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ORIGINAL ARTICLE **OPEN ACCESS**

Inter relationship between Yield and its attributing traits and variability studies in eggplant for future Breeding programme

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ABSTRACT
The genetic progress in any breeding programme is actually dependent on the variation in the present gene pool. Eggplant being native to India has diverse indigenous germplasm that can serve as a source of parental gene pool for any breeding programme. The present investigation was therefore conducted at the Department of Horticulture (Vegetable and Floriculture), Bihar Agricultural University, Sabour during 2013-14 utilizing 30 diverse genotypes to generate information related to their genetic control. It was found that majority of the characters were highly heritable in nature. Fruit weight, plant height, plant spread, fruit set percentage, fruit length, fruit girth, fruit yield per plant and number of fruits per plant had high heritability, high GCV and high genetic advance as percentage of mean, suggesting additive gene action for control of these traits. Days to 50 % flowering, test weight, number of primary branches and days to first harvest exhibited moderate amount of GCV, heritability and genetic advance as percentage of mean indicating non-additive gene action. Correlation and path analysis revealed that yield per plant was significantly positively correlated with fruit weight and fruit girth. Path coefficient analysis revealed that fruit weight and fruit girth had maximum direct positive effect on yield. Other characters like plant height and plant spread showed indirect effect mostly via fruit weight and fruit girth.It was also observed that fruit weight, fruit set percentage and number of primary branches expressed direct positive influences on yield but plant spread and petiole length had direct negative effect on yield. Therefore, fruit length, girth and weight are important characters which may be included in selection criteria for improvement in fruit yield per plant.
Keywords: *Genetic variability, heritability, genetic advance, correlation coefficient, path coefficient.*

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INTRODUCTION

Eggplant (*Solanum melongena* L.) or brinjal, worldwide known as aubergine or guinea squash,is one of the most popular vegetable crops in India and other parts of the world, and it belongs to the nightshade family Solanaceae. It is an often cross pollinated annual herbaceous plant, originated in India and shows secondary diversity in South East Asia [13].Eggplant fruits are rich sources of minerals like calcium, magnesium, potassium, iron, zinc, copper and fair source of fatty acids. It is used for medicinal purposes in curing diabetes, asthma, cholera, bronchitis and diarrhoea. The hypo cholesterolemic action is due to presence of polyunsaturated fatty acids (lionleic and linolenic) which are present in flesh and seeds of the fruit in higher amount (65.1 %) [41]. Wide diversity of eggplant,exists in their related species and wild types for morphological, physiological and biochemical properties [7] which can be used for breeding programmes. Wide spectrum of genetic variability has been induced in *Solanum melongena* using both physical and chemical mutagens in order to utilize infor agronomic improvement and inheritance studies [9].Genetically diverse parents yield maximum heterosis, though the magnitude of divergence critically importance for exploitation ofF_1 hybrids. Superior genotypes can be isolated by selection if considerable variation exists in the population. Various traits with agro-economic value like seed weight, number of branches, leaves, flowers, leaf area, etc. are very much complex in nature because they confirm polygenic inheritance and greatly influenced by minute fluctuation of environmental factors. This may raise breeder's concern, since the genetic organization provides the base for crop enhancement of environmental adaptation, yield and other associated attributes.

The genetic progress in breeding programme is actually dependent on the variation in the present gene pool [2, 11] associated with the magnitude of several genetic parameters like analysis of variance of each mean value, phenotypic and genotypic variances, phenotypic and genotypic coefficients of variation (PCV and GCV), broad sense heritability and genetic gain. Effectiveness of selection directly depends on the amount of heritability and genetic advance as percent of mean for that character [30, 3]. Keeping these facts in view, the present investigation was carried out to assess the inter relationship between different yield and yield attributing traits in eggplant to check the utility of this diverse germplasm in future breeding programme.

