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Effect of harvest time on kernel sugar concentration in sweet corn

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Abstract

Wide variation in kernel sugar concentration was found among the sweet corn genotypes. Effect of environment, mode of pollination, date of harvest, and their interactions with genotypes on kernel sugar concentration was prominent. Among the inbred lines, BLSB-RIL62 was found to be the most promising and stable inbred line in Hyderabad [35.50%, 35.53% and 34.15% brix value at 20, 24 and 28 days after pollination (DAP), respectively] under controlled-pollination. BLSB-RIL62 (22.50%) was the best at 20 DAP in Delhi, although it was not stable at later stages. Among the composites, Priya was found to be the most stable in Delhi. BLSB-RIL62 x Madhuri was the best among hybrids for kernel sugar concentration in Delhi, while in Hyderabad, no such promising hybrid was found. In general, kernel sugar concentration attained its peak at 20 DAP and gradually dropped off between 20 and 28 DAP. However, there were genotypes which attained peaks at 24 or 28 DAP instead of 20 DAP. The rate of change of kernel sugar concentration across genotypes was found to vary from -3.77 to +2.23% of brix value per day across locations and harvest dates. Differential behaviour of genotype with respect to kernel sugar concentration was found between open- and controlled-pollinations.

Key words: Harvest date, pollination mode, sugar concentration, brix, sweet corn

Introduction

Sweet corn is one of the most popular vegetables and is gaining importance throughout the globe including India. Nearly all commercial sweet corn genotypes are based on one or more simple recessive alleles [*shrunken2* (*sh2*)*, sugary1* (*su1*) and *sugary enhancer1* (*se1*)], that alter carbohydrates types and content of the endosperm and enhance the degree of sweetness [1, 2]. Considering the increasing demand of sweet corn in India as well as in international market, development of sweet corn cultivars with higher concentration of sugar in the kernel coupled with wider adaptability to different agro-ecological regions assumes importance. One of the major aims of sweet corn breeding programmes worldwide has been the development of new generation sweet corn inbred lines that show not only superior productivity but also improved kernel sugar concentration. The present investigation was aimed at identifying promising genotypes with higher and stable kernel sugar concentration and analyzing the effects of environment, mode of pollination and date of harvest on kernel sugar concentration in the sweet corn genotypes.

Materials and methods

The genetic material used in the present study consisted of seven sweet corn inbred lines, of which, four were developed by the Directorate of Maize Research (DMR), New Delhi, and three by the Maize Genetics Unit, IARI, New Delhi. The details of the inbred lines used in the study are given in Table 1. Madhuri, Priya and Win Orange (popular sweet corn composites) released in India were used as males and the inbred lines, DMR-2317, DMR-2318, DMR-2320, DMR-2322, BLSB-RIL10, BLSB-RIL62 and BLSB-RIL91, as females to make 21 cross combinations during the *kharif* (monsoon season) 2007 at the IARI Experimental Farm, New Delhi.

The crosses along with the parents and a popular sweet corn variety, Golden Sweet Corn, were evaluated at two locations (i) Maize Winter Nursery, Hyderabad, during *Rabi* (winter season) 2007-08, and (ii) IARI Experimental Farm, New Delhi during *Kharif* (monsoon

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season) 2008, respectively. The entries were planted in a randomized complete block design (RCBD) with two replications per entry (one row per replication) with a plant-to-plant spacing of 20 cm and row-to-row spacing of 75 cm. In each plot a uniform plant stand of 20 individuals were maintained and standard agronomic practices were followed for raising and maintenance of plants.

