

Original Research Article

Combining ability studies for grain yield and its component traits in sweet corn ((*Zea mays* var. *saccharata*))

ABSTRACT

Using 15 sweet corn inbreds, a line x tester design was used to perform combining ability analysis for yield and its contributing traits. For every character under study, the interaction between Line x Tester was highly significant, with the exception of days to 50% tasseling. For every attribute studied, the variation resulting from sca exceeded the variance resulting from gca. Which indicates the presence of non-additive gene action between the parents. As a result of their high *per se* performance combined with high gca effects for the majority of the yield and yield contributing traits, such as ear weight without husk, number of kernels per row, total soluble solids, 100 kernel weight, cob yield per plot and total sugar, the lines L₆, L₁₂ and testers T₁, T₂ were determined to be the best general combiners. The hybrid L₃xT₁, which had the highest *per se* performance and sca for cob yield per plot, 100 kernel weight and ear weight without husk, was determined to be the best hybrid out of the 36 hybrids examined.

Key words : Sweet corn, combining ability, Line x Tester, gca, sca

INTRODUCTION

Maize (*Zea mays*) is the poacea family cereal crop. The entire world now possesses maize since, it was extensively domesticated in Central America. Due to its adaptability it may be grown in temperate, subtropical and tropical areas (Koutsika-Sotiriou, 1999). In India it is primarily grown during kharif season, but certain states, such as Bihar, it has planted in both *kharif* and *rabi* seasons with the aim of good production and productivity.

According to FAOSTAT 2021-2022, Globally 193.70 million ha of land are planted with maize, producing 1147.70 million tonnes with a productivity of 5.75 tonnes / ha. In India 9.90 million hacters of land are under cultivation with the production of 31.50 million tonnes. Within that 0.64 million acres of corn fields are present in Bihar with the annual production of 3.34 million tonnes.

Sweet corn is a variant of normal corn with sweeter kernels that is consumed at the milky stage, which is harvested 24 days after pollination (Khanduri *et al.* 2011). Sweet corn is consumed as fresh vegetable in many western countries and its fresh, canned and processed products are popular in many Asiatic countries including india. Sweetness of kernels are by the actions of few recessive genes. Multiple endosperm genes utilised in the enhancement of sweet corn have been identified to increase sugar content and diminish starch content (Creech 1965; Boyer and Shanon 1984; Tracy 1996). There are four type of recessive mutant genes responsible for the sweetness of maximum available sweet corn genotypes were sugary1 (*su*₁), brittle (*bt*), sugary enhancer (*se*) and shrunken 2 (*sh*₂).

In order to conduct a methodical breeding programme, it is necessary to identify both the parents and the crosses that can be utilised to produce further genetic enhancement in crop output. The significance of gene action in each variable that contributes to yield is crucial in determining the most effective breeding method. Parental knowledge, which include combining abilities, is valuable for determining appropriate parents based on hybrid performance. With this background a study was conducted on sweet corn to evaluate the gene action and combining capacity of parents for important yield-contributing traits.

MATERIALS AND METHODS

In the study, a Line x Tester design was used to cross 12 lines and three testers of sweet corn during the *Rabi* 2022. **Table 1** contains the list of lines and testers utilised in our current inquiry. The hand emasculation and pollination procedure was employed as the crossover technique. The seeds of 36 recently created hybrids, together with the fifteen original parents, were assessed using a randomised block design (RBD) with three replications during *Kharif* 2023 at the Experimental Farm, TCA, Dholi, RPCAU. The entries were cultivated in two rows, each measuring 3 metres in length, with a spacing of 60 x 20 centimetres. This resulted in a plot size of 3.6 square metres. The recommended set of procedures was followed, and biometric observations were recorded on three randomly selected plants for 16 quantitative traits (days to 50% tasseling, days to 50% silking, chlorophyll concentration measured in SPAD units, plant height measured in centimetres, ear height measured in centimetres, ear weight with husk measured in grammes, ear weight without husk measured in grammes, husk ratio measured as a percentage, ear length measured in centimetres, ear girth measured in centimetres, number of rows per ear, number of kernels per row, 100 kernel weight measured in grammes, shelling percentage measured as a percentage, cob yield per plot measured in kilogrammes and fodder yield per plot measured in kilogrammes) and five quality traits (total soluble solids measured in °Bx, reducing sugar measured as a percentage, non-reducing sugar measured as a percentage, total sugar measured as a percentage and starch measured as a percentage). An analysis of variance was conducted for all the attributes using the model proposed by Panse and Sukhatme (1984). The analysis of Line Tester was conducted according to the procedure outlined by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance revealed substantial variations among the genotypes for all the variables examined (**Table 2**). The analysis of variance for combining ability revealed significant differences among line x testers for all traits, except for days to 50% tasseling. Additionally, there were significant differences among lines for all traits studied, indicating that the experimental material exhibited substantial variability (**Table 3**). The presence of substantial genetic diversity was indicated by the significant variances in the genotypes of all the characters (Amiruzzaman *et al.* 2010). Significant variance was seen among testers for 14 features, excluding husk ratio, ear length, total soluble solids, shelling percentage, non-reducing sugar, total sugar and starch. This signifies a divergence among the hybrids.

