SOME ASPECTS OF CANE DETERIORATION IN REUNION ISLAND

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Abstract

Following cane deterioration work in South Africa over the last few years, several trials were carried out at the Research Institute of Reunion Island (CERF). The purpose of this investigation was to estimate the effects of cut to crush (or burn to crush) delays on some important parameters of the sugar cane, such as juice % cane, pol % cane and purity. The validity of using ethanol on brix in juice as an indicator of deterioration was examined.

Three tests were carried out during the 1993 season. Different harvesting procedures, such as burning or trashing were investigated under different climatic conditions. Many results were found to agree well with those published in South Africa.

Concurrently, primary juice was sampled regularly at the factories and was analysed for ethanol. Ethanol levels and the results from the research trials were used to follow and compare cane quality at a number of factories. Generally a significant correlation was found between ethanol in primary juice and selected aspects of the performances of the factory.

Introduction

The purpose of this study is the estimation of the eventual correlations between some characteristic parameters of technological interest, such as purity or pol % cane, and the ethanol content of deteriorated cane.

After experimental trials on trashed and burnt cane, selected from CERF's fields, conclusions were applied to daily ethanol measurements carried out at two factories.

Materials and methods

The sugar cane harvest took place in the CERF's experimental plots. Trashed cane was cut by hand and only the tops and the main leaves were removed. Burnt cane was harvested like the unburnt cane. Most of the cane crushed in Reunion Island is trashed cane, a small part being mechanically harvested from large flat fields. Burnt cane is often caused by accident; it is not the most common harvesting practice.

The variety of sugar cane selected was R 570, the largest type on Reunion Island, but an unfortunate lack of R 570 resulted in the use of R 579 in December, a new cane recently released by the CERF.

Three trials were conducted, one each in August, September and December. A fourth trial is still being done.

The harvested cane (trashed and burnt) was kept in the open, in two separate loose stacks. The sampling procedure involved selecting 10 stalks randomly from each stack, every second day, over a period of three weeks. Thereafter, the procedure was the same for trashed and burnt cane and only that for trashed cane is described below.

Two five stalk sub-samples were made from the 10 randomly selected trashed cane stalks. Each sub-sample was then shredded separately in a Jeffco cutter-grinder and the pulp was mixed well. The pulp from each sub-sample was then again split into two further samples, each being pressed for two minutes in a cane press set at 270 bar. Each 10-stalk sample thus yielded four lots of extracted juices and four press cakes. This resulted in about 40 sets of data over the three week period.

The juices were analysed immediately for brix, pol and ethanol according to the usual laboratory methods and the press cakes were weighed.

Purity of extracted juice and pol % cane were calculated from the above data. In Reunion Island the sugar content of the delivered cane is evaluated by the formula:

$$\text{Pol \% cane} = \frac{\text{Pol} \times \left(1 - \frac{m}{c}\right)}{1{,}012 - 0{,}41 \times \left(\frac{m}{c}\right)}$$

where: Pol = pol % juice (extracted by press)
m = weight of the press fiber cake
c = weight of cane put in the press

"1,012-0,41x(m/c)" is a regression only used on Reunion Island; the parameters being based upon the characteristics of the extraction: pressure, type of press etc. Pol % cane has approximately the same meaning as the pol % cane determined in South Africa by direct analysis of cane, measured after wet disintegration.

A Schmidt & Haensch Polartronic Universal polarimeter fitted with a sodium lamp and a 589nm filter was used for the polarimetric determinations, associated with a DUR-S high resolution refractometer and a Cal-Q-lator for brix determinations.

Ethanol analyses were carried out by a Gas Chromatograph DELSI DI200 and ENICA 21 integrator.

Results

Only the data from the last two series (called series for No 2 for September and for No 3 for December) have been investigated. The protocol was established following the conclusions made in the first series. It was focused on the relationships between pol % cane and ethanol content together with purity and ethanol content.

Dextran determinations were abandoned because of the poor accuracy of the quick method of determination of dextrans. Clerget purity, with sucrose determined by double polarisation, did not give more significant information than the apparent purity.

Ethanol in juice

The ethanol (EtOH) content is expressed in ppm on brix and the formation against time (day, d) is shown in Figure 1.

