ETHANOL AS AN INDICATOR OF BURN TO CRUSH DELAY

By G. R. E. LIONNET AND J. V. PILLAY

Sugar Milling Research Institute

Abstract

Delay periods, temperatures during the delay, ethanol contents, and varieties relating to cane consignments were collected throughout the 1986/87 season from mills selected to cover most of the South African sugar cane-producing areas. Multilinear regressions were used to yield equations giving the delay as a function of the above variables. Delays calculated using these equations were within forty hours of the times actually measured. During this work, the average burn-to-crush delay of mill-tagged cane was found to be about four days.

Introduction

The suitability of using the amount of ethanol in DAC extract as an indicator of delay was demonstrated by Lionnet[1] in 1986. In that work, most of the data were obtained by storing whole stalk cane under controlled conditions and pressing juice out of a few stalks after known delays. Subsequently, the analysis of DAC extract from tagged cane at Illovo (IL) supported the results obtained from this small-scale experiment.

In the work reported here, the survey has been extended over a wider geographic area to include Malelane (ML), Darnall (DL), Gledhow (GH), Maidstone (MS), Mount Edgecombe (ME), Illovo (IL), Umzimkulu (UK) and Noodsberg (NB).

Experimental procedure

Two procedures were followed. The first involved burning and cutting a field (or just cutting, in the case of trashed cane) on day zero, and delivering one or two consignments to the mill on several consecutive days. This is referred to as a deliberate run. During the random runs, the document that accompanied the cane consignment was inspected and, if it carried the necessary dates and times, that consignment was sampled. Here, unlike the deliberate runs, there was no control over the accuracy of the delays.

The DAC extract of the consignment was sampled, frozen, and then transferred to the Sugar Milling Research Institute (SMRI) for the ethanol analysis by gas chromatography.

Results

Complete set of data

The locations of the runs, the number of observations in each run, and the time of the season are given in Appendix 1.

At DL, the level of ethanol was approximately constant although the delay varied from 24 to 240 hours. No obvious explanation could be gained from field records as these showed no abnormalities. (This aberrant behaviour was also observed in Lionnet's work in 1986 and must be investigated further). The DL results were not included in the set of data used to yield the regression equation.

Details pertaining to the factors used in the regression are given in Table 1.

Table 1

Range, mean and standard deviation

Factor	Min.	Max.	Mean	Std. deviation
Time (h)	9	363	117	76,4
EtOH (ethanol, ppm on DAC brix)	810	29 380	5 988	5 174
Temperature (°C)	13,2	26,8	20,2	2,9

The dummy variables used to describe cane varieties are shown in Table 2.

Table 2

Dummy variables for cane varieties

Variable and value	Variety	No. of observations
$V_1 = 1, V_2 = 1$	NCo376	131
$V_1 = 1, V_2 = 0$	NCo293	42
$V_1 = 0, V_2 = 1$	N14	34
$V_1 = 0, V_2 = 0$	Mixed or other	18

It had been planned to include a dummy variable to indicate whether the cane had been burnt or trashed. However, only 31 of the 225 observations involved trashed cane. This did not justify the addition of a new variable to the regression and the results thus apply only to burnt cane.

Regression equation

The 225 observations were used to obtain Equation (1):

$$\log_e(\text{time}) = 5{,}806 + 9{,}317 \times 10^{-5} \times \text{EtOH} - 0{,}207\,V_1 - 0{,}067\,V_2 - 7{,}308 \times 10^{-2} \times \text{Temp} \quad \ldots \quad (1)$$

$$(n = 225;\ r = 0{,}75)$$

In this equation the time is the burn-to-crush delay in hours, the ethanol (EtOH) concentration is in ppm on brix in DAC extract, V_1 and V_2 define varieties as given in Table 2, and the temperature is the mean of the daily maximum and minimum temperatures, averaged over the delay period. T-tests have been used to show that all these variables are statistically significant. (This applies to all the equations in this paper). Delays calculated by using Equation (1), and delays actually measured, have been plotted in a graph in Figure 1.

As can be seen, there is a large scatter. This is similar to what was found in the previous work. The value predicted by Equation (1) is, on average, within approximately 40 hours of the measured delay time. Under practical conditions, this approach will therefore be useful for delays of more than 2 days. However, this precision could be improved to one day if a mill derives a regression equation from its own data. This can be expected because of the more homogeneous weather conditions, soil type, cultural practices etc.

