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Research Article

Heterotic Potential for Green Cob Yield and Related Traits in Sweet Corn (*Zea mays* L. *saccharata*)

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ABSTRACT

A study was taken up to understand the heterotic potential of sweet corn hybrids in terms of green cob yield. The crosses were made in line x tester fashion with seven lines and testers each. The resulting 49 hybrids were evaluated against the popular private hybrid Sugar 75. Highly significant variance due to genotypes was obtained for all the characters, which indicated the presence of sufficient variability for improvement. The lines L_5 *and* L_4 *and the testers* T_6 *and* T_5 *were identified as desirable parents for developing hybrids with improved yield and quality traits due to high per se performance. The hybrids* $L_4 xT_6$, $L_4 xT_5$, L_5xT_6, $L_1 xT_7$, *and* $L_7 xT_3$ *exhibited higher mean performance for green cob yield. which The hybrid* $L_4 xT_6$ *showed favourable per se performances for thirteen traits in addition to green cob yield. The best five hybrids identified based on mean performance for green cob yield and its associated traits were* $L_4 xT_6$, $L_4 xT_5$, L_5xT_6, $L_1 xT_7$, *and* $L_7 xT_3$ *and these hybrids possess atleast one of the parents which were found to be having superiority in mean performance. For total sugar content trait, hybrids* $L_6 xT_5$, $L_5 xT_7$, $L_1 xT_3$ and $L_5 xT_6$ *showed* significant positive heterosis.*These hybrids can be potentially used after testing their performance over locations.*

Keywords: *Sweet Corn, Hybrids, Heterotic potential, Green cob yield.*

INTRODUCTION

Sweet corn *(Zea mays* L. *saccharata)* is also called as pole corn and sugar corn is one of the special types of normal corn (*Zea mays* L.) with high sugar content. It is a popular fresh vegetable in countries like USA and Canada. This specialty corn is characterized by sweet taste, thin pericarp, delicate textured endosperm and high nutritional value. The matured kernels are having translucent, horny appearance and become wrinkled when it dries (Suthar et al., 2014).

Sweet corn is harvested in the milk stage and is used for human consumption in fresh form or in processed foods. The research reports indicate that in the 19^{th} century, sweet corn has arisen as a result of natural recessive mutation in the genes controlling sugar to starch conversion inside the corn kernels.

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Total sugar content in sweet corn at milky stage ranges from 20-30% as compared to 2-5% of normal corn. In the sweet corn genome at least one of the eight genes involved in the endosperm carbohydrate biosynthesis is in recessive mutant condition, which inhibits the sugar to starch conversion. Initially the corn lines with only the sugary (*su*) allele on chromosome 4 used to be referred to as sweet corn. This standard sugary (*su*) corn is thought to have originated from a Peruvian race Chullpi *via* natural mutation. Currently, several endosperm genes affect carbohydrate synthesis are being used either singly or in combination for the development of sweet corn varieties. These genes includes sugary (*su)*, sugary enhancer (*se*), shrunken-2 (*sh2*), brittle (*bt*), brittle-2 (*bt2*), Amylose Extender (*ae*), "Dull" (*du*) and Waxy (*wx)* (Tracy et al., 2006).

Sweet corn is having high quality phyto-nutrition profile. It is one of the richest sources of dietary fiber, vitamin A, B complex vitamins such as thiamin, niacin, pantothenic acid, folates, riboflavin, pyridoxine and flavonoid antioxidant ferulic acid. It contains healthy amounts of essential minerals like iron (Fe), zinc (Zn), magnesium (Mg), copper (Cu), and manganese (Mn).

Sweet corn breeding programme was started early and several composites like Madhuri (1990), Priya (2002) were developed and released for general cultivation of farmers. Even though the composites are having high quality, their yield potential is low as compared to the hybrids. They produce small sized cobs, which reduces their market value. Among the hybrids, single cross hybrids are more advantageous than double and three way cross hybrids due to the uniformity in different agronomic traits as well as their simpler and faster breeding procedure. Heterosis breeding objectives in sweet corn depends on the market requirements, however the most important objective is to increase green cob yield and quality. Quality of sweet corn is measured in terms of higher sugar content, water soluble polysaccharides, shelf life, texture, cob size, cob length, flavor etc. This study was taken up in order to identify superior hybrids with high sugar content for commercial exploitation

MATERIALS AND METHODS

The experimental material comprised of 14 parents (7 Lines and 7 Testers) and 49 crosses derived from them along with a check (Sugar 75). Genetically pure seed materials of 14 inbred parents obtained from the Department of Millets, CPBG, TNAU, Coimbatore formed the base for the present study. List of parental lines and testers are given in Table1.

