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Variability, heritability and genetic advance in eggplant (*Solanum melongena* L.) during summer and rainy season

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Sixty three genotypes of eggplant were studied to estimate variability, heritability and genetic advance at the department of Vegetable Science, Punjab Agricultural University, Punjab. The PCV and GCV were high (during both seasons) for traits like fruits per plant, fruit weight, pseudo style flowers, long style flowers, short style flowers, medium style flowers, flowers per inflorescence, fruit setting and fruit length. Heritability and genetic advance were also high for all these traits indicating the possibility of selection to improve these characters. Hence it could be concluded that improvement by direct selection in eggplant was possible for the traits like fruits per plant, fruit weight, fruit yield per plant, long style flowers, medium style flowers, seeds per fruit.

Key words : Variability, Heritability, Genetic advance, Eggplant

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INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the most important and popular vegetable crops grown throughout the country as well as in all parts of Punjab. Being primary centre of origin, India has accumulated wide range of variability in this crop. Inspite of large number of varieties available in India, only a few have yield potentiality during summer season. This fact draws the attention of plant breeder for its improvement during summer season. Genetic variability plays an important role in a crop in selecting the best genotypes for making rapid improvement in yield and other desirable characters as well as to select the potential parent for hybridization programmes. Heritability is an index for calculating the relative influence of environment on expression of genotypes. It becomes very different to judge how much of variability is heritable and how much is non-heritable. Therefore, information of the extent of variability available in some important economic traits and their heritability along with genetic advance will be helpful to the breeders in exercising the selection effectively and to formulate sound breeding programmes. Therefore, the present investigation was carried out to study the variability, heritability and genetic advance and the scope of improvement by selection in collections of some eggplant genotypes during summer season.

RESEARCH METHODOLOGY

The experiment was conducted at the Department of Vegetable Science, Punjab Agricultural University, Ludhiana, during rainy and summer season of the 2011-12 with 63 genotypes of eggplant representing samples from Department of Vegetable Science. The summer season crop was sown on 1st week March and transplanted in 1st week April, whereas, rainy season was sown in 2nd week June and transplanted on 2nd week July. The experiment was laid out in randomized complete block design with three replications. Seedlings were transplanted at spacing of 60 x 30 cm. All recommended cultural practices were followed as per package of practices to raise a healthy crop. The observations were recorded on 7 randomly selected plants of each genotype in each replication for plant height, plant spread, primary branches per plant, leaf blade length, leaf blade width, days to 50 per cent flowering, flower type (long, medium, short, pseudo-style), flowers per inflorescence, corolla size, style length, anther length, ovary diameter, pollen viability, fruit setting, fruit length, fruit girth, fruit weight, seeds per fruit, fruits per plant, days to 1st fruit harvest and fruit yield per plant. Phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) were calculated by following the method of suggested by Burton and De Vane (1953) and Johnson *et al.* (1955).

Heritability in broad sense and expected genetic advance was also calculated as per formula given by Burton and DeVane (1953) and Johnson *et al.* (1955).

Table A: Scale for phenotypic coefficient of variation (PCV) and genotypic co-efficient of variation (GCV)

Scale		Description
20%	≥	High co-efficient of variation
10-20%	≥	Moderate co-efficient of variation
10	≤	Low co-efficient of variation

Table B: Scale for heritability in broad sense and expected genetic advance

Scale		Description
80%	≥	High
50-80%	≥	Moderate
50%	≤	Low

RESEARCH FINDINGS AND ANALYSIS

The experimental findings obtained from the present study have been discussed in following heads:

Phenotypic co-efficient of variation :

