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Study of combining ability for yield contributing traits in brinjal (*Solanum melongena* L.)

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Abstract
The combining ability analysis of 8×8 half diallel set of crosses in brinjal was undertaken for fruit yield and its attributing characters. Eight parents, twenty eight hybrids and two standard checks were evaluated during late *kharif/rabi* 2018-19 for the present study in randomized block design for two replications. The analysis of variance revealed presence of considerable variability among genotypes for all the characters under study. Combining ability analysis revealed important of both additive and non additive variances in expression of various traits. Among the parental genotypes, parent SBJH-631 and Sep-034 were good general combiners for fruit length, fruit cluster per plant, number of fruits per plant, fruit yield, number of leaves per plant, shoot borer infestation and fruit borer infestation. Followed by Utkal Keshari and IBH-2 for days to 50% flowering, fruit weight, fruit diameter, fruit cluster per plant, number of fruits per cluster and fruit borer infestation. In respect to estimates of specific combining ability effects, cross IBH-2 x SBJH-631 was good for number of branches per plant, number of fruits per plant, number of fruits per cluster and fruit yield and SBJH-631 x Sep-034 was shown best specific combining ability for number of leaves per plant, number of flowers per plant, number of fruits per plant, total yield and fruit borer infestation characters. The additive gene components were observed to be predominant for all characters except number of branches per plant, number of leaves per plant and shoot borer infestation.

Keywords: Combining ability, Genetic evolution and Brinjal

Introduction
Brinjal or eggplant is widely cultivated as one of the most important vegetable in both sub-tropical and tropical area of India as well as abroad. It is autogamous diploid with chromosome number 2n=24 and belong to family solanaceae. India is considered as the primary centre of origin of brinjal (Vavilov, 1928) [15]. It is most consumed crop in India.

It is important vegetable crop cultivated throughout the warmer region of the world and has its centre of origin as India Thomposon *et al.* (1957) [14]. It is one of the major vegetable crops grown in Maharashtra after onion occupying an area of 26000 ha and have production of 548000 MT (Hort.Glance 2017) [17]. In Maharashtra, the crop is grown during all season viz., *Kharif*, *Rabi* and Summer, usually under irrigated condition except at higher altitudes.

The productivity of brinjal crop is low in some areas. The reasons for low yield are, growing of low yielding cultivars and the problems of diseases like phomopsis blight, little leaf, leaf spot and bacterial wilt and insect pests like fruit and shoot borer, jassids and epilachna beetles. Therefore, identification of good combiner and specific cross combinations and exploitation of heterosis is in need.

Combining ability analysis is main tool for choice of parents as well as understanding of the nature of gene action. So, information on important of general and specific combining ability is of immense use in development of efficient breeding programme. Therefore, the present study of specific combining ability aid in selection of superior hybrids and general combining ability can help in selection of superior lines and to evaluate nature of gene action for fruit yield and its component characters.

Materials and Methods
The present investigation entitled "Combining Ability Studies in Brinjal (*Solanum melongena* L.)" was conducted at Experimental farm of Department of Agricultural Botany, College of Agriculture, and V.N.M.K.V. Parbhani during kharif 2018.

Twenty eight crosses were made during late *Kharif.* /rabi2017-18 using genetically diverse parents. Thus, eight parents, two check and 28 hybrids were evaluated during late *kharif /rabi* 2018-19 for the present study.

A set of 38 genotypes comprising of 8 parents and their 28 F_1S and standard checks Manjarigota and Panchaganga were sown in Randomized Block Design with two replications. Fertilizers were applied at the rate of 100 kg N/ha, 50 kg P_2O_5/ha and 50 kg K_2O/ha. P_2O_5 and K_2O were applied as basal dose with 50 kg of nitrogen before one week of transplanting, while, remaining 50 kg of nitrogen was top dressed at the time of flowering.

Result and Discussion

The analysis of variance for combining ability presented in Table 1 revealed that mean squares due to general combining ability and specific combining ability were highly significant for all the characters.

