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RESEARCH PAPER

Genotype × environment interaction and stability studies in sweet corn hybrids using Eberhart and Russell model

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Abstract: The present study was carried out to estimate genotype × environment interaction and stability for qualitative and quantitative traits in sweet corn hybrids (*Zea mays* L. var *saccharata*). Forty-five hybrids using line × tester mating design were developed, which along with their eighteen parents and three checks (Priya, Madhuri and Sugar-75) were evaluated at three different locations during *Kharif* 2019 (E1 and E2) and *Rabi* 2019-20 (E3), in randomized block design with three replications. Stability analysis was done using Eberhart and Russell (1966) model on a pooled basis for twenty different characters. The results of the analysis of variance over the three environments for phenotypic stability revealed that variance due to genotypes and environment (linear) were significant for all the studied characters. Further, stability analysis revealed that all the genotypes possessed non-significant deviations from regression (S^2d_i) reflecting their predictable behaviour for the trait green cob yield. Only the hybrid $L_{12} \times T_1$ showed stable performance for protein content over the three environments. A study of data for green cob weight/plant revealed that two sweet corn hybrids $L_7 \times T_2$ and $L_7 \times T_3$ possessed non-significant deviations from regression (S^2d_i) along with a regression coefficient value nearly equivalent to unity (b_i=1) and a mean greater than the population mean. The performances of these two hybrids thus could be predictable as well as stable for cultivation in various environments. Analysis for quality characters showed that for TSS content of the green grain, sweet corn hybrids $L_1 \times T_1$ and $L_{11} \times T_1$ showed non-significant deviations from regression (S^2d_i) and regression coefficient equivalent to unity (b_i=1) with greater mean than the population mean, thus signifying their predictable performances and stability for different environments for sweetness.

Keywords: Green cob yield · Regression · Stability · Sweet corn · TSS

Introduction

Sweet corn (*Zea mays* L. var *saccharata*) is field corn in an arrested state of development (Erwin, 1951). With high nutritional values, delicate texture and sweet taste within pericarp and endosperm, it is treated as a vegetable (Kwiatkowski and Clemente, 2007). The most useful mutations resulting in its sweetness are due to genes *sh2*, *bt1*, *su1* and *se*, which 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). 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 and ensuring a good return to the farmers, the popularity of sweet corn is increasing in the national and international market. Further, the leftover plant after the harvest of cobs can be used as fresh or dry fodder for the animals. Recombining the same inbreds repeatedly without the infusion of new heterotic combinations may lead to the depletion of heterosis (Revilla *et al*., 2000). The evaluation of genotype environmental interactions gives an idea about the stable performance of the genotype under

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varying environmental conditions, which in turn helps in assessing the genetic potential of the genotype and its nature. A lower magnitude of genotype environmental interactions indicates the consistent performance of a genotype over a wide range of environments. A study of the magnitudes of genotype × environmental interactions for yield and yield-related characters and quality parameters is a must for any breeding programme aiming to develop stable hybrids.

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 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.

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

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 ears/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, 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. The procedure proposed by Eberhart and Russell (1966) was used to estimate the stability and study different characteristics of genotypes.

Result and discussion

In the present study, genotype × environment interaction was shared by both predictable (linear) and unpredictable (deviation) components for different traits. Eberhart and Russell model (1966) considered both linear (b_i) and non-linear (S^2d_i) components of genotypes × environment interaction for predicting the performance of a genotype. According to this model, any genotype possessing a unit regression coefficient (b_i=1) and non-significantly deviation from regression (S^2d_i=0) along with higher mean performance than the population mean is regarded as a stable or ideal genotype. Further, non-significant deviation from regression (S^2d_i) indicates the predictable and stable performance of any genotype in a given set of environments.

The variance due to genotypes and environment (linear) was found significant for all the characters included in the study. The variance due to E + (G × E) interactions were found significant for most of the characters, except for the number of leaves/plant, breadth of leaf, ear length, ear girth and TSS content of green grain. The mean sum of squares due to G × E (linear) interactions were reported significant for all the characters, except for the number of leaves/plant, breadth of leaf, ear length, ear girth, 100 fresh seed weight and TSS content of green grain. Further, the analysis revealed that the characters days to 50% silking, number of leaves/plant, length of leaf, breadth of leaf, ear length, ear girth, number of grains/row, 100 fresh seed weight, green fodder yield and TSS content of green grain had significant mean sums of squares due to pooled deviations, suggesting that prediction for these characters would be difficult as the genotypes differed considerably with respect to their stability.

Analysis for yield characters revealed that for green cob weight/plant two sweet corn hybrids $L_7 \times T_2$ and $L_7 \times T_3$ possessed non-significant deviations from regression (S^2d_i) along with regression coefficient value nearly equivalent to unity (b_i=1) and mean greater than the population mean (Table 2). The performances of these two hybrids thus could be predictable as well as stable for cultivation in various environments. A study for stability parameters for green cob yield revealed that all the genotypes possessed non-significant deviations from regression (S^2d_i) reflecting their predictable behaviour (Table 3). Only one sweet corn hybrid $L_6 \times T_1$ possessed non-significant deviation from regression (S^2d_i) along with a regression coefficient nearly equivalent to unity (b_i=1) and mean higher than the population mean, thus making it stable performer and suitable for all the environments for the number of grains/row. One sweet corn hybrid $L_{13} \times T_1$ exhibited non-significant deviation from regression (S^2d_i) along with a regression coefficient value nearly equivalent to unity (b_i=1) and mean more than the population mean indicating its predictable nature and stable performance in various environments for 100 fresh seed weight. None of the sweet corn hybrids possessed a regression coefficient nearly equal to unity (b_i=1) for the number of ears/plant, ear girth, number of grain rows/ ear and green fodder yield.

