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Studies on heterosis, combining ability and gene advance for the quantitative characters in brinjal or egg plant (*Solanum melongena* L.)

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Abstract
The analysis of variance for the design of experiment indicated highly significant differences among the genotypes for all the traits. Based on mean performance of genotypes NDB-5 followed by NDB-5 followed by NDB-15, NDB-6, NDB-4, NDB-7 and NDB-16 were found as most promising genotypes for fruit yield per plant. Days to 50% flowering and plant height exhibited low value of variability. High heritability was estimated for all the traits except yield per plant followed by early yield per plant, fruit weight and yield per plant indicating opportunity for selection response. Yield per plant had exhibited highly significant and positive association with fruits per plant and early yield while primary branches showed negative and significant association with yield per plant. Fruits per plant, fruit weight and plant height were identified as most important traits which has direct effect on yield per plant while negative direct effect on yield showed by fruit circumference followed by plant height and days to 50% flowering on yield.

Keywords: Egg plant, variability, heritability, genotypes, significant

Introduction
Brinjal or egg plant (Solanum melongena L.) is one of the most important solanaceous vegetable crop having diploid chromosome number 2n=2x=24. It is grown in the tropics and subtropics of India and other parts of the world. It is called Brinjal in India and Aubergine in Europe. It is extensively grown in India, Japan, Indonesia, China, Bulgaria, Italy, France, USA, Pakistan, Bangladesh, Philippines and several African countries. Due to high productivity and wife adoptability, usually finds its place as the poor man's crop.

Brinjal being most important to growers and consumer, there is pressing need to increase its productivity to fulfill the increasing demands throughout the year. The information usually needed for developing high yield varieties in a particular species pertains to the extent of genetic variability for desirable train in the available germplasm. Evaluation of germplasm is the basic tool for identification of important genotypes. The great extent of natural variation present in various characters among the genotypes suggests good scope of improvement in economic. Large variability ensures better chance of prosucing new forms. Heritability and genetic advance, besides degree of association between the various characters and direct effect of yield contributing characters on total yield, is of paramount significance in formulating an appropriate breeding strategy aimed at exploiting the inherent variability of the original population.

Materials and Methods
The present investigation entitled "Variability, character association and genetic divergence in egg plant (*Solanum melongena*L.)" was executed at Main Experiment, Station of Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad, during *Kharif* 2010, to assess variability, heritability and genetic advance for quantitative characters The experimental field had sandy loam soil, low in organic carbon, nitrogen, medium in phosphorus, potash, and slightly alkaline in nature with pH 8.5.The mechanical composition of soil was 60.9 per cent, 27.8 per cent silt and 11.3 per cent clay. Experimental material for the study consisted of 30 genotypes including six checks (Arka Nidhi, NDB-2, SM 6-6, Pant Rituraj, KS-224 and S. Mani). The experiment was conducted in Randomized Complete Block Design with three replications. Each treatment consisted 20 plant in two row, having spacing of 60 × 45 cm with net plot size of 4.5 × 1.2 m^2. Observations were recorded on 9 quantitative characters *viz.*, days to 50% flowering,

primary branches per plant, plant height (cm), Fruit weight (g), fruit circumference (cm), polar length of fruit (cm), fruits per plant, early yield per plant (g) and yield per plant.

Heterosis expressed as per cent increase or decrease in the mean values of F1's (hybrid) over better-parent (heterobeltiosis) and standard variety as Pusa Naveen (standard heterosis) was calculated according to method suggested by Hayes *et al.* (1955).

The combining ability analysis for different characters was carried out following the method 2 model 1 of Griffing (1956 b), where parents and F1's were included but not the reciprocals. Thus the experimental material for this method comprises of n (n+1)/2 genotypes.

The genetic components of variation were calculated for the analysis of numerical approach followed the method given by Jinks and Hayman (1953), Hayman (1954a) and Askel and Johnson (1963).

Results and Discussion

Genetic variability is the back bone of any crop improvement programme and effectiveness of selection depends upon its nature and magnitude in the genetic material at the disposal of plant breeder. In other words genetic variability is the fundamental to selection and to a great extent to the breeding methodology as such. The speed of improvement in any crop depends upon the magnitude and kinds of genetic variability present in the population. The genetic variation is heritable one and hence important in the selection.

A great deal of genetic variability is available in the germplasm of brinjal in centers of its diversity. A number of reports on exploitation of variability in major crops of world are available even in pre-mendelian period and this caused improvement in yield. Among the under worked vegetable crops, the brinjal which is grown on a large acreage, it has become necessary to gather basic information on genetic and other statistical parameters which help in selection and genetic manipulations for improvement in the yield of the crop. Whit this objective, 30 genotypes collected from different places were maintained and evaluated for nine characters. The genetic and statistical parameters were estimated for genotypic and phenotypic coefficient of variation, heritability on board sense, genetic advance, correlation coefficient, path analysis and genetic divergence of these traits with yield per plant. The results of present investigation have been discussed in the following heads in reference to reported work relevant to this investigation or brinjal.