MATERIALS AND METHODS

The plant materials comprised of thirty diverse lines of eggplant differing in morphological features as well as yield attributing characters. The seedlings were transplanted in RBD with 3 replications at the spacing of 60 cm between rows and 45 cm between plants. All the recommended cultural practices and plant protection measures were followed. Observations were recorded for 24 characters viz., plant height(cm), plant spread (cm), number of primary branches, fruit set percentage, days to first flowering, days to 50% flowering, fruit length (cm), fruit girth (cm), fruit weight (gm), test weight (gm), petiole length (cm), fruit yield per plant (Kg) and quality parameters like leaf blade colour, leaf pubescence, presence of prickles on upper leaf, calyx colour, corolla colour, plant growth habit, fruit pedicel prickles, calyx spininess, fruit shape, fruit colour, seediness and seed colour.

Phenotypic and genotypic coefficients of variation were calculated by the method suggested by Burton and Devane [5].PCV and GCV were classified as low, moderate or high by Sivasubramanian and Menon [40].Heritability in broad sense is the ratio of genotypic variance to the total variance and is calculated by the formula given by Lush [18]). The estimates of genetic advance were obtained by the formula given by Lush [19]and Johnson *et al.* [14]. Phenotypic and genotypic correlations were worked out by the formula suggested by Johnson *et al.* [14] and Al-Jibouri *et al*. [1]. Path coefficient of various characters was calculated according to Dewey and Lu [8].

RESULTS AND DISCUSSION

The genotypes included in the study were genetically diverse and considerable amount of variability were recorded among the varieties for all the characters. Hence, there is ample scope for inclusion of promising genotypes in breeding programme for yield and its component traits. Similar findings for fruit yield and its component characters were also reported by Nayak and Nagre [25].

The high estimates of GCV and PCV was observed for fruit weight, fruit length, fruit girth, fruit yield per plant and number of fruits per plant. These findings are in conformity with the results of Samadia [35], Kushwah and Bandhyopadhyay [15], while petiole length, fruit set percentage, plant height and plant spread had moderate estimates of GCV and PCV same type of results was reported by Dhankhar and Dhankhar [10], Shende *et al.* [26], Patel *et al*. [37]. However, the estimates of GCV were less than PCV indicating the role of environment in the expression of traits under observation. Similar type of results was reported by Lakshmi *et al.* [17], Nayak and Nagre [25].

The characters like fruit length, fruit weight, fruit girth and number of fruits per plant, fruit yield per plant had high GCV along with heritability suggesting that selection will be more effective for these characters. The results of the present investigation are in a line with the observations of Munniappan *et al.* [24], Roychowdhury *et al.* [34], Nayak and Nagre [25].

Heritability estimates in conjunction with genetic advance is more useful than the heritability alone in predicting the resultant effects for selecting the best individuals. Thus it is clear that a character with higher GCV and moderate heritability will have high genetic gain, whereas, characters with low GCV and high heritability estimates may have low genetic gain. Hence, high heritability with genetic advance is obtained probably due to additive gene effects [4]. But when characters show moderate heritability together with low genetic advance, it suggests that it is probably due to non-additive (dominance and epistasis) gene effects [22]. The characters *viz.* fruit length, fruit weight, yield per plant, fruit girth, etc. except days to first harvest and days to 50 % flowering had high heritability and high genetic advance as percentage of mean. The higher genotypic variation of these characters is probably due to additive gene effects. Therefore, the selection based on phenotypic performance of these characters would be useful for achieving desired results. These findings are corroborative with the findings of Maitra *et al*. [21], Dhaka and Soni [9], Nayak and Nagre [25], Shende *et al.* [37].