A perusal of data presented in Table 1 showed wide range of phenotypic variability in the experimental material. In the experimental material during summer season, phenotypic co-efficient of variation ranged from 11.66 to 113.59 per cent for different traits. Phenotypic co-efficient of variation (PCV) estimates were very high for pseudo style flowers (113.59 %) and long style flowers (89.22 %), followed by fruits per plant (74.46 %), fruit weight (66.99 %), fruit yield per plant (63.62 %), seeds per fruit (63.38 %) and short style flowers (62.48 %). It was high for medium style flowers (47.36 %), flowers per inflorescence (44.95 %), fruit setting (37.66 %), fruit length (35.10 %), fruit girth (33.79 %), pollen viability (29.29 %), leaf blade width (21.6 %) and ovary diameter (20.28 %). PCV estimates were moderate for leaf blade length (18.83 %), plant spread (18.66 %), days to 1st fruit harvest (18.06 %), plant height (17.64 %), primary branches per plant (15.53 %), corolla size (13.65%), style length (12.46 %) and anther length (11.66 %). The perusal of data for rainy season presented in Table 2 showed wide range of phenotypic variability (7.13 to 160.75 %) in the experimental material. PCV was very high for pseudo style flowers (160.75 %), long style flowers (84.70 %), short style flowers (73.5%), flowers per inflorescence (58.03 %), fruit weight (55.73 %), fruits per plant (55.2 %), fruit length (51.2 %), medium style flowers (42.58 %) and seeds per fruit (42.25 %). It was high for fruit yield per plant (36.71 %), fruit girth (31.49 %), ovary diameter (23.47 %), plant spread (23.24 %), primary branches per plant (23.11

Table 1 : GCV, PCV, heritability and genetic advance for various characters during summer season

Character	CV	PCV (%)	GCV (%)	h^2	GA	GA (%)	GM
Plant height (cm)	4.01	17.64	17.18	94.82	31.71	34.46	92.03
Plant spread (cm)	4.01	18.66	18.22	95.39	31.76	36.66	86.64
Primary branches per plant	11.58	15.53	10.35	44.38	0.52	14.20	3.68
Leaf blade length (cm)	3.51	18.83	18.50	96.52	4.79	37.43	12.80
Leaf blade width (cm)	4.41	21.60	21.14	95.84	3.52	42.64	8.25
Days to 50% flowering	10.05	21.78	19.33	78.73	14.14	35.33	40.01
Long style flowers (%)	0.85	89.22	89.22	99.99	48.62	183.78	26.46
Medium style flower (%)	0.54	47.36	47.36	99.99	35.69	97.56	36.59
Short style flowers (%)	0.86	62.48	62.47	99.98	32.61	128.68	25.34
Pseudo style flowers (%)	2.33	113.59	113.57	99.96	27.91	233.91	11.93
Flowers per inflorescence	11.36	44.95	43.49	93.62	2.00	86.69	2.31
Style length (cm)	6.88	12.46	10.38	69.49	0.21	17.83	1.15
Anther length (cm)	6.99	11.66	9.33	64.05	0.11	15.39	0.74
Corolla size (cm)	6.04	13.65	12.24	80.42	0.45	22.61	1.98
Ovary diameter (cm)	6.42	20.28	19.24	89.99	0.20	37.60	0.53
Pollen viability (%)	6.47	29.29	28.57	95.13	40.88	57.39	71.22
Fruit setting (%)	17.65	37.66	33.27	78.05	25.34	60.55	41.85
Fruit length (cm)	9.49	35.10	33.80	92.70	4.89	67.03	7.29
Fruit girth (cm)	17.05	33.79	29.17	74.53	2.30	51.88	4.43
Fruit weight (g)	13.99	66.99	65.51	95.64	77.91	131.98	59.03
Seeds per fruit	11.68	63.38	62.30	96.60	533.02	126.14	422.57
Fruits per plant	10.81	74.46	73.67	97.89	15.42	150.15	10.27
Fruit yield per plant (g)	8.13	63.62	63.10	98.37	515.64	128.91	399.98
Days to 1st fruit picking	7.74	18.06	16.32	81.66	19.01	30.39	62.54

%), leaf blade width (21.54 %), plant height (21.36 %), fruit setting (21.33 %) and leaf blade length (20.04 %). PCV was moderate for days to 50 per cent flowering (15.11 %), corolla size (14.45 %), anther length (14.35 %), style length (14.08 %) and days to 1st fruit harvest (10.56 %). It was low for the pollen viability (7.13 %). The above findings are in consonance with finding of Muniappan *et al.* (2010), where high PCV for number of branches per plant, fruit length, fruit breadth, fruits per plant, average fruit weight and fruit yield per plant in eggplant was observed. Islam and Uddin (2009) obtained high PCV for fruits per plant, individual fruit weight, and yield per plant. Singh and Kumar (2005) observed that average fruit weight showed the highest PCV closely followed by fruits per plant. The lowest values were recorded in days to flowering. Mohanty (2002) observed high to moderate PCV for the fruits per plant, yield and average fruit weight, but low for branches per plant and plant height in eggplant. High values of PCV for length and diameter of fruits, yield of fruits per plant, fruit weight were observed by Patel *et al.* (2004) and Behera *et al.* (1999).

