SOME DATA ON CANE DETERIORATION IN 1992

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Abstract

Over the past two seasons, routine analysis for ethanol as an indicator of cane deterioration has been carried out on DAC samples from all Tongaat-Hulett mills. Results for the 1992 season are reviewed in this paper. Extensive runaway fires on one day in August resulted in two mills crushing this fire cane almost exclusively for two weeks. The routine ethanol data over that period showed an exponential increase and confirmed the findings from smaller scale planned trials. Evaluation of data over the whole season showed up a number of consistent trends. In particular, the average ethanol content of unburnt cane was only 40% of the level for burnt cane. A deterioration trial on unburnt cane showed that this does not reflect less sucrose loss, but rather a higher ratio of sucrose lost to ethanol formed. The use of a single loss ratio for burnt and unburnt cane is not valid.

Introduction

A method for assessing the extent of cane deterioration by analysis for ethanol has recently been developed (Lionnet and Pillay, 1988). This is now being applied routinely to estimate losses due to cane delays at most mills in South Africa.

Ethanol formation rates have been estimated from deterioration trials. Because a major effort is needed to carry out these trials, not many are done and the resultant body of information is not very extensive. Another possible source of delay time data is from bundle tagging systems. As these are costly to operate and prone to error they are not generally used. Ethanol formation rates from any other source would therefore be of value in confirming the present relationships. One such source became available as a result of serious runaway fires on 22 August 1992 that burnt some 250 000 tons of cane on the North Coast. Two Tongaat-Hulett mills crushed this fire cane almost exclusively for two weeks. Since the time of burning was known, ethanol and other measurements over that period could be evaluated to give relationships with time.

An area about which still less is known is the relationship between cane delays and ethanol formation in unburnt cane. Routine data from the 1991 season suggested that average ethanol contents were much lower in unburnt than in burnt cane. A burnt/unburnt indicator was therefore included in the 1992 ethanol records and the relevant averages are compared below.

A deterioration trial along the lines of those on burnt cane was carried out on unburnt cane and the results are summarised here.

Procedures

Fire cane data

Information was collated from a number of sources as noted below:

- Ethanol analyses from the Technical Management Department (TMD) laboratory of Tongaat-Hulett Sugar together with consignment Direct Analysis of Cane (DAC) extract analyses.
- Identification of fire cane suppliers from cane supply/cane quality staff at DL and MS.
- Daily factory data from mill staff at DL and MS.
- Central laboratory analyses on weekly mixed juice and molasses composites from the SMRI.

Routine ethanol data

Tongaat-Hulett Sugar has only two gas chromatographs for ethanol determination, one at FX and one at TMD. Portions of DAC extracts are sealed in sachets, frozen and transported to either FX (samples from AK) or TMD (samples from DL, MS and ME) for analysis. FX also analyse their own samples, although frequency was reduced in 1992 as their GC was unavailable for extended periods.

Daily results were combined into monthly data sets, sorted into burnt and unburnt cane, and average ethanol contents were calculated.

Unburnt cane deterioration trial

The procedures used were largely as reported previously (Cox and Sahadeo, 1992). The main difference involved direct mass loss determination in that all test consignments were weighed initially and on crush. In previous trials separate bundles were made up and weighed at intervals to determine the mass loss. Since there was no certainty that the rates of mass loss for these bundles and for the cane actually crushed were the same, the revised procedure therefore removes one potential source of error.

A field in Tongaat Estate containing approximately 200 tons of trashed cane of mixed variety was cut on Wednesday 07 October 1992. A hilo of loose cane was crushed on the same day to give a 'time zero' sample. The following day, 10 consignments of bundled cane with a minimum mass of 15 tons were weighed and stored under the gantry separately, each being demarcated with hazard tape.