Table 1: Parents used in the Line x Tester analysis

S. No.	Code No.	Name of the lines	Source
1	L ₁	BSCH 416078	AAU, Godhra
2	L ₂	BIO 4043	AAU, Godhra
3	L ₃	FSCH 119	AAU, Godhra
4	L ₄	MSCH 20	AAU, Godhra
5	L ₅	KDM 1263	AAU, Godhra
6	L ₆	DMSC 24	AAU, Godhra
7	L ₇	MSCH 21	AAU, Godhra
8	L ₈	MSCH 22	AAU, Godhra
9	L ₉	SC 162	AAU, Godhra
10	L ₁₀	DMSC 37-3	AAU, Godhra
11	L ₁₁	I-07-37-1-5	AAU, Godhra
12	L ₁₂	I-07-62-3-2	AAU, Godhra
Code No.		Name of the testers	
13	T ₁	BSCH 416086	AAU, Godhra
14	T ₂	Hawali Sugar	AAU, Godhra
15	T ₃	I-07-37-4-1	AAU, Godhra

For the purpose of creating an effective plant breeding programme, plant breeders need to understand both additive and non-additive gene action. The combining ability analysis makes it possible to separate the hybrids genotypic variation into variations resulting from specific combining abilities (interaction effects) and general combining abilities (main effects). Previous researchers proposed that there would be a higher likelihood of establishing superior genotype in early segregating generations if additive genetic variation was higher. Selecting for subsequent generations is the best course of action if dominant and epistatic interactions are prevalent. The ratio of gca to sca is used to express it. Higher sca indicates the presence of non-additive gene action, primarily due to dominance and epistatic interactions, while larger general combining ability (gca) indicates a higher proportion of additive gene action.

The analysis of genotypes revealed that the sca variance exceeded the gca variance for all the characters studied. This indicates that a higher proportion of non-additive genes are responsible for the inheritance of these traits. It also suggests that heterosis breeding can be effectively utilised to harness hybrid vigour. Rodrigues *et al.* (2009), Abdel *et al.* (2009) and Sing and Roy (2007) have observed similar findings. The degree of dominance was found to be less than one for all the features, except for ear height. This suggests that the parents have partial dominance over their hybrids whereas ear height degree of dominance was found more than unity, which indicates over dominance of hybrid (**Table 4**). The study revealed that parents exhibited varying levels of combining ability for different qualities. It was also shown that no single parent demonstrated exceptional combining ability for all attributes (**Table 5**).

Table 2. Analysis of variance for different morphological traits

S. V.	Df	Mean sum of squares										
		DFT	DFS	CHL	PH	EH	EWH	EW	HR	EL	EG	NRPE
Treatments	50	7.66**	7.50**	90.97**	834.22**	61.96**	1397.62**	1004.82**	30.72**	5.88**	9.65**	4.33**
Replications	2	5.26	1.97	0.71	25.32	0.97	4.60	1.74	0.31	0.24	0.06	0.04
Error	100	1.64	1.60	1.50	20.80	2.48	6.84	5.78	0.26	0.11	0.10	0.01

Table 2. Analysis of variance for different morphological traits (Contd.)

S. V.	Df	Mean sum of squares									
		NKPR	TSS	100KW	SP	CYP	FYP	RS	NRS	TS	ST
Treatments	50	9.59**	5.15**	47.66**	108.25**	0.79**	3.02**	0.22**	0.63**	1.54**	3.27**
Replications	2	0.05	0.20	0.14	4.22	0.01	0.02	0.01	0.01	0.17	0.05
Error	100	0.38	0.15	0.46	1.44	0.01	0.02	0.01	0.02	0.03	0.09

** Significant at 1% level

Table 3. Analysis of variance for combining ability for lines, testers and their crosses

S. V.	Df	Mean sum of squares										
		DFT	DFS	CHL	PH	EH	EWH	EW	HR	EL	EG	NRPE
Lines	11	8.88**	8.93**	162.56**	2405.33**	140.41**	2210.90**	1684.46**	42.59**	8.32**	11.77**	4.70**
Testers	2	9.33**	12.25**	361.44**	798.97**	91.30**	992.59**	819.50**	49.52	3.85	14.19**	9.33**
Lines×Testers	22	2.42	4.61**	24.63**	102.40**	5.65**	261.85**	151.59**	22.86**	1.82**	3.97**	2.42**
Error	100	1.74	1.61	1.50	20.80	2.47	6.84	5.78	0.26	0.10	0.10	0.08

Table 3. Analysis of variance for combining ability for lines, testers and their crosses (Contd.)

