condition	Stable landraces
Environmental variance	S_i^2	Environments	GU1, LO1, SM2, KM1 and QZ1
		Locations	GU1, LO1, KM1, TH1 and BA1
Francis and Kannenberg (1973)	CV_i	Environments	AR1, HO1, YZ2, KZ1 and IS5
		Locations	YZ2, BA1, HO1, TH1 and KS1
Finlay and Wilkinson (1963)	b_i	Environments	-
		Locations	QZ1
Eberhart and Russell (1966)	b_i , Sd_i^2	Environments	YZ2, IS5, IS8, IS4, KZ1, AR1, IS1 and BA1
		Locations	YZ2, IS5, IS8, IS4, KZ1, AR1, IS6, IS1, BA1, IS10 and YZ1
Lin and Binns (1988)	P_i	Locations	IS9, YZ2, IS8, IS7, IS4, IS5 and IS2
	MSY/P	Locations	GU1, LO1, ZA1, SM2 and KR1
Superior landraces for flower yield	$IS9^{**}$, $YZ2^{**}$, $WA1^{**}$, $IS7^{**}$, $IS1^{*}$, $IS5^{ns}$, $IS8^{ns}$, $IS4^{ns}$, $IS2^{ns}$ and $KZ1^{ns}$		

The stable and adaptable landraces with the *CV* parameter have produced flower yield about average for landraces or higher. The presence of the high yielding landrace of YZ2 among adaptable landraces, directed us to the conclusion that, although we know that stable genotypes with stability type I parameters (Static stability type) such as S^2 and *CV* usually produce a low yield because of low responses to environments, this is not an absolute rule. In other words, we can find high yielding genotypes among biologically stable genotypes such as YZ2. The negative correlation between *CV* and flower yield shows that an increase in flower yield usually occurrs with a partial decrease in *CV*. Since landraces with the smaller *CV* are the more stable and so we are searching for high yielding and stable ones, thus, this could be possible. Considering of the results specially access possibility to high yield and stable genotypes with *CV*, this parameter could be recommended as a suitable parameter for stability evaluating of flower yield in Damask rose.

There was no stable but a very low flower yield landrace as adaptable (QZ1) according to Finlay and Wilkinson's (1963) consideration (b equal to zero). This suggests that all of the studied landraces have more or less reacted to environmental changes. The regression coefficient of yield over environmental index (b value) in Finlay and Wilkinson's (1963) consideration (b equal to zero) measures static stability and, based on the results, only very low flower yield landraces showed a slope equal to zero and developed a similar phenotype over a range of environments; a strong positive correlation between *b* and flower yield is in accordance with this result. Therefore, Finlay and Wilkinson's (1963) static view of *b* equal to zero is not a useful method and so is not recommend. The stable and adaptable landraces according to Eberhart and Russell's (1966) model produced a flower yield about average for landraces or higher. Eberhart and Russell's (1966) model measures "agronomic" or "dynamic" stability and, in this model, a genotype is stable if its response to environments is parallel to the mean response of all genotypes in the trial. Therefore, by this method we are able to determine general stable, adaptable and high yielding landraces. Freeman (1973) and Bernardo (2002) have mentioned this model as the most popular method for evaluating stability in crops. This method has been used for evaluating yield stability widely in both annual and perennial plants such as *Campanula rapunculoides* (Vogler *et al.*, 1999), *Hevea brasiliensis* (Omokhafe, 2004) and *Thea sp*. (Wachira *et al.*, 2002). Therefore, we recommend the method of Eberhart and Russell (1966) as a useful one for the determination of general yield stability and adaptability of Damask rose landraces.

The landrace performance or superiority index (P) determined some of the highest flower producer as adaptable ones. Its strong negative correlation with flower yield suggestted that high flower yielding landraces always show low *P*. This statistic suggests that high yield landraces which demonstrate high yielding potential in several locations should be considered as adaptable ones. With consideration to this, Lin and Binns' (1988) superiority index (P) is also a suitable statistic for identifying high flower yield and adaptable landraces in Damask rose.

Because of mixing the year effect with the effect of plant age, variance due to years within places (MSY/P) as the other stability parameter is not a suitable parameter for flower yield and other traits that are strongly correlated with plant age in perennial plants. The stable landraces with the least *MSY/P* showed the least flower yield. Thus, *MSY/P* is also not a favorable stability parameter especially for perennial plants such as Damask rose.

We found some high flower yielding landraces, for instance YZ2 and IS5, that were stable and adaptable with varying stability statistics (belong to different types of stability) such as the coefficient of variation (CV), regression coefficient of

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yield over environmental index (b), deviation from regression (Sd^2) and superiority index (P). This suggests that a genotype can (i) demonstrate both static and dynamic kinds of stability and (ii) high flower yield and stability for yield simultaneously.

