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Combining ability studies for yield and yield attributing traits in Brinjal (*Solanum melongena* L.)

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Abstract
Combining ability analysis was carried out for fruit yield and yield attributing traits in brinjal. Both general combining ability (GCA) and specific combining ability (SCA) variances were highly significant for almost all the characters indicating the importance of both additive and non-additive gene actions. SCA variances were higher than the GCA variances except for three characters, indicating non-additive gene action in most of the traits and these traits can be improved by heterosis breeding. These hybrids would be advantageous for production and quality improvement. The three characters like plant height, fruit length and fruit length to diameter ratio showed additive gene action which can be improved by reciprocal recurrent selection. The parents like Biliuddabadane, Natibadane and Mullukaibadane showed highly significant positive GCA effects, the crosses Thailand badane x Doddamullinabadane, Sakleshpurbadane x Doddamullinabadane and Bilichandubadane x Mullukaibadane showed the highly significant positive SCA effects for the yield per plant.

Keywords: Combining ability, GCA, SCA, heterosis breeding, RRS

Introduction
Eggplant (*Solanum melongena* L.) is a popular vegetable and it belongs to the family Solanaceae. In Indian subcontinents the name Brinjal is popular and is derived from Arabic and Sanskrit. It is a self-pollinated crop but cross pollination to some extent hence it is grouped under often cross-pollinated crop. Cross pollination is due to its heteromorphic flower structure and is mainly by honey bees and bumble bees.

Crop improvement involves strategies which will increase the yield potentiality and quality components. The Selection of parent's based on *per se* performance will not lead to fruitful results. So, Line x Tester analysis is one of the precise techniques to identify parents as well as the best cross combination in the immediate generation after making the crosses. Combining ability analysis helps in the evaluation of lines in terms of their genetic value and helps in the selection of the suitable parents for hybridization which gives fruitful results. Also provides the information about the gene action involved in the expression of various quantitative characters which thus helps in deciding the breeding procedure for genetic improvement of such traits. Combining ability was proposed by Sprague and Tatum in 1942 in maize which refers to the capacity or the ability of a genotype to transmit superior performance to its crosses. The value of an inbred line depends on its ability to produce the superior hybrids in combination with other inbreeds.

Ultimately breeding of high yielding varieties of any crop mainly depends on the choice of parents. Breeding methods for the improvement of self-pollinated crops should be based on nature and magnitude of genetic variance governing the inheritance of quantitative characters. Hence, the selection of best parents for hybridization has to be based on the complete genetic information and esteemed prepotency of potential parents, so the knowledge of general combining ability (GCA) and specific combining ability (SCA) helps in choice of parents, which is worked in the present study.

Material and Methods
The present research was conducted at College of Agriculture, ZAHRS, Navile, Shivamogga which represents the Southern Transition Zone of Karnataka, Zone-7. Shivamogga lies between 130 27' to 140 39' latitude and 740 37' E longitude with the altitude of 650 m above the mean sea level. In this proposed research the 7 best lines were selected and 3 testers, which were selected, based on the pattern of thorns from local germplasm collected from OFRC and the crossing was conducted by Line x Tester mating design in polyhouse during *Kharif*, 2016.

In the evening the lines were emasculated and were covered with the white butter paper bags. Next day morning between 6:30 to 8:30 AM pollination was carried out by collecting the pollens from the opened flowers of testers. Later the pollinated flowers were covered with white butter paper bag and were labelled.

The evaluation of these 21 F_1 hybrids was conducted in 3 replications in Randomized Complete Block Design along with parents and a commercial check during *Rabi* 2016-17.

Table 1: The details of lines and testers used in the research work are presented as below.

S. No.	Lines	Name of the Genotypes	Source
1.	L1	Biliuddabadane	OFRC, UAHS, Shivamogga
2.	L2	40 A badane	OFRC, UAHS, Shivamogga
3.	L3	Nati badane	OFRC, UAHS, Shivamogga
4.	L4	Thailand badane	OFRC, UAHS, Shivamogga
5.	L5	Sakleshpurbadane	OFRC, UAHS, Shivamogga
6.	L6	Bilichandubadane	OFRC, UAHS, Shivamogga
7.	L7	Desijawaribadane	OFRC, UAHS, Shivamogga
Testers			
1.	T1	Doddamullinabadane	OFRC, UAHS, Shivamogga
2.	T2	Mullukai badane	OFRC, UAHS, Shivamogga
3.	T3	Doral badane	OFRC, UAHS, Shivamogga
Check			
1.	C1	Private company seeds	Local market

The observations like yield and yield related characters were recorded on five randomly selected plants in all the three replications and their mean was taken for the analysis.