Kernels from each of the genotypes were analyzed at 20, 24 and 28 days after pollination (DAP) for estimating kernel sugar concentration [2]. Brix value, recorded using a pocket Refractometer (ATAGO, Japan), was used for measuring kernel sweetness. The possible effect of pollination mode (open- vs. controlled-pollination) on kernel sugar concentration was measured as suggested by Hossain *et al*. [3]. In each plot, five randomly selected plants were self pollinated (in case of inbred lines and experimental hybrids) and ten plants were controlled-pollinated (in case of composites) by bulk pollen collected from all the available plants in each plot. The rest of the plants in each of the plot were allowed to open-pollinate. The randomly selected open- and controlled-pollinated plants were then tagged and brix readings were recorded on the same plant at 20, 24 and 28 DAP. Selected open- and controlled-pollinated ears (five each in case of inbreds and hybrids; and ten in case of composites) in each plot were used for estimation of kernel sweetness. Ten randomly selected tender kernels per ear were used for recording brix reading in individual ears/ plants at a particular DAP. Statistical analyses of the results were carried out using SAS 6.12.

Results and discussion

The results showed significant effects of environment, mode of pollination and date of harvest on kernel sugar concentration (Table not presented). The genotype x environment, genotype x harvest date and genotype x pollination mode interactions were also significant, indicating the sensitivity of the target trait to environmental fluctuations, date of harvest and mode of pollination, respectively.

Among the lines evaluated in Hyderabad under controlled-pollination, BLSB-RIL62 was found to be the best inbred line with 35.50%, 35.53% and 34.15% of brix value at 20, 24 and 28 DAP, respectively (Table 2). BLSB-RIL62 (22.50%) remained the most promising inbred line at 20 DAP in Delhi. However, at 24 and 28 DAP, DMR-2318 was identified as the best genotype with 27.08% and 28.65% brix values, respectively. Among the composites, Madhuri was identified as the best with 22.33% brix value in Hyderabad (under controlled-pollination) at 20 DAP, while Win Orange (18.80%) and Madhuri (17.63%) were most promising at 24 and 28 DAP, respectively. In Delhi, Win Orange was found as the best genotype at 20 DAP, while Priya was the best at both 24 and 28 DAP. Among the cross combinations, BLSB-RIL62 x Madhuri (27.88%) and BLSB-RIL62 x Win Orange (32.68%) at 20 and 24 DAP, respectively, were the most promising genotypes in Hyderabad under controlled-pollination (Table 2). In case of Delhi, BLSB-RIL62 x Madhuri was identified as the best genotype at 20, 24 and 28 DAP with brix reading of 34.65%, 34.73% and 35.60%, respectively.

The results also revealed that, in general, the kernel sugar concentration as indicated by brix value attained its peak at 20 DAP and gradually depleted at 24 and 28 DAP under controlled-pollination mode (Table 2). The rate of change of brix reading across genotypes and environments varied from –2.39 to +2.23% and -3.77 to +0.71% per day during 20-24 and 24-28 DAP under controlled-pollination, respectively. In case of 20-28 DAP period, the change in brix values varied from -1.57 to +0.38% per day. Creech [2] also demonstrated the attainment of highest kernel sugar concentration at 20 DAP. On the contrary, no significant difference in

Table 1. Details of the characteristics of sweet corn inbred lines used in the present study

S.No.	Inbreds	Source	Kernel type	Kernel colour	Maturity
1.	L1 (DMR-2317)	DMR	Shrunken	Yellow	Medium
2.	L2 (DMR-2318)	DMR	Shrunken	Yellow	Medium
3.	L3 (DMR-2320)	DMR	Shrunken	Orange	Medium
4.	L4 (DMR-2322)	DMR	Sugary	Orange	Medium
5.	L5 (BLSB-RIL10)	IARI	Shrunken	Yellow	Medium
6.	L6 (BLSB-RIL62)	IARI	Sugary	Orange	Medium
7.	L7 (BLSB-RIL91)	IARI	Shrunken	Yellow	Medium

