THE MEASUREMENT OF LOSSES ASSOCIATED WITH CANE DETERIORATION

By P. M. de ROBILLARD,[1] A. VAWDA[1] and G. R. E. LIONNET[2]

[1]*CG Smith Sugar Limited, Illovo*

[2]*Sugar Milling Research Institute, Durban*

Abstract

Experiments were done on an industrial scale to measure the pol lost and ethanol produced during cane deterioration. The cane mass and the mass of pol in cane were found to drop as deterioration proceeded. Pol % cane and the mass of pol in cane correlated well with the ethanol produced and it was found that between 2 to 3% of the original mass of pol in cane was lost for every 1000 ppm of ethanol produced. Since the average ethanol level found at Illovo over the last two seasons is about 4000 ppm on brix, about 10% of the pol in cane was lost because of cane deterioration. The financial implications of this loss are presented.

Introduction

Cane deterioration under South African conditions has been investigated by Wood[5, 6, 7] who did pioneering work in the seventies, and by Lionnet[1, 2, 3] who showed that ethanol can be used as a chemical index for the deterioration of wholestalk sugar cane. The concentration of ethanol in DAC extracts is now being used industrially to monitor cane delays.

One aspect which has not been covered, however, concerns the use of the ethanol concentration to estimate the amount of sucrose lost through the post-harvest deterioration process. Apart from sugar recovery aspects, due to the lower purities at the factory, this destruction of sucrose in the stalk represents a direct loss to the farmer who delivers the cane.

It was therefore decided to carry out tests to investigate the relationships between the ethanol formed and the mass of sucrose lost during cane deterioration.

Experimental Procedure

A test carried out under laboratory conditions at the SMRI showed good relationships between the ethanol formed and the decreases in both the pol % cane and the mass of pol in the cane. It was thus decided to repeat the experiments under industrial conditions to quantify the results under real circumstances.

A field near the Illovo factory was selected and at least one consignment was crushed by the mill as soon as possible after burning, to represent the fresh cane. This consignment was sampled by the SICB, part of the DAC extract being used for the ethanol analysis. Enough cut cane was then left in the field to provide about 20 consignments, to be sampled individually by the SICB and crushed at the mill, over a period of 3 to 4 weeks. Several bundles of about 10 kg were also made, and were left lying with the cane in the field. These were weighed every day throughout the experiment to obtain the change in mass. Meteorological data were also collected.

Three series of tests were done, one in 1988 (Crebo, personal communication) and two in 1989.

Results and Discussion

Some key details about the tests are given in Table 1.

Table 1
Details about the tests

Test	1	2	3
Duration	22/11/88 to 2/12/88	1/8/89 to 18/8/89	28/10/89 to 15/11/89
Cane	burnt	burnt	burnt
Ave. Temp (C)	23	18	21
Rain	no	no	yes
Variety	NCo 376	NCo 376	NCo 376

Loss of Mass

The average weight of the bundles left in the field was found to decrease linearly with time. The drop was due mostly to the loss of moisture as the mass of fibre was found to stay relatively constant throughout each test.

The change in mass as a function of the number of days since cutting, expressed as a percentage of the fresh mass, is given by equations 1, 2 and 3 for the three tests:

$$\%\ \text{mass} = 101{,}0 - 0{,}78 \times \text{number of days} \quad (n = 9;\ r = -0{,}87) \quad \ldots\ldots (1)$$

$$\%\ \text{mass} = 97{,}6 - 0{,}75 \times \text{number of days} \quad (n = 13;\ r = -0{,}96) \quad \ldots\ldots (2)$$

$$\%\ \text{mass} = 106{,}5 - 1{,}55 \times \text{number of days} \quad (n = 8;\ r = -0{,}94) \quad \ldots\ldots (3)$$

These results indicate that, for up to 20 days, the loss of mass is linear with time and ranges between 0,8 and 1,5% per day, at temperatures of 18 to 23°C. Wood[5,6,7] shows mass losses for trashed cane ranging from 0,6 to 1% per day, at temperatures of 21 to 24 degrees. The values obtained here thus agree with Wood's results.

Change in Pol % Cane

It is to be expected that the pol in cane will drop as the level of ethanol increases. Pol % cane has been plotted against the concentration of ethanol, expressed as ppm on brix in cane, in Figure 1, the data being that for the first test.

