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Identification Sugarcane Clones for Tolerance to Juice Quality Deterioration under Delayed Harvest and Different Time Intervals of Staling

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ABSTRACT

A study was under taken during January, 2022–March, 2023 at the Agricultural Research Station, Perumallapalle, Chittoor district, Andhra Pradesh, India to evaluate fifteen sugarcane clones including early and mid-late to identify clones with higher shelf life and tolerance to postharvest deterioration and delayed crop harvests. Juice quality parameters determined at 10th, 11th, 12th and 13thmonths of harvest /age and at different time lag intervals of staling (0, 24, 48, and 72 hours showed a linear increase in cane weight reduction regardless of crop age at harvest and staling periods after harvest. Juice extraction (%) also decreased over staling period and delayed crop harvests. Increase in cane weight loss and reduction in juice extraction was significant with increase in staling period. A progressive increase in brix (%), sucrose, purity and CCS in juice was observed up to 11th in early clones and up to 12th months of crop age in mid-late clones and thereafter decreased. Per cent brix (%) showed a linear trend at all time lag intervals of staling regardless of the clones studied. Brix (%) in juice progressively increased from 0 to 72 hours of staling. Sucrose, purity and CCS per cent declined at 48 hrs in early group and at 72 hrs in mid-late clones after harvest. Reduction in sucrose, purity and CCS was significant with increased staling periods. Among the clones 2003V46 (TC), 2016T 7, COA14328, COA20324, COA19322 and 2009V89 were found to be relatively more tolerant to delayed harvest and post-harvest deterioration compared to the popular standard CO86032 and other test clones studied. All these clones have also recorded higher cane yield and CCS yield at harvest.

KEYWORDS: Brix, sucrose, CCS, purity, post harvest deterioration, sugarcane

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Sugarcane (*Saccharum* spp hybrid) is one of the most important cash crops accounting nearly 70% of sugar production worldwide. India is the second largest producer of sugarcane after Brazil in the world. It is a C_4 crop, capable of accumulating sucrose up to 25% on its fresh weight under optimal growing conditions. About 20-30% of total sucrose synthesized by sugar cane plant is lost during various stages of raw material handling and processing in sugar mills. The economy of sugar mills is largely depends on sugar recovery from milling of sugarcane (Khan *et al.* 2020). Post-harvest losses through primary and secondary sources in sugarcane are a serious concern for farmers in sugar industry which causes significant impact on reduction in cane weight and sugar recovery (Zhao and Li, 2015 and Mishra et al. 2022). The degradation of sucrose in cane begins as soon as the cane is harvested and losses are more pronounced as the time lag between harvest and crushing increases. Acid and neutral invertases contribute to post-harvest sucrose losses in sugarcane as these actively get rapid Inversion of sucrose by plant and microbial invertase and organic acids and dextran formation by *Leuconostoc spp*. are largely responsible for loss of sugar after harvest of cane and during processing in the mill. Organic acids formation by microorganisms leads to loss of sucrose and lowering of juice P^H (Datir, 2015). Formation of chemicals during processing (chemicals and microbial activity) adds not only to e losses but also affects quality and colour of sugar. Inversion of sucrose by plant and microbial invertase and organic acids and dextran formation by *Leuconostoc spp*. are largely responsible for loss of sugar after harvest of cane and during processing in the mill. Formation of organic acids by microorganisms leads to loss of sucrose and lowering of juice P^H (Egan, 1971) Post-harvest deterioration is responsible for 93 % loss due to microbial invasion while enzymatic activity accounting 5.7% and acid degradation for 1.3 % (Eggleston, 2002). Many factors affect cane deterioration viz., variety (genetic maturity, rind hardness, cane thickness, wax coating, moisture status of cane), crop maturity, ambient temperature (high temperature 40^{o}C), low relative humidity (25-35%), delayed harvest, time lag between harvest and crushing, microbial infestation, cultivation practices, biotic and abiotic stress factors, harvesting method, transport and storage systems (Eggleston, 2002; Eggleston et al., 2008; Solomon et al.,2006 and Solomon, 2009). Among the several factors affecting cane quality and sugar recovery, variety plays a crucial role depending upon climate and management practices. Hard rind and thin canes possess tolerance to post-harvest deterioration and vice versa (Kapur and Kanwar, 1987 and Mehrotra and Sharma, 2020). Genotypes also react differently to post-harvest deterioration due to genetic diversity (Cuddihy et al., 2000). The genetic nature of the variety and morphological traits influence post-harvest deteriorations (Siddhant et al., 2009 and Saxena et al., 2010). Immature or over mature thick canes deteriorate rapidly compared to the matured canes. Full green canes are less susceptible to post-harvest deterioration compared to chopped / burned canes. (Misra et al. 2019). The present investigation was carried out to identify high cane and sugar yielding clones possessing tolerance to delayed harvest and post-harvest deterioration through juice quality parameters at different months of crop age and at different time lag intervals of staling/storage in sugarcane.

2. MATERIALS AND METHODS

The study was conducted during January, 2022–March, 2023 at the Agricultural Research Station, Perumallapalle, Chittoor district, Andhra Pradesh, India located in 13° 36' 761" N latitude and 79°20' 704" E longitude. The soils are sandy clay loams, low in organic carbon and nitrogen, medium in phosphorous, medium to high in potassium and soil reaction is neutral to slightly alkaline. Fifteen sugarcane clones comprising early and mid-late were tested in I plant crop in a randomized complete block design with three replications. Each clone was grown in four rows of five meters length adopting 80×20 cm^2 spacing. The ambient temperature ranged from 40-42°C. All the recommended packages of practices for southern zone of the state were followed in raising a healthy crop. Matured canes of uniform size were harvested in each clone and replication, topped, detrashed and kept in separate bundles /small heaps under field conditions after taking initial weight. The juice was extracted in a clean power operated horizontal crusher from freshly harvested canes and staled canes (0, 24, 48 and 72 hrs of storage) for recording juice quality parameters. Reduction in Cane weight (%), juice extraction(%), per cent brix, sucrose, purity and CCS were estimated at 24 hours intervals (0, 24, 48 and 72 hrs) of each harvest and at four months of crop age (10th, 11th, 12th and 13th). The details of observations recorded were furnished here under.

2.1. Reduction in cane weight (%)

Samples were weighed each day for determining changes in cane weight for every clone. Cane weight was recorded for each sample immediately after harvest and before crushing at each interval. The weight variations were converted to per cent changes. Reduction in cane weight (%) was calculated as detailed below (Urgesa et al., 2021).

