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RESEARCH PAPER

Heterosis and combining ability analysis in sweet corn (*Zea mays* L. var *saccharata*) hybrids for various traits

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Abstract: The present study was conducted to estimate heterosis and combining ability effects in sweet corn (*Zea mays* L. var *saccharata*) hybrids and to screen out hybrids having high green cob and fodder yield and high TSS content. About 66 genotypes comprising 45 sweet corn hybrids, 18 parental lines, and 3 standard checks (Priya, Madhuri, and Sugar-75) were evaluated in three different environments (E_1 at Instructional Farm, RCA, Udaipur during *Kharif* 2019, E_2 at ARS, Banswara during *Kharif* 2019 and E_3 at Instructional Farm, RCA, Udaipur during *Rabi* 2019–20) in randomized block design with three replications for twenty diverse traits. Maximum and positively significant heterosis over the best check were shown by the sweet corn hybrid $L_7 \times T_1$ (73.7%) for green cob weight/plant. The highest and positively perceptible economic heterosis for green fodder yield (kg/ha) and total soluble sugar (TSS) content of green grain was observed for the sweet corn hybrids $L_4 \times T_2$ (86.2%) and $L_{11} \times T_1$ (17.9%) respectively. On the basis of specific combining ability effects, among the selected best five hybrids, sweet corn hybrids $L_5 \times T_2$ and $L_6 \times T_3$ were best for green cob yield, green fodder yield, and green cob weight/plant while the hybrid $L_{10} \times T_1$ was best for green cob yield, green cob weight/plant and TSS content of green grain. Combining ability analysis for green cob yield and green cob weight/plant revealed that lines L_2, L_3, L_7, L_8, L_{11}, $L_{12,}$ and L_{13} were good general combiners over the three environments. Sweet corn hybrid $L_5 \times T_2$ was identified to exhibit the highest and positively significant specific combining ability effect for green cob yield (4090.1) over the three environments.

Keywords: Combining ability · Green cob yield · Heterosis · Sweet corn · TSS

Introduction

Sweet corn has high nutritional values, delicate texture, and sweet taste within pericarp and endosperm and is treated as a vegetable. The flavour, texture, and sweetness of sweet corn kernels are due to the presence of some endosperm mutants which alter the starch biosynthesis pathway in the endosperm. The most useful mutations among them, *sh2*, *bt1*, *su1*, and *se*, function either by accumulating sugar at the expense of starch or by changing the types and proportions of different polysaccharides stored in the endosperm (Boyer and Shannon, 1984). The total sugar content in sweet corn at the milky stage ranges from 25–30% as compared to 2–5% of normal corn (Sadaiah *et al.*, 2013). The popularity of sweet corn is increasing in the national and international market due to the sweetness and tenderness of its kernels and its appetizing taste, which has in turn resulted in its increased cultivation in the country, ensuring a good return to the farmers. Further, the leftover plants after the harvest of cobs can be used as fresh or dry fodder for the animals. Sweet corn breeding aims to improve quality and appearance as well as cob yield however, the genetic base of the sweet corn breeding programme is relatively narrow and related inbreds often

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are crossed to make hybrids that meet the strict market requirements on quality and appearance (Tracy, 1994). Sweet corn breeders have often focused on improving quality and ear appearance, rather than on enhancing yield (Tracy, 1993). But the emphasis on kernel sweetness along with yield needs to be considered as the major objective of sweet corn improvement. The quality parameters are relatively more important, especially because of the direct consumption of sweet corn as a vegetable and the preference of the consumers. Keeping in view the above facts and the growing demand for sweet corn in the domestic and international market, the development of hybrids exhibiting hybrid vigor using parents with superior combining ability has been taken as an objective of first importance of the research.