S. V.	Df	Mean sum of squares									
		NKPR	TSS	100KW	SP	CYP	FYP	RS	NRS	TS	ST
Lines	11	11.90**	12.21**	80.69**	175.35**	1.32**	5.02**	0.43**	1.24**	3.11**	7.46**
Testers	2	16.33**	2.57	83.94**	49.44	0.64**	1.91**	0.62**	0.33	1.84	2.90
Lines×Testers	22	4.52**	2.84**	13.11**	77.16**	0.12**	0.45**	0.10**	0.38**	0.83**	1.31**
Error	100	0.25	0.15	0.46	1.44	0.01	0.02	0.01	0.02	0.03	0.09

** Significant at 1% level

Table 4. Estimates of general and specific combining ability variance, gene action and degree of dominance in sweet corn

S.No	Characters	σ^2_{gca}	σ^2_{sca}	σ^2_{gca}	σ^2_A	σ^2_D	$\sigma^2_{A/}$	Degree of
1	Days to 50%	0.076	0.458	0.166	0.152	0.458	0.332	0.576
2	Days to 50%	0.056	2.001	0.028	0.112	2.001	0.056	0.237
3	Chlorophyll content	1.971	15.420	0.128	3.942	15.420	0.256	0.506
4	Plant height	24.044	54.402	0.442	48.088	54.402	0.884	0.940
5	Ear height	1.4875	2.114	0.704	2.975	2.114	1.407	1.186
6	Ear weight with	20.6035	170.008	0.121	41.207	170.008	0.242	0.492
7	Ear weight without	16.372	97.203	0.168	32.744	97.203	0.337	0.580
8	Husk ratio	0.243	15.063	0.016	0.486	15.063	0.032	0.180
9	Ear length	0.068	1.143	0.059	0.136	1.143	0.119	0.345
10	Ear girth	0.0955	2.577	0.037	0.191	2.577	0.074	0.272
11	Number of rows	0.0345	1.562	0.022	0.069	1.562	0.044	0.210
12	Number of kernels	0.094	2.845	0.033	0.188	2.845	0.066	0.257
13	TSS	0.092	1.796	0.051	0.184	1.796	0.102	0.320
14	100 Kernal weight	0.796	8.434	0.094	1.592	8.434	0.189	0.434
15	Shelling	0.9215	50.476	0.018	1.843	50.476	0.037	0.191
16	Cob yield per plot	0.0125	0.076	0.164	0.025	0.076	0.329	0.574
17	Fodder yield per	0.0475	0.287	0.166	0.095	0.287	0.331	0.575
18	Reducing sugar	0.004	0.066	0.061	0.008	0.066	0.121	0.348
19	Non-reducing	0.008	0.239	0.033	0.016	0.239	0.067	0.259
20	Total sugar	0.024	0.533	0.045	0.048	0.533	0.090	0.300
21	Starch	0.0635	0.812	0.078	0.127	0.812	0.156	0.395

Majumder and Bhowal (1998) observed a correlation between the direct performance and general combining ability (gca) impacts in enhancing any given trait. Keeping this as the reference, lines L₆ and L₁₂ as well as the testers T₁ and T₂, were identified as the best general combiners due to their high *per se* performance and high gca effects for various yield and yield contributing traits, such as ear weight without husk, number of kernels per row, total soluble solids, 100 kernel weight, cob yield per plot and total sugar. And L₅, L₆ and L₁₂ were found to be best lines for improving total soluble solids and total sugars (**Table 7**). Abdallah (2014) and Meseka and Ishaq (2012) also found similar significant effects of strong general combining ability (GCA) on yield and yield attributing variables.

Specific combining ability is a useful tool for determining the most effective cross combination to maximise hybrid vigour. The cob yield per plot was very high in the L₃ x T₁ hybrid, indicating a specific combining ability. Out of the 36 hybrids, six hybrids exhibited substantial positive sca effects for cob yield per plot, as seen in **Table 6**. The hybrids L₃xT₁, L₆xT₁ and L₇xT₂ were discovered as excellent specific combiners and also demonstrated exceptional *per se* performance for cob yield per plot. The hybrid L₃xT₁ had the highest individual performance together with sca effects, for the following characteristics: ear weight without husk, 100 kernel weight and cob yield per plot. Some of the hybrids were found high

mean and high sca for some of the traits viz., ear weight without husk ($L_3 \times T_1$, $L_6 \times T_1$), ear length ($L_3 \times T_2$, $L_6 \times T_1$), ear girth ($L_2 \times T_3$, $L_3 \times T_2$), number of rows per ear ($L_1 \times T_2$), number of kernels per row ($L_4 \times T_1$), total soluble solids ($L_{12} \times T_3$, $L_6 \times T_1$) and 100 kernel weight ($L_8 \times T_1$, $L_3 \times T_1$) (**Table 8**). Reddy *et al.* (2011) and Kumari *et al.* (2008) also found high sca values for many plant characteristics, including plant height, ear height, ear length, ear circumference, kernel rows per ear, kernel per row, 100-seed weight and grain production per plant. The good sca effects observed may be attributed to a mix of favourable genes inherited from the corresponding parents, along with non-additive gene action.

The cob yield per plot in the $L_3 \times T_1$ combination was mostly influenced by the high general combining ability of the parent L_3 , whereas the parent T_1 had a lower general combining ability. Therefore, the large yield could be attributed to the dominance or epistatic impact of a single inbred. Three hybrid combinations, specifically $L_6 \times T_2$, $L_9 \times T_1$ and $L_3 \times T_2$ exhibited excellent individual performance and demonstrated favourable specific combining ability (sca) for total sugars.

