Received: 11 Jan 2022 | Revised: 15 May 2022 | Accepted: 21 May 2022

Electronic Journal of Plant Breeding

Research Article

Identification of promising parental lines and hybrids in sweet corn (*Zea mays L. saccharata*)

Sonal Chavan[1*], D. Bhadru[2], V. Swarnalatha[3] and B. Mallaiah[2]

[1*]Department of Genetics and Plant Breeding, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad-500030.
[2]Maize Research Centre, PJTSAU, Rajendranagar, Hyderabad-500030.
[3]Seed Research and Technology Centre, Rajendranagar, Hyderabad-500030.
***E-Mail**: chavansonal440@gmail.com

Abstract
Information on combining ability and standard heterosis are crucial for the success of any hybrid breeding program. The present study was conducted in sweet corn involving crossing of twenty inbreds as female lines and five inbreds as testers in line × tester mating fashion during *kharif,* 2019. Resulted 100 F_1s were evaluated in *rabi,* 2019-2020 for twelve yields and its attributing traits. Analysis of variance for combining ability revealed the existence of wider variability in the material studied exhibiting significant differences due to lines, testers, hybrids and various interactions. Non-additive gene action was observed pre-dominant for all the traits. Inbreds SCGP-88, SCGP-111, SCGP-36-3-1, SCGP-91, BSL-4, SCGP-44-2, VNR-SC-24, VNR-SC-23, SCGP-66-1 and SCGP-61-1-4 were identified as good general combiners. Crosses *viz.,* SCGP-207-1 × SCGP-44-2, SCGP-54 × VNR-SC-29, SCGP-42 × SCGP-80, SCGP-82 × SCGP-80 and SCGP-66-1 × SCGP-44-2 were identified as promising hybrid combinations based on *per se* performance, *sca* effects and standard heterosis over the commercial checks.

Keywords: Sweet corn, Line x Tester, Hybrids, Combining ability, Heterosis.

INTRODUCTION

Sweet corn (*Zea mays L. saccharata*) (2n=20), is a variety of corn belonging to the family Gramineae, which has arisen as a result of a naturally occurring recessive mutation in the sugary (*su*) gene of the field corn. It has 4 to 8 times the total sugar found in non-mutant corn (Tracy, 2001). It is one of the most popular vegetables and is gaining importance throughout the world in recent times. Sweet corn is consumed at immature grain stages of endosperm twenty days after fertilization and is a rich source of tocopherols, carotenoids, vitamin C and phenolics (Dewanto *et al*., 2002; Ibrahim and Juvik, 2009). In India, low yielding composites (Priya, Madhuri, Win orange, HSC-1 and Punjab sweet corn 1) from the public sector and hybrids (Sugar 75 and Misthi) have been developed by the private sector which are sold to farmers at high cost (Bhadru *et al*., 2020). In order to meet the growing demands for sweet corn and to develop hybrids with early maturity and high yield potential, it is important to select suitable parents for hybridization and to develop promising hybrids. Among the various methods, study of combining ability is very important for identification of parental lines as well as hybrid combinations by obtaining the information on nature of combining ability of the parents and their performances in specific crosses i.e., general combining ability (main effects) and specific combining ability (interaction effects), respectively and by assessing the magnitude of the heterosis.

Most of the authors reported combining ability and heterosis studies in normal corn (Amegbor *et al*., 2020; Bisen *et al*., 2020; Elmyhun *et al*., 2020; Gramaje *et al*., 2020; Kamara *et al*., 2020; Keimeso *et al*., 2020; Khamphasan *et al*., 2020; Onejeme *et al*., 2020; Patil *et al*., 2020; Scaria., 2020; Upreti *et al*., 2020; Yu *et al*., 2020; Abdulazeez *et al*., 2021; Maphumulo *et al*., 2021; Nyombayire *et al*., 2021; Riache*et al*., 2021) and very few authors (Dermail *et al*., 2020; Ravikesavan *et al*., 2020; Vanipraveena *et al*., 2021) pertaining to sweet corn. Keeping up with the demand of sweet corn in the market, development of sweet corn hybrids is need of the hour. Hence, the present study was, therefore, undertaken with a view to estimate general combining ability, specific combining ability and heterosis to develop superior sweet corn hybrids.

MATERIALS AND METHODS

The present investigation in sweet corn was undertaken at Maize Research Centre, Rajendranagar, Hyderabad, situated at 17˚19' North latitude and 79˚23' East longitude. Crossing of 20 sweet corn inbred lines, used as female parents and five sweet corn inbred lines, used as male parents was taken up in Line × Tester mating fashion to obtain 100 F_1 hybrids during *kharif*, 2019. The 100 single cross hybrids, 25 parents and two checks (Madhuri and Sugar 75) were evaluated for yield and yield attributing traits in randomized block design with two replications during *rabi*, 2019-20. Each entry was sown in two rows of four meters length with a spacing of 60 × 20 cm. All the recommended practices were followed to maintain a healthy crop stand in all the entries.