Analysis for quality characters (Table 4) showed that for TSS content of the green grain, sweet corn hybrids $L_1 \times T_1$ and $L_{11} \times T_1$ showed non-significant deviations from regression (S^2d_i) and regression coefficient equivalent to unity (b_i=1) with greater mean than the population mean, thus signifying their predictable performances and stability for different environments for sweetness. While for protein content, the sweet corn hybrids $L_2 \times T_1$, $L_6 \times T_1$, $L_8 \times T_1$, $L_{10} \times T_1$, $L_{12} \times T_1$, $L_2 \times T_2$, $L_4 \times T_2$, $L_5 \times T_2$, $L_8 \times T_2$, $L_9 \times T_2$, $L_{10} \times T_2$, $L_{11} \times T_2$, $L_{14} \times T_2$, $L_{15} \times T_2$, $L_1 \times T_3$, $L_2 \times T_3$, $L_4 \times T_3$, $L_5 \times T_3$ and $L_{10} \times T_3$ showed non-significant deviations from regression (S^2d_i) and regression coefficient equivalent to unity (b_i=1) with mean at par from the population mean, thus signifying their predictable performances and stability in various environments. Only the hybrid $L_{12} \times T_1$ showed stable performance for protein content over the three environments.

Similar results for the identification of stable genotypes under different environments were reported by Sowmya *et al*. (2018); Kumar *et al.* (2019); Machado *et al.* (2019);

Table 2. Best sweet corn hybrids for green cob weight/plant on the basis of stability parameters with the corresponding value of economic heterosis and combining ability effects

S.No.	Hybrids	Mean	Suitability forenvironment	Economic heterosis (%)	SCA effects
1	$L_7 \times T_2$	0.26	All environments (b_i=1)	36.8**	-0.02**
2	$L_7 \times T_3$	0.26	All environments (b_i=1)	36.8**	-0.01*
3	$L_7 \times T_1$	0.33	Unfavourable environments (bi<1)	73.7**	0.03**
4	$L_3 \times T_1$	0.27	Unfavourable environments (bi<1)	42.1**	0.01**
5	$L_{12} \times T_1$	0.26	Favourable environments (bi>1)	36.8**	0.01**
6	$L_{10} \times T_1$	0.25	Favourable environments (bi>1)	31.6**	0.06**

**Significant at 1% level of significance

Table 3. Five best sweet corn hybrids for green cob yield on the basis of stability parameters with the corresponding value of economic heterosis and combining ability effects

S.No.	Hybrids	Mean	Suitability forenvironment	Economic heterosis (%)	SCA effects
1	$L_{12} \times T_1$	15061.1	All environments (b_i=1)	33.7**	832.6**
2	$L_7 \times T_1$	19305.6	Unfavourable environments (bi<1)	71.4**	1550.7**
3	$L_9 \times T_3$	15646.7	Unfavourable environments (bi<1)	38.9**	1999.6**
4	$L_7 \times T_3$	15314.4	Favourable environments (bi>1)	36.0**	-281.5
5	$L_{10} \times T_1$	14695.6	Favourable environments (bi>1)	30.5**	3551.1**

**Significant at 1% level of significance

Table 4. Best sweet corn hybrids for TSS content of green grain on the basis of stability parameters with the corresponding value of economic heterosis and combining ability effects

S.No.	Hybrids	Mean	Suitability forenvironment	Economic heterosis (%)	SCA effects
1	$L_1 \times T_1$	15.9	All environments (b_i=1)	10.5*	-0.07
2	$L_{11} \times T_1$	17.0	All environments (b_i=1)	17.9**	0.33
3	$L_2 \times T_3$	16.0	Favourable environments (bi>1)	11.2**	1.34**
4	$L_5 \times T_2$	15.9	Favourable environments (bi>1)	9.9**	0.92**
5	$L_{10} \times T_3$	16.4	Unfavourable environments (bi<1)	13.7**	-0.23
6	$L_1 \times T_3$	16.3	Unfavourable environments (bi<1)	13.3**	1.22**

**Significant at 1% level of significance

Pinto *et al.* (2019); Raj *et al.* (2019) and Boreddy *et al.* (2020).

Conclusion

Among all the sweet corn hybrids, $L_{12} \times T_1$ was identified as a stable performer in various environments (b_i=1) with a higher mean than the population mean for green cob yield. For unfavourable environments (b_i<1), the sweet corn hybrids $L_7 \times T_1$ and $L_9 \times T_1$ revealed stable performance with a high mean value for green cob yield. Within favourable environments (b_i>1), hybrids $L_7 \times T_3$ and $L_{10} \times T_1$ showed stable performances along with a higher mean for green cob yield. All these sweet corn hybrids also exhibited positively significant standard heterosis over the best check Sugar-75 on a pooled basis. These parents and sweet corn hybrids can be used in future breeding programmes and further multi-location testing programmes, respectively.

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. The overall results indicated that emphasis on green cob yield, green fodder yield and kernel sweetness may be considered in the objective of sweet corn hybrid development.

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Declaration

The authors do not have any conflict of interest.

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