The seven inbred lines were crossed with seven testers in Line x Tester (L x T) mating design to generate 49 crosses. For crossing, hand emasculation and pollination method was followed. The tassels of the female plants (lines) were removed immediately as soon as appeared (detasseling). The ear shoot emerging from the leaf sheath was bagged using butter paper cover to avoid pollen contamination. The tassels of male plants (testers) were also covered with brown paper cover before anthesis and two days prior to the silk emergence in the morning 9.00 – 10.00A.M in order to collect the pollen grains. Hand pollination was done during 9-11 A.M. After carefully removing the butter paper cover, pollens from the tassel bag were dusted over the silk and the cover was replaced immediately after dusting and covered to avoid contamination from other pollen sources.

The newly synthesized forty nine hybrids along with the fourteen parents were evaluated along with standard check, Sugar 75. Each hybrid/ parent was raised in two rows each of 4m length in RBD. The recommended package of practices was followed and biometrical observations were recorded on five randomly selected plants for 17 quantitative traits and three qualitative traits. In both parents and F_1s, five plants from each genotype in every replication were selected and tagged randomly for recording the biometrical observations. Eighteen yield and yield contributing characters, one physiological parameter and five quality traits were recorded. The average values obtained from the five representative plants are considered as the mean value of that genotype in each replication. These mean values were used for statistical analysis.

The overall mean value for each parent and hybrid for each character was taken for estimation of heterosis. The magnitude of heterosis in hybrids was expressed as percentage increase or decrease of a character over mid parent (di), better parent (dii) and standard check (diii) and was estimated using the following formula (Turner, 1953)

RESULTS AND DISCUSSION

Highly significant variance due to genotypes was obtained for all the characters, which indicated the presence of sufficient variability for improvement. Variance due to parents and hybrids were significant for most of the traits except days to silking (parents) and tassel branches (hybrids). The significant difference among the genotypes for all the twenty five characters were tested by analysing the different components of variance. The results revealed that variation due to genotypes were found to be significant for all the characters studied, which indicated the presence sufficient variability among the genotypes for improvement. Similar results were reported by Kumara *et al.* (2013) for plant height, days to 50% tasseling, days to 50% silking, cob length, cob breadth, number of kernel rows per cob, number of kernels per row, green cob yield, total soluble solids, total sugar, reducing sugar and non-reducing sugar. Other sources of variation *viz*., parents ,crosses and parent *vs* crosses showed significance for most of the characters except days to silking (parents), tassel branches (crosses), days to tasseling, days to 50% tasseling and total soluble solids (parent *vs* crosses).

Information on the magnitude of heterosis is a pre- requisite in the development of hybrids. A good hybrid should manifest high amount of heterosis for commercial exploitation. Kabdal *et al.* (2003) reported that more reliable results were produced when best crosses were selected based on heterosis along with *per se* performance for grain yield and cob length. For flowering traits like days to 50% tasseling and days to 50% silking, heterosis in the negative direction is considered as desirable (Kumar et al., 2014).

The hybrids $L_4 xT_6$, $L_4 xT_5$, L_5xT_6, $L_1 xT_7$, and L_7 xT_3 exhibited higher mean performance for green cob yield, in which L_4 xT_6 hybrid showed favourable *per se* performances for thirteen traits in addition to green cob yield *viz*., days to 50% silking, tassel length, cob placement height, green cob weight, cob length, cob breadth, number of kernel rows per cob, number of kernels per row, dry cob weight, seed weight per cob, hundred seed weight, total chlorophyll content and zinc content. This was followed by L_5xT_6, which exhibited desirable mean performance for ten other characters also. The next best hybrid, L_4 xT_5 exhibited significant mean performance for eight more characters besides yield which includes, days to 50% silking, green cob weight, cob length, dry cob weight, seed weight per cob, total chlorophyll content, total sugar and iron content. Following this, L_1 xT_7 was found to be good with significant *per se* performance for days to 50% tasseling, days to 50% silking, green cob weight, cob length, number of kernel rows per cob, total sugar and zinc content. The hybrid L_7 xT_3 exhibited desirable mean performances for a total of six characters under study.