The observations were recorded on twelve yield and yield attributing traits *viz*., days to 50% pollen shed, days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), the number of kernel rows per ear, the number of kernels per row, cob weight with husk (kg/ha), cob weight without husk (kg/ha), total soluble sugars (%) by using brix meter and green fodder yield (kg/ha). The analysis of variance for each character was carried out as per standard statistical procedure described by Panse and Sukhatme (1985), analysis of variance for Line × Tester model given by Singh and Chaudhary (1985), combining ability was as per the method of Kempthorne (1957) and standard heterosis as per Virmani *et al*. (1982). The mean data collected was subjected to statistical analysis using INDOSTAT software version 9.2.

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among the genotypes for all yield and yield attributing traits, indicating the presence of variability in the material studied. Significant differences were reported for parents and crosses indicating the presence of genetic diversity among parents and varying performance of cross combinations. The Line × Tester effects revealed that hybrids differed significantly in their *sca* effects for all traits except for days to 50% pollen shed and plant height. The mean sum of squares for lines was significant and was of higher magnitude than that of testers for all traits indicating that the contribution of lines towards σ^2GCA was greater for all the traits (**Table 1**). The relative magnitude of variance components determines the importance of source of variation and gene action. In Line × Tester analysis, the variance component estimates of SCA specifying non-additive gene action, were greater than the GCA specifying additive gene action for all traits except for plant height, suggesting that genetic variation among crosses was primarily due to non-additive type of gene action, favoring the exploitation of heterosis breeding in sweet corn (**Table 2**). The importance

Table 1. Mean sum of squares from Analysis of variance for yield and yield attributing traits in sweet corn

Source of Variation	d.f.	Mean sum of squares					
		Days to 50% pollen shed	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter
General analysis of all entries including crosses, parents and checks							
Replications	1	0.318	1.137	0.004	0.674	0.45	2.582
Genotypes	126	13.241**	13.039**	870.672**	290.526**	8.541**	3.453**
Error	126	8.517	2.867	284.699	1.828	0.435	0.846
Combining ability analysis							
Parents	24	15.54*	15.54**	301.19	156.94**	8.42**	2.61**
Parents vs. Crosses	1	14.16	9.4	10779.59**	2074.46**	51.76**	0.03
Crosses	99	12.65*	12.53**	926.08**	309.96**	8.25**	3.75**
Lines	19	19.27*	19.28*	3550.79**	1101.44**	15.06**	11.33**
Testers	4	12.32	14.68	826.57*	431.72**	13.25	0.27
Line x tester	76	11.01	10.74**	275.14	105.68**	6.29**	2.04**

Table 1. Continued...

Source of Variation	d.f.	Number of rows per ear	Number of kernels per row	Cob weight with husk	Cob weight without husk	Total soluble sugars	Green fodder yield
General analysis of all entries including crosses, parents and checks							
Replications	1	1.275	2.46	61391.71	23262.56	0.076	181847.6
Genotypes	126	4.565**	37.19**	39297185.992**	40638166.233**	4.705**	54352229.828**
Error	126	0.672	1.341	941113.352	1573414.37	0.249	6578697.765
Combining ability analysis							
Parents	24	3.28**	31.09**	22450695.07**	23236698.15**	2.43**	20161063.15**
Parents vs. Crosses	1	2.3	263.16**	64448622.76**	71564603.61**	21.78**	788233476.85**
Crosses	99	4.94**	36.96**	43806369.73**	45245969.16**	5.15**	56102816.26**
Lines	19	8.23*	86.78**	123106996.15**	130763927.80**	16.23**	194206675.25**
Testers	4	6.92	44.89	12955537.63	12516840.3	1.84	49820899.49
Line x tester	76	4.01**	24.09**	25604941.14**	25589065.23**	2.55**	21907476.11**

*, ** Significant at 5 and 1 per cent levels, respectively.

Table 2. Estimation of GCA and SCA variance for yield and yield attributing traits in sweet corn

	Days to 50% pollen shed	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Number of rows per ear	Number of kernels per row	Cob weight with husk	Cob weight without husk	Total soluble sugars	Green fodder yield
σ^2GCA	0.28	0.56	76.08	30.59	0.54	0.19	0.27	2.58	2684640.4	2803442.3	0.35	4618302
σ^2SCA	1.19	3.91	-5.75	51.92	2.92	0.59	1.67	11.38	12344842	12017369	1.15	7675619.8
σ^2D	0.28	0.56	76.08	30.59	0.54	0.19	0.27	2.58	2684640.4	2803442.3	0.35	4618302
σ^2H	1.19	3.91	-5.75	51.92	2.92	0.59	1.67	11.38	12344842	12017369	1.15	7675619.8
Degree of dominance	1.4	1.86	0.19	0.92	1.63	1.22	1.74	1.48	1.51	1.46	1.28	0.91

of non-additive gene action was also confirmed by the findings of Sadaiah (2011), Kumara *et al*. (2013), Worrajinda *et al*. (2013), Chinthiya *et al*. (2019) and Ravikesavan *et al*. (2020) in sweet corn, Bisen *et al*. (2020) in maize and Scaria *et al*. (2020) in quality protein maize.