Reduction in cane weight (%)=(Fresh weight of sample - weight at specified storage period of the sample/Fresh weight of sample)×100 …. (1)

2.2. Juice Extraction

Three canes from each clone and replication were used to extract juice at 24 hrs time lag interval (0, 24, 48 and 72 hrs) in a power operated horizontal crusher. The juice was filtered and weighed. Juice extraction (%) was determined as the ratio of juice weight to the cane weight for each staling period and at different months of harvest/ age.

2.3. Juice quality parameters

Per cent brix (%) in juice was measured using brix spindle (0-20 and 21-30) while sucrose (%) in juice was analysed using polariscope as described by Meade and Chen (1977). Purity (%) was calculated as the ratio of sucrose to corrected brix. Commercial cane sugar (CCS) per cent which is an indicator of total recoverable sugars in the cane was estimated by using following formula

CCS (%)=1.05S-0.3B

(S=Sucrose %; B=Brix %) …. (2)

The average values of three replications were expressed as per cent brix, sucrose, purity and CCS for each month of crop age and different time lag intervals of staling.

3. RESULTS AND DISCUSSION

Statistical analysis was carried out according to Panse and Sukahatme (1985) for each character separately at all the months of crop harvest (10th, 11th, 12th, and 13th) and different time lag intervals of staling/storage (0, 24, 48 and 72 hrs). Analysis of variance indicated significant differences among the clones at all months of crop age and time lag intervals of staling/crushing at each harvest. Results obtained were presented on character wise here under.

3.1. Reduction in cane weight (%)

Cane weight determines the ultimate cane yield of the crop. All the clones showed a reduction in cane weight over 0 hrs of staling. Reduction in cane weight (%) was significant at all time lag intervals of staling (from 0 to 72 hrs) and at all months of crop harvest (10th to 13th month) and thus reduction in cane weight was directly related to storage period. Reduction in cane weight (%) increased progressively from 0 to 72 hrs of staling at each month of crop harvest. Per cent reduction in cane weight increased from 0.756 to 5.592 at 24 hrs of staling; from 1.422 to 8.101 at 48hrs of staling and from 2.485 to 10.614 at 72 hrs of staling from 10th to 13th months of crop harvest, respectively. The reduction in cane weight was high at 72 hrs of staling irrespective of crop age and clones tested. The cumulative reduction in cane weight was low in 2003V46 (TC), 2012V123, 2016T7, 2003V 46 and COA 14328 (early) and COA19322, 2008V257 and 2009V89 (mid-late) indicating their tolerance to evaporative loss of moisture. Hard rind and wax coating on surface of canes may be responsible for less reduction in cane weight. Reduction in cane weight was high in 2009V127, CO 0238, COA 20324, COA 20327, COA 19321, 2009V 127 and CO86032 suggesting that they are susceptible for cane weight loss. Further, reduction in cane weight was low at 10th month as compared to 11th, 12th or 13th month of crop age. It was more pronounced at 13th months of crop age (Table 1). This could be due to increase in ambient temperature from 11th to 13th months of crop age. Uppal, 2003 and Fantaye Ergasi et al., 2023 have also reported that reduction in cane weight was more under delayed harvests and at long intervals of staling. The reduction in cane weight was attributed to increased evaporation and respiration (Verma et al. 2012 and Mehrotra and Shama, 2020).

3.2. Juice extraction (%)

Quantity of juice extracted was measured at all time lag intervals of crushing for each month of crop harvest. Reduction in juice extraction (%) for each time lag interval of staling was determined based on the juice weight recorded immediately after harvest (0 hr of staling). The reduction in juice extraction (%) was linear from 0 hrs to 72 hrs of crushing /staling irrespective of month of crop harvest/ crop age and clones studied (Table 2). The decrease in per cent juice extraction varied from 64.17 to 54.00 at 0 hrs of staling and from 58.45 to 49.75 at 72 hrs of staling from 10th to 13th months of crop harvest, respectively. Reduction of juice extraction (%) was found to be low in 2003V46 (TC), 2003V46, 2016T7, COA14328, 2012V 123 (early) and COA19322, 2009V 89 and 2008V257 (mid-late) indicting that the above clones are tolerant to delay in harvest and post-harvest deterioration. All these clones have also registered less per cent reduction in cane weight loss at different months of crop harvest and at different time lag intervals of staling. Reduction in juice extraction (%) was high in CO 0238, COA19321, COA20321 and CO86032. Fantaye Ergasi et al. (2023) reported that reduction in juice extraction (%) was due to loss of moisture. Juice extraction (%) was observed to be low at 13th months of crop harvest in all the clones studied which may be attributable to increased ambient temperatures.

3.3. Brix in juice (%)

Per cent brix in juice represents total soluble solids which includes all sugars and non-sugars. Higher brix (%) was recorded in early clones at 11th month and in mid-late clones at 12th month (Table 3). Per cent brix declined after 12th month in early clones and at 13th month in mid-late clones. It was increased from 18.95 to 20.19 at 0 hrs of staling from 10th to 12th months of crop age and thereafter declined to 19.30 per cent at 13th month of crop harvest. Brix (%) increased from 0 hrs to 72 hrs of staling at all months of harvest and irrespective of clones studied. The increase

Table 1: Mean data on per cent cane weight loss at different months of crop age (I plant crop) and time intervals of crushing over 0 hrs of staling during 2022–23

