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IMPACT OF DELAYED CRUSH ON POST-HARVEST DETERIORATION OF PROMISING EARLY MATURING SUGARCANE CLONES

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ABSTRACT
Sugarcane is a perishable commodity and must be processed in to sugar quickly after it is harvested. Post harvest sucrose losses have been reported from many cane producing countries due to delayed crushing as a major concern. In this context to access the effect of delayed crushing in sugarcane the present study was conducted with seven promising early maturing sugarcane clones at Agricultural Research station, Perumallapalle, A.P., India during *Rabi* 2011-2012. Different biochemical aspects like percent juice sucrose, TSS, commercial cane sugar percent, reducing sugars %, juice pH & juice extraction percent were assayed from 0-120 hrs at 24 hrs interval after harvest to identify the sugar cane clones suitable for delayed crushing. The results of the study indicated that the clones 2006T36 and 2006T3 recorded highest sucrose% (16.37%,15.18%) and lowest reducing sugars (2.50%,2.70%) respectively and were found to posses tolerance to post harvest deterioration. While the clone 2006T23 recorded highest reducing sugars (3.72%) and lowest sucrose % (12.39%) indicating the deterioration in quality. However, significantly highest cane yield was recorded in Co C 671 (1.64 kg), Co 94008 (1.42 kg) and 2006T36 (1.49 kg).

INTRODUCTION

In the present era of economic liberalization, sugar has become an important commodity for human consumption as well as trade. Sugarcane industry is considered as one of the organized sectors in the country with leading economic enterprises. Sugar is mainly extracted from sugarcane and sugar beet. Globally 70% of white crystal sugar comes from sugarcane, which popularized the crop as kalpavriksha (or) wonderful crop.

As sugarcane is a perishable commodity it should be processed in to sugar quickly after it is harvested. Sucrose losses after harvest of cane due to delayed transport and unfavorable environmental conditions are one of the most serious problems in sugar recovery process. Studies have indicated that nearly 20-30% of total sucrose synthesized by sugarcane plant is lost during various stages of raw material handling and sugar mill processing.

The post harvest sugar loss is one of the most alarming problems of sugar industry and has attracted widespread attention in the recent years. However, not much harm is caused if cane is crushed within 24 hours of harvesting. Staling beyond 24 hours results in considerable loss in cane weight due to moisture loss and reduction in juice sucrose content due to inversion (Solomon, 2009).

The harvesting of sugarcane, in Indian tropics generally starts from the month of November and continues till April or in certain cases expands up to May and June as per recommendation of the government and availability of raw materials. After harvesting of cane the stored sugar is extracted in sugar mills. In between the harvesting and milling the time lag is generally one to three days during which the extraction of maximum sugar is feasible. The ambient temperature affects adversely on stored sugar after harvesting. Therefore, the raw materials should be crushed as early as possible to avoid the sugar losses as staling losses are virtually most detrimental to sugar industry and cane growers.

According to Sharma and Sunita (1994), nearly one fourth of crushed cane in Indian sugar factories has been found to be stale in quality. The average annual loss to Indian sugar industry as a result of lower sugar recovery had been estimated to be about Rs. 1600 crores. However, the losses increase with the increase in duration of staling and varies with varieties (Solomon *et al*., 1997).

However, the sugarcane yields have been increased over the years due to release of high yielding clones and due to agro management practices. However, the sugar recovery is stable and which mainly depends on cane quality, efficiency of mills, planting and harvesting dates as well as staling due to delay in crushing after harvest. As the need of the day, evaluation of sugarcane clones to assess post harvest losses due to staling of canes after harvest is essential.

MATERIALS AND METHODS

The experiment was carried out at Agricultural Research Station, Perumallapalle during *Rabi* 2011-2012. Five promising early sugarcane varieties from yield trials along with two checks

were selected. The field experiment was laid out in RBD with three replications. The selected varieties were planted in the month of January with a seed rate of 40,000 three budded setts/ha along with irrigation. A spacing of 80 cm between furrows was followed. Atrazine @ 2kg a.i./ha was sprayed as pre-emergence herbicide at 3rd day after planting. Fertilizer dose of 224:112:112 of N:P_2O_5:K_2O kg/ha was followed. Other cultural operations like hand weeding, earthing up, trash twist propping etc.., were practiced as per recommendation. The data on yield and juice quality parameters viz., Sucrose%, Brix%, Commercial cane sugar%, Reducing sugar% etc., were recorded after staling of cane from 0-120 hr.