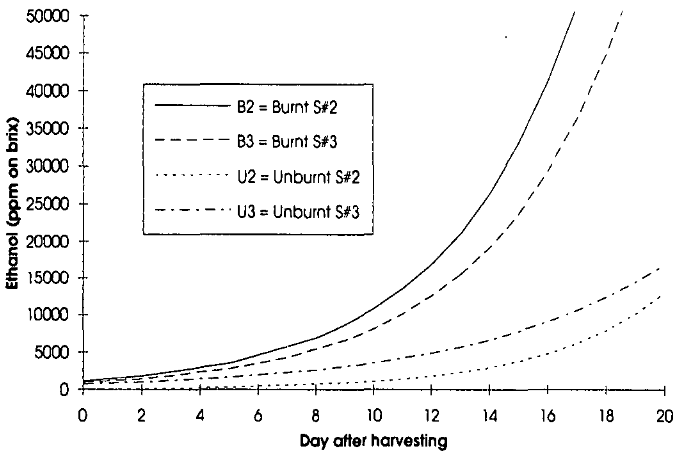

FIGURE 1 Ethanol formation with time.

The best correlations seem to be obtained with a logarithmic regression:

S #2 : unburnt cane : $EtOH = 93 \times 1{,}28^d$ $r = 0{,}89$ $n = 39$
burnt cane : $EtOH = 1153 \times 1{,}28^d$ $r = 0{,}93$ $n = 72$
S #3 : unburnt cane : $EtOH = 764 \times 1{,}28^d$ $r = 0{,}74$ $n = 40$
burnt cane : $EtOH = 964 \times 1{,}28^d$ $r = 0{,}91$ $n = 40$

According to the Fisher and Student's tests, these correlations are significant at 5 %. Burnt cane produces about two to three times more ethanol than unburnt cane; in particular after 10 days of deterioration, the production of ethanol increases rapidly.

The influence of the weather is not clearly evident. The average temperature was 21,7°C in September (series S #2) and 25,3°C in December (series S #3). If temperature influenced the degradation rate of unburnt cane by accelerating this degradation, (day #10: 1100 ppm/brix in September, 3700 ppm/brix in December), burnt cane should be affected in the same way. It appears that the opposite influence takes place (day #10: 10700 ppm/brix in September, 8300 ppm/brix in December). The only difference between the two experiments was the variety of the cane.

Purity of juice

Linear correlations (significant, at 5% level) were found between purity and number of days of deterioration, as shown in Figure 2.

S #2 : unburnt cane : $purity = 93{,}5 - 0{,}87d$ $r = 0{,}85$ $n = 39$
burnt cane : $purity = 94{,}6 - 0{,}89d$ $r = 0{,}80$ $n = 72$
S #3 : unburnt cane : $purity = 92{,}1 - 1{,}24d$ $r = 0{,}78$ $n = 40$
burnt cane : $purity = 96{,}4 - 3{,}39d$ $r = 0{,}94$ $n = 40$

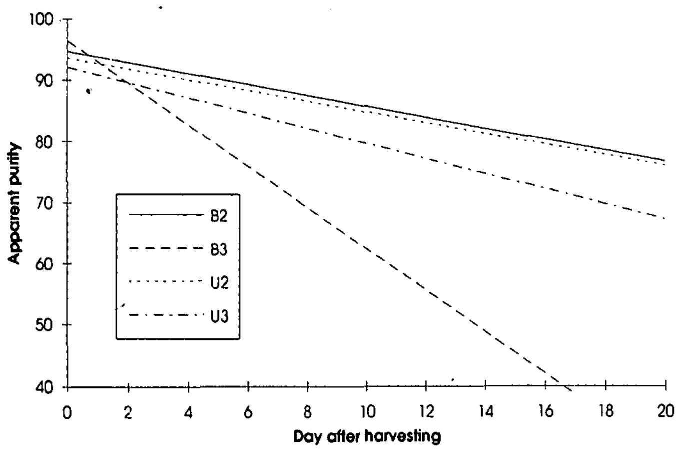

FIGURE 2 Evolution of purity with time.

In winter, unburnt and burnt cane have the same rate of drop in purity (≈ 0,9 unit per day). In summer, unburnt cane maintains a similar rate and burnt cane has a three times higher rate of degradation (3,4 units per day). Higher sensitivity to the microbiological attacks, amplified by the higher temperatures of the fire damaged cane stalks can explain this fact but, nevertheless, the possible influence of cane variety has to be noted.

Pol % cane

Statistically significant linear regressions are shown in Figure 3.