Sl. No.	Clone No.	Maturity	At 10th month			At 11th month			At 12th month			At 13th month		
			24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	0.634	1.472	2.561	1.665	2.424	4.023	3.345	5.336	7.173	5.256	7.309	8.376
2.	2009V89	ML	0.703	1.442	2.847	4.554	3.518	5.474	4.899	6.983	9.648	5.313	6.639	7.293
3.	2009V127	E	1.115	1.157	3.060	1.185	2.925	4.536	3.029	3.611	4.847	3.946	8.369	12.721
4.	2012V123	E	1.202	1.662	3.265	2.570	3.978	4.449	3.450	5.055	6.417	3.263	6.326	9.923
5.	2016T7	E	0.520	1.027	2.501	2.158	3.315	4.492	3.548	5.909	8.132	4.278	9.644	8.801
6.	CO 0238	E	0.958	1.812	3.047	2.050	3.147	5.744	3.066	6.540	7.342	3.915	8.716	13.265
7.	COA14328	E	0.800	1.261	1.949	1.761	2.138	3.589	1.837	2.823	4.667	7.172	8.548	9.847
8.	COA19321	E	0.753	1.145	1.478	3.374	3.886	5.755	3.832	6.545	5.395	5.359	8.851	13.940
9.	COA19322	ML	0.240	0.781	1.039	1.358	3.512	3.903	1.750	6.239	8.016	4.492	5.344	8.287
10.	COA20321	E	0.708	1.404	2.183	2.353	3.559	4.901	2.499	4.768	8.856	7.030	8.544	11.014
11.	COA20324	ML	0.855	1.609	2.721	1.548	4.733	4.203	3.227	3.954	10.019	6.397	10.279	13.265
12.	COA20327	E	0.598	1.844	4.185	4.341	8.234	9.545	6.865	9.796	10.715	6.956	7.752	13.271
13.	2003V46 (TC)	E	0.503	1.151	1.593	2.309	2.909	3.183	2.177	5.678	5.018	7.157	8.675	9.441
14.	2003V46 ©	E	0.518	1.213	1.847	1.764	2.327	3.468	2.972	6.389	7.799	6.743	7.224	8.174
15.	CO86032 ©	ML	1.233	2.350	3.001	3.071	5.750	9.457	4.716	8.355	9.059	6.600	9.292	11.589
Mean			0.756	1.422	2.485	2.404	3.757	5.115	3.414	5.865	7.540	5.592	8.101	10.614
SEm±			0.020	0.030	0.029	0.040	0.035	0.039	0.030	0.033	0.032	0.041	0.031	0.033
CD (p<0.05)			0.059	0.086	0.085	0.115	0.102	0.114	0.086	0.094	0.093	0.120	0.089	0.094
CV (%)			4.628	3.623	2.043	2.870	1.626	1.334	1.503	0.961	0.737	1.279	0.658	0.532
Min			0.24	0.78	1.04	1.19	2.14	3.18	1.75	2.82	4.67	3.26	5.34	7.29
Max			1.23	2.35	4.18	4.55	8.23	9.55	6.87	9.80	10.71	7.17	10.28	13.94

Table 2: Mean data on per cent juice extraction at different months of crop age (I plant crop) and time intervals of crushing during 2022–23

Sl. No.	Clone No.	Maturity	At 10th month				At 11th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	64.27	62.29	60.81	58.92	61.33	58.64	56.14	52.76
2.	2009V89	ML	64.60	63.12	60.81	59.42	60.26	58.40	55.86	50.76
3.	2009V127	E	64.22	61.34	58.63	56.64	59.47	57.16	54.08	51.82
4.	2012V123	E	62.79	59.61	55.56	55.45	59.80	57.25	54.27	51.68
5.	2016T7	E	64.39	62.43	60.72	59.41	59.81	57.40	54.82	52.21
6.	CO 0238	E	64.54	64.29	61.49	60.62	59.82	57.41	54.60	51.95
7.	COA14328	E	63.07	60.77	57.49	56.35	61.77	59.33	56.04	53.99
8.	COA19321	E	66.21	65.36	62.21	61.74	63.71	59.31	56.85	54.75
9.	COA19322	ML	64.32	63.72	60.11	59.12	61.70	59.63	56.44	53.89
10.	COA20321	E	64.26	61.38	59.05	55.00	60.51	58.04	55.74	52.68

Table 2: Continue...

Sl. No.	Clone No.	Maturity	At 10th month				At 11th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
11.	COA20324	ML	64.16	61.33	59.64	57.37	58.96	56.85	53.81	51.87
12.	COA20327	E	63.44	60.80	58.23	56.57	60.27	58.07	55.58	52.38
13.	2003V46 (TC)	E	66.42	65.55	62.46	65.45	61.42	58.51	55.89	51.56
14.	2003V46 ©	E	63.35	62.54	59.97	59.74	59.21	57.00	56.00	54.77
15.	CO86032 ©	ML	62.49	59.39	57.43	55.00	59.99	57.59	55.23	52.24
Mean			64.17	62.26	59.64	58.45	60.54	58.04	55.42	52.62
SEm±			0.291	0.553	0.562	0.541	0.742	0.218	0.177	0.156
CD (p<0.05)			0.843	1.602	1.627	1.568	2.150	0.632	0.512	0.452
CV (%)			0.785	1.538	1.631	1.604	2.123	0.651	0.552	0.514
Min			62.49	59.39	55.56	55.00	58.96	56.85	53.81	50.76
Max			66.42	65.55	62.46	65.45	63.71	59.63	56.85	54.77

Table 2: Continue...

Sl. No.	Clone No.	Maturity	At 12th month				At 13th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	57.37	55.80	54.03	52.23	53.69	51.97	51.22	50.20
2.	2009V89	ML	57.66	56.66	55.79	53.54	52.82	51.32	50.40	49.86
3.	2009V127	E	58.82	56.36	53.78	51.85	56.04	54.02	52.20	50.49
4.	2012V123	E	57.48	55.07	52.72	50.70	55.09	52.45	50.21	49.91
5.	2016T7	E	57.48	54.90	52.66	50.48	54.69	52.23	51.22	50.03
6.	CO 0238	E	57.71	55.60	53.63	51.40	53.25	51.15	49.70	48.95
7.	COA14328	E	56.11	54.10	53.48	52.25	55.85	53.90	52.27	51.19
8.	COA19321	E	57.96	55.46	52.78	51.36	55.03	52.95	50.67	49.25
9.	COA19322	ML	56.60	54.27	53.34	51.99	54.84	53.09	50.81	49.96
10.	COA20321	E	57.52	54.74	52.84	50.38	52.02	49.83	48.65	46.16
11.	COA20324	ML	58.34	56.03	53.53	51.67	53.34	51.71	49.60	48.76
12.	COA20327	E	59.18	56.66	53.65	51.71	55.20	53.01	50.76	49.82
13.	2003V46 (TC)	E	58.47	56.45	53.98	52.91	56.01	55.72	54.99	53.32
14.	2003V46 ©	E	58.56	56.48	53.85	51.65	55.78	53.73	52.34	51.71
15.	CO86032 ©	ML	58.85	56.63	53.85	51.02	55.39	52.16	48.70	46.69
Mean			57.87	55.68	53.59	51.68	54.60	52.62	50.92	49.75
SEm±			0.330	0.243	0.144	0.198	0.135	0.173	0.236	0.237
CD (p<0.05)			0.955	0.703	0.416	0.575	0.392	0.500	0.684	0.688
CV (%)			0.986	0.755	0.464	0.665	0.430	0.569	0.803	0.827
Min			56.11	54.10	52.66	50.38	52.02	49.83	48.65	46.16
Max			59.18	56.66	55.79	53.54	56.04	55.72	54.99	53.32

in per cent brix was high ranging from 19.95 to 20.43 at 72 hrs of staling from 10th to 13th months of crop harvest. The increase in per cent brix during staling period may be attributable to loss of moisture from canes and inversion of sucrose (Fantaye Ergasi et al., 2023). Progressive increase in brix (%) from 0 hrs to 72 hrs of staling was also noted by Yusof et al.(2000), Bhatia et al.(2009), Srivastava et al. (2009), Saxena et al. (2010) and Datir and Joshi(2015). Among the clones tested 2009V127, 2016T7 COA14328, COA 19321, 2003V46 (TC and 2003V46 (early) and

