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Genetic Variability, Correlation and Path Analysis for Yield and Yield Components in Brinjal (*Soalnum melongena* L.)

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ABSTRACT: Brinjal (*Solanum melongena* L.) is an important vegetable crop worldwide, particularly in tropical and subtropical regions. This study aimed to assess the genetic variability, heritability, and genetic advancement of nine key traits in brinjal. Thirty-one genotypes were evaluated focusing on traits like days to flowering, fruit yield, and quality parameters. The analysis revealed considerable genetic variability among genotypes for all traits studied. Heritability estimates were high for traits like fruit yield, indicating the potential for selection. Correlation and path-coefficient analysis identified traits like days to flowering, fruit number, and average fruit weight as crucial contributors to fruit yield. These findings contribute to the understanding of genetic diversity and provide valuable insights for breeding programs aimed at improving brinjal yield and quality.

Keywords: Solanaceae, brinjal, *Solanum melongena.*

INTRODUCTION

Brinjal is a large and important crop of the family Solanaceae. The brinjal (*Solanum melongena* L., 2n=24) also called eggplant or aubergine is the most common popular and widely grown, vegetable crop of both tropic and sub-tropics. Brinjals are grown in about 92 countries. It is being grown widely in India, Bangladesh, Pakistan, China, the Philippines, France, Italy and the USA. Brinjal shares 8.1 percent of the total vegetable production of India. The average yearly brinjal production in India is 12,764 metric tonnes over a 674.7 thousand-ha area with productivity of 18.9 MT/hectare. The major producing states are West Bengal, Orissa, Andhra Pradesh, Gujarat, Bihar, Maharashtra, Chhattisgarh, Karnataka, Madhya Pradesh, Haryana, Jharkhand, and Assam (Indiastat, 2023). It is also termed a poor man's vegetable (Kumar *et al.,* 2014). Due to its popularity amongst small-scale farmers and low-income consumers. India being one of the primary centres of its origin (Thompsom and Kelly 1957) has accumulated a wide range of variability in brinjal. Any crop improvement programme needs a good understanding of the level of genetic variability present in the genotypes for different traits and plays an important role in selecting the best genotypes for making rapid improvement in yield and other desirable characteristics as well as in selecting the potential parent for hybridization programmers. Phenotypic and genotypic coefficients of variation are useful in detecting amounts of variability present in crops. Heritability and genetic advancement help in determining the impact of the environment on the expression of characters and the extent to which improvement is possible after selection (Robinson *et al.,* 1949). Heritable variation can be effectively studied with genetic advances. High heritability alone is insufficient to make efficient selection in segregating generations and must be accompanied by a significant amount of genetic advancement (Johanson *et al.,* 1955). Indirect selection in such a situation is more effective. The study of correlation among different economic traits is essential for an effective selection programme because selection for one or more traits results in correlated responses for several other traits and the sequence of variation will also be influenced. Hence, the knowledge of the genotypic and phenotypic correlation between yield and its contributing characters is essential. Correlation study indicates the overall relationship of the independent trait with the dependent trait but it does not provide the source and effect of the relationship. With the help of path-coefficient analysis, one can resolve the correlations. Path analysis is a standardized partial regression analysis, which further permits the partitioning of correlation coefficients into components of direct and indirect effects of independent variables on the dependent variable (Wright, 1921). The more diverse parents, the greater the chance of obtaining high heterotic F_1s in the segregating genotypes with desirable character combinations (Rao, 1952). Therefore, the present investigation was carried out to study the variability, heritability and genetic advancement of nine important characters in brinjal.

MATERIAL AND METHODS

The present investigation was carried out during 2022-2023 at Kittur Rani Channamma College of Horticulture, Arabhavi. The experiment was laid out in a randomized block design with two replications and 31 genotypes (treatments). Each genotype consists of two rows with a spacing of 60 × 40 cm and each treatment contained 5 plants and the treatments were randomly assigned in each replication. Plant protection measures were taken as per the package of practice of the University of Horticultural Sciences, Bagalkot.

The seeds of 31 genotypes were pre-treated with humic acid for better germination and sown in portrays which are filled with a mixture of cocopeat and vermicompost, these portray were covered with black polythene mulch for 3-5 days to build up humidity for better and early germination of Kumar *et al.* (2021).