Results and Discussion

Best performing parents for commercial release and for usage as a parent in the crossing program is the main work considered in the plant breeding program and it can be known by combining ability. Combining ability in hybrids is defined as the ability of parents to combine among each other during crossing process such that desirable genes are transmitted to their progenies. The general combining ability and specific combining ability are estimated for seventeen different yield and yield attributing traits and are mentioned in table 2 and table 3. The results regarding these are presented as below.

Among the ten parents two parents showed the negative significant *gca* effects and two parents showed positive significant *gca* effects for days to first flowering, the maximum positive significant *gca* effect was observed in thailand badane (2.005) followed by nati badane (1.849) and maximum negative significant *gca* effect was observed in sakleshpur badane (-2.173) followed by bili chandu badane (-1.784). Three hybrids showed the positive significant *sca* effects and one hybrid showed the negative significant *sca* effect for days to first flowering among twenty one hybrids, the maximum positive significant *sca* effect was seen in the hybrid nati badane x dodda mullina badane (5.446) followed by sakleshpur badane x mullukai badane (5.344) and the maximum negative significant *sca* effect was seen in the hybrid nati badane x mullukai badane (-8.011).

Among the ten parents for days to 50% flowering three showed positive *gca* effects and none of the parents showed negative *gca* effect, highest positive *gca* effect was recorded in nati badane (2.310) followed by mullukai badane (2.208). Among twenty one hybrids three hybrids showed the positive significant *sca* effects and three hybrids showed the negative significant *sca* effects for days to 50% flowering, highest positive significant *sca* effect was observed in sakleshpur badane x mullukai badane (6.837) followed by bili chandu badane x mullukai badane (5.559) and highest negative *sca* effect was observed in nati badane x mullukai badane (-9.652) followed by bili chandu badane x dodda mullina badane (-6.489).

Among the parents, one showed positive significant *gca* effect and it was recorded in thailand badane (2.144), none of the parents showed negative significant *gca* effect for days to maturity. Six hybrids showed the positive significant *sca* effects, six hybrids showed the negative significant *sca* effects among the twenty one hybrids for days to maturity, highest positive *sca* effects were observed in sakleshpur badane x mullukai badane (6.425) followed by bili chandu badane x mullukai badane (5.937) and highest negative *sca* effects were observed in the hybrids nati badane x mullukai badane (-8.486) followed by Desi jawari badane x doral badane hybrid (-6.338).

One among the 10 parents *i.e.*, 40 A badane (4.518) showed positive significant *gca* effect for plant height and none if the parents showed the negative *gca* effect for the plant height. Two hybrids showed the positive significant *sca* effects and two hybrids showed the negative significant *sca* effects among twenty one hybrids, maximum positive *sca* effect was seen in the hybrid 40 A badane x Mullukai badane (6.069) followed by thailand badane x mullukai badane (6.226), maximum negative *sca* effect was seen in the hybrid sakleshpur badane x mullukai badane (-6.038) followed by Desi jawari badane x mullukai badane (-6.069).

One parent showed positive significant *gca* effect *i.e.*, bili udda bande (3.155) and two parents showed negative significant *gca* effects among ten parents for plant spreading, the maximum negative significant *gca* effect was seen in sakleshpur badane (-3.408) followed by doral badane (-4.583). Two hybrids showed the positive significant *sca* effects for plant spreading and none of the hybrids showed the negative significant *sca* effect among the twenty-one hybrids, the maximum *sca* effect was seen in the hybrid thailand badane x mullukai badane (9.398) followed by sakleshpur badane x doral badane (8.928).

Three parents showed positive significant *gca* effects and three parents showed negative significant *gca* effects among ten parents, the highest positive significant *gca* effect was recorded in the parent bili udda badane (0.590) and bili chandu badane (0.590) followed by nati badane (0.613) and highest negative significant *gca* effect was recorded in the parent sakleshpur badane (-0.921) followed by 40 a badane (-0.765). One hybrid showed the positive significant *sca* effect *i.e.*, sakleshpur badane x doral badane (1.854) and none of the hybrid showed the negative significant *sca* effect among the twenty-one hybrids for number of primary branches.