According to Suhasini et al. (2016), green cob yield has positive and significant correlation with with number of kernel rows per cob, plant height, green cob weight, cob length, cob breadth, 100 seed weight, number of kernels per row indicating that indirect selection for yield through these traits will be effective.

The best five hybrids identified based on mean performance for green cob yield and yield contributing traits were L_4 xT_6 , L_4 xT_5, L_5xT_6, L_1 xT_7, and L_7 xT_3 and these hybrids possess atleast one of the parents which were found to be having superiority in mean performance. Hence, from the present study it was evident that parents with good *per se* performance can result in good hybrids.

In the present study, three hybrids recorded significant positive standard heterosis over the check Sugar 75 for green cob yield *viz.*,L_4 xT_6 , L_5 x T_6 and L_4 xT_5. Besides yield, L_4 xT_6 showed significant heterosis for cob length, green cob weight, cob placement height, tassel length, days to 50% silking, number of kernel rows per cob, number of kernels per row, dry cob weight, seed weight per cob, 100 seed weight, total chlorophyll content and zinc content. Green cob weight had positive and significant relationship with cob length followed by number of kernels per row and cob breadth in the studies by Chinthiya et al. (2019), and in the present study also heterotic hybrids were identified with better green cob yield combined with yield attributing traits. Hybrids L_5xT_6 and L_4 xT_5 recorded significant economic heterosis superiority for a total of seven traits. For total sugar content trait, hybrids L_6 xT_5, L_5 xT_7, L_1 xT_3 and L_5 xT_6 showed significant positive heterosis.

Hence, the hybrids L_4 xT_6 , L_5x$T_6$and L_4 xT_5 were identified as superior based on significant standard heterosis over the check Sugar 75 for yield and contributing traits. For total sugar, hybrids L_6 xT_5, L_5 xT_7, L_1 xT_3 and L_5 xT_6 were found to be superior. Similar results for economic heterosis were reported by Kabdal et al. (2003) for grain yield and cob length, Kumar et al. (2014) for days to 50% tasseling, cob placement height, cob length, cob breadth, 100 seed weight and grain yield. Sadaiah et al. (2013) reported same findings for total sugar. Similar results for most of the traits such as green cob yield., tassel branches, cob length, cob breadth, number of kernels per row, dry cob yield, seed weight per cob and 100 seed weight were reported by Suhasini (2016).

Table 1: List of lines and testers used

Sl.No	Code No.	Name of the lines/Testers
1	L_1	WNC 12069
2	L_2	SC1107
3	L_3	USC 1-2-3-1
4	L_4	SC 11-2
5	L_5	12039-1
6	L_6	1421-5-2-1
7	L_7	12068-2
8	T_1	MRCSC 13
9	T_2	MRCSC 2
10	T_3	WNDMRSCY 19 R 773
11	T_4	DMSC 24
12	T_5	DMSC 20
13	T_6	951-7
14	T_7	DMSC 36