On subsequent days, a tared vehicle was used to reweigh a consignment (any spillage was hand loaded) which was then crushed and sampled. The consignments were crushed only on the diffuser line because the milling tandem was shut down over most of the test period. The consignments were crushed and sampled over a period of 23 days. The normal DAC extract analyses were performed by SASA Cane Testing Service (CTS). Expressed juice samples were obtained (using a hydraulic press) and analysed by TMD for ethanol and GC sugars. Ethanol was also determined on the DAC extract samples.

Results and Discussion

Fire cane data

Daily pol purities of mixed juice are plotted in Figure 1. An interesting feature is the rise in purity over the first four days. This is due to crushing out of previously cut cane, some of which was unburnt and had lower purities due to the non-sucrose in trash. Thereafter purities fell progressively at both mills, to 70 at DL and 67 at MS. Processing of fire cane had to be terminated after two weeks due to deteriorating crystallisation and centrifuging characteristics.

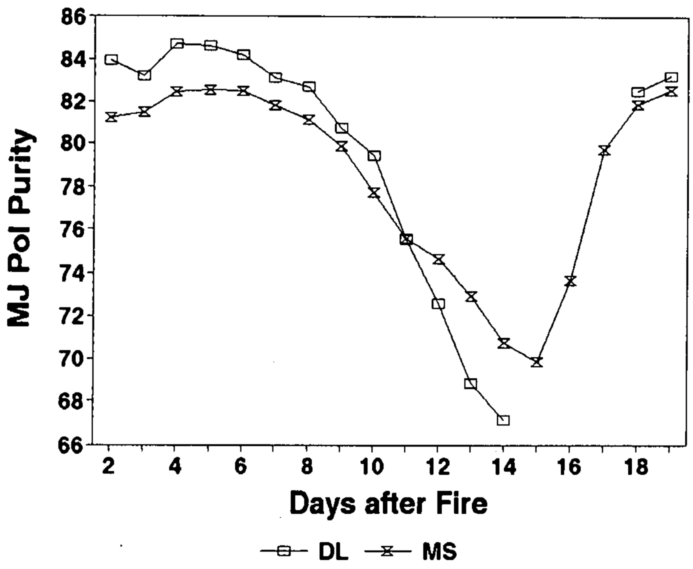

FIGURE 1 Pol purity of mixed juice from fire cane.

A major effect of deterioration is inversion of sucrose to fructose and glucose. The 1992 weekly average monosaccharide data for MS is plotted in Figure 2. Very little change is shown in the first week of processing fire cane (Week 22). Monosaccharides in mixed juice rose sharply in the second week. An interesting point is that the peak in monosaccharide output in molasses occurred in the following Week 24. This is due to the 'hold-up time' of non-sucrose in process, which is about one week.

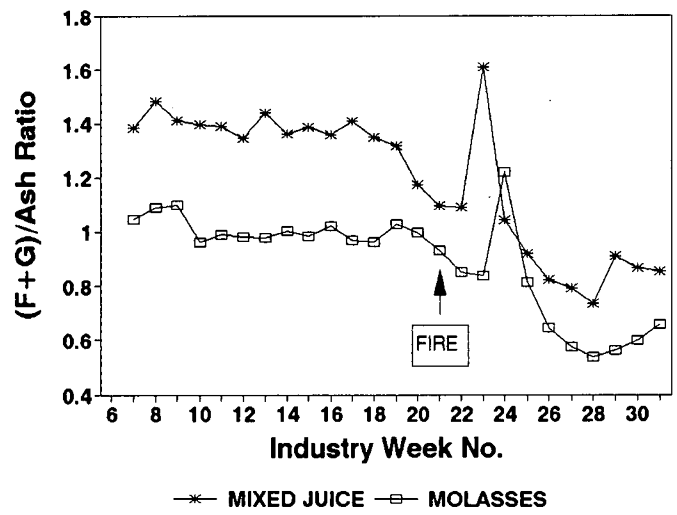

FIGURE 2 Effect of fire on MS reducing sugars in and out.