One parent and two parents showed positive significant *gca* effect and negative significant *gca* effects among ten parent for leaf blade length respectively, the positive significant *gca* effect was observed in the parent bili udda bande (1.037) and maximum significant *gca* effect was observed in the parent bili chandu badane (-1.101) followed by Desi jawari badane (-1.288). One hybrid showed the positive significant *sca* effect and none of the hybrid showed the negative significant *sca* effect among the twenty one hybrids for leaf blade length, the positive significant *sca* effect was observed in the hybrid sakleshpur badane x doral badane (1.978).

Among the ten parents two parents showed positive significant *gca* effects and one parent showed negative

significant *gca* effect for leaf blade width, the maximum positive significant *gca* effect was recorded in the parent bili udda bande (0.878) followed by Desi jawari badane (-1.395) and negative significant *gca* effect was recorded in the parent dodda mullina badane (0.468). Among the twenty one hybrids three hybrids showed the positive significant *sca* effects and three hybrids showed the negative significant *sca* effects, the maximum positive *sca* effect was observed in the hybrid bili udda badane x dodda mullina badane (2.427) followed by the hybrid sakleshpur badane x doral badane (1.812), maximum negative *sca* effect was seen in the hybrid sakleshpur badane x dodda mullina badane (-1.539) followed by the hybrid nati badane x doral badane (-1.461).

One parent among the ten parents showed positive significant *gca* effect *i.e.*, bili udda badane (0.543) and none of the parents showed negative significant *gca* effect for flowers per cluster. For the trait flowers per cluster two hybrids showed the negative significant *sca* effects and none of the hybrid showed the positive *sca* effect among the twenty one hybrids, the maximum negative *sca* effect was observed in the hybrid sakleshpur badane x doral badane (-0.683) followed by bili chandu badane x dodda mullina badane (-0.635).

For fruits per cluster one parent among the ten parents showed positive significant *gca* effect *i.e.*, bili udda badane (0.511) and none of the parents showed negative significant *gca* effect. One hybrid showed the negative significant *sca* effect for fruits per cluster among the twenty one hybrids and none showed the positive significant *sca* effect, the negative significant *sca* effect was observed in the hybrid bili udda bande x dodda mullina badane (-0.425).

For fruit length one parent showed positive significant *gca* effect *i.e.*, bili udda bande (5.060) and four parents showed negative significant *gca* effects among ten parents, the maximum negative significant *gca* effect was seen in the parent sakleshpur badane (-2.058) followed by bili chandu badane (-1.476). Four hybrids showed the positive significant *sca* effects and three hybrids showed the negative significant *sca* effects for fruit length among twenty one hybrids, highest positive significant *sca* effect was recorded in the hybrid thailand badane x dodda mullina badane (2.119) followed by bili udda badane x doral badane (1.483) and highest negative *sca* effect was recorded in the hybrid bili udda badane x dodda mullina badane (-1.781) followed by thailand badane x mullukai badane (-1.636).

Two parents showed positive significant *gca* effects and three parents showed negative significant *gca* effects for fruit diameter, the highest positive significant *gca* effect was observed in the parent sakleshpur badane (0.362) followed by dodda mullina badane (0.288) and highest negative significant *gca* effect was observed in Desi jawari badane (-0.378) followed by 40 A badane (-0.273). Among the twenty one hybrids four hybrids showed the positive significant *sca* effects and six hybrids showed the negative significant *sca* effects, the hybrid thailand badane x dodda mullina badane (1.185) showed the maximum positive significant *sca* effect followed by bili chandu badane x mullukai badane (0.844) and the hybrid bili chandu badane x dodda mullina badane (-0.882) showed the maximum negative significant *sca* effect followed by thailand badane x mullukai badane (-0.743).

Three parents showed positive significant *gca* effects and four parents showed negative significant *gca* effects for fruit length to fruit diameter ratio, the highest positive significant *gca* effect was recorded in the parent bili udda badane (1.104) followed by desi jawari badane (0.230) and highest negative significant *gca* effect was recorded in the parent sakleshpur badane (-0.575) followed by bili chandu badane (-0.315). For fruit length to fruit diameter ratio three hybrids showed the positive significant *sca* effects and four hybrids showed the negative significant *sca* effects among the twenty one hybrids, the highest positive significant *sca* effect was observed in the hybrid bili udda bande x doral badane (0.390) followed by 40 A badane x mullukai badane (0.422), and highest negative significant *sca* effect was observed in the hybrid 40 A badane x doral badane (-0.508) followed by bili udda bande x mullukai badane (-0.206).