As a rational approach for the improvement of yield, selection has to be made for components of yield, since there may not be gene for yield *per se* but for various yield components. Further, many of these yield contributing characters are interacted in desirable and undesirable direction. Hence, a knowledge regarding the association of various characters among themselves and with economic characters is

necessary for making indirect selection for improvement of economic characters. Character association or correlation is a measure of the degree of association between two characters [34]. At genotypic level, the correlation coefficient studies revealed that yield per plant had significant positive correlation with fruit weight, fruit girth and at phenotypic level both the same characters exhibited significant positive correlation. The present findings had been credence with the observations made by Munniapan *et al.*, [24], Kumar *et al.* [16], Shekar *et al.* [36] in eggplant. The inter-correlation among the yield components is a useful study to find out the relative importance of individual characters which influence the yield. Correlation studies in conjunction with path coefficient analysis revealed a better picture of the cause and effect relationship of different attributes. The path coefficients analysis indicated that fruit weight expressed high positive direct influences on yield at both genotypic and phenotypic levels. The results of present investigation are in a line with the observations of Singh *et al.* [38], Shekar *et al.* [36], Lakshmi *et al.* [17], Prabhu and Natarajan [31]. Based on direct and indirect effects of different yield components on yield, it appears that weight of fruit had high GCV, PCV, high heritability with genetic advance and high direct contribution towards yield at both genotypic and phenotypic levels. But on genotypic level, path coefficient analysis revealed that fruit weight, fruit set percentage and number of primary branches expressed direct positive influences on yield but plant spread, petiole length and number of fruits per plant had direct negative effect on yield. These results are in agreement with the findings of Nayak and Nagre [25], Kushwah and Bandhyopadhya [15], Pathania *et al*. [28], Singh *et al*. [38].

Table 1. Planting materials used in the study

Sl. no.	Genotypes	Source	Sl. no.	Genotypes	Source
1.	JB-9	IIVR	16.	71-19	IIVR
2.	EC-384970	NBPGR	17.	IC-89837	NBPGR
3.	IVBL-10	IIVR	18.	IC-89910-K	NBPGR
4.	EC-305013	NBPGR	19.	PB-70	IIVR
5.	Swarna Mani	BAU, Sabour	20.	IC-90933	NBPGR
6.	EC-169084	NBPGR	21.	IC-261802	NBPGR
7.	PB-67	IIVR	22.	KS-331	IIVR
8.	EC-305105	NBPGR	23.	Pant Rituraj	IIHR
9.	JB-8	IIVR	24.	Rajendra Baigan 2	BAU, Sabour
10.	IC-215018	NBPGR	25.	Muktakeshi	BAU, Sabour
11.	JB-15	IIVR	26.	Pusa Shyamla	IIVR
12.	EC-467273	NBPGR	27.	Nurkee	IIVR
13.	IC-89933	NBPGR	28.	PPL	IIVR
14.	IC-354666	NBPGR	29.	Punjab Sadabahar	IIHR
15.	IC-90149	NBPGR	30.	IC-112341	IIHR

Table 2: Estimates of heritability and genetic advance

Characters	h^2	GA	GA as % of mean
Plant height (cm)	0.83	18.48	27.57
Plant spread (cm)	0.85	17.30	24.35
No. of primary branches	0.81	1.02	22.60
Fruit set %	0.87	14.39	31.74
Days to 1st flowering	0.84	10.15	23.11
Days to 50 % flowering	0.74	9.18	16.83
Petiole length (cm)	0.86	0.93	31.52
Days to 1st harvest	0.59	11.99	12.08
Fruit length (cm)	0.96	10.87	69.35
Fruit girth (cm)	0.94	6.70	42.76
No. of fruits/ plant	0.85	4.11	35.72
Fruit weight (g)	0.96	90.38	69.55
Test weight (g)	0.85	1.16	23.31
Fruit yield/ plant (Kg)	0.86	0.80	53.68

Table 3. Estimates of phenotypic, genotypic variances and coefficient of variation

Characters	PV	GV	GCV	PCV
Plant height (cm)	118.15	97.50	14.73	16.22
Plant spread (cm)	96.63	82.54	12.79	13.84
No. of primary branches	0.38	0.30	12.21	13.58
Fruit set %	64.68	56.17	16.53	17.74
Days to 1st flowering	34.15	28.79	12.22	13.31
Days to 50 % flowering	35.80	26.66	9.47	10.97
Petiole length (cm)	0.28	0.24	16.48	17.75
Days to 1st harvest	98.71	57.81	7.66	10.01
Fruit length (cm)	30.01	28.91	34.30	34.95
Fruit girth (cm)	12.03	11.28	21.45	22.16
No. of fruits/ plant	5.56	4.70	18.86	20.51
Fruit weight (g)	2094.17	2007.70	34.48	35.22
Test weight (g)	0.44	0.37	12.27	13.30
Fruit yield/ plant (Kg)	0.20	0.17	28.10	30.30

