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Genetic variability, heritability and advancement in brinjal (*Solanum melongena* L.)

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Abstract
An assemblage of fifteen distinct eggplant genotypes underwent thorough evaluation to estimate the extent of genetic diversity, heritability, and genetic advancement across sixteen distinct attributes. The evaluation took place during the Rabi season of 2020-21 at the Vegetable Research Farm located within the Department of Horticulture at Banaras Hindu University's Institute of Agricultural Sciences in Varanasi. The outcomes derived from the analysis of variance clearly revealed notable genetic variations among the eggplant genotypes, implying a substantial level of diversity within these genotypes. This signifies considerable potential for improving relevant characteristics through selective breeding. Among all the observed traits, the phenotypic coefficient of variation (PCV) consistently exceeded the genetic coefficient of variation (GCV), albeit with minor differences. This suggests that the impact of environmental factors on the manifestation of these traits is comparatively limited. Particularly noteworthy were attributes such as the number of seeds per fruit, number of fruits per plant, fruit width, ascorbic acid content, fruit yield per plant, fruit yield per hectare, average fruit weight, fruit length, and test weight, all of which exhibited notable PCV and GCV values. In the case of attributes such as the number of seeds per fruit, number of fruits per plant, and ascorbic acid content, a combination of substantial heritability and significant genetic advancement was evident. This observation underscores the predominant influence of additive genes on these traits, suggesting their potential for effective enhancement through phenotypic selection.

Keywords: Variability, heritability, genetic advance, brinjal

Introduction
Eggplant, referred to as "baigan" in Hindi and "brinjal" in English, is a commonly cultivated vegetable across India and various other nations. It falls under the Solanaceae family. In Uttar Pradesh, eggplant is grown over a vast expanse of 8.01 million hectares, yielding approximately 275.40 million tonnes annually, achieving a productivity of 34.08 tonnes per hectare. The primary regions making a significant contribution to Uttar Pradesh's overall production are Agra, Kanpur, Meerut, Lucknow, Aligarh, Chitrakoot, and Gorakhpur (Anonymous, 2019) [2]. The intriguing historical usage of eggplant reveals its multifunctional role as a culinary staple, medicinal asset, and ornamental plant in India over an extended period. This vegetable has been a focal point of plant breeding initiatives aimed at augmenting its yield potential, enhancing various plant characteristics including resistance to pests and environmental stresses, and developing improved ideotypes. Evaluating both the scope and hereditary traits within the accessible germplasm is an essential precursor in an effective breeding strategy to select superior genotypes (Kumar *et al.*, 2010) [9]. Breeders leverage genetic advancement to choose offspring from preceding generations, demonstrating enhanced mean genotypic values in superior lineages compared to the foundational population. The current investigation seeks to determine the inherent characteristics and scope of genetic variability in vital economic attributes, along with the capacity for improvement through discerning procedures within selected eggplant varieties.

Material and Methods
The experiment took place at the Vegetable Research Farm located within the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during the Rabi season of 2020-21. To evaluate fifteen different genotypes, a randomized block design with three replications was employed. The transplantation of seedlings into the main field was carried out in plots spanning five rows, each of which was three meters in length.

Plant spacing was maintained at 60 × 60 cm, accommodating 25 plants per genotype within each replication. The cultivation adhered to prescribed protocols and strategies for ensuring successful crop growth. Observations were recorded for sixteen distinct traits, considering five randomly selected plants within each plot. Both the phenotypic and genotypic coefficients of variability for all attributes were computed using the formula established by Burton and De Vane (1953) [5]. The broad-sense heritability (h^2) was calculated for each trait, determined by the ratio of genotypic variance to total phenotypic variance, in line with the recommendations of Lush (1949) [10] and Hanson *et al*. (1956) [6]. Genetic advance estimates for each trait were obtained utilizing the formula introduced by Johnson *et al*. (1955) [7]. The genetic advance, expressed as a percentage of the mean, was classified following the system proposed by Johnson *et al*. (1955) [7].