Mean performance

In order to evaluate the listed genotypes the mean of thirty genotypes including check for nine characters has been presented in table 4.2. A very wide range of variation in mean performance of genotypes was observed for all the character under study. The comparison of performance of 30 genotypes for nine traits using critical differences revealed existence of very high level of variability in the used genotypes. The genotype NDB-5 (1.40kg) significantly out yielded in respect of all genotype as well as check in case of long purple and long green groups and also showed high mean performance for fruits per plant. The other high yielder's genotypes were NDB-4 (1.20kg), NDB-7(1.15kg), NDB-16(1.09kg), NDB-14(0.95kg) and NDB-12(0.87kg). these genotypes also showed high mean performance for some other characters. None of the genotypes produced higher yield per plant than the best check Pant Rituraj (1.09kg) in case of round purple and round green groups Only three genotypes NDB-15 (1.35kg), NDB-6 (1.24kg) and NDB-11(1.04kg) produced satisfactory yield per plant.

Heritability and genetic advance

Heritability in broad sense of a character is important to the breeder since it indicate the possibility and extent to which improvement is possible through selection. It also indicates direction of selection pressure to be applied for a trait during selection because it measures relationship between parents and their progeny, hence widely used in determining the degree to which a character may be transmitted from parents to offspring. However, high heritability alone is not enough to make efficient selection in advanced generation unless accompanied by substantial amount of genetic advance (Burton, 1952) [4] High estimates of heritability along with high genetic advance provides good scope for further improvement in advance generations.

That result on heritability and genetic advance in per cent of mean of present investigation had been presented in table 4.3. The heritability estimates for different character ranged from 61.50 to 98.40 per cent. High heritability was recorded for all the character except yield per plant. High heritability coupled with high genetic advance in per cent mean were recorded for fruits per plant, early yield per plant, fruit weight, fruit circumference, primary branches per plant, plant height and polar length of fruit, indicating that these traits were uninfluenced by environment. Thus require low selection intersity for improvvemrnt. Similar result was also reported by Dubi *et al*. (1983); Nagi *et al.* (2000); naik *et al.* (2009) [20] and Muniappan *et al.* (2010) [19]. The days to 50% flowing exhibited high heretabbility along with low genetic advance as per cent of mean whereas yield per plant showed moderate heritability and high genetic advance indicating that they were largely influenced by environment and thus required high selection selectioninprovingkthese traits.

Vadivel and Bapu (1990) reported high heritability for fruits per plant, yield per plant, polar length of fruit and fruit weight, Bora and Shadeque (1993) for fruit circumference, fruit weight weight, fruit per plant and yield per plant Behera *et al.* (1999) for fruit circumference polar length of fruit and yield per plant.

Sharma *et al.* (2000) [28] for polar length of fruit, fruits per plant, fruit weight and yield per plant. Nagi *et al.* (2000) found high genetic advance coupled with high heritability for fruits per plant, fruit weight and yield per plants.

Table 1: Analysis of variance (mean squares) for ten quantitative characters in brinjal germplasm

S. No	Characters	Source of variation		
		Replication	Treatments	Error
	d.f.	2	29	58
1.	Days to 50% flowering	1.90	101.06*	8.79
2.	Days to first fruit harvest	00.1	5.40**	0.10
3.	Plant height (cm)	4.72	450.60**	9.60
4.	Fruit weight (cm)	62.87	18333.87**	159.14

5.	Fruit circumference (cm)	0.17	103.40**	2.34
6.	Polar length of fruit (cm)	0.07	17.35**	0.39
7.	Fruits per plant	0.64	35.06**	0.18
8.	Early yield per plant (kg)	0.001	0.11**	0.006
9.	Yield per plant (kg)	0.002	0.30**	0.05