Table 4.Estimation of genotypic correlation coefficient for different quantitative characters in eggplant

	PH	PS	NPB	FS %	D1stF	D50 %F	PL	D1stH	FL	FG	NFPP	FW	TW
Y	**0.312**	**0.158**	**0.181**	**-0.189**	**-0.013**	**-0.005**	**0.130**	**-0.050**	**0.294**	**0.489****	**-0.148**	**0.708****	**0.153**
TW	0.040	-0.013	0.110	-0.002	-0.088	0.043	-0.444**	-0.276	0.260	-0.314	0.189	-0.110	1.000
FW	0.254	0.546**	-0.122	-0.643**	0.386*	0.334	0.310	0.565**	0.127	0.804**	-0.707**	1.000	
NFPP	-0.011	-0.475**	0.320	0.991**	-0.552**	-0.621**	-0.345	-0.734**	0.072	-0.725**	1.000		
FG	0.266	0.605**	-0.024	-0.589**	0.409*	0.366*	0.398*	0.556**	-0.043	1.000			
FL	-0.105	0.064	-0.072	-0.027	-0.243	-0.234	0.311	-0.076	1.000				
D1stH	0.051	0.378*	-0.200	-0.680**	0.972**	0.891**	0.366*	1.000					
PL	0.030	0.024	-0.049	-0.208	0.137	0.120	1.000						
D50 %F	0.033	0.202	-0.194	-0.548**	0.219	1.000							
D1stF	0.093	0.260	-0.216	-0.451**	1.000								
FS %	0.057	-0.464**	0.308	1.000									
NPB	-0.150	0.310	1.000										
PS	0.027	1.000											
PH	1.000												

***Significant at 5 % level of significance ** Significant at 1 % level of significance**

PH=Plant height, PS=Plant spread, NPB=Number of primary branches / plant, Days to first flowering(DFF), FS%=Fruit setting percentage, D1stF=Days to first flowering, D50%F= Days to 50% flowering, PL=Petiole length, D1stH=Days to first harvest, FL=Fruit length, FG=Fruit girth, NFPP=Number of fruit / plant,FW=Average fruit weight, TW=seed test weight and Y= Fruit yield / plant

Table 5.Estimation of phenotypic correlation coefficient for different quantitative characters in eggplant

	PH	PS	NPB	FS %	D 1stF	D 50 %F	PL	D 1stH	FL	FG	NFPP	FW	TW	Y
PH	1.000													
PS	0.004	1.000												
NPB	-0.038	0.279	1.000											
FS %	0.080	-0.311	0.237	1.000										
D 1stF	0.227	0.260	-0.030	-0.402*	1.000									
D 50 %F	0.140	0.187	-0.109	-0.406*	0.833**	1.000								
PL	0.019	0.122	-0.019	-0.113	0.159	0.126	1.000							
D1stH	0.018	0.436**	-0.132	-0.345	0.672**	0.676**	0.368*	1.000						
FL	-0.150	0.114	-0.037	0.007	-0.208	-0.179	0.321	0.021	1.000					
FG	0.300	0.565**	-0.015	-0.504**	0.366*	0.319	0.401*	0.451**	-0.033	1.000				
NFPP	0.047	-0.413*	0.253	0.849**	-0.467**	-0.444	-0.325	-0.534**	0.049	-0.655**	1.000			
FW	0.375*	0.502**	-0.100	-0.565**	0.356	0.364*	0.295	0.447**	0.121	0.762**	-0.614**	1.000		
TW	-0.030	0.049	0.103	0.021	-0.086	0.010	-0.350	-0.113	0.283	-0.295	0.113	-0.122	1.000	
Y	0.338	0.260	0.180	-0.097	0.025	0.034	0.203	0.123	0.320	0.459**	-0.137	0.656**	0.189	