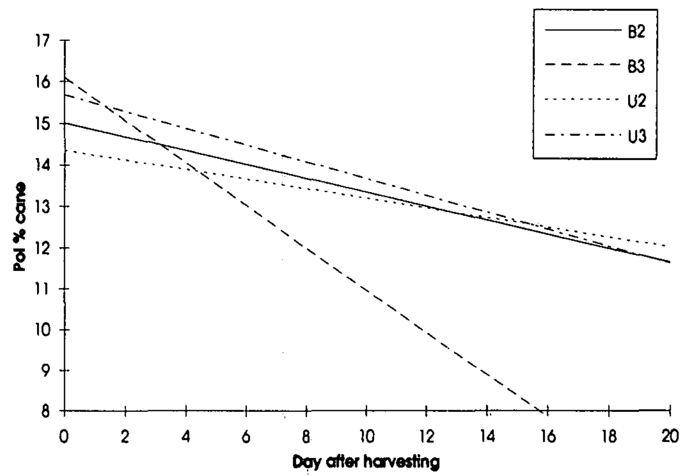

FIGURE 3 Evolution of pol % cane with time.

S #2 : unburnt cane : pol % cane $= 14{,}3 - 0{,}12d$ $r = 0{,}51$ $n = 39$
burnt cane : pol % cane $= 15{,}0 - 0{,}17d$ $r = 0{,}83$ $n = 72$
S #3 : unburnt cane : pol % cane $= 15{,}7 - 0{,}20d$ $r = 0{,}64$ $n = 40$
burnt cane : pol % cane $= 16{,}1 - 0{,}51d$ $r = 0{,}91$ $n = 32$

The correlations are poor for the unburnt cane but the trends seem to be the same. The pol % cane of burnt cane in summer falls by 0,5 point per day (after 16 days, the pol measurement was impossible in summer) as compared to 0,2 point per day for the other curves.

Effects of ethanol level on sugar content of sugar cane

Numerous studies that have been performed in South Africa over the last 10 years show a correlation between the state of deterioration of some specific varieties of sugar cane and the ethanol concentration in the juice (Lionnet, 1986, 1988, 1993). Ethanol is a well known by-product of micro-

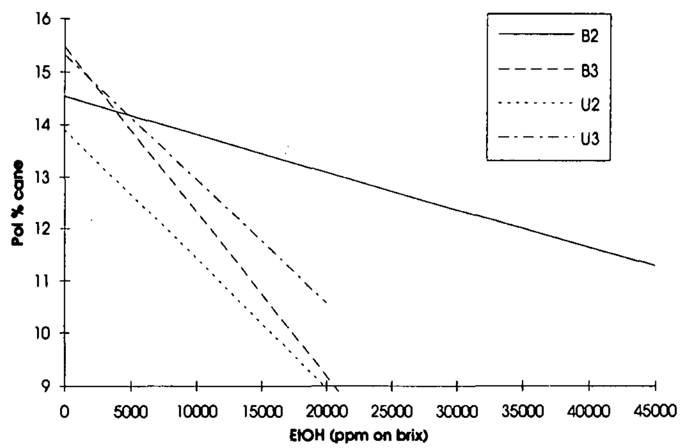

FIGURE 4 Pol % cane and ethanol.

biological fermentation activity in a sweet substrate. The aim of this study is to correlate this easy to evaluate parameter (ethanol content) to a loss in potential sugar recovery in the varieties of sugar cane grown on Reunion Island.

The pol % cane in relation to ethanol in juice

Linear regressions are shown in Figure 4.

S #2 : unburnt cane : pol % cane = 13.90 – 0,25 EtOH r = 0,67 n = 39
burnt cane : pol % cane = 14.54 – 0,073 EtOH r = 0,79 n = 72
S #3 : unburnt cane : pol % cane = 15.33 – 0,24 EtOH r = 0,71 n = 40
burnt cane : pol % cane = 14.48 – 0.31 EtOH r = 0,93 n = 32

Purity and ethanol in juice

Linear regressions are shown in Figure 5.

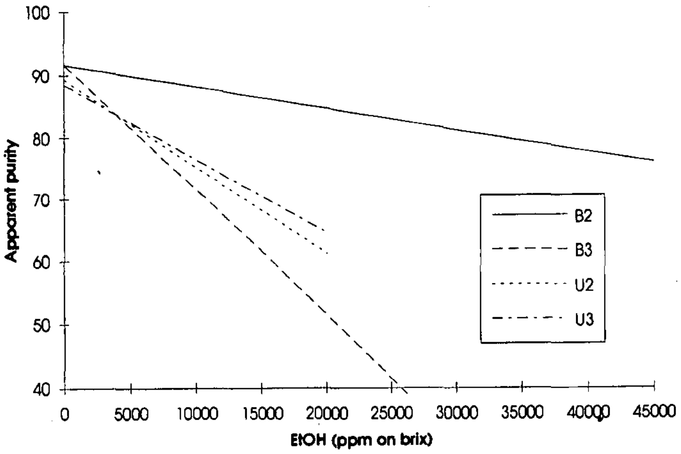

FIGURE 5 Purity and ethanol.

