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RESEARCH PAPER

Assessment of combining ability and gene action for enhancing green cob yield and related traits in sweet corn

Vijay B. Bhutiya[1] · Manish B. Patel[2] · P. K. Parmar[2]

Abstract The present study was carried out to determine the combining ability and gene action of sweet corn inbred lines and their hybrids and to ascertain the association between different biometrical and quality traits for increased green cob yield in sweet corn (*Zea mays* L. *saccharata*). An investigation was conducted during *rabi* 2023-24 at MMRS, AAU, Godhra and evaluated 13 parental lines and their 42 hybrids using a randomized complete block design. The analysis of variance for combining ability indicated that the ratio of $\sigma^2_{gca}/\sigma^2_{sca}$ was less than unity for all the studied traits except fodder weight per plant, total soluble sugar and reducing sugar which indicated the preponderance of non-additive gene action. Regarding GCA for green cob weight without husk per plant, female parent I07-62-3-2 and male parent 1820196-1 were excellent, with 182097 also being a good general combiner for multiple traits. Among 42 hybrids, nine and nine hybrids depicted a positive significant SCA effect for green cob weight without husk per plant and total soluble sugar, respectively.

Keywords: GCA · Green cob yield · SCA · Sweet corn · Line × tester analysis

✉ Vijay B. Bhutiya: rsmaize@aau.in

[1]Department of Genetics and Plant Breeding, BACA, Anand Agricultural University, Anand-388110, Gujarat, India

[2]Main Maize Research Station, Anand Agricultural University, Godhra, Gujarat-389001, India

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Introduction

Maize (*Zea mays* L.) is a widely cultivated crop around the world, known for its exceptional ability to thrive in diverse environmental conditions. In India, it ranks as the third most important cereal crop, following rice and wheat. Due to its impressive genetic potential for high yields, maize is often referred to as the "Queen of Cereals." Recent trends indicate a shift among maize farmers towards the cultivation of specialty corn with high remuneration and it creates additional employment for people, especially in urban areas.

Among these specialty corns, sweet corn (*Zea mays* L. *saccharata*) offers excellent economic yield to its cultivators. Sweet corn has a very big market potential among specialty corns and great genetic variability and scope to improve its nutritive value. Sweet corn is commercially cultivated in varied climatic regions *viz.,* temperate, tropical and subtropical regions. Sweet corn is essentially field corn halted at an early stage of development (Erwin, 1951). It is considered a vegetable because of its high nutritional content, delicate texture and sweet flavour in the pericarp and endosperm (Kwiatkowski and Clemente, 2007). Sweet corn is one of the most popular vegetable in countries like the USA and Canada (Tracy, 1994). It is characterized by the translucent, horny appearance of the kernel when matures and wrinkled when it dries.

The primary dissimilarity between sweet corn and regular corn lies in the genetic factors affecting starch synthesis in the seed endosperm. Sweet corn contains specific genes that differ from those of normal corn, leading to a decrease in normal starch synthesis. These genetic variations, which include one or more recessive alleles, increase the number of water-soluble polysaccharides (sugars) in the sweet corn endosperm (Dinges *et al.,* 2001). Sweet corn is consumed in the immature stage. The total sugar content in sweet corn at the milky stage ranges from 25-30% (Ramachandrappa and Nanjjappa, 2006). Aside from their sugar content, sweet corn kernels have a nutritional composition that includes approximately 2.1-4.5% protein, 3-20% starch, 1.1-2.7% fats and 0.9-1.9% cellulose.

Several endosperm genes affecting carbohydrate synthesis in the endosperm are being used singly or in combination to develop sweet corn varieties (Creech, 1965). The four most useful mutants are *shrunken2* (*sh2*), *brittle* (*bt*), *sugary* (*su1*) and *sugary enhancer* (*se*) identified (Coe *et al.,* 1988). These mutants vary in terms of taste, tenderness and speed in which starches in the corn kernels are transformed into sugars. Typically, (*se*) lines are considered to yield the highest quality, followed by (*sh2*) varieties and finally (*su1*) types. Very few sweet corn hybrids have been released in the public and private sectors in India. To build a strong foundation for yield-focused breeding programs, breeders need an in-depth understanding of traits directly affecting yield. For over a century, traditional breeding methods have been employed by breeders to develop commercial sweet corn hybrids.