The estimates of general combining ability (GCA) effects of eight parents and specific combining ability (SCA) effects of twenty eight hybrids are presented in Table 2 and 3, respectively, which are discussed below.

a. **Plant height:** In brinjal less height of plant is considered to be desirable because it leads to more number of branches and ultimately result in increased productivity. Among all the parents, significant negative GCA effects were exhibited by BH-2, Kavya and IBH-3 indicated their good general combining ability. On the other hand, eight hybrid combinations were identified as good specific cross combinations. The crosses, IBH-2 x BH-2, IBH-2 x Kavya, IBH-3 x SBJH-631, Utkal Keshari x Kavya and IBH-3 x BH-2. were the top five combinations which involved the parents with poor x good, poor x good, good x poor, poor x good and good x good GCA effects, respectively. Similar findings were also reported by Aswani and Khandelwal (2005), Bisht *et al*. (2009) and Pachiyappan *et al*. (2012) [1, 3, 9].

b. **Days to 50 percent flowering:** In the present studies, the parents, IBH-3 and Utkal Keshari were found good general combiners as they exhibited the significant negative GCA effects. Out of the total twentyeight cross combinations, six crosses viz., Utjal Keshari x IBH-3, IBH-2 x Kavya, SBJH631 x Kavya, Sep-034 x Kavya, IBH-3 x Sep-034 and SBJH-631 x Sep-034 exhibited significant negative SCA effects indicated their good specific combining ability. These crosses involved the parents with good x good, average x poor, average x poor, poor x poor, good x poor and average x poor GCA effects respectively. Similar reports were put forth by Kumar *et al*. (2012) and Patel *et al*. (2013) [2, 10].

c. **Fruit length (cm):** Fruit length has direct contribution to yield (Singh *et al*., 2003). The estimates of GCA effects revealed that three parents viz., Sep-034, SBJH-631 and A.Nerkanth were found good general combiners as they exhibited the significant positive GCA effects. Out of twenty eight hybrid combinations, ten were found good specific cross combinations due to their significant positive SCA effects. IBH-3 x Kavya, IBH-2 x Utkal Keshari, SBJH-631 x A. Nerkanth, Sep-034xA.Nerkanth and Utkal Keshari x SBJH-631 were the top five best combinations and involved the parents with poor x poor, poor x poor, good x good, good x good and poor x good. GCA effects, respectively. These results find support from Bisht *et al*. (2009) and Pachiyappan *et al*. (2012) [3, 9].

d. **Fruit diameter (cm):** In brinjal Fruit diameter is an important yield contributing trait. The estimates of GCA effects revealed that five parents viz., BH-2, IBH-2, IBH-3, Utkal Keshari and Kavya were found good general combiners as they exhibited the significant positive GCA effects. Out of twenty eight hybrid combinations, thriteen were found good specific cross combinations due to their significant positive SCA effects. The crosses, IBH-3 x A.Nerkanth, Utkal Keshari x Sep-034, IBH-3 x BH-2, Utkal Keshari x A.Nerkanth and Sep-034 x Kavya were the top five combinations which involved the parents with good x poor, good x poor, good x good, good x poor and poor x good GCA effects, respectively. These results also find support from Pachiyapan *et al.* (2012) [9], Singh *et al.* (2012) [8] and Patel *et al*. (2013) [10].

e. **Fruit weight (gm):** Average fruit weight has direct contribution to yield. The estimates of GCA effects revealed that four parents viz., BH-2, Utkal Keshari, IBH-2 and Kavya were found good general combiners as these exhibited the significant positive GCA effects. Out of twenty eight hybrid combinations, fifteen were found good specific cross combinations due to their significant positive SCA effects. The crosses, Utkal Keshari x Kavya, Sep-034 x Kavya, IBH-2 x Sep-034, Kavya x BH-2 and SBJH-631 x BH-2. Were the top five combinations and involved the parents with good x poor, poor x good, good x poor, good x good and poor x good gca effect respectively. Earlier reports by Shafeeq *et al.* (2007) [11] and Patel *et al*. (2013) [10] support these findings.

f. **Fruit clusters per plant:** The estimates of GCA effects revealed that three parents viz., SBJH-631, A. Nerkanth and IBH-2 were found good general combiners as they exhibited the significant positive GCA effects. Out of twenty eight hybrid combinations, eleven were found good specific cross combinations due to their significant positive SCA effects. The crosses, IBH-2 x IBH-3, Utkal Keshari x BH-2, IBH-2 x BH-2, Utkal Keshari x IBH-3 and Kavya x BH-2 were the top five combinations which involved the parents with good x poor, average x poor, good x poor, average x poor and average x poor GCA effects, respectively. These results find support from Aswani *et al.* (2005) and L. Sekhar *et al.* (2010) [1, 12].

g. **Number of fruits per plant:** Number of Fruits per plant has direct contribution to yield. The estimates of GCA effects revealed that two parents viz., SBJH-631 and Sep-034 were found good general combiners as they exhibited the significant positive GCA effects. Out of twenty eight hybrids seventeen cross combinations, were found good specific cross combinations due to their significant positive SCA effects. The crosses, Utkal Keshari x SBJH-631, Utkal Keshari x IBH-3, SBJH-631xSep-034, IBH-2 x SBJH-631 and Kavya x BH-2 were the top four best combinations and involved the parents with poor x good, poor x poor, good x good, poor x good and poor x poor GCA effects respectively. These results also find support from Bhushan *et al.* (2012) [2].