COA19322, COA20324, 2008V257 and CO86032 (mid-late) registered higher brix (%) in juice at all months of crop age because of higher content of sucrose.

3.4. Sucrose in juice (%)

Sucrose is an important component of yield in sugarcane. The quality of sugarcane at harvest is determined by the higher concentration of sucrose and lower concentration of non-sucrose components (other sugars). The clones 2016T7, 2003V46 (TC), COA14328,2012V 123,COA 20327, 2003V 46 (early) and COA19322, COA20324 and 2009V89 and (mid-late) recorded higher sucrose (%) content in juice at all time lag intervals of staling indicating that these clones are tolerant to post-harvest deterioration. The reduction in sucrose (%) was found high in CO 0238, 2009V 127, COA19321, COA20321 and CO86032 suggesting that they were susceptible to post-harvest deterioration. Irrespective of clones tested, juice sucrose (%) decreased from 0 to 72 hrs after staling at all months of crop harvest (Table 4). Among clones per cent sucrose ranged from 16.38 to 17.65 at 0 hrs of staling from 1oth to 12th months of crop age and thereafter decreased to 16.50 per cent at 13th months of crop harvest. Similarly trend of increase in juice sucrose from 15.37 to 16.50 from 10th to 12th month and reduction to 15.36 at 13th months of crop age at 72 hrs of staling was observed. Increase in storage/staling period resulted in significant reduction of extractable sucrose (%) in juice. The reduction in sucrose (%) is primarily attributable for enzymatic activity and microbial actions which converts sucrose in to reducing sugars during staling period and delayed harvests (Shivalingamurthy et al. 2018). Rakkiappan et al. (2009) have reported that each day delay in crushing of harvested cane results in significant reduction in sucrose. The decrease in sucrose with increased staling period was also reported by Srivastsva et al. (2009), Saxena et al. (2010), Misra et al. (2022) and Fantaye Ergasi et al. (2023) in sugarcane. Loss in sucrose (%) in cane over storage period was attributed to increased microbial activity (Hiranyavasit, 2016). Higher sucrose (%) was recorded in early clones at 11th month as compared to mid-late clones at 12th month. I t is also evident that mid-late clones possessed

Table 3: Mean data on per cent brix in juice at different months of crop age (I plant crop) and time intervals of crushing during 2022-23

Sl. No.	Entry name	Maturity	At 10th month				At 11th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	15.73	16.53	17.19	17.39	18.88	18.93	19.16	19.49
2.	2009V89	ML	14.93	15.99	16.79	17.23	17.76	18.19	18.36	18.59
3.	2009V127	E	20.29	20.66	20.93	21.13	20.99	21.89	22.66	23.06
4.	2012V123	E	15.19	16.39	16.69	16.89	17.06	17.43	17.59	17.79
5.	2016T7	E	22.53	22.66	22.76	22.83	22.98	23.06	23.26	23.49
6.	CO 0238	E	17.46	17.59	17.76	17.96	18.29	18.69	18.63	19.09
7.	COA14328	E	18.46	19.06	19.19	19.39	19.64	19.76	19.83	19.96
8.	COA19321	E	19.59	19.93	20.19	20.43	20.83	20.96	21.19	21.53
9.	COA19322	ML	20.33	20.46	20.76	21.09	21.68	22.49	23.13	23.33
10.	COA20321	E	18.23	18.49	19.16	19.36	19.63	19.86	20.19	20.56
11.	COA20324	ML	19.63	19.79	19.93	20.13	21.19	21.26	21.66	21.63
12.	COA20327	E	16.13	16.43	16.83	17.19	18.03	18.33	18.46	18.59
13.	2003V46 (TC)	E	22.86	23.09	23.36	23.49	22.99	24.03	24.43	24.66
14.	2003V46 ©	E	22.76	23.06	23.36	23.69	23.59	23.96	24.09	24.36
15.	CO86032 ©	ML	20.19	20.69	20.89	21.09	21.34	21.49	21.56	21.56
	Mean		18.95	19.39	19.72	19.95	20.33	20.69	20.95	21.18
	SEm±		0.106	0.056	0.071	0.078	0.082	0.108	0.082	0.122
	CD (p<0.05)		0.307	0.163	0.205	0.225	0.236	0.312	0.238	0.354
	CV (%)		0.968	0.502	0.623	0.673	0.696	0.900	0.678	0.999
	Min		14.927	15.993	16.693	16.893	17.060	17.427	17.593	17.793
	Max		22.86	23.09	23.36	23.69	23.59	24.03	24.43	24.66

Table 3: Continue...