In any breeding program aimed at achieving high yield, breeders must possess sufficient knowledge about the combining ability of parent plants, including both general and specific combining abilities, as well as the performance of their hybrids concerning yield and yield related traits. Enhancing green cob yield potential and sweetness in sweet corn varieties or hybrids necessitates selecting parents with strong general combining abilities (GCA). Assessing the GCA and SCA serves a dual purpose: it aids in the selection of suitable parent plants for crossbreeding and the subsequent development of hybrids, while also shedding light on the genetic mechanisms at play and guiding a breeding strategy to enhance the desired trait.

Materials and methods

Experimental materials

The plant material comprised six lines and seven testers. The lines were crossed in line × tester mating design procedure as proposed by Kempthorne (1957). Hybrids were produced during *kharif* 2023. Thus, 13 parents and their 42 crosses formed the experimental material for the current study. A list of parents (six lines and seven testers) used in the crossing programme is given in Table 1.

Table 1. The inbred lines used in line × tester trial of sweet corn

S.No.	Lines	Source	S.No.	Testers	Source
1.	I07-62-3-2	Procured	1.	I07-62-9-1	Procured
2.	I07-36-2-2	from AICRP	2.	I07-37-6-1	from AICRP
3.	1820162	on Maize	3.	1820196-1	on Maize
4.	182097		4.	1820196-2	
5.	180212		5.	1820228	
6.	I07-37-1-5		6.	IL-14-73	
			7.	I07-34-3-1	

Field trial

A field trial was conducted during *Rabi* 2023-24 at the Main Maize Research Station (RRS), AAU, Godhra. The study evaluated 42 hybrids, 13 parent lines and one check hybrid using a randomized complete block design (RCBD) with three replications. Each entry was sown in a double row of 2 meters in length, with inter-row and intra-row spacing of 60 cm and 20 cm, respectively. Standard agronomic practices were adhered to throughout the experiment. At the time of hybridization, to prevent cross-pollination from foreign pollen, silks were covered with butter paper bags at the silk emergence stage, ensuring the collection of selfed seeds. The recommended package of practices was followed. For biometrical observations, sweet corn was harvested 22 days after pollination and data were recorded from five randomly selected plants, covering nine quantitative traits and three qualitative traits. Total soluble sugar was determined using the phenol-sulphuric acid method as described by Dubois *et al.* (1956) with some modifications. Seed samples were initially extracted using 80% ethanol. Following the extraction, concentrated sulfuric acid (H_2SO_4) was added to the mixture. The resulting solution was then analyzed using a spectrophotometer to measure the optical density (OD) at a wavelength of 490 nm. Reducing sugars were estimated as method suggested by Somogyi, (1952). Seed samples were first extracted using 80% ethanol to determine reducing sugars. The extracted sugars were then heated with an alkaline solution of copper tartrate, resulting in the formation of cuprous oxide. This cuprous oxide subsequently reacted with arseno-molybdate. The final solution, exhibiting a blue colour, was analyzed using a spectrophotometer to measure the optical density (OD) at a wavelength of 540 nm. β-carotene content was determined using the method described by Sathya et al. (2014). Unfiltered water-saturated n-butanol was used as blank.

Statistical analysis was used to obtain estimates of general and specific combining ability variances and effects. The variance components of general combining ability (GCA) (σ^2_{gca}) and specific combining ability (SCA) (σ^2_{sca}) were calculated and used for the estimation of $\sigma^2_{sca}/\sigma^2_{gca}$ ratio and the predictability ratio 2 σ^2_{gca}/ (σ^2_{gca} + σ^2_{sca}) (Baker, 1978).

Results and discussion

Genetic variability and genetic variance

The analysis of variance for combining ability revealed that mean square values due to lines were significant for all the characters except kernel rows per cob and green cob weight with husk per plant showing the ultimate variation among lines for the studied characters. Whereas, variance due to testers was significant for the characters. The variance due to hybrids was significant for all the characters. Ravikesavan *et al.* (2020) also found similar results for mean square values of lines, testers and hybrids.