General combining ability (*gca*) effects were analyzed that enable the breeder in identifying parents with the ability to transmit their desirable characters to the offspring as additive gene effects prevail in these offspring. Inbred SCGP-111 was reported to be the best general combiner with significantly highest positive *gca* for the traits directly contributing for high yields such as cob weight with and without husk, ear length and the number of kernels per row, making it a suitable parent to use in further high yielding hybrid breeding programmes. The highest significant negative *gca* was exhibited by VNR-SC-7 for days to 50% pollen shed, SCGP-88 for days to 50% silking and SCGP-82 for plant height and ear height, suitable as parents for production of short duration and lodging resistant hybrids. The inbred SCGP-61-1-4 for ear diameter, SCGP-114-1 for the number of kernel rows per ear, SCGP-207 for total soluble sugars and SCGP-66-1 for green fodder yield recorded the highest significant positive *gca* as desirable for these traits. Out of twelve characters studied, the inbred SCGP-88 was identified as a good general combiner for ten traits followed by SCGP-111 for eight traits.

Specific combining ability (*sca*) effects that provide information about the hybrid performance for identifying promising hybrid combinations as non-additive gene effects prevail in these combinations due to large or minor gene effects were analyzed for all the cross combinations. Out of 100 crosses obtained, 33 hybrids exhibited significant positive *sca* effects for cob weight with husk, among which cross BSL-4 × SCGP-80 recorded a high *sca* effect for this trait suggesting it as a better specific combiner for high yield. The cross SCGP-82 × VNR-SC-23 for ear length, SCGP-207-1 × VNR-SC-29 for ear diameter, SCGP-2 × SCGP-44-2 for the

Table 3. Top crosses with high *sca* effects and mean performance for each trait and respective *gca* effects of their parents for yield and its attributing traits.

Crosses	Mean performance	*sca* effects	*gca* effects		*gca* status
			Line	Tester	
Days to 50% pollen shed					
SCGP-114-1 x SCGP-80	69	-4.21*	1.085	-0.19	LXL
Days to 50% silking					
SCGP-2 x VNR-SC-23	77	-4.09**	1.415**	0.19	LXL
SCGP-114-1 x SCGP-80	72	-4.065**	1.215*	-0.135	LXL
SCGP-111 x SCGP-210-2	76	-3.89**	-0.485	0.39	LXL
SCGP-82 x SCGP-80	76	-3.365**	-0.485	-0.135	LXL
BSL-4 x SCGP-44-2	73	-2.915*	2.415**	-0.985**	LXH
Ear length					
SCGP-82 x VNR-SC-23	16	3.846**	-1.990**	0.795**	LXH
SCGP-207-1 x VNR-SC-29	17	2.744**	1.198**	-0.776**	HXL
SCGP-66-1 x SCGP-44-2	18	2.643**	-0.889**	0.222*	LXH
SCGP-88 x SCGP-44-2	18	2.0829**	1.911**	0.222*	HXH
SCGP-61-1-4 x SCGP-80	20	1.907**	1.006**	-0.197	HXL
Number of kernel rows per ear					
SCGP-82 x VNR-SC-23	16	3.846**	-1.990**	0.795**	LXH
SCGP-207-1 x VNR-SC-29	17	2.744**	1.198**	-0.776**	HXL
SCGP-66-1 x SCGP-44-2	16	2.643**	-0.889**	0.222*	LXH
SCGP-88 x SCGP-44-2	16	2.0829**	1.911**	0.222*	HXH
SCGP-61-1-4 x SCGP-80	16	1.907**	1.006**	-0.197	HXL
Cob weight with husk					
VNR-SC-24 x SCGP-44-2	24241	7004.538**	4163.824**	516.266**	HXH
SCGP-207-1 x VNR-SC-29	24558	6705.287**	-2031.244**	-820.716**	LXL
SCGP-66-1 x SCGP-44-2	27323	4103.128**	3815.654**	516.266**	HXH
SCGP-207-1 x SCGP-44-2	33438	3785.806**	-2031.244**	516.266**	LXH
SCGP-54 x VNR-SC-29	29173	2915.121**	-2705.258**	-820.716**	LXL
Total soluble sugars					
SCGP-2 x VNR-SC-29	16.9	2.633**	-1.648**	0.217**	LXH
SCGP-36-3-1 x SCGP-44-2	17.5	1.615**	0.462**	-0.125	HXL
SCGP-61-1-4 x VNR-SC-29	17.7	1.543**	0.242	0.217**	LXH
VNR-SC-12 x SCGP-44-2	18.3	1.485**	1.542**	-0.125	HXL
SCGP-207 x SCGP-210-2	17.1	1.070**	1.642**	-0.06	HXL
Plant height					
BSL-4 x SCGP-44-2	196	-24.032*	0.038	1.451	LXL
Ear height					
SCGP-114-1 x VNR-SC-29	53	-13.636**	0.915	-4.489**	LXH
SCGP-91 x VNR-SC-23	59	-12.894**	12.983**	-0.464*	LXH
SCGP-207-1 x SCGP-80	47	-10.798**	1.739**	-1.401**	LXH
SCGP-111 x VNR-SC-29	46	-10.213**	17.597**	-4.489**	LXH
SCGP-91 x VNR-SC-29	56	-6.369**	12.983**	-4.489**	LXH
Ear diameter					
SCGP-207-1 x VNR-SC-29	14	2.076**	0.284	0.001	LXL
SCGP-111 x VNR-SC-29	13	1.745**	0.785**	0.001	HXL
SCGP-66-1 x SCGP-80	12	1.589*	0.846**	0.096	HXL
BSL-4 x VNR-SC-23	14	1.473*	-0.974**	0.018	LXL
SCGP-82 x SCGP-80	16	1.404*	-2.283**	0.096	LXL
Number of kernels per row					
SCGP-36-2-1 x VNR-SC-29	30	10.795**	-3.695**	-1.095**	LXL
SCGP-82 x VNR-SC-23	29	6.62**	-3.995**	1.38**	LXH
SCGP-2 x VNR-SC-23	34	4.12**	-3.995**	1.38**	LXH
BSL-4 x SCGP-210-2	39	4.02**	2.005**	-0.52**	HXL
SCGP-66-1 x SCGP-44-2	36	3.845**	-0.695	0.855**	LXH
Cob weight without husk					
SCGP-36-2-1 x VNR-SC-29	20177	6972.770**	-3886.332**	-773.622**	LXL
SCGP-207-1 x VNR-SC-29	21393	6388.478**	-1954.900**	-773.622**	LXL
SCGP-66-1 x SCGP-44-2	23475	4217.677**	3924.650**	441.908*	HXH
SCGP-207-1 x SCGP-44-2	30083	3657.427**	-1954.900**	441.908*	LXH
SCGP-54 x VNR-SC-29	25467	2771.38**	-3252.382**	-773.622**	LXL
Green fodder yield					
SCGP-207-1 x VNR-SC-29	38161	7057.32**	-3863.563**	-1428.158**	LXL
VNR-SC-24 x SCGP-44-2	38932	5852.802**	6389.878**	855.652*	HXH
SCGP-111 x SCGP-210-2	33126	5479.777**	7337.935**	-980.998*	LXH
BSL-4 x SCGP-80	42289	4570.402*	2882.293**	920.402*	HXH
SCGP-36-3-1 x SCGP-80	39624	4451.355*	3596.661**	920.402*	HXH