CONCLUSION

Parents L_6 and L_{12} along with tester T_1 were identified as effective general combiners based on their strong performance and genetic combining ability for yield-related variables (**Table 7**). Among the 36 hybrids examined, the hybrid $L_3 \times T_1$ was determined to be the superior hybrid due to its highest individual performance and specific combining ability for cob yield per plot, 100 kernel weight and ear weight without husk.

Followed by hybrids $L_6 \times T_1$ and $L_7 \times T_2$ were also identified as best hybrids which recorded high field performance coupled with high sca effect for ear weight without husk, ear length, cob yield per plot and total soluble solids (**Table 8**). All these hybrids could be commercialised after extensive yield trial.

Table 5. General combining ability (gca) effects of parents for yield and yield related traits

SV	DFT	DFS	CHL	PH	EH	EWB	EW	HR	EL	EG
Parents										
Lines:										
L1	-0.389	0.083	-9.299**	-7.932	-1.867	-17.431*	-14.666*	1.288	-1.536**	-1.618*
L2	-0.722	-0.917	-3.899*	-2.668	0.593	-22.059**	-18.710**	2.096*	-0.776	-1.508*
L3	0.611	0.750	-1.873	8.205	1.906	13.666	13.579*	-3.491**	0.818	0.949
L4	-1.722**	-1.583	3.284*	-11.545*	-4.864**	-0.969	-2.486	1.762	-1.049*	-1.094
L5	-0.389	-0.250	-0.903	23.155**	8.349**	-13.292	-11.272	0.885	-0.436	-0.821
L6	-0.056	0.083	6.611**	-12.345**	-0.981	21.698**	18.936**	-2.013*	1.248**	1.019
L7	1.611**	1.417	1.164	-4.645	-3.847*	-12.144	-11.472	3.128**	0.504	-0.354
L8	0.278	0.083	-0.983	2.225	-1.794	6.664	2.780	2.022*	-1.126**	-0.304
L9	0.611	0.417	3.951*	33.518**	6.326**	10.196	9.837	-2.151*	0.444	1.546*
L10	1.611**	1.750	0.357	-25.318**	-1.651	-6.766	-4.882	-0.884	1.118**	0.206
L11	-0.722	-0.917	-2.276	8.322	0.743	-6.001	-4.768	-0.075	-0.062	0.259
L12	-0.722	-0.917	3.867*	-10.972*	-2.914	26.438**	23.124**	-2.567*	0.851*	1.722**
CD 5%	1.151	1.984	3.036	9.166	3.253	15.138	12.698	1.984	0.833	1.250
CD 1%	1.523	2.626	4.018	12.132	4.307	20.036	16.806	2.626	1.103	1.654
Testers:										
T1	0.111	0.063	3.867*	1.953	-0.713	4.435*	3.607*	-0.406	-0.377	-0.588*
T2	-0.556	-0.583	2.199	3.421	1.824	1.363	1.803	-0.916	0.203	-0.074
T3	0.444	0.583	-3.632*	-5.373	-1.111	-5.798**	-5.410**	1.322	0.174	0.661*
CD 5%	1.746	1.984	3.492	8.491	2.857	4.206	2.976	1.329	0.496	0.516
CD 1%	2.311	2.626	4.621	11.239	3.781	5.567	3.939	1.759	0.657	0.683

DFT, Days to 50% Tasseling; DFS, Days to 50% Silking; CHL, Chlorophyll content; PH, Plant Height; EH, Ear Height; EWB, Ear Weight with Husk; EW, Ear Weight without Husk; HR, Husk Ratio; EL, Ear Length; EG, Ear Girth

Table 5. General combining ability (gca) effects of parents for yield and yield related traits (Contd.)

SV	NRPE	NKPR	TSS	100KW	SP	CYP	FYP	RS	NRS	TS	ST
Parents											
Lines											
L1	-0.611	-2.194*	-1.713**	-2.471*	-5.617**	-0.410*	-0.757*	-0.253**	-0.425**	-0.677**	-0.690**
L2	-1.278*	-1.194	-0.999**	-3.354**	-4.562**	-0.523**	-0.984**	-0.099	-0.272*	-0.373*	-0.798**
L3	0.722	-0.194	0.367	3.699**	2.753	0.381*	0.740*	0.086	0.225	0.308	-0.133
L4	-0.611	-0.194	-0.523	-1.998	-7.188**	-0.071	-0.435	0.075	0.067	0.141	0.408
L5	0.056	-0.528	1.627**	-3.271**	-2.050	-0.315	-0.586	-0.202**	-0.411**	-0.613**	-0.454
L6	0.722	1.472	1.841**	3.089*	3.368*	0.531**	1.012**	0.358**	0.527**	0.886**	1.859**
L7	-0.611	0.806	-0.333	-3.527**	-1.615	-0.321	-0.578	-0.200**	-0.283*	-0.482**	-0.191
L8	0.722	-0.528	0.811*	2.336	5.468**	0.075	0.128	0.228**	0.342**	0.570**	1.330**
L9	0.722	0.139	-0.986**	3.899**	6.478**	0.276	0.587	0.100	0.265*	0.367*	0.239
L10	-0.611	0.472	-0.133	-1.124	-1.456	-0.136	-0.228	-0.034	0.021	-0.017	-0.737**
L11	0.056	-0.194	-1.159**	-0.264	1.580	-0.133	-0.203	-0.319**	-0.523**	-0.839**	-1.257**
L12	0.722	2.139*	1.201**	2.986*	1.580	0.648**	1.303**	0.260**	0.466**	0.728**	0.423
CD 5%	1.131	2.063	0.694	2.420	3.234	0.357	0.714	0.139	0.238	0.357	0.476
CD 1%	1.497	2.731	0.919	3.203	4.280	0.473	0.945	0.184	0.315	0.473	0.630
Testers:											
T1	-0.444	0.722	0.306	1.204**	0.618	0.101*	0.103	-0.088	-0.074	-0.160	-0.252
T2	0.556	-0.611	-0.184	0.513**	0.733	0.051	0.161	-0.063	-0.034	-0.098	-0.056
T3	-0.111	-0.111	-0.123	-1.718**	-1.352	-0.152**	-0.264**	0.151	0.108	0.259	0.308
CD 5%	0.873	1.032	0.634	0.357	3.214	0.079	0.198	0.218	0.615	0.853	1.368
CD 1%	1.155	1.631	0.840	0.473	4.254	0.105	0.263	0.289	0.814	1.129	1.812

