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VARIABILITY, HERITABILITY AND ASSOCIATION ANALYSIS IN EGGPLANT (*Solanum melongena*)

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ABSTRACT

To determine the best eggplant cultivars and lines in terms of performance, nine advanced cultivars and lines were planted in transplant trays on March, 2013. In mid-April 2014, nine cultivars and lines were taken from the seedling trays and were evaluated and compared in an experiment in form of a completely randomized block design with three replications at the Agricultural Research Station, Zahak. The results of the analysis of variance showed that there was a significant difference between the studied cultivars in terms of average fruit weight, fruit length, fruit diameter, ratio of fruit length to its diameter, the relative number of seeds per fruit, and each plant yield. The total yield of Sohrab and Y6 line with an average of 41.9 and 36.7 t/ ha allocated the highest yield respectively to themselves. The results of simple correlation between the analyzed traits showed the final yield was affected by the average fruit weight due to direct and indirect effects of fruit weight and plant yield on the final yield. The genotypic and heritability values were high for fruit weight, fruit length and number of seed per fruit. The first two principal components accounted for 81.6% of the total variation among the characters describing genotypes.

Keywords: eggplant, principal component, variation, path analysis.

INTRODUCTION

Eggplant is probably native to Asia, India, and China. Initially, this plant has grown as a wild plant in India. It is an annual vegetable with the scientific name, *Solanum melongena. L* from the *Solanaceae* family, yet it may survive for more than a year, depending on its culture climate. It was originated in an area located between India and Myanmar, and probably, china has been its second cultivation growth [1]. Eggplant is a warm season crop, and it grows well at relatively high temperature. Proper weather for eggplant and tomato plants are alike, yet eggplant is more resistant to heat. Eggplant cultivars vary in terms of early agronomic traits and length of fruiting period and its yield depends on weather conditions in which they grow in [2]. Totally, 1600000 hectares is dedicated to eggplant cultivation to the world's 5 top producers of this plant in which China had got the first place and Iran with a rate of 1300000 tons, has allocated the third place to itself [3]. It is important to identify the natural mechanisms prevailing in the eggplant land races to utilize them in the future breeding programme, precise information on the nature and degree of genetic divergence of the parents is the prerequisite of variety development program. The importance of genetic diversity in the improvement of a crop has been stressed in both self and cross pollinated crop [4]. Crop improvement is dependent not only on the magnitude of the phenotypic variability but also on the extent to which the desirable characters are heritable. Hence, it is essential to partition the observed variability into its heritable and non heritable components by appropriate genetic analysis [5]. Hence, it is essential to partition the overall variability into its heritable and non heritable components with the help of genetic parameters like genetic coefficient of variation, heritability and genetic advance. The present study was, therefore, undertaken to determine the genetic variability for various characters in nine eggplant genotypes. Quamruzzaman *et al* [6] investigated the genetic diversity of 19 eggplant genotypes and divided these genotypes into 5 clusters, they observed that the studied genotypes had a desirable variety in terms of their yield and their components. Barchi *et al* [7] introduced determination of cultivars and genotypes with high yield and sustainable growth as the initial plant components which can be used by researchers to advance the breeding goals. In another report, 25 eggplant genotypes were analyzed in terms of yield, average fruit weight, and number of fruits per plant. In all traits, high phenotypic and genotypic variation was observed for the number of fruits and fruit weight [8]. Kazerani [9] compared 8 local varieties of eggplant in terms of quantity, quality, and yield and after analyzing a series of traits, introduced Dezful local mass as the most superior genotype. studying 6 important traits in 24 varieties of eggplant, Aramendis and Carlos [10] reported that there was no significant correlation between fruit weight and its yield. On the other hand, they reported a significantly negative correlation between fruit number and its weight. In present study, a small sample of nine eggplant genotypes was examined to study variation in different traits and data analyzed to calculate heritability and genetic advance of those characters.