The analysis of variance for combining ability revealed the importance of both additive and non-additive components of genetic variance. The preponderance of non-additive genetic variance for days 50% tasselling, days 50% sulking, green cob girth, green cob length, kernels per row, kernel rows per cob, green cob weight with husk per plant and green cob weight without husk per plant was seen as only σ^2_{sca} was found significant. The value more than one-half (0.5) of the predictability ratio and the ratio $\sigma^2_{gca}/\sigma^2_{sca}$ was more than unity for fodder weight per plant (Vanipraveena *et al.,* 2021), total soluble sugar (Mustafam 2020), reducing sugar (Elayaraja *et al.,* 2020), β-carotene (Wasuwatthanakool *et al.,* 2022) suggested a preponderance of additive genetic variance. Whereas, less than one-half (0.5) value of predictability ratio and the ratio $\sigma^2_{gca}/\sigma^2_{sca}$ was being less than unity for days 50% tasseling (Nivethitha *et al.,* 2023), days 50% silking (Nadeem *et al.,* 2023), green cob girth (Madhunapantula *et al.,* 2023), green cob length (Nivethitha *et al.,* 2023), kernels per row (Chavan *et al.,*

Table 2. Analysis of variance for combining ability for studied traits of sweet corn

Sources of variation	df	DT	DS	GCG	GCL	KPR	KRPC	GCWH	GCWOH	GFW	TSS	RS	β-C
Replications	2	9.39**	0.06	5.75**	0.12	0.56	1.13	215.63	116.57	973.26	0.01	0.02	0.07
Lines	5	32.14**	37.14**	4.10**	14.85**	52.09**	0.82	1801.44	1680.57*	49360.41**	13.79**	4.43**	8.11**
Testers	6	10.47**	15.66**	3.88**	7.30**	51.69**	6.18**	2720.27**	2703.98**	24316.07**	12.80**	2.60**	133.55**
Lines × testers	30	8.23**	14.21**	6.89**	7.70**	30.62**	3.39**	3527.67**	3530.84**	5535.07**	1.20**	0.45**	4.58**
Error	82	0.97	0.56	0.91	1.52	6.31	0.48	799.93	545.54	1311.43	0.09	0.04	0.05
Genetic parameters													
σ^2_{gca} (lines)		1.19**	1.09*	-0.1328	0.34	1.02	-0.12	-82.2015	-88.11	2086.92**	0.60**	0.19**	0.17
σ^2_{gca} (testers)		0.125	0.08	-0.1672	-0.02	1.17	0.16	-44.86	-45.94	1043.39**	0.65**	0.12**	7.17**
σ^2_{gca} (Average)		0.67	0.63	-0.1486	0.17	1.09	0.01	-64.97	-68.65	1605.29*	0.62**	0.16**	3.40**
σ^2_{sca}		2.42**	4.55**	1.9923**	2.06**	8.10**	0.97**	909.25**	995.10**	1407.88**	0.37**	0.14**	1.51**
$\sigma^2_{gca}/\sigma^2_{sca}$		0.28	0.14	###	0.08	0.13	0.01	###	###	1.14	1.68	1.16	2.25
Predictability ratio		0.36	0.22	###	0.14	0.21	0.01	###	###	0.70	0.77	0.70	0.82
Dominance variance (σ^2_D)		9.67	18.20	7.9693	8.24	32.42	3.89	3636.99	3980.41	5631.52	1.47	0.54	6.04
Additive variance (σ^2_A)		2.68	2.50	-0.5946	0.70	4.36	0.02	-259.86	-274.58	6421.16	2.48	0.63	13.59
Degree of dominance		1.90	2.70	###	3.45	2.73	13.26	###	###	0.94	0.77	0.93	0.67

*, **, Significant at 0.05 and 0.01 levels of probability, respectively;###: Indicates negative estimates of variance

df: Degree of freedom, DT: Days to 50% tasseling, DS: Days to 50% silking, GCG: Green cob girth, GCL: Green cob length, KPR: Kernels per row, KRPC: Kernel rows per cob, GCWH: Green cob weight with husk per plant, GCWOH: Green cob weight without husk per plant, TSS: Total soluble sugar, RS: Reducing sugar, β-C: β-Carotene

2022), kernel rows per cob (Vanipraveena *et al.,* 2021), green cob weight with husk per plant (Madhunapantula *et al.,* 2023) and green cob weight without husk per plant (Nivethitha *et al.,* 2023) suggested prime role of non-additive genetic variance for inheritance of these characters. The average degree of dominance more than one for 50% tasselling, days 50% silking, green cob girth, green cob length, kernels per row, kernel rows per cob, green cob weight with husk per plant and green cob weight without husk per plant indicated the presence of over-dominance among the interacting alleles. The remaining traits fodder weight per plant, total soluble sugar, reducing sugar and β-Carotene less than one value for degree of dominance revealed the presence of partial dominance for the inheritance of these characters.