Total Soluble Solids were measured by using Brix hydrometer with the method given by Meade and Chen (1977) and the reading was corrected to temperatures by reffering to tables (Brown and Zerban, 1941). Sucrose was analyzed in cane juice and expressed in per cent sucrose in juice by using Schmitz's table (Hawaiian Sugar Technology Association, 1931).

Reducing sugars in cane juice were analysed colorimetrically by alkaline potassium ferricyanide method (Chiranjivi Rao and Asokan, 1974) and expressed in percentage. Juice extraction percent was calculated from each treatment by taking the cane weight and weight of juice obtained after crushing and expressed as percentage. The data was subjected to statistical scrutiny by split-plot method outlined by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Effect of staling period on per cent juice sucrose

The data on effect of staling period on per cent juice sucrose of sugarcane clones was presented in Table 1. All the clones showed decreasing trend in per cent juice sucrose with increase of staling period from 0 hrs to 120 hrs. During storage, inversion of sucrose starts resulting in the formation of invert sugar which leads to loss of recoverable sugar (Gupta, 1975).

Significantly the highest per cent juice sucrose was observed at 0 hrs (16.04) after harvest but a significant decrease was observed after 48 hrs of staling period (14.62) in all the clones and the lowest per cent juice sucrose was observed at 120 hrs (13.44) of staling period. The decline in sucrose per cent was slow during first two days of storage, but it was faster later (Magdum *et al.,* 1996). Interaction effect of clones and staling period was noticed.

Effect of staling period on commercial cane sugar per cent

There was progressive decrease of CCS% with the increase of staling period from 0 hrs to 120 hrs as mentioned in Table 2. With regard to clones CoC 671 (11.36) recorded the highest CCS% followed by 2006 T36 (11.01) and Co 94008 (10.77). The lowest was noticed in 2006 T23 (7.89) indicating its higher quality deterioration. Similar results were reported by Indrajith and Natarajan (2011) and Charumathi *et al*. (2009) for promising sugarcane clones.

The grouped data on staling period revealed that there was progressive decrease in CCS% with increase of staling period. The highest CCS% was recorded at 0 hrs (11.03) after harvest indicating the quality of juice, while the lowest was recorded at 120 hrs (8.05) after staling indicating the deterioration of juice quality. Similar results were reported by Bhite *et al*. (2007) and Solomon *et al*. (1997) recorded reduction in CCS% from 13.73 to 10.62 on staling. Interaction effect was recorded as significant among the clones and staling period.

Effect of staling period on reducing sugars (%)

The data on effect of staling period on reducing sugars revealed that there was progressive increase in the content of reducing sugars as depicted in Fig. 1. Among the clones Co C 671 (2.26%) recorded the lowest reducing sugars which is at par with Co 94008 (2.40%) and 2006 T36 (2.50%) indicating the low inversion of sucrose to reducing sugars and tolerant to post harvest deterioration, while the clone 2006 T23 (3.72%) recorded the highest reducing sugars indicating their low tolerance to post harvest deterioration. The results were in accordance with findings of Bhite *et al*. (2006) and Mukunda Rao *et al*. (2010).

There was a consistent increase of reducing sugars during the staling period from 0 to 120 hrs. During staling period, sucrose content declines at a faster rate with the increase in activity of invertase enzymes due to high temperatures and microbial activities (Solomon, 2009).

On comparison of different staling periods it was found that fresh cane at 0 hrs recorded significantly lowest reducing sugars

Table 1: Effect of staling period on per cent juice sucrose

Clones	Staling period after harvest						Mean
	0 hrs	24 hrs	48 hrs	72 hrs	96 hrs	120 hrs	
2006 T3	16.31	16.06	15.47	14.96	14.44	13.84	15.18
2006 T8	15.19	14.72	14.46	13.63	13.04	12.53	13.93
2006 T19	14.87	14.39	13.95	13.01	12.22	11.54	13.33
2006 T23	14.04	13.64	12.95	12.12	11.21	10.36	12.39
2006 T36	17.24	17.01	16.75	16.24	15.86	15.14	16.37
Co C 671	17.63	17.32	17.01	16.43	16.05	15.53	16.66
Co 94008	17.03	16.84	16.56	15.95	15.46	15.16	16.17
Mean	16.04	15.71	15.31	14.62	14.04	13.44	14.86
Grand mean	14.86						
	SED	LSD (0.05)					
Clones (C)	0.042	1.37					
Staling period (S)	0.06	0.15					
C × S	0.111	0.221					
S × C	0.123	0.252					