Genotypic co-efficient of variation :

Different aspects of genetic parameters worked out as the phenotypic variations alone do not reveal the relative amount of variation. The experimental material during summer season showed wide range of genotypic variability for different characters ranging from 9.33 to 113.57 per cent (Table 1). Very high genotypic co-efficient of variation (GCV) estimated for pseudo style flowers (113.57%) followed by long style flowers (89.22 %), fruits per plant (73.67 %), fruit weight (65.51 %), fruit yield per plant (63.10 %), short style flowers (62.47 %), seeds per fruit (62.30 %), medium style flowers (47.36 %) and flowers per inflorescence (43.49 %). It was high for fruit length (33.8 %), fruit setting (33.27 %), fruit girth (29.17 %), pollen viability (28.57 %) and leaf blade width (21.14 %). GCV estimates were moderate for days to 50% flowering (19.33 %), ovary diameter (19.24 %), leaf blade length (18.50 %), plant spread (18.22 %), plant height (17.18 %), days to 1st fruit harvest (16.32 %), corolla size (12.24 %), style length (10.38 %) and primary branches per plant (10.35 %). It was found lowest for anther length (9.33 %). The experimental material during rainy season also showed wide range of GCV (6.49 to 160.74 %) for different characters (Table 2). Very high GCV estimates for pseudo style flowers (160.74 %), long style flowers (84.69 %), short style flowers (73.49 %), flowers per inflorescence (56.79 %), fruit weight (54.82 %), fruits per plant (54.49 %), fruit length (50.10 %), medium style flowers (42.57 %) and seeds per fruit (41.79 %) were observed. It was high for fruit yield per plant (35.04 %), fruit girth (29.58 %), ovary diameter (23.08 %), plant spread (22.95 %), leaf blade width (21.14 %) and plant height (21.07 %). GCV was moderate for leaf blade length (19.72 %), fruit setting (19.62 %), primary branches per plant (14.5

Table 2 : GCV, PCV, heritability and genetic advance for various characters during rainy season

Character	CV	PCV (%)	GCV (%)	h^2	GA	GA (%)	GM
Plant height (cm)	3.49	21.36	21.07	97.33	33.45	42.82	78.11
Plant spread (cm)	3.69	23.24	22.95	97.48	42.44	46.67	90.95
Primary branches per plant	17.98	23.11	14.52	39.49	1.07	18.80	5.67
Leaf blade length (cm)	3.48	20.04	19.74	96.98	4.90	40.04	12.24
Leaf blade width (cm)	4.63	21.54	21.04	95.39	3.37	42.33	7.96
Days to 50% flowering	6.64	15.11	13.57	80.68	11.46	25.11	45.65
Long style flowers (%)	0.77	84.70	84.69	99.99	49.59	174.46	28.42
Medium style flower (%)	0.53	42.58	42.57	99.98	36.94	87.70	42.13
Short style flowers (%)	0.88	73.50	73.49	99.99	32.79	151.38	21.66
Pseudo style flowers (%)	1.72	160.75	160.74	99.99	25.80	331.12	7.79
Flowers per inflorescence	11.96	58.03	56.79	95.75	3.68	114.47	3.22
Style length (cm)	6.70	14.08	12.39	77.37	0.27	22.45	1.20
Anther length (cm)	6.12	14.35	12.98	81.83	0.20	24.19	0.81
Corolla size (cm)	5.72	14.45	13.27	84.35	0.53	25.10	2.10
Ovary diameter (cm)	4.23	23.47	23.08	96.75	0.27	46.77	0.58
Pollen viability (%)	2.96	7.13	6.49	82.80	11.32	12.17	92.99
Fruit setting (%)	8.36	21.33	19.62	84.65	25.09	37.18	67.49
Fruit length (cm)	10.57	51.20	50.10	95.74	11.73	100.98	11.62
Fruit girth (cm)	10.82	31.49	29.58	88.19	3.35	57.21	5.86
Fruit weight (g)	10.04	55.73	54.82	96.75	172.20	111.08	155.03
Seeds per fruit	6.20	42.25	41.79	97.84	727.74	85.15	854.65
Fruits per plant	8.81	55.20	54.49	97.45	18.69	110.82	16.86
Fruit yield per plant (g)	6.88	36.71	35.04	96.29	1116.98	70.83	1577.05
Days to 1st fruit picking	6.24	10.56	8.52	65.08	9.32	14.16	65.85