Genotypic and phenotypic environmental variances were computed based on the expected mean sum of squares from the ANOVA by Comstock and Robinson (1952). Heritability in a broad sense was calculated at the ratio of genotypic variance to the phenotypic variance and expressed in percentage (Falconer, 1981). Expected genetic advance (GA) was calculated using the formula given by Robinson *et al.* (1949). Genetic advance as a percentage over the mean was worked out as suggested by Johanson *et al.* (1955). Genotypic (r_g) and phenotypic (r_p) correlation coefficients were estimated as suggested by A1-Jibourie *et al.* (1958). Path co-efficient analysis suggested by Wright (1921) and Dewey and Lu (1959)

RESULTS AND DISCUSSION

The analysis of variance for nine characters is given in Table 1. The analysis of variance indicated a significantly higher amount of variability among the genotypes for all the characters studied.

The data on the mean performance of 31 genotypes for 9 quantitative traits are given in Table 2.Among the characters studied, the minimum number of days to first flowering was noticed in HUB-25 (42.52) while the maximum number of days to first flowering was noticed in HUB-2 (56.17) with an average mean of 51.78. For the minimum number of days, 50 per cent flowering was observed in HUB-25 (50.00) whereas, the maximum was noticed in HUB-4 (65.00) with an overall mean of 58.90 days. Good amount of variation of fruits per plant in the genotypes studied. HUB-48 recorded the maximum number of fruits per plant (22.83) while HUB-39 with a minimum number of fruits (8.50) in several with an overall mean of 15.46. A significant and critical difference was observed for average fruit weight among the genotypes. HUB-47 recorded a minimum fruit weight of (45.95g) while the maximum in HUB-27 was (84.26g) with an overall mean of 57.80 g. A virtual difference was found for fruit yield per plant among the genotypes. The variation in the population was 0.43 kg (HUB-39) to 1.40 kg (HUB-5) with an overall mean of 0.93 kg (Table 4). A difference was noticed for field yield per plot in 31 genotypes which ranged from 2.85 kg (HUB-8) to 7.22 kg (HUB-7) with an overall mean of 4.89 kg. The data on fruit yield per hectare ranged from 105.66 Q (HUB-8) to 267.27 Q (HUB-7) with an average mean of 181.06 Q.A significant difference was noticed for TSS among the genotypes studied. It ranged from 3.38 brix (HUB-9) to 4.72 "brix (HUB-27) with an overall mean of 4.05 brix. Significant differences were noticed for total phenols among the genotypes studied. It ranged from 79.20 mg/100g (HUB-17) to 253.99 mg/100g (HUB-7) with an overall mean of 169.37 mg/100g.

In the present study, high GCV and PCV were observed (Table 2) for the number of fruits per plant, fruit yield per plant, fruit yield per plot, fruit yield per hectare, and total phenols. Moderate GCV and PCV were observed for Average fruit weight. This indicates equal importance for additive and non-additive gene action in these characters. Low GCV and PCV were observed for Days to first flowering, Days to fifty per cent flowering, and Total soluble sugars. Similar results were also observed by Datta *et al.* (2021) for the number of fruits per plant; Mahaveerprasad *et al.* (2004); Das *et al.* (2010), for fruit yield per plant, fruit yield per plot, fruit yield per hectare Soumya *et al.* (2023) for total phenols. The very high estimates of heritability coupled with high values of genetic advance over the per cent mean were observed for traits (Table 2) such as a number of fruits per plant, average fruit weight, fruit yield per plant, and total phenols. These results follow the findings of Muniappan *et al.* (2010); Banerjee *et al.* (2018) for the number of fruits per plant and fruit yield per plant; Dutta *et al.* (2018); Nand *et al.* (2018) for average fruit weight; Soumya *et al.* (2023) for total phenols.

Correlation studies indicate the degree of inter-relationship of plant characters for yield improvement as well as important quality parameters in any breeding programme (Grafius, 1959). The estimates of genotypic and phenotypic correlation coefficients are presented in Table 4 & 5 respectively. Fruit yield per plant had a positive and significant (at p=0.01) association with the fruit yield per plot and fruit yield hectare (r_g= 0.97 and r_p = 0.84), number of fruits per plant (r_g = 0.89 and r_p = 0.75), average fruit weight (r_g = 0.51 and r_p = 0.57). The higher the number of fruit yield per plot, fruit yield per hectare, number of fruits per plant, and average fruit weight, the higher will be the fruit yield per plant. Similar correlations of yield with various horticultural traits have been reported by Das *et al.* (2010); Chattopadhyay *et al.* (2012); Reshmika *et al.* (2015); Sujin *et al.* (2017); Banerjee *et al.*(2018); Divya and Sharma (2018); Dutta *et al.* (2018); Sindhuja *et al.* (2020).