Combining ability

a) General combining ability

Parents with a significant GCA effect in the desired direction were categorized as good, those with a non-significant GCA effect as average and those with a significant GCA effect in the undesired direction as poor general combiners. Similarly, the crosses were classified as good, average or poor specific combiners based on their performance. The variation in the estimates of GCA effects for parents in the present investigation ranged in both directions for all the investigated traits. Nivethitha *et al.* (2023) and Prai-Anun *et al.* (2024) also found a similar variation in the GCA estimates in both directions. Among the lines, 182097, I07-37-1-5 and 180212 for days to 50% tasseling and days to 50% silking, 180212 for green cob length, 180212 for kernels per row, I07-36-2-2 for kernel rows per cob, I07-62-3-2 for green cob weight with husk per plant and green cob weight without husk per plant, 1820162 and 180212 for fodder weight per plant, 180212, 182097 and 1820162 for total soluble sugar, 180212, 182097 and 1820162 for reducing sugar, I07-62-3-2 and 182097 for β-Carotene recorded significant values in the desired direction for the GCA effect, hence they were considered as good general combiners for respected characters.

Among the testers, IL-14-73 and I07-62-9-1 for days to 50% tasseling, IL-14-73 and I07-34-3-1 for days to 50% silking, 1820228 for green cob girth, 1820196-1 for green cob length, I07-37-6-1, I07-34-3-1 and 1820196-1 for kernels per row, 1820196-1 and 1820228 for kernel rows per cob (Table 3), 1820196-1 for green cob weight with husk per plant and green cob weight without husk per plant. The genotype I07-62-9-1, I07-37-6-1 and I07-34-3-1 for fodder weight per plant, I07-34-3-1, 1820196-2 and IL-14-73 for total soluble sugar, I07-34-3-1 and 1820196-2 for reducing sugar and 1820196-2, 1820228 and I07-37-6-1 for β-Carotene (Table 4) content recorded significant values in the desired direction for the GCA effect, hence they were considered as good general combiners for respected characters.

b) Specific combining ability

The variation in the estimates of SCA effects for the hybrids in the present investigation varied in both directions for all the studied characters. Mahato *et al.* (2021); Chavan *et al.* (2022) and Nadeem *et al.* (2023) also found a similar variation in the SCA estimates in both directions. The total number of hybrids with significant estimates of SCA effects in both directions with top-ranking three crosses for different studied traits is mentioned in Table 5.

For green cob weight without husk per plant, a total of 18 hybrids were recorded with significant SCA estimates among them nine hybrids had positive and nine hybrids had negative SCA values. The cross combination 180212 × 1820228; I07-37-1-5 × 1820228 (63.09) followed by 182097 × 1820228 (49.86) and I07-62-3-2 × IL-14-73 (43.08) had substantial SCA effect estimates.

For days to 50% tasseling, 11 hybrids had negative significant SCA estimates among them the cross I07-62-3-2 × 1820196-1 (-2.77) had the highest negative significant SCA estimate. For days to 50% silking, 13 hybrids reflected negative significant SCA estimates among them the cross combination I07-62-3-2 × 1820196-1 had a substantial negative significant SCA estimate for days to 50% silking (-4.05). Among 42 crosses, eight hybrids registered positive and significant estimates of SCA effects for green cob girth. The cross combination 182097 × I07-34-3-1 pointed out the highest significant SCA estimate in the desired direction for green cob girth (2.73). For green cob length, eight hybrids illustrated positive significant SCA effects among them the cross combination I07-36-2-2 × 1820196-1 (3.07) showed the highest significant positive sca effect followed by 182097 × I07-34-3-1 (2.55) and I07-37-1-5 × I07-

Table 3. GCA effects of parents for green cob yield and its component characters in sweet corn