Table 2: Mean squares analysis of variances

Characters	Sources of variation				
	Genotypes	**Hybrids**	**Parents**	**Parents vs hybrids**	**Error**
Days to tasseling	9.29**	10.23**	6.40**	1.96	1.56
Days to silking	4.16**	4.61**	1.66	14.97**	1.74
Days to 50% tasseling	15.28**	14.15**	20.04**	7.20	2.14
Days to 50% silking	7.77**	5.38**	10.55**	86.35**	2.05
ASI	5.73**	4.31**	10.96**	6.10**	0.21
Plant height	458.27**	327.97**	145.97**	10772.43**	37.62
Tassel length	27.93**	13.13**	26.98**	750.83**	3.40
Tassel branches	5.20**	3.75	9.48**	18.98*	2.85
Cob placement height	241.98**	211.22**	191.93**	2369.05**	22.51
Green cob yield	14.81**	3.93**	3.65**	681.14**	0.27
Green cob weight	1705.41**	810.29**	1151.25**	51875.94**	61.40
Cob length	4.35**	2.96**	5.39**	57.48**	0.17
Cob breadth	1.25**	0.75**	0.95**	29.02**	0.27
Number of kernel rows per cob	4.93**	5.00**	4.47**	7.91**	0.89
Number of kernels per row	38.72**	36.88**	46.56**	25.55**	1.42
Dry cob weight	186.95**	167.88**	54.99**	2817.29**	7.40
Seed weight per cob	150.08**	133.81**	117.77**	1351.00**	9.37
100 seed weight	10.35**	9.61**	11.41**	32.09**	0.98
Total sugar	31.55**	31.64**	32.48**	14.96**	0.90
Reducing sugar	0.48**	0.50**	0.40**	0.89**	0.01
Non reducing sugar	37.30**	37.13**	39.02**	23.20**	0.93
Total soluble solids	2.73**	2.36**	4.30**	0.01	0.13
Total chlorophyll content	28.53**	20.39**	30.39**	395.24**	6.56
Fe content	22.27**	12.82**	11.53**	615.84**	0.09
Zn content	5.89**	5.43**	2.28**	75.06**	0.03

*significant at 5% level **significant at 1% level.

Table 3: Standard heterosis (diii) exhibited by the sweet corn hybrids for various traits