NRPE, Number of Rows Per Ear; NKPR, Number of Kernels per Row; TSS, Total Soluble Solids; 100KW, 100 Kernel Weight; SP, Shelling percentage; CYP, Cob Yield per Plot; FYP, Fodder Yield per Plot; RS, Reducing Sugar; NRS, Non-Reducing Sugar; TS, Total Sugar; ST, Starch

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

UNDER PEER REVIEW

Table 6. Specific combining ability (sca) effects of hybrids for yield and yield related traits

CROSSES	DFT	DFS	CHL	PH	EH	EWH	EW
L1xT1	-1.111**	-1.333**	-0.610	-0.863	-0.190	-12.168**	-10.727**
L1xT2	0.556**	0.250	-2.276*	-0.531	-0.958	6.453*	4.917
L1xT3	0.556**	1.083**	2.885**	1.393	1.148	5.715	5.811*
L2xT1	0.222	-0.333	-3.710**	-4.186	0.120	-3.297	-2.883
L2xT2	-1.111**	-0.750	3.244**	-0.744	-0.678	-2.339	-1.279
L2xT3	0.889**	1.083*	0.465	4.930	0.558	5.636	4.162
L3xT1	-0.111	0.044	-3.846**	-0.159	-0.164	17.872**	15.868**
L3xT2	-0.444*	-0.417	3.298**	-4.528	-1.351	-8.960**	-7.248**
L3xT3	0.556**	0.417	0.549	4.687	1.515*	-8.912**	-8.620**
L4xT1	0.222	1.333**	0.787	-0.479	-0.284	4.408	3.103
L4xT2	-0.111	-0.083	1.021	-4.888	2.089**	3.931	2.717
L4xT3	-0.111	-1.250**	-1.808*	5.367	-1.805*	-8.339**	-5.820*
L5xT1	-1.111**	-1.000*	1.314	5.871*	0.333	-8.343**	-4.721
L5xT2	1.556**	2.583**	-1.362	2.602	0.346	-0.306	-1.677
L5xT3	-0.444*	-1.583**	0.049	-8.473**	-0.679	8.649**	6.398*
L6xT1	-0.444*	-0.333	1.450	-0.729	0.823	9.596**	7.550**
L6xT2	0.222	-0.750	3.014**	-1.098	-0.624	-10.248**	-8.526**
L6xT3	0.222	1.083*	-4.465**	1.827	-0.199	0.652	0.976
L7xT1	0.889**	1.333**	3.917**	-1.119	0.700	-10.159**	-8.222**
L7xT2	0.556**	-0.083	-2.249*	6.102*	-0.698	11.065**	9.642**
L7xT3	-1.444**	-1.250**	-1.668	-4.983	-0.002	-0.906	-1.421
L8xT1	-0.778**	-1.333**	2.954**	-1.919	-3.404**	12.305**	2.516
L8xT2	0.889**	1.250**	-2.092*	8.262**	1.609*	-0.733	3.440
L8xT3	-0.111	0.083	-0.861	-6.343*	1.795*	-11.572**	-5.957*
L9xT1	0.889**	0.333	-0.750	-7.513**	0.776	-0.599	-0.990
L9xT2	-0.444*	-0.083	-1.766	8.059**	-0.941	0.583	0.783
L9xT3	-0.444*	-0.250	2.515**	-0.547	0.165	0.016	0.208
L10xT1	0.889**	1.000*	-0.856	2.394	-0.137	-6.865*	-3.311
L10xT2	-0.444*	-0.417	-0.912	-8.064**	1.096	-4.308	-3.169
L10xT3	-0.444*	-0.583	1.769	5.670*	-0.959	11.172**	6.481*
L11xT1	0.222	0.667	-0.633	7.664**	1.100	-2.350	0.975
L11xT2	-1.111**	-1.750**	-2.269*	-3.614	-0.208	2.852	0.046
L11xT3	0.889**	1.083	2.902**	-4.050	-0.892	-0.502	-1.020
L12xT1	0.222	-0.333	-0.016	1.037	0.326	-0.400	0.842
L12xT2	-0.111	0.250	2.348*	-1.561	0.319	2.009	0.354
L12xT3	-0.111	0.083	-2.331*	0.523	-0.645	-1.610	-1.196
CD 5%	0.417	0.838	1.786	5.615	1.389	5.773	4.940
CD 1%	0.551	1.108	2.363	7.432	1.838	7.642	6.539