Parents	DT		DS		GCG		GCL		KPR		KRPC	
	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
Lines												
I07-62-3-2	59.67	0.44*	63.67	0.16	14.46	0.33	14.37	0.19	30.75	0.50	15.47	0.02
I07-36-2-2	60.33	1.25**	64.33	1.35**	14.44	0.30	17.52	-0.62*	32.40	-1.99**	14.67	0.33*
1820162	63.67	1.44**	67.67	1.73**	13.66	-0.44*	15.63	-0.06	32.87	-0.56	14.27	-0.05
182097	56.33	-1.66**	59.33	-1.65**	14.83	0.16	17.61	-0.57*	31.07	-0.95	15.73	-0.28
180212	56.67	-0.85**	59.00	-0.70**	14.23	0.33	14.68	1.58**	35.40	2.62**	14.40	-0.05
I07-37-1-5	57.00	-0.61**	59.67	-0.89**	13.51	-0.68**	17.56	-0.53	37.27	0.37	15.20	0.03
Testers												
I07-62-9-1	58.67	-0.73**	63.33	-0.25	12.93	-0.46*	14.41	-0.56	35.93	-1.58**	12.53	-0.98**
I07-37-6-1	62.67	0.10	66.33	-0.31	11.94	0.33	15.68	-0.12	33.43	1.77**	12.27	0.10
1820196-1	62.00	0.77**	65.33	1.19**	14.39	-0.40	16.34	1.00**	31.93	1.20*	16.67	0.79**
1820196-2	59.67	1.21**	63.67	1.19**	12.98	-0.55*	14.00	0.21	33.80	-0.52	15.20	0.17
1820228	57.33	-0.12	62.67	0.14	14.60	0.63**	17.08	-0.06	30.87	0.16	15.47	0.52**
IL-14-73	58.67	-0.84**	60.67	-1.37**	11.93	0.27	14.57	-1.00**	32.07	-2.68**	14.00	-0.29
I07-34-3-1	59.33	-0.40	63.33	-0.59**	14.35	0.19	15.39	0.45	29.20	1.64**	14.67	-0.31
Range of mean and GCA values for parents	56.33 to 63.67	-1.66 to 1.44	59.00 to 67.67	-1.65 to 1.73	11.94 to 14.83	-0.44 to 0.63	14.00 to 17.61	-0.06 to 1.58	29.20 to 37.27	-2.68 to 2.62	12.27 to 16.67	-0.98 to 0.79

*, **, Significant at 0.05 and 0.01 levels of probability, respectively
DT: Days to 50% tasseling, DS: Days to 50% silking, GCG: Green cob girth, GCL: Green cob length, KPR: Kernels per row, KRPC: Kernel rows per cob

Table 4. GCA effects of parents for green cob yield and its component characters in sweet corn

Parents	GCWH		GCWOH		GFW		TSS		RS		β-C	
	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
Lines												
I07-62-3-2	197.14	16.40**	157.74	15.94**	219.10	-37.04**	6.92	-0.73**	1.91	-0.44**	8.51	0.15**
I07-36-2-2	202.97	-2.21	167.63	-4.34	196.63	-33.21**	5.63	-0.97**	3.16	-0.11*	11.57	-0.33**
1820162	258.82	2.70	218.56	2.83	306.85	87.10**	9.24	0.89**	3.71	0.29**	10.74	-0.46**
182097	264.13	-4.50	226.79	-4.20	203.97	-28.26**	8.58	0.18**	3.84	0.50**	13.64	0.27**
180212	252.29	-1.14	210.76	-0.14	254.04	26.04**	9.58	0.95**	3.50	0.37**	10.70	-0.31**
I07-37-1-5	219.13	-11.24	180.30	-10.08	227.06	-14.64	7.40	-0.31**	2.79	-0.61**	11.62	0.10
Testers												
I07-62-9-1	247.84	-4.46	201.91	-5.01	392.16	54.90**	8.13	-0.42**	2.58	0.15**	6.90	-0.88**
I07-37-6-1	222.19	7.74	180.51	9.00	378.47	32.34**	7.37	-0.36**	1.62	-0.33**	13.46	2.78**
1820196-1	234.85	20.71**	187.10	20.87**	269.07	-25.04**	8.19	-0.36**	2.09	-0.46**	8.47	-1.85**
1820196-2	239.36	-7.45	193.96	-9.68	278.13	-12.04	8.51	0.68**	3.03	0.27**	16.38	4.00**
1820228	225.44	5.51	178.94	4.84	217.21	-19.62*	5.88	-1.28**	2.32	-0.31**	13.16	1.35**
IL-14-73	185.45	-16.89*	143.77	-14.59**	145.52	-50.08**	8.51	0.54**	2.96	0.10	6.91	-3.04**
I07-34-3-1	218.13	-5.17	175.66	-5.44	279.97	19.53*	9.34	1.20**	3.38	0.59**	7.79	-2.36**
Range of mean and GCA values for parents	185.45 to 264.13	-16.89 to 20.71	143.77 to 226.79	-14.59 to 20.87	145.52 to 392.16	-50.08 to 87.10	5.63 to 9.58	-0.97 to 1.20	1.62 to 3.84	-0.46 to 0.59	6.90 to 16.38	-3.04 to 4.00

*, **, Significant at 0.05 and 0.01 levels of probability, respectively
GCWH: Green cob weight with husk per plant, GCWOH: Green cob weight without husk per plant, TSS: Total soluble sugar, RS: Reducing sugar, β-C: β-Carotene