S.No	Hybrids	Days to 50% tasseling	Days to 50% silking	ASI	Cob placement height	Single Green cob weight	Cob length	Cob Breadth	No.of kernel rows per cob	No.of kernels per row	Green cob yield	Total sugar
1	L1 x T1	8.16 **	3.85 ns	-75.00 **	3.15 ns	-12.33	-11.82**	-2.50 ns	-10.60 *	-8.00 **	-20.81 **	-5.68 ns
2	L1 x T2	4.08 ns	1.92 ns	-50.00 **	6.54 ns	-7.26	5.31 **	1.93 ns	8.06 ns	-3.20 *	-12.52 **	-19.05 **
3	L1 x T3	0.00 ns	0.00 ns	-16.67 ns	3.68 ns	11.54 **	-10.10**	-1.40 ns	-7.83 ns	-9.60 **	-11.30 **	10.62 *
4	L1 x T4	-4.08 ns	-3.85 ns	0.00 ns	8.79 ns	-12.30	0.51 ns	-0.29 ns	5.53 ns	-20.0 **	-4.85 ns	-26.11 **
5	L1 x T5	-2.04 ns	-1.92 ns	-25.00 *	19.82 **	-5.89 ns	5.31 **	2.15 ns	5.76 ns	-13.60 **	-10.37 *	-8.95 ns
6	L1 x T6	-1.36 ns	0.00 ns	-50.00 **	23.01 **	-4.06 ns	-3.60 *	3.92 ns	-7.14 ns	-14.40 **	-17.13 **	-17.13 **
7	L1 x T7	-4.08 ns	-3.85 ns	16.67 ns	12.91 **	17.26 **	5.65 **	4.14 ns	13.36 *	-23.20 **	4.36 ns	5.98 ns
8	L2 x T1	-4.76 ns	-4.49 *	-25.00 *	12.26 *	-10.13	-6.34 **	1.26 ns	-5.53 ns	-14.40 **	-20.20 **	-8.45 ns
9	L2 x T2	2.04 ns	1.92 ns	-75.00 **	-0.37 ns	-5.87 ns	-3.94 *	2.37 ns	-1.15 ns	-16.80 **	-20.20 **	-28.35 **
10	L2 x T3	0.00 ns	-3.85 ns	0.00 ns	14.96 **	-2.77 ns	-1.37 ns	0.16 ns	2.30 ns	-9.60 **	3.13 ns	6.45 ns
11	L2 x T4	-1.36 ns	-2.56 ns	-33.33 **	23.13 **	-2.58 ns	0.68 ns	0.38 ns	-21.89 **	-6.40 **	-18.05 **	2.97 ns
12	L2 x T5	-2.04 ns	-1.92 ns	-16.67 ns	22.72 **	0.07 ns	1.20 ns	1.71 ns	-6.22 ns	-13.60 **	4.97 ns	11.82 **
13	L2 x T6	8.16 **	3.85 ns	-50.00 **	19.08 **	-16.23	-1.71 ns	3.70 ns	4.15 ns	-20.80 **	-18.97 **	-19.64 **
14	L2 x T7	-4.08 ns	0.00 ns	25.00 *	25.05 **	-2.87 ns	3.25 ns	4.14 ns	6.91 ns	-23.20 **	3.44 ns	18.93 **
15	L3 x T1	4.08 ns	-1.92 ns	-25.00 *	32.37 **	9.73 **	-0.68 ns	-6.27 *	-12.21 *	-12.80 **	-9.15 *	-3.91 ns
16	L3 x T2	0.00 ns	-3.85 ns	0.00 ns	32.24 **	8.68 **	-2.40 ns	1.04 ns	5.76 ns	-25.60 **	-8.53 *	-16.38 **
17	L3 x T3	-6.12 *	0.00 ns	25.00 *	26.28 **	3.16 ns	-7.02 **	1.04 ns	0.69 ns	-11.20 **	-35.54 **	1.57 ns
18	L3 x T4	4.08 ns	1.92 ns	-50.00 **	44.83 **	-10.41	-5.99 **	4.37 ns	5.30 ns	-4.80 **	-16.82 **	8.83 ns
19	L3 x T5	-0.68 ns	-0.64 ns	-8.33 ns	30.12 **	8.58 **	5.82 **	5.03 ns	9.68 ns	-16.00 **	-3.62 ns	5.98 ns
20	L3 x T6	0.00 ns	-1.92 ns	-25.00 *	35.55 **	8.36 **	2.74 ns	1.48 ns	15.67 **	-8.80 **	-9.15 *	9.06 *
21	L3 x T7	-2.04 ns	0.00 ns	25.00 *	17.86 **	5.58 ns	-5.82 **	-0.95 ns	-3.00 ns	-25.60 **	-4.24 ns	-55.21 **
22	L4 x T1	-4.08 ns	-1.92 ns	50.00 **	29.71 **	8.79 **	-2.40 ns	3.04 ns	-12.21 *	-11.20 **	-10.07 *	-36.71 **
23	L4 x T2	6.12 *	1.92 ns	-50.00 **	20.31 **	-1.20 ns	1.20 ns	0.60 ns	3.46 ns	-25.60 **	-19.28 **	-16.34 **
24	L4 x T3	10.20 **	1.92 ns	-75.00 **	23.42 **	2.09 ns	4.79 **	3.26 ns	2.07 ns	-14.40 **	-22.65 **	-1.85 ns