*, ** Significant at 5 and 1 per cent levels respectively.

number of kernel rows per ear, SCGP-36-2-1 × VNR-SC-29 for the number of kernels per row, VNR-SC-24 × SCGP-44-2 for cob weight without husk, SCGP-2 × VNR-SC-29 for total soluble sugars and SCGP-66-1 × VNR-SC-29 for green fodder yield recorded highest significant *sca* effects. Whereas, the cross SCGP-114-1 × SCGP-80 for days to 50% pollen shed, SCGP-2 × VNR-SC-23 for days to 50% silking, BSL-4 × SCGP-44-2 for plant height, SCGP-114-1 × VNR-SC-29 for ear height showed the highest negative *sca* effects as desirable for these traits making them best specific combiners for these traits (**Table 3**). Based on the specific combining ability, VNR-SC-24 × SCGP-44-2, SCGP-207-1 × VNR-SC-29, SCGP-66-1 × SCGP-44-2, SCGP-207-1 × SCGP-44-2 and SCGP-54 × VNR-SC-29 were identified to exhibit a high specific combining ability. Thus, the crosses with high *sca* effects along with mean performance and heterosis form a crucial criterion for the selection of hybrids due to predominance of non-additive gene action in these cross combinations.

Similar results for yield and yield attributing traits were reported in maize by Bisen *et al*. (2020), Elmyhun *et al*. (2020), Kamara *et al*. (2020), Keimeso *et al*. (2020), Onejeme *et al*. (2020) and in sweet corn by Kumari *et al*. (2008), Worrajinda *et al*. (2013), Kumara *et al*. (2013), Elayaraja *et al*. (2018) and Chinthiya *et al*. (2019), Ravikesavan *et al*. (2020) and Vanipraveena *et al*. (2021).

The best check for most of the traits was Sugar 75

Table 4. Top crosses exhibiting high heterosis percentage over the checks for yield and its attributing traits (in per cent)