The TMD ethanol data for DL and MS over the fire cane period was filtered to exclude:

- results prior to 5 days after the fires when there was still some 'non-fire' cane being crushed,
- data for growers who cut and supplied cane not burnt in the fires, and
- results for two days (30 August and 05 September) where ethanol figures were unreliable due to analytical problems in the TMD laboratory.

Regression analysis on the remaining data gave the following relationship for DL:

ppm EtOH on brix $= 38{,}4 \times (\text{days})^{2{,}32}$

($n = 237$; $r^2 = 0{,}81$)

This is plotted in Figure 3 along with mean and standard deviation indicators for each day's data. The average ethanol content after 13 days of 15 000 ppm is very much in line with data reported by Lionnet and Pillay (1988) and by Cox and Sahadeo (1992).

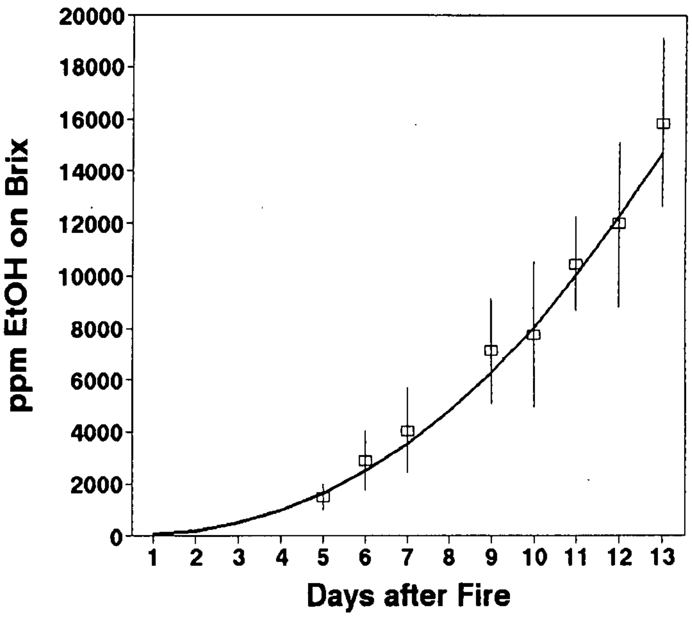

FIGURE 3 Ethanol formation after fire.

Vertical lines : Standard deviation
Curve : Regression

Routine ethanol data

Average ethanol figures for Tongaat-Hulett mills are summarised in Table 1. There appears to be an increase in ethanol levels from north to south. Ethanol is higher in burnt than in unburnt cane by a factor of two to three. The overall seasonal trend is shown in Figure 4. The high value for burnt cane in September is associated with fires. Other than that, the expected winter minimum is evident.

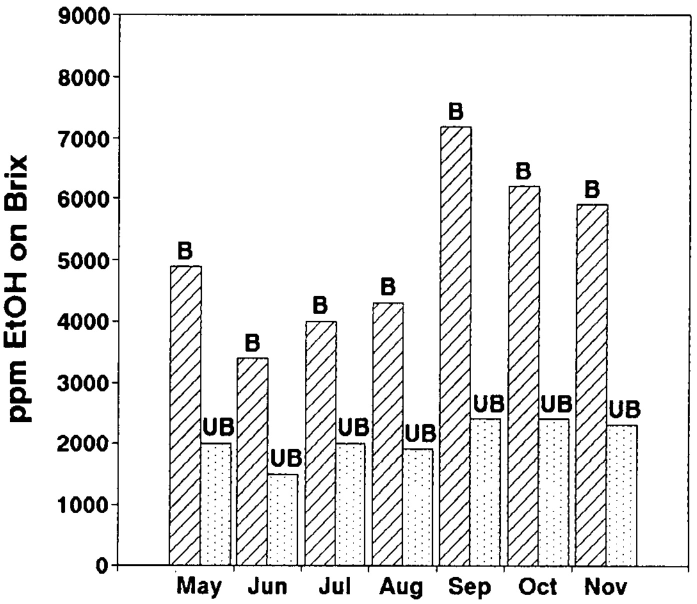

FIGURE 4 Ethanol in burnt (B) and unburnt (UB) cane – Tongaat-Hulett Mills 1992.