Table 2: Effect of staling period on commercial cane sugar per cent

Clones	Staling period after harvest						Mean
	0 hrs	24 hrs	48 hrs	72 hrs	96 hrs	120 hrs	
2006 T3	10.59	10.11	9.87	9.24	8.33	8.00	9.36
2006 T8	9.52	9.16	8.87	8.16	7.45	7.03	8.36
2006 T19	9.91	9.48	9.17	8.17	7.52	6.92	8.53
2006 T23	9.55	9.17	8.41	7.79	6.65	5.76	7.89
2006 T36	12.51	11.93	11.35	10.73	10.24	9.36	11.01
Co C 671	12.80	12.17	11.64	11.08	10.57	9.93	11.36
Co 94008	12.33	11.74	11.11	10.39	9.75	9.33	10.77
Mean	11.03	10.53	10.06	9.36	8.64	8.05	9.61
Grand mean	9.61						
	SED	LSD (0.05)					
Clones (C)	0.57	1.01					
Staling period (S)	0.55	1.20					
C × S	0.135	0.268					
S × C	0.135	0.273					

Table 3: Effect of staling period on single cane weight (kg)

Clones	Staling period after harvest						Mean
	0 hrs	24 hrs	48 hrs	72 hrs	96 hrs	120 hrs	
2006 T3	1.49	1.31	1.23	1.10	0.91	0.71	1.14
2006 T8	0.95	0.81	0.74	0.69	0.62	0.52	0.72
2006 T19	1.13	1.02	0.88	0.71	0.64	0.59	0.83
2006 T23	1.31	0.97	0.89	0.81	0.76	0.67	0.90
2006 T36	2.02	1.60	1.44	1.39	1.28	1.19	1.49
Co C 671	2.06	1.73	1.64	1.56	1.46	1.37	1.64
Co 94008	1.78	1.55	1.45	1.35	1.26	1.15	1.42
Mean	1.53	1.28	1.18	1.09	0.99	0.90	1.16
Grand mean	1.16						
	SED	LSD (0.05)					
Clones (C)	0.23	0.45					
Staling period (S)	0.34	0.73					
C × S	0.060	0.119					
S × C	0.064	0.131					

Table 4: Effect of staling period on juice extraction per cent

Clones	Staling period after harvest						Mean
	0 hrs	24 hrs	48 hrs	72 hrs	96 hrs	120 hrs	
2006 T3	54.42	52.47	50.00	47.13	40.48	37.68	47.03
2006 T8	45.47	43.96	41.09	39.70	37.04	35.07	40.39
2006 T19	47.56	45.00	43.51	41.13	38.48	35.24	41.82
2006 T23	45.04	43.96	41.88	39.49	38.24	35.23	40.64
2006 T36	60.88	57.07	54.69	52.92	48.56	46.07	55.36
Co C 671	67.00	64.57	62.07	59.17	56.86	53.34	60.50
Co 94008	63.53	61.17	59.08	53.83	51.68	47.18	56.08
Mean	54.84	52.60	50.33	47.62	44.48	41.40	48.55
Grand mean	48.55						
	SED	LSD (0.05)					
Clones (C)	4.41	8.80					
Staling period (S)	5.42	11.82					
C × S	1.168	2.329					
S × C	1.196	2.431					

(2.22%) and heavy increase of reducing sugars was noticed after 48 hrs of staling, while the highest reducing sugars were noticed at 120 hrs (3.31%) of staling. The results indicated that sucrose inversion to reducing sugar is an important indicator of cane quality deterioration. During staling juice gets concentrated due to loss in moisture which probably results in increase in invertase activity (Uppal, 2003).

Effect of staling period on juice pH

Reduction in pH of juice in all the clones was observed with increase of storage period as depicted in the Fig. 2. Among the clones the highest pH was recorded in 2006 T36 (5.75) over the storage period from 0 to 120 hrs. The clone 2006 T23 (5.43) recorded the lowest pH. Similar findings on juice quality parameters were reported by Singh and Solomon (2003) and Raja Rajeswari *et al.* (2006) for other clones in sugarcane.