Two parents and six parents showed positive significant *gca* effects and negative significant *gca* effects respectively among ten parents for fruits weight, the maximum positive significant *gca* effects was seen in the parent bili udda badane (43.095) followed by mullukai badane (13.667) and maximum negative significant *gca* effect was seen in the parent 40 A badane (-17.905) followed by sakleshpur badane (-15.127). Seven hybrids showed the positive significant *sca* effects and seven hybrids showed the negative significant *sca* effects among twenty one hybrids for fruit weight, the highest positive significant *sca* effect was seen in the hybrid thailand badane x dodda mullina badane (40.984) followed by Desi jawari badane x mullukai badane (20.333) and highest negative significant *sca* effect was recorded in the hybrid thailand badane x mullukai badane (-33.444) followed by bili udda bande x dodda mullina badane (-30.571).

Four parents showed positive significant *gca* effects and three parents showed negative significant *gca* effects for number of fruits per plant, the highest positive significant *gca* effect was seen in the parent 40 A badane (7.333) followed by sakleshpur badane (5.333) and the highest maximum negative significant *gca* effect was seen in the parent bili udda badane (-14.778) followed by thailand badane (-2.111). For number of fruits per plant four hybrids showed the positive significant *sca* effects and three hybrids showed the negative significant *sca* effects among the twenty one hybrids, maximum positive significant *sca* effect was seen in the hybrid thailand badane x mullukai badane (10.349) followed by desi jawari badane x dodda mullina badane (6.413), the maximum negative significant *sca* effect was recorded in the hybrid thailand badane x dodda mullina badane (-10.698) followed by desi jawari badane x mullukai badane (-6.873).

Four parents and five parents showed positive significant *gca* effects and negative significant *gca* effects, the highest positive significant *gca* effect was observed in the parent mullukai badane (0.284) followed by nati badane (0.250) and maximum negative significant *gca* effect was recorded in the parent Desi jawari badane (-0.220) followed by 40 A badane (-0.157). Seven hybrids showed the positive significant *sca* effects and five hybrids showed the negative significant *sca* effects for fruit yield per plant among twenty one hybrids, the maximum positive significant *sca* effect was seen in the hybrid thailand badane x dodda mullina badane (0.486) followed by sakleshpur badane x dodda mullina badane (0.441) and the maximum negative significant *sca* effect was seen in the hybrid sakleshpur badane x mullukai badane (-0.555) followed by thailand badane x mullukai badane (-0.424).

Four parents showed positive significant *gca* effects and five parents showed negative significant *gca* effects for fruit yield per hectare, the highest positive significant *gca* effect was observed in the parent mullukai badane (5.104) followed by nati badane (4.505) and highest negative *gca* effect was seen in the parent Desi jawari badane (-3.967) followed by 40 a badane (-2.817). For fruit yield per hectare seven hybrids

showed the positive significant *sca* effects and five hybrids showed the negative significant *sca* effects among twenty one hybrids, the highest positive significant *sca* effect was seen in the hybrid thailand badane x dodda mullina badane (8.750) followed by sakleshpur badane x dodda mullina badane (7.938) and the maximum negative significant *sca* effect was seen in the hybrid sakleshpur badane x mullukai badane (-9.996) followed by thailand badane x mullukai badane (-7.624). *Per se* performance and GCA effects of parents of top hybrids based on fruit yield are presented in Fig 1 and *Per se* performance of top hybrids with their SCA effects based on fruit yield are represented in Fig 2. Similar results for fruit yield were also obtained by Ramesh Kumar *et al*. (2012) [8], Omkar Singh *et al*. (2013) [3], Pratapsingh *et al*. (2013), Ramanand Mishra *et al*. (2013) [5], Ramesh Kumar and Arumugam (2013) [6], Shafeeq *et al*. (2013) [10], Abdul Majid Ansari and Singh (2014) [1], Raghvendra Dubey *et al*. (2014) [4], Reddy and Patel (2014) [9], Sharaf *et al*. (2015) [11], Venkata Naresh *et al*. (2015) [13], Gharge *et al*. (2016) [2], Ramesh Kumar *et al*. (2016) [7].