Crosses	Standard heterosis (Madhuri)	Standard heterosis (Sugar 75)	Crosses	Standard heterosis (Madhuri)	Standard heterosis (Sugar 75)
Days to 50 percent pollen shed			**Days to 50 percent silking**		
SCGP-2 x SCGP-44-2	-2.14	-8.05*	SCGP-2 x SCGP-44-2	-2.72	-7.74**
Plant height			Ear height		
SCGP-2 x SCGP-80	-15.7	-17.01	SCGP-82 x VNR-SC-29	-43.18**	-42.81**
SCGP-91 x SCGP-44-2	-14.87	-16.19	SCGP-88 x VNR-SC-29	-35.34**	-34.93**
SCGP-114-1 x SCGP-44-2	-12.15	-13.51	SCGP-207 x VNR-SC-29	-30.46**	-30.02**
SCGP-82 x VNR-SC-29	-10.86	-12.25	SCGP-111 x VNR-SC-29	-29.89**	-29.44**
SCGP-88 x VNR-SC-29	-10.83	-12.21	SCGP-207-1 x SCGP-80	-28.03**	-27.56**
Ear length			**Ear diameter**		
SCGP-54 x SCGP-44-2	16.24**	15.1**	SCGP-82 x SCGP-80	19.95**	14.86*
SCGP-61-1-4 x SCGP-80	14.42**	13.3**	VNR-SC-12 x VNR-SC-23	19.95**	14.86*
BSL-4 x VNR-SC-23	14.09**	12.97**	SCGP-2 x VNR-SC-29	18.69**	13.65*
VNR-SC-12 x VNR-SC-23	13.87**	12.75**	SCGP-207 x SCGP-210-2	17.14*	12.17
SCGP-207 x SCGP-210-2	13.05**	11.94**	SCGP-36-2-1 x SCGP-44-2	15.96*	11.04
Number of kernel rows per cob			**Number of kernels per row**		
SCGP-2 x VNR-SC-29	35.71**	26.66**	VNR-SC-7 x SCGP-80	41.37**	24.24**
SCGP-61-1-4 x VNR-SC-29	35.71**	26.66**	SCGP-61-1-4 x SCGP-210-2	36.2**	19.69**
SCGP-88 x SCGP-80	35.71**	26.66**	BSL-4 x SCGP-210-2	36.2**	19.69**
SCGP-83-1 x SCGP-210-2	28.57**	20**	SCGP-36-3-1 x VNR-SC-23	34.48**	18.18**
SCGP-54 x SCGP-210-2	28.57**	20**	BSL-4 x SCGP-80	32.75**	16.66**
Cob weight with husk			**Cob weight without husk**		
SCGP-207-1 x SCGP-44-2	66.11**	42.44**	SCGP-207-1 x SCGP-44-2	83.87**	51.98**
SCGP-61-1-4 x SCGP-210-2	57.91**	35.41**	SCGP-61-1-4 x SCGP-210-2	77.8**	46.97**
BSL-4 x VNR-SC-29	52.87**	31.09**	BSL-4 x VNR-SC-29	64.87**	36.28**
SCGP-82 x SCGP-44-2	49.96**	28.6**	SCGP-82 x SCGP-44-2	61.86**	33.79**
SCGP-91 x SCGP-80	48.74**	27.55**	SCGP-91 x SCGP-80	58.87**	31.32**
Total soluble sugars			**Green fodder yield**		
SCGP-2 x VNR-SC-23	11.91**	18.09**	SCGP-207-1 x SCGP-44-2	43.55**	38.41**
SCGP-114-1 x SCGP-44-2	9.88**	15.95**	SCGP-61-1-4 x SCGP-210-2	39.92**	34.91**
SCGP-36-3-1 x SCGP-210-2	8.43**	14.41**	SCGP-207-1 x SCGP-80	35.6**	30.75**
SCGP-91 x SCGP-80	6.97*	12.88**	SCGP-61-1-4 x SCGP-44-2	35.56**	30.71**
SCGP-114-1 x VNR-SC-23	6.39*	12.26**	BSL-4 x VNR-SC-29	34.45**	29.64**

*, ** Significant at 5 and 1 per cent levels respectively.

except for the traits viz., days to 50% pollen shed, days to 50% silking, plant height, ear height and total soluble sugars for which check Madhuri was reported as best check. The highest significant positive heterosis over commercial check was exhibited by the cross SCGP-207-1 × SCGP-44-2 for the traits cob weight with husk (42.44%), cob weight without husk (51.98%) and green fodder yield (38.41%). Cross SCGP-54 × SCGP-44-2 (15.10%) for ear length, SCGP-82 × SCGP-80 (14.86%) for ear diameter, SCGP-2 × VNR-SC-29 (26.66%) for the number of kernel rows per ear, VNR-SC-7 × SCGP-80 (24.24%) for the number of kernels per row and SCGP-2 × VNR-SC-23 (11.91%) for total soluble sugars recorded highest significant positive heterosis over their respective best check as desirable for these traits. Hybrids with early maturity and short plant height and ear height were desirable in the present study and thus heterosis was desirable in negative direction for these traits. No hybrid recorded significant negative heterosis over the best check for the traits days to 50% pollen shed, days to 50% silking and plant height. For 46 hybrids recorded significant negative heterosis among which SCGP-82 × VNR-SC-29 (-43.18%) recorded the highest heterosis (**Table 4**). Significant standard heterosis for different yield and yield attributing traits were reported by Sadaiah *et al.* (2011), Kumar *et al.* (2013), Jha *et al.* (2013), Kumara *et al.* (2013), Dagla *et al.* (2014) and Chozin *et al.* (2018) in sweet corn and by Bisen *et al*. (2020) and Onejeme *et al*. (2020) in maize.

The inbreds SCGP-88, SCGP-111, SCGP-36-3-1, SCGP-91, BSL-4, SCGP-44-2, VNR-SC-24, VNR-SC-23, SCGP-66-1 and SCGP-61-1-4 were identified as good general combiners for cob weight with husk and other yield attributing traits. These parental lines can be used in future breeding programmes to realize high yielding hybrids as well as for the development of transgressive segregants.