On comparison of staling periods from 0 to 120 hrs, the data revealed that pH was reduced with increase in staling period *i.e.,* 0 to 120 hrs in all the clones. The highest pH was noticed at 0 hrs (5.86) after harvest, while the lowest was observed at 120 hrs (5.33). The results are in accordance with findings of Saxena *et al.* (2010). Bhatia *et al.* (2009) have reported a

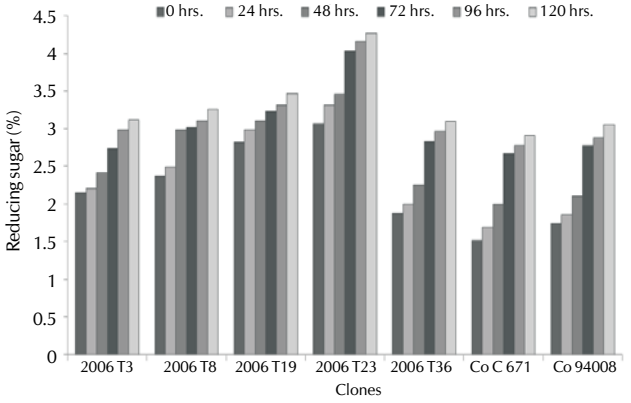

Figure 1: Effect of staling period on reducing sugars (%)

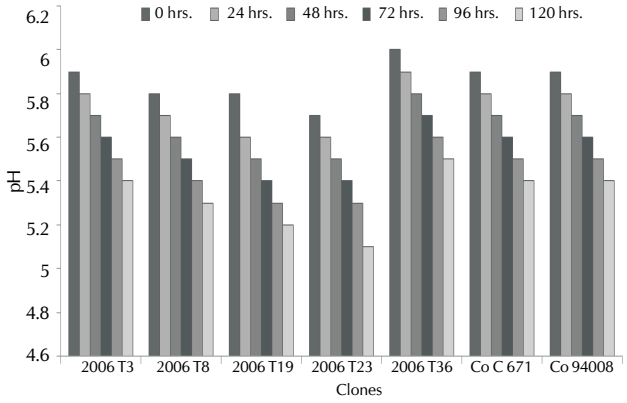

Figure 2: Effect of staling period on juice pH

gradual increase in titrable acidity with parallel decline in pH of juice was also observed in all the genotypes during storage.

Effect of staling period on single cane weight

The data on effect of staling period on single cane weight was presented in table 3. The data revealed that the clone CoC 671 recorded significantly the highest single cane weight (1.64 kg) when compared to other clones but on par with 2006 T36 (1.49 kg) and Co 94008 (1.42 kg), whereas the clone 2006 T8 (0.72 kg) recorded the lowest single cane weight .

All the clones showed decreasing trend in cane weight with increase of staling period from 0 to 120 hrs. The results were in concurrence with findings of Siddhant *et al*. (2008). However, higher fresh cane weight was recorded immediately after harvsest at 0 hrs (1.53 kg) and after 96 hrs an higher loss was noticed at 120 hrs (0.90 kg) indicating the effect of staling period on cane weight. Cane weight is mainly attributed to evaparatory loss and respiratory losses (Alexander, 1973). Interaction effect of clones and staling period was found significant between the clones and staling period.

Effect of staling period on juice extraction per cent

There was progressive decrease in juice extraction per cent with increase of staling period as shown in table 4. The data revealed that the clone Co C 671 (60.50) recorded significantly the highest juice extraction per cent followed by Co 94008 (56.08) and 2006 T36 (55.36), while 2006 T23 (40.64) and 2006 T8 (40.39) recorded low juice extraction per cent. Similar results were reported by Thangavelu (2004) for other promising sugarcane clones.

The data revealed that the highest juice extraction per cent was noticed at 0 hrs (54.84) and significant reduction was noticed after 72 hrs of staling period, while the lowest juice extraction per cent was noticed at 120 hrs (41.40) of staling period. A gradual decrease in juice extraction per cent was noticed with simultaneous increase in TSS%, Titrable acidity, Dextran and activities of acid and neutral invertases with increase of staling period was reported by Bhatia *et al*. (2009). However, significant interaction effect was found between clones and staling period.

Based on the results from the present study it was concluded that clones 2006 T36, 2006 T3 proved that they posses higher quality and yield attributes with increase of staling period along with two checks *viz.,* CoC 671 and Co 94008. Hence, these two clones 2006 T36 and 2006 T3 were found to posses tolerance to post harvest deterioration.

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