In the present study, path coefficient analysis between the components of brinjal was worked out to find out the direct and indirect effect of growth and yield-related traits on fruit yield per plant. Among the 9 traits chosen for path analysis, days to 50% flowering, number of fruits per plant, average fruit weight, and fruit yield per plot had a significant positive direct effect on fruit yield per plant on both genotypic and phenotypic levels (Table 6 & 7). In line with our investigation, the positive direct effect of these traits on yield has also been reported earlier by Nayak and Nagre (2013); Reshmika *et al.*(2015); Pujer *et al.* (2017); Tripathy *et al.* (2017); Dutta *et al.* (2018). Whereas, days to first flowering, total phenols, total soluble solids, and fruit yield per hectare had significant and negative direct effects on fruit yield. According to our findings, Pal *et al.* (2021) also obtained a negative direct effect.

Table 1: Analysis of variance (mean sum of squares) for growth, earliness and yield parameters in brinjal.

Sr. No.	Source of variation/Characters	Replications	Genotypes	Error	S. Em±
	Degrees of freedom	1	30	30	
1.	Days to first flowering	1.11	15.28*	7.01	1.87
2.	Days to 50% flowering	0.40	18.80**	0.50	0.50
3.	Number of fruits per plant	1.95	29.49**	1.45	0.85
4.	Average fruit weight (g)	61.24	134.84**	17.90	2.99
5.	Fruit yield per plant (kg)	0.09	0.11**	0.02	0.11
6.	Fruit yield per plot (kg)	2.47	2.94**	0.81	0.64
7.	Fruit yield per hectare (Q/ha)	3389.07	4030.48**	1109.34	23.55

*Significance at 1%; **Significance at 5%

Table 2: Estimates of mean, range, components of variance, heritability, genetic advance, and genetic advance over per cent mean for growth, earliness, yield and biochemical parameters.

Sr. No.	Observations	Mean± S. Em	Range	GV	PV	GCV	PCV	h^2	GA	GAM
	A. Yield and yield attributing parameters									
1.	Days to first flowering	51.78±1.87	42.52-56.17	4.13	11.14	3.93	6.45	37.13	2.55	4.93
2.	Days to 50% flowering	58.90±0.50	50.00-65.00	9.15	9.65	5.14	5.27	94.79	6.07	10.30
3.	Number of fruits per plant	15.46± 0.85	8.50-22.83	14.02	15.47	24.22	25.45	90.62	7.34	47.50
4.	Average fruit weight (g)	57.80±2.30	45.95-84.26	58.47	76.37	13.22	15.11	76.56	13.78	23.84
5.	Fruit yield per plant (kg)	0.93±0.10	0.43-1.40	0.05	0.07	22.85	28.26	65.36	0.35	38.05
6.	Fruit yield per plot (kg)	4.89± 0.64	2.85-7.22	1.06	1.87	21.11	28.00	56.83	1.60	32.78
7.	Fruit yield per hectare (Q/ha)	181.06±23.55	105.66-267.27	1460.57	2569.91	21.10	28.00	56.83	59.35	32.78
	B. Biochemical parameters									
8.	Total soluble sugars (°brix)	4.05± 0.21	3.38-4.72	0.10	0.19	7.66	10.63	51.92	0.46	11.37
9.	Total phenols (mg/g)	169.37±9.36	79.20- 253.99	1350.26	1525.38	21.70	23.06	88.52	71.21	42.05

GV- Genotypic Variance
PV- Phenotypic Variance
GCV- Genotypic Coefficient of Variance
PCV- Genotypic Coefficient of Variance
h2- Heritability (Broad sense)
GA- Genetic Advance
GAM- Genetic Advance over per cent Mean

Table 3: *Per se* performance of brinjal genotypes for growth, earliness, yield and biochemical parameters.