Table 2: General combining ability effects for yield and yield attributing characters in brinjal

Parents	DTFF	DTFIF	DTM	PH	PS	NOB	LL	LW	FLO/C
L1	-0.173	-1.313	-2.078	0.920	3.155*	0.590*	1.037*	0.878*	0.543**
L2	0.916	-0.668	0.500	4.518*	0.368	-0.765*	-0.081	-0.197	0.032
L3	1.849*	2.310*	0.900	3.436	0.997	0.613*	0.277	0.398	-0.057
L4	2.005*	0.154	2.144*	-3.546	0.583	-0.676*	0.577	0.201	-0.057
L5	-2.173**	-1.313	-1.278	-0.762	-3.408*	-0.921*	0.581	0.605	-0.079
L6	-1.784*	-1.035	-0.156	-3.035	0.155	0.590*	-1.101*	-0.490	-0.213
L7	-0.640	1.865*	-0.033	-1.531	-1.850	0.568	-1.288*	-1.395**	-0.168
S.Em±	0.172	0.319	1.045	1.855	1.022	0.191	0.489	0.323	0.171
CD @ 5%	1.370	1.665	2.113	3.771	3.066	0.573	0.989	0.652	0.346
CD @ 1%	2.171	2.567	2.827	6.722	5.066	2.573	1.323	0.873	0.462
T1	-0.424	-0.878	-0.824	-2.142	1.302	0.289	0.464	0.468*	0.102
T2	0.967	2.208*	0.352	2.934	3.282	-0.035	-0.286	-0.285	-0.117
T3	-0.543	-1.330	0.471	-0.792	-4.583*	-0.254	-0.178	-0.183	0.016
S.Em±	0.768	0.863	0.684	1.869	2.007	0.441	0.320	0.211	0.112
CD @ 5%	1.551	1.745	1.383	3.778	4.057	0.891	0.647	0.427	0.226
CD @ 1%	2.076	2.335	1.851	5.055	5.429	1.192	0.866	0.571	0.303

*, ** indicate the level of significance at 5% and 1% respectively

DTFF: Days to first flowering
DTFIF: Days to fifty percent flowering
DTM: Days to maturity
PH: Plant height (cm)
PS: Plant spread (cm)
NOB: Number of branches
LL: Leaf length (cm)
LW: Leaf width (cm)
Flo/C: Flowers per cluster
L1: Biliuddabadane
L2: 40 A badane
L3: Nati badane
L4: Thailand badane
L5: Sakleshpurbadane
L6: Bilichandubadane
L7: Desijawaribadane
T1: Doddamullinabadane
T2: Mullukai badane
T3: Doral badane

Table 2: Cont.……

Parents	F/C	FL	FD	FL/FD	FW	NOF	FY/P	Y/H
L1	0.511**	5.060**	0.062	1.104**	43.095**	-14.778**	0.218**	3.917**
L2	0.000	-0.689*	-0.273*	-0.013	-17.905**	7.333**	-0.157*	-2.817*
L3	-0.289	-0.412	0.124	-0.155**	1.762	1.333	0.250**	4.505**
L4	-0.133	-0.720**	0.258	-0.275**	1.540	-2.111*	-0.076	-1.371
L5	-0.244	-2.058**	0.362**	-0.575**	-15.127**	5.333**	-0.133*	-2.395*
L6	0.067	-1.476**	-0.156	-0.315**	-5.794**	3.111**	0.118*	2.129*
L7	0.089	0.295	-0.378**	0.230**	-7.571**	-0.222	-0.220**	-3.967**
S.Em±	0.147	0.257	0.128	0.043	1.750	0.969	0.058	1.051
CD @ 5%	0.296	0.519	0.258	0.087	3.536	1.958	0.118	2.123
CD @ 1%	0.397	0.695	0.345	0.116	4.732	2.620	0.158	2.841
T1	0.048	0.205	0.288**	-0.055	-4.095**	-0.968	-0.129**	-2.330**
T2	-0.019	-0.040	-0.271**	0.072*	13.667**	-2.016**	0.284**	5.104**
T3	-0.029	-0.165	-0.017	-0.017	-9.571**	2.984**	-0.154**	-2.773**
S.Em±	0.096	0.168	0.084	0.028	1.145	0.634	0.038	0.688
CD @ 5%	0.194	0.340	0.169	0.057	2.315	1.282	0.077	1.390
CD @ 1%	0.260	0.455	0.226	0.076	3.098	1.715	0.103	1.860