Sl. No.	Entry name	Maturity	At 12th month				At 13th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	20.23	20.63	21.16	21.76	19.19	19.26	19.69	20.03
2.	2009V89	ML	19.36	19.56	20.23	20.76	19.13	19.49	19.59	19.83
3.	2009V127	E	19.29	19.53	19.73	19.86	18.26	19.29	19.63	20.39
4.	2012V123	E	19.36	19.63	19.96	20.39	18.49	18.36	18.79	19.03
5.	2016T7	E	22.53	22.59	22.79	23.39	21.13	21.29	21.66	22.26
6.	CO 0238	E	17.16	18.46	18.86	19.39	16.13	17.46	17.39	18.06
7.	COA14328	E	22.13	22.36	22.59	23.36	20.23	20.43	20.66	20.79
8.	COA19321	E	19.46	20.26	20.29	20.43	18.69	19.69	19.49	20.13
9.	COA19322	ML	19.53	19.99	20.13	20.33	19.46	19.76	20.09	20.19
10.	COA20321	E	18.99	18.59	18.26	18.76	18.29	18.53	18.46	19.16
11.	COA20324	ML	19.49	19.63	19.73	19.99	18.49	19.56	19.83	20.19
12.	COA20327	E	19.76	20.36	20.63	21.39	18.56	19.33	19.49	19.86
13.	2003V46 (TC)	E	21.86	21.99	22.39	22.66	20.96	21.46	21.79	22.46
14.	2003V46 ©	E	21.89	22.16	22.19	22.33	21.59	21.56	21.79	21.93
15.	CO86032 ©	ML	21.79	22.63	22.93	23.19	20.89	21.93	22.03	22.16
Mean			20.19	20.56	20.79	21.20	19.30	19.83	20.03	20.43
SEm±			0.126	0.128	0.127	0.107	0.109	0.068	0.227	0.094
CD (p<0.05)			0.366	0.371	0.367	0.309	0.314	0.196	0.658	0.273
CV (%)			1.085	1.079	1.055	0.873	0.974	0.591	1.963	0.798
Min			17.160	18.460	18.260	18.760	16.127	17.460	17.393	18.060
Max			22.53	22.63	22.93	23.39	21.59	21.93	22.03	22.46

better tolerance in avoiding sucrose inversion due to lower sucrose content and less deterioration as compared to early maturing clones with higher brix and sucrose contents. The reduction in cane weight, juice extraction and sucrose (%) was significant after 24 hrs in early and at 48 hrs after staling in mid-late clones.

3.5. Purity in juice (%)

Per cent purity (%) determines per cent sucrose in cane juice. Purity (%) showed a decreasing trend with increased staling period and was observed to be high at 72hrs of harvest / staling irrespective of crop age and clones tested. Purity per cent increased from 86.75 to 87.29 from 10th to 12th months of crop age and declined to 85.54 per cent at 13th months of crop harvest at 0 hrs of staling. However, it decreased from 76.81 to 74.99 per cent from 10th to 13th months of crop age at 72 hrs of staling. Clones in both early and mid-late groups showed almost similar trend for reduction in purity coefficient (Table 5). Purity (%) reduction was more pronounced in all the clones at 13th month of crop age. Bhatia et al. (2009) reported that reduction in purity could be attributable for reduction in sucrose and increase in brix. Solomon et al. (2003) and Solomon (2009) opined that reduction in purity (%) could be due to decreased in sucrose (%) and increased reducing sugars. In the present study it was observed that reduction in purity (%) was more significant at 12th month of crop age in early clones and at 13th months of crop age in mid-late clones. Among the clones 2012V 123, 2003V46 (TC), 2003V46, 2016T7, COA 14328, COA 20327 (early) and 2009V 89, COA 19322, COA 20324 (mid-late) possessed higher per cent purity at all months of crop harvest and staling periods indicating that they were tolerant to delayed crop harvests and post-harvest deterioration. The clones *viz;* 2008V257, 2009V 127, CO 0238, COA 19321, CO 86032 and COA 20321 showed higher reduction in per cent purity and thus were found to be highly susceptible for post-harvest deterioration and delayed crop harvests.

3.6. Commercial cane sugar (CCS) in juice (%)

Higher CCS (%) was recorded in early clones at 11th months of crop age as compared to mid-late clones at 12th month. Reduction in CCS (%) was significant with increase in staling period at all months of crop harvest. CCS (%) decreased progressively from 0 to 72 hrs of staling at each harvest (Table 6). Commercial cane sugar

Table 4: Mean data on per cent sucrose in juice at different months of crop age (I plant crop) and time intervals of crushing during 2022–23

Sl. No.	Entry name	Maturity	At 10th month				At 11th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	14.09	14.15	13.76	13.43	15.88	15.13	14.86	14.54
2.	2009V89	ML	13.52	13.22	12.93	12.79	15.55	15.37	15.03	14.78
3.	2009V127	E	13.83	13.41	12.71	12.30	14.39	14.26	13.89	13.63
4.	2012V123	E	14.33	14.01	13.59	13.41	15.07	14.76	14.35	14.18
5.	2016T7	E	20.01	19.73	19.56	19.40	20.77	20.69	20.51	20.25
6.	CO 0238	E	15.25	14.92	14.62	14.41	16.49	16.30	15.94	15.59
7.	COA14328	E	15.75	14.99	14.26	13.84	16.88	16.67	16.14	15.90
8.	COA19321	E	16.72	16.26	16.00	15.77	18.00	17.51	17.01	16.19
9.	COA19322	ML	17.75	17.43	17.16	16.86	19.45	19.30	18.66	18.43
10.	COA20321	E	15.53	15.27	14.90	14.53	17.72	17.07	16.52	16.01
11.	COA20324	ML	17.36	17.23	16.70	16.37	18.45	18.24	17.86	17.62
12.	COA20327	E	14.43	14.13	13.42	12.95	15.90	15.60	15.19	14.74
13.	2003V46 (TC)	E	20.74	20.57	20.03	19.82	21.17	20.96	20.49	19.78
14.	2003V46 ©	E	19.96	19.82	19.47	19.33	20.64	20.25	19.89	19.75
15.	CO86032 ©	ML	16.44	16.09	15.75	15.14	17.88	17.63	17.31	16.99
	Mean		16.38	16.08	15.65	15.37	17.60	17.29	16.88	16.53
	SEm±		0.093	0.101	0.103	0.090	0.104	0.120	0.135	0.090
	CD (p<0.05)		0.269	0.294	0.299	0.260	0.300	0.348	0.390	0.262
	CV (%)		0.980	1.093	1.141	1.011	1.020	1.203	1.381	0.947
	Min		13.523	13.217	12.713	12.303	14.390	14.257	13.890	13.633
	Max		20.74	20.57	20.03	19.82	21.17	20.96	20.51	20.25

Table 4: Continue...