MATERIALS AND METHODS

The study was conducted in the field of agriculture research station, Zahak, located 20 km south of the city of Zabol with L 61° 41'and E30° 54' and 482 m above sea level to identify superior eggplant genotypes consistent with the conditions of area. 9 advanced cultivars and lines (Table-1) were planted in seedlings trays in March, 2013, nursery trays with perlite were filled with

peat moss to increase the porosity and air penetration and more and better rooting. The main ground of the operation was prepared, plowed, and disked. In the first half of March (2014), 9 cultivars and lines were taken from the seedling trays and were planted at a completely randomized block design with 3 replications to do evaluation. The operation of seedling transportation was performing in one day. For each treatment in each replication, a 5 meter line was considered in form of raceway and stack. During two- shift plantation period, urea fertilizer was used and weeds were removed twice. During the growing season, these traits were evaluated and measured; crop harvesting was performed in time intervals of nearly 10 days. The product was weighed accurately and notes were recorded. During the growing season, traits such as plant height, number of fruits per plant, average fruit weight, fruit length, fruit diameter, ratio of fruit length to width, number of seeds per fruit, plant yield, and total yield were measured.

Table-1. List of selected 9 cultivars and advanced lines.

No.	Line	No.	Cultivar
1	D13	6	Sohrab
2	B29	7	Yalda
3	Y6	8	Chahboland
4	BJ30	9	Malekabad
5	V44		

RESULTS AND DISCUSSIONS

The analysis of variance revealed significant variation among the genotypes for studied characters except for number fruit per plant and height (Table-2) and indicating the scope for selection of suitable initial breeding material for crop improvement. Cultivars and lines had a significant difference at the level of 1% for yield (Table-3). The results of mean comparisons with duncan method (Table-3) showed that the cultivar Sohrab with the highest yield 41.9 t/ha had no significant difference with the advanced line Y6 36.7t/ha. Genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance, genetic variance and phenotypic variance are presented in Table-3. High value of GCV was obtained for traits like fruit weight, number seed per fruit and plant yield, Similar results were reported by Sharma and Swaroop [11] for number of fruits per plant, fruit weight and plant yield. High value of GCV for the above mentioned traits indicated considerable amount of genetic variability, thus suggesting the potential of the materials for further improvement. However, it has been suggested that GCV values alone are not sufficient to identify the amount of variation which is heritable. The efficiency of selection for a character is best reflected by the heritability. Singh and Kumar [12] reported that GCV and heritability together with high values would be more valuable to be selected from selection for particular trait. Heritability values were high for traits fruit weight, fruit length and number seed per fruit, similar results were reported by Patel *et al* [13] for fruit weight, fruit length, plant yield, fruit diameter, and Singh and Kumar [12]for average fruit weight and fruit yield per plant, Babu and Patil [14] for fruit diameter. In order to have a clear predictability of the breeding value, heritability in conjunction with genetic advance was found to be more effective and reliable in predicting the result and effect of selection. Heritability and Genetic Advance when estimated together are more useful for predicting the genetic progress in selection as high heritability coupled with high genetic advance reflect preponderance of additive gene action. Number seed per fruit had high heritability and genetic advance, revealed preponderance of additive gene action. Mili *et al* [15] were reported high heritability and genetic advance for this trait. Heritability values were higher than GA values for some traits which indicated that they were affected by environmental changes as little and showed that the phenotypes were the true representative of their genotypes and selection based on phenotypic performance would be helpful. The highest fruit weight was allocated to Sohrab cultivar (285g) which was in harmony with the lines BJ30 (273 g) and D13 (206g) (Table-3). Simple correlation coefficients between traits (Table 4) showed that the total yield had a significant and positive correlation with fruit weight (0.69^{*}) as well as plant yield (0.80^{**}). Fruit weight had a significant positive correlation with the relative number of seeds per fruit (0.68^{*}) and yield per plant (0.89^{**}). The path coefficient analysis permits the separation of direct effect from indirect effects through other related traits by partitioning correlation coefficients. Plant height, fruit weight and number seed per plant had positive direct effect on total yield (Table-5). Direct selection for these characters are likely will bring improvement in final yield. Similar trend of findings were also obtained by Thangamani and Jansirani [16] for fruit yield per plant, number of branches per plant and average fruit weight in eggplant. Fruit weight also by indirect effect of fruit diameter had a positive effect on total yield. Number seed per plant also has influenced by fruit diameter to increase total yield. Multivariate PCA analysis revealed that the first two principal components cummulatively accounted for 81.6 percent of the total variance. The first principal component which explained 62.7% of total variation was defined by number of fruit and fruit length (Table-6). The second principal component was mainly defined by height, ratio length to width and plant yield. Therefore, number of fruit per plant, fruit length, height, ratio of length to width and plant yield shown to be the important variables affecting greatly total yield. Principal component analysis (PCA) reflects the importance of the largest contributor to the total variation at each axis of differentiation [17]. Ullah *et al* [18] reported the first three principal components with eigenvalues more than one explained 90.6% of variation among 15 accessions of Brinjal crop and important variables were leaf width, fruit diameter, fruit length and fr unit yield.