*, ** indicate the level of significance at 5% and 1% respectively

F/C: Fruits per cluster
FL: Fruit length (cm)
FD: Fruit diameter (cm)
FL/FD: Fruit length to diameter ratio
FW: Fruit weight (g)
NOF: Number of fruits
FY/P: Fruit yield per plant (kg)
Y/H: Fruit yield per hectare (q)
L1: Biliuddabadane
L2: 40 A badane
L3: Nati badane
L4: Thailand badane
L5: Sakleshpurbadane
L6: Bilichandubadane
L7: Desijawaribadane
T1: Doddamullinabadane
T2: Mullukai badane
T3: Doral badane

Table 3: Specific combining ability effects for yield and yield attributing characters in brinjal

Hybrids	DTFF	DTFIF	DTM	PH	PS	NOB	LL	LW	FLO/C
L1 x T1	2.668	2.589	2.268	3.742	-7.639	0.400	1.047	2.427**	0.276
L1 x T2	-0.322	-0.897	-0.441	-2.760	-1.093	0.257	-0.510	-1.099	0.029
L1 x T3	-2.346	-1.692	-1.827	-0.981	8.732	-0.657	-0.537	-1.328*	-0.305
L2 x T1	-0.621	0.811	-0.843	-4.823	4.907	1.222	-0.275	-0.364	0.121
L2 x T2	-2.411	-3.141	-3.686*	6.069*	-1.773	-0.987	0.535	0.390	-0.327
L2 x T3	3.032	2.330	4.529*	-1.246	-3.135	-0.235	-0.260	-0.026	0.206
L3 x T1	5.446*	4.367	2.824	2.826	3.772	0.111	0.121	0.187	0.343
L3 x T2	-8.011**	-9.652**	-8.486**	-0.463	4.852	-0.898	1.090	1.274*	-0.571
L3 x T3	2.565	5.286*	5.662**	-2.363	-8.623	0.787	-1.211	-1.461*	0.229
L4 x T1	-0.576	0.989	1.646	-2.512	-2.168	-0.333	0.214	-0.215	-0.124
L4 x T2	-3.300	-3.297	-5.597**	6.226*	9.398*	0.724	-0.303	0.158	-0.171
L4 x T3	3.876	2.308	3.951*	-3.715	-7.230	-0.390	0.089	0.057	0.295
L5 x T1	-1.998	-2.411	-0.598	0.270	-4.977	-0.956	-1.490	-1.539**	0.165
L5 x T2	5.344*	6.837**	6.425**	-6.038*	-3.950	-0.898	-0.488	-0.273	0.517
L5 x T3	-3.346	-4.425	-5.827**	5.768	8.928*	1.854*	1.978*	1.812**	-0.683*
L6 x T1	-3.921	-6.489**	-5.787**	-1.510	6.247	-0.267	0.372	-0.257	-0.635*
L6 x T2	4.089	5.559*	5.937**	3.035	-6.939	0.657	-0.292	-0.270	0.384
L6 x T3	-0.168	0.930	-0.149	-1.526	0.692	-0.390	-0.080	0.528	0.251
L7 x T1	-0.998	0.144	0.460	2.006	-0.142	-0.178	0.012	-0.239	-0.146
L7 x T2	4.611*	4.592	5.848**	-6.069*	-0.495	1.146	-0.032	-0.179	0.140
L7 x T3	-3.613	-4.737*	-6.338**	4.063	0.637	-0.968	0.020	0.419	0.006
S.Em±	2.031	2.284	1.810	2.946	4.321	0.671	0.847	0.559	0.296
CD @ 5%	4.104	4.617	3.659	5.996	8.735	1.357	1.713	1.130	0.599
CD @ 1%	5.492	6.178	4.896	9.376	12.364	2.153	2.292	1.512	0.801

*, ** indicate the level of significance at 5% and 1% respectively

DTFF: Days to first flowering
DTFIF: Days to fifty percent flowering
DTM: Days to maturity
PH: Plant height (cm)
PS: Plant spread (cm)
NOB: Number of branches
LL: Leaf length (cm)
LW: Leaf width (cm)
Flo/C: Flowers per cluster
L1: Biliuddabadane
L2: 40 A badane
L3: Natibadane
L4: Thailand badane
L5: Sakleshpurbadane
L6: Bilichandubadane
L7: Desijawaribadane
T1: Doddamullinabadane
T2: Mullukai badane
T3: Doral badane