Sl. No.	Entry name	Maturity	At 12th month				At 13th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	16.36	15.95	15.77	15.52	14.53	14.04	13.29	12.95
2.	2009V89	ML	18.51	18.01	17.49	17.12	16.80	16.68	16.53	16.05
3.	2009V127	E	17.39	16.41	15.99	15.66	15.52	15.30	14.95	14.79
4.	2012V123	E	16.10	15.76	15.46	15.18	16.31	15.92	15.65	15.31
5.	2016T7	E	19.74	19.45	19.08	18.80	18.69	18.25	17.94	17.61
6.	CO 0238	E	15.47	15.15	14.88	14.53	14.31	13.87	13.51	13.23
7.	COA14328	E	19.13	18.76	18.34	17.97	18.52	18.19	17.81	17.04
8.	COA19321	E	15.85	15.56	15.40	14.91	14.28	13.50	12.63	12.27
9.	COA19322	ML	17.85	17.26	16.97	16.56	17.09	16.85	16.54	16.37
10.	COA20321	E	16.20	15.78	15.32	14.88	14.83	14.45	13.81	13.45
11.	COA20324	ML	18.06	17.61	16.91	16.62	17.04	16.76	16.63	16.36
12.	COA20327	E	17.19	16.59	16.41	16.08	16.47	15.94	15.85	15.43
13.	2003V46 (TC)	E	19.84	19.59	19.16	18.74	18.55	17.95	17.45	17.16
14.	2003V46 ©	E	19.35	19.13	18.69	18.44	18.02	17.38	17.29	17.05

Table 4: Continue...

Sl. No.	Entry name	Maturity	At 12th month				At 13th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
15.	CO86032 ©	ML	17.05	16.43	15.94	15.72	16.56	15.61	15.12	14.84
Mean			17.65	17.21	16.85	16.50	16.50	16.08	15.71	15.36
SEm±			0.146	0.116	0.117	0.085	0.131	0.131	0.100	0.095
CD (p<0.05)			0.423	0.337	0.339	0.247	0.379	0.381	0.289	0.275
CV (%)			1.436	1.174	1.206	0.898	1.372	1.419	1.103	1.071
Min			15.470	15.147	14.880	14.527	14.283	13.503	12.630	12.273
Max			19.84	19.59	19.16	18.80	18.69	18.25	17.94	17.61

per cent increased from 11.52 to 12.43 at 0 hrs of staling from 10th to 12th months of crop harvest and was reduced to 11.54 at 13th months of crop age while it decreased from 10.14 to 9.96 per cent at 72 hrs of staling from 1oth to 13th months of crop harvest. Saxena et al. (2010), Fantaye Ergasi et al. (2023) and Hiranyavasit (2016) concluded that reduction in CCS may be due to inversion of sucrose by invertase enzyme, formulation of organic acids and dextrans by microorganisms. Among the clones, CCS (%) was observed to be high in 2003V46 (TC), 2003V46, 2016T7, high COA14328, 2012V123and COA20327 (early), and COA20324, COA19322 and 2009V89 (mid-late) at all months of crop harvests and staling periods indicating that these clones were tolerant to post-harvest deterioration and delayed crop harvests. Per cent CCS (%) was noted to be low in the present study in 2008V257, 2009V 127, COA19321,

Table 5: Mean data on per cent purity in juice at different months of crop age (I plant crop) and time intervals of crushing during 2022–23

Sl. No.	Entry name	Maturity	At 10th month				At 11th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	89.61	85.62	80.03	77.19	84.10	79.94	77.56	74.60
2.	2009V89	ML	90.61	82.64	77.00	74.23	87.58	84.46	81.88	79.47
3.	2009V127	E	68.17	64.89	60.75	58.24	68.55	65.16	61.30	59.12
4.	2012V123	E	94.30	85.46	81.42	79.40	88.34	84.72	81.55	79.68
5.	2016T7	E	88.84	87.07	85.94	84.98	90.41	89.71	88.18	86.21
6.	CO 0238	E	87.34	84.79	82.33	80.21	90.16	87.23	85.60	81.66
7.	COA14328	E	85.33	78.63	74.28	71.38	85.95	84.36	81.42	79.65
8.	COA19321	E	85.36	81.60	79.24	77.21	86.41	83.54	80.28	75.23
9.	COA19322	ML	87.34	85.19	82.68	79.93	89.73	85.82	80.70	79.01
10.	COA20321	E	85.19	82.56	77.77	75.03	90.31	85.93	81.81	77.89
11.	COA20324	ML	88.47	87.07	83.83	81.32	87.06	85.83	82.44	81.49
12.	COA20327	E	90.85	86.02	79.76	75.34	88.20	85.13	82.29	79.26
13.	2003V46 (TC)	E	90.74	89.06	85.73	84.35	92.06	87.23	83.90	80.24
14.	2003V46 ©	E	87.70	85.94	83.37	81.57	87.49	84.52	82.54	81.06
15.	CO86032 ©	ML	81.42	77.74	75.40	71.78	83.79	82.03	80.27	78.80
Mean			86.75	82.95	79.30	76.81	86.68	83.71	80.78	78.22
SEm±			0.720	0.717	0.710	0.455	0.560	0.764	0.791	0.643
CD (p<0.05)			2.087	2.078	2.057	1.318	1.623	2.213	2.291	1.864
CV (%)			1.438	1.498	1.551	1.026	1.120	1.581	1.696	1.424
Min			68.170	64.890	60.750	58.240	68.550	65.160	61.300	59.120
Max			94.30	89.06	85.94	84.98	92.06	89.71	88.18	86.21

Table 5: Continue...

Sl. No.	Entry name	Maturity	At 12th month				At 13th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	80.87	77.31	74.52	71.31	75.71	72.92	67.50	64.68
2.	2009V89	ML	95.61	92.08	86.47	82.49	87.83	85.55	84.21	80.79
3.	2009V127	E	90.12	84.03	81.08	78.85	85.03	79.29	76.19	72.51
4.	2012V123	E	83.14	80.30	77.45	74.45	88.21	86.72	83.28	80.49
5.	2016T7	E	87.63	86.12	83.74	80.35	88.48	85.69	82.83	79.16
6.	CO 0238	E	90.16	82.05	78.91	74.91	88.76	79.44	77.93	73.24
7.	COA14328	E	86.47	83.90	81.19	76.93	91.58	89.05	86.20	81.95
8.	COA19321	E	81.44	76.82	75.87	72.98	76.41	68.57	64.87	60.99
9.	COA19322	ML	91.43	86.31	84.32	81.47	87.81	85.26	82.32	81.05
10.	COA20321	E	85.36	84.90	83.94	79.35	81.11	78.03	74.84	70.20
11.	COA20324	ML	92.63	89.71	85.75	83.15	92.16	85.71	83.86	81.02
12.	COA20327	E	87.01	81.49	79.57	75.18	88.76	82.46	81.29	77.69
13.	2003V46 (TC)	E	90.75	89.06	85.55	82.69	88.49	83.64	80.08	76.39
14.	2003V46 ©	E	88.40	86.33	84.23	82.61	83.45	80.63	79.32	77.76
15.	CO86032 ©	ML	78.31	72.63	69.53	67.79	79.25	71.19	68.66	66.95
Mean			87.29	83.54	80.81	77.63	85.54	80.94	78.23	74.99
SEm±			1.018	0.808	0.835	0.595	0.886	0.771	1.079	0.624
CD (p<0.05)			2.950	2.339	2.420	1.725	2.567	2.234	3.126	1.808
CV (%)			2.021	1.674	1.790	1.328	1.795	1.650	2.390	1.441
Min			78.310	72.630	69.530	67.790	75.710	68.570	64.870	60.990
Max			95.61	92.08	86.47	83.15	92.16	89.05	86.20	81.95