Table 1

Ethanol analysis summary 1992

Mill	No. of tests		ppm EtOH on brix		
	Burnt	Unburnt	Burnt	Unburnt	Burnt/ Unburnt
FX	1 026	325	2 900	1 200	2,4
AK	4 611	263	3 900	2 000	2,0
DL	2 808	1 776	4 500	2 000	2,3
MS	5 095	839	5 400	1 800	3,0
ME	3 897	364	6 100	2 800	2,2
Combined	17 437	3 567	4 400	1 800	2,4

Unburnt cane deterioration trial

Table 2 gives initial and final consignment mass data. Rain in the early stages of the trial accounted for the initial mass gain. After that the mass loss due to evaporation was fairly consistent at 0,5% per day.

Table 2

Consignment mass loss

Days storage	Mass (tons)		% initial mass	mm rain
	Initial	Crush		
0	18,24	18,24	100,0	
5	15,60	15,84	101,5	41
7	17,18	17,34	100,9	11
9	17,62	17,54	99,5	
13	16,24	15,66	96,4	
14	19,18	18,50	96,5	4
16	15,34	14,60	95,2	3
19	15,56	14,78	95,0	1
21	16,72	15,74	94,1	
22	18,54	17,10	92,2	
23	20,66	19,40	93,9	4

The estimates of pol mass loss are plotted in Figure 5 together with data from a burnt cane trial at ME in 1991 (Cox and Sahadeo, 1992). There is more scatter in the unburnt cane data, which is due to the less controlled nature of the unburnt cane trial. This was done late in a drought season when the only cane available was of mixed variety, had received only intermittent supplementary irrigation and showed uneven growth. Despite these shortcomings the deterioration rates are clearly similar to those for burnt cane.

Figure 6 shows individual sugars as a percentage of brix. Again as for burnt cane, it is obvious that the main mechanism of sucrose loss is inversion.

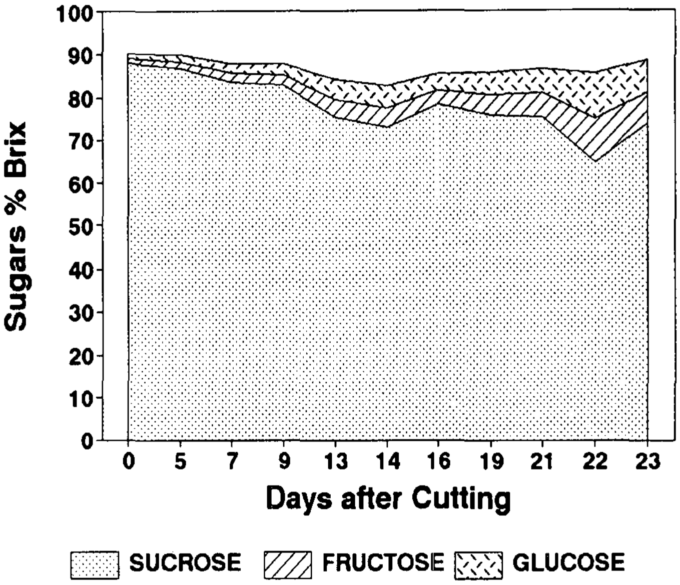

FIGURE 6 Change in sugars in unburnt cane.

The rate of ethanol formation is depicted in Figure 7, again with data from a burnt cane trial. There is a profound difference between burnt and unburnt cane in the ethanol data. After three weeks, ethanol in burnt cane is around the 20 000 ppm mark. In contrast, ethanol in unburnt cane rose from a similar start level (around 600 ppm) to only 3 000 ppm over the same period. Ethanol formation rates are too low and irregular for a sucrose loss/ethanol ratio to be derived from these results. In broad terms, however, a sucrose loss around 30% over three weeks suggests a ratio of 10% sucrose loss per 1 000 ppm ethanol, as opposed to the value of 1% derived for burnt cane.