DFT, Days to 50% Tasseling; DFS, Days to 50% Silking; CHL, Chlorophyll content; PH, Plant Height; EH, Ear Height; EWH, Ear Weight with Husk; EW, Ear Weight without Husk

Table 6. Specific combining ability (sca) effects of hybrids for yield and yield related traits (Contd.)

CROSSES	HR	EL	EG	NRPE	NKPR	TSS	100KW
L1xT1	2.725**	0.264	-1.469**	-0.222	-1.722**	-0.173	-1.691*
L1xT2	-0.578	0.574**	-0.533*	0.778	0.611	0.127	0.590
L1xT3	-2.147**	-0.838**	2.002**	-0.556	1.111**	0.046	1.101
L2xT1	0.889	-0.156	-1.049**	0.444	0.278	-0.076	-2.287**
L2xT2	-1.423**	-0.386*	-1.023**	-0.556	-1.389**	-0.076	-0.917
L2xT3	0.534	0.542**	2.072**	0.111	1.111**	0.153	3.204**
L3xT1	-1.120*	-0.739**	-0.156	0.444	0.278	-0.033	2.999**
L3xT2	0.140	0.881**	1.310**	-0.556	0.611	2.037**	-1.180
L3xT3	0.980	-0.141	-1.155**	0.111	-0.889**	-2.004**	-1.819**
L4xT1	0.619	-0.483*	-0.902**	-0.222	3.278**	-1.013**	-2.304**
L4xT2	0.559	-0.163	0.614*	0.778	-1.389**	0.257	1.047
L4xT3	-1.179*	0.646**	0.289	-0.556	-1.889**	0.756**	1.258*
L5xT1	-3.337**	-1.206**	0.724**	-0.889*	-0.389	0.487*	-0.411
L5xT2	2.285**	0.174	0.260	0.111	0.944**	-0.103	-0.920
L5xT3	1.052*	1.032**	-0.985**	0.778	-0.556	-0.384	1.331*
L6xT1	0.872	0.781**	0.184	0.444	0.611	0.964**	0.269
L6xT2	0.148	0.601**	-0.390	-0.556	-1.056**	-1.546**	-0.350
L6xT3	-1.020	-1.381**	0.205	0.111	0.444	0.583*	0.081
L7xT1	0.369	-0.036	1.308**	-0.222	-0.722*	0.687**	-2.534**
L7xT2	-2.178**	-0.756**	0.374	0.778	0.611	0.127	3.147**
L7xT3	1.809**	0.792**	-1.681**	-0.556	0.111	-0.814**	-0.613
L8xT1	6.419**	0.934**	0.218	0.444	-0.389	-0.026	3.502**
L8xT2	-3.101**	-0.916**	0.414	-0.556	-0.056	0.464*	-1.747**
L8xT3	-3.319**	-0.018	-0.631*	0.111	0.444	-0.437	-1.756**
L9xT1	0.801	0.194	-0.082	0.444	-1.056**	0.350	0.319
L9xT2	-0.190	0.314	-0.076	-0.556	1.278**	-0.720**	0.700
L9xT3	-0.611	-0.508**	0.159	0.111	-0.222	0.369	-1.019
L10xT1	-3.080**	-0.309	1.298**	-0.222	-0.389	-0.433	0.319
L10xT2	-0.668	-0.089	-0.006	-1.222**	-0.056	-0.443	0.803
L10xT3	3.747**	0.399*	-1.291**	1.444**	0.444	0.876**	-1.019
L11xT1	-4.170**	0.071	0.324	-0.889*	0.278	-0.576*	2.623**
L11xT2	3.452**	-0.039	-0.730**	2.111**	-0.389	0.854**	-0.907
L11xT3	0.718	-0.031	0.405	-1.222**	0.111	-0.277	-1.716**
L12xT1	-0.989	0.687**	-0.399	0.444	-0.056	-0.156	-0.718
L12xT2	1.554**	-0.193	-0.213	-0.556	0.278	-0.976**	-0.267
L12xT3	-0.565	-0.494*	0.612*	0.111	-0.222	1.133**	0.984
CD 5%	1.051	0.377	0.496	0.838	0.645	0.456	1.190
CD 1%	1.392	0.499	0.657	1.108	0.867	0.604	1.576

HR, Husk Ratio; EL, Ear Length; EG, Ear Girth; NRPE, Number of Rows Per Ear; NKPR, Number of Kernels per Row; TSS, Total Soluble Solids; 100KW, 100 Kernel Weight

Table 6. Specific combining ability (sca) effects of hybrids for yield and yield related traits (Contd.)