h. **Fruit yield (kg):** In the present studies, the parents, SBJH-631 and Sep-034 were found good general combiners as they exhibited the significant positive GCA effects. Out of the total twenty eight cross combinations, ten were found good specific cross combinations due to their significant positive SCA effects. From which five crosses viz., IBH-2 x SBJH-631, SBJH-631 x Sep-034, IBH2 x IBH-3, Sep-034 x Kavya and Utkal Keshari x

IBH-3 exhibited significant positive SCA effects indicated their good specific combining ability. These crosses involved the parents with poor x good, poor x poor, good x good, poor x good and poor x poor. GCA effects respectively. these results also find supports from Bhushan *et al.* (2012) [2], Shafeeq *et al.* (2013) [11], Venkatnaresh *et al.* (2015) [16] and Dhaka *et al*. (2017) [6].

Table 1: Analysis of variance for combining ability in Brinjal

Sr. No.	Characters	Mean Squares			
		GCA	SCA	Error	GCA / SCA
1.	Plant height (cm)	138.987**	31.561**	10.794	4.403
2.	Number of branches per plant	0.2857**	0.3685**	0.0735	0.775
3.	Days to 50% flowering	38.703**	19.471**	4.263	1.988
4.	Fruit length (cm)	14.361**	1.418**	0.177	10.127
5.	Fruit Weight (gm)	585.66**	306.201**	6.049	1.912
6.	Fruit Diameter (cm)	28.014**	3.675**	0.228	7.622
7.	Fruit cluster per plant	1.517**	0.249*	0.134	6.092
8.	Number of fruits per plant	134.446**	13.463**	1.293	9.986
9.	Fruit yield per plant (kg)	1.203**	0.416**	0.041	2.891
10.	Number of leaves per plant	175.808**	265.910**	22.141	0.661
11.	Number of fruits per cluster	0.142**	0.065**	0.015	2.184
12.	Number of flowers per plant	115.215**	55.262**	4.982	2.084
13.	Shoot borer infestation (%)	11.471**	14.051**	0.426	0.812
14.	Fruit borer infestation (%)	16.027**	15.338**	0.173	1.004

Significant at 5% and 1% level

Table 2: Estimation of general combining ability (gca) effects of parents for various characters in Brinjal

Parents	Plant height (cm)	No. of branches per plant	Days to 50 % flowering	Fruit length (cm)	Fruit weight/ plant(gm)	Fruit diameter (cm)	Fruit cluster per plant	No. of fruits /plant	Fruit yield/ plant(kg)	No. of leaves/ plant	No. of Fruits per cluster	No. of flowers per plant	Shoot borer infestation	Fruit borer infestation
IBH-2	3.822**	0.298**	0.502	-0.706**	2.802**	1.678**	0.311**	-1.002**	-0.280**	-2.874*	-0.071	-1.148	0.635**	-0.021
Utkal Keshari	2.147*	-0.243**	-1.831**	-0.365**	2.889**	0.559**	-0.039	-2.097**	-0.215**	1.626	0.235**	-0.051	-0.509*	-0.934**
IBH-3	-2.673**	0.036	-3.516**	-0.745**	1.220	0.578**	-0.474**	-3.122**	-0.339**	0.601	-0.053	0.470	0.514*	1.863**
SBJH-631	5.539**	0.094	0.922	1.665**	-7.273**	-3.068**	0.521**	7.308**	0.727**	3.598*	-0.100**	8.008**	-1.147**	-1.160**
Sep-034	-0.630	0.095	2.205**	1.912**	-8.779**	-1.618**	0.046	3.488**	0.220**	4.101**	0.065	-1.560*	-1.727**	-1.268**
Kavya	-3.570**	-0.049	2.017**	-0.890**	1.787*	0.480**	-0.164	-1.122**	-0.131*	-8.327**	0.074*	-1.950**	0.628**	1.208**
A.Nerkanth	0.543	-0.070	0.658	0.360**	-7.096**	-0.512**	0.356**	0.027	0.077	3.076*	-0.128**	-0.980	0.054	1.254**
BH-2	-5.178**	-0.160	-0.955	-1.232**	14.449**	1.903**	-0.559**	-3.483**	-0.058	-1.799	-0.021	-2.789**	1.552**	-0.943**
S.E. (gi) ±	0.971	0.080	0.610	0.124	0.727	0.141	0.108	0.336	0.060	1.391	0.036	0.660	0.193	0.123
S.E. Gi-Gj	1.469	0.121	0.923	0.188	0.188	0.213	0.163	0.508	0.090	2.104	0.054	0.998	0.291	0.186