The crosses exhibiting significant standard heterosis, high *sca* effects and *per se* performance for yield are presented along with the *gca* effects of parents in **Table 5**. The order of crosses with significant *sca* was high × low > low × low > high × high. In majority of the crosses, high *sca* was either due to high × low or low × low combining parents, which substantiates the role of non-additive gene action (additive × dominance

Table 5. *Per se* performance, *sca* effects, *gca* effects and *gca* status of crosses exhibiting significant standard heterosis for yield

S.No.	Hybrids	cob weight with husk						
		Mean yield (kg/ha)	*sca* effects	*gca* effects		Standard heterosis (%)		*gca* status
				Line	Tester	Madhuri	Sugar 75	
1	SCGP-207-1 x SCGP-44-2	33438	3786**	-2031**	516**	66.11**	42.44**	L × H
2	SCGP-61-1-4 x SCGP-210-2	31787	-1927**	2911**	-128	57.91**	35.41**	H × L
3	BSL-4 x VNR-SC-29	30772	-2498**	1292**	-821**	52.87**	31.09**	H × L
4	SCGP-82 x SCGP-44-2	30188	-2298**	-7127**	516**	49.96**	28.6**	L × H
7	SCGP-54 x VNR-SC-29	29173	2915**	-2705**	-821**	44.92**	24.27**	L × L
8	SCGP-42 x SCGP-80	29073	2679**	3293**	-134	44.42**	23.85**	H × L
9	SCGP-82 x SCGP-80	28206	1551*	-7127**	-134	40.12**	20.16**	L × L
11	SCGP-83-1 x SCGP-80	27591	-1434*	-5874**	-134	37.06**	17.53**	L × L
13	SCGP-66-1 x SCGP-44-2	27323	4103**	3816**	516**	35.73**	16.39**	H × H
14	VNR-SC-7 x SCGP-80	27239	-4407**	-1468**	-134	35.32**	16.04**	L × L
15	SCGP-36-2-1 x VNR-SC-23	27057	-1514*	-3863**	567**	34.41**	15.26**	L × H
18	BSL-4 x VNR-SC-23	26691	1562*	1292**	567**	32.59**	13.7**	H × H
19	SCGP-118 x VNR-SC-23	26423	-3691**	-943**	567**	31.26**	12.56**	L × H
20	SCGP-54 x SCGP-210-2	26373	2023**	-2705**	-128	31.01**	12.35**	L × L
21	SCGP-66-1 x VNR-SC-23	26356	3753**	3816**	567**	30.93**	12.28**	H × H
24	VNR-SC-12 x SCGP-44-2	26190	-2219**	-2191**	516**	30.1**	11.57**	L × H
25	SCGP-88 x SCGP-80	26125	-3133**	3489**	-134	29.78**	11.29**	H × L
26	SCGP-83-1 x VNR-SC-29	25840	-1780**	-5874**	-821**	28.37**	10.08*	L × L
27	SCGP-83-1 x SCGP-44-2	25740	2065**	-5874**	516**	27.87**	9.65*	L × H
28	SCGP-2 x VNR-SC-29	25606	-5835**	-2552**	-821**	27.2**	9.08*	L × L

*, ** Significant at 5 and 1 per cent levels, respectively.

Table 6. Top five crosses obtained in the study based on *sca* effects, standard heterosis over commercial check Sugar 75 and *gca* effects of their respective inbred lines

Top five Hybrids based on *per se* performance	*sca* effects for cob weight with husk	*gca* effects for cob weight with husk		Standard heterosis (%)					
		Line	Tester	Days to 50% pollen shed	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter
SCGP-207-1 x SCGP-44-2	3786**	-2031**	516**	-1.34	-2.58	4.64	-7.56**	-8.5*	-1.06
SCGP-54 x VNR-SC-29	2915**	-2705**	-821**	-5.36	-5.16*	7.57	18.63**	2.67	5.87
SCGP-42 x SCGP-80	2679**	3293**	-134	-5.36	-5.16*	12.69	24.07**	1.74	-1.98
SCGP-82 x SCGP-80	1551*	-7127**	-134	-1.34	-1.93	4.82	-2.66	-5.34	14.86*
SCGP-66-1 x SCGP-44-2	4103**	3816**	516**	-5.36	-5.16*	24.05*	31.13**	0.21	5.37

Table 6. Continued...

Top five Hybrids based on *per se* performance	*sca* effects for cob weight with husk	*gca* effects for cob weight with husk		Standard heterosis (%)					
		Line	Tester	Number of rows per ear	Number of kernels per row	Cob weight with husk	Cob weight without husk	Total soluble sugars	Green fodder yield
SCGP-207-1 x SCGP-44-2	3786**	-2031**	516**	13.33*	-3.03	42.44**	51.98**	-3.68	38.41**
SCGP-54 x VNR-SC-29	2915**	-2705**	-821**	20**	12.12**	24.27**	28.66**	-0.92	21.65**
SCGP-42 x SCGP-80	2679**	3293**	-134	6.66	6.06	23.85**	27.94**	-3.37	26.95**
SCGP-82 x SCGP-80	1551*	-7127**	-134	13.33*	-6.06	20.16**	24.28**	1.22	18.19*
SCGP-66-1 x SCGP-44-2	4103**	3816**	516**	0	9.09*	16.39**	18.6**	0.61	18.29*

*, ** Significant at 5 and 1 per cent levels, respectively.

and dominance × dominance epistatic interaction). The predominance of non-additive gene action is ideal for the exploitation of heterosis breeding and as a majority of the crosses had predominance of non-additive gene action, so yield can be improved by following heterosis breeding.