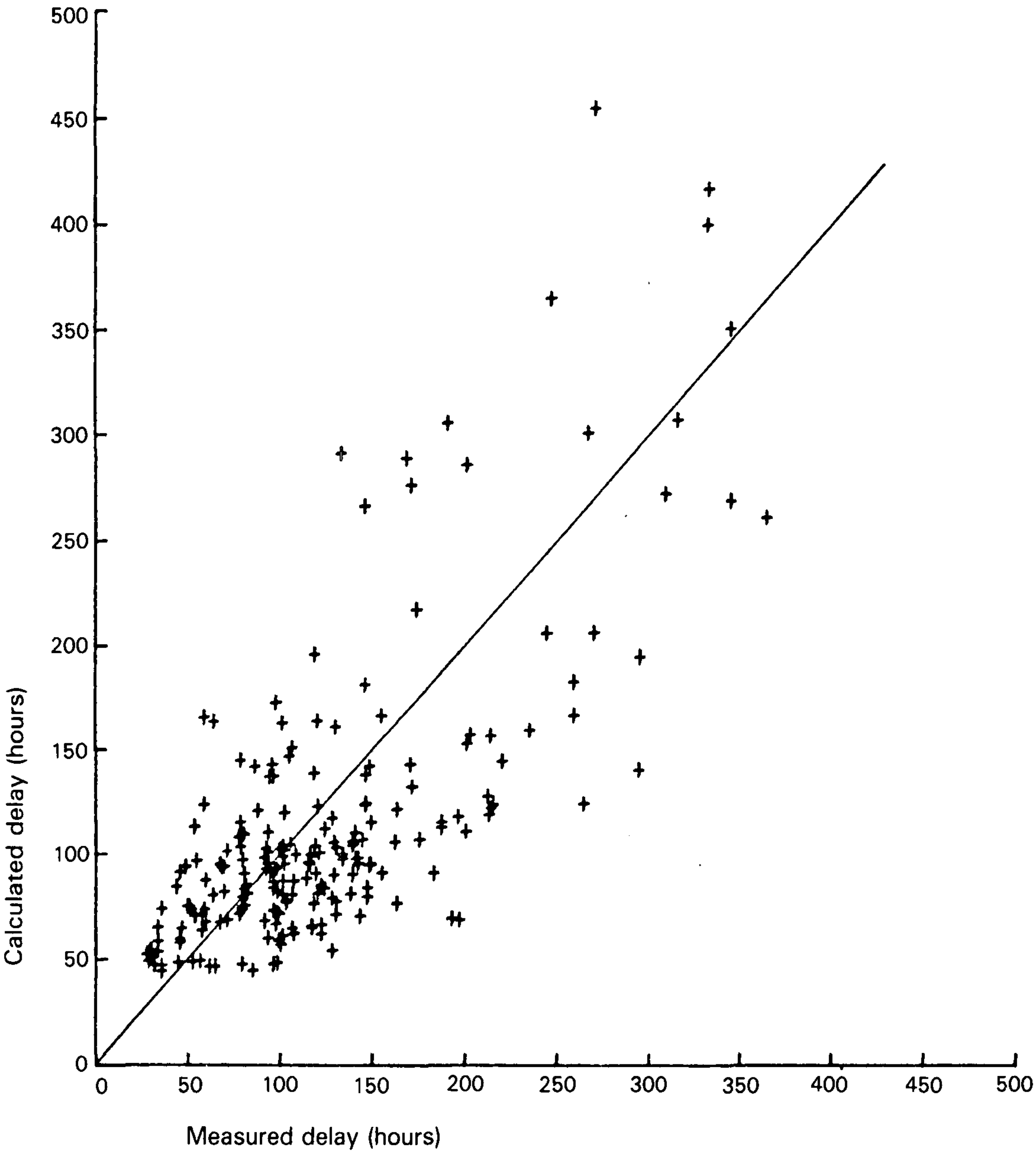

FIGURE 1: Calculated delays (Equation (1)) plotted against measured delays. The equivalence line is shown.