25	L4 x T4	-6.12 *	-3.85 ns	25.00 *	14.75 **	-1.63 ns	-0.17 ns	-2.28 ns	-12.44 *	-36.80 **	1.29 ns	-2.97 ns
26	L4 x T5	-3.40 ns	-4.49 *	0.00 ns	29.26 **	10.23 **	5.82 **	5.92 *	0.92 ns	-10.40 **	8.35 *	13.08 **
27	L4 x T6	-3.40 ns	-4.49 *	-25.00 *	38.17 **	15.01 **	7.88 **	7.25 *	10.60 *	3.20 *	19.09 **	-16.38 **
28	L4 x T7	2.04 ns	0.00 ns	-25.00 *	25.01 **	0.82 ns	-5.14 **	4.14 ns	13.82 **	-3.20 *	-11.60 **	5.43 ns
29	L5 x T1	-4.08 ns	-3.85 ns	-16.67 ns	18.51 **	-2.04 ns	-0.34 ns	5.25 ns	7.14 ns	-14.40 **	-3.93 ns	-26.52 **
30	L5 x T2	-0.68 ns	-1.92 ns	8.33 ns	2.00 ns	9.63 **	-10.10 **	-5.61 *	-13.59 *	1.60 ns	-16.82 **	-19.66 **
31	L5 x T3	0.00 ns	0.00 ns	-25.00 *	25.30 **	-1.29 ns	-1.37 ns	-0.73 ns	2.76 ns	-7.20 **	-11.60 **	-34.94 **
32	L5 x T4	4.08 ns	-1.92 ns	-25.00 *	20.15 **	2.09 ns	4.11 *	-0.95 ns	1.61 ns	-10.40 **	-7.92 ns	-11.88 **
33	L5 x T5	-4.08 ns	-3.85 ns	-25.00 *	15.53 **	-0.91 ns	-4.45 *	8.35 **	-1.38 ns	-20.80 **	-7.31 ns	-5.27 ns
34	L5 x T6	-6.12 *	-3.85 ns	-50.00 **	34.70 **	-2.87 ns	8.90 **	11.01 **	2.07 ns	-2.40 ns	9.27 *	10.15 *
35	L5 x T7	2.04 ns	0.00 ns	-50.00 **	22.68 **	-2.81 ns	-0.86 ns	3.70 ns	-12.44 *	-8.80 **	-13.44 **	25.32**
36	L6 x T1	2.04 ns	-1.92 ns	-25.00 *	24.93 **	-11.81**	-1.88 ns	7.02 *	-5.99 ns	-16.00 **	-10.99 **	6.17 ns
37	L6 x T2	-4.08 ns	-1.92 ns	0.00 ns	12.67 **	-7.86 **	-5.65 **	4.59 ns	8.99 ns	-4.00 *	-8.23 *	-39.26 **
38	L6 x T3	-2.04 ns	-3.85 ns	0.00 ns	30.20 **	-6.83*	8.90 **	1.93 ns	4.84 ns	-6.40 **	-5.46 ns	-12.82 **
39	L6 x T4	10.20 **	3.85 ns	-75.00 **	31.71 **	-1.15 ns	-4.62 **	-1.62 ns	9.91 ns	-31.20 **	-34.32 **	-30.06 **
40	L6 x T5	2.04 ns	0.00 ns	-25.00 *	31.47 **	-10.20**	-0.86 ns	2.37 ns	9.22 ns	-16.00 **	-10.68 **	27.29 **
41	L6 x T6	0.00 ns	-3.85 ns	0.00 ns	31.02 **	-6.40*	-3.42 *	1.71 ns	-9.22 ns	-20.00 **	-3.93 ns	24.93 **
42	L6 x T7	4.08 ns	-1.92 ns	-25.00 *	32.57 **	-5.11 ns	-0.17 ns	0.16 ns	6.68 ns	-5.60 **	-9.15 *	-12.90 **
43	L7 x T1	-3.40 ns	-2.56 ns	-25.00 *	24.07 **	13.03 **	1.20 ns	-0.51 ns	8.53 ns	-24.80 **	-8.84 *	-43.41 **
44	L7 x T2	4.08 ns	1.92 ns	-25.00 *	17.57 **	5.72 ns	-7.19 **	-0.73 ns	5.99 ns	-7.20 **	-9.45 *	-7.18 ns
45	L7 x T3	10.20 **	3.85 ns	-75.00 **	5.44 ns	-3.55 ns	-4.45 *	1.71 ns	11.52 *	-16.00 **	4.36 ns	-16.71 **
46	L7 x T4	-0.68 ns	-1.28 ns	-33.33 **	16.76 **	-6.59*	-5.99 **	4.81 ns	-0.23 ns	-8.80 **	-12.83 **	12.86 **
47	L7 x T5	0.00 ns	0.00 ns	-33.33 **	10.22 *	-5.11 ns	-2.23 ns	3.70 ns	-11.75 *	-22.40 **	-19.89 **	-3.79 ns
48	L7 x T6	-0.68 ns	3.85 ns	-8.33 ns	15.41 **	-2.60 ns	-8.05 **	-0.29 ns	-14.52 **	-20.80 **	-1.47 ns	-13.76 **
49	L7 x T7	6.12 *	1.92 ns	-75.00 **	10.30 *	-1.29 ns	4.79 **	6.14 *	-6.45 ns	-18.40 **	-22.34 **	-42.37 **
Range		-6.12 to10.20	-4.49 to 3.85	-75 to 50	-0.04 to 44.83	-16.23 to17.26	-11.82 to7.88	-6.27 to 11.01	-21.89 to 15.67	-36.80 to 3.2	-35.54 to 19.09	-55.21 to27.29