CONCLUSIONS

It can be concluded from the experiment that the highest correlation was found between total yield by fruit weight and plant yield. Amongst the characters the highest genotypic coefficient of variation was recorded for number seed per fruit and plant yield. The highest GA amongst all the characters was found in number seed per fruit and plant yield. Path coefficient analysis shows that fruit weight, plant yield and number of seed per plant exerts maximum direct effect on total yield and the first two principal component characters with eigenvalues were greater than unity contributed a total of 81.6% variation towards divergence.

Table-2. Analysis of variance.

Change resources	df	HT	NFP	FW	FL	FD	Ratio	NSF	PY	TY
replication	2	37.8	0.92	942.2	11.1	0.401	0.37	6165.7	50072.4	39.4
treatment	8	153.7	0.64	10579.24**	55.48**	12.8**	5.76**	497117.2**	135044.5*	250.7**
error	16	166	1.09	758.8	2.99	4	0.34	924.19	49456.8	55.9
CV%		%17	%26	%13.7	%11.8	%11.9	%18.3	%13.2	%31.7	%25.3

*, ** are respectively significant at 1% and 5%
HT: height, NFP: number of fruits per plant, FW: average fruit weight, FL: fruit length, FD: fruit diameter, Ratio: Ratio of Fruit length to diameter, NSF: number of seeds per fruit, PY: plant yield, TY: plant yield

Table-3. Comparison of genotypes in relation to traits.

Cultivar	HT (cm)	NFP	FW (gr)	FL (cm)	FD (cm)	Ratio	NSF	PY (gr)	TY (t/ha)
Sohrab	69a	3.3a	285.3a	8.8c	9.13a	0.9c	1690a	944.3a	41.9a
Yalda	75a	3a	131.6c	15.3b	4.23c	3.6b	924d	406.3b	22.2c
Chahboland	82a	2.6a	206.3b	20a	4.22c	4.7a	512g	548.3ab	19.6c
D13	58a	3a	254.3a	16b	5.83b	3.6b	1488.6b	765.6ab	18.4c
B29	79a	2.3a	144c	16.6b	4c	4.1b	525g	333b	16.3c
Y6	76a	2.3a	196b	17.3ab	4.5c	2.8ab	1051.3c	665ab	36.7ab
BJ30	68a	2.3a	273a	6.3ac	8.9a	0.7c	906.3d	636.6ab	28.5abc
V44	68a	2a	170.6b	16b	4.4c	3.5b	774.6e	362.3b	24.8bc
Malekabad	75a	2.6a	137.3c	15.5b	4.2c	3.6ab	682f	362.6b	16.3c

Dissimilar letters indicate significant differences at the 5% level
HT: height, NFP: number of fruits per plant, FW: average fruit weight, FL: fruit length, FD: fruit diameter, Ratio: Ratio of Fruit length to diameter, NSF: number of seeds per fruit, PY: plant yield, TY: plant yield

Table-4. Simple correlation coefficients between characters.