Significant at 5 % and 1% probability level, respectively

Table 2: Mean performance of thirty two genotypes for ten characters in brinjal

Group	S. No	Characters/ Genotypes	Days to 50% flowering	No. of primary branches per plant	Plant height (cm)	Fruit weight (cm)	Fruit circumference (cm)	Polar length of fruit (cm)	Fruits per plant	Early yield per plant (kg))	Yield per plant (kg)
Long purple	1.	NDB-12	61.00	4.10	81.80	192.00	22.03	15.43	3.45	0.130	0.870
	2.	NDB-13	51.00	3.20	89.90	115.33	12.53	22.73	4.33	0.330	0.520
	3.	NDB-14	53.00	4.20	68.13	138.66	15.36	17.26	8.81	0.480	0.950
	4.	NDB-16	51.00	3.10	99.10	193.33	20.00	21.43	4.57	1.460	1.090
	5.	NDB-24	62.66	2.80	82.60	11.00	15.73	15.86	3.75	0.270	0.410
	6.	NDB-26	53.66	5.00	67.13	191.33	19.03	16.73	3.37	0.520	0.640
	7.	NDB-27	50.33	6.00	64.50	192.66	20.20	18.36	2.40	0.190	0.460
	8.	NDB-28	54.33	3.90	73.86	327.66	27.60	16.73	25.30	0.560	0.750
	9.	NDB-29	52.66	6.50	64.23	134.66	13.33	21.66	4.51	0.210	0.6500
	10.	Arka Nidhi (c)	53.33	4.10	57.66	71.00	13.00	20.50	5.53	0.180	0.270
	11.	NDB-2(c)	51.00	6.50	70.40	96.00	13.10	18.40	4.70	0.130	0.450
Long green	12.	NDB-4	58.66	4.13	68.30	202.66	20.33	16.26	6.25	0.190	1.200
	13.	NDB-5	52.33	4.610	57.50	102.66	12.86	17.60	16.60	0.550	1.400
	14.	NDB-7	49.66	4.80	65.40	140.66	13.00	17.93	7.65	0.250	1.50
	15.	NDB-8	53.66	4.70	68.63	164.00	16.40	13.43	4.64	0.220	0.560
	16.	SM-6-6(c)	42.66	6.13	50.33	58.66	13.90	18.06	10.22	0.330	0.530
Round purple	17.	NDB-6	49.66	4.46	70.9*3	176.66	20.73	13.86	7.20	0.500	1.240
	18.	NDB-17	54.3	5.00	78.6+6	160.66	16.03	15.10	4.089	0.270	0.730
	19.	NDB-20	61.63	3.00	79.90	377.33	27.86	15.73	2.30	0.270	0.740
	20.	NDB-21	63.00	6.00	60.07	194.00	23.83	16.80	2.59	0.400	0.500
	21.	NDB-22	53.00	6.30	62.46	205.33	24.53	14.73	1.93	0.270	0.390
	22.	Pant Rituraj (c)	45.00	6.40	76.80	334.66	29.93	17.03	3.33	1.010	1.090
	23.	KS-224	51.00	2.66	90.53	303.33	31.56	15.76	2.15	0.350	0.650
	24.	S Mani-8(c)	62.33	6.36	78.86	204.00	26.46	13.00	2.16	0.410	0.450
Round green	25.	NDB-9	66.66	5.00	62.53	191.33	19.00	17.60	2.18	0.260	0.500
	26.	NDB-10	43.00	3.30	83.46	133.33	21.26	13.70	4.37	0.440	0.480
	27.	NDB-11	54.00	3.80	74.00	202.66	22.80	15.40	5.93	0.580	1.040
	28.	NDB-15	53.00	4.00	77.53	110.00	11.93	18.13	12.90	0.850	1.350
	29.	NDB-19	60.33	6.00	66.33	260.66	27.36	17.60	1.89	0.370	0.520
	30.	NDB-23	53.66	7.20	53.40	226.00	25.73	14.80	3.13	0.120	0.600
GM			54.03	4.79	72.12	182.54	19.91	16.92	4.97	0.380	0.470
SEm±			1.71	0.319	1.78	7.28	0.88	0.36	0.25	0.046	0.130
CD at 5%			4.84	0.54	5.06	20.61	2.50	1.02	0.70	0.130	0.370
Range (lowest)			42.66	2.66	50.43	58.66	11.93	13.00	1.89	0.130	0.279
Range Highest			66.66	7.20	99.10	377.33	31.56	22.73	16.60	1.010	1.400

Table 3: Range, grand mean, phenotypic (PCV), genotypic (GCV), environmental (ECV) coefficient of variation, heritability in broad sense, genetic advance in per cent of mean (Ga) for ten characters in brinjalgarmplasm

S. No.	Characters	Range		Grand measn	PCV (%)	GCV (%)	Heritability broad sense (%) (h^2_{bs})	Genetic advance in per cent of mean (Ga)
		Lowest	Highest					
1.	Days to 50% flowering	42.66	66.66	54.03	11.63	10.26	77.80	18.64
2.	Days to first fruit harvest	2.+66	7.20	4.79	28.57	27.72	94.10	55.41
3.	Plant height (cm)	50.43	99.10	72.12	11.35	16.81	93.90	33.55
4.	Fruit weight (cm)	58.66	377.33	182.54	43.19	42.63	97.40	86.70
5.	Fruit circumference (cm)	11.99	21.56	19.91	30.14	29.14	93.50	58.04
6.	Polar length of fruit (cm)	13.00	22.73	16.92	14.53	14.05	93.40	27.98
7.	Fruits per plant	1.89	16.60	4.97	69.05	68.49	98.40	139.97
8.	Early yield per plant (kg)	0.13	1.01	0.38	54.75	50.54	85.20	96.10
9.	Yield per plant (kg)	0.27	1.40	0.74	49.59	38.88	61.50	62.79

Conclusion

Large amount of variability existed in the population for the selection. Genotype superior for yield per plant, some of them were superior for fruits per plant and other are superior for fruit weight. These have appears plenty of scope for the selection of yield per plant, fruits per plant and fruit weight.Among the character under study, fruits per plant, plant height, primary branches per plant, fruit circumference, fruit weight, polar length and early yield per plant had high heritability coupled with high genetic advance which is important for further breeding programme.

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