Random versus deliberate runs

This investigation offered the possibility of comparing the results of the industrial tagging system to those obtained from organised tests where the delays were known precisely. This was done by separating the data and calculating Equation (2) for the random runs alone:

$$\log_e(\text{time}) = 5{,}748 + 7{,}208 \times 10^{-5} \times \text{EtOH} - 0{,}047\,V_1 - 0{,}089\,V_2 - 7{,}257 \times 10^{-2} \times \text{Temp} \quad (2)$$

$(n = 162;\ r = 0{,}75)$

Similary, the deliberate runs yielded the following regression:

$$\log_e(\text{time}) = 4{,}562 + 7{,}572 \times 10^{-5} \times \text{EtOH} - 0{,}081\,V_1 - 7{,}489 \times 10^{-3} \times \text{Temp} \quad (3)$$

$(n = 63;\ r = 0{,}73)$

(Note: the deliberate runs involved only 2 varieties).

Equations (2) and (3) were used to calculate the data in Table 3. The ethanol levels cover the range of the set of data, the temperature used is 20,2°C (the mean, see Table 1) and the dummy variables correspond to the variety NCo376 (see Table 2).

Table 3
Delays by regression equations of random and deliberate runs

Ethanol (ppm on brix of DAC extract)	Time (h) as calculated by	
	Random (Eq. (2))	Deliberate (Eq. (3))
1 000	68	82
5 000	91	111
10 000	130	162
15 000	186	236
20 000	267	345

The results in Table 3 show that the delays calculated from Equations (2) and (3) are not identical for the same temperature, variety and ethanol content. This is not unexpected and is due to the values of the correlation coefficients (0,75 and 0,73) and to the differences in the number of observations in the two sets (162 and 63). On average, the times in Table 3 differ by about 40 hours. This average difference is sufficiently small to conclude that there is no major difference between the random and deliberate tests and thus that the tagging system does give reliable cane delay times.

Conclusions and Recommendations

Cane delays have traditionally been measured by tagging. This investigation shows that this system yields results similar to more rigorous tests involving controlled delays, and is thus satisfactory. Tagging, however, depends on tag recovery (which can be poor), and delays are available only for those consignments that have been tagged. A chemical method enables delays to be measured on any consignment. Furthermore, it would be possible in principle to sample the cane for the required analysis prior to milling.

The results obtained show that ethanol can be used to estimate cane delays with, however, a reduced precision when compared with tagging. Ethanol-based delays were within approximately 40 hours of the actual value. The ethanol approach would therefore be useful for delays of more than 2 days. Where a mill employs an equation based exclusively on its own data, this scatter could be reduced to 1 day. The average delay for the 162 random observations in this investigation was 104 hours (4,3 days). If this is an indication of the average over the whole industry, considerable savings could be made by efforts to reduce this delay.

It must be pointed out that there are cases where the ethanol content has not been adequate to measure delays, indicating that cane can deteriorate by other mechanisms. This problem was, however, found in only 15 of the 225 samples. Although this is less than 10% of the number of samples, there is a definite need to investigate this abnormal behaviour.

Acknowledgements

The deliberate runs were arranged by the cane supply and mill management staffs of ML, DL, UK and NB. The Sugar Industry Central Board chemists and their personnel at these mills, and also at GH, MS, ME and IL, were always extremely helpful. The SASA Experiment Station and the agricultural departments of various mills kindly supplied the meteorological information. At the SMRI, the Chemical Division carried out the ethanol determinations. The Authors gratefully acknowledge the contributions made by all these people, without whom this investigation would not have been possible.

REFERENCE

1. Lionnet, GRE (1986). Post-harvest deterioration of whole stalk sugar cane. *Proc S Afr Sug Technol Ass* 60: 51-57.

APPENDIX 1

Locations and details of the runs

Mill	Run*	Number of observations	Time of year
ML	D1	18	June 1986
	D2	18	October 1986
	D3	4	January 1987
	R1	18	January 1987
GH	R1	21	November 1986
MS	R1	30	August 1986
	R2	16	November 1986
ME	R1	17	December 1986
IL	R1	35	April 1986
	R2	22	November 1986
	R3	26	November 1985
UK	D1	12	May 1986
	D2	8	August 1986
DL	D1	8	June 1986
	D3	7	September 1986

* In this column, R indicates a random run, D a deliberate run.