Material and methods

Eighteen diverse sweet corn inbred lines, collected from different parts of the country were used as parents (fifteen females and three testers) (Table 1). The crosses were made in line × tester matting design at Instructional Farm, RCA, Udaipur during *Kharif* 2018. Total of 66 genotypes comprising 45 sweet corn hybrids, 18 parental lines, and 3 standard checks (Priya, Madhuri, and Sugar-75) was evaluated in three different environments (E_1 at Instructional Farm, RCA, Udaipur during *Kharif* 2019, E_2 at ARS, Banswara during *Kharif* 2019 and E_3 at Instructional Farm, RCA, Udaipur during *Rabi* 2019-20) in randomized block design with three replications. Recommended agronomic practices were used to raise a healthy crop. Observations were recorded for 20 yields attributing quantitative and qualitative characteristics like days to 50% tasseling, days to 50% silking, plant height, ear height, number of leaves/plant, length of leaf, breadth of leaf, days to green cob harvest, number of ear/plant, ear length, ear girth, number of grain rows/ear, number of grains/row, 100 fresh seed weight, green cob weight/plant, moisture per cent of green grain, green cob yield, green fodder yield, total soluble sugar (TSS) content of green grain and protein content. Ten plants were taken from each row for recording observations from each replication. TSS content was recorded using a hand refractometer.

Estimation was done over the three environments on a pooled basis. Estimates of standard heterosis were calculated according to Virmani *et al*. (1982) and the significance of heterosis was tested using a 't-test'. The analysis of variance for general and specific combining ability effects over the environments and in three individual environments was done for different characters under the study using the line × tester mating design provided by Kempthorne (1957).

Table 1. List of genotypes used

S.No.	Symbol	Pedigree
1.	L_1	SC-7-2-1-2-6-1
2.	L_2	SC-18728
3.	L_3	BAJ-SC-17-6
4.	L_4	BAJ-SC-17-10
5.	L_5	BAJ-SC-17-12
6.	L_6	BAJ-SC-17-9
7.	L_7	BAJ-SC-17-11
8.	L_8	BAJ-SC-17-8
9.	L_9	BAJ-SC-17-4
10.	L_{10}	BAJ-SC-17-2
11.	L_{11}	BAJ-SC-17-1
12.	L_{12}	DMSC-28
13.	L_{13}	Mas Madu (sh2 sh2)
14.	L_{14}	MRCSC-12
15.	L_{15}	SC-33
16.	T_1	SC-35
17.	T_2	SC-32
18.	T_3	DMRSC-1

Result and discussion

The estimation of standard heterosis was done over the best check Sugar-75 over the three environments for all the characters under study. The analysis of data for economic heterosis for green cob yield over the three environments revealed that the sweet corn hybrid $L_7 \times T_1$ exhibited the highest estimates of positively significant standard heterosis against the best check Sugar-75 (71.4%). Maximum and positively significant heterosis over the best check were shown by the sweet corn hybrid $L_7 \times T_1$ (73.7%) for green cob weight/plant. The highest and positively perceptible economic heterosis for green fodder yield (kg/ha) and TSS content of green grain was observed for the sweet corn hybrids $L_4 \times T_2$ (86.2%) and $L_{11} \times T_1$ (17.9%) respectively. For ear length, the maximum estimate of economic heterosis in a positively significant direction was reported for the sweet corn hybrid $L_3 \times T_1$

(40.6%). The sweet corn hybrid $L_1 \times T_3$ (14.5%) exhibited the highest and most positively significant standard heterosis for the number of grain rows/ear. Further, $L_8 \times T_1$ (41.7%) showed a maximum estimate of significant and positive heterosis for the number of grains/rows. The present findings were in close agreement with the earlier findings of Dagla *et al.* (2014) and Kumari *et al.* (2018). None of the sweet corn hybrids were reported to exhibit significant economic heterosis in the required direction for the characters' days to 50% tasseling, plant height, days to green cob harvest, ear girth, and protein content over the three environments against the best check Sugar-75.

The general combining ability effects are considered to be the function of the additive gene effects and additive × additive type of non-allelic interactions. Combining ability analysis for green cob yield and green cob weight/plant revealed that lines L_2, L_3, L_7, L_8, L_{11}, $L_{12,}$ and L_{13} were good general combiners over the three environments. Similarly, for green fodder yield, lines L_1, L_2, L_3, L_4, L_7, L_{11}, $L_{12,}$ and L_{13}, for TSS content of the green grain, lines L_1, L_5, L_7, L_{10}, L_{11}, $L_{13,}$ and L_{14} and for protein content, line L_{12} were identified as superior general combiners over the three environments on the basis of general combining ability analysis. Among the testers, T_1 was identified as a good general combiner for green cob yield, green cob weight/plant, and TSS content of green grain on the basis of general combining ability estimates over the three environments. Similarly, testers T_1 and T_2 were reported as superior combiners for green fodder yield on the basis of general combining ability analysis in pooled environments.