Result and Discussion

Significant variations among the different varieties were identified through the variance analysis, indicating that the genotypes employed in the experiment displayed ample diversity across various traits. This diversity qualifies them for future genetic exploration. The relative distinctions in variability among different characteristics are outlined in (Table 1). Detailed findings regarding average values, range, phenotypic and genotypic coefficients of variation (PCV and GCV), broad-sense heritability (h^2) and expected genetic advancement as a percentage of the mean (GAM) for all sixteen traits are presented in (Table 2).

Genotypic and Phenotypic coefficient of variation

Assessment of variability revealed that there is lots of variability among genotypes and observed that phenotypic coefficient of variance was in general higher than the genotypic coefficient of variance for all the characters indicating that under studied are influenced to various degrees by the environmental factors. Similar findings were also in association with Sharma *et al*., 2022 [13]; Saha *et al*., 2019 [11] and Kumar *et al*., 2010 [9]. For the majority of the traits among the 15 genotypes of brinjal, the highest GCV and PCV estimates were obtained *viz*., fruit length (24.34 and 24.99), fruit width (31.81 and 33.58), average fruit weight (27.75 and 28.76), number of fruits per plant (32.79 and 33.65), ascorbic acid content (31.90 and 32.11), number of seeds per fruit (43.60 and 44.52), test weight (25.93 and 27.13), fruit yield per plant (30.47 and 31.55) and fruit yield (q/ha) (30.48 and 31.47). The higher values of PCV and GCV for the aforementioned qualities denote their greatest genetic variability contribution, which suggests that the parents selected based on these features may be used in subsequent crossing programmes to produce high-quality transgressive segregants. The result of present investigation agreed with the findings of Tripathi *et al*., (2009) [14]; Kumar *et al*., (2010) [9]; Vidhya and Kumar (2015) [15]; Banerjee *et al*., (2018) [4]; Bajpai *et al*., (2020) [3]; Sakriya *et al*., (2020) [12]; and Anbarasi and Haripriya (2021) [1]. In the present investigation it was also evident that difference between PCV and GCV were low for all the character studied which indicated that more of genetic control than environment in governing these traits and scope and importance of germplasm used in future selection for crop breeding.

Heritability and Genetic advance

Among the traits investigated, the highest heritability estimates were documented for several attributes including plant height (98.72%), ascorbic acid content (98.68%), chlorophyll content (97.74%), number of seeds per fruit (95.88%), number of fruit per plant (94.98%), fruit length (94.83%), yield per hectare (93.80%), yield per plant (93.28%), East-West plant spread (93.39%), North-South plant spread (92.72%), test weight (91.38%), with findings similarly reported by Tripathi *et al*. (2009) [14], Kumar *et al*. (2010) [9], Koundinya *et al*. (2017) [8], Banerjee *et al*. (2018) [4], Sakriya *et al*. (2020) [12] and Anbarasi and Haripriya (2021) [1]. The substantial heritability values imply that these traits were less influenced by environmental factors. The observed genetic advancement ranged widely across all attributes, spanning from 0.565 to 909.53. The greatest value was observed for number of seeds per fruit (909.53%) followed by yield per hectare (171.85%) and average fruit weight (61.41%). Genetic advance as a percentage of the mean (genetic gain) ranged from 9.63% to 65.83%. Notably, the highest values were noted for number of seed per fruit (87.94%), number of fruit per plant (65.83%), and ascorbic acid content (65.27%). Comparable outcomes were corroborated by Tripathi *et al*. (2009) [14], Kumar *et al*. (2010) [9], Saha *et al*. (2019) [11] and Anbarasi and Haripriya (2021) [1] for attributes such as number of fruit per plant, average fruit weight, yield per plant and fruit width, while the number of seed per fruit was only reported by Anbarasi and Haripriya (2021) [1]. Notably, heritability values for all traits exceeded their genetic advance as a percentage of the mean values, underscoring their relatively minor susceptibility to environmental variations and affirming that the observed phenotypes genuinely represented the genotypes, thus establishing the credibility of phenotypic-based selection**.**