Table 5: Best hybrids for important traits based on mean performance and standard heterosis

Sl.No.	Characters	Mean	Standard heterosis	Mean and standard heterosis
1	Days to 50% tasseling	L_3 x T_3 , L_4 x T_4 , L_5 x T_6 , L_2 x T_1 , L_1 x T_4 , L_1 x T_7 , L_2 x T_7 , L_6 x T_2 , L_7 x T_1 , L_7 x T_4	L_3 x T_3 , L_4 x T_4 , L_5 x T_6	L_3 x T_3 , L_4 x T_4 , L_5 x T_6
2	Days to 50% silking	L_2 x T_1 , L_4 x T_5 , L_4 x T_6 , L_1x T_4 , L_1 x T_7 , L_2 x T_3 , L_3 xT_2 , L_4 x T_4 , L_4 x T_6 , L_5 x T_1, L_5 x T_5 , L_5 x T_6 , L_6 x T_3 ,L_6 x T_6	L_2 x T_1 , L_4 x T_5 , L_4 x T_6	L_4 x T_6
3	Anthesis Silking Interval	L_1 x T_1 , L_2 x T_2 , L_1 x T_6 , L_4x T_3 , L_6 x T_4 , L_7 x T_3	L_3 x T_4 , L_5 x T_7, L_1 x T_1 , L_2x T_2 , L_5 x T_6 , L_4 x T_3 , L_6 xT_4 , L_7 x T_3	L_1 x T_1 ,L_2 x T_2 , L_4 x T_3 , L_6 x T_4 ,L_7 x T_3
4	Tassel length	L_1 x T_3 , L_7 x T_6 , L_5 x T_7 ,L_4 x T_6	L_1 x T_3 , L_1 x T_5 , L_4 x T_6, L_5x T_7 , L_7 x T_6	L_1 x T_3 , L_5 x T_7 , L_7 x T_6, L_4 x T_6
5	Tassel branches	L_1 x T_6	L_1 x T_6	L_1 x T_6
6	Cob placement height	L_3 x T_4 , L_3 x T_6 , L_4 x T_6 ,L_5 x T_6 , L_3 x T_1 , L_3 x T_2 ,L_6 x T_4	L_3 x T_4 , L_3 x T_6 , L_4 x T_6, L_5x T_6 , L_6 x T_7	L_3 x T_4 , L_3 x T_6 , L_4 x T_6,
7	Green cob weight	L_1 x T_7 , L_4 x T_6 , L_7 x T_1 , L_1x T_3 , L_4 x T_5	L_1 x T_3 , L_1 x T_7 , L_4 x T_5 , L_4 x T_6 , L_7 x T_1	L_1 x T_3 , L_1 x T_7 , L_4 x T_6 , L_4 x T_5 , L_7 x T_1
8	Cob length	L_5 x T_6 , L_6 x T_3 , L_4 x T_6 ,L_3 x T_5 , L_4 x T_5 , L_1 x T_7 ,L_2 x T_7	L_1 x T_7 , L_3 x T_5 , L_4 x T_5 , L_4 x T_6 , L_5 x T_6 , L_6 x T_3	L_1 x T_7 , L_3 x T_5 , L_4 x T_5 , L_4 x T_6 , L_5 x T_6 , L_6 x T_3
9	Cob breadth	L_5 x T_6 , L_5 x T_5 , L_4 x T_4	L_4 x T_5 , L_4 x T_6 , L_5 x T_5 , L_5 x T_6 , L_7 x T_7	L_5 x T_6 , L_5 x T_5 , L_4 x T_4
10	Number of kernel rows per cob	L_3 x T_6 , L_4 x T_6 , L_1 x T_7 ,L_7 x T_3 , L_4 x T_6	L_1 x T_7 , L_3 x T_6 , L_4 x T_6 , L_4 x T_7 , L_7 x T_3	L_1 x T_7 , L_3 x T_6 , L_4 x T_6 , L_4 x T_7 , L_7 x T_3