DMR: Directorate of Maize Research, IARI: Indian Agricultural Research Institute; RIL: Recombinant Inbred Line

starch and kernel sugar concentration was reported between 1st and 2nd harvest, although kernel sugar concentration depleted gradually after subsequent harvests [4-6]. Interestingly, some cross combinations such as BLSB-RIL62 x Win Orange recorded kernel brix value of 23.78% at 20 DAP, while it rose up to 32.68% at 24 DAP and gradually depleted to 17.60% at 28 DAP under controlled-pollination in Hyderabad (Table 2). In contrast, genotypes such as BLSB-RIL62 x Priya revealed 21.28% and 23.93% brix reading at 20 and 24 DAP, respectively, and reached up to 26.78% at 28 DAP under controlled-pollination in Delhi. This trend suggests that although in general, kernel sugar concentration reaches its peak at 20 DAP, there could be specific genotypes which attain the peak at later stages. Despite the complexity described above, the study led to the identification of some stable genotypes. BLSB-RIL62 x Madhuri in Delhi and BLSB-RIL62 in Hyderabad were identified as the best genotypes with high and stable kernel sugar concentration under

Table 2. Mean kernel brix values in selected sweet corn genotypes at different harvest dates under control- and open-pollination modes

Entries	Hyderabad (20-DAP)		Delhi (20-DAP)		Hyderabad (24-DAP)		Delhi (24-DAP)		Hyderabad (28-DAP)		Delhi (28-DAP)	
	C	O	C	O	C	O	C	O	C	O	C	O
L1	22.73	18.65	20.25	15.10	17.13	12.63	20.85	15.73	**13.40**	**12.65**	21.30	14.55
L2	20.48	18.20	22.05	16.25	18.10	15.58	27.08	14.58	**15.23**	**15.03**	28.65	12.38
L3	19.20	17.30	19.58	15.58	14.15	15.60	18.20	14.65	13.63	15.58	16.18	12.88
L4	19.48	13.15	22.18	15.38	**22.95**	**21.90**	18.55	15.85	18.50	25.80	15.45	17.48
L5	21.48	14.40	**17.20**	**16.50**	**18.00**	**18.00**	16.55	13.28	**13.25**	**13.55**	13.45	15.40
L6	35.50	30.18	22.50	12.51	35.53	20.30	**13.11**	**13.28**	34.15	22.98	**11.40**	**10.48**
L7	**19.80**	**20.03**	21.48	13.70	**20.10**	**19.93**	16.68	13.95	19.20	17.95	14.33	12.40
Mean across lines	22.67	18.84	20.75	15.00	20.85	17.71	18.72	14.47	**18.19**	**17.65**	17.25	13.65
T1	18.80	14.50	19.88	18.23	16.95	12.80	20.05	14.50	**15.50**	**14.80**	18.70	14.63
T2	20.08	16.40	21.53	16.45	18.80	12.25	15.78	13.78	17.45	14.10	**16.03**	**14.75**
T3	22.33	17.98	16.18	11.73	17.75	13.93	15.45	10.50	17.63	11.80	14.48	10.13
Mean across testers	20.40	16.29	19.20	15.47	17.83	12.99	17.09	12.93	16.86	13.57	16.40	13.17
L1 x T2	18.53	14.58	16.78	15.13	23.68	17.20	14.55	10.88	17.53	15.18	12.68	9.65
L2 x T3	16.10	20.75	**16.18**	**16.02**	16.60	15.25	**16.33**	**15.85**	14.35	16.93	**13.85**	**12.30**
L3 x T1	24.73	15.13	**17.55**	**16.55**	**19.33**	**19.43**	21.78	13.53	16.65	12.95	22.78	15.33
L3 x T2	**17.63**	**18.33**	22.15	15.75	16.65	13.70	20.40	13.08	13.10	14.18	19.70	14.35
L5 x T2	21.38	19.53	21.65	16.38	17.33	14.90	20.28	18.85	16.13	13.15	21.53	16.43
L5 x T3	20.53	17.38	17.70	13.38	**18.45**	**19.13**	**14.20**	**14.30**	16.15	18.23	13.18	11.18
L6 x T1	19.28	16.00	21.28	15.68	27.98	13.80	23.93	15.63	21.48	18.60	26.78	13.25
L6 x T2	23.78	21.10	19.70	15.38	32.68	25.08	19.18	12.70	17.60	11.91	16.65	12.13
L6 x T3	27.88	21.28	34.65	19.43	22.60	17.08	34.73	13.45	15.33	16.98	35.60	12.38
L7 x T3	23.10	20.63	26.85	15.23	17.03	19.53	18.58	13.38	14.18	16.40	15.78	10.65
Mean across crosses^	20.22	17.29	20.15	15.83	19.69	16.54	18.72	13.62	**16.20**	**15.43**	17.57	12.80
Check (Golden Sweet Corn)	**17.85**	**18.30**	14.63	11.45	16.00	12.28	**12.58**	**11.45**	**14.58**	**14.18**	12.60	8.38
Grand Mean#	20.69	17.57	20.02	15.48	19.65	16.33	18.37	13.67	**16.65**	**15.70**	17.24	12.88
SE Diff.#	**0.37**	**0.44**	**0.73**	**0.37**	**0.29**	**2.09**	**0.47**	**1.35**	**0.44**	**1.82**	**0.56**	**0.27**