Based on *per se* performance, *sca* effects and standard heterosis over commercial check (sugar 75) crosses *viz.,* SCGP-207-1 × SCGP-44-2, SCGP-54 × VNR-SC-29, SCGP-42 × SCGP-80, SCGP-82 × SCGP-80 and SCGP-66-1 × SCGP-44-2 have been identified as promising hybrids for cob weight with husk and other important yield attributing traits (**Table 6**).

The genotypes under the present study were identified to be better performing inbred lines with desirable *gca* effects, cross combinations with desirable *sca* effects, heterosis over standard checks and good *per se* performance. Thus, the inbred lines can be successfully used for future breeding programs for the improvement of yield in sweet corn.

ACKNOWLEDGEMENT

The first author acknowledges the receipt of financial help in the form of a stipend from Professor Jayashankar Telangana State Agricultural University, Telangana during her course of Post Graduate Degree programme.

REFERENCES

Abdulazeez, S.D., Kakarash, S.A. and Ismael, N.B. 2021. Estimation of heterosis and combining ability for yield, yield component using line× tester methods in maize (*Zea Mays* L.), In *IOP Conference Series: Earth and Environmental Science.,* **761**: 012083. [Cross Ref]

Amegbor, I.K., Badu-Apraku, B., Adu, G.B., Adjebeng-Danquah, J. and Toyinbo, J. 2020. Combining ability of extra-early maize inbreds derived from a cross between maize and *Zea diploperennis* and hybrid performance under contrasting environments, *Agronomy.*, **10**(8): 1069. [Cross Ref]

Bhadru, D., Mallaiah, B., Swarnalatha, V. and Anuradha, G. 2020. Selection of characters through estimation of tion of genetic parameters arameters, association and path analysis in sweet corn (*Zea mays L. saccharata*), *The Bioscan*., **15**(4): 495-499.

Bisen, V., Yadav, M.S., Verma, V., Gathiye, G.S. and Kewte, D., 2020. Heterosis and combining ability through diallel method in maize (*Zea mays* L.), *Journal of Pharmacognosy and Phytochemistry*., **9**(1): 1986-1994.

Chinthiya, A., Ganesan, K., Ravikesavan, R. and Senthil, N. 2019. Combining ability and association studies on different yield contributing traits for enhanced green cob yield in sweet corn (*Zea mays con Var saccharata*), *Electronic Journal of Plant Breeding*., **10**(2): 500-511. [Cross Ref]

Chozin, M., Sudjatmiko, S., Fahrurrozi, F., Setyowati, N. and Muktamar, Z. 2018. Hybrid performances and heterosis in sweet corn as grown under organic crop management in tropical highland climate, *International Journal of Agricultural Technology*., **14**(6): 815-832.

Dagla, M.C., Gadag, R.N., Kumar, N.S., Ajay, B.C and Ram, C. 2014. A potential scope of sweet corn for Peri-Urban farmers in India, *Popular Kheti.,* **2**(1): 69-73.

Dermail, A., Suriharn, B., Chankaew, S., Sanitchon, J. and Lertrat, K. 2020. Hybrid prediction based on SSR-genetic distance, heterosis and combining ability on agronomic traits and yields in sweet and waxy corn. *Scientia Horticulturae*., **259**: 108817. [Cross Ref]

Dewanto, V., Wu, X. and Liu, R.H. 2002. Processed sweet corn has higher antioxidant activity, *Journal of Agriculture and Food Chemistry*., **50**(14): 4959-4964. [Cross Ref]

Elayaraja, K., Gadag, R.N., Kumari, J.R and Mishra, U. 2018. Combining ability and gene action in experimental hybrids of sweet corn (*Zea mays var. saccharata*), *Indian Journal of Horticulture*., **75**(1): 64. [Cross Ref]

Elmyhun, M., Liyew, C., Shita, A. and Andualem, M. 2020. Combining ability performance and heterotic grouping of maize (*Zea mays*) inbred lines in testcross formation in Western Amhara, North West Ethiopia, *Cogent Food & Agriculture*., **6**(1): 1727625. [Cross Ref]

Gramaje, L.V., Caguiat, J.D., Enriquez, J.O.S., Dela Cruz, Q.D., Millas, R.A., Carampatana, J.E. and Tabanao, D.A.A. 2020. Heterosis and combining ability analysis in CMS hybrid rice, *Euphytica*., **216**(1): 1-22. [Cross Ref]

Ibrahim, K.E. and Juvik, J.A. 2009. Feasibility for improving phytonutrient content in vegetable crops using conventional breeding strategies: Case study with carotenoids and tocopherols in sweet corn and broccoli, *Journal of Agricultural and Food Chemistry*., **57**(11): 4636-4644. [Cross Ref]

Jha, S. K., Singh, N. K. and Agrawal, P. K. 2013. Studies on exploitable heterosis in sweet corn under assured rainfed situation of North-Western Himalayas, *Karnataka Journal of Agricultural Sciences*., **26**: 308-10.

Kamara, M.M., Rehan, M., Ibrahim, K.M., Alsohim, A.S., Elsharkawy, M.M., Kheir, A., Hafez, E.M. and El-Esawi, M.A. 2020. Genetic diversity and combining ability of white maize inbred lines under different plant densities, *Plants*., **9**(9): 1140. [Cross Ref]

Keimeso, Z., Abakemal, D. and Gebreselassie, W. 2020. Heterosis and combining ability of highland adapted maize (*Zea mays.* L) DH lines for desirable agronomic traits, *African Journal of Plant Science*., **14**(3): 121-133. [Cross Ref]

Kempthorne, O. 1957. An introduction to genetic statistics. John Willey and Sons Inc. New York.