CROSSES	SP	CYP	FYP	RS	NRS	TS	ST
L1xT1	-2.632**	-0.300**	-0.604**	0.025	-0.071	-0.042	-0.339
L1xT2	3.034**	0.137	0.281*	-0.056	-0.192*	-0.244*	0.235
L1xT3	-0.402	0.163*	0.324*	0.030	0.263**	0.286*	0.104
L2xT1	-1.263	-0.081	-0.137	-0.136**	-0.231**	-0.366**	0.439*
L2xT2	-8.289**	-0.036	-0.094	0.020	0.101	0.122	0.463*
L2xT3	9.552**	0.117	0.231	0.116*	0.130	0.245**	-0.901**
L3xT1	0.279	0.445**	0.801**	-0.170**	-0.421**	-0.591**	-0.393*
L3xT2	1.034	-0.203**	-0.373**	0.189**	0.341**	0.530**	0.098
L3xT3	-1.313	-0.241**	-0.428**	-0.019	0.080	0.060	0.294
L4xT1	0.336	0.086	-0.103	-0.099	-0.130	-0.230	0.453*
L4xT2	0.335	0.076	0.469**	-0.014	0.092	0.078	0.060
L4xT3	-0.671	-0.162*	-0.366**	0.113*	0.037	0.151	-0.513**
L5xT1	-2.875**	-0.132	-0.249	0.161**	0.318**	0.477**	-0.655**
L5xT2	2.297*	-0.047	-0.126	-0.070	-0.083	-0.152	0.119
L5xT3	0.578	0.179*	0.375**	-0.091	-0.235**	-0.325**	0.535**
L6xT1	0.493	0.212**	0.335*	-0.172**	-0.153	-0.328**	-1.011**
L6xT2	-1.670	-0.239**	-0.472**	0.143**	0.439**	0.586**	0.676**
L6xT3	1.177	0.027	0.137	0.029	-0.286**	-0.258*	0.335
L7xT1	-4.056**	-0.230**	-0.352**	-0.158**	-0.340**	-0.494**	-0.028
L7xT2	7.305**	0.270**	0.405**	0.191**	0.259**	0.454**	-0.554**
L7xT3	-3.249**	-0.040	-0.053	-0.033	0.081	0.040	0.582**
L8xT1	7.112**	0.069	0.164	-0.042	-0.018	-0.062	-0.289
L8xT2	-9.253**	0.099	0.206	0.013	0.115	0.126	0.115
L8xT3	2.142*	-0.168*	-0.369**	0.029	-0.097	-0.064	0.174
L9xT1	-0.033	-0.028	0.025	0.275**	0.419**	0.694**	1.282**
L9xT2	2.731**	0.022	-0.007	-0.379**	-0.749**	-1.132**	-0.534**
L9xT3	-2.698**	0.006	-0.018	0.104*	0.330**	0.438**	-0.748**
L10xT1	0.679	-0.092	-0.142	0.190**	0.277**	0.468**	0.227
L10xT2	-1.553	-0.089	-0.210	0.169**	0.229**	0.393**	-0.375*
L10xT3	0.874	0.182*	0.352**	-0.359**	-0.506**	-0.861**	0.148
L11xT1	2.005*	0.028	0.107	-0.016	0.040	0.020	0.557**
L11xT2	6.388**	0.001	-0.048	0.063	-0.314**	-0.362**	-0.875**
L11xT3	-8.393**	-0.029	-0.059	0.063	0.274**	0.341**	0.318
L12xT1	-0.045	0.024	0.156	0.142**	0.311**	0.453**	-0.243
L12xT2	-2.358*	0.010	-0.031	-0.159**	-0.240**	-0.400**	0.572**
L12xT3	2.402*	-0.033	-0.125	0.017	-0.071	-0.053	-0.329
CD 5%	1.964	0.139	0.258	0.100	0.159	0.238	0.357
CD 1%	2.600	0.184	0.341	0.131	0.210	0.315	0.473

SP, Shelling percentage; CYP, Cob Yield per Plot; FYP, Fodder Yield per Plot; RS, Reducing Sugar; NRS, Non-Reducing Sugar; TS, Total Sugar; ST, Starch

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

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Table 7. List of top performing parents based on mean performance and gca.