Table 5. Specific combining ability (SCA) effects of top-ranking three hybrids for different studied traits

Traits	Hybrid (Line × Tester)	Mean values of hybrids	GCA estimates of parents				SCA	Range of SCA	No. of hybrids with significant SCA estimates		
			Line		Tester				Total	Positive	Negative
DT	I07-62-3-2 × 1820196-1	57.00	0.44**	P	0.77**	P	-2.77**	-2.77 to 2.90	20	9	11
	180212 × I07-37-6-1	55.67	-0.85**	G	0.10	A	-2.15**				
	I07-36-2-2 × I07-34-3-1	60.67	1.25**	P	-0.40	A	-1.75**				
DS	I07-62-3-2 × 1820196-1	59.33	-0.16	A	1.19**	P	-4.05**	-4.05 to 4.71	23	10	13
	1820162 × 1820196-2	62.00	-0.70**	G	1.19**	P	-2.95**				
	I07-37-1-5 × IL-14-73	57.00	-0.89**	G	-1.37**	G	-2.78**				
GCG	182097 × I07-34-3-1	17.95	0.16	A	0.19	A	2.73**	-2.14 to 2.73	17	8	9
	I07-36-2-2 × 1820196-1	17.40	0.30	A	-0.40	A	2.63**				
	180212 × 1820196-2	17.00	0.33	A	-0.55*	P	2.35**				
GCL	I07-36-2-2 × 1820196-1	22.42	-0.62	P	1.00**	G	3.07**	-2.42 to 3.07	15	8	7
	182097 × I07-34-3-1	21.41	-0.57*	P	-0.45	A	2.55**				
	I07-37-1-5 × I07-34-3-1	21.43	0.53	A	-0.45	A	2.52**				
KPR	I07-62-3-2 × IL-14-73	39.14	0.50	A	-2.68**	P	4.53**	-5.31 to 4.53	16	7	9
	I07-36-2-2 × 1820196-1	40.45	-1.99*	P	1.20*	G	4.45**				
	180212 × I07-37-6-1	39.88	2.62**	G	1.77**	G	4.44**				
KRPC	I07-37-1-5 × 1820196-1	15.60	0.03	A	0.79 **	G	2.14**	-1.59 to 2.14	21	11	10
	1820162 ×1820196-1	16.14	-0.05	A	0.79 **	G	1.32**				
	I07-62-3-2 × 1820196-1	18.14	0.02	A	0.52**	G	1.20**				
GCWH	I07-37-1-5 × 1820228	224.09	-11.24	A	5.51	A	63.50**	-55.52 to 63.50	13	7	6
	180212× 1820228	301.73	-1.14	A	5.51	A	63.50**				
	182097 × 1820228	295.50	-4.50	A	5.51	A	48.43**				
GCWOH	180212 × 1820228	261.64	-0.14	A	4.84	A	63.09**	-55.01 to 63.09	18	9	9
	I07-37-1-5 × 1820228	181.30	-10.08	A	4.84	A	63.09**				
	182097 × 1820228	250.39	-4.20	A	4.84	A	49.86**				
GFW	1820162 × 1820196-1	330.49	87.10**	G	-25.04**	P	72.04**	-93.79 to 72.04	14	8	6
	180212 × 1820196-2	337.70	26.04**	G	-12.04	A	67.42**				
	I07-37-1-5 × 1820196-2	213.70	-14.64	A	-12.04	A	67.42**				
TSS	I07-37-1-5 × I07-37-6-1	9.37	-0.31**	P	-0.36**	P	1.14**	-1.05 to 1.14	20	9	11
	1820162 × 1820228	9.43	0.89**	G	-1.28**	P	0.91**				
	I07-62-3-2 × 1820196-1	8.60	-0.73**	P	-0.36**	P	0.78**				
RS	I07-36-2-2 × IL-14-73	4.48	-0.11*	P	0.10	A	0.82**	-0.67 to 0.82	17	9	8
	182097 × 1820228	4.56	0.50**	G	-0.31**	P	0.71**				
	1820162 × 1820196-1	4.12	0.29**	G	-0.46**	P	0.61**				
â-C	180212 × I07-34-3-1	9.66	-0.31**	P	-2.36**	P	1.73**	-2.86 to 1.73	33	15	18
	I07-36-2-2 × 1820196-1	12.13	-0.33**	P	-1.85**	P	1.72**				
	1820162 × I07-37-6-1	16.17	-0.46**	P	-2.78**	G	1.70**				