Table 3: Cont.……

Hybrids	F/C	FL	FD	FL/FD	FW	NOF	FY/P	Y/H
L1 x T1	-0.425*	-1.781**	-0.486*	-0.184*	-30.571**	3.635*	-0.332*	-5.982*
L1 x T2	0.041	0.298	0.566*	-0.206**	19.667**	-0.984	0.050	0.900
L1 x T3	0.384	1.483**	-0.080	0.390**	10.905**	-2.651	0.282**	5.081**
L2 x T1	0.219	-0.139	-0.477*	0.086	-1.905	-0.476	-0.171	-3.082
L2 x T2	0.019	0.940*	-0.338	0.422**	0.667	1.905	0.325**	5.846**
L2 x T3	-0.238	-0.801	0.815**	-0.508**	1.238	-1.429	-0.154	-2.765
L3 x T1	0.375	0.285	0.045	0.049	0.762	3.190	0.215*	3.870*
L3 x T2	-0.159	-0.287	-0.029	-0.048	5.667	-6.429**	-0.135	-2.436
L3 x T3	-0.216	0.002	-0.016	-0.002	-6.429*	3.238	-0.080	-1.435
L4 x T1	0.219	2.119**	1.185**	-0.103	40.984**	-10.698**	0.486**	8.750**
L4 x T2	-0.048	-1.636**	-0.743**	-0.132	-33.444**	10.349**	-0.424**	-7.624**
L4 x T3	-0.171	-0.484	-0.443	0.029	-7.540*	0.349	-0.063	-1.127
L5 x T1	-0.137	0.790	0.354	0.102	15.651**	-2.476	0.441**	7.938**
L5 x T2	-0.203	-0.404	-0.494*	0.031	-22.111**	3.571*	-0.555**	-9.996**
L5 x T3	0.340	-0.386	0.140	-0.133	6.460*	-1.095	0.114	2.057
L6 x T1	-0.181	-1.179*	-0.882**	0.018	-7.016*	0.413	-0.282**	-5.070**
L6 x T2	0.352	0.960*	0.844**	-0.044	9.222**	-1.540	0.390**	7.020**
L6 x T3	-0.171	0.219	0.037	0.027	-2.206	1.127	-0.108	-1.951
L7 x T1	-0.070	-0.096	0.261	-0.173*	-17.905**	6.413**	-0.357**	-6.426**
L7 x T2	-0.003	0.129	0.193	-0.023	20.333**	-6.873**	0.349**	6.288**
L7 x T3	0.073	-0.033	-0.454*	0.196*	-2.429	0.460	0.008	0.137
S.Em±	0.204	0.445	0.221	0.074	3.030	1.678	0.101	1.820
CD @ 5%	0.413	0.900	0.447	0.151	6.125	3.391	0.204	3.678
CD @ 1%	0.587	1.204	0.598	0.201	8.196	4.537	0.273	4.921

*, ** indicate the level of significance at 5% and 1% and respectively

F/C: Fruits per cluster
FL: Fruit length (cm)
FD: Fruit diameter (cm)
FL/FD: Fruit length to diameter ratio
FW: Fruit weight (g)
NOF: Number of fruits
FY/P: Fruit yield per plant (kg)
Y/H: Fruit yield per hectare (q)
L1: Biliuddabadane
L2: 40 A badane
L3: Natibadane
L4: Thailand badane
L5: Sakleshpurbadane
L6: Bilichandubadane
L7: Desijawaribadane
T1: Doddamullinabadane
T2: Mullukai badane
T3: Doral badane