Trait	HT	NFP	FW	FL	FD	Ratio	NSF	PY	TY
HT	1								
NFP	-0.35	1							
FW	-0.55	0.27	1						
FL	0.43	-0.05	-0.61	1					
FD	-0.49	0.18	0.86**	-0.91**	1				
Ratio	0.45	-0.13	-0.69*	0.98**	-0.95**	1			
NSF	-0.70*	0.78*	0.68*	-0.46	0.64	-0.55	1		
PY	-0.47	0.61	0.89**	-0.45	0.74*	-0.56	0.86**	1	
TY	-0.22	0.42	0.69*	-0.15	0.44	-0.30	0.58	0.80**	1

*and ** significant at 5% and 1% respectively
HT: height, NFP: number of fruits per plant, FW: average fruit weight, FL: fruit length, FD: fruit diameter, Ratio: Ratio of Fruit length to diameter, NSF: number of seeds per fruit, PY: plant yield, TY: plant yield

Table-5. Variability and heritability of characters.

Trait	Vg	Vp	GCV	PCV	h^2	GA
HT	4.1	161.9	23.81	149.62	2.53	0.66
NFP	0.15	0.94	24.89	62.32	15.95	0.31
FW	3273.48	4032.28	407.30	452.05	81.18	106.19
FL	17.49	20.48	109.28	118.25	85.40	7.96
FD	2.93	6.93	73.22	112.58	42.30	2.29
Ratio	1.80	2.14	75.13	81.90	84.16	2.54
NSF	165397.7	166321.9	1326.48	1330.18	99.44	835.45
PY	28529.23	77986.03	719.69	1189.90	36.58	210.45
TY	64.93	120.83	15.55	21.22	53.73	12.16

HT: height, NFP: number of fruits per plant, FW: average fruit weight, FL: fruit length, FD: fruit diameter, Ratio: Ratio of Fruit length to diameter, NSF: number of seeds per fruit, PY: plant yield, TY: plant yield

Table-6. Direct and indirect effects of traits on total yield.

					Indirect effects					
	Direct effect	HT	NFP	FW	FL	FD	Ratio	NSF	PY	Correlation
HT	0.95		-0.14	-0.39	0.04	-0.62	0.16	-0.12	-0.09	-0.22
NFP	-0.66	0.23		0.58	0.04	-0.12	0.09	-0.02	-0.40	0.42
FW	0.87	0.16	0.05		-0.53	0.88	-0.63	0.67	0.51	0.69
FL	-0.80	-0.34	0.05	-0.49		0.13	-0.79	0.03	0.06	-0.15
FD	-0.54	0.14	-0.17	-0.12	0.93		0.78	-0.20	-0.18	0.44
Ratio	-0.38	-0.54	0.45	0.39	-0.73	0.28		0.66	0.11	-0.30
NSF	0.91	-0.33	0.30	0.03	-0.89	0.87	-0.56		0.64	0.58
PY	-0.21	0.09	-0.13	0.69	0.10	-0.16	0.12	-0.18		0.80

HT: height, NFP: number of fruits per plant, FW: average fruit weight, FL: fruit length, FD: fruit diameter, Ratio: Ratio of Fruit length to diameter, NSF: number of seeds per fruit, PY: plant yield, TY: plant yield

Table-7. Loadings of PCA for the estimated traits of eggplant.

	Components		
Trait	**1**	**2**	**Communalities**
HT	-0.08	0.85	0.43
NF	0.68	0.60	0.74
FW	-0.97	-0.04	0.83
FL	0.92	0.34	0.940
FD	-0.96	-0.17	0.98
Ratio	0.40	0.85	0.95
NSF	0.45	0.84	0.89
PY	0.18	0.77	0.93
TY	-0.45	-0.48	0.63
% variance	62.7	18.9	0.43
Cumulative variance	62.7	81.6	0.74

HT: height, NFP: number of fruits per plant, FW: average fruit weight, FL: fruit length,
FD: fruit diameter, Ratio: Ratio of Fruit length to diameter, NSF: number of seeds per fruit, PY: plant yield, TY: plant yield

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