Table 3: Estimation of specific combining ability (SCA) effects of hybrids for various characters in Brinjal

Sr. No.	Crosses	Plant height (cm)	No. of branches per plant	Days to 50% flowering	Fruit length (cm)	Fruit weight (gm)	Fruit diameter (cm)	Fruit cluster per plant
1.	IBH-2 x Utkal Keshari	-1.344*	0.644**	8.804**	1.307**	-7.860**	-1455**	-0.282
2.	IBH-2 x IBH-3	1.876**	-0.109	0.389**	-0.517**	2.734	-1.830**	0.753**
3.	IBH-2 x SBJH-631	3.913**	0.408	-1.449	-0.092**	-4.353**	-2.328**	0.058**
4.	IBH-2 x Sep-034	-6.318	-0.294	0.268**	-2.980**	21.348**	0.822**	-0.467
5.	IBH-2 x Kavya	-4.627**	-0.554	-5.194**	-1.308**	-5.383*	0.424**	0.343
6.	IBH-2 x A. Nerkanth	1.459	-0.419	-8.435	0.842**	10.750**	1.015**	-0.477**
7.	IBH-2 x BH-2	-9.320**	0.067	-4.522	-0.031**	-21.340**	-3.100**	0.538**
8.	Utkal Keshari x IBH-3	-1.849**	0.657	-5.528**	-0.018**	10.548	-0.355**	0.453**
9.	Utkal Keshari x SBJH-631	-2.412**	0.539	-6.716	1.042**	1.215**	-1.109**	0.208**
10.	Utkal Keshari x Sep-034	-3.543	-0.158	3.501**	-0.351**	13.677**	3.141**	-1.117
11.	Utkal Keshari x Kavya	-3.952**	0.513	6.059**	0.444**	25.180*	-0.057**	0.093
12.	Utkal Keshari x A.Nerkanth	-6.116	-0.403	-1.052	-0.899**	7.563**	1.785**	-0.327**

13.	Utkal Keshari x BH-2	8.655**	-0.937	2.361	-0.272**	8.519**	-0.880**	0.638**
14.	IBH-3 x SBJH-631	-4.442**	0.275	-1.131	-1.143**	-7.081**	0.672**	-0.957**
15.	IBH-3 x Sep-034	-1.073	0.364	-0.664**	0.145**	14.816**	-2.378**	-0.282
16.	IBH-3 x Kavya	4.468**	0.168	2.424**	1.707**	13.594*	0.524	-0.572
17.	IBH-3 x A.Nerkanth	6.554	-0.211	4.133	-0.918**	-20.648**	3.915**	-0.092**
18.	IBH-3 x BH-2	-2.775**	-0.641	-2.304	-0.631**	14.063**	2.800**	0.023**
19.	SBJH-631 x Sep-034	-0.110	0.126	-0.552**	0.780**	-5.237**	-0.032**	0.723
20.	SBJH-631 x Kavya	4.955**	-0.385	-3.964**	-0.158**	3.197*	-1.150**	0.083
21.	SBJH-631 x A.Nerkanth	-9.008	-0.124	-1.205	1.137**	-0.005**	-0.738**	0.113**
22.	SBJH-631 x BH-2	-2.287	0.796	3.358	-0.731**	16.280**	0.647**	-0.322**
23.	Sep-034 x Kavya	0.274**	0.424	-3.867**	-1.296**	25.023*	1.300**	-0.092
24.	Sep-034 x A.Nerkanth	4.501	1.144	-1.638	1.134**	-20.669**	-2.588**	0.138**
25.	Sep-034 x BH-2	3.562**	0.775	2.025	-0.439**	-6.508**	1.297**	-0.297**
26.	Kavya xA.Nerkanth	-4.799	-0.651	5.250	-1.384**	-17.890**	0.386**	0.098**
27	Kavya x BH-2	11.952**	0.564	-0.487	0.468**	19.635**	1.229**	0.413**
28.	A.Nerkanth x BH-2	1.474**	0.335	4.872	-1.357**	4.383**	-1.215**	-0.407**
	S.E. (sij) +	2.979	0.245	1.872	0.382	2.230	0.433	0.332
	S.E.(sij-sik)	4.407	0.363	2.770	0.566	3.299	06.41	0.491
	S.E.(sij-skl)	4.155	0.343	2.611	0.533	3.111	0.604	0.463

Significant at 5 % level, ** Significant at 1 % level

Table 3: Contd.....