Significant at 5% level of significance** * Significant at 1 % level of significance**

PH=Plant height, PS=Plant spread, NPB=Number of primary branches / plant, Days to first flowering(DFF), FS%=Fruitsetting percentage, D1stF=Days to first flowering, D50%F= Days to 50% flowering, PL=Petiole length, D1stH=Days to first harvest, FL=Fruit length, FG=Fruit girth, NFPP=Number of fruit / plant,FW=Average fruit weight, TW=seed test weight and Y= Fruit yield / plant

Table 6. Direct (diagonal) and indirect effects of component traits attributing to fruit yield per plant in eggplant at genotypic level.

	PH	PS	NPB	FS %	D 1stF	D 50 %F	PL	D 1stH	FL	FG	NFPP	FW	TW	Y
PH	0.099	-0.019	-0.077	0.040	-0.016	-0.005	-0.011	-0.001	-0.036	0.067	0.009	0.255	0.007	0.312
PS	0.003	-0.705	0.158	-0.323	-0.044	-0.033	-0.009	-0.004	0.022	0.152	0.395	0.549	-0.002	0.158
NPB	-0.015	-0.218	0.511	0.215	0.037	0.032	0.018	0.002	-0.024	-0.006	-0.266	-0.122	0.018	0.181
FS %	0.006	0.327	0.158	0.696	0.076	0.091	0.077	0.008	-0.009	-0.148	-0.823	-0.646	0.000	-0.189
D 1stF	0.009	-0.183	-0.111	-0.314	-0.169	-0.036	-0.050	-0.011	-0.082	0.103	0.458	0.388	-0.015	-0.013
D 50%F	0.003	-0.143	-0.099	-0.381	-0.037	-0.165	-0.044	-0.010	-0.079	0.092	0.516	0.336	0.007	-0.005
PL	0.003	-0.017	-0.025	-0.144	-0.023	-0.020	-0.369	-0.004	0.105	0.100	0.287	0.312	-0.075	0.130
D 1stH	0.005	-0.266	-0.102	-0.473	-0.165	-0.147	-0.135	-0.011	-0.026	0.140	0.610	0.568	-0.046	-0.050
FL	-0.010	-0.045	-0.037	-0.019	0.041	0.039	-0.115	0.001	0.339	-0.011	-0.060	0.127	0.044	0.294
FG	0.026	-0.426	-0.012	-0.410	-0.069	-0.060	-0.147	-0.006	-0.015	0.251	0.602	0.808	-0.053	0.489
NFPP	-0.001	0.335	0.163	0.690	0.093	0.103	0.127	0.008	0.024	-0.182	-0.831	-0.710	0.032	-0.148
FW	0.025	-0.385	-0.062	-0.447	-0.065	-0.055	-0.114	-0.006	0.043	0.202	0.587	1.005	-0.018	0.708
TW	0.004	0.009	0.056	-0.001	0.015	-0.007	0.164	0.003	0.088	-0.079	-0.157	-0.110	0.168	0.153

R^2 0.9200

Residual Effect 0.27

PH=Plant height, PS=Plant spread, NPB=Number of primary branches / plant, Days to first flowering(DFF), FS%=Fruitsetting percentage, D1stF=Days to first flowering, D50%F= Days to 50% flowering, PL=Petiole length, D1stH=Days to first harvest, FL=Fruit length, FG=Fruit girth, NFPP=Number of fruit / plant, FW=Average fruit weight, TW=seed test weight and Y= Fruit yield / plant.

CONCLUSION

On the basis of result and discussion made so far, it may be concluded that weight of fruit, fruit length, fruit girth and number of fruits per plant can be put to direct selection pressure to augment yield in eggplant because these characters had high GCV, PCV, heritability, genetic advance as percent of mean and having direct effect on yield.

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