L1: DMR-2317, L2: DMR-2318, L3: DMR-2320, L4: DMR-2322, L5: BLSB-RIL10, L6: BLSB-RIL62, L7: BLSB-RIL91, T1: Priya, T2: WinOrange, T3: Madhuri; O: open-pollination; C: controlled-pollination; DAP: Days after pollination;
^Includes data of all possible combinations. # includes data from all inbred lines, testers and cross combination;
Bold combinations are not significantly different between controlled and open-pollination, while others are significantly different among the two pollination modes.

controlled-pollination. Other genotypes, such as DMR-2317, Priya, DMR-2320 x Win Orange, and BLSB-RIL10 x Win Orange in Delhi; and BLSB-RIL91 in Hyderabad, were also found to be reasonably stable under controlled-pollination.

The study also showed that the rate of change of kernel sugar concentration over days could be influenced by environment, as observed in case of DMR-2320 x Priya, which showed a gain of 1.06% brix value per day in Delhi, while it registered a depletion of 1.35% per day in Hyderabad during 20-24 DAP under controlled-pollination. In contrast, DMR2317 x Win Orange was found to have a depletion of 0.56% per day in Delhi during 20-24 DAP period, while it had an increase of 1.29% of brix reading per day under controlled-pollination in Hyderabad. Besides, in many cases, the direction of change of kernel sugar concentration remained same at both locations, but the extent of change varied. Michaels and Andrew [7] reported the effect of warmer and cooler seasons in determining the extent and quality of sweetness in sweet corn genotypes. Influence of planting dates and date of harvest on sweet corn traits have also been reported [8-10].

Genotypes such as BLSB-RIL62 x Madhuri had 34.65% brix value under controlled-pollination at 20 DAP in Delhi, while the same recorded 19.43% brix value under open-pollination (Table 2). Similar trend of drastic change in kernel sugar concentration under the two pollination modes was also observed in genotypes such as BLSB-RIL91 x Madhuri (20 DAP, Delhi), DMR-2320 x Priya (20 DAP, Hyderabad), BLSB-RIL62 x Madhuri (24 and 28 DAP, Delhi), BLSB-RIL62 x Priya (28 DAP, Delhi), BLSB-RIL62 (24 DAP, Hyderabad), DMR-2318 (24 and 28 DAP, Delhi) and DMR-2317 (28 DAP, Delhi). This could be due to poor complementation of alleles coming from other sweet corn genotypes in the trial or due to fertilization by normal wild type allele. As reported earlier [3] this study also suggested that analyses of kernel sugar concentration from controlled-pollinated ears would provide precise estimates for kernel sweetness as compared to open-pollination. Similar observation of genotype x pollination mode interaction affecting kernel modification in QPM genotypes was earlier reported by Hossain *et al*. [3].

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