Conclusion

The present investigation of eggplant demonstrated that the subject material exhibits noteworthy exploitable diversity concerning 16 variables related to yield. This implies a substantial opportunity for enhancing genetics through selection and hybridization. The study additionally illuminated that both additive and non-additive genetic factors played a pivotal role in regulating the manifestation of yield and its primary components. In the case of most scrutinized traits, there was a notable presence of high GCV, accompanied by substantial heritability and genetic advancement relative to the mean. This signifies a prevailing influence of additive genetic factors in shaping the expression of these attributes and presents a potential avenue for genetic enhancement through phenotypic selection.

Table 1: ANOVA table for various characters in brinjal genotypes

Sl.No.	Source	Replication	Treatment	Error
	Degrees of freedom	2	14	28
1	Plant Height(cm)	5.6050	417.863**	1.793
2	Plant Spread(E-W)	4.0310	204.879**	4.721
3	Plant Spread(N-S)	3.710	218.445**	5.57
4	No. of Primary Branches	0.6690	5.19**	0.572
5	Fruit Length(cm)	0.1350	20.499**	0.366
6	Fruit Width(cm)	0.3640	6.796**	0.251
7	Average Fruit weight	131.8250	2933.663**	70.507
8	No. of fruits/plant	8.1170	158.987**	2.754
9	Chlorophyll content	1.3830	787.668**	6.025
10	TSS(°Brix)	0.150	0.476**	0.091
11	Ascorbic acid content(mg/100gm)	1.1670	281.242**	1.248
12	No. of Seeds/fruit	1357.6350	618695.945**	8739.522
13	Test Weight(gm)	0.0110	4.591**	0.14
14	Fruit Yield/plant(Kg)	0.0010	1.247**	0.029
15	Fruit Yield (q/ha)	34.1870	22749.105**	490.534
16	pH	0.0470	0.412**	0.031

** Significant at 1 percent level significance

Table 2: Estimation of range, mean, GCV, PCV, genetic advance and genetic gain for 15 different genotypes for brinjal

Characters	Range	Mean	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance	Genetic gain (%)
Plant height (cm)	58.72-96.36	82.87	14.21	14.30	98.72	24.11	29.09
Plant spread (East-West) (cm)	61.85-89.47	73.76	11.07	11.46	93.39	16.26	22.05
Plant spread (North-South) (cm)	50.63-83.23	68.28	12.34	12.81	92.72	16.71	24.47
No. of primary branches per plant	4.60-10.03	10.64	15.22	17.82	72.93	2.18	26.77
Fruit length (cm)	5.94-14.20	10.64	24.34	24.99	94.83	5.20	48.83
Fruit width (cm)	2.39-8.08	4.64	31.81	33.58	89.70	2.88	62.06
Average fruit weight (g)	61.39-166.17	111.32	27.75	28.76	93.12	61.41	55.17
No. of fruits per plant	11.53-38.77	22.01	32.79	33.65	94.98	14.49	65.83
Chlorophyll content	45.17-99.19	82.02	19.68	19.91	97.74	32.87	40.08
Total soluble solids (°Brix)	4.40-6.03	5.09	7.04	9.20	58.61	0.57	11.11
Ascorbic acid content (mg/100gm)	11.37-46.91	34.92	31.90	32.11	98.68	19.77	65.27
No. of seeds/fruit	348.21-1833.20	1034.29	43.60	44.52	95.88	909.53	87.94
Test weight (g)	3.17-6.47	4.70	25.93	27.13	91.38	2.40	51.07
Fruit yield per plant (kg)	1.14-3.22	2.09	30.47	31.55	93.28	1.27	60.62
Fruit yield (q/ha)	153.84-434.89	282.62	30.48	31.47	93.80	171.85	60.81
pH	6.50-7.62	6.85	5.21	5.80	80.62	0.66	9.63

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