Sr. No.	Genotype Code	Days to 1st flowering	Days to 50% flowering	Number of fruits per plant	Average fruit weight (g)	Total yield per plant (kg	Fruit yield per plot (kg)	Fruit yield per ha (Quintal)	TSS (°Brix)	Total phenols mg/100g
1.	HUB-1	52.17	57.00	19.17	57.57	1.10	5.50	203.69	3.55	162.02
2.	HUB-2	56.17	58.17	15.67	57.96	0.93	4.65	172.33	4.30	156.70
3.	HUB-3	53.12	56.67	20.33	58.99	1.2	5.99	222.01	3.98	119.26
4.	HUB-4	54.50	65.00	13.33	71.91	0.99	4.95	183.42	4.33	121.28
5.	HUB-5	52.83	58.33	22.50	58.95	1.40	7.01	259.68	4.33	133.30
6.	HUB-6	49.67	59.17	17.67	53.23	0.98	4.92	182.05	3.58	197.55
7.	HUB-7	49.34	58.00	15.67	67.91	1.14	7.22	267.27	4.13	253.99
8.	HUB-8	50.00	58.83	10.83	52.46	0.57	2.85	105.66	3.63	204.31
9.	HUB-9	53.67	60.17	9.67	50.59	0.75	3.89	144.19	3.38	197.93
10.	HUB-10	52.67	56.50	13.67	62.65	0.87	6.46	239.17	4.25	197.29
11.	HUB-12	53.67	63.50	14.00	52.82	0.76	3.8	140.65	4.2	179.73
12.	HUB-14	52.00	61.33	20.00	68.10	1.38	6.90	255.73	4.23	139.41
13.	HUB-15	51.99	56.50	11.5	53.73	0.62	3.12	115.46	4.45	167.87
14.	HUB-16	53.84	60.50	12.33	57.34	0.75	3.73	138.18	4.38	120.16
15.	HUB-17	49.50	52.83	17.83	56.49	1.02	5.10	189.00	3.95	79.20
16.	HUB-19	47.67	59.33	10.50	58.38	0.87	4.04	149.58	4.48	165.37
17.	HUB-21	51.84	58.17	11.83	59.25	0.73	3.64	134.77	3.93	133.35
18.	HUB-24	53.32	62.50	16.67	59.83	0.99	4.95	183.2	4.63	162.34
19.	HUB-25	42.52	50.00	11.5	54.52	0.73	3.58	132.47	4.14	166.28
20.	HUB-26	47.17	61.83	14.67	61.11	0.90	5.29	195.8	4.05	113.24

21.	HUB-27	52.83	58.33	15.67	84.26	1.33	7.15	264.89	4.72	205.53
22.	HUB-28	50.34	63.17	15.00	46.16	0.71	4.07	150.58	4.33	137.87
23.	HUB-34	53.50	59.33	19.00	53.96	1.06	5.68	210.55	3.40	196.81
24.	HUB-38	54.84	56.67	17.67	64.7	1.11	5.54	205.18	3.58	176.33
25.	HUB-39	54.65	57.50	8.50	50.76	0.43	3.15	116.61	4.10	169.57
26.	HUB-40	50.17	61.33	17.50	66.04	1.15	4.89	181.18	4.28	200.80
27.	HUB-42	51.34	58.83	14.17	48.81	0.71	4.28	158.49	3.53	184.10
28.	HUB-45	53.50	59.00	10.83	59.96	0.65	4.28	158.67	4.30	204.79
29.	HUB-46	53.84	55.33	18.83	51.18	0.95	4.76	176.37	3.88	183.24
30.	HUB-47	53.32	60.67	19.83	45.95	0.95	4.73	175.13	3.43	190.11
31.	HUB-48	49.31	61.33	22.83	46.36	1.08	5.42	200.77	4.10	230.69
	Mean	**51.78**	**58.90**	**15.46**	**57.80**	**0.93**	**4.89**	**181.06**	**4.05**	**169.37**
	C.V	5.11	1.20	7.79	7.32	16.64	18.40	18.40	7.37	7.81
	S. Em	1.87	0.50	0.85	2.99	0.11	0.64	23.55	0.21	9.36
	CD at 5%	5.41	1.45	2.46	8.64	0.32	1.84	68.02	-	-
	CD at 1%	-	-	-	-	-	-	-	0.82	36.39

Table 4: Genotypic correlation coefficients among growth, yield and biochemical parameters in brinjal.

Sr. No.	1	2	3	4	5	6	7	8	9
1.	1 **	0.45 *	0.09	0.21	-0.01	-0.03	0.17	0.17	0.11
2.		1 **	0.05	0.06	0.03	0.16	0.01	0.01	0.04
3.			1 **	0.04	-0.02	-0.14	0.74 **	0.74 **	0.89 **
4.				1 **	-0.05	0.64 **	0.63 **	0.63 **	0.51 **
5.					1 **	-0.29	0.14	0.14	-0.043
6.						1 **	0.286	0.286	0.18
7.							1 **	1.00 **	0.97**
8.								1 **	0.97 **
9.									1 **

Critical rg value at 5%= 0.25   Critical rg value at 1%= 0.32
* Significant   ** Highly significant
1- Days to first flowering   5- TP-Total phenols (mg/g)
2- Days to 50% flowering   6- Total soluble sugars (^{o}brix)
3- Number of fruits per plant   7- Fruit yield per plot (kg)
4- Average fruit weight (g)   8- Fruit yield per hectare (Q/ha)
9- Fruit yield per plant (kg)

Table 5: Phenotypic correlation coefficients among growth, yield and biochemical parameters in brinjal.