Sr. No.	Crosses	No. of fruits per plant	Fruit yield per plant	No. of leaves per plant	No. of fruits per cluster	No. of flowers per plant	Shoot borer infestation	Fruit borer infestation
1.	IBH-2 x Utkal Keshari	-0.631**	-0.188**	8.166	-0.076**	-3.226	-1.264*	0.483**
2.	IBH-2 x IBH-3	2.544**	0.621**	-13.809	-0.183	4.423	-1.041*	2.601**
3.	IBH-2 x SBJH-631	3.264**	0.710**	-8.06*	0.054**	2.590**	-3.266**	-4.046**
4.	IBH-2 x Sep-034	1.684**	-1.028**	8.691**	0.330	-10.967*	0.404**	0.272**
5.	IBH-2 x Kavya	-1.806**	-0.443**	2.619**	-0.475*	-3.477**	-3.006**	2.301**
6.	IBH-2 x A. Nerkanth	0.745	0.345	3.076*	0.168**	0.753	1.869	5.635**
7.	IBH-2 x BH-2	2.555**	0.559	-2.909	0.281	3.562**	-0.890**	-0.677**
8.	Utkal Keshari x IBH-3	3.789**	0.426**	15.191	-0.274	-2.095	2.277*	-1.945**
9.	Utkal Keshari x SBJH-631	4.559**	0.275**	0.694*	0.308**	-5.983**	-1.532**	-1.897**
10.	Utkal Keshari x Sep-034	1.479**	-0.233**	-25.808**	0.013	-4.864*	-0.732**	-1.130**
11.	Utkal Keshari x Kavya	2.439**	0.492*	-7.881**	-0.036*	-0.525**	-2.393**	-2.605**
12.	Utkal Keshari x A.Nerkanth	0.640	-0.200	-5.784*	-0.164**	4.156	-0.793	-1.377**
13.	Utkal Keshari x BH-2	-0.400**	0.724	-21.909	0.204	8.715**	-3.711**	-0.794**
14.	IBH-3 x SBJH-631	1.634**	0.199**	-22.031*	0.326**	1.056**	6.676**	4.348**
15.	IBH-3 x Sep-034	1.504**	0.551**	5.216**	0.061	1.515*	2.021**	-1.297**
16.	IBH-3 x Kavya	1.214**	0.096*	-9.356**	-0.243*	-12.746**	-4.195**	-1.769**
17.	IBH-3 x A.Nerkanth	-1.035	-0.381	12.241*	-0.051**	-6.215	-3.270	-2.605**
18.	IBH-3 x BH-2	1.225**	0.688	25.116	0.017	-9.306**	-3.538**	-4.106**
19.	SBJH-631 x Sep-034	3.474**	0.625**	2.219**	-0.142	6.152**	6.676**	-6.339**
20.	SBJH-631 x Kavya	-0.216**	-0.275*	0.117**	0.199**	3.416**	2.021**	-0.064**
21.	SBJH-631 x A.Nerkanth	4.435	0.558	30.244*	0.066**	2.697	-4.195**	-7.386**
22.	SBJH-631 x BH-2	-2.655**	-0.108	-27.881	-0.166	2.856**	-3.270	4.612**
23.	Sep-034 x Kavya	0.504**	0.497*	-15.856**	-0.406*	18.685**	-3.338**	-2.273**
24.	Sep-034 x A.Nerkanth	1.005	0.175	-3.259*	-0.003**	2.995	-6.134**	-3.663**
25.	Sep-034 x BH-2	1.765**	0.269	-10.634	-0.220	6.834**	2.311**	-0.855**
26.	Kavya xA.Nerkanth	2.715	0.575	2.669*	-0.073**	6.945	-6.024	0.536**
27.	Kavya x BH-2	2.725**	0.500	4.544	0.025	1.394**	6.887**	-4.096**
28.	A.Nerkanth x BH-2	2.666**	-0.108	-16.359	0.358	-4.861**	-2.229	-1.157**
	S.E. (sij) +	1.031	0.184	4.266	0.111	2.023	0.592	0.337
	S.E.(sij-sik)	1.525	0.272	6.313	0.164	2.994	0.875	0.559
	S.E.(sij-skl)	1.438	0.257	5.951	0.154	2.823	0.825	0.527

Significant at 5 % and 1 % level

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