11	Number of kernels per Row	L_4 x T_6 , L_5 x T_2 , L_5 x T_6 ,L_1 x T_2 , L_4 xT_7	L_4 x T_6	L_4 x T_6
12	Green cob yield	L_1 x T_7, L_2 x T_3, L_2 x T_5 , L_2x T_7 , L_4 x T_4 L_4 x T_5 , L_4 xT_6 , L_5 x T_6 , L_7 x T_3 , L_7 x T_6	L_4 x T_5 , L_4 x T_6 , L_5 x T_6	L_4 x T_5 , L_4 x T_6 , L_5 x T_6
13	Dry cob weight	L_5 x T_6 , L_4 x T_5 , L_7 x T_3 , L_2 x T_5 , L_4 x T_6, L_4 x T_4	L_2 x T_5 , L_4 x T_6 , L_5 x T_6 , L_7 x T_3	L_2 x T_5 , L_4 x T_6 , L_5 x T_6 , L_7 x T_3
14	Seed weight per cob	L_4 x T_6 , L_7 x T_3 , L_2 x T_5 ,L_5 x T_6 , L_4 x T_4, L_4 x T_5	L_2 x T_5 , L_4 x T_4 , L_4 x T_6 , L_5 x T_6 , L_7 x T_3	L_2 x T_5 , L_4 x T_4 , L_4 x T_6 , L_5 x T_6 , L_7 x T_3
15	Hundred seed weight	L_7 x T_5, L_1 x T_5, L_6 x T_5 ,L_2 x T_5 , L_4 x T_6, L_5 x T_6 ,L_7 x T_3	L_1 x T_5, L_2 x T_5 , L_4 x T_6 , L_6 x T_5 , L_7 x T_3, L_7 x T_5	L_1 x T_5, L_2 x T_5 , L_4 x T_6 , L_6 x T_5 , L_7 x T_3, L_7 x T_5
16	Total chlorophyll Content	L_4 x T_5, L_4 x T_6, L_1 x T_4 , L_6 x T_2 , L_7 x T_5	L_4 x T_5, L_4 x T_6, L_1 x T_4 , L_6 x T_2 , L_7 x T_5	L_4 x T_5, L_4 x T_6, L_1 x T_4 , L_6 x T_2 , L_7 x T_5
17	Total sugar	L_6 x T_5, L_5 x T_7, L_4 x T_5 ,L_5 x T_6 , L_6 x T_6 , L_2 x T_7 ,L_1 x T_3 , L_2 x T_3 , L_2 x T_4 ,L_2x T_5, L_1 x T_7	L_5 x T_6, L_5 x T_7, L_2 x T_7 , L_6 x T_5 , L_6 x T_6 , L_3 x T_6 ,L_2 x T_5 , L_1 x T_3	L_5 x T_6, L_5 x T_7, L_2 x T_7 , L_6 x T_5 , L_6 x T_6 ,L_2 x T_5 , L_1 x T_3
18	Fe content	L_1 x T_1, L_1 x T_3 , L_1 x T_5,L_1 x T_6 , L_4 x T_5 , L_7 x T_2 ,L_7 x T_7	L_7 x T_7 , L_7 x T_2 , L_4 x T_5	L_7 x T_7 , L_7 x T_2 , L_4 x T_5
19	Zn content	L_1 x T_2, L_1 x T_3 , L_1 x T_5,L_4 x T_6 , L_1 x T_7 , L_2 x T_5 ,L_1 x T_7	L_4 x T_6, L_1 x T_2 , L_1 x T_3, L_1 x T_5	L_4 x T_6, L_1 x T_2 , L_1 x T_3, L_1 x T_5

CONCLUSIONS

The hybrids L_4 xT_6, L_5xT_6 and L_4 xT_5 were identified as superior based on significant standard heterosis over the check Sugar 75 for yield and contributing traits. For total sugar , hybrids L_6 xT_5, L_5 xT_7, L_1 xT_3 and L_5 xT_6 were found to be superior.

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