Table 6. Mean data 4on per cent CCS in juice at different months of crop age (I plant crop) and time intervals of crushing during 2022-23

Sl. No.	Entry name	Maturity	At 10th month				At 11th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	10.08	9.90	9.29	8.88	11.01	10.21	9.86	9.42
2.	2009V89	ML	9.72	9.08	8.54	8.26	11.00	10.68	10.28	9.94
3.	2009V127	E	8.44	7.88	7.07	6.58	8.81	8.40	7.79	7.40
4.	2012V123	E	10.49	9.79	9.26	9.02	10.71	10.27	9.79	9.55
5.	2016T7	E	14.26	13.92	13.71	13.52	14.92	14.80	14.56	14.22
6.	CO 0238	E	10.77	10.38	10.02	9.74	11.83	11.51	11.15	10.64
7.	COA14328	E	11.00	10.02	9.21	8.72	11.83	11.58	11.00	10.70
8.	COA19321	E	11.68	11.10	10.74	10.43	12.65	12.10	11.51	10.55
9.	COA19322	ML	12.54	12.16	11.79	11.38	13.92	13.52	12.66	12.35
10.	COA20321	E	10.84	10.48	9.90	9.45	12.72	11.96	11.29	10.65
11.	COA20324	ML	12.34	12.16	11.56	11.15	13.01	12.78	12.25	12.02
12.	COA20327	E	10.39	9.91	9.04	8.44	11.29	10.88	10.41	9.90
13.	2003V46 (TC)	E	14.92	14.67	14.02	13.76	15.33	14.80	14.19	13.37
14.	2003V46 ©	E	14.13	13.89	13.44	13.19	14.59	14.07	13.65	13.43

Table 6: Continue...

Sl. No.	Entry name	Maturity	At 10th month				At 11th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
15.	CO86032 ©	ML	11.20	10.68	10.27	9.57	12.37	12.06	11.70	11.37
Mean			11.52	11.07	10.52	10.14	12.40	11.97	11.47	11.03
SEm±			0.101	0.120	0.121	0.091	0.106	0.133	0.145	0.104
CD (p<0.05)			0.293	0.346	0.350	0.263	0.307	0.386	0.421	0.300
CV (%)			1.520	1.871	1.990	1.552	1.480	1.928	2.194	1.625
Min			8.440	7.880	7.070	6.580	8.810	8.400	7.790	7.400
x			14.92	14.67	14.02	13.76	15.33	14.80	14.56	14.22

Table 6: Continue...

Sl. No.	Entry name	Maturity	At 12th month				At 13th month			
			0 hrs	24 hrs	48 hrs	72 hrs	0 hrs	24 hrs	48 hrs	72 hrs
1.	2008V257	ML	11.11	10.56	10.21	9.76	9.50	8.97	8.05	7.59
2.	2009V89	ML	13.63	13.04	12.29	11.75	11.90	11.66	11.47	10.89
3.	2009V127	E	12.47	11.37	10.88	10.49	10.82	10.27	9.81	9.41
4.	2012V123	E	11.09	10.66	10.24	9.82	11.58	11.21	10.79	10.37
5.	2016T7	E	13.97	13.65	13.20	12.72	13.29	12.77	12.34	11.82
6.	CO 0238	E	11.10	10.37	9.97	9.44	10.19	9.33	8.97	8.47
7.	COA14328	E	13.45	12.99	12.48	11.86	13.38	12.97	12.50	11.65
8.	COA19321	E	10.80	10.26	10.08	9.52	9.39	8.27	7.41	6.85
9.	COA19322	ML	12.89	12.12	11.78	11.29	12.10	11.76	11.34	11.13
10.	COA20321	E	11.32	10.99	10.61	10.00	10.09	9.62	8.97	8.37
11.	COA20324	ML	13.11	12.60	11.84	11.45	12.35	11.73	11.51	11.12
12.	COA20327	E	12.13	11.31	11.05	10.47	11.73	10.94	10.79	10.24
13.	2003V46 (TC)	E	14.27	13.97	13.40	12.88	13.19	12.41	11.78	11.28
14.	2003V46 ©	E	13.75	13.44	12.97	12.67	12.44	11.78	11.61	11.32
15.	CO86032 ©	ML	11.37	10.47	9.86	9.55	11.12	9.81	9.27	8.93
Mean			12.43	11.85	11.39	10.91	11.54	10.90	10.44	9.96
SEm±			0.170	0.131	0.134	0.096	0.139	0.143	0.130	0.109
CD (p<0.05)			0.492	0.379	0.387	0.278	0.402	0.415	0.378	0.315
CV (%)			2.367	1.913	2.032	1.525	2.085	2.275	2.162	1.893
Min			10.800	10.260	9.860	9.440	9.390	8.270	7.410	6.850
Max			14.27	13.97	13.40	12.88	13.38	12.97	12.50	11.82

CO 0238, COA20321 and CO86032 at delayed crop harvests and increased staling periods suggesting that they were susceptible to post-harvest deterioration. These results are in agreement with the findings of Khan et al. (2020) and Rattana et al. (2020) in sugarcane.

4. CONCLUSION

Evaluation of sugarcane clones for their tolerance to delayed crop harvests(10th to 13th month) and post-harvest deterioration (0 to 72 hrs of harvest) revealed that cane weight, per cent juice extraction, sucrose, purity and CCS decreased while brix (%) increased concomitantly under delayed harvests and increased staling period. Increase in cane weight loss and reduction in juice extraction was significant with increase in staling period. Juice quality parameters decreased linearly from 0 hrs to 72 hrs at each crushing and at all months of crop harvest. Per cent brix increased from 0 hrs to 72 hrs of staling at all months of crop age and clones studied. Reduction in per cent sucrose, purity and CCS were more pronounced after 11th in early clones and after 12th months of crop age in mid-late clones. Reduction in sucrose, purity and CCS was significant with increased staling periods. Among the clones, 2003V46 (TC), 2016T7, COA14328 (early) and COA 19322, 2009V89 and COA20324 (mid-late) were found tolerant to delayed harvest and post-harvest deterioration.