S. N	Characters	Mean		Gca		Mean and gca	
		Lines	Testers	Lines	Testers	Lines	Testers
1	Ear weight without husk (g)	L ₁₂ (128.8),L ₆ (125.1)	T ₁ (60.4),T ₂ (56.0)	L ₁₂ (23.1**),L ₆ (18.9**)	T ₁ (3.6*)	L ₁₂ ,L ₆	T ₁
2	Ear length (cm)	L ₄ (15.4),L ₈ (14.5)	T ₃ (11.9),T ₂ (11.4)	L ₆ (1.2**),L ₁₀ (1.1**)	-	-	-
3	Ear girth (cm)	L ₃ (14.2),L ₄ (14.1)	T ₂ (9.1),T ₁ (8.6)	L ₁₂ (1.7**),L ₉ (1.5**)	T ₃ (0.6*)	-	-
4	Number of rows per ear	L ₃ (14),L ₄ (14)	T ₁ (10),T ₂ (10)	-	-	-	-
5	Number of kernels per row	L ₇ (20),L ₁₂ (20)	T ₁ (15),T ₃ (15)	L ₁₂ (2.13)	-	L ₁₂	-
6	Total soluble solids (°Bx)	L ₆ (16.2),L ₅ (15.2)	T ₃ (14.1),T ₂ (13.2)	L ₆ (1.8**),L ₅ (1.6**)	-	L ₆ ,L ₅	-
7	100 kernel weight (g)	L ₁₂ (32.6),L ₆ (31.3)	T ₂ (19.4),T ₁ (18.9)	L ₉ (3.9**),L ₃ (3.7**)	T ₁ (1.2**),T ₂ (0.5**)	-	T ₁ ,T ₂
8	Cob yield per plot (kg)	L ₁₂ (3.6),L ₆ (3.5)	T ₁ (1.7),T ₂ (1.6)	L ₁₂ (0.6**),L ₆ (0.5**)	T ₁ (0.1*)	L ₁₂ ,L ₆	T ₁
9	Total sugars (%)	L ₉ (8.1),L ₁₂ (8)	T ₃ (7.7),T ₂ (6.6)	L ₆ (0.5**),L ₁₂ (0.5**)	-	L ₁₂	-

Table 8. List of top performing hybrids based on mean performance and sca.

S.No.	Characters	Mean	Sca	Mean and Sca
1	Ear weight without husk (g)	L ₃ ×T ₁ (113.2),L ₆ ×T ₁ (110.3) L ₁₂ ×T ₁ (107.8),L ₁₂ ×T ₂ (105.5)	L ₃ ×T ₁ (15.9**),L ₇ ×T ₂ (9.6**) L ₆ ×T ₁ (7.6**),L ₁₀ ×T ₃ (6.5**)	L ₃ ×T ₁ , L ₆ ×T ₁
2	Ear length (cm)	L ₆ ×T ₂ (16.1),L ₃ ×T ₂ (15.9) L ₁₀ ×T ₃ (15.8),L ₆ ×T ₁ (15.8)	L ₅ ×T ₃ (1**),L ₈ ×T ₁ (0.9**) L ₃ ×T ₂ (0.9**),L ₆ ×T ₁ (0.8**)	L ₃ ×T ₂ , L ₆ ×T ₁
3	Ear girth (cm)	L ₁₂ ×T ₃ (14.7),L ₂ ×T ₃ (12.9) L ₉ ×T ₃ (14),L ₃ ×T ₂ (14)	L ₂ ×T ₃ (2.1**),L ₁ ×T ₃ (2**) L ₃ ×T ₂ (1.3**),L ₇ ×T ₁ (1.3**)	L ₂ ×T ₃ , L ₃ ×T ₂
4	Number of rows per ear	L ₁₁ ×T ₂ (14),L ₃ ×T ₁ (12) L ₆ ×T ₁ (12),L ₈ ×T ₁ (12)	L ₁₁ ×T ₂ (2.1**),L ₁₀ ×T ₃ (1.4**) L ₅ ×T ₃ (0.8**),L ₇ ×T ₂ (0.8**)	L ₁₁ ×T ₂
5	Number of kernels per row	L ₄ ×T ₁ (21),L ₆ ×T ₁ (20)	L ₄ ×T ₁ (3.3**),L ₉ ×T ₂ (1.3**)	L ₄ ×T ₁
6	Total soluble solids (°Bx)	L ₆ ×T ₁ (17.2),L ₁₂ ×T ₃ (16.3) L ₅ ×T ₁ (16.54),L ₃ ×T ₂ (16.3)	L ₃ ×T ₂ (2**),L ₁₂ ×T ₃ (1.1**) L ₆ ×T ₁ (0.9**),L ₁₀ ×T ₃ (0.9**)	L ₁₂ ×T ₃ , L ₆ ×T ₁
7	100 kernel weight (g)	L ₃ ×T ₁ (30.1),L ₈ ×T ₁ (29.3) L ₉ ×T ₁ (27.6),L ₉ ×T ₂ (27.3)	L ₈ ×T ₁ (3.5**),L ₂ ×T ₃ (3.2**) L ₇ ×T ₂ (3.1**),L ₃ ×T ₁ (3**)	L ₈ ×T ₁ , L ₃ ×T ₁
8	Cob yield per plot (kg)	L ₃ ×T ₁ (3.2),L ₆ ×T ₁ (3.1) L ₁₂ ×T ₁ (3),L ₇ ×T ₂ (2.2)	L ₃ ×T ₁ (0.4**),L ₇ ×T ₂ (0.3**) L ₆ ×T ₁ (0.2**),L ₅ ×T ₃ (0.2**)	L ₃ ×T ₁ , L ₆ ×T ₁ L ₇ ×T ₂

9	Total sugars (%)	L ₆ ×T ₂ (8.9),L ₉ ×T ₃ (8.6) L ₉ ×T ₁ (8.4),L ₃ ×T ₂ (8.2)	L ₉ ×T ₁ (0.7**),L ₆ ×T ₂ (0.6**) L ₃ ×T ₂ (0.5**),L ₅ ×T ₁ (0.5**)	L ₆ ×T ₂ , L ₉ ×T ₁ L ₃ ×T ₂
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