Sr. No.	1	2	3	4	5	6	7	8	9
1.	1 **	0.24	0.09	0.04	-0.03	-0.05	0.05	0.05	0.04
2.		1 **	0.05	0.05	0.04	0.16	0.02	0.02	0.07
3.			1 **	0.023	-0.03	-0.16	0.64 **	0.64 **	0.75 **
4.				1 **	-0.02	0.38**	0.56 **	0.56 **	0.57 **
5.					1 **	-0.11	0.07	0.07	-0.03
6.						1 **	0.03	0.03	0.06
7.							1 **	1.00 **	0.84 **
8.								1 **	0.84 **
9.									1 **

Critical rg value at 5% = 0.25   Critical rg value at 1%= 0.32 * Significant   ** Highly significant
1- Days to first flowering   5- TP-Total phenols (mg/g)
2- Days to 50% flowering   6- Total soluble sugars (^{o}brix)
3- Number of fruits per plant   7- Fruit yield per plot (kg)
4- Average fruit weight (g)   8- Fruit yield per hectare (Q/ha)
9- Fruit yield per plant (kg)

Table 6: Genotypic path coefficient analysis for yield and its components in brinjal.

Sr. No.	1	2	3	4	5	6	7	8	rG
1.	**-0.12**	0.04	0.03	0.04	0.00	0.00	0.20	-0.08	0.11
2.	-0.06	**0.09**	0.02	0.01	-0.01	-0.02	0.01	-0.01	0.04
3.	-0.01	0.01	**0.37**	0.01	0.00	0.02	0.84	-0.34	0.89 **
4.	-0.03	0.01	0.01	**0.17**	0.01	-0.09	0.72	-0.29	0.51 **
5.	0.00	0.01	-0.01	-0.01	**-0.16**	0.04	0.15	-0.06	-0.043
6.	0.01	0.02	-0.05	0.11	0.05	**-0.14**	0.32	-0.13	0.18
7.	-0.02	0.00	0.27	0.11	-0.02	-0.04	**1.14**	-0.46	0.97**
8.	-0.02	0.00	0.27	0.11	-0.02	-0.04	1.14	**-0.46**	0.97 **

Diagonal indicates direct effect   * Significant   ** Highly significant
Residual effect = 0.045   rG – Genotypic correlation with total yield per plant
1- Days to first flowering   5- TP-Total phenols (mg/g)
2- Days to 50% flowering   6- Total soluble sugars (^{o}brix)
3- Number of fruits per plant   7- Fruit yield per plot (kg)
4- Average fruit weight (g)   8- Fruit yield per hectare (Q/ha)

Table 7: Phenotypic path coefficient analysis for yield and its components in brinjal.

Sr. No.	1	2	3	4	5	6	7	8	rP
1.	**-0.05**	0.01	0.05	0.02	0.00	0.00	0.01	-0.01	0.04
2.	-0.01	**0.03**	0.03	0.02	-0.01	-0.01	0.01	0.00	0.07
3.	-0.01	0.01	**0.61**	0.01	0.00	0.01	0.17	-0.05	0.75 **
4.	-0.01	0.01	0.01	**0.47**	0.00	-0.02	0.14	-0.04	0.57 **
5.	0.01	0.01	-0.02	-0.01	**-0.01**	0.01	0.02	-0.01	-0.03
6.	0.01	0.01	-0.10	0.18	0.00	**-0.04**	0.01	0.00	0.06
7.	-0.01	0.00	0.39	0.26	0.00	0.00	**0.26**	-0.07	0.84 **
8.	-0.01	0.00	0.39	0.26	0.00	0.00	0.26	**-0.07**	0.84 **

Diagonal indicates direct effect * Significant ** Highly significant
Residual effect = 0.045 rP – Phenotypic correlation with total yield per plant
1- Days to first flowering 5- TP-Total phenols (mg/g)
2- Days to 50% flowering 6- Total soluble sugars (brix)
3- Number of fruits per plant 7- Fruit yield per plot (kg)
4- Average fruit weight (g) 8- Fruit yield per hectare (Q/ha)

CONCLUSIONS

Results of the experiment confirm that the genotypes HUB-5, HUB-7, HUB-14 and HUB-27 were found to be superior with regards to most characters and with high yielding capacity. From this, we can suggest that these genotypes can be utilized for commercial production and crop improvement for quality and yield.

FUTURE SCOPE

Further scope for experiment is to screening for major pest and disease incidence need to be studied in the suggested genotypes and develop resistant genotypes for better use in through crop improvement programmes.

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