6. ACKNOWLEDGEMENT

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7. REFERENCES

Bhatia, S., Jyoti., Uppal, S.K., Thind, K.S., Batta,S.K., 2009. Post-harvest quality deterioration in sugarcane under different environmental conditions. Sugar Tech 11(2), 154–156.

Cuddihy, J.A., Raouch, J., Mendez, F., Bernhard, C., 2000. Dextranase in sugar production factory experience. Journal of American Society of Sugarcane Technologists 20, 95–102.

Datir, J., 2015. Dynamics of postharvest sucrose losses in sugarcane during late crushing period. Procceedings of 61st Sugarcane Technologist association of India.

Egan, B.T., 1971. Postharvest deterioration losses in sugarcane. Sugar Journal 33(9), 9–13.

Eggleston, G., 2002. Determination of sugarcane juice sources and indicators. Food Chemistry 78(1), 95–103

Eggleston, G., Morel, P.G., Walford, S.N., 2008. A review of sugarcane deterioration in United States and Africa. Proceedings of South African Sugar Technologists' Association 81, 72–85.

Fantaye, E., Khan, A.Q., Keyata, E.O., 2023. Effect of storage periods on quality characteristics and sugar yield of pre-harvest burnt and unburnt cane of sugarcane varieties (*Saccharum* spp. hybrid) at Finchaa Sugar Factory, Oromia, Ethiopia, Cogent Food & Agriculture 9, 1, 2258776.

Hiranyavasit, C., 2016. Corporate sustainability practices in the Thai sugar industry. Proceedings of the NIDA International Business Conference, Bangkok, Thailand, 8–16.

Kapur, J.K., Kanwar, R.S., 1987. Comparative rates of post-harvest deterioration in promising sugarcane genotypes. Bhartiya Sugar, 17–20.

Khan, M.T., Yasneen, S., Khan, I.A., 2020. Comparative analysis of sugarcane genotypes for post-harvest deterioration under natural conditions. Pakistan Journal of Botany 52(4), 1389–1395

Mathur, R.B.L., 1986. Hand book of cane sugar technology. Oxford and I.B. H. Publishing Co; Bombay. Second Edition.

Meade, C.P., Chen, J.C.P., 1977. Cane sugar handbook. 10th edition. John Wiley & Sons INC. New York, 1–947.

Mehrotra, P., Sharma, N., 2020. Effect of different storage conditions on sugarcane weight loss. International Journal of Engineering and Applied Science & Technology 5(5), 2455–2143.

Mishra, V., Mall, A.K., Solomon, S., Ansari, M.I., 2022. Post-harvest biology, and recent advances of storage technologies in sugarcane. Biotechnology Reports 33, 1–10.

Misra, V., Mall, A.K., Shrivastava, A.K., Solomon, S., Shukla, S.P., Ansari, M.I., 2019. Assessment of Leuconostic spp. invasion in standing sugarcane with crack internode. Journal of Environmental Biology 40(3), 316–321.

Panse, V.G., Sukhatme, P.V., 1985. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi.

Rakkiappan, P., Shekinah, D.E., Gopalasundaram, P., Mathew, M.D., Asokan, S., 2009. Post-harvest deterioration of sugarcane with special reference to quality loss. Sugar Tech 11(2), 167–177.

Rattana, M., Chapanya, P., Anutin, P., 2020. Post-harvest deterioration of green billeted and green whole stalk sugarcane in North-east Thailand. International Journal of Postharvest Technology and Innovation. 7(1), 29–41

Saxena, P., Srivastava, R.P., Sharma, M.L., 2010. Impact of cut to crush delay and biochemical changes in sugarcane. Australian Journal of Crop Science 4(9), 692–699.

Shivalingamurthy, S.G., Anangi, D., Kalaipandian, S., Glassop, D., King, G.F., Rae, A.L., 2018. Identification and functional characterization of sugarcane invertase inhibitor (ShI NH 1): Apotential candidate for reducing pre- and post-harvest loss of sucrose in sugarcane. Frontline Plant Science, 9.

Siddhant, Srivastava, R.P., Singh, S.B., Sharma, M.L., 2009. Post-harvest sugar losses in sugarcane varieties at high ambient temperature under sub-tropical conditions. Sugar Tech 11(2), 222–224

Solomon, S., 2009. Post-harvest deterioration of sugarcane. Sugar Tech 11(2), 109–123

Solomon, S., Banerjii, R., Shrivastava, A.K., Singh, P., Singh, I., Verma, M., Prajapathi, C.P., Sawnani, A., 2006. Post-harvest deterioration of Sugarcane and chemical methods to minimize sugar losses. Sugar Tech 8(1), 74–78.

Solomon, S., Ramadurai, R., Shanmugnathan, S., Shrivastava,

A.K., Deb, S., Singh, I., 2003. Management of biological losses in milling tandem to improve sugar recovery. Sugar Tech 5(3), 137–142
Srivastava, R.P., Siddhant, Sharma, M.L., 2009. Studies on minimizing variety and quantity losses in stale cane. Sugar Tech 11(2), 176–180
Uppal, S.K., 2003. Post-harvest lossess in sugarcane. Sugar Tech 5, 93-94
Urgesa, G.D., Keyata, E.O., Amante, E., 2021. Effect of harvesting ages on yield and yield components of sugar cane varieties cultivated at Finchaa sugar factory, Oromia, Ethiopia. International Journal of Food Science, 1–6.
Verma, A.K., Sigh, S.B., Agarwal, A.K., Solomon, S., 2012. Influence of post-harvest storage temperature, time and invertase enzyme activity on sucrose and weight loss in sugarcane. Postharvest Biology and Technology 73, 14–21.
Yusof, S., Shian, L.S., Osman, A., 2000. Changes in quality of sugarcane juice upon delayed extraction and storage. Food Chemistry 68, 395–401.
Zhao, D., Li, Y.R., 2015. Climate change and sugarcane production : Potential impact and mitigation strategies. International Journal of Agronomy, 1–10.