%), days to 50 per cent flowering (13.5 %), corolla size (13.27 %), anther length (12.98 %) and style length (12.39 %). It was low for pollen viability (6.49 %) and days to 1st fruit harvest (8.52%). The results are corroborated the views of Behera *et al.* (1999), Patel *et al.* (2004) and Islam and Uddin (2009), where high values of GCV for length and diameter of fruits, yield of fruits per plant, fruits per plant and fruit weight was observed. Singh and Kumar (2005) found highest GCV for average fruit weight and fruits per plant in eggplant, and lowest for days to 50% first flowering. High GCV for the branches per plant, fruit length, fruit breadth, fruits per plant, average fruit weight and fruit yield per plant was recorded by Muniappan *et al.* (2010).

The PCV and GCV were comparatively high (during both seasons) for pseudo style flowers, long style flowers, fruits per plant, fruit weight, fruit yield per plant, seeds per fruit, short style flowers, medium style flowers, flowers per inflorescence, fruit setting, fruit length and low for pollen viability, days to flowering, days to first fruit harvest, primary branches per plant, corolla size, style length and anther length. In all the cases, GCV were less than the phenotypic ones, indicating the role of environment in the expressions of the traits under observations. Characters like long, medium, short and pseudo-style flowers did not show any difference between PCV and GCV. However, there was narrow difference in most of the characters, which indicated low environmental influence (in both seasons) for the expression of these traits. It implies that phenotypic variability is a reliable measure of genotypic variability in this case and selection for improvement is possible and effective on the basis of phenotypic expression. The character having high genotypic co-efficients of variability possessed better potential for the improvement through selection. Hence, direct selection in eggplant is possible for traits like fruits per plant, fruit weight, pseudo style flowers, long style flowers, short style flowers, medium style flowers, flowers per inflorescence, fruit setting and fruit length.

Heritability (h^2) :

In present study, high to moderate heritability estimates were obtained for most of the characters in both the environmental conditions. In the experimental material, during summer season, heritability ranged from 44.38 to 99.99 per cent. Very high heritability estimates were obtained for long style flowers (99.99 %), medium style flowers (99.99 %), short style flowers (99.98 %), pseudo style flowers (99.96 %), fruit yield per plant (98.37 %), fruits per plant (97.89 %), seeds per fruit (96.60 %) and leaf blade length (96.52 %), High heritability estimates were obtained for leaf blade width (95.84 %), plant height (94.82 %), fruit weight (95.64 %), plant spread (95.39 %), pollen viability (95.13 %), flowers per inflorescence (93.62 %), fruit length (92.70 %), ovary diameter (89.99 %), days to 1st fruit harvest (81.66 %) and corolla size (80.42 %). Moderate heritability was estimated for days to flowering (78.73 %), fruit setting (78.05 %), fruit girth (74.53 %), style length (69.49 %) and anther length (64.05 %). Low heritability was estimated for primary branches per plant (44.38 %) only. In the experimental material during rainy season, heritability ranged from 39.49 to 99.99 %. Very high heritability estimates were obtained for long style flowers (99.99 %), short style flowers (99.99 %), pseudo style flowers (99.99 %), medium style flowers (99.98 %), seeds per fruit (97.84 %), plant height (97.48 %), fruits per plant (97.45 %) and plant spread (97.33 %). High heritability estimates were obtained for leaf blade length (96.98 %), fruit weight (96.75 %), ovary diameter (96.75 %), fruit yield per plant (96.29 %), flowers per inflorescence (95.75 %), fruit length (95.74 %), leaf blade width (95.39 %), fruit girth (88.19 %), fruit setting (84.65 %), corolla size (84.35 %), anther length (81.83 %), pollen viability (82.80 %) and days to flowering (80.68 %). Moderate heritability was estimated for style length (77.37 %) and days to 1st fruit harvest (65.08 %). The low heritability was estimated for primary branches per plant (39.49 %) only. Behera *et al.* (1999) observed high heritability for fruit yield, diameter and length of the fruit. Prasad *et al.* (1999) estimated high heritability for yield per plant, fruit weight and plant height. Naik *et al.* (2010), Islam and Uddin (2009) and Singh and Kumar (2005) observed the maximum heritability for average fruit weight, fruits per plant and yield per plant.