S #2 : unburnt cane : purity = 89.30 – 1,41 EtOH r = 0,85 n = 39
burnt cane : purity = 91,65 – 0,35 EtOH r = 0,69 n = 72
S #3 : unburnt cane : purity = 88,5 – 1,20 EtOH r = 0,73 n = 40
burnt cane : purity = 91.74 – 2,00 EtOH r = 0,93 n = 32

The pol % cane in unburnt cane follows the same trend in winter and summer: slopes are identical (0,25 point per 1000 ppm/brix of ethanol), the only difference being the higher starting point in December because the cane has reached its maturity. The ethanol content indicates a lower degradation in burnt cane in September (loss of 0,07 point per 1000 ppm/brix) but, on the contrary, in December losses are multiplied by 4 (0,31 point per 1000 ppm/brix).

The same comments can be made about the decrease of purity. The regressions indicate that the correlations between pol % cane, purity and ethanol, although not very strong, are not obtained by chance. Numerous molecules produced during cane deterioration could affect the pol determination; optically active substances, such as dextrans, were not investigated, although Ravelo *et al.* (1991), in Cuba, show a good correlation between cane deterioration and the level of oligosaccharides and polysaccharides in juice. Lactic acid could also be a reliable indicator instead of ethanol. Such parameters have not been studied here because they are not as quick and easy to measure as ethanol is, and the practical applications would have been impossible to consider in factories.

Meteorological conditions, in particular temperature, do not seem to affect unburnt cane deterioration in terms of loss of sugar per 1000 ppm/brix of ethanol, but the production of ethanol is accelerated by temperature. Concerning burnt cane there is still a doubt because of the eventual effect of the variety: an increase in temperature does not lead to a corresponding increase in ethanol production. But whatever the season, the ethanol production rate in burnt cane is always higher than in unburnt cane.

Technological consequences

At the beginning of this last season, a regular sampling of primary juice was started in two of the three sugar factories on Reunion Island. Every day samples were taken, immediately frozen, and then analysed for ethanol the week later at the CERF's laboratory.

Some explanations have to be given for a better understanding of the situation. The method of calculation of the pol ratio by sugar manufacturers on Reunion Island is quite different to that used in South Africa. Instead of determining pol in cane by DAC, the CTICS (Reunion control board) takes samples of 5-10 kg of raw materials, by mean of a horizontal core sampler, from every cane consignment. These analyses take place at the reception centres located in the middle of a cane production area (there are three to five centres per factory) where cane is delivered by the growers, weighed and analysed to determine the growers' payment. The cane is then loaded on trucks to be delivered at factories, which can be situated up to 100 km away, and stored in a yard before processing. The time of storage may fluctuate depending on growers' delivery rate and factory time efficiency. The percentage ratio of pol % cane by mill balance to pol in cane by CTICS gives the pol ratio. When far from 100%, it is a source of much annoyance to the millers!

The ethanol content of primary juice at factories A and B during the 1993 season, day by day, is shown in Figures 6a and 6b, respectively. Usually, factory A does not receive much burnt cane, the largest part being trashed cane. On the other hand, factory B receives much accidentally burnt cane which could explain its higher overall ethanol level.

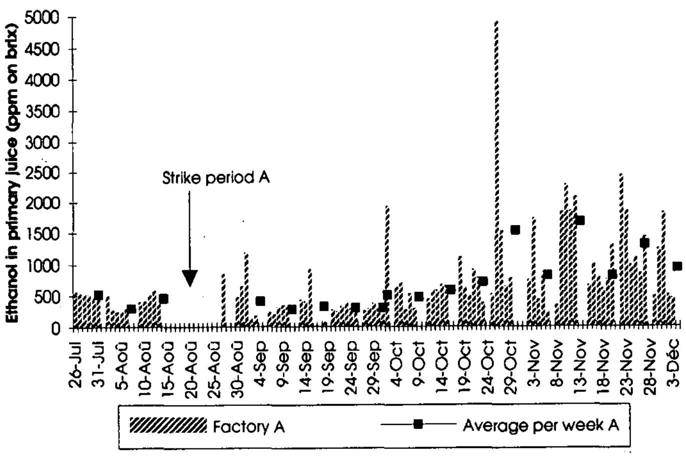

FIGURE 6a Evolution of ethanol content at factory A. 1993 season.