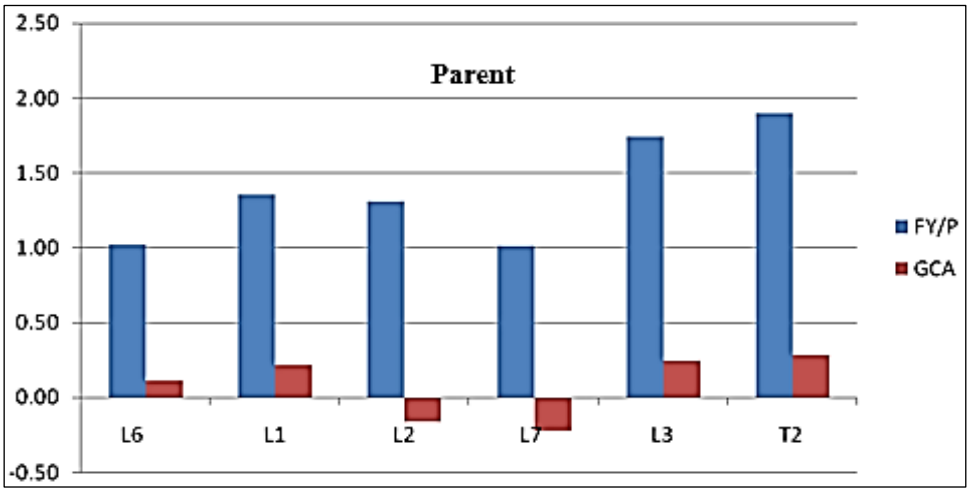

Fig 1: *Per se* performance and GCA effects of parents of top hybrids based on fruit yield

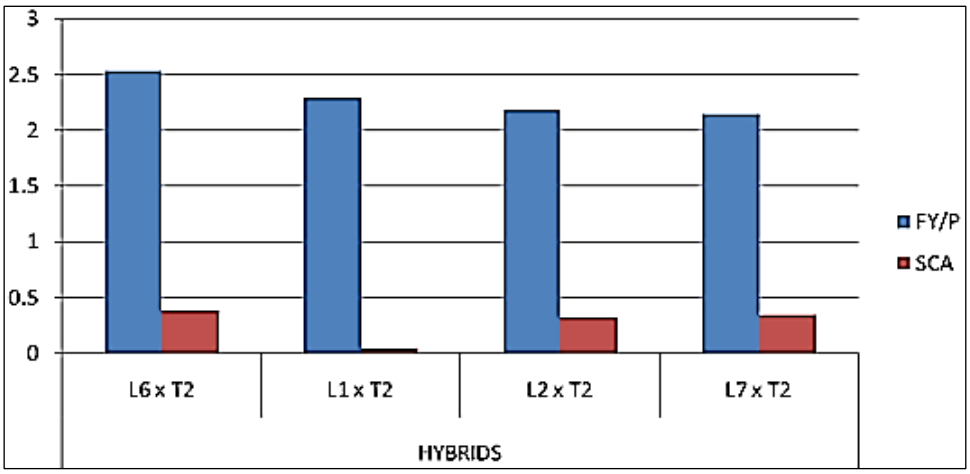

Fig 2: *Per se* performance of top hybrids and their SCA effects based on fruit yield

Conclusion

Hybrids offer opportunities for improvement in earliness, uniformity, productivity, quality, wider adaptability and rapid deployment of dominant genes for resistance to disease and pests. Hence these hybrids were evaluated and combining ability was estimated. The parents like Biliuddabadane, Natibadane and Mullukai badane showed highly significant positive GCA effects, the crosses Thailand badane x Doddamullinabadane, Sakleshpurbadane x Doddamullinabadane and Bilichandubadane x Mullukai badane showed the highly significant positive SCA effects for the yield per plant.

The combining ability studies revealed that the SCA variances were higher than the GCA variances except for three characters *i.e.*, plant height, fruit length and fruit length to diameter ratio. The non-additive gene action was observed in the character like days to first flowering, days to 50% flowering, days to maturity, plant spread, number of branches, leaf length, leaf width, flowers per cluster, fruits per cluster, fruit diameter, fruit weight, number of fruits, fruit yield per plant, fruit yield per hectare, these traits can be improved by heterosis breeding. These hybrids would be advantageous for production and quality improvement. The traits like plant height, fruit length and fruit length to diameter ratio showed additive gene action which can be improved by reciprocal recurrent selection.

The parents like Mullukai badane and Nati badane were good combiner for yield trait. The hybrids like Thailand badane x Doddamullinabadane followed by Sakleshpurbadane x Doddamullina badane were good specific combiners for yield trait. The parents of these hybrids with good combining ability can be used as the parent's in future crossing program.

Future Scope

These superior hybrids can be forwarded to next generation to obtain superior segregants. The parents of these hybrids with good combining ability can be used as parents in future crossing program. The superior hybrids can be tested in multiplication trial to confirm their potentiality over different environmental conditions.

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