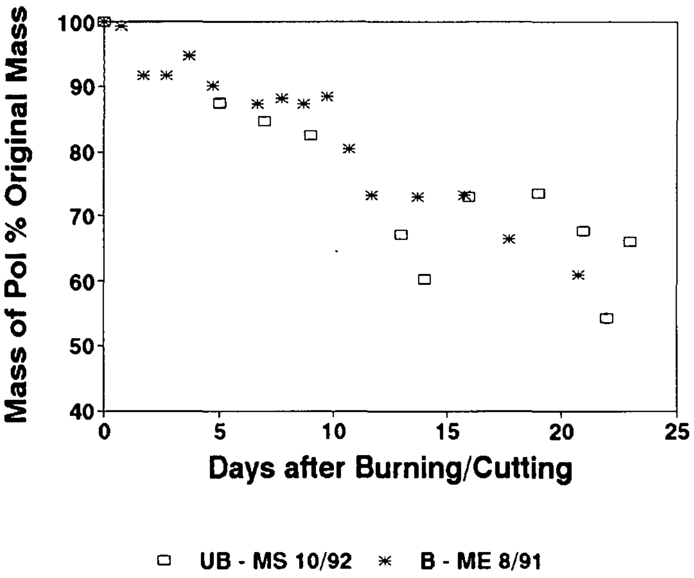

FIGURE 5 Sucrose loss in unburnt and burnt cane.

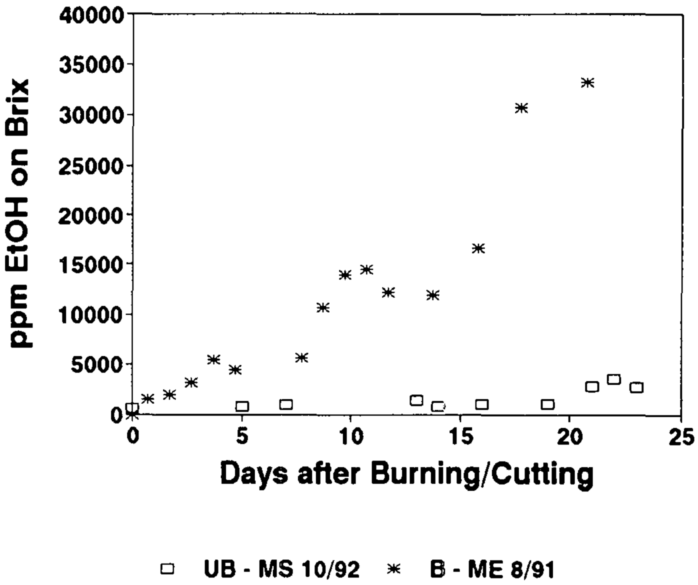

FIGURE 7 Ethanol formation in unburnt and burnt cane.

Conclusions

Earlier findings of deterioration trials on burnt cane have been confirmed on an industrial scale, as a result of runaway fires in 1992. No significant change in cane quality was apparent for the first four days, when the effects of fire cane deterioration were offset by removal from the system of older trashy cane. After that purities dropped off and ethanol contents increased exponentially. The numerical values found were similar to those from the planned trials.

The validity of ethanol as an indicator of deterioration in unburnt cane has been found to be questionable. Evaluation of 21 000 ethanol results from 5 mills in 1992 showed average levels in unburnt cane only one-third to one-half of the corresponding figures for burnt cane. The inference that this shows lower deterioration rates has been disproved by the results of a deterioration trial on unburnt cane. This trial showed similar sucrose loss rates and the same main degradation products (fructose and glucose) as for burnt cane. The rate of ethanol formation was however lower by an order of magnitude.

Further investigations into ethanol formation in unburnt cane are desirable. Meanwhile, the ratio of 1% sucrose per 1 000 ppm ethanol derived for burnt cane should not be applied to unburnt cane as it would seriously underestimate the true losses.

Acknowledgements

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