Sweet corn hybrid $L_5 \times T_2$ was identified to exhibit the highest and positively significant specific combining ability effect for green cob yield (4090.1) over the three environments (Table 2). The five best sweet corn crosses which possessed significantly positive specific combining ability effects for green cob yield on pooled basis were $L_5 \times T_2$, $L_{15} \times T_3$, $L_{10} \times T_1$, $L_6 \times T_3$, and $L_9 \times T_1$, among which $L_5 \times T_2$, $L_{10} \times T_1$ and $L_9 \times T_1$ exhibited positively significant standard heterosis over the best check Sugar-75. The sweet corn hybrids $L_5 \times T_2$, $L_{15} \times T_3$ and $L_6 \times T_3$ were crossed between poor general combining ability effects parents, while the hybrids $L_{10} \times T_1$ and $L_9 \times T_1$ were crossed between poor × good and average × good general combining ability effects parents. For green fodder yield, the best five sweet corn hybrids that showed maximum and positively significant specific combining ability effects were $L_4 \times T_2$ followed by $L_{13} \times T_1$, $L_5 \times T_2$, $L_6 \times T_3$ and $L_8 \times T_3$ on the pooled basis (Table 3). The sweet corn hybrids $L_4 \times T_2$ and $L_{13} \times T_1$ were crosses between parents with good general combining ability effects while the hybrids $L_6 \times T_3$ and $L_8 \times T_3$ were crosses between parents with poor general combining ability effects. Hybrid $L_5 \times T_2$ was crossed between the parents with poor × good general combining ability effects. Analysis for green cob weight/plant identified $L_5 \times T_2$, $L_{10} \times T_1$, $L_{15} \times T_3$, $L_6 \times T_3$ and $L_7 \times T_1$ as the top five sweet corn hybrids to exhibit the highest and positively significant specific combining ability effects on a pooled basis. Hybrids $L_5 \times T_2$, $L_{15} \times T_3$ and $L_6 \times T_3$ were produced by crossing both parents with poor general combining ability effects, while $L_{10} \times T_1$ was crossed

Table 2. Five best sweet corn hybrids for green cob yield on the basis of specific combining ability effects over the three environments

S.No.	Sweet corn hybrids/parents	SCA effects	Economic heterosis (%)	Mean green cob yield (kg/ha)
1	$L_5 \times T_2$	4090.05**	35.12**	15,222.2
2	$L_{15} \times T_3$	3584.42**	-19.2**	9,101.1
3	$L_{10} \times T_1$	3551.09**	30.47**	14,695.6
4	$L_6 \times T_3$	3463.68**	1.28	11,407.8
5	$L_9 \times T_1$	1999.60**	38.92**	15,646.7

Table 3. Five best sweet corn hybrids for green fodder yield on the basis of specific combining ability effects over the three environments

S.No.	Sweet corn hybrids/parents	SCA/GCA effects	Economic heterosis (%)	Mean fodder yield (kg/ha)
1	$L_4 \times T_2$	13,377.43**	86.24**	37,163.3
2	$L_{13} \times T_2$	8,799.65**	75.11**	35,061.1
3	$L_5 \times T_2$	8,237.06**	44.16**	28,765.6
4	$L_6 \times T_3$	7,598.84**	-1.11	19,732.2
5	$L_8 \times T_3$	6,938.47**	14.23*	22,794.4

between parents with poor × good general ability combining ability effects. The hybrid $L_7 \times T_1$ was crossed between both parents with good general combining ability effects. Analysis of TSS content of green grain over the three environments identified $L_{14} \times T_2$, $L_{12} \times T_1$, $L_2 \times T_3$, $L_1 \times T_3$ and $L_{10} \times T_3$ as the best five sweet corn hybrids possessing the highest and significantly positive specific combining ability effects. The sweet corn hybrids $L_{14} \times T_2$, $L_1 \times T_3$ and $L_{10} \times T_3$ were crossed between good × poor general combining ability effects parents, $L_{12} \times T_1$ between poor × good general combining ability effects parents while $L_2 \times T_3$ between parents with average × poor combining ability effects. Ola *et al.* (2018); Chinthiya *et al.* (2019); Nanditha *et al.* (2019); Sharma *et al.* (2019) and Tesfaye *et al.* (2019) reported similar results for combining ability analysis on maize.

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Declaration

The authors do not have any conflict of interest.

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