Genetic advance :

The heritable variation can be estimated with greater degree of accuracy when heritability is studied along with genetic advance. A high heritability coupled with high genetic advance gives effective criterion for selection. The reason for this is that selection for a particular character is done on the basis of phenotype and the phenotype is produced by joint action of genotype and environment. Hence, the phenotypic superiority of selected plants may not be due to their superior genotype, but can be due to favorable environmental conditions that causes inflation in estimates. In such situations genetic advance gives good idea for actual position. Burton (1953) and Johnson *et al.* (1955) also stressed that heritability estimates along with the knowledge of genetic gain are more useful than heritability alone in predicting the values of selection. In the present study during summer season, the highest genetic advance was predicted for the pseudo style flowers (233.91 %), long style flowers (183.78 %), fruits per plant (150.15 %), fruit weight (131.98 %), fruit yield per plant (128.91 %), short style flowers (128.68 %), seeds per fruit (126.14 %), medium style flowers (97.56 %), flowers per inflorescence (86.69 %). The moderate genetic advance was predicted for fruit length (67.03 %), fruit setting (60.55 %), pollen viability (57.39 %) and fruit girth (51.88 %). The lowest genetic advance

was predicted for primary branches per plant (14.20 %), anther length (15.39 %), style length (17.83 %), corolla size (22.61 %), days to 1st fruit harvest (30.39 %), plant height (34.46 %), days to flowering (35.33 %), plant spread (36.66 %), leaf blade length (37.43 %), ovary diameter (37.60 %) and leaf blade width (42.64 %). The experimental material during rainy season showed highest genetic advance predicted for the pseudo style flowers (331.12 %), long style flowers (174.46 %), short style flowers (151.38 %), flowers per inflorescence (114.47 %), fruit weight (111.08 %), fruits per plant (110.82 %), fruit length (100.98 %), medium style flowers (87.70 %) and seeds per fruit (85.15 %). The moderate genetic advance was predicted for fruit yield per plant (70.83 %) and fruit girth (57.21 %). The lowest genetic advance was predicted for pollen viability (12.17 %), days to 1st fruit harvest (14.16 %), primary branches per plant (18.80 %), style length (22.45 %), anther length (24.19 %), corolla size (25.10 %), days to flowering (25.11 %), fruit setting (37.18 %), leaf blade length (40.04 %), leaf blade width (42.33 %), plant height (42.82 %), plant spread (46.67 %) and ovary diameter (46.77 %). Naik *et al.* (2010) recorded high genetic advance for fruits length, fruits per plant and total yield per plant. Islam and Uddin (2009), Singh and Kumar (2005) and Patel *et al.* (2004) obtained high genetic advance for fruits per plant, individual fruit weight, and yield per plant. Mohanty (2002) observed low value of genetic advance for plant height, days to first harvest and yield, whereas moderate to high genetic advance for average fruit weight, fruits per plant and branches per plant. High genetic advance for diameter and length of fruit and fruit yield was observed by Behera *et al.* (1999). Based upon high heritability as well as high genetic advance, it could be concluded that improvement by direct selection in eggplant was possible for the traits like fruits per plant, fruit weight, fruit yield per plant, long style flowers, medium style flowers, seeds per fruit.

Conclusion :

The PCV and GCV were high (during both seasons) for traits like fruits per plant, fruit weight, pseudo style flowers, long style flowers, short style flowers, medium style flowers, flowers per inflorescence, fruit setting and fruit length. The GCV for all the traits except flower types (long, medium, short, pseudo-style flower) was less than PCV indicated the role of environment in expressions of traits under observation. The high values of GCV and GA were exhibited by flowers per inflorescence, fruit weight, fruits per plant, fruit length, seeds per fruit, fruit yield per plant and all flower types (long, medium, short, pseudo style) during both the seasons. Hence, these traits have high potential for improvement through selection. Heritability and genetic advance were also high for all these traits indicating the possibility of selection to improve these characters. Hence, it could be concluded that improvement by direct selection in eggplant was possible for the traits like fruits per plant, fruit weight, fruit yield per plant, long style flowers, medium style flowers, seeds per fruit.

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