It is evident that, as the concentration of ethanol increases, the level of pol in the cane drops. It should be noted that the extracts were also analysed for sucrose by gas chromatography and that the sucrose trends were very similar, confirming the pol based results.

Equations 4, 5 and 6 were derived to quantify the loss of pol % cane as ethanol is produced.

$$\text{Pol \% cane} = 13{,}87\exp(-1{,}0909 \times 10^{-5} \times \text{EtOH}) \quad (n = 23;\ r = -0{,}79) \quad \ldots\ldots (4)$$

$$\text{Pol \% cane} = 13{,}58\exp(-8{,}4400 \times 10^{-6} \times \text{EtOH}) \quad (n = 10;\ r = -0{,}55) \quad \ldots\ldots (5)$$

$$\text{Pol \% cane} = 12{,}94\exp(-1{,}7820 \times 10^{-5} \times \text{EtOH}) \quad \ldots\ldots (6)$$
$$(n = 7;\ r = -0{,}80)$$

Equations 4, 5 and 6 have been used to calculate pol % cane as the level of ethanol increases. The results are shown in Table 2.

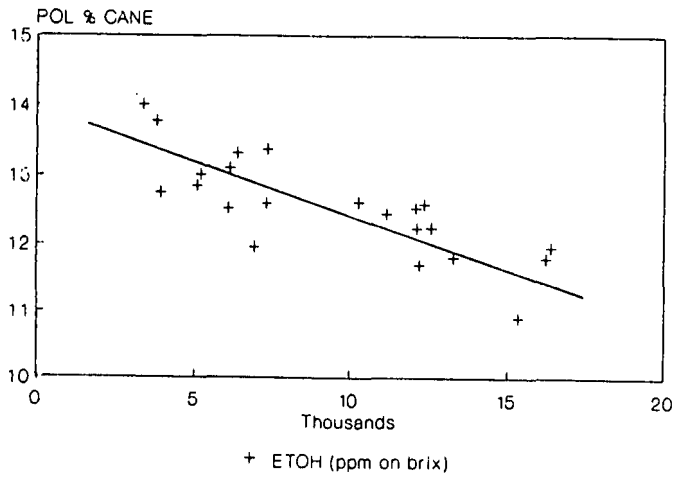

FIGURE 1 Pol % cane plotted against ethanol in cane

Table 2

The change in pol % cane as the concentration of ethanol increases

Ethanol (ppm on brix)	Test		
	1	2	3
0	13,87	13,58	12,94
2 000	13,57	13,35	12,48
4 000	13,28	13,13	12,05
6 000	12,99	12,91	11,63
8 000	12,71	12,69	11,22
10 000	12,44	12,48	10,83

These results show that significant decreases in pol % cane are associated with the formation of ethanol. As an approximation, the pol % cane value will decrease by about 1,5% for every 1000 ppm on brix of ethanol found in the cane.

Change in the Mass of Pol in Cane

Since both the mass of cane and the pol % cane decrease as deterioration proceeds, a significant decrease in the mass of pol in cane is expected. The change in the mass of pol in cane, expressed as a percentage of the mass in the fresh cane, has been plotted for test 3 in Figure 2.

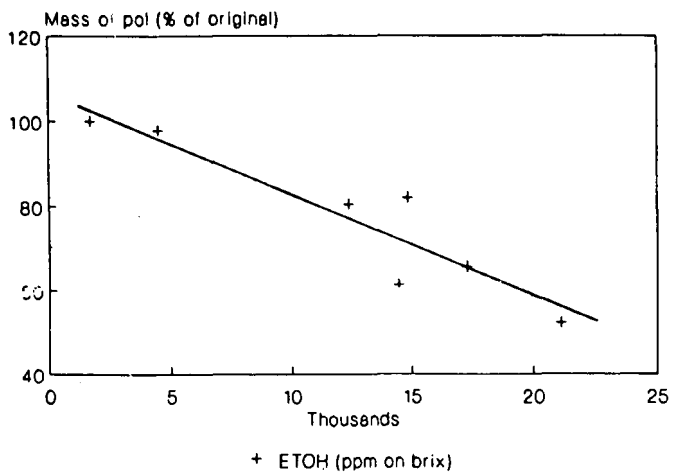

FIGURE 2 The percent change in the mass of pol with ethanol

As is evident from Figure 2, there is a marked decrease in the amount of pol in cane as ethanol increases. The results obtained have therefore been used to correlate the decrease in the mass of pol in cane against the concentration of ethanol in the cane. Equations 7, 8 and 9 were obtained.