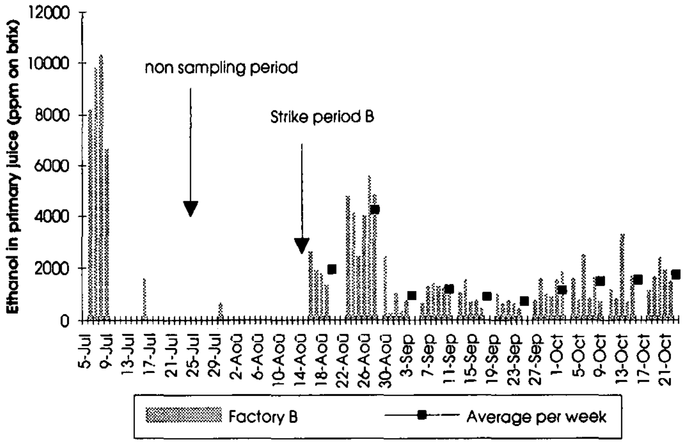

FIGURE 6b Evolution of ethanol content at factory A. 1993 season.

There are some peaks, like at the very beginning of the season at factory B, because of a large amount of old burnt cane. A strike by growers hit the factories in August, especially factory A. Degradation of cane during this period resulted in higher ethanol levels in juice. The ethanol content fluctuates, with an increasing trend by the end of the season. For technical reasons, juice at factory B could not be sampled during the whole season.

The ethanol content at factory A is shown with the pol ratio in Figure 7. The shapes of the two curves are similar, but the correlation is poor (r = 0,65). The state of deterioration of the cane, well characterised by the ethanol level in primary juice, cannot explain fully the gap between pol % cane by CTICS and sugar recovery as evaluated by mill balance. It is a complex notion in which many factors are involved, not only the cane quality but validity of sampling when leaves or stones are present in the consignment, losses during transportation of cane, sampling and analyses of mixed juice and bagasse, and weighing of mixed juice and imbibition water to calculate the mass balance.

The direct application of the regressions found during this study to the ethanol levels in primary juice at the two factories gives some interesting numbers. Factory A: about 1,5% of the sugar in the cane would have been lost by deterioration, which means that, finally, 1360 t of sugar (0,17% cane) disappeared. Factory B, which receives large amounts of burnt cane, would have lost 1560 t of sugar, that is almost 3% of the potential sugar (0,38% cane).

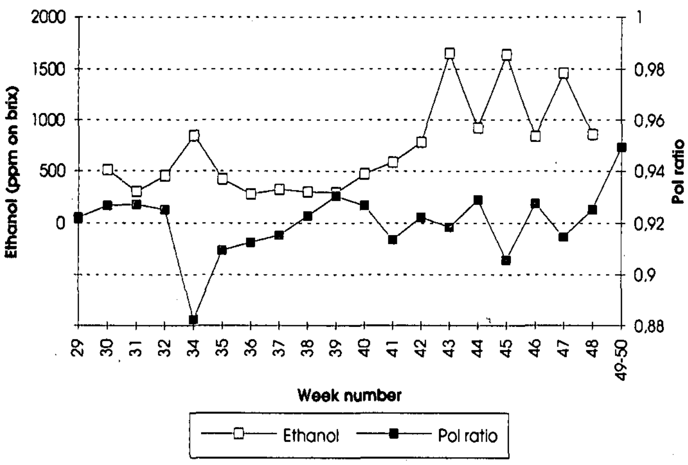

FIGURE 7 Weekly comparison of ethanol in primary juice and pol ratio at factory A. 1993 season.

The third factory of Reunion Island could not be investigated in 1993, but the generally poor quality of its cane indicates that the ethanol content, and the sugar losses involved, would be even higher than at the two other mills. Some ethanol measurements will be done during the next season at this factory.

Conclusions

The ethanol level in sugar cane juice correlates well with deterioration. It is a good and simple qualitative evaluation of the state of degradation of two varieties of cane used in Reunion. On the miller's side, it could answer the questions: "Is this cane consignment deteriorated?" and "To reduce losses, should we process it immediately, rather than this one which arrived sooner, but seems less deteriorated?".

On the grower's side, it should be a means of making growers aware of real decreases in their income when they deliver deteriorated cane.

Hence, a better organisation during harvesting and delivering operations, and then during yard operation at the factory, should improve the cut to crush delay and avoid money losses for each partner of the cane industry.However, the production of ethanol is probably one of the most representative factors, but not the only one. Cane degradation is a complex phenomenon which cannot be reduced to the study of a single parameter.

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