Khamphasan, P., Lomthaisong, K., Harakotr, B., Scott, M.P., Lertrat, K. and Suriharn, B. 2020. Combining ability and heterosis for agronomic traits, husk and cob pigment concentration of maize, *Agriculture*., **10**(11): 510. [Cross Ref]

Kumar, R., Shahi, J.P and Srivastava, K. 2013. Estimation of heterosis in field corn and sweet corn at marketable stage, *The Bioscan*., **8** (4): 1165-1170.

Kumara, B., Ganesan, K.N., Nallathambi, G. and Senthil, N. 2013. Heterosis of single cross sweet corn hybrids developed with inbreds of domestic genepool, *Madras Agricultural Journal*., **100**: 52-56.

Kumari, J., Gadag, R.N. and Jha, G.K. 2008. Combining ability and heterosis in field x sweet corn hybrids using line by tester mating design, *Indian Journal of Agricultural sciences*., **78** (3): 261-264.

Maphumulo, S., Derera, J., Sibiya, J. and Mathew, I. 2021. Combining ability, gene action and heterosis analyses of maize lines that were developed for maize streak virus resistance and acidic soil tolerance, *Euphytica*., **217**(2): 1-18. [Cross Ref]

Nyombayire, A., Derera, J., Sibiya, J. and Ngaboyisonga, C. 2021. Heterotic groups, gene action and heterosis among maize inbred lines selected for the major agro-ecologies of rwanda, *Journal of Plant Sciences*., **9**(5): 245-252. [Cross Ref]

Onejeme, F.C., Okporie, E.O. and Eze, C.E. 2020. Combining ability and heterosis in diallel analysis of maize (*zea mays* l.) lines, *international annals of science*., **9**(1): 188-200. [Cross Ref]

Panse, V.G. and Sukhatme, P.V. 1985. Statistical methods for Agricultural workers, Indian council of Agricultural Research, New Delhi.

Patil, M.S., Motagi, B.N. and Kachapur, R.M. 2020. Heterosis and combining ability studies in maize (*Zea mays* L.) for drought tolerance, TLB disease resistance and productivity in Northern dry tract of Karnataka, *Int. J. Curr. Microbiol. App. Sci.*, **9**(10): 1054-1064. [Cross Ref]

Ravikesavan, R., Suhasini, B., Yuvaraja, A. and Kumari Vinodhana, N. 2020. Assessment of combining ability for yield and yield contributing traits in sweet corn, *Electronic Journal of Plant Breeding.*, **11**(01): 224-229. [Cross Ref]

Riache, M., Revilla, P., Maafi, O., Malvar, R.A. and Djemel, A. 2021. Combining ability and heterosis of algerian saharan maize populations (*Zea mays* L.) for tolerance to no-nitrogen fertilization and drought, *Agronomy.*, **11**(3): 492. [Cross Ref]

Sadaiah, K. 2011. Heterosis and combining ability studies in sweet corn (*Zea mays* L. *saccharata*). *M. Sc.(Ag.) Thesis*. Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad.

Scaria, S. 2020. Genetic evaluation of quality protein maize hybrids for heterosis and combining ability for grain yield and its component characters, *Journal of Pharmacognosy and Phytochemistry*, **9**(2): 1101-1105.

Singh, R.K. and Chaudhary, B.D. 1985. Biometrical Methods in Quantitative Genetic Analysis. *Kalayani Publishers*, New Delhi, India. 318.

Tracy, W.F. 2001. Sweet corn. In: Hallauer, A.R. (ed.) *Speciality Corns*, second edition. CRC Press, Boca Raton, Florida. 155-197. [Cross Ref]

Upreti, J., Acharya, P., Upadhyaya, J. and Shrestha, J. 2020. Heterosis in maize hybrids at farmer's field in Dang district of Nepal, *Fundamental and Applied Agriculture.*, **5**(2): 188-193. [Cross Ref]

Vanipraveena, M., Talekar, S., Kachapur, R.M. and Harlapur, S. 2021. Elite general and specific combiners for high sugar content and green ear yield in sweet corn (*Zea mays L. saccharata*), *J. Farm Sci.*, **34**(1): 10-14.

Virmani, S.S., Aquino, R.O. and Khush, G.S. 1982. Heterosis breeding in rice (*Oryza sativa* L.), *Theoretical and Applied Genetics.*, **63**: 373-380. [Cross Ref]

Worrajinda, J., Lertrat, K. and Suriharn, B. 2013. Combinig ability of super sweet corn inbred lines with different ear sizes for ear number and whole ear weight, *SABRAO Journal of Breeding and Genetics.*, **45** (3): 468- 477.

Yu, K., Wang, H., Liu, X., Xu, C., Li, Z., Xu, X., Liu, J., Wang, Z. and Xu, Y. 2020. Large-scale analysis of combining ability and heterosis for development of hybrid maize breeding strategies using diverse germplasm resources, *Frontiers in plant science.*, **11**: 660. [Cross Ref]