$$\frac{\textit{mass of pol}}{\text{\% original}} = 98{,}9 - 1{,}256 \times 10^{-3} \times \text{EtOH} \quad \ldots\ldots (7)$$
$$(n = 23;\ r = -0{,}85)$$

$$\frac{\textit{mass of pol}}{\text{\% original}} = 98{,}9 - 1{,}788 \times 10^{-3} \times \text{EtOH} \quad \ldots\ldots (8)$$
$$(n = 10;\ r = -0{,}77)$$

$$\frac{\textit{mass of pol}}{\text{\% original}} = 107 - 2{,}448 \times 10^{-3} \times \text{EtOH} \quad \ldots\ldots (9)$$
$$(n = 7;\ r = -0{,}93)$$

Equations 7, 8 and 9 have been used to calculate the losses in the mass of pol for varying levels of ethanol in cane. The results are given in Table 3.

Table 3

The % change in the mass of pol in cane for varying levels of ethanol

Ethanol (ppm on brix)	% change in mass of pol			
	1	2	3	Average
0	0	0	0	0
2 000	−3	−4	−5	−4
4 000	−5	−7	−10	−7
6 000	−8	−11	−15	−11
8 000	−10	−14	−20	−15
10 000	−13	−18	−24	−18

On average about 2% of the mass of pol in cane is lost for every 1000 ppm of ethanol produced. It is interesting to compare these results with those of Ravnö[4] concerning the stoichiometry of ethanol formation from sucrose by yeast in pure culture. In that case, about two mass units of sucrose are required for each mass unit of ethanol. The results obtained here show that between 10 to 15 parts of sucrose have been lost for each part of ethanol. This indicates that sucrose is lost through a number of other mechanisms during deterioration, which is not unexpected.

Conclusions

The results obtained have shown that both cane mass and pol % cane decrease as deterioration proceeds. It has been possible to estimate that for every 1 000 ppm of ethanol on brix, the pol % cane decreases by about 1,5%. Since the mass of cane has also decreased, a significant loss of sucrose is expected. This has been found to be between 2 and 3% of the mass of sucrose in the fresh cane for every 1 000 ppm of ethanol on brix.

The Illovo factory has been measuring the ethanol content in cane for the past 3 seasons. An average value of 4 070 ppm has been found. Based on the above results this represents a loss of about 10% of the mass of sucrose in the fresh cane, which in the case of Illovo would represent 12 825 tons of sucrose for an average season of 950 000 tons of cane at 13,5% pol. At R380 per ton, this is equivalent to R4 873 500 which the cane farmers could have collected, had the ethanol concentration been zero. Under industrial conditions however it would be difficult to reach this level, but a target of 2 000 ppm appears feasible, particularly since an average concentration of 2 870 ppm was achieved at Illovo, over the last season. This target still represents a gain

in excess of R2 000 000. It should be noted that this analysis does not include all the benefits, which are considerable, that the factory would get from processing higher purity materials.

REFERENCES

1. Lionnet, GRE (1986). Post harvest deterioration of wholestalk sugar cane. *Proc S Afr Sug Technol Ass* 60: 52-57.
2. Lionnet, GRE and Pillay, JV (1987). Ethanol as an indicator of burn to crush delay in wholestalk sugar cane. *Proc S Afr Sug Technol Ass* 61: 5-7.
3. Lionnet, GRE and Pillay, JV (1988). Ethanol as an indicator of cane delays under industrial conditions. *Proc S Afr Sug Technol Ass* 62: 6-8.
4. Ravnö, AB (1979). Perspective on ethanol manufacture. *Proc S Afr Sug Technol Ass* 53: 6-9.
5. Wood, RA (1973). Varietal differences in the rate of deterioration of wholestalk sugar cane. *Proc S Afr Sug Technol Ass* 47: 133-137.
6. Wood, RA (1976). Cane deterioration as affected by billet size, delay in milling and other factors. *Proc S Afr Sug Technol Ass* 50: 12-17.
7. Wood, RA; du Toit, JL and Bruin, J (1972). Deterioration losses in wholestalk sugar cane. *Proc S Afr Sug Technol Ass* 46: 151-159.