*, **, Significant at 0.05 and 0.01 levels of probability, respectively; General combing ability of parents: G = Good, A = Average, P = Poor
DT: Days to 50% tasseling, DS: Days to 50% silking, GCG: Green cob girth, GCL: Green cob length, KPR: Kernels per row, KRPC: Kernel rows per cob, GCWH: Green cob weight with husk per plant, GCWOH: Green cob weight without husk per plant, TSS: Total soluble sugar, RS: Reducing sugar, β-C: β-Carotene

34-3-1 (2.52) for green cob length. For kernels per row and kernel rows per cob, crosses I07-62-3-2 × IL-14-73 (4.53) and I07-34-3-1 × 1820196-1 (2.14) exhibited maximum significant SCA effects in the desired direction, respectively. Total of seven and 11 hybrids registered positive significant SCA effects for kernels per row and kernel rows per cob, respectively. For green cob weight with husk per plant, out of 42 hybrids evaluated, 13 depicted significant estimates, among them seven crosses had positive SCA effects, of which the crosses I07-37-1-5 × 1820228 (63.50) and 180212× 1820228 (63.50) had a substantial estimate. For green cob weight without husk per plant, nine crosses recorded positive significant values of SCA effects. Crosses, 180212 × 1820228; I07-37-1-5 × 1820228 (63.09), 182097 × 1820228 (49.86) and I07-62-3-2 × IL-14-73 (43.08) reflected maximum SCA estimates in desired direction among them for green cob weight without husk per plant. For fodder weight per plant, eight crosses recorded positive significant SCA effects. The crosses I07-37-1-5 × I07-37-6-1 (1.14), I07-36-2-2 × IL-14-73 (0.82) and 180212 × I07-34-3-1 (1.73) showed highest significant SCA estimates in desired direction for total soluble sugar, reducing sugar and β-Carotene, respectively. The hybrids that were recorded with significant values in the desired direction for the SCA effect, hence they were considered as good specific combiners for respected characters.

The SCA effect values largely inform the role of intra- and inter-allelic interactions in heterosis expression. The crosses with high SCA effects do not necessarily yield higher mean values or heterotic effects and *vice versa*. Therefore, plant breeders must consider all these aspects independently when selecting crosses to exploit heterotic effects or develop parental lines. Based on the data on combing ability, parents such as 182097, I07-37-6-1, 1820196-2 and IL-14-73 exhibit notable performance across multiple traits, these genotypes can be effectively utilized in future breeding programmes. Their superior combining ability in key areas such as days to 50% flowering, green cob length and green cob weight without husk per plant traits suggests their potential to develop high yielding hybrids. Plant breeders can harness the genetic potential of these parent plants to develop strong, high performing cultivars that achieve economic objectives.

Out of 42 hybrids examined, nine hybrids depicted a positive significant sca effect for green cob weight without husk per plant. The hybrids *viz.,* 180212 × 1820228 (A × A), I07-37-1-5 × 1820228 (A × A), 182097 × 1820228 (A × A), I07-62-3-2 × IL-14-73 (G × P), I07-36-2-2 × 1820196-1 (A × G), I07-62-3-2 × I07-62-9-1 (G × A), 180212 × 1820196-2 (A × A), 1820162 × I07-37-6-1 (A × A) and I07-37-1-5 × 1820196-2 (A × A).

The selected hybrids based on their SCA effect were categorized into four groups of general combiner parents: G × A, G × P, A × Gand A × A. The results of the specific combining ability effects for these crosses indicated that hybrids with high SCA effects don't always involve parents with high GCA effects, highlighting the importance of both intra- and inter-allelic interactions. Also, high sca effects were observed in crosses involving good × average, average × good and average × average combining parents.

This suggests that for accurate prediction of a cross's value, information on general combining ability effects should be supplemented with sca effects and the mean performance of the crosses.

Conclusion

The analysis of variance for combining ability demonstrated the significance of both additive and non-additive genetic variance across multiple traits in sweet corn. The majority of yield contributing traits except fodder weight, total sugar, reducing sugar and β-Carotene, were governed mostly through non-additive gene action suggesting that these traits could be enhanced through hybridization. For green cob weight without husk per plant, the parental genotypes I07-62-3-2, 1820196-1, 182097 and I07-36-2-2 were shown to be good general combiners due to their favourable gca effects. These paternal lines also contributed to the high yielding hybrids. The hybrids I07-37-1-5 × 1820228, 182097 × 1820228 and I07-62-3-2 × IL 14-73 registered favourable higher significant sca estimates and were determined to be effective specific combiners for yield contributing characteristics and green cob weight without husk. These hybrids can be effectively utilized in future breeding programmes. The investigation underscores that hybrids showing significant sca effects may not consistently show high average values or strong heterotic effects and the reverse can also be true. Hence, when choosing hybrids for future breeding programmes, it is crucial to evaluate each aspect independently.