In addition, the stability parameters of Francis and Kannenberg's (1973) coefficient of variation (CV), Eberhart and Russell's (1966) model and Lin and Binns’ (1988) superiority index (P_i) are recommended as desirable parameters and methods for yield stability evaluating of Damask rose landraces.

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ارزیابی پارامترهای سنجش پایداری در تشخیص ارقام بومی پایدار، سازگار و پر عملکردگل محمدی (*Rosa damascena* Mill.)

ب. یوسفی ، س. ر.ا طبایی عقدایی، م. ح. عصاره و ف. درویش

چکیده

به منظور مقایسه کارائی آماره‌های مختلف در ارزیابی پایداری عملکرد گل اکسشنهای مختلف گل محمدی (*Rosa damascene* Mill)، شش آماره متعلق به تیپهای مختلف پایداری برای ۳۵ اکسشن گل محمدی در قالب طرح بلوکهای کامل تصادفی با سه تکرار در ۸ منطقه مختلف اکولوژیکی کشور و طی سالهای ۱۳۸۶الی ۱۳۸۷ مورد مطالعه قرار گرفتند. همبستگی مثبت و معنی دار ($P\leq 0.01$) مشاهده شده بین آماره واریانس محیطی (S^2)با عملکرد گل بیانگر آن است که فقط اکسشنهای با تولید گل کم، فنوتیپ مشابهی را در طیفی از محیطهای مختلف به نمایش می‌گذارند. اکسشنهای پایدار و سازگار با آماره ضریب تغییرات محیطی (CV) دارای عملکرد گل حدود متوسط کل اکسشنها و یا بالاتر از آن بودند. آماره های واریانس محیطی (S^2)و ضریب تغییرات محیطی (CV) پایداری استاتیک یا بیولوژیکی را اندازه می‌گیرند. اگر چه تمام اکسشنهای پایدار و سازگار با آماره S^2 عملکرد گل خیلی کمی داشتند، برخی اکسشنهای سازگار باCV مانند اکسشن YZ2 دارای عملکرد بالا و پایداری عملکرد به صورت توام بودند. ضریب رگرسیون عملکرد گل بر محیط (b) اکسشنها با عملکرد گل دارای رابطه مثبت بود. ضرایب رگرسیون عملکرد گل بر محیط تمام اکسشنها به صورت معنی‌داری با صفر اختلاف نشان دادند. بنابراین با دیدگاه مطلق Finlay و Wilkinson (فرض اکسشن دارای ضریب رگرسیون برابر صفر به عنوان پایدار) اکسشن پایدار برای عملکرد گل در بین اکسشنهای مورد بررسی وجود نداشت. اکسشنهای پایدار و سازگار با روش Eberhart و Russell (آماره های b و واریانس انحراف از رگرسیون Sd^2)، عملکرد گل حدود میانگین کل اکسشنها و یا بالاتر از آن تولید نمودند. با استفاده از شاخص برتری Lin و Binns (P) اکسشنهای دارای برترین عملکرد

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گل به عنوان اکسسشنهای سازگار تعیین گردید. به‌واسطه عملکرد گل بسیار کم و همچنین اختلاط اثر سال با سن گیاه، آماره واریانس سال درون مکان (MSY/P) برای ارزیابی پایداری صفاتی نظیر عملکرد گل معیار مناسبی نبوده و برای ارزیابی پایداری صفات در گل محمدی توصیه نمی‌گردد. برخی اکسسشنهای با عملکرد گل بالا مانند YZ2 و IS5 دارای پایداری و سازگاری با آماره های مختلف نظیر ضریب تغییرات محیطی (CV_i)، ضریب رگرسیون عملکرد گل بر شاخص محیطی(b_i)، واریانس انحراف از رگرسیون(Sd_i^2) و همچنین شاخص برتری (P_i) بودند که نشانگر آن است که یک ژنوتیپ می‌تواند هم دارای پایداری استاتیک (بیولوژیکی) و هم پایداری دینامیک (زراعی) بوده و ضمنا دارای عملکرد گل بالائی هم به‌طور همزمان باشد. در مجموع با در نظر داشتن عملکرد گل و پایداری و سازگاری عملکرد گل ضریب تغییرات محیطی (CV_i)، روش Eberhart و Russel و شاخص برتری (P_i) Lin و Binns به عنوان آماره‌ها و روشهای مناسب ارزیابی پایداری و سازگاری عملکرد گل در گل محمدی توصیه می شوند.

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