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References

Baker, R. J. (1978). Issues in diallel analysis. *Crop Science*, **18**(4): 533-536.

Chavan, S., Bhadru, D., Swarnalatha, V. & Mallaiah, B. (2022). Identification of promising parental lines and sweet corn (*Zea mays* L. *saccharata*). *Electronic Journal of Plant Breeding*, **13**(2): 549-557.

Coe Jr, E. H., Neuffer, M. G. & Hoisington, D. A. (1988). The genetics of corn. *Corn and Corn Improvement*, **18**: 81-258.

Creech, R. G. (1965). Genetic control of carbohydrate synthesis in maize endosperm. *Genetics*, **52**(6): 1175-1186.

Dinges, J. R., Colleoni, C., Myers, A. M. & James, M. G. (2001). Molecular structure of three mutations at the maize sugary 1 locus and their allele-specific phenotypic effects. *Plant Physiology*, **125**: 1406-1418.

Elayaraja, K., Gadag, R. N., Kumari, J. & Mishra, U. (2020). Gene action and heterosis for yield and kernel quality traits in experimental hybrids in sweet corn relevant for Indian conditions. *Indian Journal of Horticulture*, **77**(1): 125-133.

Erwin, A. T. (1951). Sweet corn- Mutant or historic species? *Economic Botany*, **5**(3): 302-306.

Kempthorne, O. (1957). *An Introduction to Genetic Statistics*. John Wiley & Sons Inc. New York, USA, pp 468-473.

Kwiatkowski, A. and Clemente, E. (2007). Characteristics of sweet corn (*Zea mays* L. *saccharata*) for industrialization. *Brazilian Journal of Agro-industrial Technology*, **1**: 93-103.

Madhunapantula, V. P., Talekar, S. C., Kachapur, R. M., Salakinkop, S. R., Lal, M. & Naidu, G. (2023). Frequency of heterotic hybrids in relation to general combining ability of parents in sweet corn. *Peer Journal*, **11**: e16134.

Mustafa, N. R. (2020). Diversity, performance and selection of tropical sweet corn inbred lines and their combining abilities in hybrid combinations (Doctoral dissertation, School of Graduate Studies, University Putra Malaysia).

Nadeem, T., Khalil I. H. & Jadoon S. A. (2023). Combining ability analysis for maturity and yield attributes in sweet corn across environments. *Journal of Breeding and Genetics*, **52**(2): 319-328.

Nivethitha, T., Ravikesavan, R., Vinodhana, N. K. & Senthil, N. (2023). Development and genetic evaluation of single cross super-sweet (*shrunken2*) corn hybrids (*Zea mays var. saccharata* L.). A novel choice for the commercial market. *Electronic Journal of Plant Breeding*, **14**(2): 429-438.

Prai-Anun, K., Jirakiattikul, Y., Suriharn, K. & Harakotr, B. (2024). The Combining ability and heterosis analysis of sweet-waxy corn hybrids for yield-related traits and Carotenoids. *Plants*, **13**(2): 296.

Ramachandrappa, B. K. & Nanjjappa, H. V. (2006). Specialty corns. popcorn, sweet corn, baby corn. Kalyani Publication. pp 32.

Ravikesavan, R., Suhasini, B., Yuvaraja, A. & Kumari Vinodhana, N. (2020). Assessment of combining ability for yield and yield contributing traits in sweet corn. *Electronic Journal of Plant Breeding*, **11**(1): 224-229.

Tracy, W. F. (1994) Sweet corn in speciality corn (Eds. Arnel R. Hallauer) CRC Press, London pp 148-187.

Vanipraveena, M., Talekar, S. C., Kachapur, R. M. & Harlapur, S. I. (2021). Elite general and specific combiners for high sugar content and green ear yield in sweet corn (*Zea mays* L. *saccharata*). *Journal of Farma Science*, **34**(1): 10-14.

Wasuwatthanakool, W., Harakotr, B., Jirakiattikul, Y., Lomthaisong, K. & Suriharn, K. (2022). Combining ability and testcross performance for carotenoid content of S2 super sweet corn lines derived from temperate germplasm. *Agriculture,* **12**(10): 1561.